6 Effects Analysis for Delta Smelt and Terrestrial Species

6.1 Effects on Delta Smelt

The potential effects of the proposed action (PA) on Delta Smelt are evaluated in this section for Water Facility Construction; Water Facility Maintenance; Water Facility Operations; Conservation Measures; Monitoring Activities; and Cumulative Effects.

Within each of the subsections, effects are evaluated for five life stages: migrating adults (December–March), spawning adults (February–June), eggs/embryos (spring: ~March–June), larvae/young juveniles (spring: ~March–June), and juveniles (~July–December). As previously described, for each life stage, individual-level effects are considered (*i.e.*, the effects to individual fish), as well as population-level effects (*i.e.*, the proportion of the population that could be affected by the individual-level effects).

The ability to estimate population-level effects has uncertainty, and by necessity is qualitative. In recent years, there have been several modeling efforts to determine factors driving long-term species abundance trends, but the results have been disparate, suggesting multiple factors. The population-level analysis in this document does not quantitatively evaluate the magnitude of change in Delta Smelt abundance that a predicted change in the analyzed factors could cause, which would require the use of a population/life cycle model (e.g., Maunder and Deriso 2011; Rose *et al.* 2013a,b; Newman *et al.* in preparation) incorporating the factors of importance for which predictions of values for NAA and PA could be made.

Scientific uncertainty exists with respect to the potential effects of the PA on Delta Smelt. As described in Section 3.4.7 *Collaborative Science and Adaptive Management Program* of Chapter 3, the Collaborative Science and Adaptive Management Program will help to address scientific uncertainty by guiding the development and implementation of scientific investigations and monitoring for both permit compliance and adaptive management, and applying new information and insights to management decisions and actions.

Each subsection also includes analysis of effects to critical habitat, with specific reference to the primary constituent elements, which USFWS has defined as follows[1]:

- 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

[1] This text is adapted from the USFWS Biological Opinion on the 2014 Georgiana Slough Floating Fish Guidance Structure Project.

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 (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 2002). 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 as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km). 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.

Although the analysis focuses on these definitions of critical habitat, it is acknowledged that important aspects of habitat occur outside these definitions. For example, as noted by the IEP MAST Team (2015: 106), although some researchers describe the low salinity zone as the center of distribution for juvenile Delta Smelt, Delta Smelt occur in relatively high abundance in the Cache Slough complex, which can also be considered as nursery habitat. In addition, recent laboratory studies suggest that Delta Smelt acclimate easily to LSZ salinity and above (up to 10 ppt), which points to other factors such as food, turbidity, or temperature playing a greater role in survival (Kammerer *et al.* 2015).

6.1.1 Effects of Water Facility Construction on Delta Smelt

6.1.1.1 Preconstruction Studies (Geotechnical Exploration)

Geotechnical investigations in open water at the proposed locations for the water conveyance facilities and alignments have the potential to affect Delta Smelt and its designated critical habitat. Approximately 100 over-water borings are currently proposed to collect geotechnical data at the proposed locations of the north Delta intakes, barge landings, tunnel alignment crossings, HOR gate, and CCF facilities (Table 3-4). Site-specific studies will investigate several geotechnical properties of these sites, including the stability of canal embankments and levees, liquefaction of soils, seepage through coarse-grained soils, settlement of embankments and structures, subsidence, and soil-bearing capacity. Specific field activities will include drilling of sample soil borings, cone penetration, and other *in situ* tests (slug tests, aquifer/pumping tests, and test pits) to evaluate subsurface conditions. In-water borings will be conducted using a mud rotary method in which a conductor casing will be pushed into the sediment to isolate the drilling area, drilling fluids (bentonite), and cuttings from the surrounding water. Drilling fluids and cuttings will be contained within the conductor casing and returned to a recirculation tank on the drill ship or barge where they will be transferred to drums for storage and disposal.

DWR plans to restrict in-water drilling to the approved in-water work window (August 1 to October 31) between the hours of sunrise and sunset. The duration of drilling at each location will vary depending on the number and depth of the holes, drill rate, and weather conditions, but activities are not expected to exceed 60 days at any one location. Overwater borings for the intake structures and river crossings for tunnels will be carried out by a drill ship and barge-mounted drill rigs. A number of AMMs are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts (e.g., bentonite or contaminant spills) on listed species and aquatic habitat during geotechnical activities: AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*) (Appendix 3.F, *General Avoidance and Minimization Measures*).

Restricting in-water drilling to August 1 to October 31 will effectively avoid the periods when Delta Smelt may be present in the action areas of the proposed geotechnical activities. Therefore, no direct effects on Delta Smelt are anticipated. Geotechnical activities in open water may affect the designated critical habitat of Delta Smelt through suspension and deposition of sediment (resulting in burial of potential spawning substrate) or direct disturbance of spawning substrate or shallow water habitat. However, these effects are expected to be negligible based on the small areas and nature of disturbance resulting from installation and removal of the casings, and the general lack of physical features at the propose sites that are thought to be preferred by Delta Smelt for spawning (see 6.1.1.3, North Delta Intakes. 6.1.1.4, Barge Landings, 6.1.1.5, Head of Old River Gate, and 6.1.1.6, Clifton Court Forebay). Consequently, with implementation of the proposed in-water work window and AMMs, geotechnical exploration is not likely to adversely affect Delta Smelt or its designated critical habitat.

6.1.1.2 North Delta Intakes

Three intakes will be constructed on the east bank of the Sacramento River between Clarksburg and Courtland at river miles (RMs) 41.1, 39.4, and 36.8 (Intakes 2, 3, and 5) (Appendix 3.A, *Map Book for the Proposed Action*). Each intake can divert a maximum of 3,000 cfs of river water. Each intake consists of an intake structure fitted with on-bank fish screens; gravity collector box conduits extending through the levee to convey flow to the sedimentation system; a sedimentation system consisting of sedimentation basins to capture sand-sized sediment and drying lagoons for sediment drying and consolidation; a sedimentation afterbay providing the transition from the sedimentation basins to a shaft that will discharge into a tunnel leading to an

IF; and an access road, parking area, electrical service, and fencing (as shown in Appendix 3.C, *Conceptual Engineering Report*, Volume 2, Sheets 11, 12, and 13). Additional details on the intake design, construction methods, and proposed construction schedule are described in Chapter 3, *Description of the Proposed Action*.

Construction activities that could potentially affect Delta Smelt include the following in-water activities: cofferdam installation and removal, levee clearing and grubbing, riprap placement, dredging, and barge operations. In-water construction or work activities are defined here as activities occurring within the active channel of the river, which would be part of, or immediately adjacent to, the river (e.g., at waterline, in water column, on riverbed, or along river shoreline). All other sediment-disturbing activities associated with construction of the north Delta intakes and associated facilities, including construction of the sedimentation basins, will be isolated from the Sacramento River and will use appropriate BMPs and AMMs to prevent the discharge of sediment to the river.

Construction of the three intakes is expected to take 5 years, with the construction of each facility beginning in different years (Intake 5 in year 1, Intake 3 in year 2, and Intake 2 in year 3) and requiring 3 years to complete. Construction of each intake structure will involve the installation of a sheetpile cofferdam in the Sacramento River during the first construction season, which will isolate the majority of work area from the river during the remaining years of construction. Some clearing and grubbing at the construction site may be required prior to cofferdam installation depending on site conditions (e.g., presence of vegetation). Once the cofferdam is installed, the area within the perimeter of the cofferdam will be dewatered to the extent possible. Dewatering of the cofferdam will be performed using a screened intake to prevent entrainment of fish. Before dewatering is complete, fish rescue and salvage activities will be performed to collect any stranded fish and return them to the river. Water pumped from within the cofferdams will be discharged to settling basins or Baker tanks to remove the sediment before being returned to the river via pumping or gravity flow. After the cofferdams have been dewatered, dredging, foundation pile driving, and other construction activities will proceed within the perimeter of the cofferdams.

It is assumed that once the intakes are completed and the cofferdams are removed, the area in front of each intake will be dredged to provide appropriate water depths and hydraulic conditions at each intake. If dredging is required, it will occur within the in-water construction window (June 1 through October 31) when listed fish species are least likely to occur in the action area. It is also assumed that periodic maintenance dredging will be needed to maintain appropriate flow conditions and would occur only during the approved in-water work window.

During the in-water construction period, a total of approximately 13.1 acres of shallow water habitat will be permanently[2] affected by construction activities. These impacts include 9.9 acres that will be altered by dredging and barge operations through changes in channel depths, benthic habitat, cover, and temporary in-water and overwater structure (barges, spud piles) within active work areas adjacent to the proposed intake structure and levee slope. The footprints of proposed intake structures, transition walls, and bank protection will result in the permanent loss of

[2] All impacts to Delta Smelt habitat are assumed to be permanent because they would occur over multiple years, which could affect multiple generations of Delta Smelt, given that the species generally lives for ~1 year.

approximately 3.2 acres of shallow water habitat. Permanent modifications of nearshore habitat due to the presence of these structures will encompass a total of 5,367 feet of shoreline. At each intake, between 1.6 and 3.1 acres of river area will be located within the cofferdams during construction.

6.1.1.2.1 Turbidity and Suspended Sediment

Construction activities that disturb the riverbed and banks within the footprints of the north Delta intake facilities may temporarily increase turbidity and suspended sediment levels in the Sacramento River. These activities include cofferdam installation and removal, levee clearing and grading, riprap placement, dredging, and barge operations. These activities will be restricted to the in-water construction window (June 1 through October 31) when listed fish species are least likely to occur in the action area. In addition to limiting activities to the in-water work window, AMMs are proposed to avoid or minimize impacts due to increases in turbidity and suspended sediment levels on water quality and direct and indirect affects to listed fish species resulting from sediment-disturbing activities. AMMs include the following: AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*). (

All other sediment-disturbing activities associated with construction of the north Delta intake facilities, including construction of the sedimentation basins, will be isolated from the Sacramento River and will not result in the discharge of sediment to the river with implementation of the proposed avoidance and minimization measures and best management practices related to off-bank (land-based) construction activities.

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with the timing restrictions on in-water activities and implementation of the proposed erosion and sediment control AMMs, no adverse water quality effects are anticipated during this period.

6.1.1.2.1.1 Migrating Adults (December-March)

6.1.1.2.1.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment.

6.1.1.2.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.1.2.1.2 Spawning Adults (February-June)

6.1.1.2.1.2.1 Individual-Level Effects

During cofferdam installation, levee clearing and grubbing, riprap placement, and barge operations, turbidity and suspended sediment levels in the river are anticipated to exceed ambient river levels in the immediate vicinity of these activities. Increases in turbidity and suspended sediment levels associated with these activities will be temporary and localized, and unlikely to reach levels causing direct injury or mortality to Delta Smelt.

Little is known about the spawning requirements of Delta Smelt or the sensitivity of spawning adults to turbidity and suspended sediment. In general, Delta Smelt are adapted to turbid waters where they presumably benefit from increased feeding efficiency and avoidance of sight-feeding predators. In laboratory experiments, the feeding rates of Delta Smelt generally were found to be highest at turbidities less than or equal to 12 NTU, relatively persistent over a broad range of turbidities (12-120 NTU), and showed a strong decline at 250 NTU (Hasenbein *et al.* 2013). This finding is consistent with monitoring data which shows that Delta Smelt are often captured in turbidities between 10 and 50 NTU (Feyrer *et al.* 2007).

During in-water construction activities at the proposed intake sites, turbidity and suspended sediment levels in the river are anticipated to exceed ambient river levels in the immediate vicinity of these activities, creating turbidity plumes that may extend several hundred feet downstream of construction activities. NMFS (2008) reviewed observations of turbidity plumes during installation of riprap for bank protection projects along the Sacramento River and concluded that visible plumes are expected to be limited to only a portion of the channel width, extend no more than 1,000 feet downstream, and dissipate within hours of cessation of in-water activities. Based on these observations, NMFS concluded that such activities could result in turbidity levels exceeding 25–75 NTUs. These levels would not be expected to adversely affect Delta Smelt based on the general association and feeding responses of Delta Smelt to turbidity (Hasenbein *et al.* 2013).

Increases in suspended sediment during in-water construction activities may result in localized sediment deposition in the vicinity of the proposed intakes, degrading potential spawning habitat of Delta Smelt through burial of suitable substrates. However, the Sacramento River in the vicinity of the proposed intake sites do not likely support significant spawning of Delta Smelt because of the low quality of spawning habitat in the action area. There appears to be little or no habitat thought to be preferred by Delta Smelt for spawning in this reach, which is dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation.

6.1.1.2.1.2.2 Population-Level Effects

Spawning adults may be present in the vicinity of the intakes during February through June. Thus, the timing of in-water construction activities (June 1–October 31) will avoid most of the spawning season (January through June, with peak numbers during February through May). In addition, historical survey data indicate that most of the Delta Smelt population is distributed downstream of the proposed intake sites. Adults and larvae have been reported to occur in the north Delta and farther upstream (Vincik and Julienne 2012) but the results from various surveys and general life history information suggest that the proportion of the population occupying the action area is low and most likely to occur during the primary winter and spring migration and spawning periods. For example, the mean densities of Delta Smelt larvae collected in the vicinity of the proposed intakes during the 1991-1994 egg and larval surveys was 4-6% of the mean densities collected downstream of these locations during April and May (Section 6.1.3, *Effects of Water Facility Operations on Delta Smelt*). The low proportion of migrating adults that would be expected to occur near the proposed intake sites during construction and operation of these facilities is also supported by the results of the DSM2-PTM analysis described in Section 6.A.2.1, *Migrating Adult Movement Upstream (DSM2-PTM)*, of Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*. Thus, the potential effects of increased turbidity and suspended sediment would be limited to a small proportion of the population that may be present in the action area in June. The low quality of spawning habitat and expected low utilization of the intake sites by spawning adults further reduces the likelihood of population-level effects.

6.1.1.2.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.1.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is low, individual eggs would be subject to burial by the deposition of suspended sediment generated by in-water construction activities.

6.1.1.2.1.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, the low proportion of the population utilizing the action area, and the low quality of spawning habitat in the affected reaches.

6.1.1.2.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.1.4.1 Individual-Level Effects

Based on the general discussion of effects above (see *Spawning Adults*), Delta Smelt larvae and early juveniles are not likely to adversely affected by the levels of turbidity and suspended sediment generated by in-water construction activities at the north Delta intake sites.

6.1.1.2.1.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, the low proportion of the population utilizing the action area, and general association and feeding responses of Delta Smelt to turbidity within the range generated by in-water activities.

6.1.1.2.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore would be unaffected by increased turbidity and suspended sediment during in-water construction activities.

6.1.1.2.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.2.2 Contaminants

Construction of the north Delta intakes could result in accidental spills of contaminants, including oil, fuel, hydraulic fluids, concrete, paint, and other construction-related materials, resulting in localized water quality degradation and potential adverse effects on Delta Smelt and other listed fish species. The risk of such effects is highest during in-water construction activities because of the proximity of construction activities to the Sacramento River. Other construction activities that occur in upland areas or are isolated from fish-bearing waters have little or no risk of contaminant effects on aquatic habitat or listed fish species. Implementation of the following AMMs (Appendix 3.F, *General Avoidance and Minimization Measures*) is expected to minimize the potential for introduction of contaminants to surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials*:* AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan;* AMM14 *Hazardous Materials Management Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan*).

Contaminants may also enter the aquatic environment through the disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. The proposed intake sites are located downstream of major urban and agricultural regions where sediments have been affected by discharges from these sources for many decades. No information on sediment contaminants at these sites is currently available. Metals, PCBs, hydrocarbons (typically oil and grease), and ammonia are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Many of these contaminants readily adhere to sediment particles and tend to settle out of solution relatively close to the primary source of contaminants. PCBs are persistent, adsorb to soil and organic matter, and accumulate in the food web. Lead and other metals also will adhere to particulates and can bioaccumulate to levels sufficient to cause adverse biological effects. Mercury is also present in the Sacramento River system and could be sequestered in riverbed sediments. Hydrocarbons biodegrade over time in an aqueous environment and do not tend to bioaccumulate or persist in aquatic systems.

The potential for introduction of contaminants from disturbed sediments will be addressed through the development and implementation of an HMMP with specific measures to address the containment, handling, storage, and disposal of contaminated sediments. Because the potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, implementation of the erosion and sediment control AMMs would further minimize this risk.

6.1.1.2.2.1 Migrating Adults (December-March)

6.1.1.2.2.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Some risk would also exist outside the in-water construction period. However, with the implementation of proposed pollution prevention and erosion and sediment control AMMs, there is little or no risk of exposure of migrating adults to contaminants.

6.1.1.2.2.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.2.2 Spawning Adults (February-June)

6.1.1.2.2.2.1 Individual-Level Effects

Exposure of fish to contaminants as a result of spills or sediment disturbance can cause effects that range from physiological stress, potentially resulting in delayed effects on growth, survival, and reproductive success, to direct mortality (acute toxicity) depending on the on the concentration, toxicity, solubility, bioavailability, and duration of exposure, as well as the sensitivity of the exposed organisms. For example, Delta Smelt are highly sensitive to sublethal levels of pyrethrin which causes neurological damage and results in impaired swimming ability and potential effects on chemosensory abilities (Connon *et al.* 2009). Such impairments may affect the ability of Delta Smelt to swim against tides or water currents, increasing their susceptibility to predation and lowering their ability to find food (Connon *et al.* 2009). Chemosensory impairment may also affect the ability of Delta Smelt to detect pheromones and find mates (Connon *et al.* 2009). In addition, contaminants can enter the aquatic food web and accumulate in fish through their diet, leading to adverse effects on behavior, tissues and organs, reproduction, growth, and immune system (Connon *et al.* 2009).

Based on the timing of in-water construction activities (June 1–October 31), spawning adults in the vicinity of the intake sites would be subject to direct exposure to contaminant spills or sediment-borne contaminants (i.e., through exposure to turbidity plumes) in June. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk.

6.1.1.2.2.2.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, distribution of spawning adults, low quality of spawning habitat in the vicinity of the intake sites, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.2.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.2.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although exposure of eggs or embryos is expected to be minimal, individual eggs could suffer adverse effects if directly exposed to contaminant spills or sediment-borne contaminants during construction. Implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.2.2.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of spawning adults in the action area, low quality of spawning habitat, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.2.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.2.4.1 Individual-Level Effects

Based on the general discussion of effects above (see *Spawning Adults*), individual larvae and early juveniles, if present, may be adversely affected by direct exposure to contaminant spills or sediment-borne contaminants during construction of the intakes. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.2.2.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of the population utilizing the action area, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.2.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction of the intakes.

6.1.1.2.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.3 Underwater Noise

Pile driving conducted in or near open water can produce underwater noise of sufficient intensity to injure or kill fish. During construction of the north Delta intakes, potentially harmful underwater noise levels could occur during installation of temporary sheet piles (cofferdams), permanent foundation piles for the intake facilities, and permanent bridge piers for the Highway 160 bridge.

Restriction of pile driving activities in or near open water in the Sacramento River to June 1 through October 31 will minimize the exposure of Delta Smelt to potentially harmful underwater noise. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that can be employed to further minimize potential impacts on Delta Smelt (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory methods or other non-impact driving methods (e.g., drill-shaft methods) that are not expected to produce noise levels high enough to cause injury. However, the degree to which vibratory and non-impact driving methods can be performed is unknown at this time due to uncertain geologic conditions at the proposed intake sites. If impact pile driving is required, DWR, in coordination with the USFWS, NMFS, and CDFW, will evaluate the feasibility of other protective measures including dewatering, physical devices (e.g., bubble curtains), and operational measures (e.g., restricting pile driving to specific times of the day) to limit the intensity and duration of underwater noise levels when Delta Smelt and other listed fish species may be present. Coordination, implementation, and monitoring of these measures will performed in accordance with the underwater sound control and abatement plan, which includes hydroacoustic monitoring to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions that will be taken should the thresholds be exceeded.

6.1.1.2.3.1 Migrating Adults (December-March)

6.1.1.2.3.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.2.3.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.3.2 Spawning Adults (February-June)

6.1.1.2.3.2.1 Individual-Level Effects

Restricting impact pile to June 1–October 31 would avoid most of the Delta Smelt spawning season, although some potential for exposure of spawning adults would occur in June. In general, the effects of pile driving noise on fish may include behavioral responses, physiological stress, temporary and permanent hearing loss, tissue damage (auditory and non-auditory), and mortality. Factors that influence the magnitude of effects include species, life stage, and size of fish; type and size of pile and hammer; frequency and duration of pile driving; site characteristics (e.g., depth); and distance of fish from the source. In Delta Smelt and most other teleost fish, the presence of a swim bladder to maintain buoyancy increases their vulnerability to underwater noise (Hastings and Popper 2005). Sublethal effects of elevated noise include damage to hearing organs that may temporarily affect swimming ability and hearing sensitivity, which may reduce the ability of fish to detect predators or prey. Non-injurious levels of underwater noise may also cause behavioral effects (e.g., startle or avoidance responses) that can disrupt or alter normal activities (e.g., migration, holding, or feeding), potentially increasing an individual's vulnerability to predation or reducing growth or spawning success.

Dual interim criteria have been established to provide guidance for assessing the potential for injury of fish resulting from pile driving noise (Fisheries Hydroacoustic Working Group 2008) (Table 6.1-1). The dual criteria for impact pile driving are (1) 206 decibels (dB) for peak sound pressure level (SPL); and (2) 187 dB for cumulative sound exposure level (SEL) for fish larger than 2 grams, and 183 dB SEL for fish smaller than 2 grams. Peak SPL is considered the maximum sound pressure level a fish can receive from a single strike without injury. Cumulative SEL is considered the total amount of acoustic energy that a fish can receive from single or multiple strikes without injury. The cumulative SEL threshold is based on the total daily exposure of a fish to noise from sources that are discontinuous (in this case, noise that occurs up to 12 hours a day, with 12 hours between exposures). This assumes that the fish is able to recover from any effects during this 12-hour period. These criteria relate to impact pile driving only. Vibratory pile driving is generally accepted as an effective measure for minimizing or eliminating the potential for injury of fish from pile driving operations.

Table 6.1-1. Interim Criteria for Injury to Fish from Pile Driving Activities.

Interim Criteria	Agreement in Principle
Peak Sound Pressure Level (SPL)	206 dB re: 1μPa (for all sizes of fish)
Cumulative Sound Exposure Level (SEL)	187 dB re: 1μPa^2-sec—for fish size ≥ 2 grams 183 dB re: 1μPa^2-sec—for fish size < 2 grams

Fish smaller than 2 grams are more sensitive to underwater noise than larger individuals, and may experience injury at 183 dB (Fisheries Hydroacoustic Working Group 2008). Larval and juvenile delta smelt are generally smaller than 2 grams while adults average 2 to 3 grams (Foott and Bigelow 2010]). Because some adult delta smelt are less than the 2 grams, the lower injury threshold (183 dB) applies to this life stage as well. The interim criteria were set to be conservatively protective of fish.

In the following effects analysis, the potential for physical injury of fish from exposure to pile driving sounds was evaluated using a spreadsheet model developed by NMFS to calculate the distances from a pile that sound attenuates to the peak or cumulative criteria. These distances define the area in which the criteria are expected to be exceeded as a result of impact pile driving. The NMFS spreadsheet calculates these distances based on estimates of the single-strike sound levels for each pile type (measured at 10 meters from the pile) and the rate at which sound attenuates with distance. In the following analysis, the standard sound attenuation rate of 4.5 dB per doubling of distance was used in the absence of other data. To account for the exposure of fish to multiple pile driving strikes, the model computes a cumulative SEL for multiple strikes based on the single-strike SEL and the number of strikes per day or pile driving event. The NMFS spreadsheet also employs the concept of "effective quiet". This assumes that cumulative exposure of fish to pile driving sounds of less than 150 dB SEL does not result in injury.

Other sources of in-water noise include generator and engine vibration transmitted through the hulls of work barges and associated vessels, and dredge equipment. Noise levels produced by these sources typically are less than those associated with vibratory pile driving and are likely to be comparable to ambient noise conditions in the vicinity of the intakes caused by traffic, boats, water skiers, etc. For routine vessel traffic, these noise levels typically range from peak levels of 160 to 190 dB at a range of 10 meters, depending on vessel size (Thomsen et al. 2009). Dredge equipment noise will vary depending on equipment type. For example, a hydraulic cutterhead dredge working in the Stockton Deepwater Ship Channel produced noise levels of around 152 to 157 dB at 1 meter from the source (Reine and Dickerson 2014). Removal of pilings or other underwater structures could involve use of vibratory methods. This could generate sounds that could cause avoidance behavior of any fish present. However, the noise levels generated by vibratory driving do not approach the peak or cumulative sound criteria outlined above.

Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper *et al.* 2006). NMFS generally assumes that a noise level of 150 dB root mean square (RMS) is an appropriate threshold for behavioral effects. NMFS acknowledges this uncertainty in other BiOps but believes this noise level is appropriate for identifying the potential for behavioral effects of pile driving sound on fish until new information indicates otherwise.

Table 6.1-2 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*. This analysis considers only those pile driving activities that could generate noise levels sufficient to exceed the interim injury thresholds in the Sacramento River or other waters potentially supporting listed fish species. These activities include impact pile driving in open water, in cofferdams adjacent to open water, or on land within 200 feet of open water. Because the extent to which impact driving will be required is unknown at this time, the following analysis presents underwater noise impacts based on the worst-case scenario in which all piles are driven with an impact driver with no attenuation (no dewatering or attenuation devices). In addition, the computed distances over which pile driving sounds are expected to exceed the injury and behavioral thresholds assume an unimpeded sound propagation path. However, site conditions such as major channel bends and other in-water structures can reduce these distances by impeding the propagation of underwater sound waves.

Table 6.1-2. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at the North Delta Intake Sites

Facility or Structure	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 183 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Number of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving (days)
Intake 2						
Cofferdam	33	2,814	13,058	1	Jun-Oct	42
Foundation	46	3,280	32,800	1	Jun-Oct	8
SR-160 Bridge	33	1,522	7,065	1	Jun-Oct	5
Intake 3						
Cofferdam	33	2,814	13,058	1	Jun-Oct	42
Foundation	46	3,280	32,800	1	Jun-Oct	8
SR-160 Bridge	33	1,522	7,065	1	Jun-Oct	5
Intake 5						
Cofferdam	33	2,814	13,058	1	Jun-Oct	42
Foundation	46	3,280	32,800	1	Jun-Oct	8
SR-160 Bridge	33	1,522	7,065	1	Jun-Oct	5

1 In this case, distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).

2 Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 33–46 feet of the source piles (Table 6.1-2). Based on cumulative (daily) exposures of fish to pile driving noise, the risk of injury may extend 2,814 feet during installation of the cofferdams, 3,280 feet during installation of the foundation piles, and 1,522 feet during installation of the SR-160 bridge piers assuming worst-case conditions. Based on a threshold of 150 dB RMS, the potential for behavioral effects would extend 13,058, 32,800, and 7,065 feet, respectively. However, the extent of noise levels exceeding the injury and behavioral thresholds would be constrained to varying degrees by major channel bends that range from approximately 2,300 to 10,700 feet away from each intake facility. The potential for effects would occur over periods of 42 days during cofferdam installation, 8 days during foundation pile installation, and 5 days during bridge pile installation.

6.1.1.2.3.2.2 Population-Level Effects

Pile driving noise may have adverse effects on spawning delta smelt that are present or passing through the NDD construction sites during June while pile driving is occurring. Adults occur in the north Delta and farther upstream but the results from various surveys and general life history information suggest that the proportion of the population seasonally occupying the action area is low and most likely to occur during the winter and spring (December through May), when no in-water work would occur. Some potential exists for adults to occur in the action area in June when pile driving and other in-water construction activities for the north Delta intakes are scheduled to begin. However, because of the low abundance of delta smelt in this part of their range in June and the low quality of potential spawning habitat in the action area, the potential for exposure of delta smelt to pile driving noise is considered low. Potential exposure of the population to pile driving noise will be further minimized by implementation of an underwater sound control and abatement plan (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*) that includes the use of vibratory and other non-impact pile driving methods, attenuation devices, and other potential physical and operational measures to avoid or minimize impacts on Delta Smelt. This plan will also include hydroacoustic monitoring and compliance requirements that will be developed in coordination with USFWS, NMFS, and CDFW to avoid and minimize potential impacts on listed fish species.

6.1.1.2.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.3.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is low, any individual eggs in the vicinity of the intake sites would be unable to avoid prolonged exposure to pile driving noise and potential adverse effects on survival, development, or viability.

6.1.1.2.3.3.2 Population-Level Effects

Based on the small proportion of spawning adults in the action area at the time of pile driving operations and expected low utilization of the affected reaches by spawning adults, any mortality of eggs or embryos due to pile driving noise would not be expected to have a significant effect on population abundance. Any potential losses will be further reduced by the use of vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that may be implemented as part of the underwater sound control and abatement plan.

6.1.1.2.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.3.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles originating from upstream spawning areas may encounter pile driving noise during their downstream movement to estuarine rearing areas. Although the potential for exposure is low, any larval Delta Smelt passing the intakes during impact pile driving would be unable to avoid exposure to pile driving noise and therefore could be injured or killed depending on their proximity to the source piles and the duration of exposure.

6.1.1.2.3.4.2 Population-Level Effects

Based on the proportion of the adult population occurring in or upstream of the north Delta in June, any losses of larvae or early juveniles that encounter pile driving noise would represent a small proportion of total larval production in each year of pile driving operations. Potential losses will be further reduced by the use of vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that may be implemented as part of the underwater sound control and abatement plan.

6.1.1.2.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be affected by pile driving noise.

6.1.1.2.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.3.5.3 Population-Level Effects

No population-level effects would occur.

6.1.1.2.4 Fish Stranding

Installation of cofferdams to isolate the construction areas for the proposed intake sites has the potential to strand fish, resulting in direct mortality of fish from dewatering, dredging, and pile driving within the enclosed areas of the channel. To minimize entrapment risk and the number of fish subject to capture and handling during fish rescue and salvage operations, cofferdam construction will be limited to the proposed in-water construction period (June 1–October 31) to avoid the peak abundance of adults and larvae in the north Delta. DWR will prepare and submit a fish rescue and salvage plan (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM8 *Fish Rescue and Salvage Plan*) to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if permitted.

6.1.1.2.4.1 Migrating Adults (December-March)

6.1.1.2.4.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31), including cofferdam construction, will avoid the Delta Smelt adult migration season. Therefore, migrating adults are not at risk of being stranded.

6.1.1.2.4.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.4.2 Spawning Adults (February-June)

6.1.1.2.4.2.1 Individual-Level Effects

Although present in low numbers, spawning adults may be present in the action area in June and subject to stranding in cofferdams. Adults would be expected to move away from active construction areas, but some risk of stranding would exist as long as the affected areas are accessible to fish. Fish rescue and salvage activities using accepted fish collection methods can result in injury or mortality, but these effects are typically minor, and can often be avoided with appropriate training. However, adverse effects may still occur because of varying degrees of effectiveness of the collection methods and potential stress and injury associated with various capture and handling methods.

6.1.1.2.4.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the low densities of adults that may be present in the action area during cofferdam installation, the low utilization and expected avoidance of the intake sites by spawning adults, and implementation of fish rescue and salvage activities.

6.1.1.2.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.4.3.1 Individual-Level Effects

Based on the low utilization and expected avoidance of the intake sites by spawning adults, there is little or no risk of stranding of Delta Smelt eggs or embryos.

6.1.1.2.4.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.4.4.1 Individual-Level Effects

Although the potential for exposure is low, Delta Smelt larvae and early juveniles may be particularly vulnerable to stranding because of their limited swimming abilities and potential entrainment in open cofferdams. In addition, conventional fish collection methods are less effective and more likely to cause injury or death of these life stages compared to larger juveniles or adults.

6.1.1.2.4.4.2 Population-Level Effects

Population-level effects would be expected to be negligible based on the small proportion of adults that spawn in or upstream of the north Delta in June, the resulting low densities of larvae and juveniles passing the intake sites, and the limited influence of cofferdams on passage conditions in the river.

6.1.1.2.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be stranded in cofferdams.

6.1.1.2.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.5 Direct Physical Injury

During construction of the north Delta intakes, fish could be injured or killed by direct contact with equipment or materials that enter open waters of the Sacramento River. Potential mechanisms include fish being crushed by falling rock (riprap), impinged by sheetpiles, entrained by dredges, or struck by propellers. In addition to the proposed work window, the potential for injury of listed fish species would be minimized by limiting the duration of in-water construction activities to the extent practicable and implementing the following AMMs: AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan; Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan;* and AMM8 *Fish Rescue and Salvage Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*).

6.1.1.2.5.1 Migrating Adults (December-March)

6.1.1.2.5.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, migrating adults are not at risk of being injured.

6.1.1.2.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.5.2 Spawning Adults (February-June)

6.1.1.2.5.2.1 Individual-Level Effects

Spawning adults may be present in very small numbers in June and therefore subject to injury. Although adults would be expected to move away from active construction areas, it is assumed that some potential for injury exists whenever heavy equipment or materials are operated or placed in open water.

6.1.1.2.5.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the low densities of adults that may be present in the action area during in-water construction activities, and the low utilization and expected avoidance of the intake sites by spawning adults.

6.1.1.2.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.5.3.1 Individual-Level Effects

Based on the low utilization and expected avoidance of the intake sites by spawning adults, there is little or no risk of injury of Delta Smelt eggs or embryos.

6.1.1.2.5.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.5.4.1 Individual-Level Effects

Although the potential for exposure is low, Delta Smelt larvae and early juveniles may be particularly vulnerable to injury because of their limited swimming abilities.

6.1.1.2.5.4.2 Population-Level Effects

Population-level effects would be expected to be negligible based on the small proportion of adults that spawn in or upstream of the north Delta in June, the resulting low densities of larvae and juveniles passing the intake sites, and the limited influence of construction equipment and materials on passage conditions in the river.

6.1.1.2.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be injured by construction activities.

6.1.1.2.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.6 Loss or Alteration of Habitat

Construction of the north Delta intakes will result in permanent loss or alteration of aquatic habitat that includes the designated critical habitat of Delta Smelt. The effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. A total of approximately 13.1 acres of shallow water habitat will be permanently[3] affected by intake construction. This consists of 9.9 acres that will be altered by dredging and barge operations through changes in channel depths, benthic habitat, cover, and temporary in-water and overwater structure (barges, spud piles) within active work areas adjacent to the proposed intake structure and levee slope. The footprints of proposed intake structures, transition walls, and bank protection will result in the permanent loss of approximately 3.2 acres of shallow water habitat. Permanent losses of nearshore habitat due to the presence of the three NDD intake structures will encompass a total of 5,367 feet of shoreline.

During construction activities, DWR will implement AMM2 *Construction Best Management Practices and Monitoring,* to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. DWR proposes to offset unavoidable habitat impacts at the proposed intake sites through on-site and/or off-site mitigation, including the purchase of conservation credits at an approved conservation bank.

6.1.1.2.6.1 Migrating Adults (December-March)

6.1.1.2.6.1.1 Individual-Level Effects

Construction of the three intake structures will result in a permanent loss or alteration of 13.1 acres of shallow water habitat and 5,367 feet of channel margin habitat near the northern limit of the geographic area used by Delta Smelt for migration, potential spawning, and larval dispersal to the estuary. Cofferdams will isolate the work areas, temporarily reducing the width of the river channel and eliminating the shallow, low-velocity nearshore zones currently available to migrating Delta Smelt along the east bank of the river. The creation of deeper, higher-velocity zones adjacent to the cofferdams and riprap could also increase predator habitat. Although affecting a small proportion of the population that may migrate past these sites, these changes may impair adult passage and subject adults to an elevated risk of predation as they attempt to pass the construction sites.

6.1.1.2.6.1.2 Population-Level Effects

The loss of low-velocity shoreline areas and increased predation risk at the intake construction sites could potentially reduce the number of migrating adults that successfully pass the sites and survive to reach upstream spawning areas. The effect on passage success depends on the number attempting to pass the site on the east side of river and the ability of adults to use alternative routes (e.g., the west side of the river would remain unaffected) or spawning areas (e.g., returning downstream to spawn). Overall, however, the small proportion of the population that migrates and spawns in the reaches upstream of the intake site indicates that any population-level effects would be small.

[3] All impacts to Delta Smelt habitat are assumed to be permanent because they would occur over multiple years, which could affect multiple generations of Delta Smelt, given that the species generally lives for ~1 year.

6.1.1.2.6.2 Spawning Adults (February-June)

6.1.1.2.6.2.1 Individual-Level Effects

There appears to be little or no habitat thought to be preferred by Delta Smelt for spawning at the proposed intake sites, which are dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation. Consequently, permanent losses of nearshore habitat resulting from construction of the intakes would have little or no effect on spawning site selection or spawning success of adults.

6.1.1.2.6.2.2 Population-Level Effects

The existing value and function of the habitat for Delta Smelt within the footprint of the proposed intakes and work areas is low compared to core areas of the species' habitat which occurs farther downstream in the estuary. Loss or alteration of this habitat would likely have a negligible population-level effect because of the small proportion of the population spawning in the action area, expected low utilization of the intake sites by spawning adults, and negligible contribution of this habitat to the overall spawning capacity of the upper estuary.

6.1.1.2.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.6.3.1 Individual-Level Effects

Based on the small proportion of the population spawning in the action area, expected low utilization of the intake sites by spawning adults, and negligible contribution of this habitat to the overall spawning capacity, there is little risk of direct or indirect effects on egg/embryo production or survival.

6.1.1.2.6.3.2 Population-Level Effects

Population-level effects are expected to be negligible.

6.1.1.2.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.6.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles migrating from upstream spawning areas to estuarine rearing areas may be subject to an elevated risk of predation as they pass the intake construction sites because of the presence of in-water and overwater structures and the loss of shallow, low-velocity nearshore areas. To the extent that these conditions provide beneficial habitat or increased predation opportunities for predators of larvae and early juveniles (e.g., silversides; Baerwald et al. 2012), there could be an elevated risk of predation for these young life stages. However, it is not clear that these structures provide beneficial habitat as these small predators may be susceptible to the same larger predators that consume adult Delta Smelt. Therefore, elevated predation on Delta Smelt larvae is unlikely.

6.1.1.2.6.4.2 Population-Level Effects

Even if larvae and juveniles are subject to elevated predation rates as they pass the construction sites for the NDD intakes, the population-level effect would be small based on the small proportion of the population occurring in or upstream of the action area.

6.1.1.2.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be affected by losses or alteration of habitat during construction.

6.1.1.2.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3 Barge Landings

Temporary barge landings will be constructed at each of the TBM launch shaft sites for the loading and unloading of construction equipment, materials, fill, and tunnel spoils. A total of seven barge landings are currently proposed (Appendix 3.A, *Map Book for the Proposed Action*) at the following locations:

- Snodgrass Slough north of Twin Cities Road (adjacent to proposed intermediate forebay)
- Little Potato Slough (Bouldin Island south)
- San Joaquin River (Venice Island south)
- San Joaquin River (Mandeville Island east at junction with Middle River)
- Middle River (Bacon Island north)
- Middle River (Victoria Island northwest)
- Middle River (junction with West Canal at Clifton Court Forebay)

These locations are approximate but represent the general areas for these facilities based on their proximity to the launch shaft sites. Major construction elements of this action include barge landing construction, levee clearing and armoring (as necessary), and barge operations.

The schedule for construction of the barge landings will likely extend over 2 to 3 years. The specific design of the barge landings is unknown at this time. Permanent docks supported by steel piles are currently proposed although floating barges will be used where possible to minimize in-water construction activities. Docks would occupy an area of approximately 300 by 50 feet (0.34 acre) that would be bordered by a backfilled perimeter sheet pile wall where barges would be moored during loading and unloading operations. Dock construction will require the installation of a sheet-pile perimeter wall and 800 steel pipe piles (18-inch diameter) to support the dock. Other in-water and over-water structures may include mooring dolphins, ramps, and possibly conveyors for loading and unloading materials. Some clearing and armoring of the levee may be required to provide access and protect the levee from wave erosion.

Construction of the barge landings will result in permanent impacts to approximately 22.4 acres of tidal perennial aquatic habitat that includes the footprint of the docks, mooring structures, and adjacent channel area that will be affected by propeller wash and scour from barges and tidal action. Estimates of the amount of shallow water habitat or suitable spawning substrate potentially affected by construction are not currently available.

6.1.1.3.1 Turbidity and Suspended Sediment

Pile driving, barge operations, and levee armoring will be the principal sources of turbidity and suspended sediment during construction of the barge landings. These activities will result in disturbance of the channel bed and banks, resulting in periodic increases in turbidity and suspended sediment in the adjacent waterways. In-water vibratory and impact driving of the sheet piles are expected to generate turbidity plumes that could extend beyond the immediate vicinity of the source piles depending on the direction and velocity of tidal flows. Based on an estimated installation rate of 60 piles per day, elevated turbidity and suspended levels due to pile driving activities will occur over several weeks at each landing facility. Pile driving will be restricted to the in-water construction window (June 1 through October 31) to avoid the primary periods of occurrence of listed species in the action area. Propeller wash and wakes from towing vessels and barges may also generate turbidity and suspended sediment during construction of the barge landings.

Potential turbidity and sediment impacts on listed fish species and aquatic habitat will be minimized by complying with a *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (Appendix 3.F, *General Avoidance and Minimization Measures*). Other AMMs that are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts include AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan; Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM 14 *Hazardous Material Management Plan;* and AMM 6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F).

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with the timing restrictions on in-water activities and implementation of the proposed erosion and sediment control AMMs, no adverse water effects are anticipated during this period.

6.1.1.3.1.1 Migrating Adults (December-March)

6.1.1.3.1.1.1 Individual-Level Effects

The timing of in-water construction activities at the barge landing (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment.

6.1.1.3.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.1.3.1.2 Spawning Adults (February-June)

6.1.1.3.1.2.1 Individual-Level Effects

Potential individual-level effects of elevated turbidity and suspended sediment on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). Based on this analysis, it is generally concluded that the levels of turbidity and suspended sediment generated by in-water construction are not expected to adversely affect Delta Smelt. However, it is plausible that excessive levels of suspended sediment could disrupt spawning activity and abandonment of preferred spawning sites, or degrade potential spawning habitat through burial of suitable substrates.

6.1.1.3.1.2.2 Population-Level Effects

Based on the general timing and abundance of Delta Smelt in the east and south Delta, the potential for exposure of spawning adults to construction-related increases in turbidity and suspended sediment is low. Because Delta Smelt are generally found in the west Delta and Cache Slough/Liberty Island area during spring and summer, the majority of the population will not be exposed to construction activities at the proposed barge landing sites. In addition, the timing of in-water construction activities (June 1–October 31) will avoid most of the spawning season (January through June, with peak numbers during February through May). Thus, the potential effects of increased turbidity and suspended sediment would be limited to a small proportion of the population that may be present in the action area in June. Furthermore, potential adverse effects of sedimentation on physical habitat (spawning substrate) would be minimized by siting the barge landings on levees with steep, riprapped banks and deep nearshore areas that lack shallow water areas where spawning could occur. With the timing restrictions on in-water activities and implementation of the proposed erosion and sediment control AMMs, no population-level effects attributable to increased turbidity and suspended sediment are anticipated.

6.1.1.3.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.1.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is low, any eggs within the influence of the sediment plumes could be adversely affected by entrapment or suffocation if they are buried by deposited sediments.

6.1.1.3.1.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, the low proportion of the population utilizing the action area, and the low quality of spawning habitat in areas where the barge landings are likely to be sited.

6.1.1.3.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.1.4.1 Individual-Level Effects

Based on the general discussion of individual-level effects described previously (6.1.1.3 *North Delta Intakes*), Delta Smelt larvae and early juveniles are not likely to be adversely affected by the levels of turbidity and suspended sediment generated by in-water construction activities at the barge landings.

6.1.1.3.1.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, the low proportion of the population utilizing the action area, and the general association and feeding responses of Delta Smelt to turbidity levels generated by in-water activities.

6.1.1.3.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the barge landing locations in the summer and fall and therefore would be unaffected by increased turbidity and suspended sediment during in-water construction activities.

6.1.1.3.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.3.2 Contaminants

Construction of the barge landings poses an exposure risk to Delta Smelt from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other hazardous materials during construction of the barge landings would be similar to that described for the north Delta intakes due to the proximity of construction activities to the waters of the Delta. However, because the barge landings would be constructed on smaller waterways adjacent to major agricultural islands, these sites are more likely to contain agricultural-related toxins such as copper and organochlorine pesticides. Implementation of the following AMMs is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials: AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan;* AMM14 *Hazardous Materials Management Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM 6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan*.

The potential for introduction of contaminants from disturbed sediments will be addressed through the development and implementation of an HMMP with specific measures to address the containment, handling, storage, and disposal of contaminated sediments. Because the potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, implementation of the erosion and sediment control AMMs would further minimize this risk.

6.1.1.3.2.1 Migrating Adults (December-March)

6.1.1.3.2.1.1 Individual-Level Effects

The potential effects of contaminants on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Some risk of contaminant spills and runoff of contaminated soil would exist outside the in-water construction period but implementation of proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk.

6.1.1.3.2.1.2 Population-Level Effects

With implementation of proposed pollution prevention and erosion and sediment control AMMs, there is little or no risk of exposure of migrating adults to contaminants. No population-level effects would occur.

6.1.1.3.2.2 Spawning Adults (February-June)

6.1.1.3.2.2.1 Individual-Level Effects

The potential effects of contaminants on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). Based on the timing of in-water construction activities (June 1–October 31), spawning adults in the vicinity of the intake sites would be subject to direct exposure to contaminant spills or sediment-borne contaminants in June. Some risk would also exist outside the in-water construction period. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.3.2.2.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.3.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.2.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is low, individual eggs in the vicinity of the barge landings would be subject to direct exposure to contaminant spills or sediment-borne contaminants during construction.

6.1.1.3.2.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of spawning adults in the action area, and low quality of spawning habitat in areas where the barge landings are likely to be sited. Implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize the risk of contaminant exposure throughout the construction period.

6.1.1.3.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.2.4.1 Individual-Level Effects

Based on the general discussion of potential individual-level effects of contaminants on Delta Smelt (see 6.1.1.3 *North Delta Intakes*), larvae and early juveniles may be adversely affected by direct exposure to contaminant spills or sediment-borne contaminants during construction of the intakes. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.3.2.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of the population utilizing the action area, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.3.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction of the barge landings.

6.1.1.3.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.3 Underwater Noise

Impact pile driving at the barge landing sites would potentially produce underwater noise levels of sufficient intensity and duration to cause injury to fish. Currently, it is estimated that each barge landing would require vibratory and/or impact driving of several hundred sheet piles (number is unknown at this time) and 800 steel pipe piles (18-inch diameter) to construct the dock and mooring facilities. Based on the concurrent operation of 4 impact pile drivers at each site and an estimated installation rate of 60 piles per day, pile driving noise would be expected to occur over a period of several weeks depending on the number of sheet piles required to construct the perimeter wall.

Based on the general timing and abundance of Delta Smelt in the east and south Delta, restriction of pile driving activities to June 1 through October 31 will minimize the exposure of Delta Smelt to pile driving noise. In addition, as described in Section 6.1.1.3, *North Delta Intakes*, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when Delta Smelt and other listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions that will be taken should the thresholds be exceeded.

6.1.1.3.3.1 Migrating Adults (December-March)

6.1.1.3.3.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.3.3.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.3.2 Spawning Adults (February-June)

6.1.1.3.3.2.1 Individual-Level Effects

Based on the timing of pile driving operations at the barge landings (June 1–October 31) and the general timing and abundance of Delta Smelt in the east and south delta, spawning adults may be exposed to pile driving noise in June. As discussed previously (6.1.1.3 *North Delta Intakes*), the potential responses of fish to pile driving noise can range from behavioral effects to direct injury or mortality, depending on a number of biological, physical, and exposure variables. Sound exposure criteria currently in use by state and federal resource and transportation agencies in California, Oregon, and Washington to evaluate the potential for injury to pile driving activities are presented in Table 6.1-3. The peak SPL is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL is considered the total amount of acoustic energy that a fish can receive from a single or multiple strikes without injury. Pile driving and other sources of construction noise can also cause behavioral responses that could disrupt or delay normal activities, potentially leading to adverse effects on survival, growth, and reproductive success. Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper *et al.* 2006); however, it is generally assumed that 150 dB RMS is an appropriate threshold for behavioral effects.

Other construction activities that can generate underwater noise exceeding background levels (e.g., barge operations) are not expected to result in direct injury of fish. These kinds of activities typically produce noise levels below the behavioral effects threshold of 150 dB RMS, and therefore are unlikely to adversely affect Delta Smelt or other listed fish species.

Because the extent to which impact driving will be required to install the barge landing piles is unknown at this time, the following analysis presents underwater noise impacts based on the worst-case scenario in which all piles are driven with an impact driver with no attenuation (no dewatering or attenuation devices). Assumptions for pile driving for each intake are detailed in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*, which specifies the type, size, and number of piles required, as well as the number of piles driven per day, the number of impact strikes per pile, and whether piles will be driven in water or on land.

Table 6.1-3 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*. These estimates indicate that single-strike peak SPLs exceeding the injury thresholds are expected to be limited to areas within 33–46 feet of the source piles. Based on the cumulative (daily) exposure threshold (in this case, the distance to "effective quiet"), the risk of injury may extend 2,814 feet during sheet pile installation and 3,280 feet during dock pile installation. Based on a threshold of 150 dB RMS, the potential for behavioral effects would extend 13,057 and 9,607 feet away, respectively. Such exposures would occur over a period of 2-4 weeks for cofferdam installation and 13 days for dock pile installation.

Table 6.1-3. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at the Barge Landing Sites

Facility or Structure	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 183 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Number of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving (days)
Barge Landings						
Sheet Pile Wall	<33	2,814	13,057	1	June-Oct	--[3]
Docks	46	1,774	9,607	1	June-Oct	13

[1] Distance to cumulative injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).
[2] Distances to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.
3 Duration of pile driving to construct the sheet-pile perimeter wall is unknown at this time but is expected to require 2-4 weeks.

6.1.1.3.3.2.2 Population-Level Effects

Based on the general distribution and timing of spawning, potential exposure of Delta Smelt to pile driving noise would be limited to a small proportion of adults, eggs, and larvae that may occur in the vicinity of the barge landings in June. During pile driving operations, all waters extending across the width of the adjacent Delta channels (less than 1,000 feet in width) and upstream and downstream 1,774 to 2,814 feet away would be subject to noise levels exceeding the injury thresholds. The potential for behavioral effects would extend beyond these distances but would likely be constrained by the presence of major channel bends that typically occur within 1 to 2 miles of the proposed barge landing sites. The potential for injury or behavioral effects on spawning Delta Smelt depends on the proximity of preferred spawning habitat, which is thought to include areas with complex channels, broad shoals, and tidal marsh (Sommer and Mejia 2013). Consequently, siting the barge landings on levees with steep, riprapped banks away from such areas is likely to avoid or minimize exposure of adults to pile driving noise. It should also be recognized that the above estimates represent worst-case impacts that, to the extent feasible, will be reduced by the use of vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that will be identified in DWR's underwater sound control and abatement plan (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). With the implementation of this measure and proposed restrictions on the frequency, timing, and duration of pile driving operations (Table 6.1-3), no substantial population-level effects are expected.

6.1.1.3.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.3.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure would be low, individual eggs in the vicinity of the intake sites would be unable to avoid prolonged exposure to pile driving noise and potential adverse effects on survival, development, or viability.

6.1.1.3.3.3.2 Population-Level Effects

Based on the small proportion of spawning adults in the action area at the time of pile driving operations and expected low utilization of channel types where the barge landings will likely be sited, any mortality of eggs or embryos due to pile driving noise would not be expected to have a significant effect on population abundance. Potential losses can be further reduced by the use of vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that may be implemented as part of the underwater sound control and abatement plan.

6.1.1.3.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.3.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles originating from upstream spawning areas may encounter pile driving noise during their downstream movement to estuarine rearing areas. Although the potential for exposure is low, any larval Delta Smelt passing the barge landings during impact pile driving would be unable to avoid exposure to pile driving noise and therefore could be injured or killed depending on their proximity to the source piles and the duration of exposure.

6.1.1.3.3.4.2 Population-Level Effects

Based on the small proportion of adults occurring in the east and south Delta in June, any losses of larvae or early juveniles that encounter pile driving noise would represent a small proportion of total larval production in each year of pile driving operations. Potential losses would be further minimized by using vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that may be implemented as part of the underwater sound control and abatement plan.

6.1.1.3.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landing sites in summer and fall and therefore are unlikely to be affected by pile driving noise.

6.1.1.3.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.4 Fish Stranding

Installation of the perimeter sheet pile wall has the potential to strand fish, resulting in direct injury and mortality of fish that become trapped behind the structures. To minimize this risk, sheet pile installation will be limited to the proposed in-water construction period (June 1–October 31) to avoid the peak abundance of Delta Smelt in the action area. During periods when listed species may be present, DWR will further minimize potential losses of stranded fish by implementing a fish rescue and salvage plan (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM8 *Fish Rescue and Salvage Plan*).

6.1.1.3.4.1 Migrating Adults (December-March)

6.1.1.3.4.1.1 Individual-Level Effects

The timing of sheet pile installation (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, migrating adults are not at risk of being stranded.

6.1.1.3.4.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.4.2 Spawning Adults (February-June)

6.1.1.3.4.2.1 Individual-Level Effects

Spawning adults may be present in small numbers in the action area in June and therefore subject to stranding. Although adults would be expected to move away from active construction areas, it is assumed that some potential for stranding exists as long as the affected areas are accessible to fish. Fish rescue and salvage activities using accepted fish collection methods can result in injury or mortality, but these effects are typically minor, and can often be avoided with appropriate training. However, adverse effects may still occur because of varying degrees of effectiveness of collection methods and potential stress and injury associated with various capture and handling methods.

6.1.1.3.4.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the low densities of adults that may be present in the action area during sheet pile installation, the low utilization and expected avoidance of the construction sites by spawning adults, and implementation of fish rescue and salvage activities.

6.1.1.3.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.4.3.1 Individual-Level Effects

Based on the low utilization and expected avoidance of active construction sites by spawning adults, there is little or no risk of stranding of Delta Smelt eggs or embryos.

6.1.1.3.4.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.4.4.1 Individual-Level Effects

Although the potential for exposure is low, Delta Smelt larvae and early juveniles may be particularly vulnerable to stranding because of their limited swimming abilities and potential entrainment in off-channel areas. In addition, conventional fish collection methods used during rescue and salvage efforts are less effective and more likely to cause injury or death of these life stages compared to larger juveniles or adults.

6.1.1.3.4.4.2 Population-Level Effects

Population-level effects would be expected to be negligible based on the small proportion of adults that spawn in the action area in June, the resulting low densities of larvae and juveniles passing the intake sites, and the limited influence of the sheet pile wall on passage conditions in the river.

6.1.1.3.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be stranded.

6.1.1.3.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.5 Direct Physical Injury

During construction of barge landings, fish could be injured or killed by direct contact with equipment or materials that are operated or placed in open waters of the adjacent Delta channels. Potential mechanisms include fish being crushed by falling rock (riprap), impinged by sheetpiles or mooring piles, or struck by propellers. In addition to the proposed work window, the potential for injury of listed fish species would be minimized by limiting the duration of in-water construction activities to the extent practicable and implementing the following AMMs: AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan; and Fish Rescue and Salvage Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*).

6.1.1.3.5.1 Migrating Adults (December-March)

6.1.1.3.5.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, migrating adults are not at risk of being injured.

6.1.1.3.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.5.2 Spawning Adults (February-June)

6.1.1.3.5.2.1 Individual-Level Effects

Spawning adults may be present in small numbers in the action area in June and therefore subject to injury. Although adults would be expected to move away from active construction areas, it is assumed that some potential for injury exists whenever heavy equipment or materials are operated or placed in open water.

6.1.1.3.5.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the low densities of adults that may be present in the action area during in-water construction activities, and the low utilization and expected avoidance of the intake sites by spawning adults.

6.1.1.3.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.5.3.1 Individual-Level Effects

Based on the low utilization and expected avoidance of the intake sites by spawning adults, there is little or no risk of injury of Delta Smelt eggs or embryos.

6.1.1.3.5.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.5.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may be particularly vulnerable to injury because of their limited swimming abilities.

6.1.1.3.5.4.2 Population-Level Effects

Population-level effects would be expected to be negligible based on the small proportion of adults that spawn in the east and south Delta in June, the resulting low densities of larvae and juveniles, and the limited influence of construction equipment and materials on passage conditions in the adjacent channels.

6.1.1.3.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be injured by construction activities.

6.1.1.3.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.6 Loss or Alteration of Habitat

Construction of the barge landings will result in temporary to permanent losses or alteration of aquatic habitat in several channels of the east and south Delta that are within the designated critical habitat of Delta Smelt. Temporary effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. With implementation of the proposed water quality and sound abatement and control AMMs, in-water construction activities will result in temporary, localized increases in turbidity, suspended sediment, and noise in the vicinity of construction sites but these parameters are expected to return to baseline levels following cessation of construction activities and will not result in long-term impacts on aquatic habitat.

Construction of the barge landing would result in permanent impacts to approximately 22.4 acres of tidal perennial aquatic habitat (approximately 3.2 acres per landing). Approximately 0.34

acres of tidal perennial aquatic habitat will be replaced by the permanent dock and mooring structures or alternatively, floating docks supported by temporary piles. During construction, and continuing during operation of the barge landings, the channel banks, bed, and waters adjacent to the dock will be periodically disturbed by propeller wash and scour from barges and tidal action, resulting in changes in water depths, benthic substrates, and loss of submerged and emergent vegetation that may be present. Estimates of the amount of shallow water habitat that could be affected by construction are not currently available.

During construction activities, DWR will implement AMM2 *Construction Best Management Practices and Monitoring,* to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. To further minimize adverse effects to aquatic habitat associated with barge operations, DWR also proposes to implement a *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (Appendix 3.F, *General Avoidance and Minimization Measures*). Unavoidable impacts to critical habitat of listed fish species will be offset through on-site and/or off-site mitigation, including the purchase of conservation credits at an approved conservation bank.

6.1.1.3.6.1 Migrating Adults (December-March)

6.1.1.3.6.1.1 Individual-Level Effects

Although affecting a small proportion of the population, migrating adults may be subject to an elevated risk of predation as they pass the construction sites because of potential increases in predator habitat. The presence of in-water and overwater structures (sheet pile wall, floating docks, piles, and vessels) provides shade and cover that may attract certain predatory fish species (e.g., striped bass, largemouth bass, Sacramento pikeminnow) and increase their ability to ambush prey. These structures may also improve predation opportunities for piscivorous birds (e.g., gulls, terns, cormorants) by providing perch sites immediately adjacent to open water.

6.1.1.3.6.1.2 Population-Level Effects

Increased predation risk at the barge landing sites would potentially result in increased mortality of migrating adults. The small proportion of the population spawning in the east and south Delta indicates that the population-level effect would be small.

6.1.1.3.6.2 Spawning Adults (February-June)

6.1.1.3.6.2.1 Individual-Level Effects

Loss or alteration of aquatic habitat within the footprints of the docks, mooring structures, and operational areas of the barges may result in reductions in the amount of shallow water habitat potentially available to spawning adults. Because the barge landings will likely be sited in areas with steep, riprapped levees and deep nearshore areas, the potential for utilization of these sites by Delta Smelt for spawning is low. Consequently, permanent losses or alteration of nearshore habitat resulting from construction of the barge landings would not likely have a significant effect on spawning habitat use or spawning success of adults.

6.1.1.3.6.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the small proportion of the population spawning in the action area and expected low utilization of the barge landing sites by spawning adults.

6.1.1.3.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.6.3.1 Individual-Level Effects

Based on the small proportion of the population spawning in the action area and expected low utilization of the barge landing sites by spawning adults, there is little risk of adverse effects on eggs or embryos.

6.1.1.3.6.3.2 Population-Level Effects

Population-level effects are expected to be negligible.

6.1.1.3.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.6.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles migrating from upstream spawning areas to estuarine rearing areas may be subject to an elevated risk of predation as they pass the barge landings because of the presence of in-water and overwater structures and the loss of shallow, low-velocity nearshore areas. To the extent that these conditions provide beneficial habitat or increased predation opportunities for predators of larvae and early juveniles (e.g., silversides; Baerwald et al. 2012), there could be an elevated risk of predation for these young life stages. However, it is not clear that these structures provide beneficial habitat as these small predators may be susceptible to the same larger predators that consume adult Delta Smelt. Therefore, elevated predation on Delta Smelt larvae is unlikely.

6.1.1.3.6.4.2 Population-Level Effects

Even if larvae and juveniles are subject to elevated predation rates as they pass the construction sites, the population-level effect would be small based on the small proportion of the population occurring in or upstream of the action area.

6.1.1.3.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landing sites in the summer and fall and therefore are unlikely to be affected by losses or alteration of habitat during construction.

6.1.1.3.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4 Head of Old River Gate

A permanent gate (Head of Old River [HOR] gate) will be constructed at the HOR to prevent migrating juvenile salmonids from entering Old River from the San Joaquin River, and thereby minimize their exposure to the CVP/SWP pumping facilities. The gate will be located at the divergence of the HOR and the San Joaquin River (Appendix 3.A, *Map Book for the Proposed Action*), and will be 210 feet long and 30 feet wide, with top elevation of +15 feet (Appendix 3.C, *Conceptual Engineering Report*, Volume 2, Sheets 11, 12, and 13). The gate will include seven bottom-hinged gates, fishway, boat lock, control building, boat lock operator’s building, and communications antenna. Additional details on the intake design, construction methods, and proposed construction schedule are described in Chapter 3.

Construction of the HOR gate is expected to take 3 years. The HOR gate will be constructed in two phases using cofferdams to isolate and dewater half the channel during the first phase and the other half during the second phase. All in-water construction work, including cofferdam installation, riprap placement, dredging, and barge operations, would be restricted to August 1-November 30 to minimize or avoid potential effects on Delta Smelt and juvenile salmonids. In addition, all pile driving requiring the use of an impact pile driver in or near open water (cofferdams and foundation piles) will be restricted to this period to avoid or minimize exposure of listed species to potentially harmful underwater noise levels. Construction of the HOR gate will require dredging of approximately 500 feet of channel (150 feet upstream to 350 feet downstream from the proposed gate) and removal of up to 1,500 cubic yards of material with a barge-mounted hydraulic or a sealed clamshell dredge. The need for additional clearing and grading of the site for construction, staging, and other support facilities is expected to be minimal because of the presence of existing access roads and staging areas that have been used in the past for installation of a temporary rock barrier.

Construction of the HOR gate will result in permanent impacts to approximately 2.9 acres of tidal perennial aquatic habitat that includes the footprint of the gate and the channel segments upstream and downstream of the structure that will be affected by dredging. Estimates of the amount of shallow water habitat potentially affected by construction are not currently available.

6.1.1.4.1 Turbidity and Suspended Sediment

In-water construction activities would result in disturbance of the channel bed and banks, resulting in temporary increases in turbidity and suspended sediment levels in Old River and potentially the San Joaquin River. These activities include cofferdam construction (sheet pile installation), dredging, riprap placement, and barge operations. All other sediment-disturbing activities will be outside or isolated from the active channel and would not result in the discharge of sediment to the river. Water pumped from the cofferdams will be treated (removing all sediment) using settling basins or Baker tanks, and returned to the river. Dredging, foundation pile driving, and other construction activities will proceed within the confines of the cofferdams.

In addition to the in-water work window, a number of AMMs are proposed to avoid or minimize potential impacts on water quality and listed fish species during construction of the HOR gate. These AMMs include AMM1 *Worker Awareness Training;*AMM2 *Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* and AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*).

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with the timing restrictions on in-water activities and implementation of the proposed erosion and sediment control AMMs, no adverse water effects are anticipated during this period.

6.1.1.4.1.1 Migrating Adults (December-March)

6.1.1.4.1.1.1 Individual-Level Effects

The timing of in-water construction activities (August 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment.

6.1.1.4.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.1.4.1.2 Spawning Adults (February-June)

6.1.1.4.1.2.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt spawning season. However, increases in suspended sediment during in-water construction activities may result in localized sediment deposition, degrading potential spawning habitat of Delta Smelt through burial of suitable substrates. However, Old River in the vicinity of the proposed HOR gate does not likely support significant spawning of Delta Smelt, serving mainly as a migration corridor for adults during their migration to upstream spawning areas and larvae during their downstream dispersal to estuarine habitat. There appears to be little or no habitat thought to be preferred by Delta Smelt for spawning in this reach, which is dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation.

6.1.1.4.1.2.2 Population-Level Effects

Most of the Delta Smelt population is distributed downstream of the proposed HOR gate (Moyle 2002) but Delta Smelt have been found as far upstream as Moss Landing (Vincik and Julienne 2012). Available monitoring data suggest that adult Delta Smelt occur in very low numbers near the HOR gate. Over 2,300 beach seine samples[4] in the San Joaquin River between Dos Reis (river mile 51) and Weatherbee (river mile 58) between 1994 and 2015 yielded four Delta Smelt (all in February–April). Nearly 30,000 trawl samples at Mossdale[5] from 1994 to 2011 resulted in the capture of 44 Delta Smelt, principally in March-June. The low abundance of Delta Smelt and low quality of potential spawning habitat in the vicinity of the HOR gate indicates that any impacts on potential spawning habitat resulting from sedimentation of suitable substrates would have negligible population-level effects.

6.1.1.4.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.1.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure would be low, individual eggs would be subject to burial by the deposition of suspended sediment.

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[4] Data were obtained from http://www.fws.gov/lodi/jfmp/, files <Beach Seines CHN _ POD Species 1976-2011.xlsx> and <Beach Seines CHN _ POD Species 2012-2015.xlsx> accessed September 14, 2015.

[5] Data were obtained from http://www.fws.gov/lodi/jfmp/, files < Mossdale Trawls CHN _ POD Species 1994-2011.xlsx> and < Mossdale Trawls CHN & POD Species 2012-2015.xlsx> accessed September 14, 2015.

6.1.1.4.1.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of the population utilizing the action area, and low quality of spawning habitat in the vicinity of the HOR gate.

6.1.1.4.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.1.4.1 Individual-Level Effects

Based on the general discussion of effects above for migrating and spawning adults, Delta Smelt larvae and early juveniles are not likely to be adversely affected by turbidity and suspended sediment generated by in-water construction activities.

6.1.1.4.1.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, the low proportion of the population utilizing the action area, and general association and feeding responses of Delta Smelt to turbidity within the range generated by in-water activities.

6.1.1.4.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed HOR gate in the summer and fall and therefore would be unaffected by increased turbidity and suspended sediment during in-water construction activities.

6.1.1.4.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.4.2 Contaminants

Construction of the HOR gate poses an exposure risk to listed fish species from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other potentially hazardous materials would be similar to that described for the north Delta intakes due to the proximity of construction activities to the waters of the Delta. Implementation of the following AMMs (Appendix 3.F, *General Avoidance and Minimization Measures*) is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials: AMM1 *Worker Awareness Training; Construction Best Management Practices and Monitoring;* AMM2 *Stormwater Pollution Prevention Plan; Erosion and Sediment Control Plan;* AMM14 *Hazardous Materials Management Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan*).

Contaminated sediments may be present in Old River and within the footprint of the proposed HOR gate because of the proximity of the site to major municipal, industrial, and agricultural areas. The potential for introduction of contaminants from disturbed sediments will be addressed through the development and implementation of an HMMP with specific measures to address the containment, handling, storage, and disposal of contaminated sediments. Because the potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, implementation of the erosion and sediment control AMMs would further minimize this risk. Some risk of contaminant spills and runoff of contaminated soil would exist outside the in-water construction period but implementation of proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk.

6.1.1.4.2.1 Migrating Adults (December-March)

6.1.1.4.2.1.1 Individual-Level Effects

The potential effects of contaminants on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt adult migration season. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.2 Spawning Adults (February-June)

6.1.1.4.2.2.1 Individual-Level Effects

The timing of in-water construction activities (August 1-November 30) will avoid the Delta Smelt adult migration season. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.2.3.1 Individual-Level Effects

The timing of in-water construction activities (August 1-November 30) will avoid the Delta Smelt incubation season. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.2.4.1 Individual-Level Effects

The timing of in-water construction activities (August 1-November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction of the intakes.

6.1.1.4.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3 Underwater Noise

Impact pile driving at the HOR gate would potentially produce underwater noise levels of sufficient intensity and duration to injure or kill fish. Currently, it is estimated that the HOR gate would require the installation of 550 temporary sheet piles to construct the cofferdams and 100 14-inch steel pipe or H-piles to construct the foundation. Based on an assumed installation rate of 15 piles per day, pile driving would be expected to occur up to 19 days per season during installation of the sheet piles, and up to 4 days per season during installation of the foundation piles. DWR proposes to avoid exposure of Delta Smelt to pile driving noise and other water quality impacts by conducting all in-water construction activities between August 1 and November 30. This will effectively avoid the periods when Delta Smelt adults, larvae, and early juvenile may be present.

6.1.1.4.3.1 Migrating Adults (December-March)

6.1.1.4.3.1.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.4.3.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.2 Spawning Adults (February-June)

6.1.1.4.3.2.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the Delta Smelt spawning season. There would be no risk of exposure of spawning adults to impact pile driving noise.

6.1.1.4.3.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.3.3.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the Delta Smelt incubation season. There would be no risk of exposure of eggs or embryos to impact pile driving noise.

6.1.1.4.3.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.3.4.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. There would be no risk of exposure of larvae or early juveniles to impact pile driving noise.

6.1.1.4.3.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be affected by pile driving noise.

6.1.1.4.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4 Fish Stranding

The use of cofferdams to construct the HOR gate will exclude fish from active construction areas but could also strand fish that are not able to avoid these areas, resulting in direct injury and mortality from dewatering, dredging, and pile driving activities within the enclosed cofferdams. To minimize fish stranding losses, DWR will implement a fish rescue and salvage plan (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM8 *Fish Rescue and Salvage Plan*). The plan will be submitted to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if permitted. DWR proposes to minimize the potential for stranding of Delta Smelt and juvenile salmonids by conducting all in-water construction activities between August 1 and November 30. This will effectively avoid the periods when Delta Smelt adults, larvae, and early juvenile may be present.

6.1.1.4.4.1 Migrating Adults (December-March)

6.1.1.4.4.1.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of stranding of migrating adults.

6.1.1.4.4.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.2 Spawning Adults (February-June)

6.1.1.4.4.2.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the Delta Smelt spawning season. There would be no risk of stranding of spawning adults.

6.1.1.4.4.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.4.3.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the Delta Smelt incubation season. There would be no risk of stranding of eggs or embryos.

6.1.1.4.4.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.4.4.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. There would be no risk of stranding of larvae or early juveniles.

6.1.1.4.4.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be stranded in the cofferdams.

6.1.1.4.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5 Direct Physical Injury

During construction of the HOR gate, fish could be injured or killed by direct contact with equipment or materials that are operated or placed in open waters of Old River. Potential mechanisms include fish being impinged by sheetpiles, entrained by dredges, or struck by propellers during barge operations. DWR proposes to minimize the potential for injury of Delta Smelt and juvenile salmonids by conducting all in-water construction activities between August 1 and November 30. This will effectively avoid the periods when Delta Smelt adults, larvae, and early juvenile may be present. In addition to the proposed work window, the potential for injury of listed fish species would be minimized to the extent practicable by limiting the duration of in-water construction activities and implementing the AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures*. Applicable AMMs include AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan;* and AMM8 *Fish Rescue and Salvage Plan*.

6.1.1.4.5.1 Migrating Adults (December-March)

6.1.1.4.5.1.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of injury of migrating adults.

6.1.1.4.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.2 Spawning Adults (February-June)

6.1.1.4.5.2.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt spawning season. There would be no risk of injury of spawning adults.

6.1.1.4.5.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.5.3.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt incubation season. There would be no risk of injury of eggs or embryos.

6.1.1.4.5.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.5.4.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. There would be no risk of injury of larvae or early juveniles.

6.1.1.4.5.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be injured by in-water construction activities.

6.1.1.4.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.6 Loss or Alteration of Habitat

Construction of the HOR gate would result in temporary to permanent losses or alteration of aquatic habitat in Old River. Temporary effects of construction activities on water quality were previously discussed. With implementation of the proposed water quality and sound abatement and control AMMs, in-water construction activities will result in temporary, localized increases in turbidity, suspended sediment, and noise in the vicinity of construction sites but these parameters are expected to return to baseline levels following cessation of construction activities and will not result in long-term impacts on aquatic habitat.

Construction of the HOR gate will result in permanent impacts to approximately 2.9 acres of tidal perennial aquatic habitat, including the footprint of the gate and the channel segments upstream and downstream of the structure that will be affected by dredging. Estimates of the amount of shallow water habitat potentially affected by construction are not currently available.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. DWR proposes to offset unavoidable impacts to critical habitat through on-site and/or off-site mitigation, including the purchase of conservation credits at an approved conservation bank.

6.1.1.4.6.1 Migrating Adults (December-March)

6.1.1.4.6.1.1 Individual-Level Effects

Although affecting a small proportion of the population, migrating Delta Smelt adults may be subject to potential delays in migration and increased predation as they attempt to pass the cofferdams during the three-year construction period. Cofferdams that constrict the flow to half the channel's width would increase water velocities and potentially impede the migration of adults attempting to pass the site. The presence of in-channel cofferdams and/or the partially competed HOR gate may also increase the amount of predatory fish habitat and create hydraulic conditions that improve their ability to prey on Delta Smelt as they migrate past the site.

6.1.1.4.6.1.2 Population-Level Effects

Based on the apparent low abundance of Delta Smelt in the San Joaquin River in the vicinity of HOR, potential adverse effects on migration and survival of migrating adults would likely be limited to a very small proportion of the population, resulting in negligible effects on the total spawning stock of Delta Smelt.

6.1.1.4.6.2 Spawning Adults (February-June)

6.1.1.4.6.2.1 Individual-Level Effects

Loss or alteration of aquatic habitat within the footprints of the cofferdams, riprapped banks, and dredged channel areas would reduce the amount of shallow water habitat potentially available to spawning adults. However, this portion of the Old River channel is frequently disturbed by the annual installation of a temporary rock barrier and is dominated by steep levee slopes, riprap, and low quantities of riparian and aquatic vegetation. There is little or no potential spawning habitat that would be affected by construction of HOR gate and thus little likelihood of adverse effects on spawning adults.

6.1.1.4.6.2.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.4.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.6.3.1 Individual-Level Effects

Based on the lack of preferred spawning habitat for delta, the potential for adverse effects on eggs and embryos is negligible.

6.1.1.4.6.3.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.4.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.6.4.1 Individual-Level Effects

Similar to migrating adults, Delta Smelt larvae and early juveniles may be subject to an elevated risk of predation as they pass the cofferdams and/or partially completed HOR gate.

6.1.1.4.6.4.2 Population-Level Effects

Based on the apparent low abundance of Delta Smelt in the San Joaquin River in the vicinity of HOR, potential adverse effects on survival of larvae and juveniles would likely be limited to a very small proportion of the population, resulting in negligible effects on juvenile and adult recruitment.

6.1.1.4.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be affected by losses or alteration of habitat during construction.

6.1.1.4.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5 Clifton Court Forebay

Construction activities at Clifton Court Forebay (CCF) that may potentially affect Delta Smelt include the construction of the Clifton Court Pumping Plant (CCPP), construction of divider and perimeter embankments, dredging of CCF, construction of outlet canals and siphons, excavation and connection of South CCF (SCCF) expansion area, and construction of a new SSCF intake structure and North CCF (NCCF) emergency spillway. The estimated 8-year construction period at CCF will be phased, beginning with excavation of the expansion area of the SCCF (Phase 1 and 2); removal of the embankment separating the existing CCF from the expansion area (Phase 3); dredging CCF to design depths (Phase 4); construction of the embankment dividing NCCF and SCCF (Phase 5); and construction of the NCCF east, west, and north side embankments (Phases 6, 7, and 8).

In-water construction activities, including pile driving, dredging, riprap placement, and barge operations, would be conducted over a 6-month period each year. The timing of these activities is unknown but it is assumed that all in-water construction activities would be restricted to the months of June 1 to November 30 to avoid peak abundance of listed fish species in the south Delta. Pile driving operations include the installation of an estimated 27,000 temporary sheet piles to isolate the construction areas of the CCPP, embankments, outlet canals and siphons, intake, and spillways; and 2,160 concrete or steel pipe piles to construct the permanent foundation of the NCCF siphon. A total of 4 construction seasons will likely be required to complete pile driving operations based on the estimated duration of pile installation (see Section 6.1.1.5.3 *Underwater Noise*).

Dredging would be performed with a cutter head dredge, a dragline type dredge, or other acceptable dredging technique. The NCCF will be dredged to an approximate elevation of -5.0

feet, and SCCF will be dredged to an approximate elevation of -10.0 feet. An estimated 1,932 acres of tidal perennial aquatic habitat would be dredged, resulting in the removal of an estimated volume of 7 million cubic yards of material. Dredged material will be disposed of at an approved disposal site or reused for embankment and levee construction if determined to be suitable. Dredging would be performed by two dredges (425 cubic yards capacity each) operating within 200-acre cells enclosed by silt curtains to limit the extent of turbidity and suspended sediment. Dredging of CCF is estimated to require 38 months over 6 construction seasons.

Permanent impacts on aquatic habitat include the loss of an estimated 258 acres of tidal perennial aquatic habitat in CCF that would be replaced by permanent fill and structures associated with the new CCPP, perimeter and divider embankments, outlet canals and siphons, and intake structure and spillway (Mapbook M3.A). Estimates of the amount of shallow water habitat potentially affected by construction are not currently available.

6.1.1.5.1 Turbidity and Suspended Sediment

In-water construction activities at CCF would result in elevated turbidity and suspended sediment levels in CCF and Old River. The principal sources of increased turbidity and suspended sediment are dredging and cofferdam construction (sheet pile installation and removal). Minor increases in turbidity and suspended sediment in CCF and Old River are also expected during construction of the CCPP, outlet canals and siphons, SSCF intake structure, and North CCF (NCCF) emergency spillway. All other sediment-disturbing activities within cofferdams, upland areas, or non-fish-bearing waters pose little or no risk to listed fish species or aquatic habitat.

The potential for adverse effects of elevated turbidity and suspended sediment on listed fish species would be minimized by restricting all in-water construction activities to June 1-November 30, limiting the duration of these activities to the extent practicable, and implementing the AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures* to protect listed fish species from water quality impairment. These measures include AMM1*Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan; Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan,* and AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan*.

Dredging could cause extensive, long-term effects on turbidity and suspended sediment within CCF. Potential secondary effects include potential increases in chemical and biological oxygen demand associated with the decomposition of vegetation and organic material in disturbed sediments. In addition to implementing the AMMs listed above, DWR proposes to limit the potential exposure of listed species to water quality impacts by restricting the timing, extent, and frequency of major sediment-disturbing events. For example, DWR proposes to limit the extent of dredging impacts in CCF by restricting daily operations to two dredges operating for 10-hour periods (daylight hours) within 200-acre cells enclosed by silt curtains (representing approximately 10% of total surface area of CCF). In addition, dredging will be monitored and regulated through the implementation of the *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan*, which includes preparation of a sampling and analysis plan, compliance with NPDES and SWRCB water quality requirements during dredging activities, and compliance with applicable in-water work windows established by CDFW, NMFS, and USFWS.

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with the timing restrictions on in-water activities and implementation of the proposed erosion and sediment control AMMs, no adverse water effects are anticipated during this period.

6.1.1.5.1.1 Migrating Adults (December-March)

6.1.1.5.1.1.1 Individual-Level Effects

The timing of in-water construction activities at CCF (June 1–November 30) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment.

6.1.1.5.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.1.5.1.2 Spawning Adults (February-June)

6.1.1.5.1.2.1 Individual-Level Effects

Potential individual-level effects of elevated turbidity and suspended sediment on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). Based on this analysis, it is generally concluded that the levels of turbidity and suspended sediment generated by in-water construction activities are not expected to adversely affect Delta Smelt.

6.1.1.5.1.2.2 Population-Level Effects

Based on the general timing and abundance of Delta Smelt inferred from salvage and fish monitoring data, restriction of dredging and other in-water construction activities in CCF to June 1-November 30 will avoid most of the spawning season (January through June) and peak abundance of adults, eggs, and larvae in the south Delta (February through May). Salvage records indicate that adults and larvae may be present through June and July but abundance is low and declining in these months, especially in July as water temperatures typically exceed the upper tolerance levels for successful reproduction. In addition, Old River in the vicinity of CCF is highly channelized and lacks the general attributes of preferred spawning habitat (complex channels, shoals, and tidal marsh), and CCF is not considered suitable habitat because of the low likelihood of survival of larvae, juveniles, and adults that are entrained into the forebay (Castillo *et al.* 2012). No population-level effects are anticipated.

6.1.1.5.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.1.3.1 Individual-Level Effects

Although increases in suspended sediment could result in the burial of eggs or embryos that may be present in the action area in June, any adverse effects on individual eggs or embryos would be negligible because the survival of larvae that successfully hatch in CCF or in the adjacent channels leading to CCF would be near zero. Therefore, no adverse individual-level effects are expected.

6.1.1.5.1.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities and expected low survival of Delta Smelt in this region of the Delta.

6.1.1.5.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.1.4.1 Individual-Level Effects

Based on the general tolerances and adaptations of Delta Smelt to turbidity and suspended sediment, Delta Smelt larvae and early juveniles are not likely to be adversely affected by turbidity and suspended sediment generated by in-water construction activities.

6.1.1.5.1.4.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.5.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF and the adjacent south Delta channels in the summer and fall and therefore would be unaffected by increases in turbidity and suspended sediment during construction.

6.1.1.5.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.5.2 Contaminants

Dredging and expansion of the CCF and construction of new water conveyance facilities presents an exposure risk to Delta Smelt from potential spills of hazardous materials from construction equipment and from potential mobilization of contaminated sediment. The risk of accidental spills of oil, fuel, hydraulic fluids, concrete, paint, and other potentially hazardous substances would be similar to that described for the north Delta intakes due to the proximity of construction activities to the waters of the Delta. Implementation of the following AMMs (described in Appendix 3.F, *General Avoidance and Minimization Measures*) is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials: AMM1*Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan; Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan,* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan,* and AMM7 *Barge Operations Plan.*

Proposed dredging, excavation, and expansion of CCF will potentially result in the release of contaminants from disturbance or exposure of sediments. Current estimates indicate the dredging will affect up to 1,932 acres of CCF while expansion of the SCCF will create an additional 590 acres of newly exposed sediment. Contaminated sediments pose a risk to fish from direct exposure from mobilized sediment or indirectly through accumulation of contaminants in the food web. The proximity of the south Delta waterways to agricultural, industrial, and municipal sources indicates that a broad range of contaminants that are toxic to fish and other aquatic biota, including metals (e.g., copper, mercury), hydrocarbons, pesticides, and ammonia, could be present. Mud and silt in south Delta waterways have been shown to contain elevated concentrations of contaminants, including mercury, pesticides (chlorpyrifos, diazinon, DDT), and other toxic substances (California State Water Resources Control Board 2010). Impairments in Delta waterways also include heavy metals such as selenium, cadmium, and nickel (G. Fred Lee & Associates 2004). Thus, resuspension of sediments during in-water construction could lead to degradation of water quality and adverse effects on fish or their food resources in the action area.

Prior to dredging and excavation activities, DWR proposes to evaluate the risk of contamination from sediment sources and determine appropriate testing and remediation procedures through the implementation of *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (AMM6), Appendix 3.F, *General Avoidance and Minimization Measures*). In addition, because the potential for mobilization of contaminants is closely linked to turbidity and suspended sediment generated by construction activities, implementation of the AMMs designed to minimize erosion and the discharge of suspended sediment (see *Turbidity and Suspended Sediment*) will also minimize potential risks associated with the mobilization of contaminated sediment. These AMMs include the development and implementation of an HMMP with specific measures to address the containment, handling, storage, and disposal of contaminated sediments.

6.1.1.5.2.1 Migrating Adults (December-March)

6.1.1.5.2.1.1 Individual-Level Effects

The potential effects of contaminants on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). The timing of in-water construction activities (June 1–November 30) will avoid the Delta Smelt adult migration season. Some risk of contaminant spills and runoff of contaminated soil would exist outside the in-water construction period but implementation of proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk.

6.1.1.5.2.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.2.2 Spawning Adults (February-June)

6.1.1.5.2.2.1 Individual-Level Effects

Based on the timing of in-water construction activities (June 1-November 30), spawning adults in CCF and Old River would be subject to direct exposure to contaminant spills or sediment-borne contaminants in June. Some risk would also exist outside the in-water construction period. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.5.2.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.2.3.1 Individual-Level Effects

Based on the timing of in-water construction activities (June 1-November 30), Delta Smelt eggs and embryos in CCF and Old River would be subject to direct exposure to contaminant spills or sediment-borne contaminants in June. Some risk would also exist outside the in-water construction season. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.5.2.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.2.4.1 Individual-Level Effects

Based on the timing of in-water construction activities (June 1-November 30), Delta Smelt larvae and early juveniles in CCF and Old River would be subject to direct exposure to contaminant spills or sediment-borne contaminants in June. Some risk would also exist outside the in-water construction season. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.5.2.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF and the adjacent south Delta channels in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction.

6.1.1.5.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.3 Underwater Noise

Pile driving conducted in or near open water can produce underwater noise of sufficient intensity to injure or kill fish within a certain radius of the source piles. Currently, pile driving information for CCF is available only for the embankments, divider wall, siphon at NCCF outlet, and siphon at Byron Highway (Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*). Pile driving operations include the installation of an estimated 27,000 temporary sheet piles to isolate the construction areas for the embankments and divider wall, and 2,160 14-inch diameter concrete or steel pipe piles to construct the permanent foundation of the NCCF siphon. Pile driving at the Byron Highway siphon is not addressed in the following analysis because all pile driving would be conducted on land and more than 200 feet from water potentially containing listed fish species. A total of 4 construction seasons will likely be required to complete pile driving operations based on the estimated duration of pile installation.

Based on the general timing and abundance of Delta Smelt in the east and south Delta, restriction of pile driving activities to June 1 through November 30 will avoid the peak spawning periods of Delta Smelt. In addition, as described in Section 6.1.1.2 *North Delta Intakes,* DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when Delta Smelt and other listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions that will be taken should the thresholds be exceeded.

6.1.1.5.3.1 Migrating Adults (December-March)

6.1.1.5.3.1.1 Individual-Level Effects

The timing of impact pile driving activities (June 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.5.3.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.3.2 Spawning Adults (February-June)

6.1.1.5.3.2.1 Individual-Level Effects

As discussed previously (6.1.1.3, *North Delta Intakes*), the potential responses of fish to pile driving noise can range from behavioral effects to direct injury or mortality, depending on a number of biological, physical, and exposure variables. Sound exposure criteria currently in use by state and federal resource and transportation agencies in California, Oregon, and Washington to evaluate the potential for injury to pile driving activities are presented in Table 6.1-1. The peak SPL is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL is considered the total amount of acoustic energy that a fish can receive from a single or multiple strikes without injury. Pile driving and other sources of construction noise can also cause behavioral responses that could disrupt or delay normal activities, potentially leading to adverse effects on survival, growth, and reproductive success. Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper *et al.* 2006); however, it is generally assumed that 150 dB RMS is an appropriate threshold for behavioral effects. Other construction activities that can generate underwater noise exceeding background levels (e.g., barge operations) typically produce noise levels below the behavioral effects threshold of 150 dB RMS, and therefore are unlikely to adversely affect Delta Smelt or other listed fish species.

Because the extent to which impact driving will be required to install the temporary sheet piles and foundation piles for the NCCF siphon is unknown at this time, the following analysis presents underwater noise impacts based on the worst-case scenario in which all piles are driven with an impact driver with no attenuation (no dewatering or attenuation devices). Assumptions for pile driving for each intake are detailed in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*, which specifies the type, size, and number of piles required, as well as the number of piles driven per day, the number of impact strikes per pile, and whether piles will be driven in water or on land.

Table 6.1-4 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*. These estimates indicate that single-strike peak SPLs exceeding the injury thresholds are expected to be limited to areas within 33–46 feet of the source piles. Based on the cumulative (daily) exposure threshold (in this case, the distance to "effective quiet"), the risk of injury may extend 2,814 feet during sheet pile installation and 1,774 feet during installation of the foundation piles for the NCCF siphon. Based on a threshold of 150 dB RMS, the potential for behavioral effects would extend 13,058 and 9,607 feet away, respectively. Such exposures would occur over a period of 450 days during cofferdam installation and 72 days during foundation pile installation.

Table 6.1-4. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at CCF

Facility or Structure	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 183 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Number of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving (days)
Clifton Court Forebay						
Cofferdams	<33	2,814	13,058	5	June-Nov	450
NCCF Siphon	46	1,774	9,607	2	June-Nov	72

[1] Distance to cumulative injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).

[2] Distances to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

6.1.1.5.3.2.2 Population-Level Effects

Based on the timing of pile driving operations (June 1-November 30) and the general timing and abundance of Delta Smelt in the south delta, spawning adults may be exposed to pile driving noise in June and possibly July. Based on worst-case conditions (impact pile driving in open water with no attenuation), spawning adults within 2,814 feet from the cofferdam sheet piles or 1,774 feet from the foundation piles would be subject to underwater noise levels exceeding the injury thresholds. These distances correspond to areas of less than 100 acres to a maximum of 571 acres (less than 5% to 25% of the total surface area of CCF), depending on the location of the source piles. The potential for behavioral effects would extend throughout most of CCF. The extent to which adult smelt spawn in CCF is unknown but the ultimate survival of larvae or juveniles in CCF has been shown to be very low due to high levels of pre-screening mortality and entrainment (Castillo *et al.* 2012). Consequently, potential injury or mortality of spawning adults from pile driving noise is unlikely to have significant population-level effects. It should also be recognized that the above estimates represent worst-case impacts that, to the extent feasible, will be reduced by the use of vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that will be identified in DWR's underwater sound control and abatement plan (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*).

6.1.1.5.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.3.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although exposure would be low, individual eggs or embryos would be unable to avoid prolonged exposure to pile driving noise. However, any adverse effects on individual eggs or embryos would have negligible effects on overall survival because of the low probability of survival of larvae that successfully hatch in CCF or in the adjacent channels. Therefore, no adverse individual-level effects are expected.

6.1.1.5.3.3.2 Population-Level Effects

Based on the small proportion of adults potentially spawning in CCF in June and low likelihood of survival of Delta Smelt, potential injury or mortality of eggs or embryos from pile driving noise would have negligible effects on population abundance.

6.1.1.5.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.3.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles are particularly sensitive to pile driving noise because of their inability to avoid prolonged exposure to intense underwater noise.

6.1.1.5.3.4.2 Population-Level Effects

No significant population-level effects would occur because of the low likelihood of survival of larvae and juveniles in CCF under existing conditions.

6.1.1.5.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in the summer and fall and therefore are unlikely to be affected by pile driving noise.

6.1.1.5.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.4 Fish Stranding

Installation of cofferdams or silt curtains to isolate construction and dredging areas in CCF and the adjacent Old River channel has the potential to strand fish, resulting in direct injury and mortality of fish that become trapped inside the cofferdams or silt curtains. To minimize potential fish stranding losses, DWR will implement a fish rescue and salvage plan (Appendix 3.F, *General Avoidance and Minimization* Measures, AMM8 *Fish Rescue and Salvage Plan*). This plan will be submitted to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if permitted.

6.1.1.5.4.1 Migrating Adults (December-March)

6.1.1.5.4.1.1 Individual-Level Effects

The timing of cofferdam and silt curtain installation (June 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of stranding of migrating adults.

6.1.1.5.4.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.4.2 Spawning Adults (February-June)

6.1.1.5.4.2.1 Individual-Level Effects

Spawning adults may be present in CCF and Old River in June and possibly July. Although adults would be expected to avoid active construction areas, it is assumed that some adults may be unable to avoid or escape from areas enclosed by cofferdams or silt curtain before they are fully installed. Fish rescue and salvage activities using accepted fish collection methods will minimize these losses but some injury or mortality will still occur because of varying degrees of effectiveness of the collection methods and potential stress and injury associated with various capture and handling methods. In addition, it may be impractical or infeasible to rescue fish from large, deep areas surrounded by silt curtains in CCF. The fate of Delta Smelt that may become trapped inside silt curtains is uncertain but these fish would be subject to long periods of entrapment (3-4 months) and exposure to predators, poor water quality, or entrainment from dredging operations. Regardless, such measures may not be warranted given the high baseline levels of pre-screening mortality and entrainment of Delta Smelt in CCF.

6.1.1.5.4.2.2 Population-Level Effects

Based on the small proportion of spawning adults that may be present during cofferdam and silt curtain installation (June 1–November 30), and the low likelihood of survival of larvae and juveniles in CCF, potential injury or mortality of spawning adults from stranding would not be expected to have a significant effect on population abundance.

6.1.1.5.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.4.3.1 Individual-Level Effects

Because eggs and embryos are immobile and attached to substrate or other structures during incubation, they are particularly susceptible to stranding and subsequent injury or mortality from construction activities within cofferdams and silt curtains.

6.1.1.5.4.3.2 Population-Level Effects

Based on the small proportion of adults potentially spawning in CCF in June and July and the low likelihood of survival of Delta Smelt in CCF, potential losses of eggs or embryos due to stranding in cofferdams or silt curtains would not be expected to have a significant effect on population abundance.

6.1.1.5.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.4.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may be particularly vulnerable to stranding because of their limited swimming abilities. In addition, conventional fish collection methods are less effective and more likely to injure or kill these life stages compared to larger juveniles or adults.

6.1.1.5.4.4.2 Population-Level Effects

Based on the small proportion of adults potentially spawning in or adjacent to CCF in June and the low likelihood of survival of their progeny, stranding of larvae and early juveniles in cofferdams or silt curtains would not be expected to have a significant effect on population abundance.

6.1.1.5.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in summer and fall and therefore are unlikely to be exposed to in-water construction activities.

6.1.1.5.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.5 Direct Physical Injury

Fish could be injured or killed by direct contact with equipment or materials during in-water construction activities in CCF and the adjacent Old River channel. Potential mechanisms include fish being crushed by rock (riprap), impinged by sheetpiles, entrained by dredges, or struck by propellers. In addition to the proposed in-water work period, DWR proposes to implement a number of AMMs to minimize the potential for impacts on listed fish species, including AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan;* AMM9 *Underwater Sound Control and Abatement Plan,* and AMM8 *Fish Rescue and Salvage Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*).

6.1.1.5.5.1 Migrating Adults (December-March)

6.1.1.5.5.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of injury of migrating adults.

6.1.1.5.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.5.2 Spawning Adults (February-June)

6.1.1.5.5.2.1 Individual-Level Effects

Spawning adults may be present in low numbers in CCF and Old River in June and therefore subject to injury during in-water construction activities. Although adults would be expected to move away from active construction areas, it is assumed that some potential for injury exists whenever heavy equipment or materials are operated or placed in open water in these months.

6.1.1.5.5.2.2 Population-Level Effects

Based on the small proportion of spawning adults that may be present during the in-water construction season (June 1-November 30) and the low likelihood of survival of Delta Smelt in CCF, potential losses of spawning adults due to direct injury or mortality from in-water construction activities would not be expected to have a significant effect on population abundance.

6.1.1.5.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.5.3.1 Individual-Level Effects

Because eggs and embryos are immobile and attached to substrate or other structures during incubation, they are particularly vulnerable to direct injury and mortality from in-water construction activities such as dredging, pile driving, and riprap placement.

6.1.1.5.5.3.2 Population-Level Effects

Based on the small proportion of adults potentially spawning in CCF during the in-water construction season (June 1-November 30) and low likelihood of survival of Delta Smelt in CCF, potential losses of eggs or embryos due to direct injury or mortality from in-water construction activities would not be expected to have a significant effect on population abundance.

6.1.1.5.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.5.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may be particularly vulnerable to direct injury and mortality from in-water construction activities because of their limited swimming abilities.

6.1.1.5.5.4.2 Population-Level Effects

Based on the small proportion of adults potentially spawning in CCF in June and July and the low likelihood of survival of Delta Smelt in CCF, potential losses of larvae or early juveniles due to direct injury or mortality from in-water construction activities would not be expected to have a significant effect on population abundance.

6.1.1.5.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in summer and fall and therefore are unlikely to be exposed to in-water construction activities.

6.1.1.5.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.6 Loss or Alteration of Habitat

Dredging and expansion of CCF and construction of the new water conveyance facilities at CCF would result in long-term or permanent impacts on aquatic habitat. Dredging, cofferdam installation, levee armoring, and barge operations would affect an estimated 1,932 acres of tidal perennial aquatic habitat (Mapbook M3.A) through changes in water quality, water depths, vegetation, and other structural components. Temporary to long-term effects on aquatic habitat associated with increases in turbidity and suspended sediment, underwater noise, and contaminants were previously discussed. Permanent impacts on aquatic habitat include the loss of an estimated 258 acres of tidal perennial aquatic habitat in CCF that would be replaced by permanent fill and structures associated with the new CCPP, perimeter and divider embankments, outlet canals and siphons, and intake structure and spillway (Mapbook M3.A). Estimates of the amount of shallow water habitat potentially affected by construction are not currently available.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F, *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. Compensation for unavoidable impacts on aquatic habitat in CCF is not proposed because CCF is not considered suitable habitat for Delta Smelt.

6.1.1.5.6.1 Migrating Adults (December-March)

6.1.1.5.6.1.1 Individual-Level Effects

The potential effects of turbidity and suspended sediment, underwater noise, and other construction-related hazards on Delta Smelt were previously discussed. Potential changes in physical habitat resulting from dredging, installation of cofferdams, and construction of new water conveyance facilities include the loss of shallow water habitat, removal of vegetation, placement of riprap, and changes in hydraulic conditions. These changes could adversely affect migrating adults by increasing predator habitat but would likely have little effect on individual spawning success because of the low quality of spawning habitat and low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.1.2 Population-Level Effects

CCF and Old River in the vicinity of CCF have been highly altered for the purpose of water conveyance and lack many of the structural and functional attributes (PCEs) of the designated critical habitat of Delta Smelt due to channelization, levee clearing and armoring, maintenance dredging, unfavorable hydrodynamic conditions, high predator densities, and entrainment. Although the expected changes in physical habitat resulting from construction activities could affect the survival of migrating adults, the degraded status of spawning and larval/juvenile transport habitat in this portion of the Delta suggests that there would be no measurable effect on spawning success or recruitment of larvae and juveniles to the adult population.

6.1.1.5.6.2 Spawning Adults (February-June)

6.1.1.5.6.2.1 Individual-Level Effects

The expected changes in physical habitat in CCF and Old River, including deepening of CCF, disturbance of benthic substrates, and removal of vegetation, may affect potential spawning habitat for Delta Smelt but the effects on individual spawning success would be negligible because of the low quality of spawning habitat and low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.2.2 Population-Level Effects

As described above, CCF and Old River in the vicinity of CCF generally lack the physical attributes of preferred spawning habitat for Delta Smelt or the habitat conditions supporting larval and juvenile transport to suitable estuarine rearing habitat. Consequently, no population-level effect would occur.

6.1.1.5.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.6.3.1 Individual-Level Effects

The modification of physical habitat in CCF and Old River would have little if any effect on individual spawning success or the viability of eggs or embryos because of the low quality of spawning habitat and low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.3.2 Population-Level Effects

Based on the degraded status of habitat for Delta Smelt spawning and larval and juvenile transport in CCF and Old River, no substantial population-level effects are expected.

6.1.1.5.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.6.4.1 Individual-Level Effects

Similar to migrating adults, Delta Smelt larvae and early juveniles may experience reduced survival in CCF and Old River because of the loss of shallow water habitat, removal of vegetation, placement of riprap, and changes in hydraulic conditions, but the effects of these changes on survival would be negligible because of the low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.4.2 Population-Level Effects

Based on the degraded status of habitat for larval and juvenile transport in CCF and Old River, no substantial population-level effects are expected.

6.1.1.5.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in summer and fall and therefore are unlikely to be affected by losses or alteration of habitat associated with construction activities.

6.1.1.5.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.6 Effects of Construction Activities on Delta Smelt Critical Habitat

Construction activities would not affect the Delta Smelt critical habitat PCEs 3 and 4 because there would be no effect on river flows or salinity as a result of these activities. The effects to PCEs 1 and 2 are described below.

6.1.1.6.1 PCE 1: Physical Habitat (Spawning Substrate)

Construction of the north Delta intakes would result in the temporary or permanent loss of approximately 13.1 acres of shallow water habitat for Delta Smelt, and construction of the HOR gate would permanently affect 2.9 acres. Estimates of the amount of shallow water habitat or suitable spawning substrate potentially affected by barge landing construction are not currently available. Based on existing site conditions, none of this habitat is considered preferred spawning habitat for Delta Smelt.

Increases in suspended sediment generated by in-water construction activities may result in localized sediment deposition in the vicinity of the proposed intakes, barge landings, and HOR gate, degrading potential spawning habitat of Delta Smelt through burial of suitable substrate. However, potential adverse effects of sedimentation on physical habitat (spawning substrate) from construction would be minimized by siting the barge landings on levees with steep, riprapped banks and deep nearshore areas that lack shallow water areas where spawning could occur. Additionally, the Sacramento River and Old River in the vicinity of the proposed NDD and HOR gate, respectively, do not likely support significant spawning of Delta Smelt. Similar to the barge landings area, there appears to be little or no habitat thought to be preferred by Delta

Smelt for spawning in the vicinity of the NDD or HOR gate, which is dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation.

6.1.1.6.2 PCE 2: Water (Quality)

Construction activities could affect Delta Smelt critical habitat PCE 2, water quality in the vicinity of the NDD, HOR gate, and barge landings through elevated noise, increased turbidity and suspended sediments, and potential increases in contaminants, predation risks, and other construction-related hazards. Elevated noise levels from pile driving and other sources will result in a temporary reduction in water of suitable quality for Delta Smelt, adversely affecting its designated critical habitat. Adverse effects on critical habitat will occur within areas subjected to sound levels associated with potential injury and behavioral effects. Underwater noise levels will return to baseline levels following cessation of pile driving and other construction activities.

Increases in turbidity and suspended sediment levels during sheet pile and cofferdam installation, riprap placement, and barge operations will cause temporary, localized reductions in water quality. Water quality is expected to return to baseline levels following cessation of construction activities. The potential release of contaminants through spills or sediment disturbance could result in temporary impacts on water quality. With implementation of the proposed pollution prevention and erosion and sediment control AMMs, potential adverse effects on the critical habitat of Delta Smelt will likely be avoided.

Other effects include the risk of stranding and direct injury that would adversely affect the suitability of water in for Delta Smelt over four years during the in-water construction period (June 1-November 30) the vicinity of the NDD, barge landings, and HOR gate. The overall effect on the designated critical habitat of Delta Smelt would be minimal because of the timing of in-water construction activities and construction AMMs.

6.1.2 Effects of Water Facility Maintenance on Delta Smelt

6.1.2.1 North Delta Intakes

Maintenance of the proposed intake facilities (including intakes, pumping plants, sedimentation basins, and solids lagoons) includes regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. It is anticipated that major equipment repairs and overhauls would be conducted at a centralized maintenance shop at one of the intake facilities or at the intermediate pumping plant site.

Maintenance activities that could affect listed fish species and aquatic habitat include suction dredging or mechanical excavation of accumulated sediment around the intake structures; periodic removal of debris and biofouling organisms (e.g., algae, clams, mussels) from the log boom, fish screen panels, cleaning system, and other structural and mechanical elements exposed to the river; and levee maintenance activities, including repairs (e.g., RSP replacement) and vegetation control on the waterside levee slope. It is anticipated that in-river dredging will be required every 2-3 years on average. A formal dredging plan describing specific maintenance dredging activities will be developed prior to dredging activities. Guidelines related to dredging activities and disposal and reuse of spoils, including compliance with in-water work windows and turbidity standards, are described in AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*). The replacement of RSP may necessitate access and work either from the levee crest (e.g., using an excavator) or from the water (e.g., using a barge and crane).

It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (June 1-October 31), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*).

6.1.2.1.1 Migrating Adults (December-March)

6.1.2.1.1.1 Individual-Level Effects

The timing of in-water maintenance activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.1.2 Spawning Adults (February-June)

6.1.2.1.2.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, increases in turbidity and suspended sediment, noise, and other hazards associated with dredging, riprap replacement, and barge operations (e.g., direct physical injury) could adversely affect Delta Smelt through harassment, injury, or mortality of spawning adults, depending on the location, timing, and nature of the activities. Spawning adults may also be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of channel areas adjacent to the intakes that are periodically disturbed by dredging or levee repair activities.

6.1.2.1.2.2 Population-Level Effects

Spawning adults may be present in the Delta during February through June, with peak spawning typically occurring from March to May. Thus, the timing of in-water maintenance activities (June 1–October 31) will avoid most of the spawning season and the months when adults are most likely to occur in the north Delta. In addition, as described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, exposure of the population to maintenance activities would be further limited by the low proportion of the population utilizing the north Delta, the low quality of spawning habitat in the affected reaches, and implementation of the AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures*. Population-level effects are expected to be negligible.

6.1.2.1.3 Eggs/Embryos (Spring: ~March–June)

6.1.2.1.3.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, Delta Smelt eggs and embryos are demersal and adhesive and therefore unable to avoid exposure to suspended sediment (*i.e.*, potential burial by deposited sediment), contaminants, or direct physical contact with machinery or materials (e.g., riprap) during in-water maintenance activities.

6.1.2.1.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults described above.

6.1.2.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.1.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may encounter active dredges and levee repair activities at the intake sites during their downstream movement from upstream spawning areas to estuarine rearing areas. Although the proposed work windows and BMPs would avoid or minimize exposure of larvae and early juveniles to potential water quality impacts or other hazards, this life stage, if present, would be unable to avoid active work areas and would therefore be particularly susceptible to the hazards of in-water maintenance activities.

6.1.2.1.4.2 Population-Level Effects

Population-level effects are expected to be negligible based on the small proportion of adults that spawn in or upstream of the north Delta in June, the resulting low densities of larvae and early juveniles in this region of the Delta, and implementation of the AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures*.

6.1.2.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intakes in the summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.1.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.2 Barge Landings

Maintenance activities at the barge landings include regular visual inspections, routine maintenance, and periodic repairs of the docking, loading, and unloading facilities. Maintenance dredging from barges may be required to maintain sufficient water depths for access, maneuvering, and mooring of barges over the course of barge landing operations. Maintenance activities also include levee repairs (e.g., riprap replacement) and vegetation control measures on the waterside slope of the levee. The replacement of RSP may necessitate access and work either from the levee crest (e.g., using an excavator) or from the water (e.g., using a barge and crane). It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (June 1-October 31), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4

Erosion and Sediment Control Plan; AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*).

6.1.2.2.1 Migrating Adults (December-March)

6.1.2.2.1.1 Individual-Level Effects

The timing of in-water maintenance activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.2.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.2.2 Spawning Adults (February-June)

6.1.2.2.2.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* increases in turbidity and suspended sediment, noise, and other hazards associated with dredging, riprap replacement, and barge operations (e.g., direct physical injury) could adversely affect Delta Smelt through harassment, injury, or mortality of spawning adults. Spawning adults may be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of channel areas adjacent to the landings that are periodically disturbed by dredging or levee repair activities.

6.1.2.2.2.2 Population-Level Effects

Because Delta Smelt are generally found in the west Delta and Cache Slough/Liberty Island area during spring and summer, the majority of the population will not be exposed to maintenance activities at the proposed barge landing sites. In addition, the timing of in-water maintenance activities (June 1-October 31) will avoid most of the spawning season and the months when adults are most likely to occur in the east and south Delta. In addition, as described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, exposure of the population to temporary and long-term effects of maintenance activities on aquatic habitat would be limited by the low quality of spawning habitat at preferred sites for barge access and loading and unloading operations.

6.1.2.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.2.2.3.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* Delta Smelt eggs and embryos are demersal and adhesive and therefore unable to avoid exposure to suspended sediment (*i.e.*, potential burial by deposited sediment), contaminants, or direct physical contact with machinery or materials (e.g., riprap) during in-water maintenance activities.

6.1.2.2.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults described above.

6.1.2.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.2.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may encounter active dredges and levee repair activities at the barge landings during their downstream movement from upstream spawning areas to estuarine rearing areas. This life stage would be unable to avoid active work areas and would therefore be particularly susceptible to the hazards of in-water maintenance activities.

6.1.2.2.4.2 Population-Level Effects

Population-level effects are expected to be negligible based on the small proportion of adults that spawn in the east and south Delta in June, the resulting low densities of larvae and early juveniles in this region of the Delta, and implementation of the AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures*.

6.1.2.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landings in the summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.3 Head of Old River Gate

Maintenance of the Head of Old River (HOR) gate, including fishway, boat lock, and navigation structures, includes require regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. Routine maintenance includes regular servicing and repair of motors, compressors, and control systems, and periodic repairs to the mechanical and structural elements of the gate, fishway, and boat lock. Maintenance activities include periodic dredging to remove accumulated sediment from around the gate structure, dewatering of the gate facilities for inspection and maintenance, and replacement of riprap to repair eroded or damaged portions of the waterside levee slope. Vegetation control measures would be performed as part of levee maintenance. It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (August 1-November 30), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F*, General Avoidance and Minimization Measures*).

Maintenance dredging may be required every 3 to 5 years to remove sediment that may potentially interfere with gate operations, navigation, and fish passage. Dredging would be conducted with a sealed clamshell dredge operated from a barge or from the top of the levee. A floating turbidity control curtain will be used to limit the dispersion of suspended sediment during dredging operations. A formal dredging plan describing specific maintenance dredging activities will be developed prior to dredging activities. Guidelines related to dredging activities and disposal and reuse of spoils, including compliance with in-water work windows and turbidity standards, are described in AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*).

Each gate bay would be inspected annually at the end of the wet season for sediment accumulation. Each miter or radial gate bay would include stop log guides and pockets for stop log posts to facilitate the dewatering of individual bays for inspection and maintenance. Major maintenance could require a temporary cofferdam upstream and downstream for dewatering. When listed fish species may be present during dewatering operations, DWR proposes to minimize potential stranding losses by implementing a fish rescue and salvage plan (Appendix 3.F, *General Avoidance and Minimization Measures*, AMM8 *Fish Rescue and Salvage Plan*).

6.1.2.3.1 Migrating Adults (December-March)

6.1.2.3.1.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–November 30) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.3.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.3.2 Spawning Adults (February-June)

6.1.2.3.2.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–October 31) will avoid the Delta Smelt spawning season. Therefore, there would be no direct effects of maintenance activities on spawning adults. However, spawning adults may be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of channel areas adjacent to the HOR gate that are periodically disturbed by dredging or levee repair activities.

6.1.2.3.2.2 Population-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, most of the Delta Smelt population is distributed downstream of the proposed HOR gate (Moyle 2002) although adults have been detected in the lower San Joaquin River near the HOR junction. Based on the general lack of habitat thought to be preferred by Delta Smelt for spawning, Old River in the action area of the proposed gate does not likely support significant spawning of Delta Smelt, serving mainly as a migration corridor for adults during their migration to upstream spawning areas and larvae during their downstream dispersal to estuarine habitat. Thus, any impacts on potential spawning habitat resulting from sedimentation or direct disturbance of the channel bed would have negligible population-level effects.

6.1.2.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.2.3.3.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–November 30) will avoid the Delta Smelt incubation season. Therefore, there would be no direct effects of maintenance activities on eggs and embryos.

6.1.2.3.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults and habitat described above.

6.1.2.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.3.4.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–November 30) will avoid the potential occurrence of Delta Smelt larvae and early juveniles within the action area of the HOR gate.

6.1.2.3.4.2 Population-Level Effects

No population-level effect would occur.

6.1.2.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.4 Clifton Court Forebay

Maintenance of the water conveyance facilities and other infrastructure at CCF (including Clifton Court Pumping Plant [CCPP], divider and perimeter embankments, outlet canals and siphons, South CCF [SCCF] intake structure, and North CCF [NCCF] emergency spillway) will include regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. Maintenance requirements potentially affecting listed fish species and aquatic habitat in CCF and Old River include dredging or mechanical excavation of accumulated sediment around the pumping, intake, and outlet facilities, and embankment maintenance activities, including repairs (e.g., RSP replacement) and vegetation control on the divider and perimeter embankments. With upstream sediment removal at the north Delta sedimentation facilities and expansion of storage capacity at CCF, the need for additional dredging of NCCF and SCCF over the first 50 years following construction is expected to be minimal. It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (June 1-November 30), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F, *General Avoidance and Minimization Measures*) (Appendix 3.F, *General Avoidance and Minimization Measures*).

6.1.2.4.1 Migrating Adults (December-March)

6.1.2.4.1.1 Individual-Level Effects

The timing of in-water maintenance activities (June 1–November) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.4.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.4.2 Spawning Adults (February-June)

6.1.2.4.2.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, increases in turbidity and suspended sediment, noise, and other hazards associated with dredging, riprap replacement, and barge operations (e.g., direct physical injury) could adversely affect Delta Smelt through harassment, injury, or mortality of spawning adults. Spawning adults may be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of sediments adjacent to the water conveyance facilities that are periodically disturbed by dredging or levee repair activities.

6.1.2.4.2.2 Population-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, restriction of in-water maintenance activities in CCF to June 1-November 30 will avoid most of the spawning season (January through June) and peak abundance of adults, eggs, and larvae in the south Delta (February through May). In addition, Old River in the vicinity of CCF is highly channelized and lacks the general attributes of preferred spawning habitat, and CCF is not considered suitable habitat because of the low likelihood of survival of larvae, juveniles, and adults that are entrained into the forebay (Castillo *et al.* 2012). No population-level effects are anticipated.

6.1.2.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.2.4.3.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, Delta Smelt eggs and embryos are demersal and adhesive and therefore unable to avoid exposure to suspended sediment (*i.e.*, potential burial by deposited sediment), contaminants, or direct physical contact with machinery or materials (e.g., riprap) during in-water maintenance activities.

6.1.2.4.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults described above.

6.1.2.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.4.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may encounter active dredges and levee repair activities in CCF or Old River during June and possibly into early July. This life stage would be unable to avoid active work areas and would therefore be particularly susceptible to the hazards of in-water maintenance activities.

6.1.2.4.4.2 Population-Level Effects

Population-level effects are expected to be negligible based on the small proportion of adults that spawn in the south Delta in June, the resulting low densities of larvae and early juveniles in this region of the Delta, and the low likelihood of survival of larvae or early juveniles due to high pre-screen mortality and entrainment losses in CCF and the Skinner Fish Facility.

6.1.2.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landings in the summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.5 Effects for Maintenance Activities on Delta Smelt Critical Habitat

Maintenance activities would not affect the Delta Smelt critical habitat PCEs 3 and 4 because there would be no effect on river flows or salinity as a result of these activities. The effects to PCEs 1 and 2 are described below.

6.1.2.5.1 PCE 1: Physical Habitat (Spawning Substrate)

Potential effects of maintenance activities on physical habitat include loss or degradation of spawning substrate from the deposition of sediment generated by dredging and levee repair activities. Spawning adults may also be affected by changes in water depths, substrate, and hydraulic conditions in areas adjacent to the water conveyance facilities that are periodically disturbed by dredging or levee repair activities, potentially affecting areas defined as shallow water habitat; however, as described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, these areas re not considered preferred spawning habitat, and CCF is not part of the designated critical habitat.

6.1.2.5.2 PCE 2: Water (Quality)

Increases in turbidity, suspended sediment, and noise during dredging, levee repair activities, and other in-water maintenance activities are expected to cause temporary, localized reductions in water quality at times when few Delta Smelt are likely to be present (August 1–November 30) at the intake sites, and in Old River and CCF. Water quality is expected to return to baseline levels following cessation of maintenance activities.

6.1.3 Effects of Water Facility Operations on Delta Smelt

6.1.3.1 Introduction

This section analyzes the effects of water facility operations on Delta Smelt. There are eight main subsections:

- North Delta Exports: Analyzes the potential for entrainment, impingement, and elevated predation rates.
- South Delta Exports: Analyzes the potential for entrainment and elevated predation rates.

- Head of Old River (HOR) Gate: Analyzes potential effects on Delta hydraulics and near-field impacts (elevated predation rates and fish passage).
- Habitat Effects: Analyzes the combined effects of PA operations on Delta flows, abiotic habitat, water temperature, sediment removal (water clarity), entrainment of phytoplankton, conditions contributing to growth of *Microcystis*, and loading and bioaccumulation of contaminants (selenium).
- Delta Cross Channel: Analyzes the effects of Delta Cross Channel operations on Delta hydraulics.
- Suisun Marsh Facilities: Analyzes potential effects of the Suisun Marsh Salinity Control Gates, Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall.
- North Bay Aqueduct: Analyzes potential for entrainment, impingement, and predation.
- Other Facilities: Analyzes the effects of Contra Costa Water District Facilities and the Clifton Court Forebay Aquatic Weed Control Program.

6.1.3.2 North Delta Exports

The reach of the Sacramento River where the NDDs are proposed to be built is considered to be near the northern extent of where Delta Smelt occur. Surveys conducted within the Sacramento River reach of the proposed NDD locations indicate few Delta Smelt are found in the vicinity. On one occasion, the species has been found as far upstream as Knights Landing (Vincik and Julienne 2012). Thus, it is expected that there will be some entrainment and impingement of Delta Smelt at the proposed NDD. For the effects analysis below, population-level effects were considered in light of survey data in the general vicinity of the proposed intakes that were examined to inform the extent of exposure of the species. The survey data used included USFWS beach seine data (1976–2011, January–December), Interagency Ecological Program (IEP) fall midwater trawl data (1991–2010, September–December), and CDFW striped bass egg and larval survey data (1991–1994, February–July). For each of these surveys, data from stations on the Sacramento River between Georgiana Slough and approximately the northern limit of the statutory Delta (City of Sacramento at the I Street Bridge) were summarized to represent the potential occurrence of Delta Smelt that could be entrained or impinged (Figure 6.1-1). Summed catch data for these locations were then compared to other survey locations, which were designated as downstream sites. In addition, for migrating adult Delta Smelt, a DSM2-PTM-based analysis was used to infer potential spatial overlap with the NDD.

The analyses of the potential effects of north Delta exports on Delta Smelt that are presented in this section are limited to the near-field effects of the NDD (entrainment, impingement/screen contact, and predation). Potential far-field effects on Delta Smelt habitat are considered in Section 6.1.3.5, *Habitat Effects*, because both north and south Delta exports contribute to such effects together and it would be impractical to attempt to parse out these effects for the facilities separately.

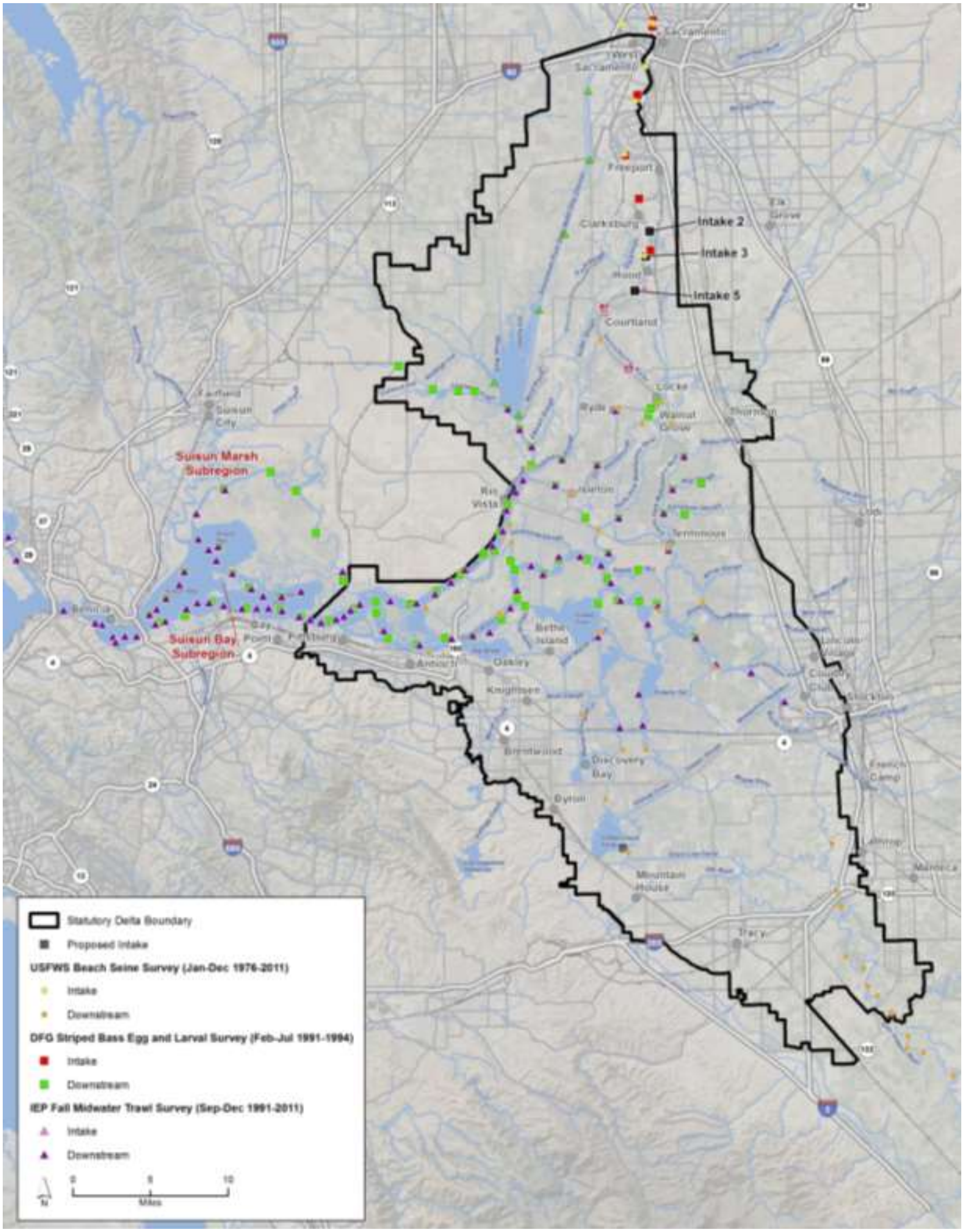


Figure 6.1-1. Survey Station Locations Used to Assess the Potential Presence of Delta Smelt Near the Proposed CVP/SWP North Delta Intakes

6.1.3.2.1 Entrainment

6.1.3.2.1.1 Migrating Adults (December-March)

6.1.3.2.1.1.1 Individual-Level Effects

Based on Delta Smelt body depth to body length ratios and using the screening effectiveness analysis described in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.2, the proposed NDD screen mesh of 1.75 mm would prevent Delta Smelt greater than standard length of around 20-21 mm from being entrained through the fish screens. Therefore, Delta Smelt older than approximately 90 days (Hobbs *et al.* 2007) could not be entrained through the NDD fish screens. All adult Delta Smelt exceed 90 days of age and 20-21 mm in length. Therefore, there would be no adverse effect to individual adult Delta Smelt.

6.1.3.2.1.1.2 Population-Level Effects

As there would be no individual-level adverse effect, there would be no population-level adverse effect to migrating adult Delta Smelt from entrainment at the NDD.

6.1.3.2.1.2 Spawning Adults (February-June)

6.1.3.2.1.2.1 Individual-Level Effects

As described for migrating adult Delta Smelt, the proposed NDD screen mesh of 1.75 mm would prevent Delta Smelt greater than standard length of around 22 mm from being entrained. Therefore, there would be no adverse effect to individual spawning adult Delta Smelt.

6.1.3.2.1.2.2 Population-Level Effects

Following from no individual-level adverse effect, there therefore would be no population-level adverse effect to spawning adult Delta Smelt from entrainment at the NDD.

6.1.3.2.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.2.1.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). As such, individual eggs would not be subject to entrainment and there would be no individual-level adverse effect.

6.1.3.2.1.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the NDD with respect to entrainment.

6.1.3.2.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.2.1.4.1 Individual-Level Effects

As noted for adult Delta Smelt, based on Delta Smelt body depth to body length ratios (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt, S*ection 6.A.2.2), the proposed screen mesh of 1.75 mm would exclude Delta Smelt greater than standard length of around 20-21 mm (generally, fish less than 90 days old). Therefore, Delta Smelt smaller than 20-21 mm could be entrained; however, fish that are over 20-21 mm may also be injured or killed by impingement whether they pass all the way through the screen or not because they may not be able free themselves from the fish screen if water is being drawn through it; impingement is discussed further in Section 6.1.3.2.2.

The Freeport Regional Water Authority's water intake is the most analogous to the proposed NDD. The intake is located at Freeport Bend (river mile 47 on the Sacramento River) and therefore is ~6 river miles upstream of the PA's Intake 2, the most upstream of the three proposed intakes. The Freeport intake is also considerably smaller than the proposed NDD: the intake has a capacity up to 286 cfs (*i.e.*, about 10% of the 3,000 cfs for each NDD intake), and the fish screen panels are 9.92 feet wide by 10.71 feet tall (compared to 15.6 feet wide by 12.5 to 17.0 feet for the NDD screens), with a total of 16 fish screens (compared to 66–90 screens for the NDD intakes 2, 3, and 5). Both facilities are designed to meet a 0.2 ft/s approach velocity criterion. Entrainment monitoring was undertaken in winter/spring of water years 2012–2014, although pumping rate was low in 2012 and 2013 (generally 23 cfs or less), whereas in 2014 pumping rate was greater (132–163 cfs) (ICF International 2015a). Hoop net and larval light trap monitoring behind the fish screens did not detect delta smelt in any of the years sampled, although in 2014 three unidentifiable smelt larvae were detected, in addition to two wakasagi larvae (*Hypomesus nipponensis*). USFWS trawls and beach seining upstream of the Freeport intake (Sherwood Harbor and Garcia Bend) have sometimes detected Delta Smelt during the period of entrainment monitoring, so adults and therefore possibly larvae are present in the general area, albeit in low abundance. The analysis of the Freeport intake suggests that when Delta Smelt larvae do occur in front of the NDD screens, some entrainment will occur.

For this effects analysis, it is assumed that entrainment risk of early life stage Delta Smelt is related to the proportion of river flow diverted by the intakes, with the risk increasing as higher proportions of flow are diverted (as shown for other species by ICF Jones & Stokes 2008). Given this assumption, the CalSim monthly mean modeling outputs can be used to provide estimates of the proportion of flow diverted, by dividing the NDD flow by the Sacramento River flow at Freeport. The proportion of flow diverted by the NDD increases as bypass flow constraints decrease: in wet years, the median proportion of flow diverted ranged from 7% in April (range 0% to 15%) to 32% in June (range 7–38%); in contrast, in critical years, the median percentage of flow diverted ranged from 3% in April (range 0% to 6%) to 6% in June (range 6% to 8%) (Table 6.1-5). Thus, the risk to individual fish is expected to be lower in drier years and the risk would be lower in April and May than in March or June.

Table 6.1-5. Summary Statistics of CalSim-Modeled Average Monthly North Delta Diversion as a Percentage of Sacramento River at Freeport Flows for the Proposed Action

Water Year Type		March	April	May	June
Wet	Maximum	35%	15%	21%	38%
	75th percentile	26%	9%	12%	35%
	Mean	20%	7%	9%	29%
	Median	17%	7%	8%	32%
	25th percentile	13%	5%	5%	25%
	Minimum	6%	0%	3%	7%
Above Normal	Maximum	34%	14%	15%	38%
	75th percentile	24%	9%	11%	36%
	Mean	21%	6%	8%	30%
	Median	19%	5%	10%	32%
	25th percentile	15%	4%	5%	28%
	Minimum	13%	1%	2%	16%
Below Normal	Maximum	31%	8%	12%	36%
	75th percentile	24%	7%	6%	28%
	Mean	16%	4%	4%	19%
	Median	13%	4%	2%	21%
	25th percentile	9%	0%	1%	6%
	Min	6%	0%	0%	6%
Dry	Max	32%	15%	16%	37%
	75th percentile	22%	6%	6%	26%
	Mean	18%	4%	4%	17%
	Median	20%	1%	3%	13%
	25th percentile	13%	0%	2%	6%
	Minimum	6%	0%	0%	6%
Critical	Maximum	17%	6%	6%	8%
	75th percentile	6%	4%	6%	6%
	Mean	7%	3%	4%	6%
	Median	6%	3%	4%	6%
	25th percentile	6%	1%	2%	6%
	Minimum	6%	0%	0%	6%

6.1.3.2.1.4.2 Population-Level Effects

Catch of Delta Smelt per cubic meter in the egg and larval survey in 1991–1994 was an order of magnitude lower in the vicinity of the proposed north Delta intakes than in downstream areas Table 6.1-6), and total catch in the vicinity of the intakes was considerably less than total catch downstream. Catch density tended to be greatest in April and May which, as shown previously, are expected to be the months when the lowest proportion of Sacramento River water would be diverted by the NDD (Table 6.1-5). These pieces of evidence suggest that any adverse population-level effect from entrainment by the NDD would be small.

It is not possible to provide a precise estimate of the proportion of the larval population that might be entrained by the NDD. However, to provide a coarse perspective, the ratio (intake/downstream) of the mean densities in April and May were 0.04–0.06 (*i.e.*, the density in the intake area was 4–6% that of the downstream area). Volumetric estimates of Delta channels used in DSM2 (Jones & Stokes 2005, Section 5.2, Table 5.2-1) suggest the downstream portion of the Delta included in the egg and larval survey (see Figure 6.1-1; note that much of the south Delta is excluded) is over 20 times greater than the volume of the Sacramento River upstream of Georgiana Slough and Delta Cross Channel, from which the intake density estimates were taken. Therefore, perhaps 0.25% of larvae could occur in the NDD reach. If 10% of water was diverted, this suggests that the order of magnitude of population-level larval entrainment from the NDD would be considerably less than 0.1% (and closer to 0.01%). Mean estimates of potential March–June larval population-level entrainment by the NDD using a DSM2-PTM analysis described in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.2, ranged from <0.1% in critical years to nearly 0.2% in other water year types (see further discussion in the Entrainment section for South Delta Exports). However, that analysis assumed density in the Sacramento River was the same as at all locations in the north Delta, including Cache Slough and surrounding areas, where density would be expected to be higher than in the Sacramento River, which may have biased these estimates somewhat high.

Further perspective on the proportion of the Delta Smelt population that could occur near the NDD was provided by a DSM2-PTM analysis incorporating movement into the upper 10% of the water column during flood tides, to simulate the upstream migration of adult Delta Smelt; as described in more detail in Section 6.1.3.2.2.1.2, this analysis also provided evidence that a very low proportion of the Delta Smelt population (migrating adults, and therefore their progeny) would be expected to occur near the NDD, as no particles originating downstream were entrained at the NDD (or moved upstream of Isleton; Table 6.1-8, indicating that there is no hydraulic reason to expect significant fractions of the Delta Smelt population to reach the NDDs.

Table 6.1-6. Number of Delta Smelt Larvae Collected and Catch per Cubic Meter during the CDFW Striped Bass Egg and Larval Survey in the Action Area

Year	Month	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Cubic Meter (Intake Area)	Catch Per Cubic Meter (Downstream)
		Intake Area	Downstream					
1991	2	14	74	2	0	1.00	0.01	0.00
	3	7	82	0	25	0.00	0.00	0.10
	4	21	362	2	33	0.06	0.01	0.13
	5	105	442	31	101	0.23	0.15	0.51
	6	70	279	2	24	0.08	0.01	0.12
1992	2	34	205	0	7	0.00	0.00	0.03
	3	55	348	4	38	0.10	0.02	0.17
	4	77	482	43	202	0.18	0.19	0.93
	5	101	509	6	228	0.03	0.03	1.10
	6	76	353	0	36	0.00	0.00	0.16
	7	12	167	0	1	0.00	0.00	0.00
1993	2	27	273	0	185	0.00	0.00	0.82
	3	59	405	16	284	0.05	0.07	1.32
	4	55	415	38	318	0.11	0.19	1.44
	5	64	419	44	487	0.08	0.19	3.03
	6	48	411	0	102	0.00	0.00	1.23
	7	8	237	0	55	0.00	0.00	0.37
1994	2	40	306	0	25	0.00	0.00	0.11
	3	64	453	20	565	0.03	0.09	2.46
	4	56	431	8	1723	0.00	0.04	7.39
	5	64	491	4	338	0.01	0.02	1.82
	6	56	432	0	258	0.00	0.00	1.31
	7	32	235	0	46	0.00	0.00	0.18
mean	2	28.8	214.5	0.5	54.3	0.25	0.00	0.24
	3	46.3	322.0	10.0	228.0	0.05	0.04	1.01
	4	52.3	422.5	22.8	569.0	0.09	0.10	2.47
	5	83.5	465.3	21.3	288.5	0.09	0.10	1.62
	6	62.5	368.8	0.5	105.0	0.02	0.00	0.71
	7	17.3	213.0	0.0	34.0	0.00	0.00	0.19

Source: California Department of Fish and Game unpublished data.

6.1.3.2.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.2.1.5.1 Individual-Level Effects

As described for adult Delta Smelt, the proposed NDD screen mesh of 1.75 mm would prevent Delta Smelt greater than standard length of around 22 mm from being entrained, and therefore would be expected to allow juvenile Delta Smelt to avoid entrainment but not necessarily impingement. There would be no adverse effect to individual juvenile Delta Smelt from entrainment.

6.1.3.2.1.5.2 Population-Level Effects

Based on the lack of effect to individual juvenile Delta Smelt, there would not be an adverse population-level effect from entrainment at the NDD to Delta Smelt juveniles.

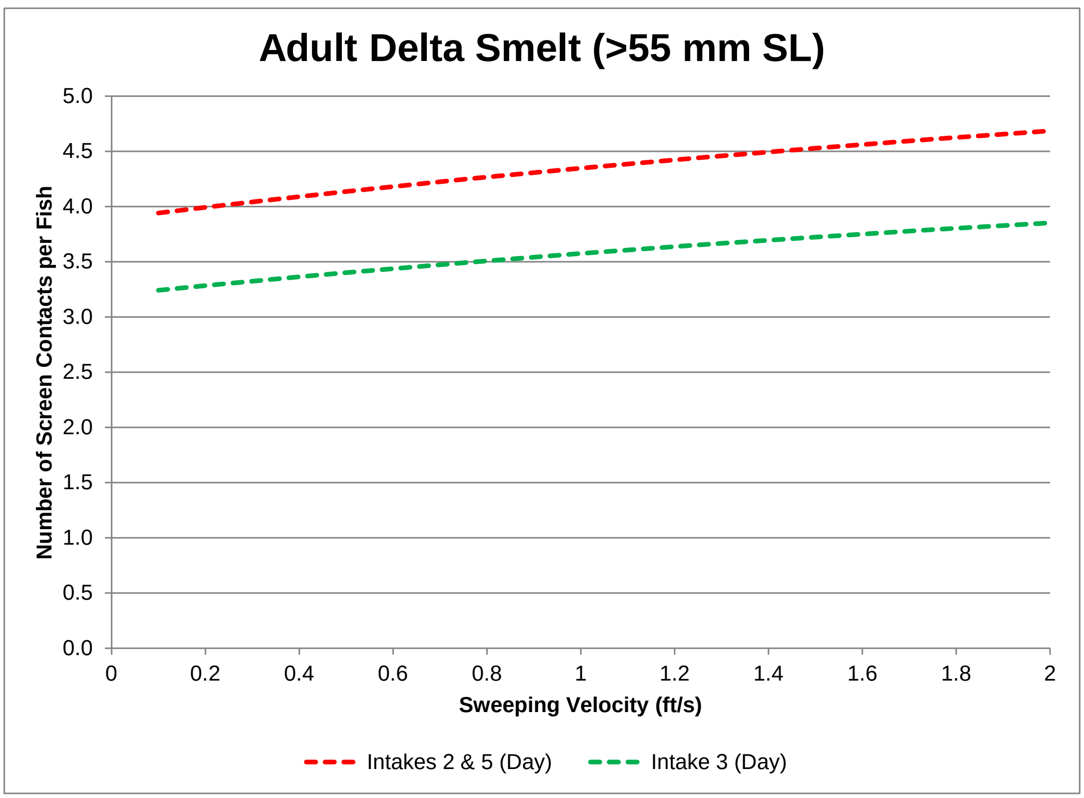
6.1.3.2.2 Impingement and Screen Contact

6.1.3.2.2.1 Migrating Adults (December-March)

6.1.3.2.2.1.1 Individual-Level Effects

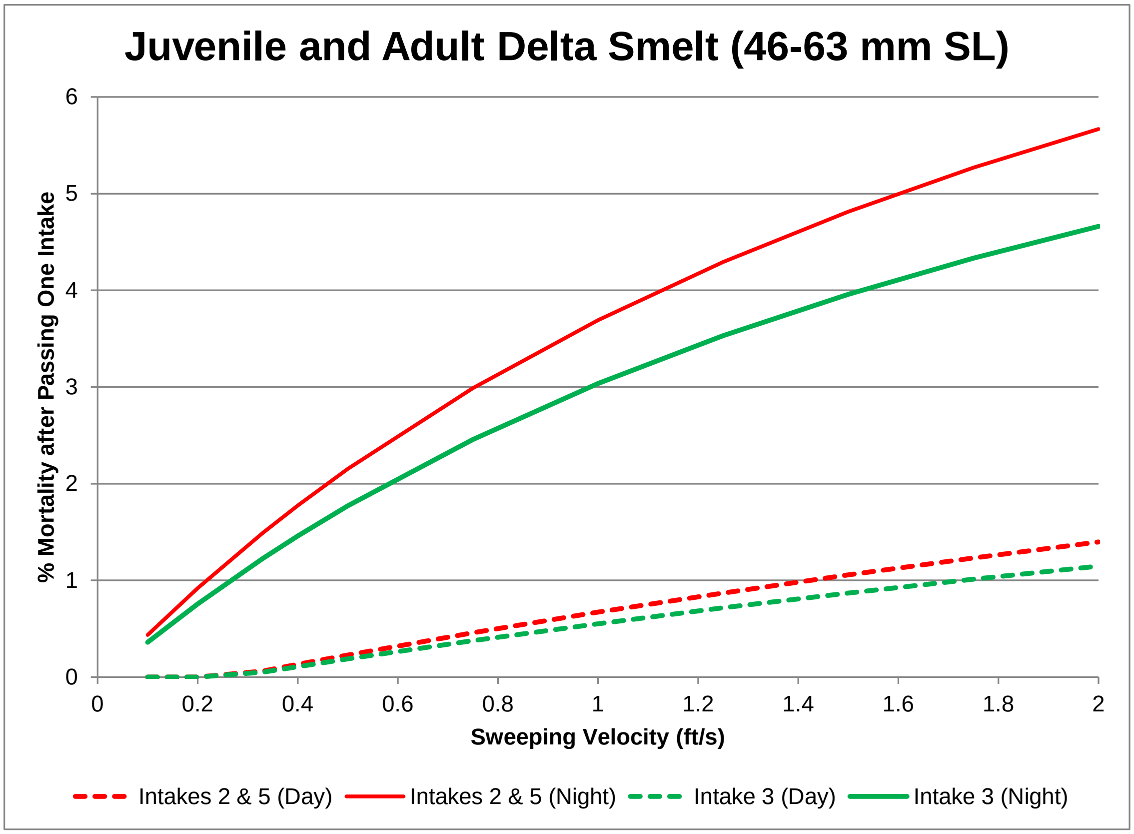
As noted in Chapter 3, *Description of the Proposed Action*, the NDD would be operated such that approach velocity is consistent with recommendations for Delta Smelt (0.2 ft/s). However, there remains the potential that Delta Smelt larger than the minimum screenable size of ~20-21 mm could contact the NDD screens and be injured or die. This potential exists for several reasons: (1) even at 0.2-ft/s approach velocity, Delta Smelt had some injurious screen contact in an experimental flume (White *et al.* 2007), (2) the sweeping flow velocity at which it was assumed that NDD diversions could commence (0.4 ft/s; see Section 5.A.5.2.4.9, *North Delta Diversion Bypass Flows*, in Appendix 5.A, *CALSIM Methods and Results*, and Section 5.B.2.3.5, *North Delta Diversion Operations*, in Appendix 5.B, *DSM2 Modeling and Results*) is within the velocity range at which captive Delta Smelt switched swimming modes from a noncontinuous stroke and glide behavior to continuous swimming, resulting in swimming failure because of inability (or unwillingness) to swim steadily (Swanson *et al.* 1998), and (3) the proposed fish screens are very long requiring that Delta Smelt will need to swim continuously against what they consider strong current for lengthy periods of time and it has not been determined that they can or will do so. The behavior-based PTM analysis (see Section 6.1.3.2.2.1.2, *Population-Level Effects*) supports the hypothesis that adult Delta Smelt migrating upstream in the vicinity of the NDD need to use the lower velocity periphery of the channel to swim upstream against unidirectional flow during periods when the NDD would be operating (*i.e.*, the typical tidal surfing behavioral conceptual model [Bennett and Burau 2015] would not move fish this far upstream). As a result, individuals that do migrate this far upstream may face a higher risk of contact with the screens if they migrated along the left bank of the river where the NDD would be located. Juvenile/adult injury and mortality has been found to occur following screen contact in laboratory experiments conducted at the UC Davis Fish Treadmill Facility (Swanson *et al.* 2005; White *et al.* 2007), and stress (measured as plasma cortisol) is positively correlated with screen contact in adult Delta Smelt (Young *et al.* 2010).

The published studies on Delta Smelt from the UC Davis Fish Treadmill Facility were used to assess the potential for screen contact, screen passage, and mortality. As described in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.3, two of the methods (Section 6.A.2.3.1.1 *Adult Delta Smelt (Number of Screen Contacts)*; Section 6.A.2.3.1.2, *Juvenile and Adult Delta Smelt (Percentage Mortality)*) were based on an assessment methodology undertaken as part of the BDCP Fish Facilities Technical Team planning effort. From these analyses, it is estimated the adult Delta Smelt passing one of the NDD screens—moving against the flow, *i.e.*, in an upstream direction, based on the laboratory studies—would contact the screen 3 to 5 times, and that there would be little variation in this estimate across a wide range of sweeping velocity (Figure 6.1-2). In addition, application of the relationships from the laboratory studies show that mortality is estimated to be 1% or less for fish encountering one of the intakes when sweeping velocity is low (0.2–0.3 ft/s), possibly increasing to 4–6% at sweeping velocity above 1.5 ft/s if encountered at night (Figure 6.1-3). A third analysis (Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)*) was adapted from an analysis provided by USFWS. This analysis focused on the ability of Delta Smelt moving upstream near the left bank of the river to pass the lowermost NDD fish screen, given historic Sacramento River at Freeport water velocity, and also examined potential survival of those successfully passing the screen. Using December-June Freeport velocity information, the probability that an individual adult Delta Smelt would successfully pass the lowermost NDD fish screen was estimated to range from 0.073 to 0.075. When the data were restricted to the more likely December-March period, the estimate was 0.040 (0.0398 to 0.0405). The survival estimates for fish that actually pass the screen were relatively high and had low variability: mean ± standard deviation = 0.916 ± 0.0079, but the survival estimates had little influence on passage (*P*) because river velocity is almost always too high for Delta Smelt to swim the required distance upstream. As described in Section 3.2.2.2, *Fish Screen Design*, 22-foot-wide refugia could be provided between each of the six screen bay groups at the three intakes, which, if effective, could provide resting areas and predator refuge for Delta Smelt occurring near the intakes. However, given that the refugia are still in the conceptual design phase and there is uncertainty as to their effectiveness for Delta Smelt, the analyses presented above only accounted for the refugia by excluding the refugia length from the estimates of overall screen length at each intake.



Note: This plot is only relevant to the Delta Smelt occurring in the reach of the Sacramento River where the proposed NDD would be situated, and of those, only the ones encountering the intake screens at the river margins where the on-bank intakes would be sited.

Figure 6.1-2. Estimated Number of Screen Contacts of Adult Delta Smelt Encountering Fish Screens the Length of Intakes 2 and 5 (1,350 feet) and Intake 3 (1,110 feet) at an Approach Velocity of 0.2 feet per second during the Day



Note: This plot is only relevant to the Delta Smelt occurring in the reach of the Sacramento River where the proposed NDD would be situated, and of those, only the ones encountering the intake screens at the river margins where the on-bank intakes would be sited.

Figure 6.1-3. Estimated 48-hour Mortality of Juvenile and Adult Delta Smelt Encountering Fish Screens The Length of Intakes 2 and 5 (1,350 feet) and Intake 3 (1,110 feet) at an Approach Velocity of 0.2 feet per second during the Day and Night

Overall, the UC Davis Fish Treadmill studies indicate that there is potential for lethal and nonlethal take of juvenile and adult Delta Smelt from screen contact and impingement, for the subset of the population occurring in the reach of the river where the NDD would be located. However, monitoring by sonar cameras and diver surveys at the Freeport intake to evaluate impingement impacts did not reveal any impinged fish (eggs, larvae, or later life stages) in 2014 (or in 2011–2013), and there was no significant debris accumulation on screen panels (which can affect screen performance). A hydraulic evaluation of the Freeport intake in 2014 showed that approach velocity ranged from 0.09 ft/s to 0.27 ft/s and that 70% of approach velocity measurements did not exceed the target design approach velocity of 0.2 ft/s, although the facility was operating at 85% of capacity (ICF International 2015b). The analysis of the ability of migrating adult Delta Smelt to pass the most downstream intake if occurring near the left bank suggested that only a very small proportion (4%) of fish would be expected to do so. If successfully passing one intake and remaining near the left bank, the remaining Delta Smelt would have to pass the two other intakes, again with a similarly low probability of success. The extent to which these factors could constitute a barrier to migration to upstream habitat would depend on the ability of Delta Smelt to use lower velocity habitat on the right (west) bank of the river, near the channel bottom, or within the refugia along the intakes.

6.1.3.2.2.1.2 Population-Level Effects

For an assessment of distribution in relation to the NDD based on seine data, Delta Smelt adults for this analysis were assumed to be represented by fish ≥60 mm fork length (FL), based on Moyle's (2002) designation of adults as ~55-mm standard length. The proportion of Delta Smelt ≥60 mm FL collected in the reach of the Sacramento River where the proposed intakes would be situated averaged slightly below one fifth of the total catch from seining and was highly variable between years, with mean catch per seine in some years comparable to downstream areas, and in other years substantially lower. It should be noted that seining is not extensive in some of the more important areas of Delta Smelt's current distribution (e.g., the Cache Slough and Sacramento Deep Water Ship Channel area, Suisun Bay and the Sacramento-San Joaquin river confluence) but seine sampling in the Sacramento River is quite common in order to target the Chinook salmon fry the survey was designed to monitor (Table 6.1-7). Seine data do indicate that adult Delta Smelt occur in low numbers in the reach of the river where the proposed north Delta intakes would be sited; however, as the proposed intake location is outside the main range of Delta Smelt, the potential for any adverse effect at the population level from impingement is minimal to nil. Further perspective on the proportion of the Delta Smelt population that could occur near the NDD was provided by a DSM2-PTM analysis incorporating movement into the upper 10% of the water column during flood tides (*i.e.* modeled tidal surfing behavior), to simulate the upstream migration of adult Delta Smelt, as described in Section 6.A.2.1 of Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*. This analysis also provided evidence that a very low proportion of the migrating adult Delta Smelt population would be expected to occur near the NDD if relying on tidal migration upstream (Bennett and Burau 2015), as no particles originating downstream were entrained at the NDD (or moved upstream of Isleton on the Sacramento River[6]; Table 6.1-8). Therefore tidal migration upstream toward the NDD would not be enhanced by the PA.

Conceptually, the population-level effect of the NDD on migrating adult Delta Smelt passage is the individual take of fish caused by impingement-related injury or mortality (including incidental loss to predators) multiplied by the fraction of the adult population that is anticipated to reach the NDD *and* attempt to pass them, but is unable to do so. Based on application of the equation predicting mortality as a function of contact rate, temperature, and approach velocity to February 1991 conditions (Appendix 6.A, Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)*), the predicted mortality rate of fish swimming past the fish screen is about eight percent. If for the sake of argument, one percent of all adult Delta Smelt attempt to pass one or more of the NDDs, the population loss would be eight percent of one percent, which is 0.08 percent or about eight of every 10,000 fish. As described in Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)* of Appendix 6.A, February 1991 was a low flow period in a drought in which river velocity was less and therefore more likely to have allowed upstream migration by Delta smelt at a sufficient rate to pass the first NDD intake. As such, it would be expected that a smaller fraction of the population would attempt or even be able to successfully pass the intake during higher flow periods. It is not known what fraction of the adult Delta Smelt population ascends the Sacramento River and how that fraction varies from year to year. The catches and CPUEs of Delta Smelt using beach seines were summarized in Table 6.1-7, but these

[6] A breakdown of the fates of particles by geographic subregion is also provided in Section 6.A.2.1.2 of Appendix 6.A.

are challenging to compare quantitatively because, as described in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.3.1.3, *Adult Delta Smelt (Screen Passage and Survival)*, fish ascending the Sacramento River very likely have to use nearshore habitat sampled by the beach seines much more extensively than they do further downstream in the estuary. In addition, there is no known reason that Delta Smelt *have to* ascend the Sacramento River past the proposed NDD locations in order to spawn; most spawning seems to occur in Suisun Marsh, the river channels around Sherman Island, and in the Cache Slough/Deepwater Shipping Channel area. Thus, it is also possible that there will be no measurable population-level impact caused by migrating adult Delta Smelt either prevented from continuing past the NDD or being injured/impinged trying to pass them, because few or no individuals may attempt to keep moving upstream along the left bank once they encounter elevated velocities associated with the first diversion. However, Delta Smelt can currently ascend the river along its east bank if they choose to do so. Thus, the loss of low-velocity shoreline and increase in shoreline water velocity along the river's east (left) bank that will occur as a result of the NDD fish screens will have an impact to critical habitat because it will alter the capacity of the fish to ascend the river along its east bank. As previously discussed in the Individual-Level Effects section, the overall magnitude of this potential effect on individual Delta Smelt would depend on the ability of Delta Smelt to use lower velocity habitat on the right bank of the river, near the channel bottom, or within the refugia along the intakes. However, given the spatial distribution of most of the Delta Smelt population, *i.e.*, well downstream of the NDD, any effects from not being able to access habitat upstream of the NDD are not expected to affect Delta Smelt at a population level.

Table 6.1-7. Number of Delta Smelt (≥60 mm Fork Length) Collected and Catch per Seine during USFWS Beach Seine Sampling in the Action Area (December–March)

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1977	15	15	0	0	.	0.00	0.00
1978	4	4	0	0	.	0.00	0.00
1979	4	7	0	0	.	0.00	0.00
1980	4	27	0	0	.	0.00	0.00
1981	10	35	0	13	0.00	0.00	0.37
1982	16	48	2	3	0.40	0.13	0.06
1983	13	54	4	5	0.44	0.31	0.09
1984	17	71	4	2	0.67	0.24	0.03
1985	12	39	0	0	.	0.00	0.00
1986	15	60	0	0	.	0.00	0.00
1987	12	48	0	0	.	0.00	0.00
1988	12	48	0	1	0.00	0.00	0.02
1989	12	48	0	0	.	0.00	0.00
1990	4	13	0	0	.	0.00	0.00
1991	16	58	0	0	.	0.00	0.00
1992	20	68	0	0	.	0.00	0.00
1993	13	41	0	2	0.00	0.00	0.05

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1994	16	70	0	0	.	0.00	0.00
1995	44	41	1	2	0.33	0.02	0.05
1996	94	100	0	13	0.00	0.00	0.13
1997	29	34	0	2	0.00	0.00	0.06
1998	48	66	1	0	1.00	0.02	0.00
1999	38	83	0	0	.	0.00	0.00
2000	83	82	0	2	0.00	0.00	0.02
2001	61	75	0	1	0.00	0.00	0.01
2002	52	81	0	2	0.00	0.00	0.02
2003	41	72	0	3	0.00	0.00	0.04
2004	51	82	0	1	0.00	0.00	0.01
2005	67	74	0	0	.	0.00	0.00
2006	21	48	0	0	.	0.00	0.00
2007	36	86	0	0	.	0.00	0.00
2008	33	78	0	0	.	0.00	0.00
2009	28	81	0	0	.	0.00	0.00
2010	32	63	0	1	0.00	0.00	0.02
2011	29	66	0	0	.	0.00	0.00
Mean	29	56	0	2	0.18	0.02	0.03
5th percentile	4	11	0	0	0.00	0.00	0.00
25th percentile	13	41	0	0	0.00	0.00	0.00
Median	20	60	0	0	0.00	0.00	0.00
75th percentile	40	75	0	2	0.35	0.00	0.03
95th percentile	72	84	3	7	0.75	0.16	0.10

Source: U.S. Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (Speegle pers. comm.).

Table 6.1-8. Adult Delta Smelt Upstream Movement Analysis Based on DSM2-PTM: Fate (Mean Percentage) of Particles By Release Location, Water Year Type, and Flux or Entrainment Location After 30 Days.

Release Location	Water Year Type	Downstream Flux Past Martinez			Downstream Flux Past Chipps Island			Entrainment into Clifton Court Forebay (State Water Project)			Entrainment into Jones Pumping Plant (Central Valley Project)			Entrainment into North Bay Aqueduct Barker Slough Pumping Plant			Upstream Flux Past Isleton			North Delta Diversion		
		NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
Cache Sl. at Liberty Island (Node 323)	W	63.0	61.2	-1.8 (-3%)	70.1	67.9	-2.1 (-3%)	1.5	1.0	-0.5 (-36%)	0.9	0.7	-0.2 (-24%)	0.5	0.7	0.1 (19%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	61.6	60.0	-1.6 (-3%)	68.5	68.3	-0.2 (0%)	0.9	0.7	-0.2 (-22%)	0.6	0.2	-0.4 (-68%)	0.1	0.1	0.0 (-3%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	19.3	13.8	-5.5 (-29%)	27.2	21.4	-5.8 (-21%)	0.7	0.7	0.0 (-6%)	0.5	0.3	-0.2 (-31%)	0.1	0.1	0.0 (8%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	11.6	9.5	-2.0 (-17%)	15.8	13.6	-2.2 (-14%)	0.7	0.7	0.0 (-4%)	0.6	0.5	-0.2 (-24%)	0.0	0.0	0.0 (13%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	1.3	0.9	-0.4 (-30%)	3.6	2.7	-0.9 (-24%)	0.1	0.1	0.0 (-25%)	0.1	0.1	0.0 (-14%)	0.0	0.0	0.0 (-28%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
Decker Island (Node 353)	W	77.1	73.9	-3.3 (-4%)	87.3	84.4	-2.9 (-3%)	0.9	0.5	-0.4 (-48%)	0.5	0.5	0.0 (-2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	73.7	74.7	1.0 (1%)	79.3	79.9	0.6 (1%)	2.3	2.4	0.1 (7%)	1.5	1.0	-0.5 (-34%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	38.0	30.9	-7.1 (-19%)	49.2	46.9	-2.3 (-5%)	4.4	3.1	-1.3 (-29%)	3.1	2.6	-0.5 (-15%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	20.2	18.3	-1.9 (-9%)	32.2	28.6	-3.6 (-11%)	5.9	4.5	-1.4 (-24%)	4.0	4.0	0.1 (2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	5.3	4.4	-0.9 (-18%)	10.3	8.8	-1.5 (-15%)	7.2	6.5	-0.7 (-9%)	4.2	3.6	-0.5 (-13%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
Montezuma Slough (Node 420)	W	18.9	18.5	-0.4 (-2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	0.6	0.6	0.0 (2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	0.2	0.0	-0.2 (-86%)	0.0	0.0	0.0 (-80%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	0.3	0.2	-0.1 (-45%)	-0.1	-0.1	0.1 (-50%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	0.9	0.6	-0.3 (-31%)	-0.5	-0.3	0.2 (-36%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
Chipps Island (Node 465)	W	83.6	80.6	-3.0 (-4%)	94.1	92.3	-1.9 (-2%)	0.2	0.1	-0.1 (-52%)	0.1	0.1	0.0 (-25%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	78.5	78.9	0.4 (1%)	84.8	85.2	0.4 (0%)	1.3	1.4	0.1 (9%)	1.0	0.7	-0.3 (-29%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	43.6	39.5	-4.1 (-9%)	57.6	58.1	0.5 (1%)	2.1	1.1	-1.0 (-48%)	1.4	0.9	-0.5 (-33%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	27.6	24.9	-2.8 (-10%)	44.2	40.4	-3.8 (-9%)	2.6	1.7	-0.9 (-35%)	1.8	1.6	-0.2 (-10%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	7.3	6.6	-0.7 (-10%)	13.2	12.2	-1.0 (-7%)	3.1	2.4	-0.7 (-23%)	2.0	1.3	-0.6 (-31%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)

Note: Grey shading indicates that no particles had this fate for either the NAA or PA.

6.1.3.2.2.2 Spawning Adults (February-June)

6.1.3.2.2.2.1 Individual-Level Effects

Presumably the risk to adult Delta Smelt from impingement at the NDD would be greater for actively migrating adults, if spawning adults hold in a similar location prior to, during, and after spawning (possibly to spawn more than once). However, for those spawning adults moving past the NDD, the risk of impingement-related injury and mortality would be as described for migrating adults.

6.1.3.2.2.2.2 Population-Level Effects

As with migrating adults during December-March, in some years, the catch per unit effort of adult (≥60 mm) Delta Smelt in the vicinity of the NDD is comparable to that in downstream areas, although the bulk of the catch still occurs downstream and, as noted previously, the seine survey was designed to collect Chinook salmon fry (as opposed to Delta Smelt) (Table 6.1-9). The reported catch from the early years, particularly before the 1990s, is uncertain as it is widely recognized that Delta Smelt were frequently misidentified by survey staff. As with migrating adults, given the spatial distribution of most of the Delta Smelt population, *i.e.*, well downstream of the NDD, any effects from not being able to access habitat upstream of the NDD are not expected to affect spawning adult Delta Smelt at a population level.

Table 6.1-9. Number of Delta Smelt (≥60 mm Fork Length) Collected and Catch per Seine during USFWS Beach Seine Sampling in the Action Area (February-June)

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1976	29	126	10	187	0.05	0.34	1.48
1977	87	169	9	115	0.07	0.10	0.68
1978	68	147	36	124	0.22	0.53	0.84
1979	71	282	28	411	0.06	0.39	1.46
1980	74	308	1	36	0.03	0.01	0.12
1981	83	273	78	195	0.29	0.94	0.72
1982	69	233	9	112	0.07	0.13	0.48
1983	52	213	13	56	0.19	0.25	0.26
1984	49	185	10	8	0.56	0.20	0.04
1985	47	191	0	29	0.00	0.00	0.15
1986	18	108	1	19	0.05	0.06	0.18
1987	32	124	0	19	0.00	0.00	0.15
1988	31	116	0	2	0.00	0.00	0.02
1989	37	154	0	5	0.00	0.00	0.03
1990	11	39	0	0	.	0.00	0.00
1991	28	94	4	0	1.00	0.14	0.00
1992	62	227	4	15	0.21	0.06	0.07
1993	81	255	18	7	0.72	0.22	0.03
1994	80	415	0	72	0.00	0.00	0.17
1995	134	355	5	10	0.33	0.04	0.03

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1996	158	348	4	40	0.09	0.03	0.11
1997	132	342	6	20	0.23	0.05	0.06
1998	78	331	7	65	0.10	0.09	0.20
1999	70	434	28	34	0.45	0.40	0.08
2000	102	419	16	38	0.30	0.16	0.09
2001	82	395	2	21	0.09	0.02	0.05
2002	73	439	7	4	0.64	0.10	0.01
2003	76	404	17	23	0.43	0.22	0.06
2004	78	403	26	19	0.58	0.33	0.05
2005	81	420	25	2	0.93	0.31	0.00
2006	82	368	5	52	0.09	0.06	0.14
2007	62	387	1	8	0.11	0.02	0.02
2008	68	373	1	0	1.00	0.01	0.00
2009	85	397	6	4	0.60	0.07	0.01
2010	85	361	26	5	0.84	0.31	0.01
2011	80	348	35	5	0.88	0.44	0.01
Mean	72	287	12	45	0.33	0.16	0.18
5th percentile	25	104	0	0	0.00	0.00	0.00
25th percentile	57	188	1	5	0.07	0.02	0.02
Median	74	331	6	19	0.22	0.09	0.06
75th percentile	82	391	18	46	0.57	0.24	0.16
95th percentile	133	424	35	145	0.95	0.46	0.75

Source: U.S. Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (Speegle pers. comm.).

6.1.3.2.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.2.2.3.1 Individual-Level Effects

As noted for entrainment, Delta Smelt eggs and embryos are demersal and adhesive, and so would not be subject to impingement.

6.1.3.2.2.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the NDD with respect to impingement.

6.1.3.2.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.2.2.4.1 Individual-Level Effects

Delta Smelt larvae and young juveniles that are large enough (>20-21 mm) to be excluded from entrainment by the NDD screens would be susceptible to impingement and screen contact. There are no quantitative laboratory studies to inform the potential risk to these sizes of fish, in contrast to larger juveniles and adults (> 45 mm; see previous discussion for migrating adults). However, it seems reasonable to assume that the potential injury and mortality effects on these early, more fragile life stages would be greater than for larger Delta Smelt, for which mortality was estimated to be up to ~6% of the small number of fish passing each of the longer intakes (2 and 5) during the night at the highest sweeping velocity.

6.1.3.2.2.4.2 Population-Level Effects

As described in the discussion for NDD entrainment risk, the available egg and larval survey data suggest that a very low proportion of the early life stages would be in the Sacramento River near the NDD (possibly < 0.1%). Therefore, adverse effects from impingement and screen contact would only affect a small proportion of the population, and be unlikely to have population-level effects.

6.1.3.2.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.2.2.5.1 Individual-Level Effects

The analysis presented previously for migrating adult Delta Smelt also included consideration of juvenile sizes of Delta Smelt (> 45 mm) and suggested that mortality could occur for up to ~6% of the fish passing each of the longer intakes (2 and 5) during the night at the highest sweeping velocity.

6.1.3.2.2.5.2 Population-Level Effects

Survey data and the opinions of numerous experts that have sampled the Delta extensively[7] suggest that juvenile Delta Smelt are mostly distributed downstream of the proposed north Delta intakes. During fall (September–December), very few Delta Smelt have been collected at the midwater trawl stations near the proposed intakes, with catches occurring in only 3 years from 1991 to 2010 (Table 6.1-10); these years were critically dry, wet, and below normal water year types. Relatively few Delta Smelt <60 mm FL (fork length) were collected during seining in July–December, and those were mostly collected downstream (Table 6.1-11). Therefore, it is concluded that the population-level effects of impingement at the NDD would usually be near zero (Table 6.1-9).

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[7] These opinions are reflected in the distribution of surveys targeting Delta Smelt, e.g., the Spring Kodiak Trawl survey (see map at http://www.dfg.ca.gov/delta/data/skt/skt_stations.asp).

Table 6.1-10. Number of Delta Smelt Collected and Catch per Trawl during the Fall Midwater Trawl Survey (September–December)

Year	Number of Samples		Total Caught		Proportion (Intake Area/Total)	Mean Catch Per Trawl	
	Intake Area	Downstream Area	Intake Area	Downstream Area		Intake Area	Downstream Area
1991	9	590	0	855	0.00	0.00	1.45
1992	21	685	0	223	0.00	0.00	0.33
1993	18	875	0	1040	0.00	0.00	1.19
1994	24	805	4	438	0.01	0.17	0.54
1995	21	713	0	924	0.00	0.00	1.30
1996	22	719	0	460	0.00	0.00	0.64
1997	18	626	1	345	0.00	0.06	0.55
1998	6	509	0	427	0.00	0.00	0.84
1999	12	532	0	997	0.00	0.00	1.87
2000	13	581	0	1126	0.00	0.00	1.94
2001	21	628	0	702	0.00	0.00	1.12
2002	9	356	0	143	0.00	0.00	0.40
2003	12	359	0	222	0.00	0.00	0.62
2004	12	357	0	170	0.00	0.00	0.48
2005	12	359	0	28	0.00	0.00	0.08
2006	8	351	0	39	0.00	0.00	0.11
2007	12	360	0	27	0.00	0.00	0.08
2008	12	356	0	22	0.00	0.00	0.06
2009	12	382	0	23	0.00	0.00	0.06
2010	12	384	1	49	0.02	0.08	0.13

Source: California Department of Fish and Game unpublished data.

Table 6.1-11. Number of Juvenile Delta Smelt (<60 mm Fork Length) Collected and Catch per Seine during USFWS Beach Seine Sampling in the Action Area (July–December)

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1977	16	21	0	29	0.00	0.00	1.38
1979	20	74	0	19	0.00	0.00	0.26
1980	26	105	0	2	0.00	0.00	0.02
1982	16	40	0	0	.	0.00	0.00
1983	1	1	0	0	.	0.00	0.00
1990	4	4	0	0	.	0.00	0.00
1992	21	43	0	0	.	0.00	0.00
1993	55	117	0	0	.	0.00	0.00
1994	119	246	1	1	0.50	0.01	0.00
1995	319	249	6	0	1.00	0.02	0.00
1996	394	334	0	0	.	0.00	0.00
1997	283	317	0	10	0.00	0.00	0.03
1998	234	385	0	6	0.00	0.00	0.02
1999	215	337	0	3	0.00	0.00	0.01
2000	187	325	0	12	0.00	0.00	0.04
2001	221	454	0	32	0.00	0.00	0.07
2002	206	550	0	2	0.00	0.00	0.00
2003	215	538	0	8	0.00	0.00	0.01
2004	230	530	0	5	0.00	0.00	0.01
2005	238	512	0	2	0.00	0.00	0.00
2006	221	512	0	2	0.00	0.00	0.00
2007	262	521	0	4	0.00	0.00	0.01
2008	240	499	0	0	-	0.00	0.00
2009	245	492	0	0	-	0.00	0.00
2010	242	426	0	0	-	0.00	0.00
2011	238	438	0	0	-	0.00	0.00
2012	95	95	0	0	-	0.00	0.00
Mean	175	313	0	4	0.10	0.00	0.02
5th percentile	7	13	0	0	0.00	0.00	0.00
25th percentile	65	108	0	0	0.00	0.00	0.00
Median	218	336	0	2	0.00	0.00	0.00
75th percentile	240	497	0	5	0.00	0.00	0.01
95th percentile	310	536	1	17	0.65	0.01	0.06

Source: U.S. Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (Speegle pers. comm.).

6.1.3.2.3 Predation at the North Delta Diversions

6.1.3.2.3.1 Migrating Adults (December-March)

6.1.3.2.3.1.1 Individual-Level Effects

Delta Smelt occurring in front of the NDD screens may be susceptible to an elevated risk of predation as they approach and attempt to pass the fish screens because the structures would result in a vertical wall with little cover, other than (possibly) the proposed in-screen refugia and the hydraulic effects of the water diversion described above. It is uncertain to what extent the predation rate in front of the screens will differ from the predation rate that would otherwise occur in this reach without the NDD present because there are no data available to estimate predation rates on Delta Smelt in this reach. A hydroacoustic survey as part of Freeport intake monitoring in 2014 (when diversions were over 130 cfs) found that predator-sized fish (*i.e.*, 12 inches long [305 mm long] and larger) density at the intake was similar or less than the density in upstream and downstream control reaches (ICF International 2015a), although only four surveys were undertaken, so there are few data from which to draw conclusions[8]. As discussed in Section 6.1.1.3, *Water Facilities Construction*, riprap used in association with the intakes could result in increased predator habitat and therefore predation risk. Inclusion of the conservation measure to reduce predation potential may limit predation risk (Section 6.1.4.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities*), but there is uncertainty in the effectiveness of this measure given that the area is open to immigration and emigration of predators and turnover may be appreciable in a relatively short period of time (Cavallo *et al.* 2013).

6.1.3.2.3.1.2 Population-Level Effects

The potential adverse effect to individual migrating adult Delta Smelt from predation at the NDD would be a minimal adverse effect at the population level because, as discussed previously for impingement and screen contact, there generally would be expected to be a very small proportion of the Delta Smelt population near the NDD.

6.1.3.2.3.2 Spawning Adults (February-June)

6.1.3.2.3.2.1 Individual-Level Effects

To the extent that spawning adult Delta Smelt occur near the NDD, similar effects as described above for migrating adults would be expected, *i.e.*, potentially elevated predation. However, individual spawning adults would not be expected to undergo major movements, and therefore would be likely to have limited risk of predation at the NDD.

6.1.3.2.3.2.2 Population-Level Effects

As with migrating adult Delta Smelt, there generally would be expected to be a small proportion of the spawning Delta Smelt population near the NDD, so there would be a minimal adverse effect from predation at the NDD on this life stage.

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[8] NMFS also has been conducting hydroacoustic surveys of predator-sized fish near the Freeport intake; these data were not yet available for inclusion in this effects analysis.

6.1.3.2.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.2.3.3.1 Individual-Level Effects

Following Bennett (2005), it is generally thought that egg/embryo habitat for Delta Smelt consists of shallow sandy areas, which is not the type of habitat that would be found at the NDD. There therefore would be no effects on individual eggs or embryos.

6.1.3.2.3.3.2 Population-Level Effects

Following from the lack of individual-level effects of the NDD in terms of predation, there would therefore be no adverse population-level effect on eggs/embryos.

6.1.3.2.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.2.3.4.1 Individual-Level Effects

To the extent that the NDD provide beneficial habitat for predators of larval and early juvenile Delta Smelt (e.g., silversides; Baerwald *et al.* 2012), there could be an elevated risk of predation for these young life stages. However, it is not clear that the NDD would provide beneficial habitat, as presumably these small predators would be susceptible to the same larger predators that could consume adult Delta Smelt. Therefore, elevated predation on Delta Smelt larvae is unlikely.

6.1.3.2.3.4.2 Population-Level Effects

Even if all of the larvae passing the screens were eaten, the population-level effect would be small, based on the low (potentially < 0.1%) proportion of the population occurring near the NDD; see more detailed discussion in the analysis of the effects of entrainment.

6.1.3.2.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.2.3.5.1 Individual-Level Effects

As with adult Delta Smelt, elevated levels of predation risk could occur to individual juvenile Delta Smelt occurring near the NDD.

6.1.3.2.3.5.2 Population-Level Effects

Even if all of the juvenile Delta Smelt near the NDDs were eaten, the potential for population-level effects of predation on juvenile Delta Smelt near the NDD would be minimal because, as discussed for impingement and screen contact, monitoring data indicate a very small proportion of the population occurs near the NDD.

6.1.3.3 South Delta Exports

6.1.3.3.1 Entrainment

The entrainment of Delta Smelt into the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. See Brown *et al.* (1996) for a description of fish salvage operations from which Delta Smelt entrainment estimates have historically been derived (e.g., Kimmerer 2008). However, the salvage estimates are indices - most entrained fish are not observed (Table 6.1-12), so most of the fish are not salvaged and therefore do not survive. Bennett (2005) suggested that many, if not most, of the Delta Smelt that do reach the fish facilities likely die due to handling stress and predation, however recent studies suggest there may be relatively high survival of adult Delta Smelt during collection, handling, transport, and release when they are salvaged during cool temperature conditions (Morinaka 2013). Pre-screen loss due to predation near and within the CVP and SWP fish facilities, is an additional cause of mortality for Delta Smelt. Pre-screen loss of captive-reared Delta Smelt released into Clifton Court Forebay ranged from about 90% to 100% for adults and nearly 100% for juveniles during a recent study (Castillo *et al.* 2012)[9].

Table 6.1-12. Factors Affecting Delta Smelt Entrainment and Salvage

Factor	Adults	Larvae < 20 mm	Larvae >20 mm and Juveniles	Source
Pre-screen loss (predation prior to encountering fish salvage facilities)	CVP: unquantified; SWP: 89.9–100%	Unquantified	CVP: unquantified; SWP: 99.9%	SWP: Castillo *et al.* (2012)
Fish facility efficiency	CVP: 13%; SWP: 43–89%	~0%	CVP: likely < 13% at all sizes, << 13% below 30 mm (based on adult data); SWP: 24–30%	CVP (Kimmerer 2008; adults only); SWP: Castillo *et al.* (2012)
Collection screens efficiency	~100%	~0%	<100% until at least 30 mm	USFWS (2011a)
Identification protocols	Identified from subsamples, then expanded in salvage estimates	Not identified	Identified from subsamples, then expanded in salvage estimates	USFWS (2011a)
Collection and handling	48-hour experimental mean survival of 93.5% (not statistically different from control) in 2005; 88.3% in 2006 (significantly less than 99.8% of control)	Unquantified	48-hour experimental mean survival of 61.3% in 2005 and 50.9% in 2006 (both significantly less than mean control survival of 82.0–85.9%)	Morinaka (2013)
Trucking and release (excluding post-release predation)	No significant additional mortality beyond collection and handling (above)	Unquantified	No significant additional mortality than collection and handling (above), although mean survival was 37.4% in 2005	Morinaka (2013)

The population-level effects of Delta Smelt entrainment vary; Delta Smelt entrainment can be characterized as a sporadically significant influence on population dynamics. Kimmerer (2008) estimated that annual entrainment of the Delta Smelt population (adults and their progeny combined) ranged from approximately 10 to 60% per year from 2002–2006. Major population

[9] Although relatively high temperatures (for juveniles) and relatively low pumping (for juveniles and adults) could have affected the magnitude of pre-screen loss estimated by Castillo et al. (2012), high pre-screen loss has been estimated for other species such as Chinook salmon (Gingras 1997) and steelhead (Clark et al. 2009).

declines during the early 1980s (Moyle *et al.* 1992) and during the recent POD years (Sommer *et al.* 2007) were both associated with hydrodynamic conditions that greatly increased Delta Smelt entrainment losses as indexed by numbers of fish salvaged. However, currently published analyses of long-term associations between Delta Smelt salvage and subsequent abundance do not support the hypothesis that entrainment is driving population dynamics year in and year out (Bennett 2005; Manly and Chotkowski 2006; Kimmerer 2008; Mac Nally *et al.* 2010; Maunder and Deriso 2011[10]; Miller *et al.* 2012). However, this is an area of scientific debate with some researchers finding that entrainment (or water diversions during the time period when entrainment would be of concern) may affect population dynamics (Rose *et al.* 2013; Thomson *et al.* 2010). The USFWS (2008) and NMFS (2009) BiOps and their RPA actions related to south Delta entrainment have reduced the potential for entrainment loss since 2008–2009.

6.1.3.3.1.1 Migrating Adults (December–March)

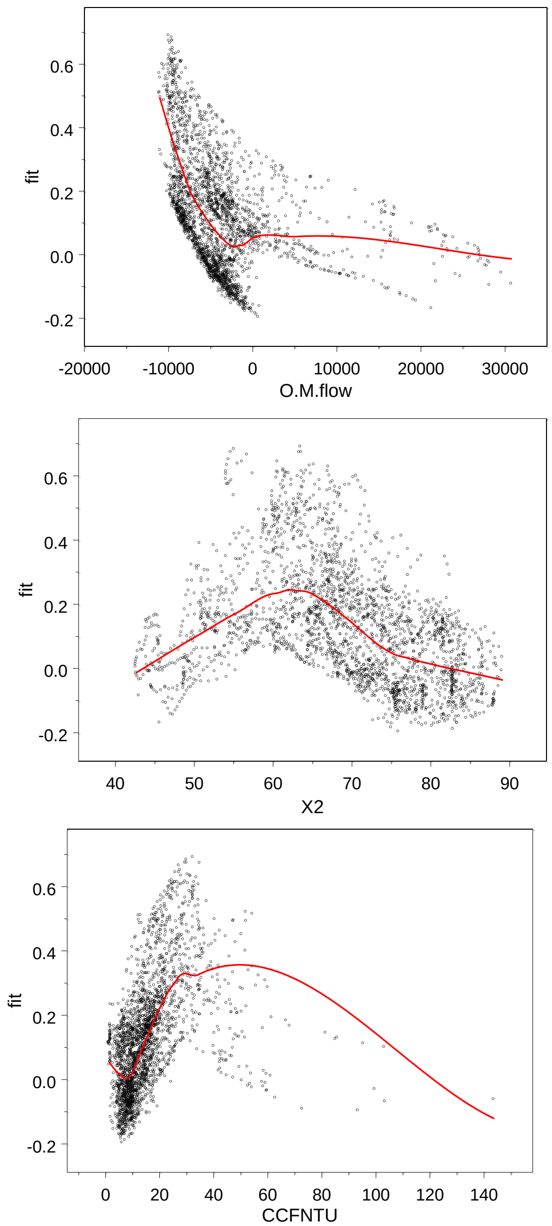
6.1.3.3.1.1.1 Individual-Level Effects

Adult Delta Smelt are entrained into the south Delta export facilities during spawning migrations (Grimaldo *et al.* 2009; Sommer *et al.* 2011). Their spawning migrations occur during the winter when precipitation increases the freshwater flow and turbidity in the Delta. Salvage of adult Delta Smelt at the south Delta export facilities is an index of entrainment, albeit a very rough index (IEP MAST Team 2015: 59). Salvage of adults has mainly occurred from late December through March (Kimmerer 2008; Grimaldo *et al.* 2009). For migrating adults, the risk of entrainment is influenced by flow cues and turbidity in the south Delta (Grimaldo *et al.* 2009). Old and Middle Rivers are distributary channels of the San Joaquin River. Project pumping (*i.e.*, the export of water from the Delta) can cause the tidally filtered or “net” flows in these channels to move “upstream”. This occurs because water removed by Banks and Jones, along with other diversions in the area, is back-filled by tidal and river flows. This phenomenon is mathematically depicted as negative flow. Negative Old and Middle River (OMR) flows and greater turbidity are often associated with adult Delta Smelt entrainment, but no particular OMR flow assures entrainment will or will not occur. The net OMR flows indicate how strongly the tidally averaged flows in these channels are moving toward Banks and Jones pumping plants. Thus, it is possible the net flows themselves are the mechanism that increases entrainment risk for Delta Smelt. However, high exports can also lead to strong tidal asymmetry in Old and Middle Rivers where flood tides toward the pumps become much stronger than the ebb tides away from the pumps (U.S. Fish and Wildlife Service 2011a), so altered tidal flows are a second, covarying mechanism that could increase Delta Smelt’s risk of entrainment.

The empirical shape of the associations between estuarine salinity distribution (X2), OMR, turbidity and adult Delta Smelt salvage normalized by the FMWT is shown in Figure 6.1-4. Normalized Delta Smelt salvage is correlated in a nonlinear way with X2. An interpretation of this is that the intermediate river flow or X2 conditions are associated with the highest salvage because flows are high enough to disperse turbidity around the Delta, but not so high that most Delta Smelt are distributed seaward of the Delta. Figure 6.1-4 shows that even when X2 and

[10] The automated statistical procedure that Maunder and Deriso (2011) developed to choose a “best” life cycle model based on their input data determined that a model with strong density-dependence between generations and a very strong influence of adult entrainment was the best-fitting statistical model. However, the authors determined that the density-dependence was too strong and the parameter estimate for the entrainment effect was too high to be plausible, so they determined the second best-fitting model was the most believable LCM. This second best-fitting model did not retain entrainment as an important predictor of Delta Smelt population dynamics.

south Delta turbidity are accounted for, there is no OMR flow that assures Delta Smelt entrainment will or will not occur. The predicted relationship is a smooth, accelerating function with increasing normalized salvage as OMR flow becomes more negative (Figure 6.1-4).



Note: The scatter in each panel is caused by the interacting effects of the other two variables.

Figure 6.1-4. Empirical Trends in Predictions of Adult Delta Smelt Salvage (y-axis) During December–March, 1993–2013, as a Function of Old and Middle River Flow (O.M. flow, cfs), X2 (km from Golden Gate Bridge), and Turbidity at Clifton Court Forebay (CCFNTU, NTU)

The association of adult Delta Smelt with turbid water (see Figure 42 of U.S. Fish and Wildlife Service 2011a) can lead to greater entrainment by the south Delta export facilities when turbid conditions occur in the regions that are under the hydraulic influence of the export facilities

(Grimaldo *et al.* 2009). Recognition of the combined importance of OMR flow and turbidity is provided in the USFWS proposal to set incidental take of Delta Smelt as a function of OMR flow and turbidity, given a population abundance estimate.[11]

Under the PA, OMR flows would be less negative than under the NAA during the months of concern for adult Delta Smelt (Figure 6.1-5, **Figure 6.1-6**, Figure 6.1-7, Figure 6.1-8; see Table 5.A.6-25 and Figures 5.A.6-25-1 to 5.A.6-25-19 in Appendix 5.A, *CALSIM Methods and Results*). As described in Chapter 3, Section 3.3.2.2, *Operational Criteria for South Delta CVP/SWP Export Facilities*, the OMR flow requirements would be those of USFWS (2008) and NMFS (2009) until completion of the NDD, after which the newly proposed criteria would generally improve OMR flows more in wetter years under the PA compared to the existing BiOps; provided, as discussed in Chapter 3, that the research and results of the Collaborative Science and Adaptive Management program show these criteria are required to avoid jeopardy of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat for those species. Real-time management of entrainment risk would also occur (if needed), in a manner similar to the existing Smelt Working Group process. It therefore would be expected that individual Delta Smelt would be less susceptible to entrainment under the PA than the NAA. This is analyzed at the population level in the next section.

[11] The proposal is available at http://deltacouncil.ca.gov/sites/default/files/2015/10/Item%201%20USFWS%20reports%20-%20Past,%20Present%20and%20Future%20Approaches%20to%20Incidental%20Take.pdf (accessed October 24, 2015) and is one of the subjects of the 2015 Long-term Operations Biological Opinions Annual Science Review.

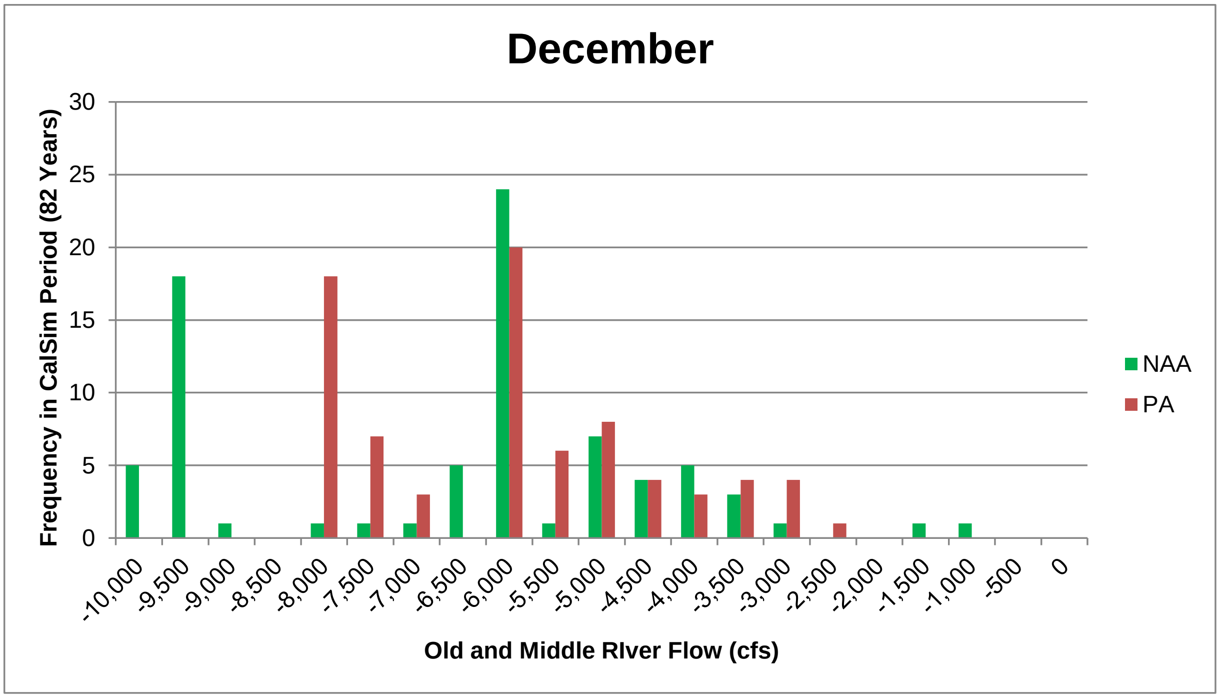


Figure 6.1-5. Frequency of December Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

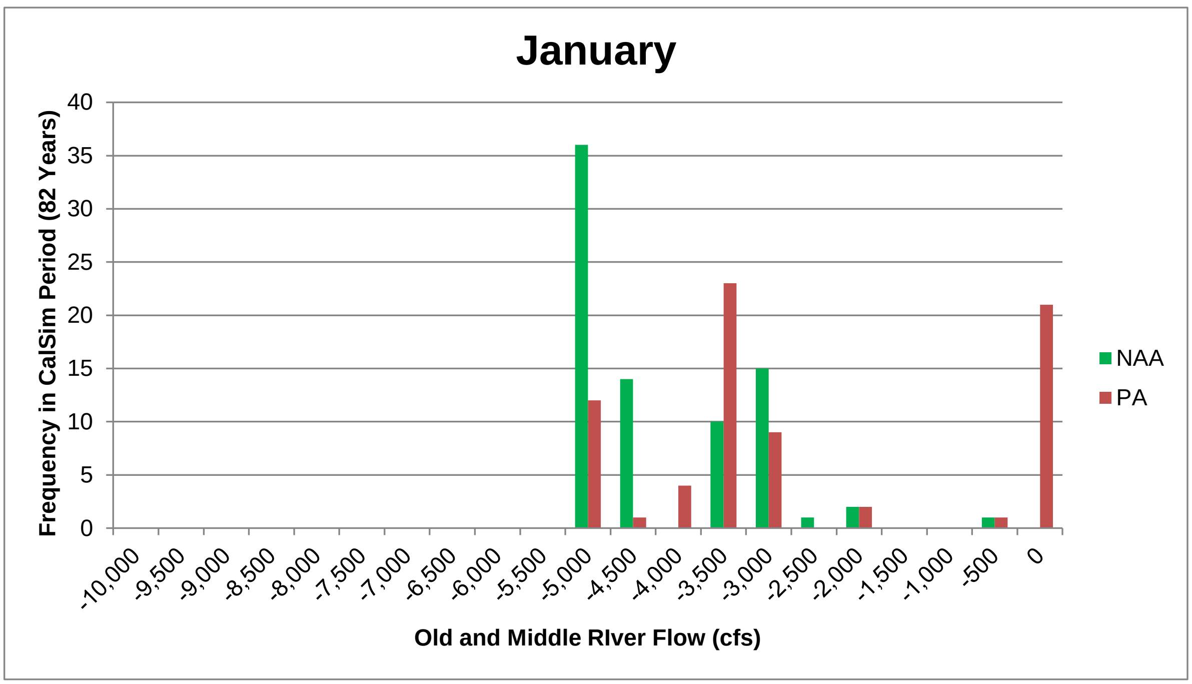


Figure 6.1-6. Frequency of December Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

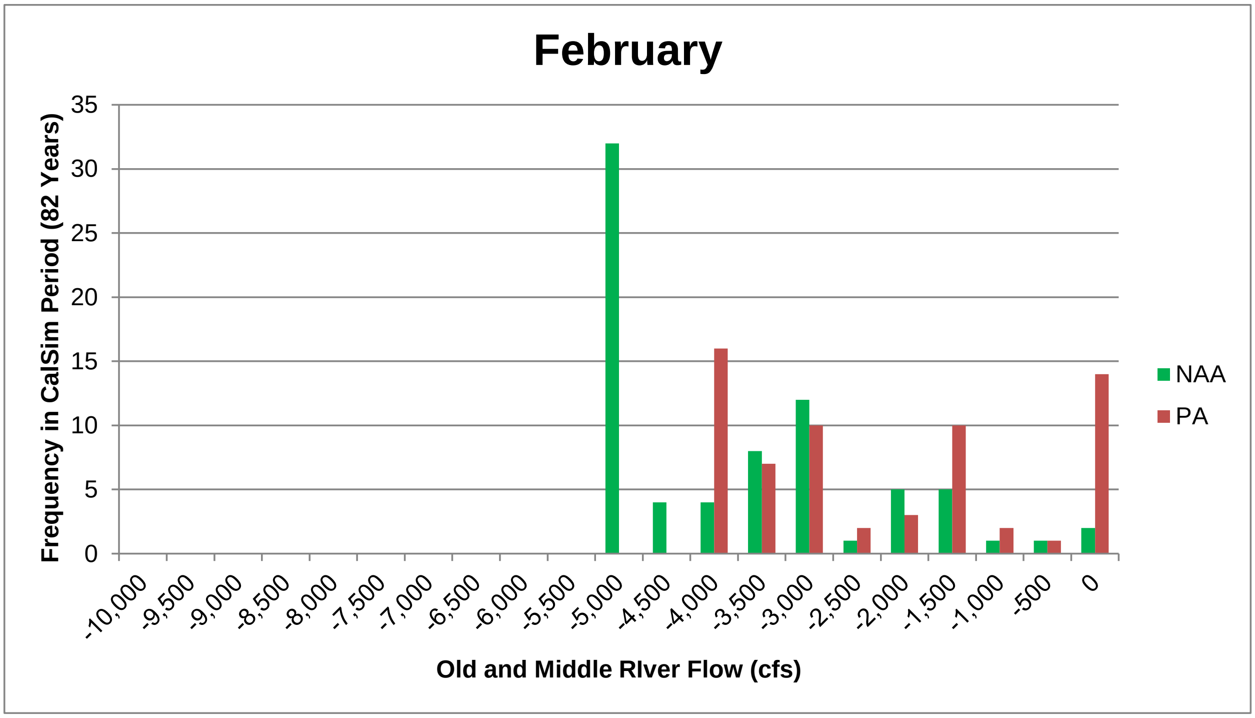


Figure 6.1-7. Frequency of February Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

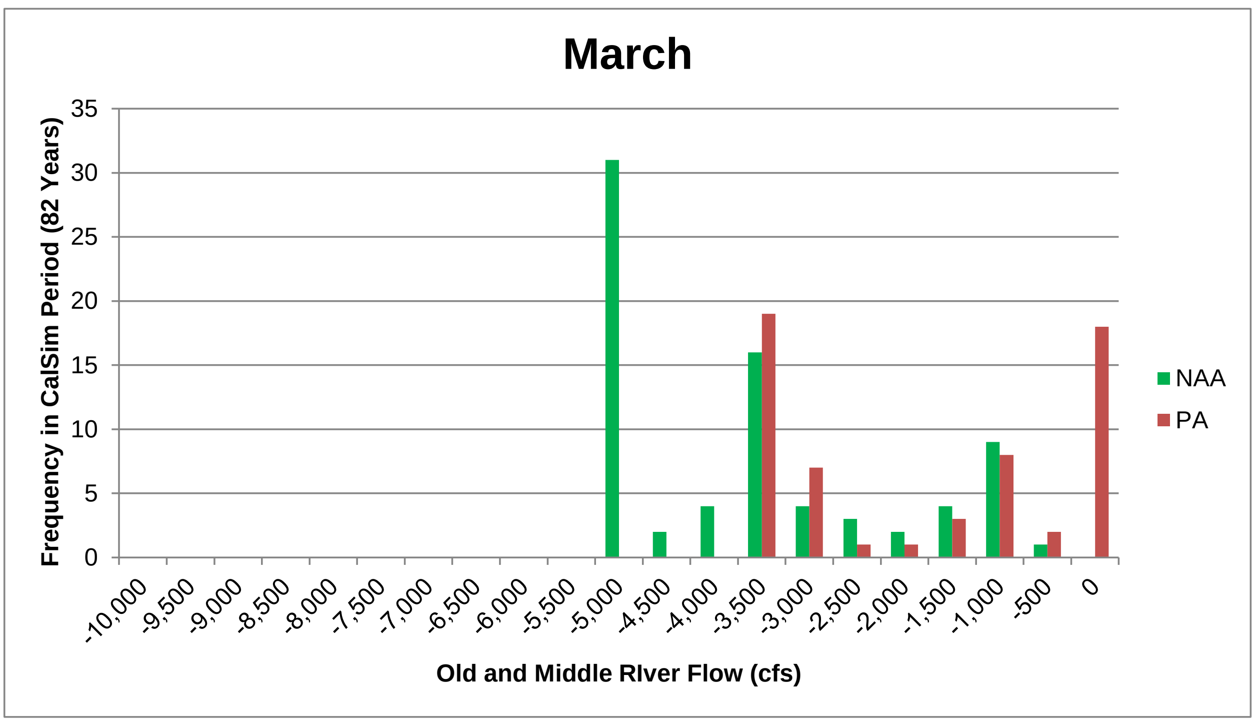


Figure 6.1-8. Frequency of March Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

6.1.3.3.1.1.2 Population-Level Effects

No tools are currently available with which to model adult entrainment risk at the south Delta export facilities in relation to future operations as well as it can be hindcast (*i.e.*, estimates of historical proportional loss as a function of historical OMR flows, for example), because of the difficulty in forecasting turbidity and abundance. For this effects analysis, the proportional entrainment of adult Delta Smelt was estimated using OMR flow predictions derived from CalSim II model outputs (U.S. Fish and Wildlife Service 2008; Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.1). As noted in Appendix 6.A, although much of the variability in proportional loss is left unexplained by this regression equation and the confidence intervals on the original estimates are relatively wide in some cases, the predictions in the models do follow the expected trend that salvage and population losses will decrease in response to the proposed action.

The analysis indicates that proportional entrainment loss of adult Delta Smelt would be lower under the PA than NAA, with variable differences when the results are summarized by water year type (Table 6.1-13; Figure 6.1-9). In drier years, the need to maintain suitable bypass flows in the Sacramento River and to maintain D-1641 compliant Delta outflows limits the use of the NDD. The result is predictions that there will be little difference between the NAA and PA in south Delta exports and entrainment loss of adult Delta Smelt. The USFWS (2008) and NMFS (2009) BiOps and their RPA actions related to south Delta entrainment have considerably reduced the potential for entrainment loss since 2008–2009. Therefore, even in drier water years, the predicted entrainment of adult Delta Smelt is considerably lower than what sometimes occurred historically. The overall conclusion is that the adverse effect of adult Delta Smelt entrainment in the south Delta would be appreciably lessened under the PA.

Less entrainment risk to migrating adults may result in a greater proportion of adults successfully spawning in the lower San Joaquin River. Spring Kodiak trawling in the lower San Joaquin River suggests frequent occurrence of spawning adults in this area (~10% of samples from 2002–2009 [Merz *et al.* 2011]; ~22% of samples during intensive sampling during extreme drought conditions in 2014 [Polansky *et al.* 2014]), which may imply a modest beneficial population-level effect. Recognition of the need to manage entrainment risk as a function of both OMR flows and south Delta turbidity is likely to guide management under both the NAA and PA, as illustrated by the previously mentioned USFWS proposal for the 2016 incidental take limit calculation.

Table 6.1-13. Mean Estimated Annual Proportional Entrainment Loss of Adult Delta Smelt at CVP/SWP South Delta Export Facilities by Water-Year Type for the No Action Alternative (NAA) and Proposed Action (PA), Based on the USFWS (2008) Proportional Entrainment Regression

Water Year Type	NAA	PA	PA vs. NAA[1]
All	0.08	0.06	-0.02 (-20%)
Wet	0.07	0.04	-0.03 (-40%)
Above Normal	0.08	0.06	-0.02 (-25%)
Below Normal	0.08	0.07	-0.01 (-15%)
Dry	0.08	0.07	-0.01 (-8%)
Critical	0.07	0.07	0.00 (-3%)

Note:
[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

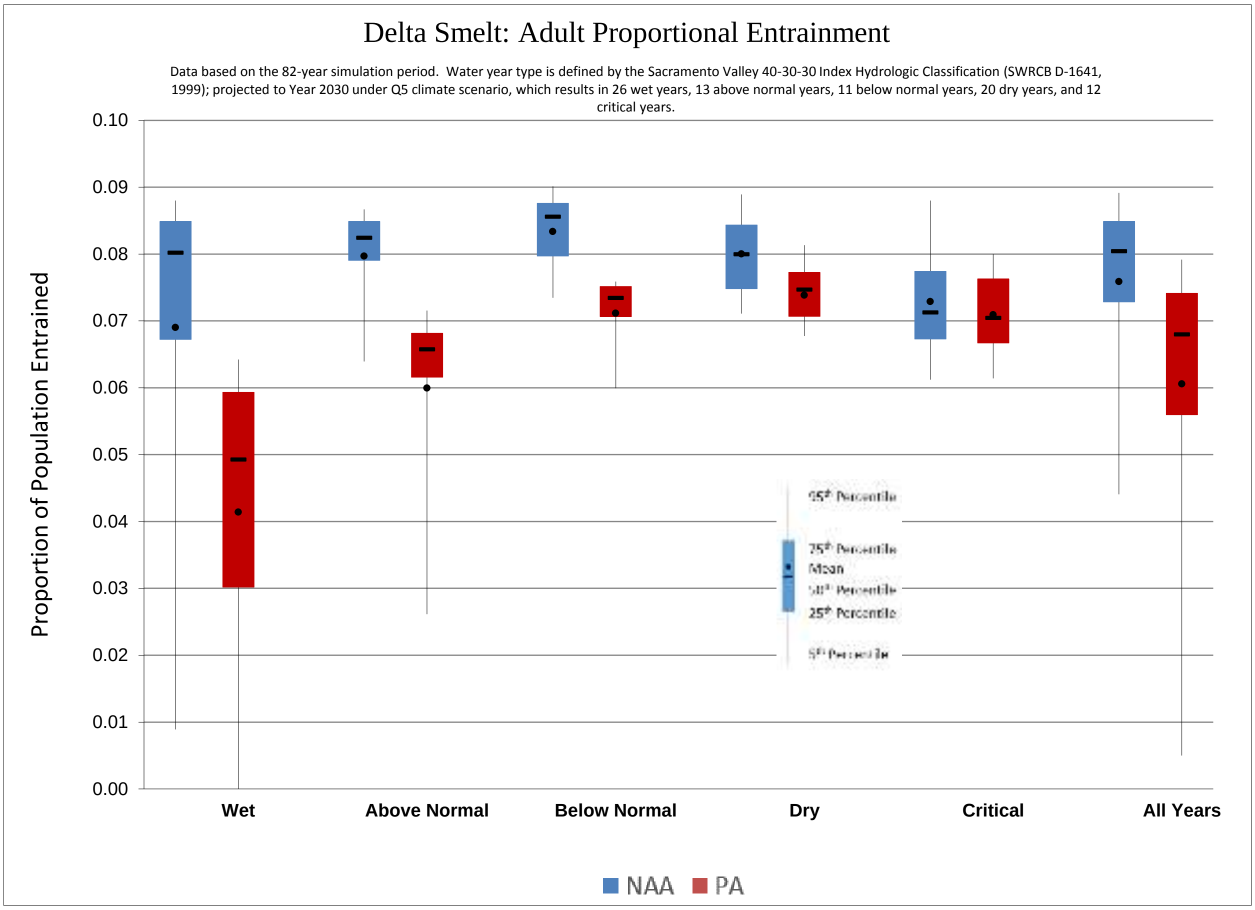


Figure 6.1-9. Box Plots of Adult Delta Smelt Proportional Entrainment from the Regression of USFWS (2008), Grouped by Water Year Type

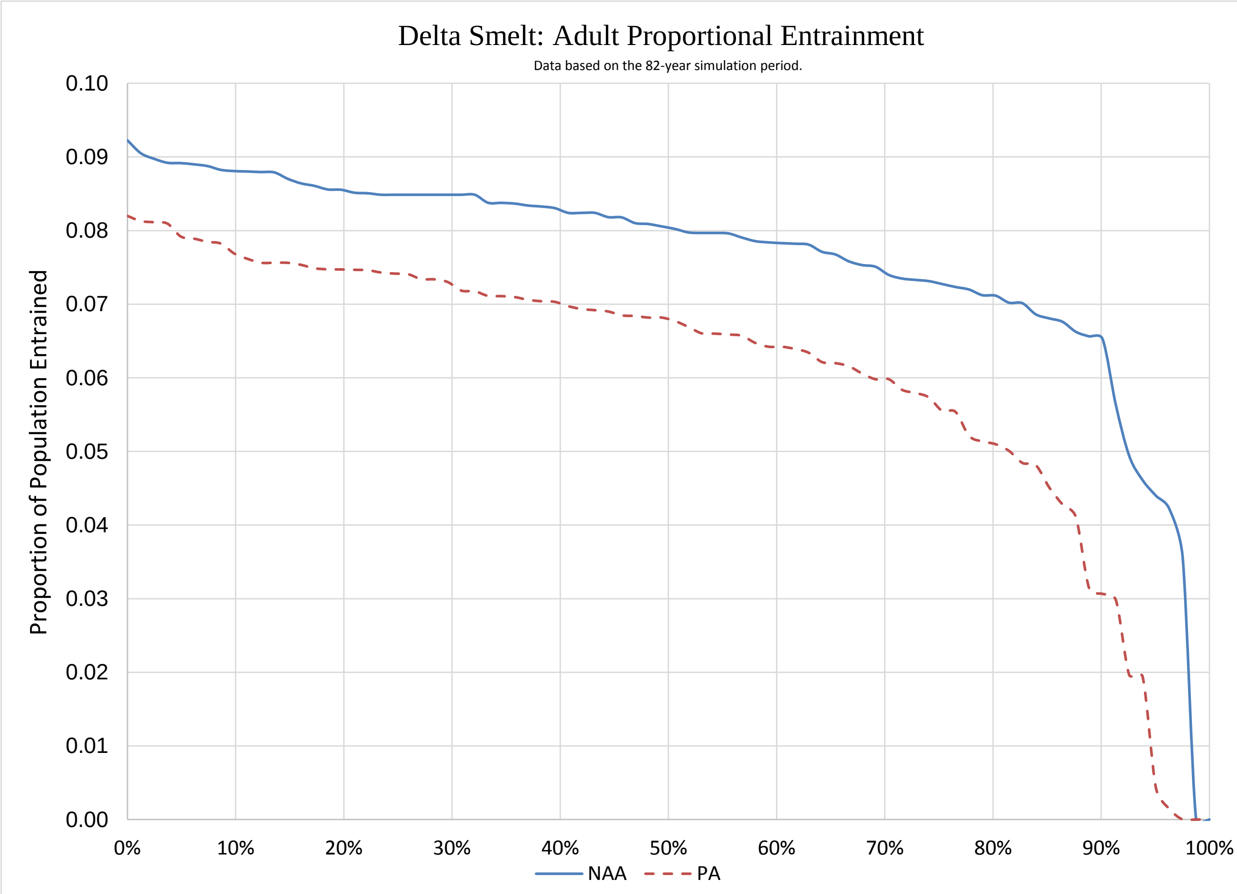


Figure 6.1-10. Exceedance Plot of Adult Delta Smelt Proportional Entrainment from the Regression of USFWS (2008)

6.1.3.3.1.2 Spawning Adults (February-June)

6.1.3.3.1.2.1 Individual-Level Effects

After completion of the migration to spawning areas, spawning adults presumably hold in a similar location prior to, during, and after spawning (possibly to spawn more than once). Therefore, there may not be appreciable risk of entrainment at the south Delta export facilities once the adults begin staging. The primary risk to adults occurs during the spawning migration, as described previously, but the persistently less negative OMR flows predicted for the PA suggest that entrainment risk will be reduced throughout the spawning season regardless of nuances about adult behavior and movements.

6.1.3.3.1.2.2 Population-Level Effects

Under the assumption that spawning adults are not undergoing broad-scale migrations, there would not be an adverse population-level effect of entrainment from south Delta exports to this life stage, but the persistently less negative OMR flows predicted for the PA suggest that proportional entrainment will be reduced and kept very similar to current conditions throughout the spawning season regardless of nuances about adult behavior and movements. As previously discussed, less entrainment risk for migrating adult Delta Smelt may increase the availability of lower San Joaquin River spawning habitat.

6.1.3.3.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.3.1.3.1 Individual-Level Effects

As noted for entrainment and impingement at the NDD, Delta Smelt eggs and embryos are demersal and adhesive, and so would not be subject to entrainment at the south Delta export facilities.

6.1.3.3.1.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from south Delta exports with respect to entrainment.

6.1.3.3.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.3.1.4.1 Individual-Level Effects

Most age–0 Delta Smelt entrainment at the south Delta export facilities occurs during the true larval stage and is not observed and counted (Kimmerer 2008). The salvage of age-0 Delta Smelt reflects the tail end of the entrainment of age–0 cohorts that started before the fish were large enough to be observed in the fish salvage facilities. Delta smelt are not counted in fish salvage until they reach a minimum length of 20 mm. Kimmerer (2008) showed that Delta Smelt salvage was inefficient until the fish were 30 mm long (by which time they are morphologically juveniles; Mager *et al.* 2004). Delta Smelt typically reach 20-30 mm in May and June. Thus, April is likely to be the month of highest south Delta entrainment of age-0 Delta Smelt, while May-June are the months of highest salvage (Kimmerer 2008).

USFWS (2008) translated Kimmerer's (2008) data-intensive age-0 Delta Smelt entrainment estimates into multiple linear regression equations using multi-month averages of X2 and OMR flow as predictor variables. The regressions were a quantitative representation of the following conceptual model: (1) the geographic distribution of much of the population is strongly associated with Delta outflow (or its surrogate, X2; Dege and Brown 2004). Thus, Delta outflow may influence the proportion of the age-0 Delta Smelt population that rears in the Delta during the spring and early summer where it is potentially vulnerable to entrainment, and (2) OMR reflects the hydrodynamic influence of the water projects' diversions on the southern half of the Delta and thus the degree of entrainment risk for fishes in that region (Kimmerer 2008; Grimaldo *et al.* 2009). Long-term declines in April–May exports and E:I ratio, and April–June X2 (all results of State Board Decision 1641) may all have contributed to reduced entrainment risk of age-0 Delta Smelt; implementation of the RPAs from USFWS (2008) and NMFS (2009) has likely further reduced entrainment since 2008-2009, as a result of restrictions on export pumping that are made in consideration of environmental conditions that result in listed fishes being susceptible to entrainment (e.g., greater south Delta turbidity for Delta Smelt). In addition, entrainment risk may be continuing to decline due to a general shift in Delta Smelt spawning distribution toward the north Delta (Kimmerer 2011; Miller 2011).

Under the PA, individual larval/juvenile Delta Smelt would be susceptible to entrainment at the south Delta export facilities. The analysis presented below focuses on the population-level effect, by examining the proportion of the population that could be entrained under PA and NAA.

6.1.3.3.1.4.2 Population-Level Effects

For this effects analysis, two approaches were used to estimate entrainment effects on larval/young juvenile Delta Smelt. First, proportional entrainment loss regression equations from the USFWS (2008) were used to estimate differences in potential larval/juvenile Delta Smelt entrainment at the south Delta export facilities given the basic operations simulated in CalSim II (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.1.2). These regressions used two averaging periods: March–June and April–May. The analyses indicate that the proportional entrainment of larval/juvenile Delta Smelt would tend to be very similar under the PA and the NAA (Table 6.1-14; Table 6.1-15; Figure 6.1-11; and Figure 6.1-12).

Table 6.1-14. Mean Annual Proportional Entrainment Loss of Larval and Juvenile Delta Smelt at CVP/SWP South Delta Export Facilities by Water-Year Type for the No Action Alternative (NAA) and Proposed Action (PA), Based on the USFWS (2008) Proportional Entrainment Regression Using Mean March-June Old and Middle River Flows and X2.

Water Year Type	NAA	PA	PA vs. NAA[1]
All	0.12	0.11	-0.01 (-10%)
Wet	0.04	0.02	-0.02 (-43%)
Above Normal	0.08	0.05	-0.03 (-40%)
Below Normal	0.16	0.15	-0.01 (-4%)
Dry	0.16	0.16	0.00 (-1%)
Critical	0.22	0.22	0.00 (1%)

Note:
[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

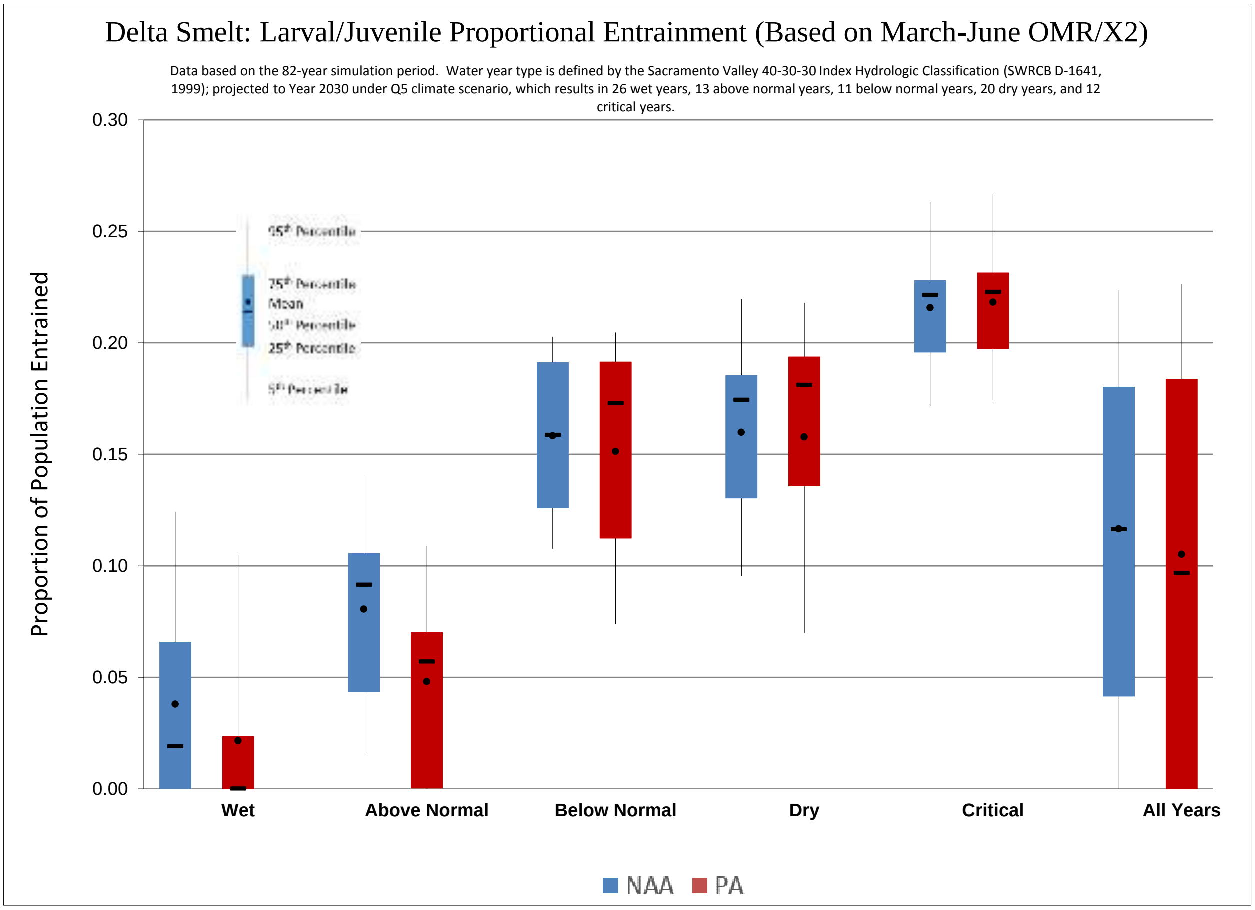


Figure 6.1-11. Box Plots of Larval/Juvenile Delta Smelt Proportional Entrainment from the Regression of USFWS (2008), Grouped by Water Year Type, Based on Mean March-June Old and Middle River Flows and X2

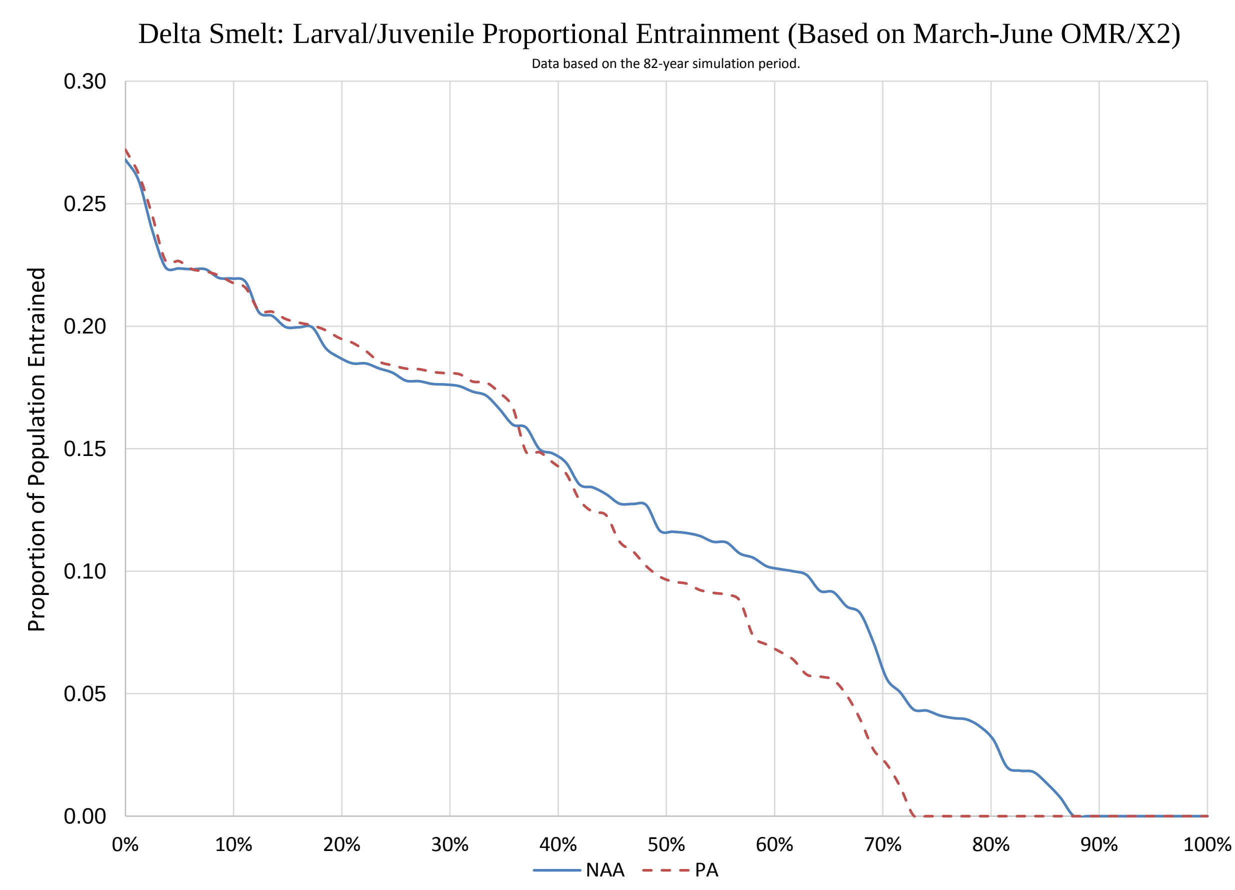


Figure 6.1-12. Exceedance Plot of Larval/Juvenile Delta Smelt Proportional Entrainment from the Regression of USFWS (2008), Based on Mean March-June Old and Middle River Flows and X2

Table 6.1-15. Mean Annual Proportional Entrainment Loss of Larval and Juvenile Delta Smelt at CVP/SWP South Delta Export Facilities by Water-Year Type for the No Action Alternative (NAA) and Proposed Action (PA), Based on the USFWS (2008) Proportional Entrainment Regression Using Mean April-May Old and Middle River Flows and X2.

Water Year Type	NAA	PA	PA vs. NAA[1]
All	0.09	0.09	0.00 (3%)
Wet	0.01	0.01	0.00 (2%)
Above Normal	0.04	0.03	0.00 (-11%)
Below Normal	0.12	0.13	0.01 (7%)
Dry	0.14	0.14	0.00 (2%)
Critical	0.21	0.22	0.01 (3%)

Note:
[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

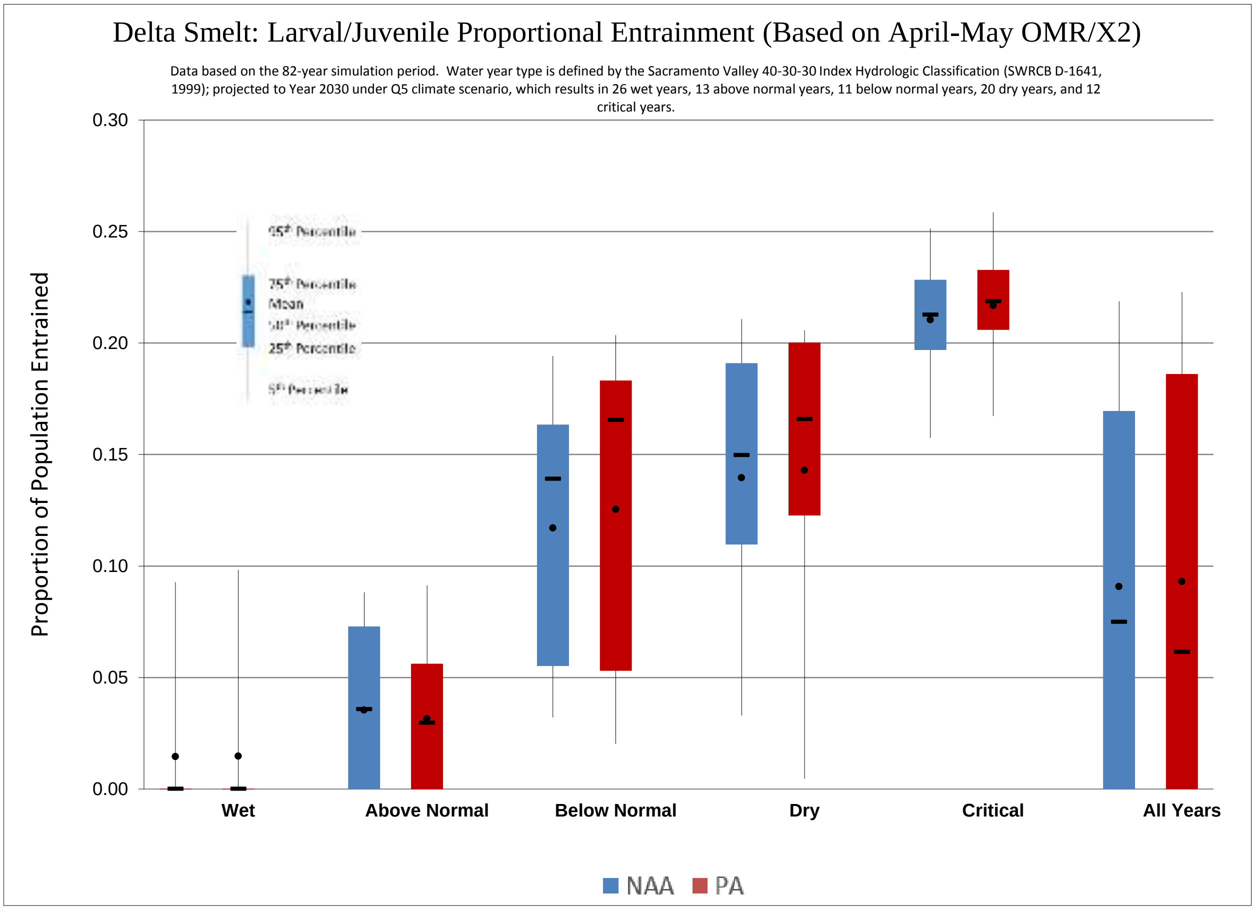
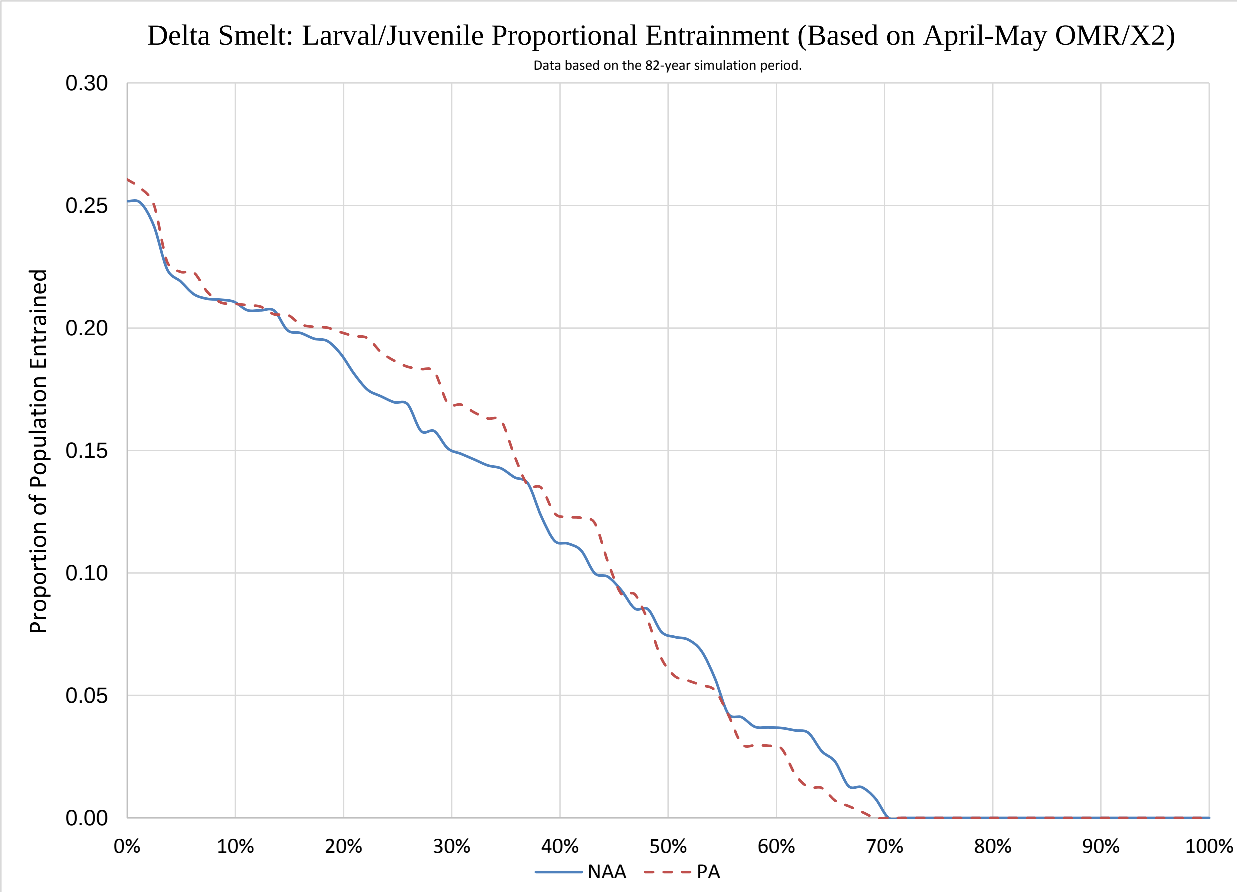


Figure 6.1-13. Box Plots of Larval/Juvenile Delta Smelt Proportional Entrainment from the Regression of USFWS (2008), Grouped by Water Year Type, Based on Mean April-May Old and Middle River Flows and X2



Note: x-axis indicates the percentage of years that the entrainment estimate would be expected to be exceeded.

Figure 6.1-14. Exceedance Plot of Larval/Juvenile Delta Smelt Proportional Entrainment from the Regression of USFWS (2008), Based on Mean April-May Old and Middle River Flows and X2

The second approach used to estimate larval/juvenile entrainment was based on DSM2-PTM. Note that this alternative method is not expected to produce results that are dramatically different than the method used by USFWS (2008) because survey-based and PTM based estimates are generally correlated (Kimmerer 2008). However, the PTM based approach is a more spatially explicit way to estimate population-level entrainment loss because it accounts for particle fates throughout the Delta and considered losses not only at the south Delta export facilities, but also at the NDD and the North Bay Aqueduct (NBA).The previously described analyses of proportional entrainment at the south Delta export facilities and the NDD are limited in that they cannot be compared directly, for the calculations are not made with the same analytical tool. The PTM analysis summarized below addresses this shortcoming, and also allows assessment of the potential entrainment at the NDD and NBA. The method is described in detail in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.2, and essentially involved the following steps:

- Use the historical 20-mm Survey(1995–2011) data to apply a post-processed weighting to DSM2-PTM particle release locations in order to represent assumed hatching distributions of larval Delta Smelt;

- Match the Delta outflows that occurred for the 20-mm Survey months from which the hatching distributions were derived to the closest Delta outflow for each month simulated in DSM2-PTM (March–June, 1922–2003);

- Calculate the percentage entrainment at the CVP/SWP south Delta export facilities, NDD, and NBA, while accounting for the percentage of the population that was not within the Delta (and therefore not vulnerable to entrainment in the SWP or CVP's diversions located in the Delta).

As described in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.2, it should be noted that there are two important limitations to this PTM-based analysis. First, a number of 20-mm Survey stations in the Cache Slough area were only sampled in the later years of the survey, and were not included when calculating the particle starting distributions. If NBA pumping is the same in the NAA and PA, then this could affect the absolute value of the entrainment predictions, but not their relative differences. Second, there are no 20-mm Survey stations above the NDD, so the NDD received the same weighting of particles as other stations in the north Delta: from the 1995-2011 20-mm Survey data, the mean percentage at each of these stations was 2.7% (range 0% to nearly 10%).

The percentage of Delta Smelt larvae assumed to occur downstream of the Delta decreased as water years became drier (Table 6.1-16), in keeping with the expectation that entrainment risk generally would be greater in drier years, when the population tends to be distributed further upstream. This is consistent with the influence of X2 on the regression methods described above. The results of the entrainment analysis suggested that, accounting for the four main SWP and CVP entrainment locations in the Delta, there would be less entrainment under the PA than NAA, averaged over the March-June period, in wetter years, whereas in drier years, there would be little to no difference between PA and NAA. However, there were important differences by month (Table 6.1-16; Figure 6.1-15, Figure 6.1-16, Figure 6.1-17, Figure 6.1-18, Figure 6.1-19, Figure 6.1-20, Figure 6.1-21, Figure 6.1-22). Total entrainment was driven by trends in south Delta entrainment, which, when examined month by month, suggested that under the PA there may be some increases in CVP entrainment (particularly in April/May) but generally greater decreases in SWP entrainment (except in April). The overall pattern of entrainment at the south Delta export facilities combined in terms of differences between PA and NAA across water year types matches the general pattern observed in the USFWS proportional entrainment regression analysis for March–June (Table 6.1-17) and April–May (Table 6.1-18). The relatively greater entrainment under PA suggested by the DSM2-PTM analysis in drier years in large part reflects not only slightly less (more negative) OMR flows because of the HOR gate (as well as modeling assumption differences related to the San Luis rule curve), but also that there has historically been a higher proportion of larvae in the central and south Delta in drier years (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Table 6.A-5). There is very little difference in Delta outflow between NAA and PA in April and May (Table 5.A.6-26 in Appendix 5.A, *CALSIM Methods and Results*), which means that the influences of the NAA and PA on larval distribution would be expected to be broadly similar.

The percentage of particles entrained at the NDD under the PA always averaged well below 1% (Table 6.1-16); this percentage would be greater if it was assumed that a greater percentage of Delta Smelt larvae originate upstream of the NDD, or lower if it was assumed that a lower percentage originated upstream of the NDD. As described in Section 6.1.3.2.1.4.2, extrapolation of catch density in the egg and larval survey suggested that a small proportion (perhaps ~0.25%) of the larval Delta Smelt population might occur in the NDD reach. In addition, further perspective on the proportion of the Delta Smelt population that could occur near the NDD was provided by the DSM2-PTM analysis incorporating simplified model behavior to mimic hypothesized migration strategies (*i.e.* "tidal surfing") suggests that the fraction of Delta Smelt expected to migrate past the NDDs is ~ 0.000 (see Section 6.1.3.2.2.1.2). Thus, it is possible that the fraction of Delta Smelt larvae assumed in this analysis to originate upstream of the NDDs could be too high. Adjusting the weighting percentage of particles representing Delta Smelt larvae that were inserted in the Sacramento River at Sacramento downward[12] to reflect lower occurrence than the other locations in the Cache Slough and North Delta area (see Table 6.A-5 in Appendix 6.A) gave considerably lower entrainment at the NDD under PA (water-year-type means of 0.00-0.01% in March-May, and 0.03-0.05% in June) than with the unadjusted original values, but only slightly less of a relative difference between NAA and PA in total entrainment: for example, in April, the mean total entrainment was 18% greater under PA in wet years (compared to 22% without the adjustment), 1% greater under PA in above normal years (compared to 2% without the adjustment), 35% greater under PA in above normal years (compared to 37% without the adjustment), 22% greater under PA in dry years (compared to 22% without the adjustment), and 13% greater under PA in above normal years (compared to 14% without the adjustment).

For the DSM2-PTM analysis described here for larval/juvenile Delta Smelt, there was little difference in entrainment at the NBA, reflecting similar operations under the PA and NAA (Table 6.1-16).

The results of the DSM2-PTM modeling do not incorporate real-time management that would occur under both the NAA and PA, incorporating the latest information gained from the results of coordinated monitoring and research under the Collaborative Science and Adaptive Management Program about fish distribution and other factors that would affect entrainment risk. Therefore, it may be possible to manage exports and HOR gate operations more carefully to avoid increasing entrainment. Additional discussion of HOR gate effects is provided in Section 6.1.3.4, *Head of Old River Gate Operations.*

[12] Specifically, the values were adjusted to be the minimum of 0.1 of the previous unadjusted value, or 0.25%; the percentages at the other locations in the Cache Slough and North Delta area were increased to give the same total percentage for the area as in the original, unadjusted analysis.

Table 6.1-16. Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, from DSM2 Particle Tracking Modeling.

Month	Water Year Type[1]	% Downstream of Delta	Clifton Court Forebay (State Water Project)			Jones Pumping Plant (Central Valley Project)			North Delta Diversion			North Bay Aqueduct Barker Slough Pumping Plant			Total Entrainment		
			NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]
March-June Monthly Mean	W	43.92	3.03	1.41	-1.62 (-53%)	2.06	1.07	-0.99 (-48%)	0.00	0.18	0.18	1.18	1.18	0.00 (0%)	6.27	3.85	-2.43 (-39%)
	AN	28.39	5.16	2.47	-2.70 (-52%)	3.77	2.49	-1.29 (-34%)	0.00	0.19	0.19	1.27	1.28	0.01 (1%)	10.21	6.42	-3.79 (-37%)
	BN	14.13	5.72	4.36	-1.35 (-24%)	4.04	4.36	0.32 (8%)	0.00	0.18	0.18	2.20	2.22	0.02 (1%)	11.96	11.12	-0.83 (-7%)
	D	13.77	7.37	5.51	-1.87 (-25%)	4.54	5.47	0.92 (20%)	0.00	0.19	0.19	1.71	1.72	0.02 (1%)	13.63	12.88	-0.74 (-5%)
	C	5.97	3.85	2.84	-1.01 (-26%)	3.20	4.22	1.02 (32%)	0.00	0.08	0.08	1.22	1.32	0.10 (8%)	8.27	8.46	0.18 (2%)
March	W	54.69	3.24	0.92	-2.32 (-72%)	1.68	0.28	-1.40 (-84%)	0.00	0.29	0.29	1.19	1.20	0.01 (1%)	6.11	2.68	-3.43 (-56%)
	AN	57.96	5.78	1.28	-4.50 (-78%)	3.38	0.77	-2.61 (-77%)	0.00	0.04	0.04	0.16	0.16	0.00 (2%)	9.32	2.25	-7.07 (-76%)
	BN	31.80	9.74	6.83	-2.91 (-30%)	5.48	5.67	0.19 (4%)	0.00	0.28	0.28	2.62	2.63	0.01 (0%)	17.84	15.41	-2.43 (-14%)
	D	23.27	9.61	8.20	-1.40 (-15%)	6.78	7.64	0.85 (13%)	0.00	0.34	0.34	1.36	1.30	-0.05 (-4%)	17.75	17.48	-0.27 (-2%)
	C	13.31	5.65	3.90	-1.75 (-31%)	3.62	5.01	1.40 (39%)	0.00	0.13	0.13	1.01	1.39	0.39 (39%)	10.27	10.44	0.17 (2%)
April	W	54.11	0.63	0.78	0.15 (25%)	0.18	0.40	0.22 (126%)	0.00	0.05	0.05	1.17	1.17	0.00 (0%)	1.98	2.40	0.43 (22%)
	AN	36.60	1.88	1.74	-0.14 (-7%)	0.54	0.70	0.16 (29%)	0.00	0.06	0.06	0.98	0.98	0.00 (0%)	3.39	3.47	0.08 (2%)
	BN	12.20	2.03	2.47	0.44 (22%)	0.55	1.64	1.09 (199%)	0.00	0.05	0.05	1.84	1.91	0.07 (4%)	4.41	6.07	1.65 (37%)
	D	22.43	4.38	4.29	-0.09 (-2%)	2.16	3.92	1.76 (81%)	0.00	0.02	0.02	1.38	1.47	0.08 (6%)	7.93	9.70	1.77 (22%)
	C	6.21	2.72	2.54	-0.18 (-7%)	2.27	3.23	0.96 (43%)	0.00	0.03	0.03	0.87	0.87	0.00 (0%)	5.85	6.66	0.81 (14%)
May	W	43.42	0.87	0.45	-0.42 (-48%)	0.27	0.21	-0.06 (-21%)	0.00	0.05	0.05	1.17	1.17	0.00 (0%)	2.31	1.88	-0.42 (-18%)
	AN	16.96	2.30	1.08	-1.22 (-53%)	0.72	0.73	0.02 (2%)	0.00	0.18	0.18	2.36	2.37	0.01 (0%)	5.38	4.36	-1.02 (-19%)
	BN	10.43	2.66	1.91	-0.76 (-28%)	0.70	1.85	1.15 (164%)	0.00	0.06	0.06	2.74	2.74	0.00 (0%)	6.10	6.56	0.45 (7%)
	D	8.14	5.13	3.64	-1.50 (-29%)	1.93	3.29	1.36 (71%)	0.00	0.07	0.07	2.41	2.44	0.03 (1%)	9.47	9.43	-0.04 (0%)
	C	2.06	4.25	3.29	-0.97 (-23%)	3.17	5.12	1.94 (61%)	0.00	0.05	0.05	1.49	1.50	0.01 (1%)	8.92	9.96	1.04 (12%)
June	W	23.48	7.39	3.50	-3.89 (-53%)	6.11	3.39	-2.73 (-45%)	0.00	0.33	0.33	1.19	1.20	0.01 (1%)	14.70	8.42	-6.28 (-43%)
	AN	2.04	10.69	5.77	-4.92 (-46%)	10.45	7.74	-2.71 (-26%)	0.00	0.46	0.46	1.60	1.62	0.02 (1%)	22.75	15.59	-7.16 (-31%)
	BN	2.07	8.43	6.25	-2.19 (-26%)	9.44	8.30	-1.14 (-12%)	0.00	0.32	0.32	1.60	1.60	-0.01 (0%)	19.48	16.46	-3.01 (-15%)
	D	1.25	10.37	5.89	-4.48 (-43%)	7.30	7.03	-0.27 (-4%)	0.00	0.31	0.31	1.68	1.69	0.01 (1%)	19.36	14.93	-4.43 (-23%)
	C	2.29	2.78	1.65	-1.13 (-41%)	3.73	3.50	-0.23 (-6%)	0.00	0.08	0.08	1.53	1.53	0.00 (0%)	8.05	6.77	-1.28 (-16%)

Note:
[1] W = Wet, AN = Above Normal, BN = Below Normal, D = Dry, C = Critical.
[2] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

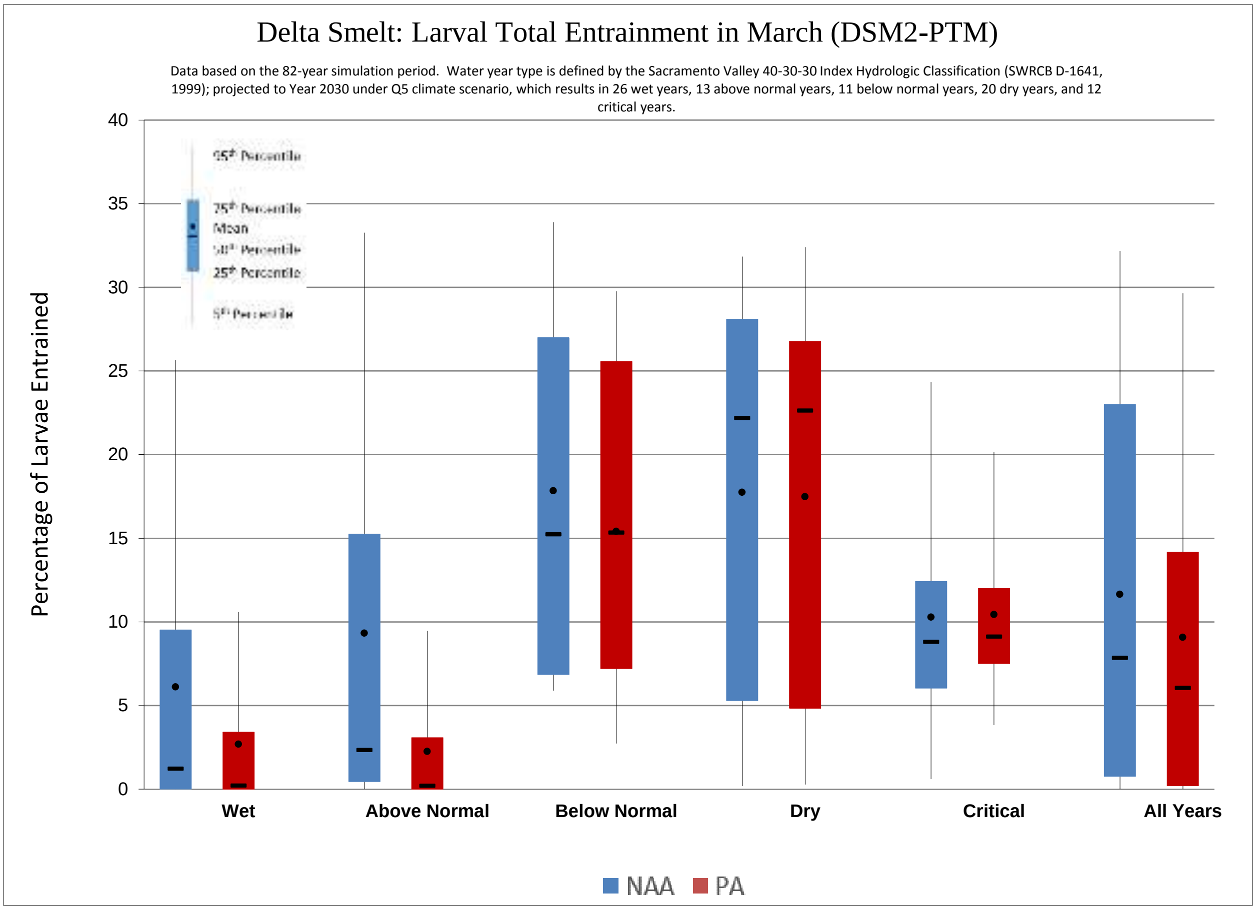


Figure 6.1-15. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of March 1922–2003

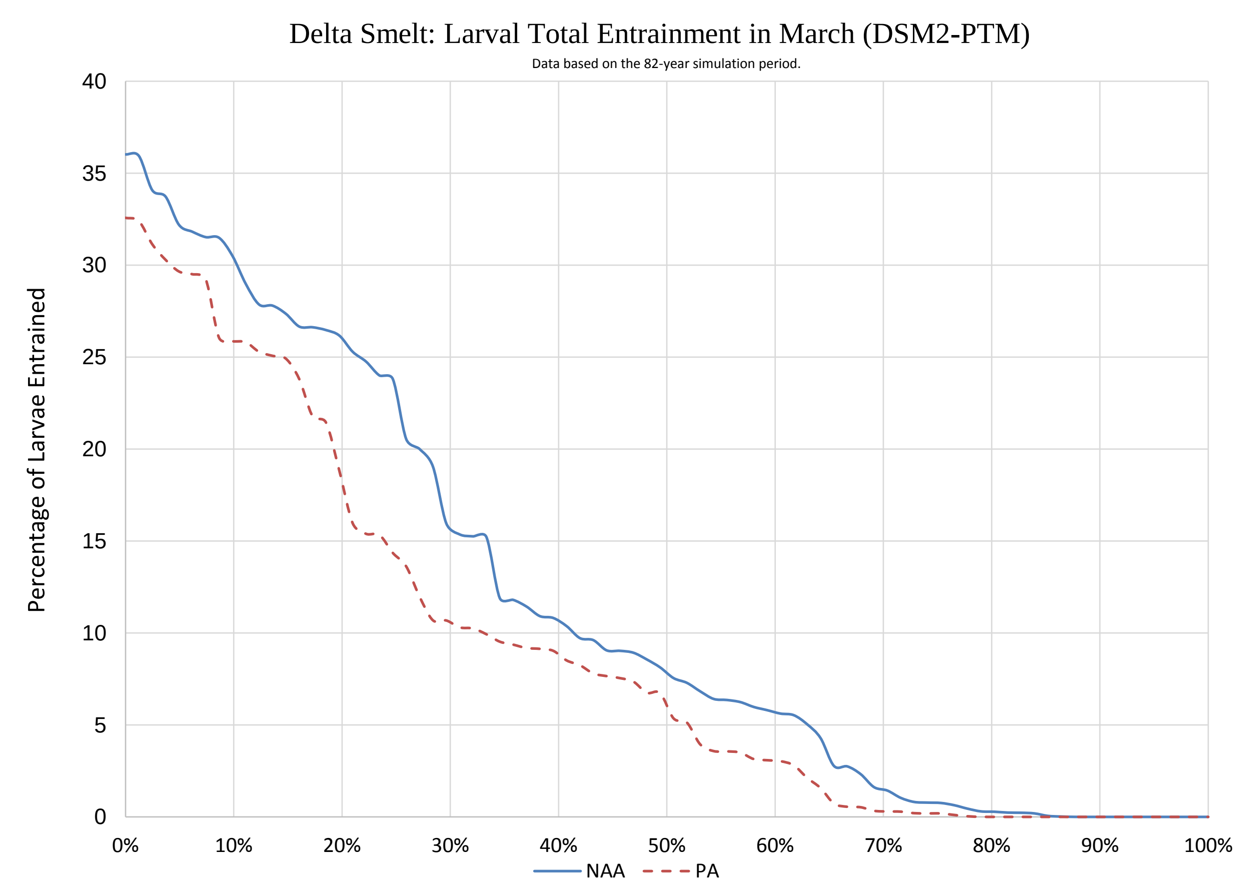


Figure 6.1-16. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of March 1922–2003

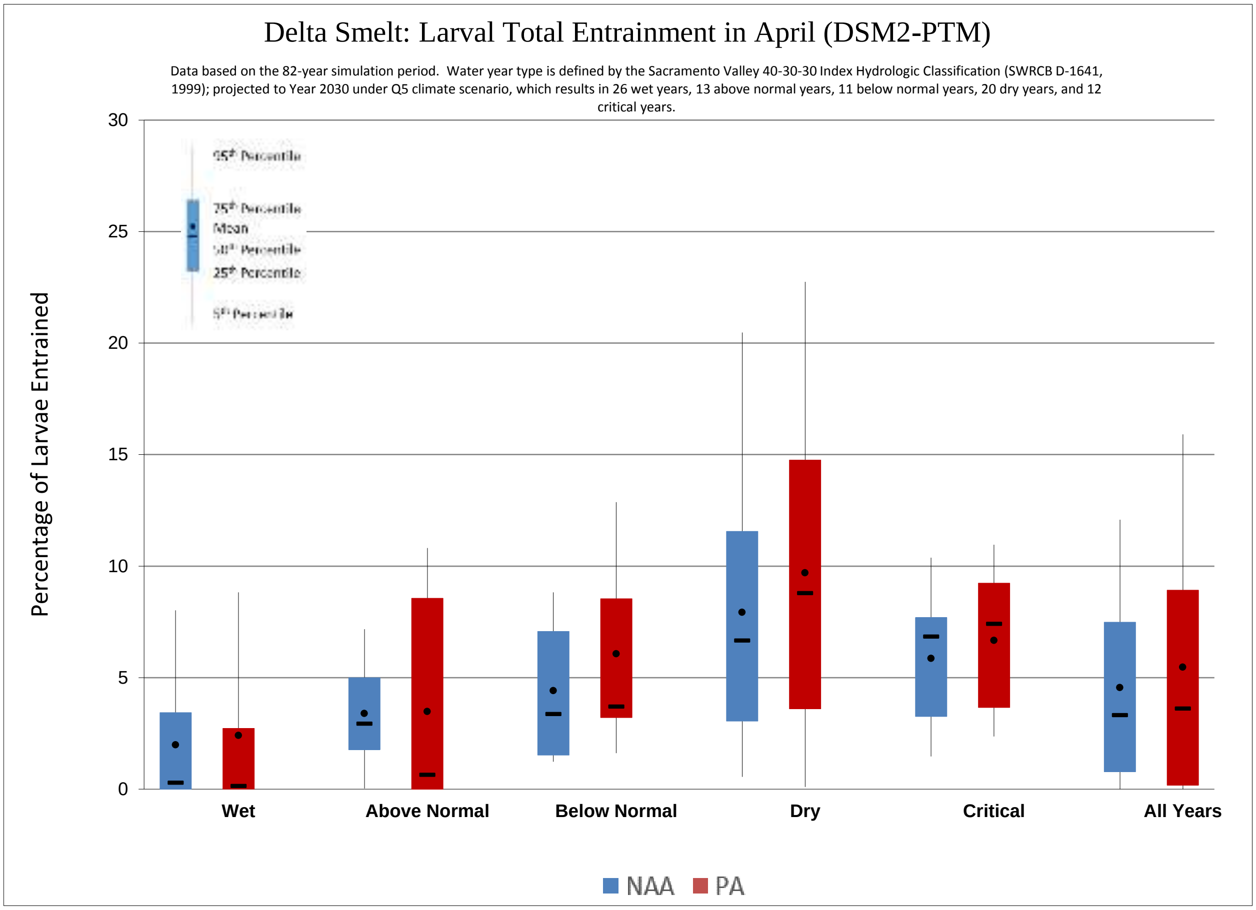


Figure 6.1-17. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of April 1922–2003

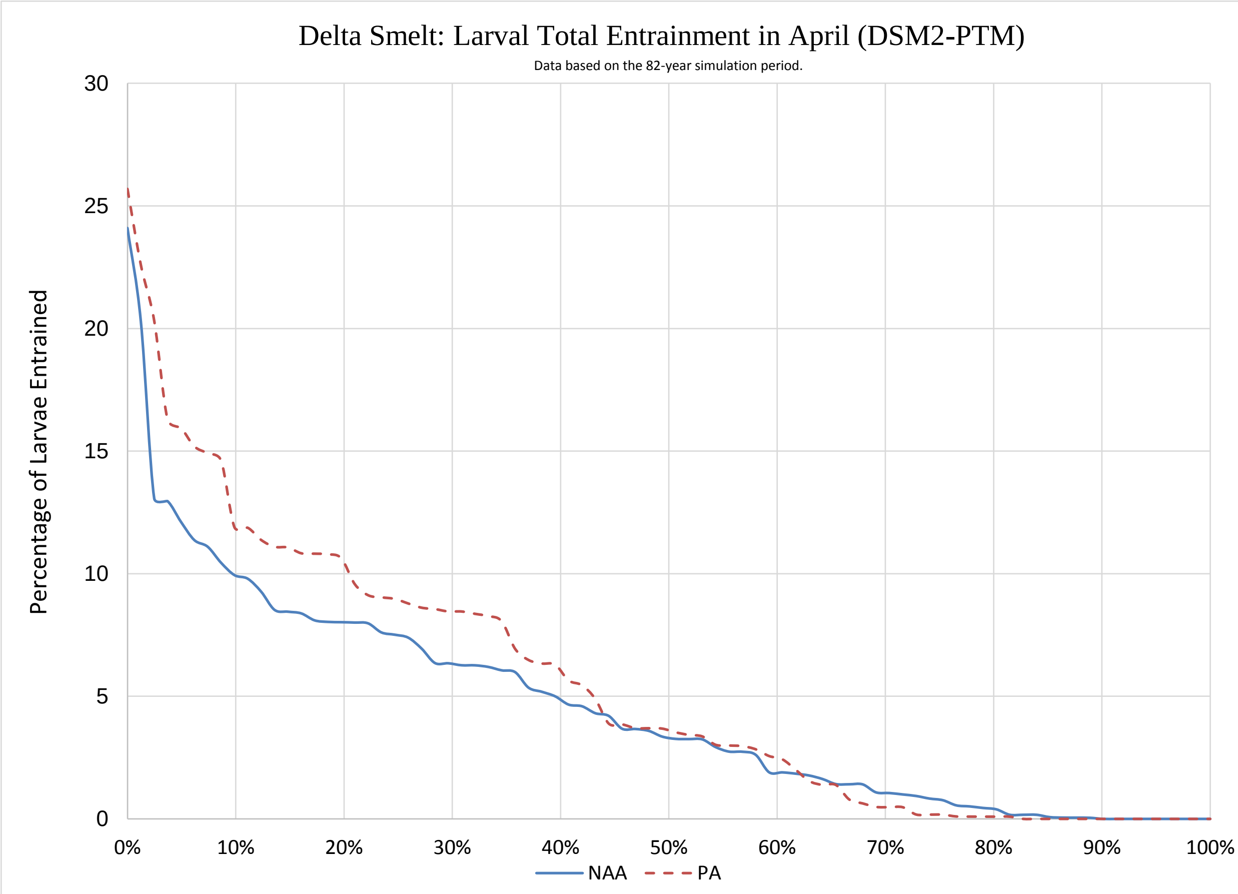


Figure 6.1-18. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of April 1922–2003

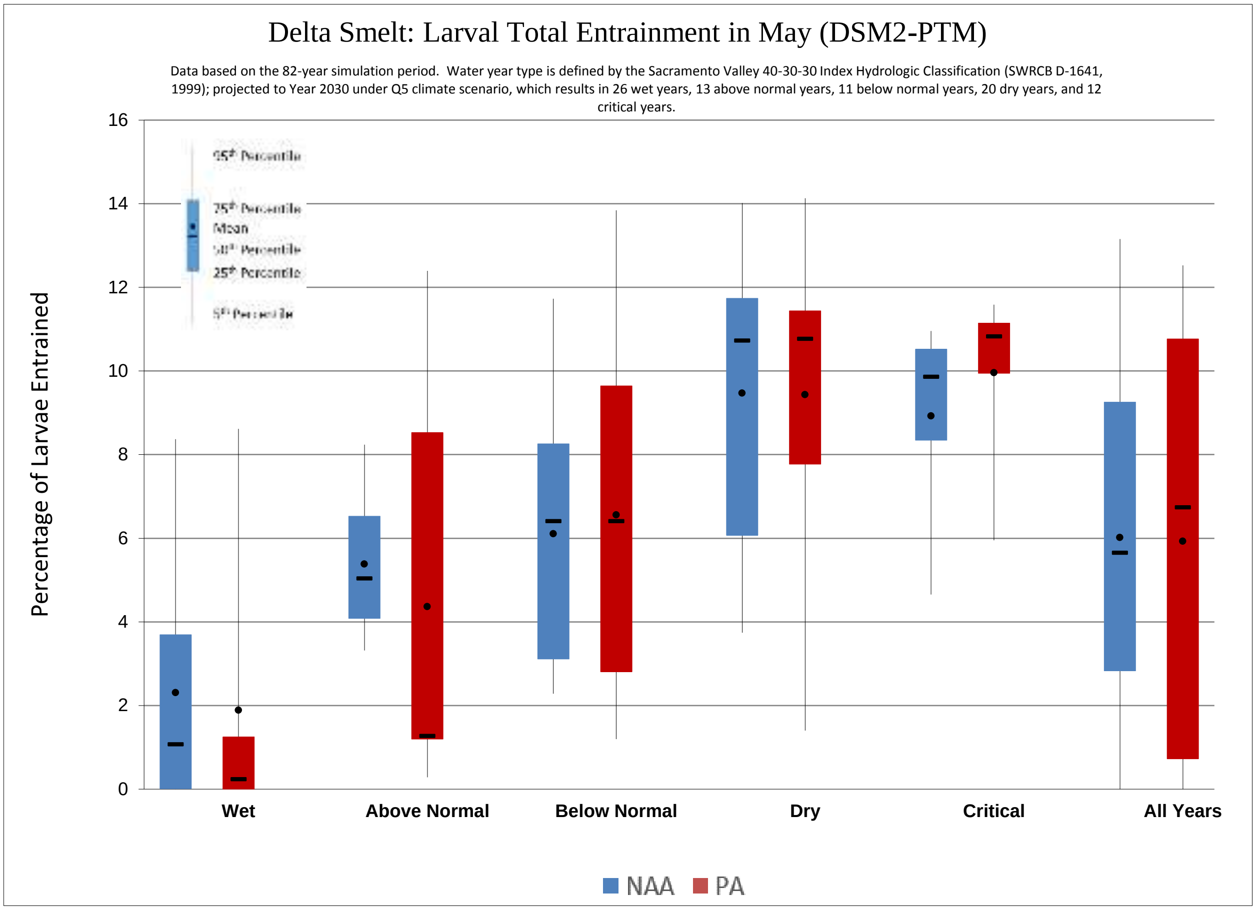


Figure 6.1-19. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of May 1922–2003

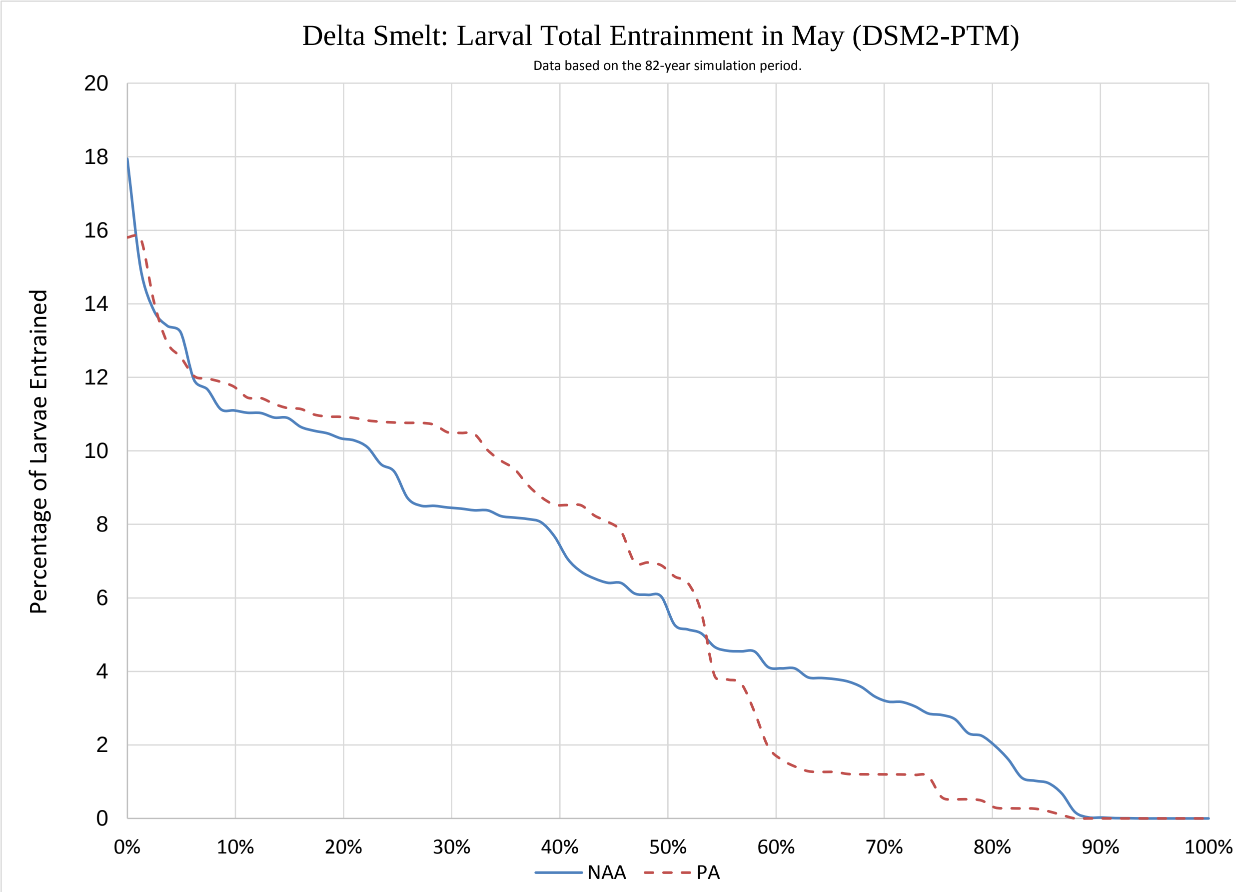


Figure 6.1-20. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of May 1922–2003

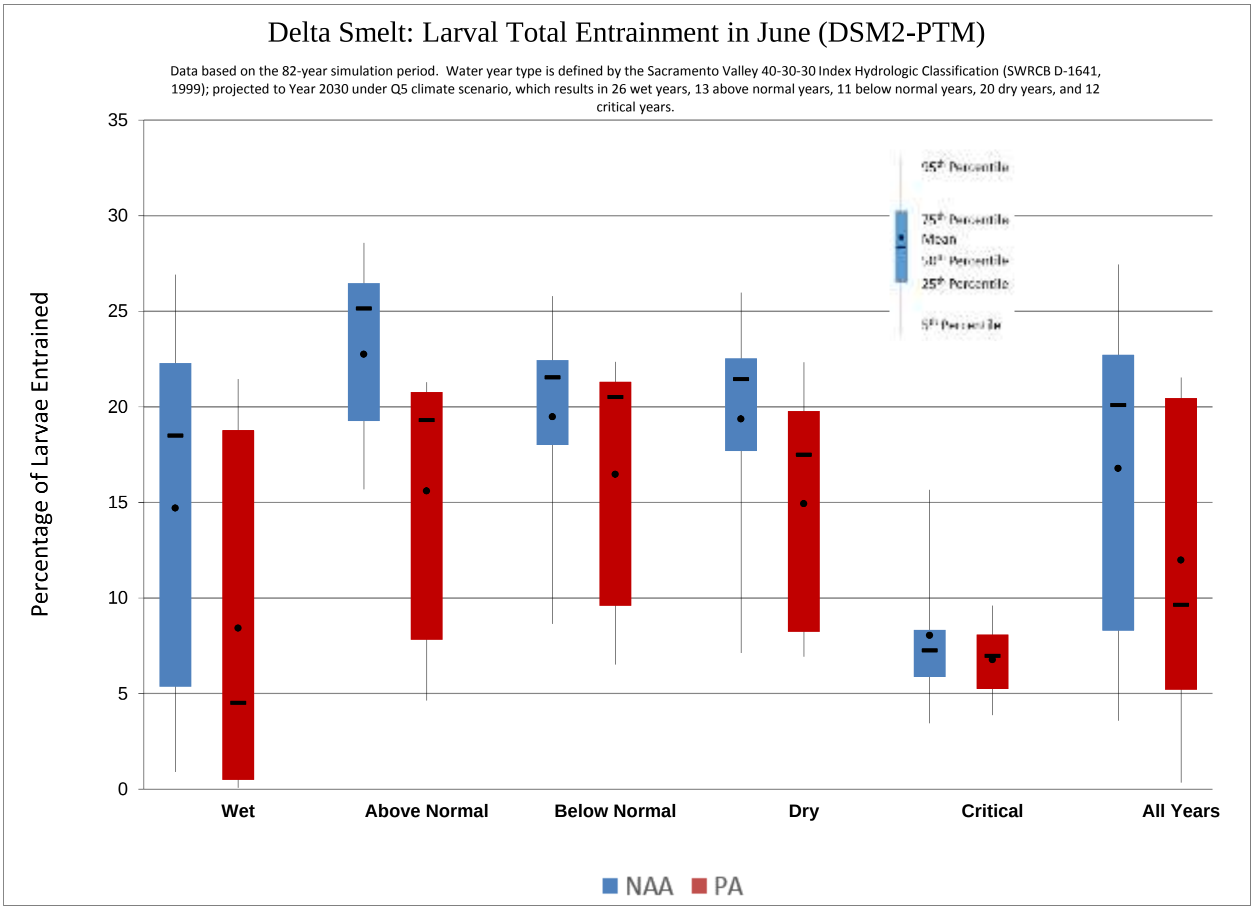


Figure 6.1-21. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of June 1922–2003

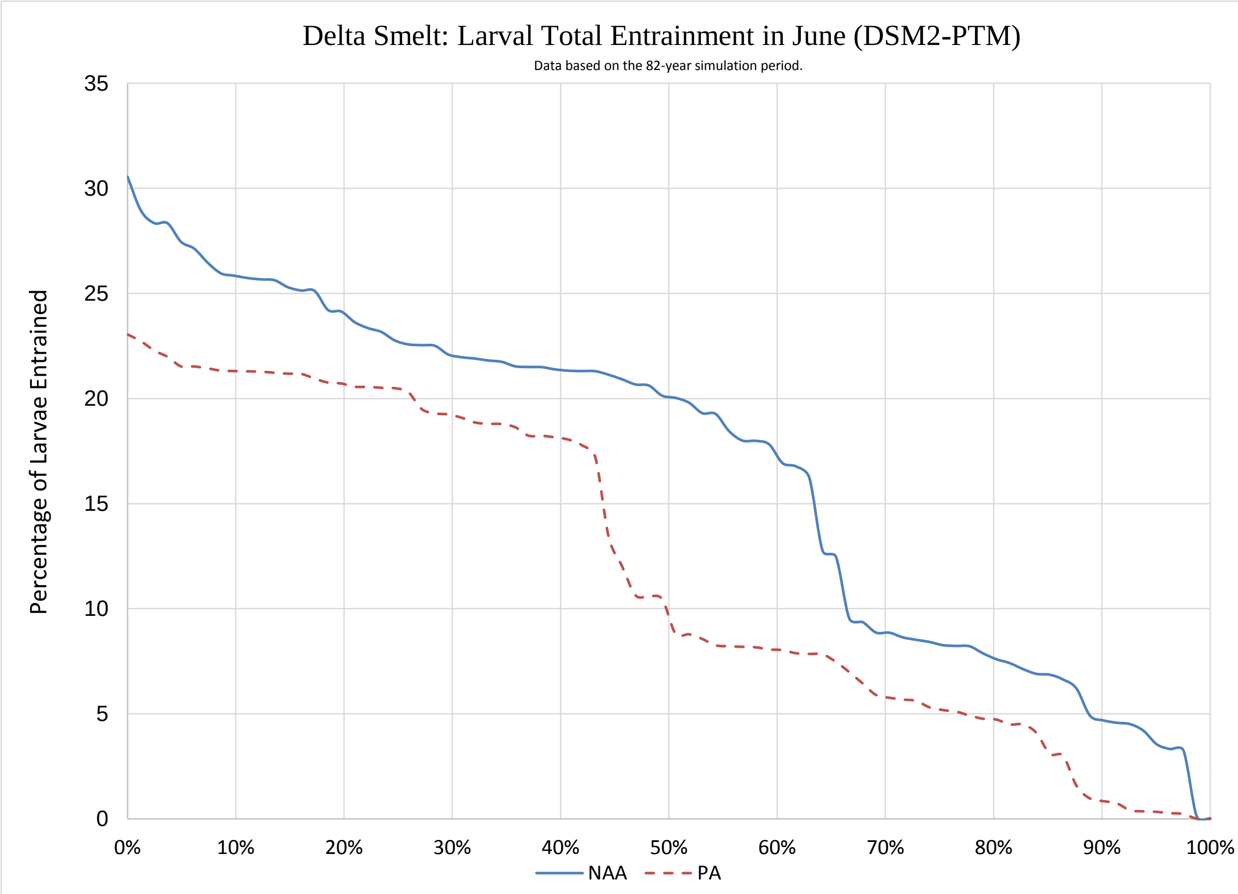


Figure 6.1-22. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of June 1922-2003

Table 6.1-17. Comparison of Trends in Delta Smelt Larval Entrainment Loss at the South Delta Export Facilities from the USFWS March-June Proportional Entrainment Regression and DSM2-PTM Results for March-June (Monthly Mean).

Water Year Type	USFWS Proportional Entrainment Regression[1]			DSM2-PTM Results (% Entrained at South Delta Only)		
	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[1]
Wet	3.79	2.15	-1.64 (-43%)	5.09	2.48	-2.61 (-51%)
Above Normal	8.05	4.81	-3.25 (-40%)	8.94	4.95	-3.98 (-45%)
Below Normal	15.83	15.13	-0.70 (-4%)	9.76	8.73	-1.03 (-11%)
Dry	15.98	15.78	-0.20 (-1%)	11.92	10.97	-0.94 (-8%)
Critical	21.57	21.82	0.25 (1%)	7.05	7.06	0.01 (0%)

Note:
[1] Proportions have been changed to percentages for consistency with the DSM2-PTM results. [2]Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

Table 6.1-18. Comparison of Trends in Delta Smelt Larval Entrainment Loss at the South Delta Export Facilities from the USFWS April-May Proportional Entrainment Regression and DSM2-PTM Results for April-May (Monthly Mean).

Water Year Type	USFWS Proportional Entrainment Regression[1]			DSM2-PTM Results (% Entrained at South Delta Only)		
	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[1]
Wet	1.45	1.47	0.02 (2%)	0.97	0.92	-0.05 (-5%)
Above Normal	3.53	3.14	-0.39 (-11%)	2.72	2.12	-0.59 (-22%)
Below Normal	11.70	12.54	0.84 (7%)	2.97	3.93	0.96 (32%)
Dry	13.96	14.29	0.33 (2%)	6.80	7.56	0.76 (11%)
Critical	21.04	21.69	0.65 (3%)	6.21	7.08	0.88 (14%)

Note:
[1] Proportions have been changed to percentages for consistency with the DSM2-PTM results. [2]Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

6.1.3.3.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.3.1.5.1 Individual-Level Effects

Juvenile Delta Smelt can be entrained at the south Delta export facilities after June, but patterns of salvage suggest that entrainment loss is very low after June (see Figure 3 of Kimmerer 2008). Recognizing this, USFWS (2008) established June 30 as the latest date to which restrictions on south Delta export pumping are presently applied to limit entrainment of larval/young juvenile Delta Smelt. The restrictions can end earlier than this if the daily mean water temperature at Clifton Court Forebay reaches 25°C for three consecutive days, because this indicates that conditions are no longer conducive to smelt survival (U.S. Fish and Wildlife Service 2008: 368), consistent with broad-scale observations on distribution (Nobriga *et al.* 2008).

6.1.3.3.1.5.2 Population-Level Effects

The entrainment of juvenile Delta Smelt during July-November is expected to be very low as it has been in the recent past, because the south Delta water is warmer and clearer than the habitat that Delta Smelt occupy (Nobriga *et al.* 2008). Thus, entrainment of juvenile Delta Smelt is not expected to impact the population.

6.1.3.3.2 Predation at the South Delta Export Facilities

6.1.3.3.2.1 Migrating Adults (December-March)

6.1.3.3.2.1.1 Individual-Level Effects

The previously presented analyses of entrainment effects of the PA on migrating adult Delta Smelt at the south Delta export facilities incorporated predation loss, e.g., prescreen losses across Clifton Court Forebay when estimating a proportion of the population that was ultimately lost due to changes in exports via their effect on OMR flow (Kimmerer and Nobriga 2008). For adult Delta Smelt, predation probably kills a large proportion of individuals before they actually reach the fish facilities or the export pumps behind them (Castillo *et al.* 2012; see Table 6.1-12). Thus, a lower entrainment risk to individual Delta Smelt under the PA in relation to NAA, should decrease mortality rates experienced by the adult stock[13]. To the extent that the localized reduction of predatory fishes conservation measure, discussed further in Section 6.1.4.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities,* reduces predator abundance in Clifton Court Forebay, predation risk to adult Delta Smelt could be reduced under the PA. However, there is uncertainty in the efficacy of this conservation measure, given that previous efforts did not yield measurable changes in predator population size within the Forebay (Brown *et al.* 1996).

6.1.3.3.2.1.2 Population-Level Effects

Given that a measurable proportion of the migrating adult Delta Smelt population can be lost to entrainment and associated predation, lower entrainment under PA should translate into lower overall adult mortality, compared to NAA.

[13] Note that the proportional loss regressions used to assess entrainment include losses from predation.

6.1.3.3.2.2 Spawning Adults (February-June)

6.1.3.3.2.2.1 Individual-Level Effects

It is not known whether an individual Delta Smelt occupying the south Delta faces a higher risk of predation than an individual occupying another staging or spawning location (e.g., Suisun Marsh, Decker Island, Sacramento Deepwater Shipping Channel).

6.1.3.3.2.2.2 Population-Level Effects

As described for entrainment, under the assumption that spawning adults are not undertaking broad-scale migrations, there are no data available to suggest they face an adverse population-level effect of predation beyond what occurs at the SWP and CVP facilities. Similar to migrating adults, lower entrainment under PA should translate into lower overall adult mortality, compared to NAA.

6.1.3.3.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.3.2.3.1 Individual-Level Effects

As noted for entrainment at the south Delta export facilities, Delta Smelt eggs and embryos are demersal and adhesive and would not be subject to changes in predation at the south Delta export facilities as a result of changes in south Delta water exports under the PA relative to NAA. There also would not be an effect of localized predatory fish reduction, as the sizes of fish targeted by this action would be larger than the sizes of fish that typically prey upon early life stages of Delta Smelt (e.g., silversides; Baerwald *et al.* 2012).

6.1.3.3.2.3.2 Population-Level Effects

Changes to exports are not expected to change the distribution of Delta Smelt eggs once they have been spawned. Thus, this is not a likely impact mechanism.

6.1.3.3.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.3.2.4.1 Individual-Level Effects

As summarized in Table 6.1-12, predation losses of larval Delta Smelt in association with the south Delta export facilities have not been quantified, whereas losses of juvenile Delta Smelt have been shown to be substantial, at least under some conditions (Castillo *et al.* 2012), as is the case with other species (Gingras 1997; Clark *et al.* 2009). The influence of water project operations on facility-associated predation on larval and small juvenile Delta Smelt is built into the proportional loss estimates described above, which were based on estimates from Kimmerer (2008). There is no additional effect to analyze under this impact mechanism.

6.1.3.3.2.4.2 Population-Level Effects

As described for the Individual-Level Effects, the influence of water project operations on facility-associated predation on larval and small juvenile Delta Smelt is built into the proportional loss estimates described above. There is no additional effect to analyze under this impact mechanism.

6.1.3.3.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.3.2.5.1 Individual-Level Effects

As discussed for entrainment, individual juvenile Delta Smelt would be expected to generally have left the south Delta as temperatures increase, so it is not anticipated that there would be changes in predation risk to individuals at or near the south Delta export facilities.

6.1.3.3.2.5.2 Population-Level Effects

There would be minimal population-level effects of changes in predation at the south Delta export facilities to juvenile Delta Smelt because this life stage is largely absent from the south Delta in summer/fall.

6.1.3.4 Head of Old River Gate Operations

6.1.3.4.1 Migrating Adults (December-March)

6.1.3.4.1.1 Individual-Level Effects

The potential for effects of the HOR gate is similar to the effects described for the south Delta Temporary Barriers Project (TBP), as previously noted by USFWS (2008: 225-226). Unlike the rock barrier currently used in some years, however, HOR gate operations would occur in the context of real-time changes in both gate position and management of north and south Delta exports in order to limit the potential for adverse hydraulic effects to adult Delta Smelt during their winter dispersal. In particular, careful management of OMR flows in consideration of fish distribution and turbidity cues (among other factors), would be undertaken to limit adverse effects to Delta Smelt. USFWS (2008: 225-226) noted the potential for negative effects of the TBP, including a HOR gate, on Delta Smelt:

> The TBP does not alter total Delta outflow, or the position of X2. However, the TBP causes changes in the hydraulics of the Delta, which may affect delta smelt. The HORB blocks San Joaquin River flow, which prevents it from entering Old River at that point. This situation increases the flow toward Banks and Jones from Turner and Columbia cuts, which can increase the predicted entrainment risk for particles in the East and Central Delta by up to about 10 percent (Kimmerer and Nobriga 2008). In most instances, net flow is directed towards the Banks and Jones pumps and local agricultural diversions. Computer simulations have shown that placement of the barriers changes South Delta hydrodynamics, increasing Central Delta flows toward the export facilities (Reclamation 2008). In years with substantial numbers of adult delta smelt moving into the Central Delta, increases in negative OMR flow caused by installation of the [temporary barriers] can increase entrainment. The directional flow towards Banks and Jones increases the vulnerability of fish to entrainment. Larval and juvenile delta smelt are especially susceptible to these flows.
>
> The varying proposed operational configurations of the TBP, natural variations in fish distribution, and a number of other physical and environmental variables limit statistical confidence in assessing fish salvage when the TBP is operational versus when it is not. In 1996, the installation of the spring HORB caused a sharp reversal of net flow in the South Delta to the upstream direction. Coincident with this change was a strong peak in delta smelt salvage (Nobriga *et al.* 2000). This observation indicates that short-term salvage can significantly increase when the HORB is installed in such a manner that it causes a sharp change or reversal of positive net daily flow in the South and Central Delta.

Based on the assessment by USFWS (2008), there is the potential for the HOR gate to result in short-term negative effects to Delta Smelt by influencing the hydraulics of Old and Middle

Rivers, particularly in terms of creating greater short-term increased reverse OMR flows when the HOR gate is initially closed. However, the general improvements to OMR flows because of less south Delta exports, combined with the flexibility to manage the proposed HOR gate in real time would limit the potential for adverse effects. If necessary, opening and closing of the HOR gate could be done in consideration of the most recent fish distribution information (e.g., Spring Kodiak Trawl or 20-mm Survey) as well as simulation (e.g., PTM) modeling of the likely effects of the HOR gate operational switches; adjustments to south Delta exports could then be done accordingly to avoid short-term increases in entrainment.

In addition to broad-scale, far-field effects of the HOR gate on south Delta hydrodynamics, there may be localized effects on migrating adult Delta Smelt. Studies of the rock barrier installed at the HOR in 2012 suggested the structure created eddies that could have resulted in enhanced predatory fish habitat and increased predation on juvenile salmonids (California Department of Water Resources 2015a); such adverse effects could also occur to Delta Smelt as a result of HOR gate operations.

6.1.3.4.1.2 Population-Level Effects

Over 2,300 beach seine samples[14] in the San Joaquin River between Dos Reis (river mile 51) and Weatherbee (river mile 58) between 1994 and 2015 yielded only four Delta Smelt (all during February–April). Nearly 30,000 trawl samples at Mossdale[15] from 1994 to 2011 resulted in the capture of 44 Delta Smelt, principally during March-June. As described in the individual-level effects sections, careful management of OMR flows and HOR gate operations will limit movement of adult Delta Smelt into the south Delta where they would be subject to high entrainment risk and impact mechanisms directly associated with the presence and operation of the HOR gates. Therefore, there should be no meaningful adverse effect to the population of migrating adult Delta Smelt.

6.1.3.4.2 Spawning Adults (February-June)

6.1.3.4.2.1 Individual-Level Effects

The effects to spawning adults are assumed to be the same as those described above for migrating individuals (section 6.1.3.4.1.1).

6.1.3.4.2.2 Population-Level Effects

The effects to spawning adults are assumed to be the same as those described above for migrating individuals (section 6.1.3.4.1.2).

6.1.3.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.4.3.1 Individual-Level Effects

As noted for other potential effects of the PA, Delta Smelt eggs and embryos are demersal and adhesive, and so the potential hydrodynamic effects of the HOR gate would not be expected to result in adverse effects to individuals.

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[14] Data were obtained from http://www.fws.gov/lodi/jfmp/, files <Beach Seines CHN _ POD Species 1976-2011.xlsx> and <Beach Seines CHN _ POD Species 2012-2015.xlsx> accessed September 14, 2015.

[15] Data were obtained from http://www.fws.gov/lodi/jfmp/, files < Mossdale Trawls CHN _ POD Species 1994-2011.xlsx> and < Mossdale Trawls CHN & POD Species 2012-2015.xlsx> accessed September 14, 2015.

6.1.3.4.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the HOR gate.

6.1.3.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.4.4.1 Individual-Level Effects

Larval/young juvenile Delta Smelt are inherently more vulnerable to far-field hydrodynamic effects of exports and barrier/gate operations (e.g., greater risk of south Delta entrainment with HOR gate closure). It is not known if they are more vulnerable than adults to near-field effects (e.g., greater predation because of near-field changes in hydraulics). As described above, modeling in support of the PA does not indicate that there will be a consistent decrease in the proportional entrainment of larval and small juvenile Delta Smelt, in part because of the modeling assumption about the frequency of HOR gate closures during spring.

6.1.3.4.4.2 Population-Level Effects

Based on the infrequent occurrence of adult Delta Smelt near the HOR gate, it is likely that larval and young juvenile Delta Smelt will only very rarely occur near the HOR gate. Thus, there should be no population impact of the structures themselves.

6.1.3.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.4.5.1 Individual-Level Effects

Effects to individual juvenile Delta Smelt from HOR gate operations would be similar to those for adult Delta Smelt, in terms of potential for broad-scale and local effects; however, as discussed in population-level effects next, these effects would apply to very few individuals.

6.1.3.4.5.2 Population-Level Effects

Based on the infrequent occurrence of adult Delta Smelt near the HOR gate, it is likely that larval and young juvenile Delta Smelt will only very rarely occur near the HOR gate. Thus, there should be no population impact of the structures themselves.

6.1.3.5 Habitat Effects

6.1.3.5.1 Abiotic Habitat

Conceptually, the freshwater flow regime and its interaction with the system bathymetry and landscape affect the quantity and quality of available habitat (e.g., Peterson 2003). The USFWS (2008) BiOp's RPA included an action to increase Delta outflow in fall following wet and above normal years based on specific targets for X2, the geographic location of the 2-ppt salinity isohaline in the estuary. This action aimed to restore a greater extent and quality of fall habitat for juvenile Delta Smelt in wetter years in order to counteract the lower variability and smaller size of the low-salinity zone during fall of recent years (fall abiotic habitat) that had been assessed by USFWS (2008) to have occurred as a result of CVP/SWP operations (see also Feyrer *et al.* 2011; Cloern and Jassby 2012). This RPA element has been included as part of the PA and this section compares results for PA versus NAA using the abiotic habitat index of Feyrer *et al.* (2011); there is scientific debate and uncertainty regarding this method, as described in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*. Year-around summaries of X2 are provided in Appendix 5.A, *CALSIM Methods and Results* (box plots: 5.A.6-29-1 to 5.A.6-29-6; exceedance plots: Figures 5.A.6-29-7 to 5.A.6-29-19; Table 5.A.6-29).

6.1.3.5.1.1 Juveniles (Fall: ~September-December)

6.1.3.5.1.1.1 Individual-Level Effects

As described by USFWS (2008: 233), during the fall (September-December), Delta Smelt are maturing pre-adults that rely heavily on suitable habitat conditions in the low salinity portion of the estuary. USFWS (2008: 233) briefly defined suitable habitat for Delta Smelt during this time period as “the abiotic and biotic components of habitat that allow Delta Smelt to survive and grow to adulthood: biotic components of habitat include suitable amounts of food resources and sufficiently low predation pressures; abiotic components of habitat include the physical characteristics of water quality parameters, especially salinity and turbidity.”

As noted by Feyrer *et al.* (2007; 2011), analyses conducted over this portion of the Delta Smelt life cycle provide support for a population-level effect of fall habitat conditions or indices of those conditions. In addition, analyses by Miller *et al.* (2012) and Rose *et al.* (2013a, b) suggest that prey density/food limitation during this part of the life cycle may also have population-level effects on Delta Smelt.

As previously noted, in the USFWS (2008) BiOp, the RPA included an action to increase Delta outflow in fall following wet and above normal years based on specific targets for X2. This action aimed to restore a greater extent of fall habitat for juvenile Delta Smelt following wetter years in order to counteract a trend toward lower variability and smaller size of the low-salinity zone during fall of recent years (Feyrer *et al.* 2011; Cloern and Jassby 2012). Feyrer *et al.* (2011) suggested that increased habitat area provides more space for individuals to safely live and reproduce, presumably lessening the likelihood of density-dependent effects (e.g., food limitation, disease, and predation), and lessening the probability of stochastic events increasing the risk of mortality (e.g., cropping by predators, contaminant events, or the direct/indirect effects of water diversions).

As described in Section 3.3.2, *Operational Criteria*, of Chapter 3, *Description of the Proposed Action*, the fall X2 action from the USFWS (2008) BiOp has also been proposed to be included in the PA provided, as discussed in Chapter 3, that the research and results of the Collaborative Science and Adaptive Management program show it is required to avoid jeopardy of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat for those species. Thus, no meaningful difference in fall abiotic habitat index is expected to occur. To confirm this, a quantitative examination of the PA effects on abiotic habitat suitability was undertaken based on the abiotic habitat index method of Feyrer *et al.* (2011) (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6A.4.1). The considerable similarity in mean fall abiotic habitat index by water-year type between NAA and PA emphasizes that there would be little difference in fall outflow management under the PA in all water year types, relative to NAA (Table 6.1-19; Figure 6.1-23 and Figure 6.1-24). Any differences are model “noise”.

Table 6.1-19. Mean Fall Abiotic Habitat Index, Based on the Method of Feyrer *et al.* (2011).

Water Year Type	NAA	PA	PA vs. NAA[1]
All	5,026	5,048	21 (0%)
Wet	7,251	7,245	-6 (0%)
Above Normal	5,386	5,441	55 (1%)
Below Normal	3,748	3,742	-6 (0%)
Dry	3,845	3,911	66 (2%)
Critical	2,985	2,985	0 (0%)

Note:
[1] Negative values indicated abiotic habitat index under the proposed action (PA) than under the no action alternative (NAA).

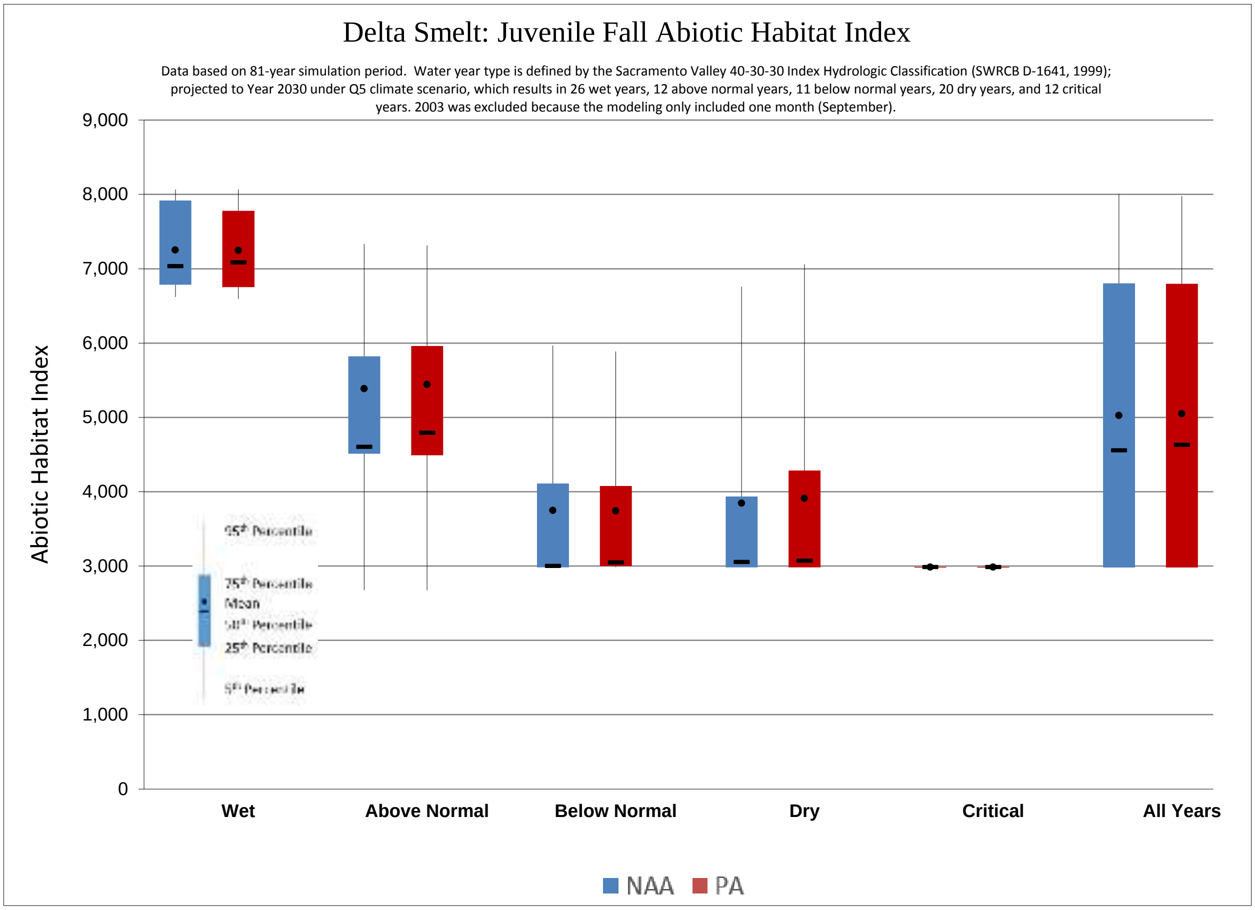

Figure 6.1-23. Box Plot of Mean Fall Abiotic Habitat Index, Grouped by Water Year Type, Based on the Method of Feyrer *et al.* (2011)

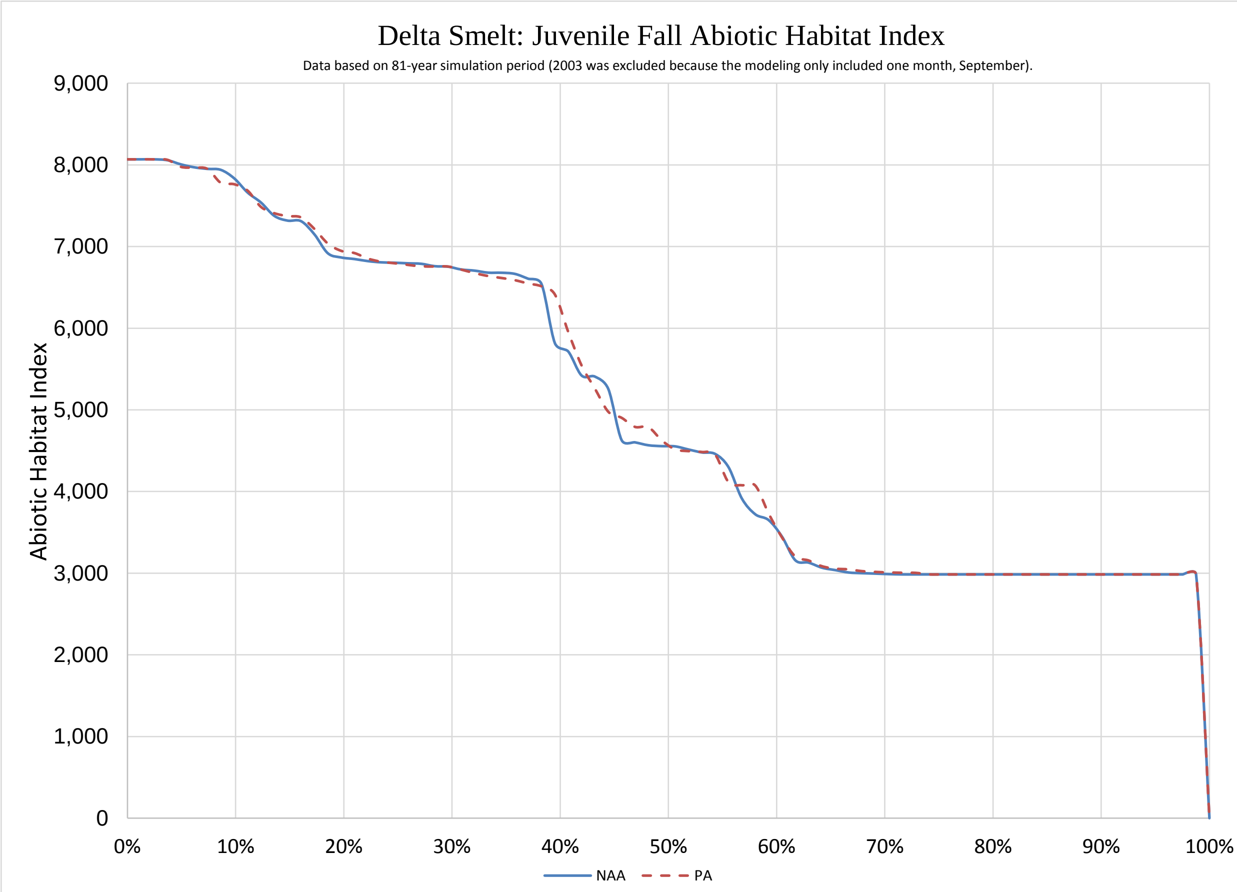

Figure 6.1-24. Exceedance Plot of Mean Fall Abiotic Habitat Index, Based on the Method of Feyrer *et al.* (2011).

6.1.3.5.1.1.2 Population-Level Effects

The PA would not have an adverse effect on Delta Smelt juveniles in the fall.

6.1.3.5.2 Water Temperature

As noted in the effects analysis for NMFS-managed species (Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*), Kimmerer (2004: 19-20) described water temperature in the San Francisco Estuary as depending mainly on air temperature, and that even in the Delta the relationship between air and water temperature is only slightly affected by freshwater inflow. As examples, Kimmerer (2004: 20) noted that at Freeport, high inflow reduces water temperature on warm days, presumably because water reaches the Delta before its temperature equilibrates with air temperature, and at Antioch, low inflow increases water temperature on cool days, probably because of the moderating effect of warmer estuarine water moving farther upstream. USFWS (2008: 194) suggested, based on Kimmerer (2004) that water temperatures at Freeport can be cooled up to about 3°C by high Sacramento River flows, but only by very high river flows that cannot be sustained by CVP/SWP operations. In general, flow-related effects on Delta water temperature are expected to be minor (Wagner *et al.* 2011). Specifically, Delta water temperatures are primarily driven by air temperatures and the lagged effects from previous days' conditions (Wagner et al. 2011).

However, operational changes under the PA with respect to dual conveyance means that it is prudent to investigate whether water temperature is expected to differ between the NAA and the PA, and if so, why. To do this, DSM2-QUAL modeling was undertaken to predict water temperatures for the NAA and PA scenarios at four locations: Sacramento River at Rio Vista, San Joaquin River at Prisoners Point, Stockton Deep Water Ship Channel, and San Joaquin River at Brandt Bridge. Detailed methods are presented in Attachment 5.B.A.4, *DSM2 Temperature Modeling*, of Appendix 5.B, *DSM2 Methods and Results*, with results in Section 5.B.5, *DSM2 Results*, of the same appendix. The analysis below focuses on the two stations of greatest relevance to Delta Smelt: Rio Vista and Prisoners Point. Note that the nature of the DSM2-QUAL modeling is such that absolute projections of water temperature must be made with caution (e.g., regional correction factors must be applied), but site-specific comparisons between scenarios can be made. As described in Attachment 5.B.A.4, *DSM2 Temperature Modeling*, of Appendix 5.B, the DSM2 QUAL simulations result in somewhat higher different water temperatures than historical conditions: For Rio Vista, the DSM2-QUAL estimates of water temperature are 0.3–0.6°C less than historical in April–June; 0.3–0.5°C greater than historical in July–August; and 0.1–0.5°C less than historical in September-November. No specific comparison was made for Prisoner's Point, but comparisons for nearby stations in the east Delta (Mokelumne River at San Joaquin River and Little Potato Slough) were always biased low, averaging -0.2°C to -0.8°C.

6.1.3.5.2.1 Migrating Adults (December-March)

6.1.3.5.2.1.1 Individual-Level

From examination of exceedance plots of Rio Vista mean water temperatures (Figure 5.B.5.40-1 in Appendix 5.B, *DSM2 Methods and Results*, Section 5.B.5), the only discernible differences in water temperature were in March, and these were small differences (~0.1°C greater under PA). At Prisoners Point (Figure 5.B.5.41-1 in Appendix 5.B, Section 5.B.5), differences were evident in January-March, presumably as a result of the HOR gate retaining a greater proportion of slightly warmer San Joaquin River water in the main stem, combined with less Sacramento River inflow entering the interior Delta. Differences in March were of the order of 0.3–0.4°C. Although differences in water temperature between NAA and PA were modeled, these were during a relatively cool part of the year and therefore are not expected to have significant effects on migrating adults in that portion of the Delta.

From examination of exceedance plots of Rio Vista mean water temperatures (Figure 5.B.5.40-1 in Appendix 5.B, *DSM2 Methods and Results*, Section 5.B.5), there were no discernible differences in water temperature (maximum "differences" were well within model noise, e.g., ~0.1°C greater under PA in March). At Prisoners Point (Figure 5.B.5.41-1 in Appendix 5.B, Section 5.B.5), modeled differences were comparable to model noise during January-March (+0.3 to +0.4°C), presumably as a result of the HOR gate retaining a greater proportion of the slightly warmer San Joaquin River water in the main stem, combined with less Sacramento River inflow entering the interior Delta. This may reflect a water temperature change that would actually occur, but if it did, it would occur during a cool part of the year and therefore should not affect Delta Smelt.

6.1.3.5.2.1.2 Population-Level Effects

Migrating adult Delta Smelt may experience slightly warmer temperatures in the lower San Joaquin River, but given that these temperatures would be expected to well within the tolerance of the species, there should not be any population level impact.

6.1.3.5.2.2 Spawning Adults (February-June)

6.1.3.5.2.2.1 Individual-Level Effects

As described previously for migrating adult Delta Smelt, there might be slightly greater water temperatures under PA compared to NAA in the San Joaquin River. Delta smelt may begin spawning in the San Joaquin River in February, and will spawn during March of most years (see data collected for Spring Kodiak Trawling; https://www.wildlife.ca.gov/Conservation/Delta/Spring-Kodiak-Trawl). Previously published modeling studies have indicated that warmer temperatures (caused by climate change) would tend to result in earlier spawning, but they provide no indication that the duration of the spawning window would be affected (Wagner *et al.* 2011; Brown *et al.* 2013). Earlier spawning could result in spawning adults being of smaller mean size, as they would have had less time to grow to maturity (Brown *et al.* 2013).

6.1.3.5.2.2.2 Population-Level Effects

The recent simulation-based life cycle modeling by Rose *et al.* (2013a,b) indicates that egg supply has been a major factor affecting Delta Smelt abundance in the recent past. Climate change is anticipated to warm Delta water temperatures and as such could affect the length of time that Delta Smelt have to reach adulthood (Brown *et al.* 2013). If this occurs, it would affect egg supply. As described above, it is uncertain whether the PA will actually affect water temperature in the Delta, but if it does, that effect would be very minor and very localized. Thus, it is unlikely that project effects on water temperature would translate into a population-level effect on Delta Smelt. In general it is expected that air temperature is the main driver on water temperature in the Delta, as shown by detailed temperature modeling that does not include the effects of flow and has higher correspondence with observed temperatures than DSM2-QUAL estimates (Wagner *et al.* 2011).

6.1.3.5.2.3 Eggs/Embryos (Spring: ~March–June)

6.1.3.5.2.3.1 Individual-Level Effects

Most Delta Smelt hatch during March-May. In warm years, hatching can begin in February and in cool years, it can extend at least into June. Bennett (2005: 17) reviewed Delta Smelt embryo and larval survival data from laboratory studies and found that optimal hatching occurred at 15–17°C. As previously noted for adult Delta Smelt, there would be little if any difference in temperature between NAA and PA because river flows have such a minor influence on water temperatures in the Delta except at the inflowing river margins (Kimmerer 2004; Wagner *et al.* 2011). Although strict comparisons to absolute thresholds are not appropriate for the DSM2-QUAL data, the general pattern for Prisoners Point in March suggests that the greater water temperature under PA would be slightly closer toward optimum hatching temperature than under NAA (Figure 5.B.5.41-1 in Appendix 5.B, *DSM2 Methods and Results*, Section 5.B.5), whereas in May, temperatures under PA may be marginally further away from optimum compared to NAA, although these differences were very small. Bennett (2005: 17) also noted that incubation time of embryos decreases with increasing water temperature, from around 18 days at 10°C to 9 days at 15°C and 7 days at 20°C. Therefore, for example, a 0.3°C greater water temperature under PA could give a 0.5-day shorter incubation time for Delta Smelt occurring in the lower San Joaquin River.

6.1.3.5.2.3.2 Population-Level Effects

The slightly greater Prisoners Point water temperature under PA that was estimated by DSM2-QUAL could result in shorter embryo incubation time, as well as slightly lower or higher hatching success, depending on the month. The effects would be limited to the portion of the Delta Smelt population occurring in the San Joaquin River which, as inferred from the spawning adult distribution (see previous discussion), generally would be expected to be a lower proportion of the population than would occur in the north Delta. As previously noted, in general it is expected that air temperature would be the main driver on water temperature in the Delta (Wagner *et al.* 2011), and the differences between PA and NAA scenarios were very small.

6.1.3.5.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.2.4.1 Individual-Level Effects

Bennett's (2005: 17) review of the laboratory studies on water temperature effects on larval Delta Smelt found that greater water temperature leads to smaller length at hatching and smaller length at first feeding. The marginally higher water temperatures estimated under the PA relative to NAA in at Prisoners Point (see discussion above) therefore could result in Delta Smelt that are slightly smaller, although the differences between scenarios was very small. There could be several effects to Delta Smelt from this smaller size (IEP MAST Team 2015: 37). First, small size would result in small gape size, which would limit the size of prey items that could be eaten. Second, there may be greater vulnerability to a wider range of predators. Third, smaller larvae could be more susceptible to hydrodynamic transport toward the south Delta export facilities for a given level of pumping. Bennett (2005: 11) noted that there is higher mortality of larvae above 20°C; the DSM2-QUAL modeling data for Prisoners Point in June suggested that there could be a slight increase in the number of days in this range (Figures 5.B.5.41-3 to 5.B.5.41-6 in Appendix 5.B, *DSM2 Methods and Results,* Section 5.B.5; although as noted previously, it is not appropriate to examine more than general patterns when comparing the NAA and PA scenarios).

6.1.3.5.2.4.2 Population-Level Effects

Overall, the DSM2-QUAL analysis suggested that there may be slightly lower larval Delta Smelt survival in the lower San Joaquin River because of slightly higher water temperature. This would affect the portion of the population occupying this area. Data from the 20-mm survey indicate that larval Delta Smelt occur frequently in this area (see Table 7 of Merz *et al.* 2011), so an appreciable portion of the population could be subject to this adverse effect. However, as previously noted, in general it is expected that air temperature would be the main driver on water temperature in the Delta and flow effects would be of minor importance (Wagner *et al.* 2011).

6.1.3.5.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.2.5.1 Individual-Level Effects

Water temperatures above 20°C become increasingly stressful to juvenile Delta Smelt up to the range that has been observed to be lethal (~25–29°C; Swanson *et al.* 2000; Komoroske *et al.* 2014). The DSM2-QUAL modeling results suggested water temperature would be similar or slightly warmer under the PA compared to NAA, at both the Sacramento River at Rio Vista and San Joaquin River at Prisoners Point during the summer (July–September). The differences that occurred in the warmer 50% years indicated about 0.1–0.2°C greater temperature under the PA

(Figure 5.B.5.40-1 and Figure 5.B.5.41-1 in Appendix 5.B, *DSM2 Methods and Results*, Section 5.B.7)

6.1.3.5.2.5.2 Population-Level Effects

As reviewed by the IEP MAST team (2015), high summer water temperature has a negative effect on the Delta Smelt population, as it has been linked to Delta Smelt subadult abundance in the fall (Mac Nally *et al.* 2010) and long-term population dynamics (Maunder and Deriso 2011; Rose *et al.* 2013a, b). The marginally greater water temperature in the summer could have a small adverse effect on the whole Delta Smelt population, through mechanisms such as reduced habitat extent, increased metabolic requirements (reduced energy intake for growth), and greater susceptibility to disease or the effects of contaminants (IEP MAST Team 2015). The difference in water temperature was small, however, perhaps suggesting limited adverse effects at the population level, particularly given that air temperature is the main driver of Delta water temperature and effects of flow have very little importance (Wagner *et al.* 2011).

6.1.3.5.3 Sediment Removal (Water Clarity)

Water clarity (turbidity) is a very important habitat characteristic for Delta Smelt and is a significant predictor of larval feeding success (presumably by providing a visual contrast to enable the larvae to locate and ingest prey; Baskerville-Bridges *et al.* 2004) and juvenile distribution (Nobriga *et al.* 2008; Feyrer *et al.* 2011) that has been correlated to long-term changes in abundance or survival either by itself or in combination with other factors (Thomson *et al.* 2010; Maunder and Deriso 2011). Cloern *et al.* (2011) noted the uncertainty in future turbidity trends in the Delta: specifically, it is unclear whether a 40-year average decline in turbidity of 1.6% per year will continue at this rate, slow down, or level off. Should such a trend continue, it presumably will further decrease the downward trend in Delta Smelt habitat quality estimated by Feyrer *et al.* (2011) (as described in Brown *et al.* (2013).

Most sediment entering the Delta comes from the Sacramento River (Wright and Schoellhamer 2004). The NDD is expected to divert a portion of the Sacramento River's sediment load, which could result in higher water clarity downstream because less sediment may over time allow greater erosion and less wind- and velocity-driven resuspension of sediment into the water column. The BDCP public draft included estimates of sediment diverted by the NDD at the late long term time frame (2060) based on historic sediment load estimates for 1991–2002 (see Section 5C.D.3 in the BDCP public draft, Attachment 5C.D to Appendix 5.C, *Upstream Water Temperature Methods and Results*). For the present effects analysis of the PA, very similar analytical methods were used based on sediment load estimates for water years 1991–2003, matched to CalSim flow and NDD diversion estimates for the same years. The analysis suggested that a mean of 10% (range: 5–15%) of combined sediment load entering the Delta from combined inflow at Freeport and the Yolo Bypass would be removed by the NDD. Considering only the Sacramento River load at Freeport, it was estimated that a mean of 11% (range: 7–16%) of sediment load would be removed by the NDD. If this sediment, some of which will be collected in the sedimentation basins (described in Section 3.2.2, *North Delta Diversions*, of Chapter 3, *Description of the Proposed Action*) is not returned to the system, it is possible that water transparency in the Delta will increase over time due to project operations. However, the extent of increases in water clarity cannot be accurately predicted without application of a full suspended sediment model incorporating the whole estuary; modeling has been noted to be necessary for assessment of the effects of managing regional transport of sediment in the Delta (Schoellhamer *et al.* 2012). Thus, the following effects analysis should be understood to have low certainty. Note that the analysis did not attempt to provide a quantitative estimate for sediment removal by the south Delta export facilities under the NAA or PA; based on the estimates by Wright and Schoellhamer (2005), sediment removal by the south Delta export facilities in 1999-2002 averaged around 2% of the sediment entering the Delta at Freeport, i.e., an order of magnitude less than estimated to be removed at the NDD, so the net sediment removal under the PA (NDD exports plus less south Delta exports than NAA) would be expected to be appreciably greater than sediment removal under NAA. As described in Section 3.2.10.6, *Dispose Spoils*, in Chapter 3, DWR will collaborate with USFWS and CDFW to develop and implement a sediment reintroduction plan that provides the desired beneficial habitat effects of maintained turbidity while addressing related permitting concerns (the proposed sediment reintroduction is expected to require permits from the Water Control Board and USACE). This would mitigate the effects of sediment removal by the NDD.

6.1.3.5.3.1 Migrating Adults (December-March)

6.1.3.5.3.1.1 Individual-Level Effects

As described previously for south Delta entrainment, some adult Delta Smelt migrate upstream in response to winter increases in suspended sediment and flow (Grimaldo *et al.* 2009). Suspended sediment may conceal Delta Smelt from visual predators (reviewed by Sommer and Mejia 2013), so that increases in water clarity may result in lower survival. Turbidity could also influence Delta Smelt's sampling gear avoidance, as suggested by Latour (2015). Given the timing of the upstream migration in the often high-flow winter months, during which suspended sediment concentration is greatest (Table 6.1-20), removal of sediment by the NDD may have limited adverse effects on individual Delta Smelt because the transparency of inflowing Sacramento River would not be expected to be altered in real-time. To the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern rather than a real-time concern for individual migrating adult Delta Smelt.

6.1.3.5.3.1.2 Population-Level Effects

Following from the discussion of individual-level effects, population-level adverse effects on migrating adult Delta Smelt from sediment removal by the NDD may be limited by the occurrence of this life stage in higher flow months, when suspended sediment concentration often is relatively high. The population-level impact of sediment removal at the NDD cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. As previously described, DWR will collaborate with USFWS and CDFW to develop and implement a sediment reintroduction plan that provides the desired beneficial habitat effects of maintained turbidity while addressing related permitting concerns.

Table 6.1-20. Mean Monthly Suspended Sediment in the Sacramento River at Freeport, 1957-2014 (mg/l).

Month	Concentration
January	99
February	104
March	86
April	63
May	51
June	34
July	32
August	29
September	33
October	28
November	40
December	77

Source:
http://waterdata.usgs.gov/nwis/monthly/?referred_module=sw&site_no=11447650&por_11447650_4=2209860,80154,4,1956-10,2014-09&start_dt=1956-10&end_dt=2014-09&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list. Accessed: September 17, 2015.

6.1.3.5.3.2 Spawning Adults (February-June)

6.1.3.5.3.2.1 Individual-Level Effects

Given the timing of the upstream migration in the often high-flow winter months, during which suspended sediment concentration is greatest (Table 6.1-20), removal of sediment by the NDD may have limited adverse effects on individual Delta Smelt because the transparency of inflowing Sacramento River would not be expected to be altered in real-time. To the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern, for individual Delta Smelt. However, as described in Section 3.2.10.6, *Dispose Spoils*, DWR will collaborate with CDFW and USFWS to develop and implement a sediment reintroduction plan that would mitigate the effects of sediment removal by the NDD.

6.1.3.5.3.2.2 Population-Level Effects

The population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.5.3.3.1 Individual-Level Effects

Increases in water clarity during the latter parts of spring when river inflow’s suspended sediment concentration goes down (Table 6.1-20) may have the potential to result in adverse effects to individual Delta Smelt eggs/embryos should they become more visible to predators. To the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern for individual Delta Smelt. As described for other life stages, development and implementation of a sediment reintroduction plan would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.3.2 Population-Level Effects

As noted for spawning Delta Smelt, the population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.3.4.1 Individual-Level Effects

As noted earlier, water clarity is related to larval/young juvenile Delta Smelt feeding success (Baskerville-Bridges *et al.* 2004) and spatial distribution (Sommer and Mejia 2013). As with eggs/embryos and the latter portion of the spawning adult life stage, the occurrence of larval/young juvenile Delta Smelt bridges the transition between higher flow winter months and lower flow summer months, during which time the suspended sediment concentration in inflowing Sacramento River water decreases and resuspension of sediment delivered in the higher flow months becomes more important. As noted for other life stages, to the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern for individual Delta Smelt. Development and implementation of a sediment reintroduction plan would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.4.2 Population-Level Effects

As noted for other life stages, the population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.3.5.1 Individual-Level Effects

Occurrence of juvenile Delta Smelt during the low-flow time of year when suspended sediment concentration in inflow is at a minimum (Table 6.1-20) suggests that the NDD's removal of sediment could affect individual juvenile Delta Smelt by increasing water clarity, given the importance of resuspension of sediment delivered to the estuary by higher flows in winter/early spring. As noted for other life stages, to the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern for individual Delta Smelt. Development and implementation of a sediment reintroduction plan would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.5.2 Population-Level Effects

As noted for other life stages, the population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD., *Dispose Soils*

6.1.3.5.4 Entrainment of Food Web Materials

As highlighted by Arthur *et al.* (1996), Jassby and Cloern (2000) and Jassby *et al.* (2002), and the USFWS (2008) BiOp, CVP/SWP water exports directly entrain phytoplankton and zooplankton which are the base of the food web supporting the production of Delta Smelt. Although these food web materials are exported (and export-related hydrodynamics limit transport of a lot of production into Suisun Bay; Jassby and Cloern 2000), it is not known whether export losses greatly affect overall fish production because other large impacts are also occurring in tandem (clam grazing and ammonium inhibition of per capita diatom growth rates). Entrainment of phytoplankton and zooplankton by the south Delta export facilities generally would be expected to be somewhat less under the PA, but the NDD would add a new source of loss along the Sacramento River. The impact of this was examined using an assessment of phytoplankton carbon entrained, based on cholorophyll *a* concentration data for Hood (representing the load of entrained phytoplankton), in relation to the biomass of phytoplankton in the Delta (taken from Antioch chlorophyll *a* data, multiplied up to the volume of the Delta). The methods for this analysis are presented in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6A.4.2. This analysis is essentially an approximation of potential entrainment of phytoplankton carbon load that could be entrained by the NDD. Factors that could offset any potential effects to Delta Smelt include the in situ productivity of phytoplankton carbon within the Delta, which could be relatively large, and reduced entrainment of phytoplankton carbon by the south Delta export facilities under the PA. These factors are discussed qualitatively in the analysis.

Median (50^{th} percentile) estimates of phytoplankton carbon load entrained by the NDD ranged from around 0.2 metric tons/day in April and May (5^{th} to 95^{th} percentile ranges were 0.00–0.02 to ~ 1.8 metric tons/day) to ~ 1.6 metric tons/day in February (5^{th} to 95^{th} percentile range ~ 0.13 to 5.7 metric tons/day) (Table 6.1-21). Estimates of phytoplankton carbon biomass in the Delta for 2004–2015 ranged from just under 23 metric tons (December 2011) to over 230 metric tons (May 2010) (Table 6.1-22). Thus, the percentage of Delta phytoplankton carbon biomass estimated to be entrained by the NDD ranged from 0.0% based on the 5^{th} percentile of entrained load estimates at the NDD during several months up to 12% at the 95^{th} percentile load estimate combined with the minimum biomass estimate in December (Table 6.1-23). The median estimates of total fraction of phytoplankton biomass removed by the NDDs ranged from ~ 0.5% to 2% per month when compared to minimum Delta phytoplankton carbon biomass estimates, down to ~ 0.1% to 1% when compared to maximum Delta phytoplankton carbon biomass estimates. On the basis of the 95^{th} percentiles, it appears that the NDD would seldom if ever entrain more than ~5% of the Delta's standing stock of phytoplankton in any given month.

Table 6.1-21. Percentiles of Phytoplankton Carbon Load Estimated to be Entrained (metric tons/day) by the NDD.

Month	Min.	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	Max.
Jan.	0.00	0.11	0.13	0.17	0.21	0.29	0.50	1.20	1.88	2.28	3.18	4.31	35.16
Feb.	0.00	0.13	0.17	0.25	0.41	1.01	1.62	2.09	2.52	3.03	4.24	5.35	11.51
Mar.	0.00	0.11	0.17	0.26	0.45	0.91	1.33	1.85	2.38	2.89	3.48	3.90	8.51
Apr.	0.00	0.00	0.01	0.04	0.07	0.13	0.20	0.30	0.47	0.70	1.22	1.76	12.95
May	0.00	0.02	0.04	0.07	0.10	0.14	0.19	0.26	0.38	0.58	1.09	1.77	10.78
Jun.	0.05	0.11	0.13	0.17	0.24	0.40	0.65	0.93	1.20	1.48	2.01	2.51	4.80
Jul.	0.00	0.03	0.06	0.40	0.65	0.91	1.12	1.34	1.51	1.66	2.10	2.44	3.77
Aug.	0.00	0.02	0.03	0.07	0.20	0.47	0.64	0.82	0.99	1.27	1.56	1.89	3.15
Sep.	0.00	0.01	0.04	0.15	0.22	0.30	0.37	0.46	0.56	0.73	1.12	1.43	5.35
Oct.	0.00	0.00	0.01	0.04	0.13	0.24	0.33	0.43	0.55	0.69	0.92	1.13	2.82
Nov.	0.00	0.00	0.01	0.04	0.14	0.22	0.33	0.46	0.64	0.91	1.32	1.67	4.73
Dec.	0.00	0.03	0.07	0.13	0.17	0.20	0.24	0.30	0.42	0.81	2.08	2.76	9.72

Note: Values in shaded cells were used in subsequent estimation of percentage of Delta biomass entrained by the NDD.

Table 6.1-22. Mean Daily Biomass (metric tons) of Phytoplankton Carbon Estimated to be Present in the Delta During 2004-2015.

Month	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Min.	Max.
Jan.		125.3	109.2	62.9	139.3	92.3	127.0	71.3	66.7	104.6	66.7	140.1	62.9	140.1
Feb.		95.8	75.2	124.4	122.0	109.4	110.8	82.5	133.8	104.8	122.6	129.4	75.2	133.8
Mar.		132.6	81.6	107.0	116.8	110.1	106.1	123.4	117.8	162.3	125.7	174.8	81.6	174.8
Apr.		96.7	115.9	46.1	156.8	129.4	142.1	89.4	115.4	155.3	116.2	148.1	46.1	156.8
May		96.9	85.1	51.3	110.0	88.6	231.2	47.2	82.3	124.2	86.8	103.4	47.2	231.2
Jun.		90.1	78.1	53.7	95.9	81.1	81.5	46.5	80.3	69.2	66.4	104.7	46.5	104.7
Jul.		100.2	76.6	67.1	83.0	64.3	76.7	66.0	77.6	50.1	70.5	109.4	50.1	109.4
Aug.		74.4	60.2	83.0	76.0	63.6	62.9	89.7	66.7	46.2	84.2		46.2	89.7
Sep.	36.2	49.6	79.7	124.9	71.8	61.9	72.3	84.3	53.6	43.0	84.8		36.2	124.9
Oct.	31.6	75.8	76.2	112.5	59.4	88.3	63.5	106.6	106.8	42.2	73.6		31.6	112.5
Nov.	41.1	61.8	50.6	56.5	61.4	75.3	48.6	112.0	49.4	51.7	76.5		41.1	112.0
Dec.	41.5	71.6	58.3	78.7	72.9	72.5	56.5	22.8	106.0	69.2	121.6		22.8	121.6

Note: Values in shaded cells were used in subsequent estimation of percentage of Delta biomass entrained by the NDD.

Table 6.1-23. Range of Percentage of Phytoplankton Carbon Biomass in the Delta Estimated to be Entrained by the NDD.

Month	Based on Minimum Biomass				Based on Maximum Biomass		
	5%	50%	95%		5%	50%	95%
Jan.	0.2%	0.8%	6.8%		0.1%	0.4%	3.1%
Feb.	0.2%	2.2%	7.1%		0.1%	1.2%	4.0%
Mar.	0.1%	1.6%	4.8%		0.1%	0.8%	2.2%
Apr.	0.0%	0.4%	3.8%		0.0%	0.1%	1.1%
May	0.1%	0.4%	3.7%		0.0%	0.1%	0.8%
Jun.	0.2%	1.4%	5.4%		0.1%	0.6%	2.4%
Jul.	0.1%	2.2%	4.9%		0.0%	1.0%	2.2%
Aug.	0.0%	1.4%	4.1%		0.0%	0.7%	2.1%
Sep.	0.0%	1.0%	3.9%		0.0%	0.3%	1.1%
Oct.	0.0%	1.1%	3.6%		0.0%	0.3%	1.0%
Nov.	0.0%	0.8%	4.1%		0.0%	0.3%	1.5%
Dec.	0.1%	1.1%	12.1%		0.0%	0.2%	2.3%

The loss of phytoplankton carbon at the NDD also must be considered in the context of all CVP/SWP water diversions because inflows to and exports from the Delta strongly affect the flux of bioavailable carbon into the confluence and Suisun Bay (Arthur *et al.* 1996; Jassby and Cloern 2000). If used as the only source for Delta exports and without any change in total Delta exports, the NDD would in principle increase the export of biological productivity to the western Delta and Suisun Bay because the San Joaquin River is much richer in its organic matter load than the Sacramento River (Jassby and Cloern 2000). The PA does not cease exports from the south Delta, but it does reduce them considerably, generally by half or more: the long-term (1922–2003) average reduction compared to NAA from the CalSim modeling ranged from 45% less under PA in January to ~70% less in October; only in December (12% less under the PA) were the differences not close to half or more (Appendix 5.A, *CALSIM Methods and Results*, Figures 5.A.6-27-1 to 5.A.6-27-19 and Table 5.A.6-27). Jassby *et al.* (2002) estimated that on average during spring through fall, the Delta produces 44 metric tons/day of phytoplankton carbon and another 12 metric tons/day flows into the Delta from its tributaries. Of that 56 tons/day, the south Delta export facilities remove ~8 metric tons/day or about 14% (Jassby *et al.* 2002)[16]. It is anticipated that the overall long-term ~50% reduction in south Delta exports will increase the loading of relatively productive San Joaquin River water to the western Delta and Suisun Bay (Table 6.1-24) and therefore should offset some or all of the loss attributable to the NDD, and perhaps could even provide a net beneficial effect.

[16] An additional ~5 metric tons per day were estimated to be removed by agricultural diversions. Such losses would present under both the NAA and PA.

Table 6.1-24. Mean Percentage of Water at Collinsville Originating in the San Joaquin River, from DSM2-QUAL Fingerprinting.

Month	Wet			Above Normal			Below Normal			Dry			Critical		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
Jan	1.3	3.4	2.1 (63%)	0.1	0.8	0.7 (92%)	0.2	0.5	0.3 (68%)	0.4	1.2	0.7 (63%)	0.2	0.2	0.0 (24%)
Feb	2.1	5.5	3.4 (62%)	1.0	3.0	2.0 (67%)	0.5	2.8	2.3 (83%)	0.3	1.2	0.9 (79%)	0.1	0.3	0.2 (66%)
Mar	4.1	11.4	7.3 (64%)	1.9	6.8	4.9 (72%)	1.4	5.0	3.7 (72%)	0.9	2.7	1.8 (67%)	0.3	1.0	0.7 (71%)
Apr	8.5	15.6	7.0 (45%)	4.2	11.7	7.5 (64%)	2.0	6.0	4.1 (67%)	1.6	3.9	2.4 (61%)	0.6	1.7	1.2 (68%)
May	13.6	19.8	6.3 (32%)	10.0	16.6	6.6 (40%)	5.7	9.7	4.1 (42%)	3.7	6.5	2.8 (43%)	0.9	2.3	1.4 (60%)
Jun	11.3	21.4	10.0 (47%)	8.5	15.1	6.7 (44%)	4.9	8.5	3.6 (43%)	3.3	6.0	2.7 (45%)	1.1	2.4	1.3 (55%)
Jul	5.5	14.5	8.9 (62%)	2.0	6.3	4.3 (68%)	1.3	3.4	2.1 (62%)	0.9	2.4	1.5 (62%)	0.6	1.5	0.9 (58%)
Aug	1.8	6.3	4.5 (71%)	0.2	1.6	1.4 (85%)	0.2	0.9	0.7 (80%)	0.2	0.8	0.6 (75%)	0.2	0.6	0.4 (61%)
Sep	0.2	1.9	1.6 (89%)	0.0	0.5	0.4 (91%)	0.0	0.3	0.3 (86%)	0.1	0.3	0.2 (76%)	0.1	0.3	0.1 (58%)
Oct	0.1	3.1	3.0 (96%)	0.0	0.7	0.7 (98%)	0.0	0.3	0.3 (94%)	0.0	0.2	0.2 (85%)	0.1	0.1	0.1 (53%)
Nov	0.6	9.6	9.0 (94%)	0.1	3.9	3.8 (98%)	0.1	1.2	1.1 (95%)	0.1	0.7	0.6 (89%)	0.1	0.4	0.2 (59%)
Dec	0.8	5.1	4.3 (84%)	0.1	3.2	3.1 (98%)	0.1	0.7	0.6 (89%)	0.2	0.6	0.5 (71%)	0.2	0.3	0.1 (39%)

CalSim estimates of total Delta exports also provide context for the difference in potential food web productivity between PA and NAA: total Delta exports on average (1922–2003) would be somewhat greater under PA (almost 4.9 million acre feet/year) than under NAA (just under 4.7 million acre feet/year). In general, total Delta exports would be less under PA than NAA in September-November; similar in April-May and August; and generally lower under PA than NAA in the remaining months, to varying degrees (Appendix 5.A, *CALSIM Methods and Results*, Figures 5.A.6-28-1 to 5.A.6-28-19 and Table 5.A.6-28). If phytoplankton availability was a linear function of SWP/CVP exports, then the annual average change in biomass would be around -4%. However, the timing of differences in exports in relation to different life stages is important, and consideration should also be made of the in situ productivity that would occur in the Delta, and the relative contribution of this to the Delta Smelt food web. This is addressed in the analyses of effects to the different Delta Smelt life stages, presented next.

6.1.3.5.4.1 Migrating Adults (December-March)

6.1.3.5.4.1.1 Individual-Level Effects

The primary mechanisms by which entrainment of planktonic organisms might affect individual Delta Smelt is by temporarily reducing density of zooplankton immediately downstream of the NDDs or by reducing the load of phytoplankton further into the estuary, causing some unknown reduction in food for the zooplankton that Delta Smelt eat. These are highly unlikely to cause starvation of any individual Delta Smelt and would most likely fall between no effect and some immeasurably small impact on growth rates of individual fish.

6.1.3.5.4.1.2 Population-Level Effects

At the population level, the effects of entrainment of phytoplankton carbon are likely to be low in terms of affecting Delta Smelt prey abundance. As noted by Baxter *et al.* (2010: 59) and the IEP MAST Team (2015: 76), there has been little study of prey importance for adult Delta Smelt, and there is no evidence for food limitation in the adult life stage.

6.1.3.5.4.2 Spawning Adults (February-June)

6.1.3.5.4.2.1 Individual-Level Effects

As described for migrating adults, the primary mechanisms by which entrainment of planktonic organisms might affect individual Delta Smelt is by temporarily reducing density of zooplankton immediately downstream of the NDDs or by reducing the load of phytoplankton further into the estuary causing some unknown reduction in food for the zooplankton that Delta Smelt eat. These are highly unlikely to cause starvation of any individual Delta Smelt and would most likely fall between no effect and some immeasurably small impact on growth rates of individual fish.

6.1.3.5.4.2.2 Population-Level Effects

As described for migrating adults, at the population level, the effects of entrainment of phytoplankton carbon are likely to be low in terms of affecting Delta Smelt prey abundance. As previously described, there has been little study of prey importance for adult Delta Smelt, and there is no evidence for food limitation in the adult life stage.

6.1.3.5.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.5.4.3.1 Individual-Level Effects

This life stage does not feed externally and so would not be affected by entrainment of food web materials.

6.1.3.5.4.3.2 Population-Level Effects

As stated for individual effects, this life stage does not feed externally and so would not be affected by entrainment of food web materials.

6.1.3.5.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.4.4.1 Individual-Level Effects

As with adult Delta Smelt, lower loads of phytoplankton carbon into the estuary because of NDD entrainment could translate into less food for individual Delta Smelt larvae and young juveniles, but this is not an assured outcome. It was estimated that a range from less than 0.1% to over 5% of phytoplankton carbon entering the Delta could be entrained by the NDD in March–June (Table 6.1-23). However, the phytoplankton has to be converted into copepod biomass to be prey for larval Delta Smelt and that process is not always directly related to phytoplankton density as indexed by chlorophyll *a* concentrations in the water (e.g., Kimmerer 2002). Given lower south Delta exports when north Delta exports are relatively high, there may be a net increase in phytoplankton carbon production in the Delta due to higher loading from the comparatively productive San Joaquin River that could offset some or possibly even all of the loss estimated for the NDD, and perhaps could even provide a net beneficial effect.

6.1.3.5.4.4.2 Population-Level Effects

The feeding success of Delta Smelt larvae appears to be related to prey density (Nobriga 2002). Some statistical analyses of Delta Smelt population dynamics have shown evidence that prey abundance for Delta Smelt during the larval and early juvenile life stage affects Delta Smelt abundance (Maunder and Deriso 2011; Miller *et al.* 2012), while others have found less support for this hypothesis (Mac Nally *et al.* 2010; Thomson *et al.* 2010). The hypothesis was also not supported in a recent empirical study of Delta Smelt feeding ecology and food limitation (Slater and Baxter 2014). In this study, evidence of food limitation was greater for juvenile fish in the late summer than it was for larvae or small juveniles during the late spring. Most likely, food limitation would act as a chronic problem extending across multiple life stages (Rose *et al.* 2013a,b). Less phytoplankton carbon loading to the estuary because of NDD entrainment could reduce the abundance of Delta Smelt's zooplankton prey. However, the estimates of phytoplankton carbon entrainment were not large (up to 5.4% at the higher end 95^{th} percentile (Table 6.1-22). This, in conjunction with observations that in situ production of phytoplankton carbon within the Delta is several times greater than inputs from freshwater inflow (Jassby *et al.* 2002) and that this in situ production is the dominant supply to the planktonic food web that includes Delta Smelt (Sobczak *et al.* 2002), suggests that the entrainment of phytoplankton carbon by the NDD would only have a minor, if any, adverse population-level effect, particularly given the offsetting increases in relatively more productive San Joaquin River water during these months (Table 6.1-24).

6.1.3.5.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.4.5.1 Individual-Level Effects

The empirical evidence for food limitation during this life stage is generally stronger than it is for other life stages (Slater and Baxter 2014; Hammock *et al.* 2015). Thus, lower phytoplankton carbon load available to the food web (as a result of NDD entrainment) could result in less prey for individual juvenile Delta Smelt. During July-November, it was estimated that less than 5% of phytoplankton standing stock could be entrained by the NDD (95th percentile for high end estimates; Table 6.1-23). It is possible this loss will be offset by higher loading of phytoplankton from the San Joaquin River such that there is no effect to individual Delta Smelt.

6.1.3.5.4.5.2 Population-Level Effects

As described in the Individual-Level Effects section, there could be less prey available for juvenile Delta Smelt because of NDD exports. It is possible this loss will be offset by higher loading of phytoplankton from the San Joaquin River, as well as in situ production of phytoplankton, such that there is no effect to the Delta Smelt population.

6.1.3.5.5 Microcystis

The toxic cyanobacteria *Microcystis* has been shown to have negative effects on the aquatic foodweb of the Delta (Brooks *et al.* 2012), principally in the south Delta and the middle to upper portions of the west/central Delta near locations such as Antioch, and Franks Tract (Lehman *et al.* 2010). As reviewed by Brooks *et al.* (2012), *Microcystis* could affect Delta Smelt through direct ingestion, consumption of prey containing high concentrations of toxins, or toxic effects to prey leading to lower prey abundance. *Microcystis* blooms generally occur from June to October, when water temperature is at least 19°C (Lehman *et al.* 2013)[17]. However, this analysis focused on July-November to stay consistent with the general timing of Delta Smelt's juvenile life stage, which co-occurs with *Microcystis* blooms. Lehman *et al.* (2013) suggested that net flows are probably the most important factor maintaining *Microcystis* blooms because low flows with longer residence times allow the slow-growing colonies to accumulate into blooms. Other factors including nutrients are also of importance to *Microcystis* (Lehman *et al.* 2014), but these are not readily predictable for comparison of the NAA and PA scenarios, which introduces some uncertainty to the results.

The potential effects of PA water operations on *Microcystis* were assessed using two approaches. First, the frequency of flow conditions conducive to *Microcystis* occurrence (as defined by Lehman *et al.* 2013) was assessed in the San Joaquin River past Jersey Point (QWEST) and in the Sacramento River at Rio Vista (QRIO), based on DSM2-HYDRO modeling. Second, DSM2-QUAL water temperature modeling (Section 6.1.3.5.2, *Water Temperature*) and DSM2-PTM for estimates of residence time (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.4.3, methods discussion) were used to inform the potential for *Microcystis* occurrence, given the importance of water temperature and the probable importance of residence time (although there are no published relationships between *Microcystis* occurrence and residence time in the Delta). Note that more weight is placed on the analysis based on the published flow conditions at which *Microcystis* occurs (Lehman *et al.* 2013), because there are

[17] During the current drought conditions, *Microcystis* has been detected in appreciable quantities in December, presumably because relatively warm temperatures and low inflow have favored growth beyond the typical period of occurrence.

no published analyses between *Microcystis* occurrence and residence time. Both sets of quantitative analyses (*i.e.*, the flow analysis and the residence time/temperature analysis) focused on the summer/fall (July-November) period because it is during this time of the year that *Microcystis* blooms are likely to occur. Note that other factors including nutrients are also of importance to *Microcystis* (Lehman *et al.* 2014), but these are not readily predictable for comparison of the NAA and PA scenarios, which introduces some uncertainty to the results based only on flow or residence time/temperature.

The first analysis examined the frequency of years during July-November in which mean monthly flows were within the range at which *Microcystis* has been shown to occur, per Lehman *et al.* (2013: 155): -240 to 50 m^3/s (approx. -8,500 to 1,800 cfs) for QWEST, and 100-450 m^3/s (approx. 3,500 to 15,900 cfs) for QRIO[18]. This analysis suggested that flow conditions conducive to *Microcystis* bloom occurrence would tend to occur less frequently under the PA than NAA in the San Joaquin River, based on QWEST. For NAA, the percentage of years with QWEST within the range for *Microcystis* occurrence ranged from 89% in October to 98% in August, whereas for PA, the range was from 9% of years in October to 99% of years in August (Table 6.1-25). In neither the NAA nor the PA scenario were mean monthly flows below the range noted for *Microcystis* occurrence, whereas for PA there were substantially more years above the range than for NAA. The results reflected greater mean QWEST flows under the NAA compared to PA, with monthly means under the PA ranging from just under 0 m^3/s (-100 cfs) in August (compared to -168 m^3/s or -5,900 cfs under NAA) to 245 m^3/s (8,600 cfs) in October (compared to 16 m^3/s or 570 cfs under NAA). These results are attributable to less south Delta export pumping under PA than NAA.

[18] The DSM2-HYDRO output locations used for estimating QWEST were RSAN018 + SLTRM004 + SLDUT007; and for QRIO was RSAC101.

Table 6.1-25.Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the San Joaquin River Past Jersey Point (QWEST) Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman *et al.* 2013).

	NAA					PA			
	Below Range (< -240 m^3/s)	Within Range (-240 to 50 m^3/s)	Above Range (> 50 m^3/s)	Mean Flow, m^3/s (cfs)		Below Range (< -240 m^3/s)	Within Range (-240 to 50 m^3/s)	Above Range (> 50 m^3/s)	Mean Flow, m^3/s (cfs)
July	0%	95%	5%	-162 (-5,714)		0%	78%	22%	68 (2,384)
August	0%	98%	2%	-168 (-5,931)		0%	99%	1%	-3 (-103)
September	0%	96%	4%	-128 (-4,531)		0%	52%	48%	191 (6,729)
October	0%	89%	11%	16 (568)		0%	9%	91%	245 (8,637)
November	0%	91%	9%	-39 (-1,391)		0%	53%	47%	178 (6,281)

Implementation of north Delta export pumping under the PA would result in less Sacramento River flow compared to NAA, as reflected in the examination of QRIO (Table 6.1-26). The percentage of years within the range at which *Microcystis* has been noted to occur ranged from 59% in September to 89% in August under NAA, compared to a range from 48% in September to 96% in July for PA (Table 6.1-26). Given that Lehman *et al.'s* (2013) suggested mechanism for the importance of flow was lower flows leading to sufficiently long residence time to allow *Microcystis* colonies to accumulate into blooms, flows below the range noted for *Microcystis* occurrence by Lehman *et al.* (100-450 m^3/s) could also be favorable for bloom occurrence, whereas flows above the range may reduce residence time sufficiently to limit bloom formation. The percentage of years in which mean monthly flow was above the range that Lehman *et al.* (2013) found for *Microcystis* occurrence was less under PA than NAA in July (0%, compared to 10% under NAA), September (0%, compared to 29% under NAA), and November (10%, compared to 16% under NAA). On the basis of differences in QRIO flow, therefore, there could be greater potential for *Microcystis* occurrence in the lower Sacramento River under the PA than NAA. However, this is presently not an area of intense *Microcystis* blooms and if it remains turbid in the future, it is expected that current conditions will continue.

Table 6.1-26.Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the Sacramento River at Rio Vista Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman *et al.* 2013).

	NAA					PA			
	Below Range (< -100 m^3/s)	**Within Range (-100 to 450 m^3/s)**	**Above Range (> 450 m^3/s)**	**Mean Flow, m^3/s (cfs)**		**Below Range (< -100 m^3/s)**	**Within Range (-100 to 450 m^3/s)**	**Above Range (> 450 m^3/s)**	**Mean Flow, m^3/s (cfs)**
July	5%	85%	10%	702 (24,793)		4%	96%	0%	396 (13,984)
August	11%	89%	0%	462 (16,331)		11%	89%	0%	282 (9,942)
September	12%	59%	29%	754 (26,612)		52%	48%	0%	457 (16,136)
October	15%	84%	1%	420 (14,839)		15%	84%	1%	291 (10,275)
November	7%	77%	16%	769 (27,162)		0%	90%	10%	541 (19,097)

The results of the DSM2-PTM-based residence time analysis presented here focus only on the particle insertion locations upstream (east) of Suisun Bay and Suisun Marsh, because this is where effects of the proposed action (PA) on hydraulic residence time are highest. The effects of the PA on residence time varied by subregion. As previously described, there has been no published analysis of the relationship between *Microcystis* occurrence and residence time, so there is uncertainty as to what the differences described here may mean in terms of potential for *Microcystis* occurrence. The results showed that regions with short residence times sometimes are predicted to have large proportional changes in residence time (e.g., locations near the NDDs) and regions with comparatively long residence times typically had moderate to low proportional changes in residence time (Table 6.1-27 through Table 6.1-47). Differences between NAA and PA ranged from almost no change in the Sacramento River Deepwater Shipping Channel to sometimes substantial increases in predicted residence times (e.g., Disappointment Slough where median predictions ranged from -3.8 to + 11.9 days, Mildred Island where median predictions ranged from + 5.8 to + 16.5 days, and Victoria Canal where median predictions ranged from + 3.0 to + 11.7 days). These results indicate that *Microcystis* may have considerably more opportunity for growth in parts of the southern Delta where water temperatures are relatively high during the summer and present-day blooms are often observed.

Table 6.1-27. Summary Statistics of Residence Time (Days) in the Upper Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.4	0.7	0.3 (65%)	0.6	1.2	0.6 (107%)	0.5	0.7	0.3 (57%)	0.5	1.1	0.7 (148%)	0.4	0.8	0.4 (99%)
25%	0.5	1.1	0.7 (135%)	0.6	1.5	0.8 (126%)	0.5	1.0	0.5 (83%)	0.8	1.4	0.7 (87%)	0.6	1.1	0.4 (69%)
50% (median)	0.5	1.2	0.7 (124%)	0.7	1.8	1.1 (164%)	1.2	2.2	1.0 (89%)	1.0	1.7	0.6 (63%)	1.0	1.4	0.4 (45%)
75%	0.8	1.4	0.6 (76%)	1.8	2.0	0.2 (14%)	2.4	2.7	0.4 (15%)	1.6	1.9	0.2 (13%)	1.8	1.7	0.0 (-2%)
95%	2.4	2.7	0.2 (9%)	3.2	3.1	0.0 (-1%)	20.1	11.5	-8.7 (-43%)	2.3	2.3	0.0 (0%)	16.2	10.6	-5.5 (-34%)

Table 6.1-28. Summary Statistics of Residence Time (Days) in the Sacramento River Near Ryde Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	0.4	0.1 (33%)	0.5	0.9	0.4 (69%)	0.5	0.6	0.1 (29%)	0.3	0.6	0.3 (76%)	0.4	0.7	0.3 (85%)
25%	0.5	0.8	0.4 (80%)	0.6	1.1	0.5 (89%)	0.5	0.7	0.2 (33%)	0.6	1.2	0.5 (83%)	0.5	0.9	0.4 (78%)
50% (median)	0.5	1.0	0.5 (89%)	0.7	1.3	0.6 (89%)	0.7	1.5	0.8 (113%)	0.9	1.5	0.6 (65%)	0.8	1.3	0.6 (72%)
75%	0.7	1.2	0.5 (65%)	1.3	1.8	0.5 (40%)	1.7	2.1	0.5 (29%)	1.4	1.7	0.2 (16%)	1.1	1.5	0.4 (32%)
95%	1.8	1.7	-0.1 (-6%)	2.4	2.7	0.2 (10%)	2.5	2.5	0.0 (0%)	2.1	2.3	0.2 (12%)	1.9	1.9	0.0 (-1%)

Table 6.1-29. Summary Statistics of Residence Time (Days) in the Sacramento River Ship Channel Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	43.3	43.4	0.1 (0%)	43.2	43.1	0.0 (0%)	43.2	43.2	0.0 (0%)	42.5	42.5	0.0 (0%)	39.8	39.7	-0.1 (0%)
25%	43.4	43.5	0.0 (0%)	43.3	43.4	0.1 (0%)	43.3	43.3	0.0 (0%)	43.4	43.3	0.0 (0%)	42.3	42.2	0.0 (0%)
50% (median)	43.6	43.6	0.0 (0%)	43.7	43.8	0.1 (0%)	43.7	43.7	0.1 (0%)	43.7	43.6	0.0 (0%)	43.1	43.1	0.0 (0%)
75%	44.0	44.1	0.0 (0%)	44.0	44.1	0.0 (0%)	43.9	44.0	0.0 (0%)	43.9	43.9	0.0 (0%)	44.1	44.0	0.0 (0%)
95%	44.3	44.3	0.0 (0%)	44.2	44.2	0.0 (0%)	44.3	44.3	0.1 (0%)	44.4	44.4	0.0 (0%)	44.3	44.3	0.0 (0%)

Table 6.1-30. Summary Statistics of Residence Time (Days) in the Cache Slough and Liberty Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	20.4	22.5	2.1 (10%)	16.5	19.5	3.0 (18%)	13.1	14.2	1.1 (8%)	11.4	13.8	2.4 (21%)	8.3	9.6	1.3 (15%)
25%	21.3	23.3	2.0 (9%)	17.2	20.8	3.6 (21%)	14.8	17.5	2.7 (18%)	14.6	17.1	2.4 (17%)	11.5	13.1	1.6 (14%)
50% (median)	22.0	23.8	1.8 (8%)	18.3	21.1	2.8 (15%)	16.1	18.7	2.7 (16%)	15.9	18.2	2.2 (14%)	13.4	14.5	1.2 (9%)
75%	22.7	25.1	2.4 (11%)	20.6	22.1	1.5 (7%)	18.2	21.1	2.9 (16%)	17.6	18.6	1.0 (6%)	14.9	15.6	0.7 (5%)
95%	25.8	27.0	1.2 (5%)	22.3	23.7	1.4 (6%)	22.5	22.3	-0.2 (-1%)	19.0	19.5	0.5 (3%)	16.7	16.4	-0.3 (-2%)

Table 6.1-31. Summary Statistics of Residence Time (Days) in the Sacramento River Near Rio Vista Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.4	2.0	0.7 (48%)	5.8	7.4	1.6 (27%)	3.2	1.8	-1.4 (-43%)	3.8	2.7	-1.1 (-29%)	3.6	3.9	0.3 (9%)
25%	6.6	7.7	1.2 (17%)	9.2	9.2	0.0 (0%)	5.0	2.7	-2.3 (-46%)	5.6	5.3	-0.3 (-5%)	5.0	5.3	0.3 (5%)
50% (median)	7.4	11.9	4.5 (60%)	10.4	13.6	3.2 (31%)	7.8	9.0	1.2 (16%)	9.2	8.1	-1.1 (-12%)	6.2	6.6	0.5 (7%)
75%	13.7	14.9	1.1 (8%)	14.7	17.0	2.3 (16%)	15.5	14.7	-0.8 (-5%)	11.9	10.2	-1.7 (-14%)	8.0	9.9	1.9 (24%)
95%	17.3	17.1	-0.2 (-1%)	17.9	19.6	1.7 (10%)	18.9	17.9	-1.0 (-5%)	15.9	14.7	-1.1 (-7%)	12.3	12.1	-0.2 (-2%)

Table 6.1-32. Summary Statistics of Residence Time (Days) in the Lower Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.2	4.7	1.6 (49%)	10.1	12.2	2.1 (21%)	4.8	3.5	-1.3 (-26%)	6.7	6.7	0.0 (0%)	6.1	6.0	-0.1 (-2%)
25%	9.1	12.3	3.2 (35%)	13.5	13.6	0.1 (1%)	7.0	4.4	-2.6 (-37%)	8.8	8.4	-0.4 (-5%)	7.5	7.4	-0.1 (-1%)
50% (median)	12.9	15.0	2.1 (17%)	17.4	18.7	1.3 (8%)	13.4	12.5	-0.9 (-7%)	13.4	12.9	-0.5 (-4%)	10.2	10.8	0.6 (6%)
75%	20.9	21.0	0.2 (1%)	21.7	23.4	1.7 (8%)	22.6	21.2	-1.5 (-6%)	18.4	16.9	-1.5 (-8%)	13.2	14.6	1.4 (11%)
95%	22.4	22.2	-0.2 (-1%)	23.5	24.4	0.9 (4%)	24.3	23.4	-0.9 (-4%)	20.9	20.5	-0.4 (-2%)	18.7	18.4	-0.3 (-1%)

Table 6.1-33. Summary Statistics of Residence Time (Days) in the Lower San Joaquin River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.1	4.6	1.4 (45%)	12.0	12.7	0.7 (6%)	5.5	3.7	-1.8 (-32%)	7.5	6.8	-0.7 (-9%)	7.1	5.2	-2.0 (-27%)
25%	11.3	13.0	1.7 (15%)	15.4	14.2	-1.2 (-8%)	10.4	4.3	-6.1 (-58%)	9.8	7.8	-2.0 (-21%)	9.6	8.1	-1.5 (-15%)
50% (median)	14.1	16.0	2.0 (14%)	17.8	18.3	0.5 (3%)	14.5	11.9	-2.6 (-18%)	13.4	11.5	-1.9 (-14%)	12.2	10.9	-1.3 (-11%)
75%	20.4	21.5	1.1 (5%)	22.4	23.3	1.0 (4%)	22.9	20.7	-2.2 (-10%)	19.9	16.7	-3.2 (-16%)	14.5	15.7	1.2 (8%)
95%	22.7	23.4	0.7 (3%)	24.8	25.2	0.4 (2%)	25.5	24.3	-1.1 (-4%)	22.3	21.0	-1.3 (-6%)	19.3	20.1	0.8 (4%)

Table 6.1-34. Summary Statistics of Residence Time (Days) in the San Joaquin River at Twitchell Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.7	3.1	0.4 (14%)	9.5	12.1	2.6 (27%)	8.1	4.3	-3.8 (-47%)	8.4	5.3	-3.2 (-38%)	7.6	6.0	-1.6 (-21%)
25%	10.2	13.5	3.3 (32%)	10.8	13.6	2.8 (26%)	10.3	5.9	-4.3 (-42%)	12.4	8.0	-4.3 (-35%)	10.6	9.6	-1.0 (-9%)
50% (median)	12.0	16.1	4.1 (35%)	12.6	17.0	4.5 (36%)	11.6	13.3	1.6 (14%)	14.5	11.8	-2.7 (-18%)	12.6	11.8	-0.8 (-6%)
75%	13.6	18.1	4.5 (33%)	19.4	20.4	1.1 (6%)	19.0	20.0	1.0 (5%)	18.2	16.9	-1.4 (-8%)	15.3	15.9	0.6 (4%)
95%	21.0	21.1	0.1 (0%)	23.4	22.2	-1.2 (-5%)	23.0	22.6	-0.4 (-2%)	20.8	20.2	-0.6 (-3%)	18.9	19.7	0.8 (4%)

Table 6.1-35. Summary Statistics of Residence Time (Days) in the San Joaquin River at Prisoners Point from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	2.7	3.0	0.3 (10%)		4.3	8.4	4.1 (95%)		4.4	5.3	0.9 (20%)		7.5	6.5	-1.0 (-14%)		3.9	6.6	2.7 (68%)
25%	4.9	9.7	4.7 (96%)		5.0	10.5	5.5 (109%)		5.4	7.7	2.3 (43%)		9.8	8.3	-1.5 (-15%)		7.4	8.4	1.0 (14%)
50% (median)	6.0	10.7	4.7 (79%)		6.3	11.0	4.7 (74%)		7.4	11.0	3.7 (50%)		10.7	11.0	0.3 (3%)		8.6	10.6	2.0 (24%)
75%	7.3	12.2	4.9 (66%)		12.5	13.3	0.9 (7%)		10.9	15.0	4.1 (38%)		14.1	14.8	0.7 (5%)		11.1	12.4	1.3 (11%)
95%	13.6	14.8	1.2 (9%)		18.7	16.2	-2.5 (-13%)		16.8	16.7	-0.1 (-1%)		16.5	17.2	0.7 (4%)		14.6	15.0	0.4 (3%)

Table 6.1-36. Summary Statistics of Residence Time (Days) in the North and South Forks Mokelumne River Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	4.9	8.7	3.8 (79%)		3.0	6.7	3.7 (126%)		3.9	5.8	1.9 (50%)		6.3	7.5	1.2 (18%)		5.6	5.3	-0.2 (-4%)
25%	12.6	15.6	3.0 (24%)		4.2	8.9	4.7 (112%)		6.7	8.7	2.0 (30%)		9.4	8.7	-0.7 (-7%)		7.1	9.7	2.6 (36%)
50% (median)	20.8	20.8	0.0 (0%)		8.3	11.9	3.6 (44%)		11.4	12.4	1.0 (9%)		10.0	10.7	0.7 (7%)		8.9	10.3	1.4 (16%)
75%	26.1	24.6	-1.5 (-6%)		17.2	17.9	0.7 (4%)		17.0	17.7	0.7 (4%)		13.6	14.0	0.4 (3%)		11.1	12.5	1.3 (12%)
95%	34.2	31.5	-2.7 (-8%)		27.2	20.1	-7.1 (-26%)		24.7	22.2	-2.5 (-10%)		21.5	16.6	-4.9 (-23%)		16.5	14.2	-2.3 (-14%)

Table 6.1-37. Summary Statistics of Residence Time (Days) in the Disappointment Slough Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	12.1	15.5	3.4 (29%)	10.9	18.2	7.2 (66%)	10.8	15.2	4.4 (40%)	13.2	9.5	-3.7 (-28%)	14.7	15.1	0.3 (2%)
25%	17.9	26.7	8.9 (50%)	20.8	20.9	0.1 (1%)	16.8	18.4	1.6 (9%)	15.8	17.8	2.0 (13%)	18.6	17.9	-0.6 (-3%)
50% (median)	25.0	36.9	11.8 (47%)	25.7	29.9	4.2 (16%)	20.6	23.0	2.4 (12%)	19.6	22.9	3.3 (17%)	24.8	21.0	-3.8 (-15%)
75%	34.0	39.4	5.5 (16%)	29.3	33.0	3.8 (13%)	23.3	25.1	1.8 (8%)	23.7	28.7	5.0 (21%)	29.0	29.6	0.7 (2%)
95%	38.2	41.9	3.7 (10%)	34.2	35.6	1.4 (4%)	27.5	29.3	1.8 (7%)	27.5	30.8	3.3 (12%)	34.9	33.2	-1.7 (-5%)

Table 6.1-38. Summary Statistics of Residence Time (Days) in the San Joaquin River Near Stockton Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.3	1.5	0.2 (12%)	3.2	3.9	0.7 (22%)	4.1	4.3	0.1 (4%)	3.0	3.5	0.5 (17%)	2.8	3.1	0.4 (13%)
25%	5.8	7.8	2.0 (35%)	6.5	8.0	1.5 (23%)	5.9	6.8	0.9 (16%)	4.1	5.1	1.0 (25%)	4.4	5.0	0.6 (14%)
50% (median)	13.9	11.7	-2.3 (-16%)	9.7	9.8	0.1 (1%)	6.7	8.6	1.9 (29%)	5.2	6.2	1.1 (21%)	5.7	6.8	1.1 (19%)
75%	18.1	13.0	-5.0 (-28%)	12.1	10.9	-1.1 (-9%)	8.7	9.8	1.1 (13%)	6.4	7.4	1.1 (17%)	7.5	7.6	0.2 (2%)
95%	29.2	23.0	-6.2 (-21%)	15.1	14.4	-0.7 (-5%)	10.0	11.0	1.1 (11%)	8.3	9.0	0.7 (8%)	8.7	9.3	0.6 (7%)

Table 6.1-39. Summary Statistics of Residence Time (Days) in the Mildred Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.0	7.1	4.1 (138%)	1.8	5.0	3.3 (183%)	2.0	7.4	5.4 (270%)	2.9	8.9	6.0 (205%)	2.1	4.1	2.0 (93%)
25%	4.4	15.5	11.1 (255%)	2.2	8.1	5.8 (262%)	3.2	9.2	6.0 (188%)	3.7	11.6	7.9 (215%)	3.0	6.1	3.1 (106%)
50% (median)	6.9	23.4	16.5 (238%)	3.7	9.5	5.9 (160%)	4.7	10.7	6.0 (127%)	5.2	13.0	7.8 (150%)	4.6	13.9	9.3 (205%)
75%	11.1	27.1	16.0 (144%)	13.6	11.9	-1.7 (-12%)	6.9	14.9	8.0 (115%)	9.5	16.5	7.0 (73%)	15.9	15.7	-0.2 (-1%)
95%	25.1	30.0	4.9 (20%)	19.3	19.6	0.3 (2%)	15.4	16.8	1.4 (9%)	21.6	22.6	1.0 (4%)	21.1	21.5	0.4 (2%)

Table 6.1-40. Summary Statistics of Residence Time (Days) in the Holland Cut Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.4	3.8	2.4 (169%)	1.2	3.7	2.4 (198%)	1.5	4.7	3.3 (225%)	2.5	6.5	3.9 (156%)	1.8	3.3	1.5 (81%)
25%	2.0	4.2	2.2 (114%)	1.6	5.1	3.5 (226%)	1.8	5.5	3.7 (208%)	3.4	8.0	4.6 (134%)	2.6	4.0	1.4 (52%)
50% (median)	2.5	4.8	2.3 (95%)	2.4	5.7	3.3 (139%)	3.0	7.5	4.5 (154%)	3.9	8.6	4.7 (123%)	3.3	5.8	2.5 (75%)
75%	3.5	6.0	2.5 (73%)	5.4	6.6	1.1 (21%)	5.7	8.8	3.1 (55%)	5.8	9.1	3.3 (57%)	4.9	8.5	3.7 (76%)
95%	5.6	6.8	1.2 (22%)	9.8	7.8	-2.0 (-21%)	9.7	9.7	-0.1 (-1%)	7.5	9.8	2.3 (31%)	6.9	9.6	2.8 (41%)

Table 6.1-41. Summary Statistics of Residence Time (Days) in the Franks Tract Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	9.4	10.7	1.2 (13%)	10.0	11.1	1.1 (11%)	9.0	8.2	-0.8 (-9%)	9.1	8.6	-0.5 (-5%)	8.1	8.0	-0.1 (-1%)
25%	10.9	12.2	1.3 (12%)	10.9	13.2	2.4 (22%)	10.3	9.4	-0.8 (-8%)	11.1	9.7	-1.5 (-13%)	11.2	10.3	-0.9 (-8%)
50% (median)	11.6	14.4	2.8 (24%)	11.9	16.1	4.3 (36%)	11.8	14.1	2.3 (20%)	13.9	12.5	-1.4 (-10%)	12.3	12.0	-0.3 (-3%)
75%	12.8	16.6	3.8 (30%)	17.0	17.8	0.8 (5%)	16.2	17.4	1.1 (7%)	15.4	13.8	-1.6 (-10%)	14.4	15.1	0.7 (5%)
95%	16.9	17.5	0.6 (3%)	18.0	19.9	1.9 (10%)	18.7	18.5	-0.2 (-1%)	18.6	17.0	-1.7 (-9%)	18.1	18.0	-0.1 (-1%)

Table 6.1-42. Summary Statistics of Residence Time (Days) in the Rock Slough and Discovery Bay Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	4.8	7.4	2.6 (54%)	3.9	8.5	4.6 (119%)	4.7	11.0	6.3 (135%)	5.4	8.4	3.0 (55%)	5.0	6.9	1.9 (37%)
25%	5.6	8.8	3.3 (59%)	5.3	9.7	4.4 (84%)	5.6	14.6	8.9 (159%)	7.3	10.0	2.8 (38%)	5.9	8.2	2.3 (39%)
50% (median)	6.4	10.0	3.7 (57%)	5.7	11.9	6.2 (109%)	6.8	17.5	10.7 (158%)	8.8	15.2	6.4 (72%)	7.5	9.8	2.2 (29%)
75%	7.3	11.4	4.1 (56%)	10.1	15.9	5.9 (58%)	16.6	19.3	2.7 (17%)	12.1	17.1	5.0 (42%)	10.8	12.1	1.3 (12%)
95%	10.7	13.9	3.1 (29%)	19.2	22.3	3.1 (16%)	19.8	25.2	5.4 (27%)	20.6	19.2	-1.4 (-7%)	12.2	13.6	1.5 (12%)

Table 6.1-43. Summary Statistics of Residence Time (Days) in the Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	1.5	1.0 (212%)	0.4	1.4	1.0 (275%)	0.6	1.7	1.1 (199%)	0.6	2.5	1.9 (304%)	0.7	1.3	0.6 (82%)
25%	0.7	1.8	1.1 (164%)	0.6	1.6	1.1 (189%)	0.8	2.5	1.7 (208%)	1.0	3.4	2.3 (228%)	0.9	1.7	0.8 (89%)
50% (median)	1.0	2.3	1.3 (131%)	1.0	2.0	1.0 (102%)	1.1	3.5	2.5 (231%)	1.3	5.9	4.6 (363%)	1.1	1.9	0.7 (64%)
75%	1.4	2.8	1.4 (101%)	2.0	2.5	0.5 (23%)	1.9	6.4	4.5 (243%)	1.7	8.0	6.4 (382%)	1.8	7.2	5.4 (299%)
95%	4.2	3.8	-0.3 (-8%)	4.1	4.8	0.7 (17%)	2.7	12.0	9.3 (347%)	2.4	12.0	9.6 (393%)	2.8	8.6	5.8 (205%)

Table 6.1-44. Summary Statistics of Residence Time (Days) in the Middle River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	0.8	0.3 (62%)	0.4	0.7	0.3 (78%)	0.4	1.1	0.7 (180%)	0.5	1.5	1.0 (196%)	0.4	0.7	0.3 (58%)
25%	0.6	1.1	0.6 (101%)	0.4	0.9	0.5 (114%)	0.4	1.2	0.7 (177%)	0.6	2.0	1.4 (228%)	0.6	0.9	0.3 (51%)
50% (median)	0.7	1.3	0.6 (93%)	0.5	1.0	0.5 (99%)	0.5	1.4	0.8 (155%)	0.7	2.8	2.1 (292%)	0.7	1.1	0.4 (63%)
75%	0.8	1.6	0.8 (100%)	0.9	1.1	0.3 (29%)	0.8	1.6	0.8 (95%)	1.0	7.9	7.0 (727%)	0.8	10.9	10.1 (1,218%)
95%	2.4	4.5	2.1 (88%)	1.9	1.7	-0.2 (-13%)	1.3	2.4	1.1 (84%)	1.2	18.0	16.8 (1351%)	1.1	11.8	10.7 (979%)

Table 6.1-45. Summary Statistics of Residence Time (Days) in the Victoria Canal Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	2.5	2.2 (713%)	0.2	0.5	0.3 (116%)	0.3	0.7	0.4 (170%)	0.3	3.7	3.4 (1082%)	0.3	0.5	0.2 (51%)
25%	0.3	7.4	7.0 (2074%)	0.3	2.2	2.0 (731%)	0.3	4.1	3.8 (1339%)	0.4	5.4	5.1 (1353%)	0.4	0.6	0.2 (57%)
50% (median)	1.3	13.0	11.7 (939%)	4.6	7.6	3.0 (64%)	1.2	7.2	5.9 (480%)	0.6	10.5	9.9 (1734%)	0.6	7.1	6.5 (1052%)
75%	10.0	19.9	9.9 (99%)	14.5	14.2	-0.3 (-2%)	10.6	11.6	1.0 (10%)	3.9	14.7	10.8 (278%)	4.9	11.1	6.2 (126%)
95%	16.8	25.4	8.7 (52%)	26.4	21.1	-5.3 (-20%)	20.4	19.9	-0.5 (-3%)	15.7	17.8	2.1 (13%)	12.3	14.1	1.8 (15%)

Table 6.1-46. Summary Statistics of Residence Time (Days) in the Grant Line Canal and Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.2	3.0	0.8 (35%)	9.3	9.3	-0.1 (-1%)	2.7	6.2	3.4 (125%)	3.6	3.1	-0.5 (-14%)	4.4	5.4	1.0 (23%)
25%	29.3	29.6	0.3 (1%)	20.2	23.5	3.2 (16%)	8.5	10.0	1.5 (18%)	6.7	4.3	-2.4 (-36%)	8.2	8.1	-0.1 (-1%)
50% (median)	38.7	40.0	1.4 (4%)	27.3	29.1	1.8 (6%)	16.9	23.3	6.4 (38%)	13.6	10.1	-3.4 (-25%)	11.8	9.2	-2.7 (-22%)
75%	40.4	41.0	0.6 (1%)	36.2	35.5	-0.7 (-2%)	32.9	35.8	3.0 (9%)	19.5	14.7	-4.8 (-24%)	14.4	11.2	-3.3 (-23%)
95%	42.8	42.0	-0.9 (-2%)	40.8	37.0	-3.8 (-9%)	38.1	38.0	-0.1 (0%)	24.2	24.8	0.6 (3%)	21.2	13.1	-8.0 (-38%)

Table 6.1-47. Summary Statistics of Residence Time (Days) in the Upper San Joaquin River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.2	0.2	0.0 (0%)	0.2	0.2	0.0 (-1%)	0.4	0.4	0.0 (-2%)	0.3	0.3	0.0 (16%)	0.3	0.3	0.0 (-8%)
25%	0.8	0.7	-0.1 (-11%)	0.9	0.8	-0.1 (-16%)	0.7	0.7	-0.1 (-10%)	0.5	0.6	0.1 (23%)	0.4	0.3	0.0 (-6%)
50% (median)	2.0	1.4	-0.7 (-33%)	1.5	1.2	-0.3 (-18%)	1.0	0.8	-0.1 (-13%)	0.6	0.7	0.1 (25%)	0.5	0.5	0.0 (-8%)
75%	3.3	1.8	-1.5 (-46%)	1.9	1.6	-0.3 (-15%)	1.2	1.1	-0.2 (-14%)	0.7	0.8	0.2 (27%)	0.6	0.6	0.0 (-7%)
95%	13.5	6.7	-6.8 (-50%)	2.8	2.4	-0.4 (-15%)	1.5	1.3	-0.2 (-16%)	0.8	0.9	0.1 (18%)	0.6	0.6	0.0 (-1%)

6.1.3.5.5.1 Migrating Adults (December–March)

6.1.3.5.5.1.1 Individual-Level Effects

Microcystis blooms occur during the summer and early fall so there will be no effect on migrating adult Delta Smelt during the winter months.

6.1.3.5.5.1.2 Population-Level Effects

As there would be no adverse effect to individual migrating adult Delta Smelt from *Microcystis,* there would likewise be no adverse population-level effect.

6.1.3.5.5.2 Spawning Adults (February–June)

6.1.3.5.5.2.1 Individual-Level Effects

Microcystis blooms occur during the summer and early fall so there will be no effect on adult Delta Smelt during the spring months. The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm an individual spawning adult Delta Smelt.

6.1.3.5.5.2.2 Population-Level Effects

The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm the population of spawning adult Delta Smelt.

6.1.3.5.5.3 Eggs/Embryos (Spring: ~March–June)

6.1.3.5.5.3.1 Individual-Level Effects

The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm individual Delta Smelt eggs.

6.1.3.5.5.3.2 Population-Level Effects

The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm Delta Smelt eggs.

6.1.3.5.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.5.4.1 Individual-Level Effects

There is some potential overlap in timing between larval life stages of Delta Smelt and *Microcystis* blooms. However, this impact is captured in the discussion of the juvenile stage which has most of the seasonal overlap with blooms.

6.1.3.5.5.4.2 Population-Level Effects

The very limited potential effects to individual larval/young juvenile Delta Smelt would be reflected in minimal population-level adverse effects to this life stage.

6.1.3.5.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.5.5.1 Individual-Level Effects

As previously discussed in the water temperature analysis, climate change is likely to increase summer water temperature but it is not clear whether the PA would change water temperature. The warming climate may however increase the length of the viable growing season for

Microcystis blooms and that effect would interact with PA-related changes in residence time and possibly other conditions (e.g., nutrient loads; Lehman *et al.* 2013) to affect the duration and intensity of blooms. The threshold could be reached earlier in the year under the PA (see previous discussion of timing shifts for spawning Delta Smelt), which would increase the length of exposure for Delta Smelt and their prey, although air temperature as opposed to flow (operations) is the primary driver of water temperature in the Delta (Wagner *et al.* 2011). On the basis of the previously presented analysis based on the published ranges of flows that *Microcystis* occurs at (Lehman *et al.* 2013), greater flows in the lower San Joaquin River (QWEST) under the PA generally would be expected to give somewhat less potential for *Microcystis* to occur in that area, relative to the NAA; under the PA, a greater percentage of years were above the range of flows at which *Microcystis* has occurred. Therefore, under the PA, individual juvenile Delta Smelt could experience a lower likelihood of lethal or sublethal effects, or have greater feeding opportunities if lower prevalence of *Microcystis* results in less toxicity to zooplankton prey or a greater abundance of phytoplankton available for zooplankton, for example (Lehman *et al.* 2010; Brooks *et al.* 2012). However, as summarized in the analysis of residence time presented at the start of this section, higher residence time was most evident in predictions for the central/south Delta subregions, but also occurred elsewhere to some extent, for instance in the lower Sacramento River (Chipps Island to Rio Vista) and the Cache Slough/Liberty Island area. With the possibility of longer duration and more intense *Microcystis* blooms resulting in part from longer residence time, individual juvenile Delta Smelt may experience a greater likelihood of lethal or sublethal toxicity, or have lower prey availability (Ger *et al.* 2009; 2010; Lehman *et al.* 2010; Acuña *et al.* 2012; Brooks *et al.* 2012).

6.1.3.5.5.5.2 Population-Level Effects

Most of the Delta Smelt population is not distributed in the southern Delta during the summer and fall because the water is too warm and too clear (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Therefore, the Delta Smelt population does not overlap the peak of the ***Microcystis*** bloom in space and time. Nonetheless, there is overlap in the low-salinity zone and Microcystis can be toxic to copepods so there is potential for the regionally higher residence times to intensify blooms that harm or kill Delta Smelt directly, by killing their prey, or by increasing toxin concentrations within their prey. In the lower San Joaquin River, the analysis based on QWEST flow suggested that generally there would be less potential for *Microcystis* occurrence under the PA. The analysis based on residence time showed that in portions of the south Delta there may be potential for greater *Microcystis* occurrence because of greater residence time, although there are no published relationships between *Microcystis* and residence time from which to make firm conclusions. There is potential to mitigate such effects through preferential south Delta export pumping: the modeling currently assumes that in the summer months (July–September), the first 3,000 cfs of exports would be from the south Delta, with any additional allowable exports able to be diverted from either the north or the south Delta, and preference for this additional pumping generally being given to the north Delta (because of higher water quality); it would be possible to shift to additional south Delta pumping as opposed to north Delta pumping in order to reduce water residence time, for example. Given that multiple factors affect *Microcystis* bloom occurrence and maintenance, the analysis presented here has some uncertainty given that only two factors—albeit very important factors—were examined.

6.1.3.6 Delta Cross Channel

6.1.3.6.1 Migrating Adults (December-March)

6.1.3.6.1.1 Individual-Level Effects

USFWS (2008: 174) suggested that "closures of the DCC for juvenile salmonid protection are likely to create more natural hydrologies in the Delta, by keeping Sacramento River flows in the Sacramento River and Georgiana Slough, which provide flow cues for migrating adult Delta Smelt." Closure of the DCC would occur during most, if not all, of the December-March upstream migration period of adult Delta Smelt, and essentially would not differ between NAA and PA (see Table 5.A.6-31 in Appendix 5.A, *CALSIM Methods and Results*). Therefore any individual-level effects on adult Delta Smelt (e.g., flow cues for migration) would be similar between NAA and PA.

6.1.3.6.1.2 Population-Level Effects

As noted for individual-level effects, any population-level effects of DCC closure (e.g., providing flow cues for migrating adult Delta Smelt) would be similar between NAA and PA scenarios.

6.1.3.6.2 Spawning Adults (February-June)

6.1.3.6.2.1 Individual-Level Effects

Given that the main effect of DCC operations on adult Delta Smelt may be on migrating adults (U.S. Fish and Wildlife Service 2008: 174), as discussed above, there would be limited potential for DCC operations to affect individual spawning adults, which presumably would be much less limited in terms of movements and may be holding near spawning locations. Any effect would be very similar for NAA and PA (see Table 5.A.6-31 in Appendix 5.A, *CALSIM Methods and Results*).

6.1.3.6.2.2 Population-Level Effects

The limited potential for individual-level effects of DCC operations on spawning adult Delta Smelt would result in minimal potential for population-level effects, with any effects being similar between NAA and PA.

6.1.3.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.6.3.1 Individual-Level Effects

Given that the DCC's principal effects would be on the motile life stages of Delta Smelt (by changing flows in Delta channels), the demersal and adhesive egg/embryo life stage would not be affected by DCC operations.

6.1.3.6.3.2 Population-Level Effects

Lack of individual-level effects from DCC operations on Delta Smelt eggs/embryos means that there would be no population-level effects.

6.1.3.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.6.4.1 Individual-Level Effects

USFWS (2008: 174) noted that "Larval and juvenile Delta Smelt are probably not strongly affected by the DCC if it is closed or open. Previous PTM modeling done for the [Smelt Working Group] has shown that having the DCC open or closed does not significantly affect flows in the Central Delta (Kimmerer and Nobriga 2008). There could be times, however, when the DCC closure affects Delta Smelt by generating flows that draw them into the South Delta." Any such effects are captured in the PTM modeling that was undertaken in relation to south Delta entrainment (Section 6.1.3.3.1.4, *Larvae/Young Juveniles (Spring: March-June*)). There would be little to no difference in DCC operations between NAA and PA, with the DCC only being for an average of 5 days more under PA in wet years (see Table 5.A.6-31 in Appendix 5.A, *CALSIM Methods and Results*).

6.1.3.6.4.2 Population-Level Effects

Given the limited potential for DCC operations to affect individual larval/young juvenile Delta Smelt (U.S. Fish and Wildlife Service 2008: 174), there would be expected to be a minimal population-level effect which would essentially not differ between NAA and PA.

6.1.3.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.6.5.1 Individual-Level Effects

Given that the main effect of DCC operations would be to change the quantity of Sacramento River flow entering the interior Delta (central/south Delta), there would be expected to be minimal effects to juvenile Delta Smelt given that habitat suitability in this area is low during this portion of the life history (Nobriga *et al.* 2008). In the fall, the DCC may be open somewhat more often under the PA (see Section 6.1.3.3.1.4, *Larvae/Young Juveniles (Spring: March-June*)).). This is because of several operational criteria described in Section 5.A.5.1.4.2 of Appendix 5.A, *CALSIM Methods and Results*. The CalSim modeling showed that in September of ~20% of years, sufficient water was exported by the NDD that the 25,000-cfs threshold for closure of the DCC is not exceeded, whereas it is exceeded under the NAA in the same years and results in closure of the DCC more than under PA (see Table 5.A.6-31 in Appendix 5.A). Additionally, in October-November, reservoir releases later in the year under the NAA triggered the 7,500-cfs Sacramento River at Wilkins Slough threshold assumed to coincide with juvenile salmon migration into the Delta, which resulted in a greater number of days with DCC closed under NAA. Last, the DCC may also have been open more under the PA to maintain water quality conditions per D-1641 (Rock Slough salinity standard). However, given that most juvenile Delta Smelt would be expected to be in the low-salinity zone or in the Cache Slough area during this time period, any effects would be expected to be limited; the extent and location of the low-salinity zone would not differ between NAA and PA during September-December, as shown in the analysis of abiotic habitat for juvenile Delta Smelt (Section 6.1.3.5.1.1, *Juveniles (Fall: September-December)*).

6.1.3.6.5.2 Population-Level Effects

The limited potential for DCC gate operations on individual juvenile Delta Smelt would result in minimal potential for effect at the population level, and this would be similar between NAA and PA.

6.1.3.7 Suisun Marsh Facilities

6.1.3.7.1 Suisun Marsh Salinity Control Gates

6.1.3.7.1.1 Migrating Adults (December-March)

6.1.3.7.1.1.1 Individual-Level Effects

Migrating adult Delta Smelt may be entrained behind the SMSCG when the SMSCG are closed (U.S. Fish and Wildlife Service 2008: 218), with operations expected to occur during ~10-20 days per year based on recent historical observations (Section 3.3.2.5.1, *Suisun Marsh Salinity Control Gates*). As further described by USFWS (2008: 218), "Fish may enter Montezuma Slough from the Sacramento River when the gates are open to draw freshwater into the marsh and then may not be able to move back out when the gates are closed. It is not known whether this harms Delta Smelt in any way, but they could be exposed to predators hovering around the SMSCG or they could have an increased risk of exposure to water diversions in the marsh" (see subsequent sections for effects of the RRDS, MIDS, and Goodyear Slough outfall). USFWS (2008: 218) also noted that "The degree to which movement around the LSZ is constrained by opening and closing the SMSCG is unknown." Any effects of the SMSCG on Delta Smelt movement in Montezuma Slough would be similar between NAA and PA, based on the December-March flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Modeling and Results*).

USFWS (2008: 219) also noted that SMSCG affects the distribution of the LSZ (indexed by X2), causing it to shift upstream for a given level of Delta inflow and exports, which could affect susceptibility to entrainment at the south Delta export facilities. However, as noted by USFWS (2008: 219), operations to meet D-1641 would limit such potential effects; these operations would be undertaken under the NAA and PA, and are reflected in there being little meaningful difference between NAA and PA in X2 during December-March (see Table 5.A.6-29 in Appendix 5.A, *CALSIM Methods and Results*).

6.1.3.7.1.1.2 Population-Level Effects

Given that the SMSCG would be expected to be operated for no more than around 10-20 days per year, this may limit potential population-level effects on migrating adult Delta Smelt. As described in the individual-level effects, any effects would be expected to be similar between NAA and PA.

6.1.3.7.1.2 Spawning Adults (February-June)

6.1.3.7.1.2.1 Individual-Level Effects

Spawning adult Delta Smelt would be less susceptible to the effects of the SMSCG than migrating adult Delta Smelt because they would not be undertaking the broad-scale movements of migrating adults. Movement may still be restricted, however, and near-field effects (e.g., predation) similar to those suggested by USFWS (2008: 218) could occur. Any such effects would be similar for NAA and PA based on the February-June flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.1.2.2 Population-Level Effects

Given the relatively limited area of effect for the SMSCG in terms of affecting spawning adult Delta Smelt, relative to the overall area of potential spawning habitat, it may be that there would be minimal population-level effects on spawning adult Delta Smelt from the SMSCG; the magnitude of any effects would be similar for the NAA and PA.

6.1.3.7.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.1.3.1 Individual-Level Effects

Operation of the SMSCG would not affect Delta Smelt eggs/embryos, which as previously noted are demersal and adhesive.

6.1.3.7.1.3.2 Population-Level Effects

The lack of individual-level effects means that there would be no population-level effects of the SMSCG on Delta Smelt eggs/embryos.

6.1.3.7.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.1.4.1 Individual-Level Effects

As noted for adult Delta Smelt life stages, operation of the SMSCG could trap larval/young juvenile Delta Smelt in Montezuma Slough downstream of the SMSCG, with resultant near-field (e.g., predation) and far-field (greater entrainment susceptibility at diversions within Suisun Marsh; see subsequent sections). Any such effects would be similar for NAA and PA based on the March-June flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.1.4.2 Population-Level Effects

Given that the range of habitat that can be occupied by larval/young juvenile Delta Smelt is large compared to the area affected by the SMSCG, as well as the similarity of NAA and PA operations of the SMSCG in a manner consistent with recent operations, any population-level effects of the SMSCG on larval/young juvenile Delta Smelt would be expected to be small and would not differ between NAA and PA.

6.1.3.7.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.1.5.1 Individual-Level Effects

Similar effects to those noted for adult Delta Smelt could also occur for juvenile Delta Smelt with respect to SMSCG operations, *i.e.*, near-field predation or movement blockage, as well as susceptibility to effects of Suisun Marsh diversions. Any such effects would be similar for NAA and PA based on the July-December flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Modeling and Results*). As described for migrating adult Delta Smelt, USFWS (2008: 218) emphasized the potential upstream shift in the low salinity zone (indexed by X2) that is associated with SMSCG operations, for a given Delta inflow and exports. However, the analysis of abiotic fall rearing habitat presented in Section 6.1.3.5.1.1, *Juveniles (Fall: September-December)* illustrated that X2 and the low salinity zone would be similar between NAA and PA, reflecting adherence of both scenarios to the USFWS (2008) BiOp RPA requiring fall X2 management.

6.1.3.7.1.5.2 Population-Level Effects

The relatively few days (~10-20) which the SMSCG might be operated, coupled with SWP/CVP management of X2 for juvenile Delta Smelt fall rearing habitat per the USFWS (2008) BiOp RPA, suggests that there would be minimal population-level effects of the SMSCG on juvenile Delta Smelt, and that these would not differ between NAA and PA.

6.1.3.7.2 Roaring River Distribution System

6.1.3.7.2.1 Migrating Adults (December-March)

6.1.3.7.2.1.1 Individual-Level Effects

The Roaring River Distribution System (RRDS)'s water intake (eight 60-inch-diameter culverts) is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 ft/s for Delta Smelt protection, eliminating the risk of entrainment and minimizing the risk of impingement, so that any potential adverse effects to individual migrating adult Delta Smelt would be minimal.

6.1.3.7.2.1.2 Population-Level Effects

There would be expected to be essentially no population-level effects from the RRDS on migrating adult Delta Smelt.

6.1.3.7.2.2 Spawning Adults (February-June)

6.1.3.7.2.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, the screens on the RRDS intake would be expected to minimize any potential adverse effects to individual spawning adult Delta Smelt.

6.1.3.7.2.2.2 Population-Level Effects

There would be expected to be essentially no population-level effects from the RRDS on spawning adult Delta Smelt.

6.1.3.7.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.2.3.1 Individual-Level Effects

As previously noted, Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). As such, individual eggs would not be subject to entrainment and there would be no individual-level adverse effect from the RRDS.

6.1.3.7.2.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the RRDS with respect to entrainment.

6.1.3.7.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.2.4.1 Individual-Level Effects

Based on the RRDS screen specifications and applying the methods used for the NDD (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.2), individual larval and young juvenile Delta Smelt smaller than around 30 mm (SL) could be susceptible to entrainment by the three RRDS intake culverts. Small juveniles slightly larger than this size could be impinged on the screens without being entrained. Prior to screening of the intakes, Pickard *et al.* (1982) found appreciable number of older life stages were entrained[19] which, although partly a function of greater overall abundance of Delta Smelt at the time of the study (1980-1982), suggests that larval/juvenile entrainment also occurs.

[19] Sampled individuals were 30-100 mm FL, which to some extent would have been a function of the mesh size (3.2 mm) on the fyke nets used on the culverts.

6.1.3.7.2.4.2 Population-Level Effects

Any population-level effects on larval/young juvenile Delta Smelt from the RRDS that do occur would be expected to be similar between NAA and PA, and would represent a continuation of existing operations; as previously noted, flows in Montezuma Slough as a result of SMSCG operations were similar for NAA and PA. Entrainment risk into RRDS appears limited, given that DSM2-PTM modeling for the DFG (2009) longfin smelt incidental take permit application did not observe any particles entering RRDS. Therefore, the population-level effect of the RRDS would be expected to be minimal.

6.1.3.7.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.2.5.1 Individual-Level Effects

As with migrating adult Delta Smelt, the screens on the RRDS intake would be expected to minimize any potential adverse effects to individual juvenile Delta Smelt.

6.1.3.7.2.5.2 Population-Level Effects

There would be expected to be minimal, if any, population-level effects from the RRDS on juvenile Delta Smelt.

6.1.3.7.3 Morrow Island Distribution System

6.1.3.7.3.1 Migrating Adults (December-March)

6.1.3.7.3.1.1 Individual-Level Effects

Individual migrating adult Delta Smelt could be entrained by the three unscreened 48-inch intakes that form the MIDS intake. However, Enos *et al.* (2007:17) noted that this would generally only occur in wet years, per Hobbs *et al.* (2005); Enos *et al.* (2007) did not collect any adult Delta Smelt during sampling of the MIDS intake in 2004-2006, although they did capture adult Delta Smelt with purse seines during sampling in the adjacent Goodyear Slough.

6.1.3.7.3.1.2 Population-Level Effects

The population-level effects of the MIDS to migrating adult Delta Smelt would be minimal, if any, given that entrainment would only be expected to occur in wet years. Any entrainment under the PA would also be likely to occur under the NAA, given that operations of the MIDS would not be changing (see Tables 5.B.5-31, 5.B.5-32, and 5.B.5-33 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.3.2 Spawning Adults (February-June)

6.1.3.7.3.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, spawning adults would only be susceptible to entrainment at the MIDS in wet years.

6.1.3.7.3.2.2 Population-Level Effects

As with migrating adult Delta Smelt, the population-level effects of the MIDS to spawning adult Delta Smelt would be minimal, if any, given that entrainment would only be expected to occur in wet years; any entrainment would be expected to be similar under NAA and PA.

6.1.3.7.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.3.3.1 Individual-Level Effects

As previously noted, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not be subject to entrainment and there would be no individual-level adverse effect from the MIDS.

6.1.3.7.3.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs/embryos means that there would be no adverse population-level effects from the RRDS with respect to entrainment.

6.1.3.7.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.3.4.1 Individual-Level Effects

Individual larval/young juvenile Delta Smelt could be entrained by the MIDS, although Enos *et al.* (2007) did not collect any individuals during sampling in 2004-2006. Enos *et al.* (2007: 17) noted that under normal operations, MIDS is often closed or diverting very little during spring, which may provide some protection of spring-spawning and spring-migrating fish, particularly open-water fish like Delta Smelt that do not aggregate around in-stream structures such as diversions.

6.1.3.7.3.4.2 Population-Level Effects

As noted by USFWS (2008: 218), entrainment into MIDS may be unlikely based on particle tracking studies that have demonstrated low entrainment vulnerability for particles released at random locations throughout Suisun Marsh (3.7 percent), and almost no vulnerability (<0.1 percent) to particles released at Rio Vista (Culberson *et al.* 2004). This suggests at most a minimal population-level adverse effect, which would be similar under NAA and PA (see Tables 5.B.5-31, 5.B.5-32, and 5.B.5-33 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.3.5.1 Individual-Level Effects

To the extent that juvenile Delta Smelt occur near the MIDS, they could be entrained, as with other life stages; none were collected during the extensive sampling by Enos *et al.* (2007) during 2004-2006, however.

6.1.3.7.3.5.2 Population-Level Effects

Given the absence of juvenile Delta Smelt in entrainment samples at MIDS by Enos *et al.* (2007), the population-level effect of the MIDS would be expected to be minimal. Any effect would be similar between NAA and PA.

6.1.3.7.4 Goodyear Slough Outfall

6.1.3.7.4.1 Migrating Adults (December-March)

6.1.3.7.4.1.1 Individual-Level Effects

Opening of the Goodyear Slough outfall culvert flap gates results in a small net flow south, with fresher water from Suisun Slough being drawn into Goodyear Slough. Although this may increase the possibility of entry of migrating adult Delta Smelt into Goodyear Slough, and therefore increases the potential for entrainment by the MIDS intakes (as previously discussed), operation of the flap gates also improves circulation and therefore may provide a beneficial effect.

6.1.3.7.4.1.2 Population-Level Effects

As discussed previously for MIDS, the available sampling data in the area suggest that migrating adult Delta Smelt would only be susceptible to effects from the Goodyear Slough outfall in wet years (Enos *et al.* 2007), and at most only a minimal population-level effect would therefore be likely to occur, with this effect being common to NAA and PA on the basis of similar flows in Goodyear Slough (see Table 5.B.5-34 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.4.2 Spawning Adults (February-June)

6.1.3.7.4.2.1 Individual-Level Effects

As with migrating adults, potential effects to individuals include entrainment into Goodyear Slough and therefore more potential for entrainment by MIDS, as well as beneficial effects from improved circulation.

6.1.3.7.4.2.2 Population-Level Effects

As discussed for migrating adults, the available information suggests that the population-level effect of the Goodyear Slough outfall would be minimal because of infrequent Delta Smelt occurrence in the area, with the effect not differing between NAA and PA.

6.1.3.7.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.4.3.1 Individual-Level Effects

Eggs/embryos would not be susceptible to any entrainment effects from the Goodyear Slough outfall, but may experience improved circulation because of flap gate operations which may be beneficial during incubation.

6.1.3.7.4.3.2 Population-Level Effects

As noted for adult Delta Smelt, only a small portion of Delta Smelt eggs/embryos would be expected to occur in Goodyear Slough (*i.e.*, possibly only in wet years), so the population-level effects of the Goodyear Slough outfall would be small and similar between NAA and PA.

6.1.3.7.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.4.4.1 Individual-Level Effects

As with adult Delta Smelt, operation of the Goodyear Slough outfall could increase entrainment into Goodyear Slough and therefore give more potential for entrainment by MIDS, as well as providing beneficial effects from improved circulation.

6.1.3.7.4.4.2 Population-Level Effects

As noted for adult Delta Smelt and in the analysis of the effects of the MIDS, only a small portion of Delta Smelt larvae/young juveniles would be expected to occur in Goodyear Slough, at most resulting in small population-level effects that would be similar between NAA and PA.

6.1.3.7.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.4.5.1 Individual-Level Effects

Similar to adult Delta Smelt, operation of the Goodyear Slough outfall could increase entrainment into Goodyear Slough of juvenile Delta Smelt and therefore give more potential for entrainment by MIDS, as well as providing beneficial effects from improved circulation.

6.1.3.7.4.5.2 Population-Level Effects

As concluded for other life stages, only a small portion of Delta Smelt juveniles would be expected to occur in Goodyear Slough, resulting in no more than a small population-level effect that would be similar between NAA and PA.

6.1.3.8 North Bay Aqueduct

6.1.3.8.1 Migrating Adults (December-March)

6.1.3.8.1.1 Individual-Level Effects

As noted by USFWS (2008: 217), the NBA fish screen at the Barker Slough pumping plant was designed to exclude Delta Smelt larger than 25 mm and as such would be expected to exclude migrating adult Delta Smelt from being entrained by the NBA. As described in section 3.3.2.6, *Operational Criteria for the North Bay Aqueduct Intake*, the intake is screened to comply with Delta Smelt screening criteria, which would be expected to limit the potential for entrainment and impingement. If predatory fish are concentrated near the fish screen, Delta Smelt that are excluded from being screened could be susceptible to increased predation. Pumping rates at the North Bay Aqueduct Barker Slough Intake generally would be similar under the NAA and PA (see Table 5.B.5-35 in Appendix 5.B, *DSM2 Modeling and Results*), so the potential risk of impingement and predation may also be similar.

6.1.3.8.1.2 Population-Level Effects

Exclusion of migrating adult Delta Smelt by the fish screens at the Barker Slough pumping plant, coupled with predation risk being similar between the NAA and PA, would greatly limit the potential for adverse effects from the NBA, so that population-level effects would be minimal.

6.1.3.8.2 Spawning Adults (February-June)

6.1.3.8.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, the Barker Slough pumping plant's fish screen would exclude spawning adult Delta Smelt from entrainment into the NBA, with some potential for impingement and predation that would be similar between NAA and PA.

6.1.3.8.2.2 Population-Level Effects

As with migrating adult Delta Smelt, exclusion of spawning adult Delta Smelt by the fish screens at the Barker Slough pumping plant, coupled with impingement and predation risk being similar between the NAA and PA, so that population-level effects would be minimal.

6.1.3.8.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.8.3.1 Individual-Level Effects

As previously noted, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not be subject to entrainment and there would be no individual-level adverse effect from the NBA.

6.1.3.8.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs/embryos means that there would be no adverse population-level effects from the NBA with respect to entrainment.

6.1.3.8.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.8.4.1 Individual-Level Effects

Larval and young juvenile Delta Smelt could be subject to entrainment at the Barker Slough pumping plant, given that the fish screen excludes Delta Smelt of 25 mm and greater; as noted for the NDD, individuals slightly greater than 25 mm could experience adverse effects from impingement. However, as noted by USFWS (2008: 217), a study of a fish screen built to Delta Smelt standards in Horseshoe Bend on the Sacramento River found that over 99% of fish were excluded from entrainment, even though most fish were only 15-25 mm long (Nobriga *et al.* 2004); USFWS (2008: 217) concluded on that basis that the fish screen at the NBA may protect many, if not most, of the Delta Smelt larvae that hatch and rear in Barker Slough.

6.1.3.8.4.2 Population-Level Effects

As previously discussed in Section 6.1.3.3.1.4, *Larvae/Young Juveniles (Spring: March-June)*). the DSM2-PTM analysis of larval Delta Smelt entrainment showed that in general, estimated entrainment at the NBA under the PA and NAA was similar (Table 6.1-15), reflecting the fact that operational criteria would not differ between NAA and PA. Therefore any adverse effects would be similar between scenarios.

6.1.3.8.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.8.5.1 Individual-Level Effects

As with adult Delta Smelt, juvenile Delta Smelt would be expected to be excluded from entrainment at the NBA by the fish screens of the Barker Slough pumping plant, although some impingement and near-field predation could occur. Pumping rates at the North Bay Aqueduct Barker Slough Intake generally would be similar under the NAA and PA (see Table 5.B.5-35 in Appendix 5.B, *DSM2 Modeling and Results*), so the potential risk of impingement and predation may also be similar.

6.1.3.8.5.2 Population-Level Effects

Exclusion of juvenile Delta Smelt by the fish screens at the Barker Slough pumping plant would avoid adverse population-level effects from NBA diversions in terms of entrainment, and generally similar pumping between NAA and PA would limit the potential for near-field predation and impingement risk.

6.1.3.9 Other Facilities

6.1.3.9.1 Contra Costa Canal Rock Slough Intake

6.1.3.9.1.1 Migrating Adults (December-March)

6.1.3.9.1.1.1 Individual-Level Effects

The 1.75-mm-opening, 0.2 ft/s-approach-velocity fish screen installed at the Rock Slough intake is intended to prevent entrainment of Delta Smelt into the Contra Costa Canal. However, the 4 mechanical rakes making up the screen cleaning system are unable to handle the large amount of aquatic vegetation that ends up on the fish screen (National Marine Fisheries Service 2015a: 2), leading to operation of the fish screen only on ebb tides (National Marine Fisheries Service 2015b). At these times, migrating adult Delta Smelt could be susceptible to entrainment. The operational issues with the fish screen have led Reclamation to test alternative technology (a prototype rake) to improve vegetation removal, an action that NMFS (2015a: 4) concluded would improve fish protection (*i.e.*, screen efficiency) by minimizing the chance a listed fish would be entrained or impinged on the fish screen. In addition, mechanical removal of aquatic weeds within Rock Slough in 2015 to facilitate testing of the new rake design was expected by NMFS (2015b: 4) to improve screen efficiency, reduce predation of juvenile salmonids by vegetation-associated predatory fishes, and reduce adult salmonid mortality during screen maintenance. During the December-March period of most relevance to migrating adult Delta Smelt, Rock Slough intake diversions would be very similar between NAA and PA, indicating that the potential for adverse effects to migrating adult Delta Smelt would be similar under the PA compared to NAA. Resolution of the aforementioned issues with screen effectiveness would be expected to minimize the potential for any adverse effects to individual migrating adult Delta Smelt.

6.1.3.9.1.1.2 Population-Level Effects

USFWS (2008: 217) noted that Rock Slough is a dead-end slough with poor habitat for Delta Smelt, so the numbers of Delta Smelt using Rock Slough are usually low, as reflected in very few Delta Smelt having been collected during sampling at the intake. This, combined with relatively small diversions that are very similar between NAA and PA (see discussion in the Individual-Level Effects) suggests that any population-level effect of the Rock Slough intake on migrating adult Delta Smelt would be minimal.

6.1.3.9.1.2 Spawning Adults (February-June)

6.1.3.9.1.2.1 Individual-Level Effects

The issues discussed for migrating adult Delta Smelt with respect to screen effectiveness of the Rock Slough intake also apply to spawning adult Delta Smelt. Modeled pumping of the Rock Slough intake suggested that diversions under the PA generally would be similar to NAA in February, March and June, but not in April and May, when diversions were modeled to be greater under the PA (see Table 5.B.5-36 in Appendix 5.B, *DSM2 Modeling and Results*). The overall diversions for the Rock Slough intake and the other CCWD intakes on Old River and Middle River do not differ greatly between NAA and PA, suggesting that Rock Slough may have been favored in the modeling of PA for operational reasons, e.g., Old and Middle River flow criteria, for example. This could indicate greater potential for adverse effects to spawning adult Delta Smelt under the PA compared to NAA. However, as noted for migrating adult Delta Smelt, resolution of the aforementioned issues with screen effectiveness would be expected to minimize the potential for any adverse effects to individual spawning adult Delta Smelt.

6.1.3.9.1.2.2 Population-Level Effects

As described for migrating adult Delta Smelt, it would be expected that there would be minimal, if any, population-level effects on spawning adult Delta Smelt because Delta Smelt appear to occur in low numbers in Rock Slough, as a result of poor habitat (U.S. Fish and Wildlife Service 2008: 217).

6.1.3.9.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.9.1.3.1 Individual-Level Effects

As previously noted, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not be subject to entrainment and there would be no individual-level adverse effect from the Rock Slough intake.

6.1.3.9.1.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs/embryos means that there would be no adverse population-level effects from the NBA with respect to entrainment.

6.1.3.9.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.9.1.4.1 Individual-Level Effects

As noted in the previous discussions for adult Delta Smelt, there have been operational issues with the Rock Slough intake's effectiveness. Regardless of these issues, some larval and juvenile Delta Smelt could be sufficiently small to not be screened by the Rock Slough intake's fish screen, which would be expected to exclude fish of ~22 mm (see Section 6.1.3.2.1.1.1, *Individual-Level Effects*, related to the NDD). Modeled pumping of the Rock Slough intake suggested that diversions under the PA generally would be similar to NAA in March and June, but not in April and May, when diversions would be greater under the PA (see Table 5.B.5-36 in Appendix 5.B, *DSM2 Modeling and Results*). The overall diversions for the Rock Slough intake and the other CCWD intakes on Old River and Middle River do not differ greatly between NAA and PA, suggesting that Rock Slough may have been favored in the modeling of PA for operational reasons, e.g., Old and Middle River flow criteria, for example. Operation of the Rock Slough intake would be included in the no-fill and no-diversion periods associated with all diversions for CCWD, which would minimize the potential for larval entrainment.

6.1.3.9.1.4.2 Population-Level Effects

As noted by USFWS (2008: 224), larval fish monitoring found few larval Delta Smelt being entrained at the Rock Slough intake, which suggests that any population-level effect of the intake would be very small, particularly in light of the no-fill and no-diversion criteria that are in place to protect listed species during spring.

6.1.3.9.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.9.1.5.1 Individual-Level Effects

Potential effects to juvenile Delta Smelt would be similar to those previously discussed for adult Delta Smelt in terms of potential entrainment. Diversions at the Rock Slough intake would be essentially the same under PA as NAA during July-December (see Table 5.B.5-36 in Appendix 5.B, *DSM2 Modeling and Results*), so any entrainment would be expected to be similar.

6.1.3.9.1.5.2 Population-Level Effects

There would be expected to be minimal, if any, population-level effect from diversions at the Rock Slough intake during the juvenile Delta Smelt life stage because habitat suitability in Rock Slough generally is poor for Delta Smelt (USFWS: 217), and abiotic habitat conditions in the summer in the south Delta also are poor for Delta Smelt (Nobriga *et al.* 2008).

6.1.3.9.2 Clifton Court Forebay Aquatic Weed Control Program

6.1.3.9.2.1 Migrating Adults (December-March)

6.1.3.9.2.1.1 Individual-Level Effects

Herbicide treatment of aquatic weeds in Clifton Court Forebay in July/August would avoid potential effects to Delta Smelt migrating adults because treatment would occur well after migration was complete. Mechanical removal of aquatic weeds in Clifton Court Forebay would occur on an as needed basis and therefore could coincide with occurrence of migrating adult Delta Smelt. Delta Smelt generally would not be expected to found near aquatic weeds (Ferrari *et* *al.* 2014), but may occur near the weeds if both fish and weeds are concentrated into particular areas by prevailing water movement in the Forebay. Any potential adverse effects to individual Delta Smelt from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Fish Delta Fish Protective Facility because of reduced smothering by weeds.

6.1.3.9.2.1.2 Population-Level Effects

Given the mixture of potential adverse and beneficial effects from mechanical removal of aquatic weeds in Clifton Court Forebay, it is unlikely that there would be a population-level effect on migrating adult Delta Smelt.

6.1.3.9.2.2 Spawning Adults (February-June)

6.1.3.9.2.2.1 Individual-Level Effects

Herbicide treatment of aquatic weeds in Clifton Court Forebay in July/August would avoid potential effects to Delta Smelt spawning adults because any spawning adults present in the Forebay would occur earlier in the year. Any mechanical removal effects would be as described for migrating adults.

6.1.3.9.2.2.2 Population-Level Effects

As described for migrating adults, it is unlikely that there would be a population-level effect on spawning adult Delta Smelt from mechanical removal of aquatic weeds in Clifton Court Forebay.

6.1.3.9.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.9.2.3.1 Individual-Level Effects

Herbicide treatment of aquatic weeds in Clifton Court Forebay in July/August would avoid potential effects to Delta Smelt eggs/embryos because eggs/embryos would occur earlier in the year. Mechanical removal of aquatic weeds on an as-needed basis could coincide with egg/embryo occurrence, but may be limited in effect if focusing on water hyacinth in the upper water column, which would avoid eggs/embryos adhering to benthic substrates.

6.1.3.9.2.3.2 Population-Level Effects

Any population-level adverse effects from physical predator reduction methods at Clifton Court Forebay would be minimal to nil, given the lack of temporal and spatial overlap for potential individual-level effects and the low probability of eggs/embryos to survive the salvage process in subsequent life stages.

6.1.3.9.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.9.2.4.1 Individual-Level Effects

As with adults and eggs/embryos, larval/young juvenile Delta Smelt would not temporally overlap the period of herbicide treatment of aquatic weeds in Clifton Court Forebay (July-August). Mechanical removal effects may be similar to those noted previously for migrating adult Delta Smelt.

6.1.3.9.2.4.2 Population-Level Effects

Population-level effects from mechanical removal at Clifton Court Forebay would be essentially zero, given the mixture of potential adverse and beneficial effects and the low probability of larvae/young juveniles to survive the salvage process.

6.1.3.9.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.9.2.5.1 Individual-Level Effects

There would be essentially no potential for individual juvenile Delta Smelt to be adversely affected by either herbicide treatment or mechanical removal of aquatic weeds because this life stage occurs outside of Clifton Court Forebay; Delta Smelt that are susceptible to entrainment into Clifton Court Forebay are either migrating adults or larvae/young juveniles, and the waters in the Forebay would be expected to become too warm for juvenile Delta Smelt by July.

6.1.3.9.2.5.2 Population-Level Effects

Following from the lack of individual-level effects, there would be no population-level effect on juvenile Delta Smelt.

6.1.3.10 Effects from Water Facility Operations on Delta Smelt Critical Habitat

The assessment of effects from water facility operations on Delta Smelt critical habitat presented in this section follows the basic structure of the analyses of Individual-Level and Population-Level effects presented in Sections 6.1.3.2 to 6.1.3.9, with the effects generally analyzed by facility. One exception is Section 6.1.3.10.4, *Habitat Effects,* which discusses the effects to critical habitat in relation to the factors discussed in Section 6.1.3.5, *Habitat Effects, i.e.*, abiotic habitat, water temperature, sediment removal, and *Microcystis*.

6.1.3.10.1 North Delta Exports

6.1.3.10.1.1 PCE 1: Physical Habitat (Spawning Substrate)

The potential effect of north Delta exports on spawning substrate could occur only if the NDD remove enough sand from the inflowing sediment load (over several decades of operation) to significantly change the location or quantity of existing sandy beaches, as discussed further in Section 6.1.3.10.4.1. The ability of migrating adult Delta Smelt to access spawning substrate upstream of the NDD could be affected by changes in river flow/velocity near the NDD; see discussion for PCE 3.

6.1.3.10.1.2 PCE 2: Water (Quality)

Water that otherwise would be of suitable quality for Delta Smelt may be affected by the loss of low-velocity habitat to the NDD, which make them susceptible to injury or death by entrainment, impingement, or screen contact, and could affect access to habitat at and upstream of the NDD. This is discussed further in relation to PCE 3. In addition, enhanced predation along the NDD could affect the function of PCE 2. Potential effects to other aspects of PCE 2 such as sediment removal (influencing water clarity) and entrainment of food web materials are discussed in Section 6.1.3.10.4, *Habitat Effects*.

6.1.3.10.1.3 PCE 3: River Flow (Facilitating Movement)

The NDD would affect the river flow PCE 3 by changing water velocity, which could make Delta Smelt susceptible to entrainment (smaller life stages), impingement, or screen contact, which could result in injury or death, although their potential to occur in the vicinity of the NDD is very low. Any effects would be avoided and minimized by the location of the NDD, as well as screen design and operational criteria (e.g., 0.2 ft/s approach velocity), with final design subject to review and approval by the fish and wildlife agencies (i.e., USFWS, NMFS, and CDFW) (see Chapter 3, Section 3.2.2.2, *Fish Screen Design*). As assessed in Section 6.1.3.2.2.1, *Migrating Adults (December-March)*, for effects to migrating adult Delta Smelt, the higher velocity habitat along the screens of the NDD would be likely to reduce, along the east bank of the Sacramento River, the probability of accessing upstream designated critical habitat—which extends to the upstream boundary of the statutory Delta at the I Street Bridge in Sacramento—for Delta Smelt. This habitat is likely to have limited value to Delta Smelt, other than perhaps providing a relatively small area of spawning habitat. The extent to which the PA could limit access to the relatively small area of upstream critical habitat would depend on the extent that Delta Smelt would use lower velocity habitat on the right (west) bank of the river (opposite the NDD), near the channel bottom, or within the refugia along the intakes. Due to these considerations, the PA is not considered to appreciably diminish the overall critical habitat value for both survival and recovery of Delta Smelt in regards to PCE 3. However, recognizing the potential effect to partially limit access of designated critical habitat upstream of the NDD, DWR proposes to compensate by providing up to 55 acres of tidal wetland restoration, with the final acreage to be based on the extent that continuing beach seine monitoring at Garcia Bend demonstrates that Delta Smelt occur upstream at rates similar to those observed before the start of NDD construction and operation. The 55 acres represents a preliminary estimate of the extent of sandy beach habitat (PCE 1) from the lowermost extent of intake 5 to the upstream boundary of designated critical habitat, based on examination of aerial photographs (Section 6.A.2.4, *Compensation for Potential Reduced Access to Critical Habitat Upstream of NDD*, in Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*). The initial estimate of 55 acres would be refined with field surveys.

6.1.3.10.1.4 PCE 4: Salinity (Low Salinity Zone)

The location and extent of the low salinity zone is determined by Delta outflow, which would be affected by north and south Delta exports combined. See the discussion related to PCE 4 in Section 6.1.3.10.4.4, *PCE 4: Salinity (Low Salinity Zone).*

6.1.3.10.2 South Delta Exports

6.1.3.10.2.1 PCE 1: Physical Habitat (Spawning Substrate)

Spawning substrate would not be affected by operations of the south Delta export facilities.

6.1.3.10.2.2 PCE 2: Water (Quality)

The general reduction in entrainment risk for Delta Smelt under the PA with respect to the south Delta export facilities, as a result of less south Delta pumping and improved south Delta hydrodynamic conditions, would be expected to beneficially affect the water quality PCE. Although there would still be an effect to PCE 3 because of the PA, it would be less than under NAA.

6.1.3.10.2.3 PCE 3: River Flow (Facilitating Movement)

As with PCE 2, less south Delta pumping and improved south Delta hydrodynamic conditions would be expected to beneficially modify the river flow PCE. Although there would still be an effect to PCE 3 because of the PA, it would be less than under NAA.

6.1.3.10.2.4 PCE 4: Salinity (Low Salinity Zone)

The location and extent of the low salinity zone is determined by Delta outflow, which would be affected by north and south Delta exports combined. See the discussion related to PCE 4 in Section 6.1.3.10.4.4, *PCE 4: Salinity (Low Salinity Zone).*

6.1.3.10.3 Head of Old River Gate Operations

6.1.3.10.3.1 PCE 1: Physical Habitat (Spawning Substrate)

Spawning substrate would not be affected by operations of the HOR gate.

6.1.3.10.3.2 PCE 2: Water (Quality)

Operations of the HOR gate have some potential to affect the water PCE, e.g., by affecting susceptibility to entrainment at the south Delta export facilities (see PCE 3 discussion) when water quality is otherwise suitable, and affecting water temperature (see discussion for PCE 2 in Section 6.3.10.4, *Habitat Effects (Combined North/South Delta Exports*).

6.1.3.10.3.3 PCE 3: River Flow (Facilitating Movement)

As demonstrated in the analysis of larval/young juvenile entrainment, closure of the HOR gate has the potential to affect river flow in the south Delta, and therefore the risk of entrainment. The CALSIM II modeling to support the PA indicates that OMR flow rules can be met with the proposed HOR gates closed up to 50% of the time during the spring months.

6.1.3.10.3.4 PCE 4: Salinity (Low Salinity Zone)

Head of Old River gate operations would not affect the extent or location of the low salinity zone nursery habitat.

6.1.3.10.4 Habitat Effects

6.1.3.10.4.1 PCE 1: Physical Habitat (Spawning Substrate)

The spawning microhabitat of Delta Smelt is not presently known, but the current conceptual model is that it is sandy beaches (Bennett 2005). If this conceptual model is correct, spawning substrate would only be modified by water operations if they remove enough sand from the inflowing sediment load (over several decades of operation) to significantly change the location or quantity of existing sandy beaches. Whether or not this would happen cannot be accurately estimated without use of a full suspended sediment model. As described in 6.1.3.5.3, *Sediment Removal (Water Clarity)*, DWR will collaborate with USFWS and CDFW to develop and implement a sediment reintroduction plan that provides the desired beneficial habitat effects of maintained turbidity while addressing related permitting concerns (the proposed sediment reintroduction is expected to require permits from the Water Control Board and USACE). This would mitigate the effects of sediment removal by the NDD.

6.1.3.10.4.2 PCE 2: Water (Quality)

As noted in the effects by life stages presented in Section 6.1.3.5.2, *Water Temperature*, water temperature under the PA could be somewhat greater than under the NAA for spawning, larval/young juvenile, and juvenile Delta Smelt. In general it is expected that air temperature is the main driver on water temperature in the Delta, as shown by detailed temperature modeling that does not include the effects of flow and has higher correspondence with observed temperatures than DSM2-QUAL estimates (Wagner *et al.* 2011); therefore, the effects to PCE 2 may be limited.

Water transparency is a key habitat attribute for Delta Smelt. Thus, any reduction in sediment entering the Delta because of entrainment at the NDD that is sufficient to increase water clarity would affect the water quality PCE. Whether or not this would happen cannot be accurately estimated without use of a full suspended sediment model, and may be a long-term effect. As noted for PCE 1, DWR will collaborate with USFWS and CDFW to develop and implement a sediment reintroduction plan that provides the desired beneficial habitat effects of maintained turbidity while addressing related permitting concerns, which would be intended to minimize potential effects to PCE 2.

Entrainment of phytoplankton carbon by the NDD, if not sufficiently offset by potential decreases in south Delta entrainment of the same materials and in-Delta production, would have the potential to decrease the availability of prey for Delta Smelt by reducing food available for Delta Smelt prey. As described in Section 6.1.3.5.4, *Entrainment of Food Web Materials*, in general only a small percentage (5% or less) of the standing stock of phytoplankton would be expected to be entrained in this manner, so the effect to PCE 2 may be limited.

Greater prevalence of *Microcystis* because of operational effects under the PA relative to NAA has the potential to affect the water quality PCE in some Delta channels (see Section 6.1.3.5.5, *Microcystis*). As noted in Section 6.1.3.5.5.5.2, *Population-Level Effects*, the modeling currently assumes that in the summer months (July–September), the first 3,000 cfs of exports would be from the south Delta, with any additional allowable exports able to be diverted from either the north or the south Delta, and preference for this additional pumping generally is given to the north Delta (because of higher water quality); it would be possible to shift to additional south Delta pumping as opposed to north Delta pumping in order to reduce water residence time, which may reduce the potential for effects of *Microcystis*.

6.1.3.10.4.3 PCE 3: River Flow (Facilitating Movement)

The potential effects to PCE 3 with respect to the winter/spring periods during which time Delta Smelt may be susceptible to entrainment, impingement, and other effects from north and south Delta exports were presented in Sections 6.1.3.10.1.3, *PCE3: River Flow (Facilitating Movement)* and 6.1.3.10.2.3. During the fall rearing period for juvenile Delta Smelt, the PA proposes essentially the same Delta outflow as the NAA, so this PCE would not be affected (see Section 6.1.3.5.1, *Abiotic Habitat*).

6.1.3.10.4.4 PCE 4: Salinity (Low Salinity Zone)

As discussed for PCE 5, the PA proposes essentially the same Delta outflow as the NAA during the period of juvenile fall rearing that may occur within the low salinity zone, so this PCE would not be affected.

6.1.3.10.5 Suisun Marsh Facilities

6.1.3.10.5.1 PCE 1: Physical Habitat (Spawning Substrate)

Operations of the Suisun Marsh facilities (SMSCG, MIDS, RRDS, and Goodyear Slough Outfall) would not affect the spawning substrate PCE for Delta Smelt.

6.1.3.10.5.2 PCE 2: Water (Quality)

In general, the Suisun Marsh facilities would have little effect on water quality for Delta Smelt. Although water quality in Montezuma Slough may otherwise be suitable for Delta Smelt close to the RRDS intake, the risk of entrainment of larval/young juvenile Delta Smelt through the RRDS intake screens (or impingement on the screens) would produce a localized effect to this PCE, in combination with PCE 3. This would also be true for the unscreened MIDS in Goodyear Slough. Operation of the Goodyear Slough outfall is intended to improve water circulation in Suisun Marsh and therefore would be expected to provide beneficial effects to the water quality PCE for Delta Smelt critical habitat.

6.1.3.10.5.3 PCE 3: River Flow (Facilitating Movement)

As noted in the discussion for migrating adult Delta Smelt, operation of the SMSCG could entrain Delta Smelt into Montezuma Slough downstream of the SMSCG during ebb tide, and not allow return with the flood tide as the gates are closed. The DSM2-HYDRO modeling data demonstrated that these effects would be very similar between NAA and PA, and the extent to which movement around the low salinity zone is constrained is unknown (U.S. Fish and Wildlife Service 2008: 218). Operation of the RRDS and MIDS intakes results in a localized effect on channel flow in Montezuma Slough for larval/early juvenile Delta Smelt and Goodyear Slough for Delta Smelt, which may result in entrainment into the RRDS and/or MIDS, respectively. This effect would be similar under the NAA and PA, and represents a continuation of ongoing operations.

6.1.3.10.5.4 PCE 4: Salinity (Low Salinity Zone)

As discussed in the analysis of effects to juvenile Delta Smelt, although operation of the SMSCG moves the low salinity zone (indexed by X2) upstream for a given Delta outflow, operations would be managed in such a way that X2 would be very similar between NAA and PA, so there would be no effect on the salinity PCE.

6.1.3.10.6 North Bay Aqueduct

6.1.3.10.6.1 PCE 1: Physical Habitat (Spawning Substrate)

Operation of the NBA would not modify the spawning substrate PCE for Delta Smelt.

6.1.3.10.6.2 PCE 2: Water (Quality)

Diversions to the NBA could produce a localized effect on otherwise suitable water quality by increasing susceptibility of larval Delta Smelt to entrainment by the NBA; however, as previously noted in Individual-Level and Population-Level Effects sections, such effects would be similar between the NAA and PA.

6.1.3.10.6.3 PCE 3: River Flow (Facilitating Movement)

As with PCE 2, diversions to the NBA could produce a localized effect on flow in Barker Slough which could increase susceptibility of larval Delta Smelt to entrainment by the NBA. Such effects would be similar between the NAA and PA.

6.1.3.10.6.4 PCE 4: Salinity (Low Salinity Zone)

The small size of the diversions to the NBA would produce minimal changes to the low salinity zone and, as shown in the analysis of fall rearing abiotic habitat for juvenile Delta Smelt, there would be little difference between NAA and PA in the low salinity zone extent as indexed by the fall abiotic habitat index, because of overall management of exports in the Delta.

6.1.3.10.7 Other Facilities

6.1.3.10.7.1 Contra Costa Canal Rock Slough Intake

6.1.3.10.7.1.1 PCE 1: Physical Habitat (Spawning Substrate)

Operation of the Rock Slough intake would not modify the spawning substrate PCE for Delta Smelt.

6.1.3.10.7.1.2 PCE 2: Water (Quality)

Diversions to the Rock Slough intake could produce a localized effect to otherwise suitable water quality by increasing susceptibility of Delta Smelt to entrainment; however, as previously noted in Section 6.1.3.9.1, *Contra Costa Canal Rock Slough Intake*, Rock Slough generally has low habitat quality for Delta Smelt.

6.1.3.10.7.1.3 PCE 3: River Flow (Facilitating Movement)

As with PCE 2, diversions by the Rock Slough intake could produce a localized effect on flow in Rock Slough which could increase susceptibility of larval Delta Smelt to entrainment. Modeled diversions during April and May were greater under the PA, although the no-fill and no-diversion periods discussed in Section 6.1.3.9.1, *Contra Costa Canal Rock Slough Intake*, are intended to minimize the potential for effects to Delta Smelt and other listed species and adverse modification of critical habitat.

6.1.3.10.7.1.4 PCE 4: Salinity (Low Salinity Zone)

The small size of the diversions to the Rock Slough intake would produce minimal changes to the low salinity zone and, as shown in the analysis of fall rearing abiotic habitat for juvenile Delta Smelt, there would be little difference between NAA and PA in the low salinity zone extent as indexed by the fall abiotic habitat index, because of overall management of exports in the Delta.

6.1.3.10.7.2 Clifton Court Forebay Aquatic Weed Control Program

6.1.3.10.7.2.1 PCE 1: Physical Habitat (Spawning Substrate)

Spawning substrate would not be adversely modified by herbicide treatment and is unlikely to be adversely modified by mechanical removal of aquatic weeds. Any effects on spawning substrate in Clifton Court Forebay are not considered important, given that the water quality PCE is severely modified by the risk of entrainment, with low prospects of survival to any successfully spawned Delta Smelt.

6.1.3.10.7.2.2 PCE 2: Water (Quality)

As described for motile life stages such as migrating adult Delta Smelt in Section 6.1.3.7.2, *Clifton Court Forebay Aquatic Weed Control Program*, water quality effects would not be expected from herbicide treatment because there would not be a temporal overlap in treatment (July-August) with Delta Smelt occurrence (December-June). The potential for adverse modification of this PCE because of mechanical removal of aquatic weeds (e.g., injury from contact with cutting blades) may be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Fish Delta Fish Protective Facility because of reduced smothering by weeds.

6.1.3.10.7.2.3 PCE 3: River Flow (Facilitating Movement)

The Clifton Court Forebay Aquatic Weed Control Program would not modify river flows that facilitate movement of Delta Smelt life stages.

6.1.3.10.7.2.4 PCE 4: Salinity (Low Salinity Zone)

The Clifton Court Forebay Aquatic Weed Control Program would not modify the extent or location of low salinity zone nursery habitat.

6.1.4 Effects of Conservation Measures on Delta Smelt

6.1.4.1 Tidal and Channel Margin Habitat Restoration

6.1.4.1.1 Migrating Adults (December-March)

6.1.4.1.1.1 Individual-Level Effects

Construction at habitat restoration sites would be undertaken during approved in-water work windows (summer/fall) and therefore would not affect individual migrating adult Delta Smelt. To the extent that individual Delta Smelt encounter restoration sites (e.g., when occupying nearshore areas during ebb tides of upstream migrations; Bennett and Burau 2015), the restoration is intended to enhance habitat value in these areas, relative to the unrestored state of the habitat where the restoration is undertaken, e.g., by increasing production of zooplankton prey or increasing subtidal habitat diversity. As suggested for the Lower Yolo Ranch Restoration Project (National Marine Fisheries Service 2014), potential adverse effects to migrating adult Delta Smelt at habitat restoration sites under construction include degraded water quality (e.g., liberation of contaminants from soils, if such contaminants have not been removed by soil grading activities) and increased predation risk depending on site characteristics, although the latter can be avoided by careful design of restoration sites to limit potential for colonization by invasive aquatic vegetation.

6.1.4.1.1.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on migrating adult Delta Smelt, if there is one, should be beneficial.

6.1.4.1.2 Spawning Adults (February-June)

6.1.4.1.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, construction at habitat restoration sites would be undertaken during approved in-water work windows (summer/fall) and therefore individual spawners would not be affected by construction per se. Should restored habitat include suitable holding and spawning microhabitat for Delta Smelt (the latter being hypothesized to be sandy shallow areas, per Bennett [2005]), completed restoration projects may provide greater spawning opportunities to individual adult Delta Smelt than NAA; they may also increase feeding opportunities if zooplankton prey production increases. As with migrating adults, there may be water quality and predation risks associated with habitat restoration that could result in some adverse effects to individual fish.

6.1.4.1.2.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on spawning adult Delta Smelt, if there is one, should be beneficial.

6.1.4.1.3 Eggs/Embryos (Spring: ~March–June)

6.1.4.1.3.1 Individual-Level Effects

As stated above, construction at habitat restoration sites would be undertaken during approved in-water work windows (summer/fall) and therefore would not affect eggs/embryos in spring. When construction is completed, and if suitable spawning microhabitat was successfully provided, individual Delta Smelt may spawn eggs at the site, producing a positive individual impact.

6.1.4.1.3.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on Delta Smelt eggs/embryos, if there is one, should be beneficial.

6.1.4.1.4 Larvae/Young Juveniles (Spring: ~March–June)

6.1.4.1.4.1 Individual-Level Effects

It is anticipated that habitat restoration work would occur during a late spring/summer/fall work window (June through October) (see Section 3.4.4.1, *Tidal Wetland Restoration*, in Chapter 3), so there would be limited potential for effects of construction on individual Delta Smelt larvae using the temporal definition applied in this effects analysis. The types of effects described for juvenile Delta Smelt could occur for larval Delta Smelt occurring near construction of habitat restoration.

6.1.4.1.4.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on Delta Smelt larvae/young juveniles, if there is one, should be beneficial.

6.1.4.1.5 Juveniles (Summer/Fall: ~July–December)

6.1.4.1.5.1 Individual-Level Effects

Habitat restoration projects intended to ultimately benefit Delta Smelt have to be located where Delta Smelt are likely to occur. Thus, there is the potential for adverse effects on individuals during construction. Juveniles are the only Delta Smelt life stage that would be affected by construction at habitat restoration sites, on the basis of temporal overlap with the summer/fall in-water work windows. As with other life stages, there would be long-term positive effects once habitat restoration is complete. Potential short-term adverse effects from tidal habitat restoration are exemplified by those described as potential effects for the Lower Yolo Tidal Restoration Project (National Marine Fisheries Service 2014). To the extent practicable, grading and excavation of marsh plains and tidal channels would be done prior to excavation of levee perimeter notches, to minimize adverse effects on juvenile Delta Smelt. Excavation of levee perimeter notches to allow tidal exchange could result in several effects to juvenile Delta Smelt: temporary loss of aquatic and riparian habitat (e.g., increasing predation potential because of reduced cover, reduced substrate for prey, and increased water temperature); degraded water quality from contaminants liberated from soils and increased suspended sediment which could affect fish directly if in very high concentration, as well as affecting prey availability; heavy machinery noise resulting in fish being inhibited from movements near the work areas, and possibly being startled away from work areas and therefore becoming more susceptible to predation as a result; direct strikes to fish from construction equipment performing notch excavation; and stranding of fish within dewatered areas (e.g., within cofferdams) that may be required during construction. However, as shown for the Lower Yolo Tidal Restoration Project, such potential adverse effects can be minimized by construction techniques such as not operating heavy machinery from the water; limiting construction to only the small areas necessary to restore tidal connections; limiting work to low tide and daylight hours; and installing sheet pile exclusion barriers with vibratory hammers.

6.1.4.1.5.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on juvenile Delta Smelt, if there is one, should be beneficial.

6.1.4.2 Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities

As described in Appendix 3.F, *General Avoidance and Minimization Measures*, localized reduction of predatory fishes is proposed to occur at the NDD and Clifton Court Forebay using physical reduction methods, including boat electrofishing, hook-and-line fishing, passive capture by net or trap (e.g., gillnetting, hoop net, fyke trap), and active capture by net (e.g., beach seine). The goal of this measure is to reduce predation on juvenile salmonids occurring at the north Delta and south Delta export facilities, and as such would be focused on the winter/spring period (~December-June) when juvenile salmonids are migrating through the Delta. As described in the predation effects assessments for Delta Smelt at the north Delta (Section 6.1.3.2.3, *Predation at the North Delta Export Facilities*) and south Delta (Section 6.1.3.3.2, *Predation* at the *South Delta Export Facilities*, this conservation measure could also potentially reduce predation on Delta Smelt, but predator removal in CCF has no meaningful capacity to impact Delta Smelt and if Delta Smelt numbers at the NDD are very low (as described above), predator removal from in front of the NDD fish screens will also have no meaningful impact.

6.1.4.2.1 Migrating Adults (December-March)

6.1.4.2.1.1 Individual-Level Effects

The methods that could be used to minimize the local abundance of predatory fish at the NDD and Clifton Court Forebay would have some potential to adversely affect migrating adult Delta Smelt. The main effect perhaps being startling of individuals during gear deployment (which could ironically increase predation susceptibility, assuming predators in the vicinity are not also startled) or injure fish if they contacted nets trying to escape through the mesh. Capture of adult Delta Smelt by hook-and-line fishing would not occur, and passive or active capture methods involving traps or nets would involve mesh sizes through which Delta Smelt would be able to escape. Electrofishing gear would be set to target fish of the size likely to be predators on juvenile salmonids and as such would have lesser impact on Delta Smelt than large-bodied fish because at a given voltage gradient, total body voltage increases with length, resulting in greater potential to capture larger fish without effects to smaller fish (Reynolds and Kolz 2012). As described in the predation effects assessments for Delta Smelt at the north Delta (Section 6.1.3.2.3, *Predation at the North Delta Export Facilities*) and south Delta (Section 6.1.3.3.2, *Predation* at the *South Delta Export Facilities*), to the extent that predatory fish density reduction is successful, it could reduce predation on Delta Smelt adults occurring near the NDD and in Clifton Court Forebay.

6.1.4.2.1.2 Population-Level Effects

As previously described in the analysis of entrainment and impingement at the NDD (Section 6.1.3.2, *North Delta Exports*), it is anticipated that very low numbers of migrating adult Delta Smelt would occur near the NDD, so predator removal in front of the NDD fish screens would be expected to have no meaningful effect on migrating adult Delta Smelt at the population level. In addition, the survival of Delta Smelt reaching the south Delta fish facilities is likely to be very low, so predator removal in CCF has no meaningful capacity to affect the Delta Smelt population.

6.1.4.2.2 Spawning Adults (February-June)

6.1.4.2.2.1 Individual-Level Effects

The analysis presented in Section 6.1.4.2.1.1, *Individual-Level Effects*, for migrating adult Delta Smelt would also apply to spawning adults.

6.1.4.2.2.2 Population-Level Effects

As previously described in the analysis of entrainment and impingement at the NDD (Section 6.1.3.2, *North Delta Exports*) and discussed for migrating adults, it is anticipated that very low numbers of spawning adult Delta Smelt would occur near the NDD, so predator removal in front of the NDD fish screens would be expected to have no meaningful effect on spawning adult Delta Smelt at the population level. In addition, the survival of Delta Smelt reaching the south Delta fish facilities is likely to be very low, so predator removal in CCF has no meaningful capacity to affect the Delta Smelt population

6.1.4.2.3 Eggs/Embryos (Spring: ~March–June)

6.1.4.2.3.1 Individual-Level Effects

If Delta Smelt spawned in Clifton Court Forebay, the survival of the progeny once they hatched would be likely to be close to zero. The proposed predator removal tactics are designed to catch larger piscivorous fishes and not the small fishes and shrimp that likely comprise the major predators of Delta Smelt eggs. The capture techniques generally are not anticipated to catch eggs attached to sandy substrates. Thus, there is unlikely to be an effect on individual Delta Smelt eggs.

6.1.4.2.3.2 Population-Level Effects

The lack of effects on individual eggs/embryos from predator reduction would result in no population-level effects on this life stage. Larvae/Young Juveniles (Spring: ~March–June)

6.1.4.2.3.3 Individual-Level Effects

The biggest known predator of Delta Smelt larvae is inland (a.k.a. Mississippi) silverside (Baerwald *et al.* 2012). This fish is the same size as Delta Smelt and therefore will not be vulnerable to the methods proposed to catch large piscivorous fishes. Therefore it is unlikely that there would be an effect on individual larval and young juvenile Delta Smelt from predator capture.

6.1.4.2.3.4 Population-Level Effects

Adverse population-level effects to larval/young juvenile Delta Smelt from predatory fish reduction would not occur because of the limited prospect of individual-level effects, the small proportion of the population likely to occur near the NDD, and the low probability of individuals occurring in Clifton Court Forebay surviving the salvage process.

6.1.4.2.4 Juveniles (Summer/Fall: ~July-December)

6.1.4.2.4.1 Individual-Level Effects

The December-June period in which predator reduction activities are proposed to be focused essentially does not overlap the period of occurrence of juvenile Delta Smelt, so the types of effects noted for other life stages are unlikely.

6.1.4.2.4.2 Population-Level Effects

The lack of temporal overlap of this life stage with predator reduction activities means that there would be no population-level effect.

6.1.4.3 Georgiana Slough Nonphysical Fish Barrier

As described in Appendix 3.F, *General Avoidance and Minimization Measures*, the Georgiana Slough Nonphysical Fish Barrier (NPB) would consist of an NPB to reduce the likelihood of Sacramento River-origin juvenile salmonids entering the interior Delta through Georgiana Slough. Based on a recent evaluation of different technology to achieve this goal, a bioacoustic fish fence (BAFF) appears to offer more potential than a floating fish guidance structure (FFGS) for this location (DWR 2015b), although these and other options are possibilities. The analysis presented herein focuses on the potential effects of these types of NPB, as there is precedent for their installation at this location: a BAFF was tested in 2011 and 2012, and a FFGS was tested in 2014. Both technologies block the upper portion of the water column[20] because the focus for protection is surface-oriented juvenile salmonids, but the BAFF consists of acoustic deterrence stimuli broadcast from loudspeakers and contained within a bubble curtain that is illuminated with strobe lights (to allow the fish to orient away from the sound stimulus better), whereas the FFGS is a floating series of metal plates that deters fish based on them seeing the barrier and sensing the change in flow. Whereas the pilot studies of these technologies and their construction occurred in winter/spring, for the PA construction and removal would be done outside the main period of juvenile salmonid occurrence (November/December-June).

6.1.4.3.1 Migrating Adults (December-March)

6.1.4.3.1.1 Individual-Level Effects

Individual Delta Smelt migrating upstream via Georgiana Slough or the Sacramento River would not be affected by the construction of this NPB because construction would occur before any smelt moved this far upstream. The operational effects could include enhanced risk of predation near the NPB, as they include in-water structures that predatory fish may use as ambush habitat, and the NPB is designed to startle fish to cause them to change their course (particularly the BAFF, with its acoustic deterrence). However, there was no evidence from acoustic tracking that juvenile salmonids were being preyed upon at higher rates near the BAFF compared to sites farther away in 2011 and 2012, and little evidence from acoustic tracking of predators that they occupied areas near the BAFF more frequently than other areas (DWR 2012, 2015a). Indeed, the

[20] In the case of the BAFF, the top half of the water column (~10–12 feet); in the case of the FFGS, 5 feet for the 2014 pilot study because of lower water levels caused by drought conditions, whereas 10 feet would be possible with greater river flow.

2011 and 2012 BAFF pilot studies provided evidence that predatory fish were deterred by the BAFF,[21] with general evidence for increasing avoidance over time for all species combined, although some species may have become conditioned to the BAFF over time and therefore would not have been deterred. Studies of the 2014 FFGS have not been completed to address these topics. Migrating adult Delta Smelt encountering the NPB could be dissuaded from moving further upstream or startled by the NPB particularly if attempting to move upstream from Georgiana Slough to the Sacramento River, although based on the configurations used during the pilot studies[22], they would be able to swim under/around the FFGS, or under the BAFF. Further, there is no known reason that Delta Smelt need to move beyond this junction to spawn. Most fish spawn in places distant from the junction of Georgiana Slough and the Sacramento River.

6.1.4.3.1.2 Population-Level Effects

Few Delta Smelt are known to spawn in the Sacramento River and Georgiana Slough where the NPB will be located. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.3.2 Spawning Adults (February–June)

6.1.4.3.2.1 Individual-Level Effects

The potential effects to spawning adult Delta Smelt from NPB would be similar to those noted for migrating adult Delta Smelt. However, these effects would be less likely to occur because spawning adult Delta Smelt would not be undergoing the broad-scale movements of migrating adults and therefore would have less potential to encounter the NPBs.

6.1.4.3.2.2 Population-Level Effects

As described for migrating adult Delta Smelt, few Delta Smelt are known to spawn in the Sacramento River and Georgiana Slough where the NPB will be located. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.3.3 Eggs/Embryos (Spring: ~March–June)

6.1.4.3.3.1 Individual-Level Effects

Delta smelt eggs/embryos would not overlap the construction or removal periods of the NPB and there would be no potential for adverse individual-level effects from operations.

6.1.4.3.3.2 Population-Level Effects

The lack of individual-level effects from the NPB on eggs/embryos means there would be no population-level effect.

6.1.4.3.4 Larvae/Young Juveniles (Spring: ~March–June)

6.1.4.3.4.1 Individual-Level Effects

Larval/young juvenile Delta Smelt moving down the Sacramento River could encounter the NPB. Given their weak swimming abilities, they may be subject to near-field hydraulic effects

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[21] The BAFF was switched on and off every ~25 hours in order to test its effectiveness in deterring migrating juvenile salmonids.

[22] The BAFF pilot studies in 2011 and 2012 blocked the entire entrance to Georgiana Slough, whereas the FFGS pilot study in 2014 had the FFGS slightly upstream of the entrance to Georgiana Slough to deter juvenile salmonids away from the left bank.

such as slight alterations of direction in response to changes in flows, and possibly injury when contacting the structures associated with the NPB.

6.1.4.3.4.2 Population-Level Effects

Few Delta Smelt are known to spawn in the Sacramento River and Georgiana Slough where the NPB will be located, resulting in few larvae/young juveniles in the area. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.4.3.5.1 Individual-Level Effects

The Delta Smelt juvenile life stage would be the only part of the life cycle that would have the potential to experience adverse effects to individuals from construction and removal of the NPB. Any pile-driving that would occur would be done with a vibratory hammer, which would minimize the potential for injury and probably limit adverse effects by deterring fish from the construction site. In-water work would be performed consistent with the biological opinions for the pilot implementations of the BAFF (U.S. Fish and Wildlife Service 2011b) and FFGS (U.S. Fish and Wildlife Service 2014). As with adults, altered behavior and locally elevated predation could occur.

6.1.4.3.5.2 Population-Level Effects

Few juvenile Delta Smelt are known to rear in the Sacramento River and Georgiana Slough where the NPB will be located. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.4 Effects of Conservation Measures on Delta Smelt Critical Habitat

6.1.4.4.1 PCE 1: Physical Habitat (Spawning Substrate)

Although minimal, if any, effects to spawning substrate are anticipated, restoration of tidal habitat and channel margin habitat would have the potential to offset losses in spawning substrate.

As described above for effects to eggs/embryos, substrate-disturbing localized predatory fish reduction methods (e.g., beach seining) would have the potential to affect the spawning substrate PCE. However, such methods would only seem to be feasible in Clifton Court Forebay and not near the NDD (because of the deep-water habitat and steeply sloping banks in the vicinity), and effects on spawning substrate in Clifton Court Forebay are not considered important, given that the water quality PCE is severely modified by the risk of entrainment, with low prospects of survival to any successfully spawned Delta Smelt.

Implementation of a NPB at Georgiana Slough would have minimal effects on Delta Smelt spawning substrate, which most likely would be limited to piles driven into the substrate, or anchoring of associated structures.

6.1.4.4.2 PCE 2: Water (Quality)

Construction-related effects to water quality (e.g., increases in suspended sediment during earth-moving activities) would of similar nature to construction related effects described above, but would be limited in duration, would occur during work windows to minimize exposure of Delta

Smelt, and minimized with standard AMMs. Therefore there would not be effects on the water quality PCE.

Sediment disturbance and releases of contaminants (e.g., fuel spills) during construction/removal activities of NPB would have the potential to result in effects on the water quality PCE (e.g., by liberating contaminants), but the implementation of standard AMMs and the limited duration of the work would minimize effects on this PCE, as concluded for the pilot projects (U.S. Fish and Wildlife Service 2011b, 2014).

6.1.4.4.3 PCE 3: River Flow (Facilitating Movement)

None of the conservation measures would affect river flow.

6.1.4.4.4 PCE 4: Salinity (Low Salinity Zone)

None of the conservation measures would affect salinity.

6.1.5 Effects of Monitoring Activities

As described in Section 3.4.9.2.4 of Chapter 3, effectiveness monitoring for fish would consist of a combination of continuation of existing monitoring authorized under the 2008/2009 BiOps (*i.e.*, principally salvage and larval smelt monitoring at the south Delta export facilities), as well as additional monitoring of the NDD (principally entrainment and impingement monitoring). Entrainment monitoring at the NDD would consist of sampling entrained fish behind the fish screens with a fyke net (see Table 3.4-5 in Chapter 3); impingement monitoring methods are not specified at this time, but on the basis of existing monitoring (e.g., Freeport Regional Water Authority intake's fish screen), would be likely to consist of visual observation by diver survey or acoustic imaging camera. Other monitoring activities that are part of the PA would be unlikely to affect Delta Smelt and are not discussed here. Existing monitoring activities that would inform operations of the PA (e.g., trawl and seines surveys by DFW and USFWS) are not part of the PA. Although monitoring activities at restoration sites have not been determined, they are not expected to include in-water work with any potential to harm Delta Smelt or any other listed fishes.

6.1.5.1 Migrating Adults (December-March)

6.1.5.1.1 Individual-Level Effects

As discussed in Section 6.1.3.2.1.1, *Migrating Adults (December-March*) for the NDD, the NDD fish screens would exclude migrating adult Delta Smelt from entrainment, so there would be no effect from entrainment monitoring at the NDD. If impingement monitoring were to consist of visual observation by diver survey, there would be minor potential for individual migrating adult Delta Smelt occurring immediately adjacent to the fish screens to be startled and leave the immediate area if encountering the divers; there would be no effect if conducting observations with an acoustic imaging camera. At the south Delta export facilities, salvage of migrating adult Delta Smelt would be done in the same way under NAA and PA. Individual migrating adult Delta Smelt collected during sampling of salvaged fish would die; however, as shown in Section 6.1.3.3.1.1, entrainment at the south Delta export facilities is expected to be lower under the PA than NAA, therefore any effects to individual Delta Smelt from salvage monitoring would be lower under the PA than NAA.

6.1.5.1.2 Population-Level Effects

Given the low percentage of the migrating adult Delta Smelt population expected to be near the NDD (Section 6.1.3.2.2.1.2, *Population-Level Effects*), any effects of impingement monitoring at the NDD would be inconsequential at the population level. South Delta exports salvage monitoring also would be expected to have essentially no population-level effect, given that only a subsample of fish would be collected, entrainment would be limited (and would be less under the PA than NAA), and that for the SWP, the main source of mortality (pre-screen loss) occurs before salvage sampling. Given that monitoring informs adjustments to operations to protect migrating adult Delta Smelt, the ultimate net effect of monitoring should be positive to the population.

6.1.5.2 Spawning Adults (February-June)

6.1.5.2.1 Individual-Level Effects

The potential effects of monitoring on individual spawning adult Delta Smelt would be similar to those effects noted for migrating adult Delta Smelt (*i.e.*, principally the lethal take during south Delta salvage monitoring), although spawning adults would be less likely to be sampled during monitoring activities if primarily holding near spawning sites.

6.1.5.2.2 Population-Level Effects

As discussed for migrating adult Delta Smelt, there would be essentially no population-level effects of monitoring on spawning adult Delta Smelt.

6.1.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.5.3.1 Individual-Level Effects

As noted for other potential effects of the PA, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not affected by the monitoring proposed under the PA.

6.1.5.3.2 Population-Level Effects

The lack of individual-level effects from monitoring of the PA on Delta Smelt eggs/embryos means that there would be no population-level effects.

6.1.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.5.4.1 Individual-Level Effects

At the NDD, entrainment sampling behind the fish screens would result in lethal take of individual larval and young juvenile Delta Smelt that are small enough to pass through the screens. These fish might otherwise survive passage to the Intermediate Forebay or the north cell of the reconfigured Clifton Court Forebay. Entrainment surveys of young smelt at the south Delta export facilities would also result in lethal take of any sampled larval or young juvenile Delta Smelt, and would occur under NAA and PA.

6.1.5.4.2 Population-Level Effects

Any collections of larval or young juvenile Delta Smelt during entrainment monitoring at the NDD or south Delta export facilities would have no effect at the population level because these fish would die anyway, either immediately (through injury during passage through conveyance infrastructure) or subsequently (e.g., if surviving and growing in Clifton Court Forebay, they would be expected to either die from predation or from excessive water temperatures in the summer).

6.1.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.5.5.1 Individual-Level Effects

Effects to juvenile Delta Smelt would be as discussed for migrating adult Delta Smelt in terms of the potential to be lethally taken during salvage monitoring at the south Delta export facilities; however, as discussed in Section 6.1.3.3.1.5, *Juveniles: (Summer/Fall: July-December)*, few juvenile Delta Smelt would be expected to occur at this time. Less south Delta exports under the PA than NAA would results in this being less of an effect. It is unlikely that monitoring of impingement potential at the NDD would be undertaken during the summer/fall, given the periods of occurrence of listed fishes, so there would be no effect from diver surveys.

6.1.5.5.2 Population-Level Effects

As discussed in the individual-level effects, the minimal temporal and spatial overlap of juvenile Delta Smelt with south Delta salvage monitoring means that there would be no population-level effect on juvenile Delta Smelt from monitoring.

6.1.5.6 Effects of Monitoring Activities on Delta Smelt Critical Habitat

6.1.5.6.1 PCE 1: Physical Habitat (Spawning Substrate)

There would be no effect of monitoring on the physical habitat PCE.

6.1.5.6.2 PCE 2: Water (Quality)

There would be no effect of monitoring on the water PCE.

6.1.5.6.3 PCE 3: River Flow (Facilitating Movement)

There would be no effect of monitoring on the river flow PCE.

6.1.5.6.4 PCE 4: Salinity (Low Salinity Zone)

There would be no effect of monitoring on the salinity PCE.

6.1.6 Cumulative Effects on Delta Smelt

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area (50 CFR 402.02). Future Federal actions that are unrelated to the PA are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. A list of specific projects considered for the cumulative effects analysis is included as Appendix 5.G, *Projects Considered for Cumulative Effects Analysis for the Conveyance Section 7 Biological Assessment*.

6.1.6.1 Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions have the potential to entrain and kill many life stages of aquatic species, including Delta Smelt. However, the vast majority of private unscreened diversions in the Delta are small pipes in large channels that do not operate every day of the year. As a result, even where they do regularly co-occur with these diversions, Delta Smelt appear to have low vulnerability to entrainment (Nobriga *et al.* 2004). Most of the 370 water diversions operating in Suisun Marsh are likewise unscreened (Herren and Kawasaki 2001). However the two major Suisun Marsh distribution systems, both part of the SWP, divert most of the water into the marsh that is subsequently redistributed further by the many smaller diversions. Of the two SWP distribution systems, Roaring River is screened while Morrow Island is not. Delta smelt entrainment into the Morrow Island Distribution system is very low due to high salinity in western Suisun Marsh (Enos *et al.* 2007); the effects of these systems on Delta Smelt was analyzed in Section 6.1.3.7, *Suisun Marsh Facilities.*

New municipal water diversions in the Delta are routinely screened per biological opinions. Private irrigation diversions in the Delta are mostly unscreened but the total amount of water diverted onto Delta farms has remained very stable for decades (Culberson *et al.* 2008) so the cumulative impact should remain similar to baseline. Ongoing non-Federal diversions of water within the action area (e.g., municipal and industrial uses, as well as diversions through intakes serving numerous small, private agricultural lands) are not likely to entrain very many Delta Smelt based on the results of a study by Nobriga *et al.* (2004). Nobriga *et al.* reasoned that the littoral location and low-flow operational characteristics of these diversions reduced their risk of entraining Delta Smelt. A study of the Morrow Island Distribution System by DWR produced similar results, with one demersal species and one species that associates with structural environmental features, together accounting for 97–98% of entrainment; only one Delta Smelt was observed to be entrained during the 2 years of the study (Enos *et al.* 2007).

6.1.6.2 Agricultural Practices

Farming occurs throughout the Delta adjacent to waterways used by Delta Smelt. Agricultural practices introduce nitrogen, ammonium, and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman *et al.* 2014); however, wastewater treatment provides the bulk of ammonium loading, for example (Jassby 2008). Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect Delta Smelt reproductive success and survival rates (Dubrovsky *et al.* 1998; Kuivila *et al.* 2004; Scholz *et al.* 2012). Discharges occurring outside the action area that flow into the action area also contribute to cumulative effects of contaminant exposure.

6.1.6.3 Increased Urbanization

The Delta Protection Commission’s Economic Sustainability Plan for the Delta reported an urban growth rate of about 54% within the statutory Delta between 1990 and 2010, as compared with a 25% growth rate statewide during the same period (Delta Protection Commission 2012). The report also indicated that population growth had occurred in the Secondary Zone of the Delta but not in the Primary Zone and that population in the central and south Delta areas had decreased since 2000. Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the state as a whole. Total population in the Delta counties is projected to grow at an average annual rate of 1.2% through 2030 ((California Department of Finance 2012). Table 6.1-48 illustrates past, current, and projected population trends for the five counties in the Delta. As of 2010, the combined population of the Delta counties was approximately 3.8 million. Sacramento County contributed 37.7% of the population of the Delta counties, and Contra Costa County contributed 27.8%. Yolo County had the smallest population (200,849 or 5.3%) of all the Delta counties.

Table 6.1-48. Delta Counties and California Population, 2000–2050

Area	2000 Population (millions)	2010 Population (millions)	2020 Projected Population (millions)	2025 Projected Population (millions)	2050 Projected Population (millions)
Contra Costa County	0.95	1.05	1.16	1.21	1.50
Sacramento County	1.23	1.42	1.56	1.64	2.09
San Joaquin County	0.57	0.69	0.80	0.86	1.29
Solano County	0.40	0.41	0.45	0.47	0.57
Yolo County	0.17	0.20	0.22	0.24	0.30
Delta Counties	3.32	3.77	4.18	4.42	5.75
California	34.00	37.31	40.82	42.72	51.01

Sources: California Department of Finance 2012.

Table 6.1-49 presents more detailed information on populations of individual communities in the Delta. Growth rates from 2000 to 2010 were generally higher in the smaller communities than in larger cities such as Antioch and Sacramento. This is likely a result of these communities having lower property and housing prices, and their growth being less constrained by geography and adjacent communities.

Table 6.1-49. Delta Communities Population, 2000 and 2010

Community	2000	2010	Average Annual Growth Rate 2000–2010
Contra Costa County			
Incorporated Cities and Towns			
Antioch	90,532	102,372	1.3%
Brentwood	23,302	51,481	12.1%
Oakley	25,619	35,432	3.8%
Pittsburg	56,769	63,264	1.1%
Small or Unincorporated Communities			
Bay Point	21,415	21,349	-0.0%
Bethel Island	2,252	2,137	-0.5%
Byron	884	1,277	4.5%
Discovery Bay	8,847	13,352	5.1%
Knightsen	861	1,568	8.2%
Sacramento County			
Incorporated Cities and Towns			
Isleton	828	804	-0.3%
Sacramento	407,018	466,488	1.5%
Small or Unincorporated Communities			
Courtland	632	355	-4.4%
Freeport and Hood	467	309[a]	-3.4%
Locke	1,003	Not available	—
Walnut Grove	646	1,542	13.9%
San Joaquin County			
Incorporated Cities and Towns			
Lathrop	10,445	18,023	7.3%
Stockton	243,771	291,707	2.0%
Tracy	56,929	82,922	4.6%
Small or Unincorporated Communities			
Terminous	1,576	381	-7.6%
Solano County			
Incorporated Cities and Towns			
Rio Vista	4,571	7,360	6.1%
Yolo County			
Incorporated Cities and Towns			
West Sacramento	31,615	48,744	5.4%
Small or Unincorporated Communities			
Clarksburg	681	418	-3.9%

Sources: U.S. Census Bureau 2000; U.S. Census Bureau 2011.
[a] Freeport had a population of 38; Hood had a population of 271.

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require Federal permits and thus will not undergo review through the Section 7 consultation process.

Adverse effects on Delta Smelt and their critical habitat may result from urbanization-induced 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, and oil and gasoline product discharges. Increased urbanization also is expected to result in increased recreational activities in the region.

6.1.6.4 Waste Water Treatment Plants

Two wastewater treatment plants (one located on the Sacramento River near Freeport and the other on the San Joaquin River near Stockton) have received special attention because of the magnitude of their discharge of ammonia. The Sacramento Regional Wastewater Treatment Plan (SRWTP), in order to comply with Order no. R5-2013-0124, has begun implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board 2013). By May 11, 2021, the SRWTP must reach a final effluent limit of 2.0 milligrams per liter (mg/L total ammonia nitrogen) per day from April to October, and 3.3 mg/L per day from November to March (Central Valley Regional Water Quality Control Board 2013). However, the treatment plant is currently releasing several tons of ammonia in the Sacramento River each day. A study by Werner *et al.* in 2008 concluded that ammonia concentrations present in the Sacramento River below the SRWTP are not acutely toxic to 55-day-old Delta Smelt. However, based on information provided by EPA (1999) and other related studies, it is possible that concentrations below the SRWTP may be chronically toxic to Delta Smelt and other sensitive fish species (Werner *et al.* 2010). In 2010 the same group conducted three exposure experiments to measure the effect concentration of SRWTP effluent. No significant effects of effluent on the survival of larval Delta Smelt or rainbow trout was found. More recent studies (which used concentrations of ammonia higher than typically experienced by Delta Smelt) have shown that Delta Smelt that are exposed to ammonia exhibit membrane destabilizations. This results in increased membrane permeability and increased susceptibility to synergistic effects of multi-contaminant exposures (Connon *et al.* 2009; Hasenbein *et al.* 2014). Results are unclear at this time as to what the effect of ammonia exposure is on Delta smelt, and research is ongoing. EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. Studies are ongoing to further determine the effect of ammonia on Delta Smelt and other fish populations. The Freeport location of the SRCSD discharge places it upstream of the confluence of Cache Slough and the mainstem Sacramento River, a location just upstream of where Delta Smelt have been observed to congregate in recent years during the spawning season. The potential for exposure of a substantial fraction of Delta Smelt spawners to elevated ammonia levels has heightened the importance of this investigation.

In addition to concerns about direct toxicity of ammonia to Delta Smelt, another important concern is that ammonium inputs have suppressed diatom blooms in the Delta and Suisun Bay, thereby reducing the productivity in the Delta Smelt food web. The IEP MAST Team (2015: 71) provided the following summary: "Dugdale *et al.* (2007) and Wilkerson *et al.* (2006) found that high ammonium concentrations prevented the formation of diatom blooms but stimulated flagellate blooms in the lower estuary. They propose that this occurs because diatoms preferentially utilize ammonium in their physiological processes even though it is used less efficiently and at high concentrations ammonium can prevent uptake of nitrate (Dugdale *et al.* 2007). Thus, diatom populations must consume available ammonium before nitrate, which supports higher growth rates, can be utilized or concentrations of ammonium need to be diluted. A recent independent review panel (Reed *et al.* 2014) found that there is good evidence for preferential uptake of ammonium and sequential uptake of first ammonium and then nitrate, but that a large amount of uncertainty remains regarding the growth rates on ammonium relative to nitrate and the role of ammonium in suppressing spring blooms." The IEP MAST Team (2015: 71-72) further discussed this issue as follows: "Glibert (2012) analyzed long-term data (from 1975 or 1979 to 2006 depending on the variable considered) from the Delta and Suisun Bay and related changing forms and ratios of nutrients, particularly changes in ammonium, to declines in diatoms and increases in flagellates and cyanobacteria. Similar shifts in species composition were noted by Brown (2009), with loss of diatom species, such as *Thalassiosira* sp., an important food for calanoid copepods, including *Eurytemora affinis* and *Sinocalanus doerri* (Orsi 1995). More recently, Parker *et al.* (2012) found that the region where blooms are suppressed extends upstream into the Sacramento River to the SRWTP, the source of the majority of the ammonium in the river (Jassby 2008). Parker *et al.* (2012) found that at high ambient ammonium concentrations, river phytoplankton cannot efficiently take up any form of nitrogen including ammonium, leading to often extremely low biomass in the river. A study using multiple stable isotope tracers (Lehman *et al.* 2014) found that the cyanobacteria *M. aeruginosa* utilized ammonium, not nitrate, as the primary source of nitrogen in the central and western Delta. In 2009, the ammonia concentration in effluent from SRWTP was reduced by approximately 10%, due to changes in operation (K. Ohlinger, Sacramento Regional County Sanitation District, personal communication). In spring 2010 unusually strong spring diatom blooms were observed in Suisun Bay that co-occurred with low ammonia concentrations (Dugdale *et al.* 2013)."

Ammonia discharge concerns have also been expressed with respect to the City of Stockton Regional Water Quality Control Plant, but its remoteness from the parts of the Estuary frequented by Delta Smelt and its recent upgrades suggest that it is more a potential issue for migrating salmonids than for Delta Smelt.

6.1.6.5 Other Activities

Other future, non-Federal actions within the action area that are likely to occur and may adversely affect Delta Smelt and their critical habitat 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; and state or local levee maintenance that may also destroy or adversely affect habitat and interfere with natural, long-term habitat-maintaining processes. The Contra Costa Power Plant, which was owned and operated by NRG Delta, LLC, was retired in 2013 and replaced with the new natural gas power plant, Marsh Landing Generating Station. The Pittsburg Generating Station (PGS) remains in operation and consisted of seven once-through cooling systems, four of which have been retired, one of which is in the process of being retired, and two of which remain in operation. The once-through cooling system intake process can cause the impingement and entrainment of marine animals, kill organisms from all levels of the food chain, and disrupt the normal processes of the ecosystem. Additionally, the plant can discharge heated water that can reach temperatures as high as 100°F into the action area. This sudden influx of hot water can adversely affect the ecosystem and the animals living in it (San Francisco Baykeeper 2010).

On May 4, 2010, the SWRCB adopted a Statewide Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling under Resolution No. 2010–0020 which required existing cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts (State Water Resources Control Board State Water Resources Control Board 2010). The PGS was required to submit an implementation plan to comply with this policy by December 31, 2017. The PGS chose to comply by retrofitting two of the existing units and retiring one unit. The retrofit and retirement of these units is underway (a).

6.2 Effects on Riparian Brush Rabbit

Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.5.7, *Head of Old River Gate Habitat Assessment*, provides the results of a survey to identify suitable riparian brush rabbit habitat within the vicinity of the PA. The survey found the nearest potentially suitable habitat to be 1,260 feet from the activity area. Figure 6.2-1 shows the location of the HOR gate relative to riparian brush rabbit occurrences. See Appendix A, Section 4.A.5.6, S*uitable Habitat Definition*, for a description of suitable riparian brush rabbit habitat.

6.2.1 Geotechnical Exploration

Geotechnical exploration activities will not overlap with suitable riparian brush rabbit habitat therefore activities associated with geotechnical exploration will not affect riparian brush rabbit. Suitable habitat for riparian brush rabbit is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.5.6, *Suitable Habitat Definition.*

6.2.2 Safe Haven Work Areas

The construction footprint for the tunnel alignment does not overlap with any suitable riparian brush rabbit habitat therefore the construction of safe haven work areas will not affect riparian brush rabbit.

6.2.3 North Delta Intake Construction

There is no suitable riparian brush rabbit habitat within or near the construction footprint for the north Delta intakes therefore activities associated with the intakes will not affect this species.

6.2.4 Tunneled Conveyance Facilities

There is no suitable riparian brush rabbit habitat within or near the construction footprint for the water conveyance facilities therefore activities associated with the water conveyance facilities will not affect this species.

6.2.5 Clifton Court Forebay Modification

There is no suitable riparian brush rabbit habitat within or near the construction footprint for the water conveyance facilities therefore activities associated with the Clifton Court Forebay modifications will not affect this species.

6.2.6 Power Supply and Grid Connection

The transmission lines will not be constructed within or near riparian brush rabbit suitable habitat and therefore activities associated with constructing and stringing the transmission lines will not affect this species.

6.2.7 Head of Old River Gate

6.2.7.1 Habitat Loss and Fragmentation

A habitat assessment performed at the HOR gate found no suitable habitat within the proposed HOR gate activity area (Figure 6.2-2). The results of the habitat assessment can be found in Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* Section 4.A.5.7, *Head Old River Gate Habitat Assessment*.

6.2.7.2 Construction Related Effects

The HOR gate will be constructed between Stewart Tract and Roberts Island, where a temporary barrier currently exists. HOR gate construction has two major components: dredging and construction. Dredging to prepare the channel for gate construction will occur along 500 feet of channel, from 150 feet upstream to 350 feet downstream from the proposed barrier. Dredging would occur at a time between August 1 and November 30, lasting approximately 15 days, and would otherwise occur as described in Chapter 3, Section 3.2.10.8, *Dredging and Riprap Placement*. Dredging and riprap placement equipment will be operated from a barge in the channel.

The construction of the cofferdam and the foundation for the HOR gate will require in-water pile driving performed as described in Chapter 3, Section 3.2.10.11, *Pile Driving*. The construction duration is estimated to be up to 32 months. A temporary work area of up to 15 acres will be sited in the vicinity of the barrier. Site access roads and staging areas used in the past for rock barrier installation and removal will be used for construction, staging, and other construction support facilities for the proposed barrier. The installation of the cofferdam will require up to 700 strikes per pile over an estimated 40 day period. The installment of the foundation for the operable barrier will require 15 piles to be set per day with up to 1,050 strikes per pile over an estimated 7-day period.

Construction of the HOR gate will avoid direct injury or mortality to individual riparian brush rabbits because there is no suitable habitat in the activity area. To avoid effects from noise or light, a lighting and pile driving will be excluded to an area at least 1,400 feet from the edge of any potentially suitable habitat. In addition, measures to reduce the effects of indirect light and limit noise from pile driving to daytime hours will be implemented as described in Section 3.3.2.3, *Head of Old River Gate*. With these measures in place, and given the distance to the nearest patch of known suitable habitat and occurrences, any potential effect to an individual riparian brush rabbit from noise or light would be so small as to be immeasurable and is therefore considered insignificant and would not result in take of riparian brush rabbit.

6.2.7.3 Operations and Maintenance

Operation of the HOR gate could vary from completely open (lying flat on the channel bed) to be completely closed (erect in the channel, prohibiting any flow of San Joaquin River water into Old River), with the potential for operations in between that would allow partial flow. The new HOR gate will replace the temporary rock barrier that is typically installed at the same location. Because the HOR gate is replacing an existing temporary barrier, no adverse effects to the potentially suitable habitat from hydrological changes are expected.

Periodic maintenance of the HOR gates would occur every 5 to 10 years. Depending on the rate of sedimentation, maintenance would occur every 3 to 5 years. Effects on riparian brush rabbit are not expected because all maintenance activities would take place within the developed footprint, which is primarily in the channel areas. No terrestrial habitats would be disturbed by maintenance activities. Therefore, the operations and maintenance of the HOR gate will not adversely affect the riparian brush rabbit.

6.2.8 Reusable Tunnel Material

There is no riparian brush rabbit habitat within or near the construction footprint for the North Delta intakes (Figure 6.2-1), therefore activities associated with reusable tunnel material will not affect this species.

6.2.9 Restoration

Restoration activities will be sited in the north, west, and east Delta. Since these areas do not overlap with any suitable riparian brush rabbit habitat, and because these areas are not known to support riparian brush rabbit, restoration activities are not expected to affect riparian brush rabbit. Furthermore, as described in Chapter 3, Section 3.4.7.1.1.1, *Activities with Fixed Locations*, the restoration activities will be sited to avoid effects on riparian brush rabbit habitat, with a 100-foot buffer between restoration areas and suitable riparian brush rabbit habitat. Suitable habitat for riparian brush rabbit is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.5.6, *Suitable Habitat Definition.*

6.2.10 Effects on Critical Habitat

Critical habitat has not been designated for the riparian brush rabbit.

6.2.11 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of riparian brush rabbit will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect riparian brush rabbit in the action area when foraging habitat degradation occurs without USFWS authorization. The most likely activity to affect riparian brush rabbit habitat would be unauthorized removal of riparian habitat on private lands. Climate change threatens to modify annual weather patterns and is likely to reduce the frequency of flooding. While flooding can result in the mortality of individual of riparian brush rabbits, it is also necessary to maintain the early-successional riparian habitat used for cover and foraging for riparian brush rabbit. Because the proposed action is expected to avoid effects on riparian brush rabbit habitat and individuals, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.3 Effects on San Joaquin Kit Fox

Appendix 6.B, *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.8.6, *Suitable Habitat Definition*, provides a definition of suitable San Joaquin kit fox habitat. Appendix A, Section 4.A.8.7 *Species Habitat Suitability Model*, provides a description of the suitable habitat model for San Joaquin kit fox.

Activities associated with geotechnical exploration, tunneled conveyance facility construction, Clifton Court Forebay modifications, power supply and grid connections, reusable tunnel material (RTM) storage areas, and habitat restoration may affect San Joaquin kit fox, as described below. Figure 6.3-1 provides an overview of the locations of surface impacts relative to San Joaquin kit fox modeled habitat. There are 5,192 acres of modeled San Joaquin kit fox habitat in the action area. An estimated 293 acres (6% of total modeled habitat in action area) of San Joaquin kit fox modeled habitat will be permanently lost as a result of the PA Table 6.3-1 and Table 6.3-2 summarize the total estimated loss of San Joaquin kit fox modeled habitat.

Table 6.3-1. Maximum Habitat Loss on Modeled Habitat for San Joaquin Kit Fox by Activity Type (Acres)

San Joaquin Kit Fox Modeled Habitat	Total Modeled Habitat in Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	RTM Storage Area	Restoration	Total Maximum Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Modeled Habitat	5,192	0	0	4	216	0	62	11	293	225	46

Table 6.3-2. Maximum Direct Effects on and Conservation of Modeled Habitat for San Joaquin Kit Fox

San Joaquin Kit Fox Modeled Habitat	Permanent Habit Loss	Compensation Ratios		Total Compensation (Acres)	
	Total Maximum Habitat Loss (Acres)	Protection	Restoration	Protection	Restoration
Modeled Habitat	293	2:1		586	

6.3.1 Geotechnical Exploration

6.3.1.1 Habitat Loss and Fragmentation

The only loss of San Joaquin kit fox habitat resulting from geotechnical exploration inside the footprint will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches in diameter) and would have no or negligible effects on the San Joaquin kit fox.

6.3.1.2 Construction Related Effects

Geotechnical exploration activities will temporarily affect 225 acres of modeled San Joaquin kit fox habitat inside the footprint during the geotechnical exploration. This effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (2 to 21 days). Given the low likelihood of San Joaquin kit fox being present in the areas to be affected, effects on San Joaquin kit fox from geotechnical exploration will be minimal. Construction related actions could injure or kill San Joaquin kit fox if individuals are present, but the potential for this effect will be minimized by limiting activity to the day time, monitoring by a USFWS-approved biologist, and other measures as described in described in Chapter 3, Section 3.4.7.2.1.2, *Activities with Flexible Locations*.

6.3.1.3 Operations and Maintenance

There will be no ongoing operations and maintenance associated with the geotechnical exploration activities, therefore no effects on San Joaquin kit fox.

6.3.2 Safe Haven Work Areas

Safe haven work areas are not expected to be needed in any areas of San Joaquin kit fox modeled habitat, therefore this activity is not expected to affect San Joaquin kit fox.

6.3.3 North Delta Intake Construction

The north Delta intake construction area does not overlap with San Joaquin kit fox modeled habitat. Thus north Delta intake construction will not affect the species (Figure 6.3-1).

6.3.4 Tunneled Conveyance Facilities

6.3.4.1 Habitat Loss and Fragmentation

The construction footprint for a concrete batch plant associated with tunneled conveyance facility construction overlaps with 4 acres of modeled San Joaquin kit fox habitat (Figure 6.3-2). The habitat to be removed is adjacent to cultivated lands and disconnected from the contiguous grassland habitat to the west, therefore has low habitat value for San Joaquin kit fox. As shown on Figure 6.3-1, the site is at the easternmost edge of San Joaquin kit fox habitat in the action area, and therefore its loss will not result in habitat fragmentation or isolation. The permanent loss of 4 acres (>0.1% of modeled San Joaquin kit fox habitat in the action area) of San Joaquin kit fox habitat will be offset through habitat protection at a ratio of 2:1 (protected:lost), for a total of 8 acres of habitat protection. As detailed in Chapter 3, Section 3.4.7.2.3, *Siting Criteria for Compensation for Effects,* the conservation lands will be sited in a location that provides high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for San Joaquin kit fox. As detailed in Chapter 3, Section 3.4.7.2.4, *Management and Enhancement,* these lands will be protected and managed for the species in perpetuity.

6.3.4.2 Construction Related Effects

Facilities to be constructed at tunnel work areas include a concrete batch plant, offices, parking areas, and a shop. Access routes and new permanent access roads will be constructed within the existing impact footprint. Construction of the intermediate forebay includes excavation and building the embankment. See Chapter 3, Section 3.2.3, *Tunnel Conveyance*, and Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*, for complete construction activity and timing details. To allow time for soil consolidation and pad curing at the tunnel work areas and the intermediate forebay, the construction footprint will be cleared very early in the construction schedule; at the intermediate forebay, for instance, earthwork begins 2.5 years prior to ground improvement, and is then followed by a 9-month period of ground improvement, before the site is ready for construction. The duration of active tunnel construction areas is expected to be approximately eight years. The duration of construction activity at the intermediate forebay is expected to be approximately five years.

Construction noise up to 60 dBA (the standard noise threshold for avian species [Dooling and Popper 2007]) will occur within 1,200 feet of the footprints for tunnel work areas, conveyors, and vent shafts. Construction and pile driving noise up to 60 dBA will occur up to 2,000 feet from the edge of the barge landing construction footprint. Light associated with nighttime activities is also possible.

Construction activities will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. Vehicles and heavy equipment used to clear the site and transport equipment and material could injure or kill San Joaquin kit foxes if individuals are present within the construction footprint. Kit foxes could be struck by moving vehicles, or could be entrapped in trenches, pipes, or culverts. Noise and lighting associated with construction could disrupt San Joaquin kit fox behavioral patterns, if kit foxes are present in the vicinity. However, the species has not been detected, nor is it expected to occur, in the area to be affected. Numerous surveys have been conducted for San Joaquin kit fox in the action area and immediately surrounding lands, with negative results (Bradbury, Mike, pers. comm., 2015, Clark et al. 2007; Smith et al. 2006). Given the remote likelihood of active kit fox dens in the vicinity of the conveyance facility, the potential for this effect is small. The likelihood of this effect will also be minimized with the implementation of seasonal no-disturbance buffers around occupied dens, if any, observance of a 20 mile per hour speed limit when possible, inspection of trenches, pipes and culverts by a USFWS-approved biologist, and other measures as described in Section 3.4.7.2.1.1 *Activities with Fixed Locations*. Although measures will be applied to minimize the risk of injuring San Joaquin kit fox or disrupting their behavioral patterns during construction, some potential remains for these effects to occur with all the minimization measures in effect.

6.3.4.3 Operations and Maintenance

The concrete batch plant will be in operation during tunnel conveyance facility construction, a duration of approximately 10 years. Noise and lighting associated with the concrete batch plant could disrupt San Joaquin kit fox behavioral patterns, if kit foxes are present in the vicinity.

6.3.5 Clifton Court Forebay Modification

6.3.5.1 Habitat Loss and Fragmentation

An estimated 216 acres (4% of modeled habitat in action area) of San Joaquin kit fox modeled habitat overlaps with the mapped Clifton Court Forebay modifications (Figures 6.3-2 through 6.3-4). The modeled habitat to be removed is surrounded by cultivated lands and disconnected from the contiguous grassland habitat to the west, and therefore has low habitat value for San Joaquin kit fox. As shown on Figure 6.3-1, the forebay is at the easternmost edge of San Joaquin kit fox habitat in the action area, and therefore effects to this habitat will not result in habitat fragmentation or isolation.

As described in Chapter 3, Section 3.4.7.2.1.1, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. The loss of 216 acres of habitat will be compensated through protection and management of San Joaquin kit fox habitat at a 2:1 ratio, for a total of 432 acres. As detailed in Chapter 3, Section 3.4.7.2.3, *Siting Criteria for Compensation for Effects*, the conservation lands will be sited in a location that provides high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for San Joaquin kit fox. As detailed in Chapter 3, Section 3.4.7.2.4, *Management and Enhancement,* these lands will be protected and managed for the species in perpetuity.

6.3.5.2 Construction Related Effects

Construction activities at Clifton Court Forebay include vegetation clearing, pile driving, excavation, dredging, and cofferdam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately six years. The concurrent use of the six loudest pieces of construction equipment varies by activity types at Clifton Court Forebay. The construction of the divider wall, embankment, and siphons at Clifton Court Forebay will all require pile driving, in combination with the six loudest pieces of construction equipment, noise at these construction areas could reach 60 dBA at up to 2,000 feet from the edge of the footprint. For complete details on construction activities and phasing, see Chapter 3, Section 3.2.5, *Clifton Court Forebay*, for more details on schedule, see Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*.

The construction related effects and measures to minimize them are similar to those described above for water conveyance facilities construction in Chapter 6, Section 6.3.4.2, *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring San Joaquin kit fox or disrupting their behavioral patterns during construction, some potential remains for these effects to occur with all the minimization measures in effect. The potential is very small, however, because kit foxes are unlikely to occur in the area to be affected.

6.3.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures, and siphons. The features will not be operated in or near San Joaquin kit fox habitat and are not expected to affect the species.

Maintenance of the forebay and canals will entail control of vegetation and rodents, and embankment repairs. Maintenance of control structures could entail removal or installation of roller gates, radial gates, and stop logs. Maintenance of the spillway would entail removal and disposal of any debris blocking the outlet culverts. Use of heavy equipment for maintenance may injure San Joaquin kit foxes: these effects and associated minimization measures are as described in Chapter 6, Section 6.3.2.2, *Construction Related Effects.* Additionally, removal of vegetation, embankment repairs, and rodent control measures may result in injury or mortality of San Joaquin kit fox. These effects will be minimized through avoidance of occupied dens, observance of speed limits where possible, and other measures described in Section 3.4.7.6.1.1, *Activities with Fixed Locations.* Even with these measures in place there is a potential for kit foxes to be injured or killed, or for behavioral patterns to be disrupted as a result of noise or light. The possibility of these effects is remote, however, because San Joaquin kit foxes are not likely to be present in the vicinity of the forebay.

6.3.6 Power Supply and Grid Connections

6.3.6.1 Habitat Loss and Fragmentation

To conservatively asses impacts from transmission line placement due to the flexibility of the final alignment, a 50-foot wide disturbance area along the length of the transmission line corridor was assumed (see Appendix 6.B, *Terrestrial Effects Analysis Methods*, for additional details about the impact assessment method). Based on this method, an estimated 40 acres of San Joaquin kit fox modeled habitat will be temporarily affected as a result of the construction of both temporary and permanent transmission lines, substations, and transmission line relocation (Figures 6.3-1 through 6.3-6 and Table 6.3-1). Most of the effect from transmission line construction will be temporary. Temporary impacts are incurred from activities that will not last more than one year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas.

Because the disturbance is primarily from short-term, temporary effects, specific compensation for the 46 acres of San Joaquin kit fox habitat disturbance will be offset by returning these areas to pre-project conditions. Due to the conservative nature of the water conveyance facility impact analysis, and thus the overestimate of mitigation needs, mitigation proposed to compensate for effects from the water conveyance facility is assumed to also provide compensation for the small amount of permanent transmission line effects. As detailed in Chapter 3, Section 3.4.7.2.3, *Siting Criteria for Compensation for Effects*, the conservation lands will be sited in a location that provides high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for San Joaquin kit fox. As detailed in Chapter 3, Section 3.4.7.2.4, *Management and Enhancement*, these lands will be protected and managed for the species in perpetuity.

6.3.6.2 Construction Related Effects

New temporary power lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Construction of new transmission lines will require site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line-stringing phase; for stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Construction-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than one year at any one location. See Chapter 3, Section 3.2.7.2, *Construction*, for a full description of the construction activities.

The operation of equipment during construction of the transmission lines could injure or kill San Joaquin kit fox if individuals are present. The construction related effects and measures to minimize them are similar to those described above for construction of the intake facilities under Chapter 6, Section 6.3.4.2, *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring or killing San Joaquin kit fox during construction, and to minimize the risk of disrupting behavior through noise or lighting, some potential remains for these effects to occur even with all minimization measures in effect. The possibility of these effects is remote, however, because San Joaquin kit foxes are not likely to occur in the area.

6.3.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately ten years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Ongoing vegetation management around the poles and under the lines is expected to be minimal (mechanical mowing and/or trimming) in San Joaquin kit fox habitat because grassland areas seldom if ever need to be cleared to maintain transmission line corridors. Effects on San Joaquin kit fox from transmission line operations and maintenance, if any, are expected to be negligible.

6.3.7 Reusable Tunnel Material Storage Area

6.3.7.1 Habitat Loss and Fragmentation

An estimated 62 acres of San Joaquin kit fox modeled habitat overlaps with the RTM storage area north of Western Farm Ranch Road (Figures 6.3-2 and 6.3-4). This site overlaps with modeled San Joaquin kit fox habitat north of Western Farm Ranch Road, between the Byron Highway and CCF. The habitat to be removed is adjacent to cultivated lands and disconnected from the contiguous grassland habitat to the west, and therefore has low habitat value for San Joaquin kit fox. As shown on Figure 6.3-1, the RTM site is at the easternmost edge of San Joaquin kit fox modeled habitat in the action area, and therefore effects to this site will not result in habitat fragmentation or isolation. The permanent loss of 62 acres of habitat will be compensated through protection and management of San Joaquin kit fox habitat at a 2:1 ratio, for a total of 124 acres. As detailed in Chapter 3, Section 3.4.7.2.3, *Siting Criteria for Compensation for Effects*, the conservation lands will be sited in a location that provides high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for San Joaquin kit fox. As detailed in Chapter 3, Section 3.4.7.2.4, *Management and Enhancement*, these lands will be protected and managed for the species in perpetuity.

6.3.7.2 Construction Related Effects

The RTM storage area that will affect San Joaquin kit fox habitat will take five to eight years to construct and fill. This RTM storage site will be the first to be constructed and filled (see Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*). Construction activities will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. The movement of the material to another site is not an activity covered in the assessment. For more details about the activities associated with RTM placement see Chapter 3, Section 3.2.10.6, *Dispose Spoils*.

Vehicles and heavy equipment used to clear the RTM sites and transport equipment and material could injure or kill San Joaquin kit foxes if individuals are present within the RTM footprint. Kit foxes could be struck by moving vehicles, or could be entrapped in trenches, pipes, or culverts. Noise and lighting associated with construction could disrupt San Joaquin kit fox behavioral patterns, if kit foxes are present in the vicinity. However, the species has not been detected, nor is it expected to occur, in the area to be affected. Numerous surveys have been conducted for San Joaquin kit fox in the action area and immediately surrounding lands, with negative results (Bradbury, Mike, pers. comm., 2015, Clark et al. 2007; Smith et al. 2006). Given the remote likelihood of active kit fox dens in the vicinity of the conveyance facility, the potential for this effect is small. The likelihood of this effect will also be minimized with the implementation of seasonal no-disturbance buffers around occupied dens, if any, observance of a 20 mile per hour speed limit when possible, inspection of trenches, pipes and culverts by a USFWS-approved biologist, and other measures as described in Section 3.4.7.2.1.1 *Activities with Fixed Locations*. Although measures will be applied to minimize the risk of injuring San Joaquin kit fox or disrupting their behavioral patterns during construction, some potential remains for these effects to occur with all the minimization measures in effect.

6.3.7.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to San Joaquin kit fox. While reuse of the RTM is possible, end uses for the material have not yet been identified. It is likely that the material will remain in designated storage areas for a period of years before a suitable end use is identified, and any such use will be subject to environmental evaluation and permitting independent of the PA. Therefore disposition of RTM is assumed to be permanent and future reuse of this material is not part of the PA.

6.3.8 Head of Old River Gate

The HOR gate construction area does not overlap with San Joaquin kit fox modeled habitat and activities associated with HOR gate construction will not affect the species (Figure 6.3-1).

6.3.9 Restoration

6.3.9.1 Habitat Loss and Fragmentation

Restoration activities will avoid effects on San Joaquin kit fox and its habitat with the exception of vernal pool complex restoration which may result in loss of 12 acres of San Joaquin kit fox habitat. While the exact location of vernal pool restoration is not known, it is likely that it will be in the region directly west, north, or south of CCF where San Joaquin kit fox modeled habitat exists. Although vernal pool restoration in grasslands will result in some loss of San Joaquin kit fox habitat, protection and management of surrounding grasslands associated with the vernal pools is expected to benefit San Joaquin kit fox. The loss of 12 acres of habitat will be offset through protection at a 2:1 ratio.

6.3.9.2 Construction Related Effects

Vernal pool restoration will involve use of heavy equipment to excavate areas within grasslands to create topographic depressions. San Joaquin kit foxes could be injured or killed by heavy equipment or struck by vehicles associated with vernal pool construction. The types of effects and measures to minimize these effects are as described in Chapter 6, Section 6.3.2.2, *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring or San Joaquin kit fox during construction, and to minimize the risk of disrupting behavior through noise or lighting, some potential remains for these effects to occur with all the minimization measures in effect.

6.3.9.3 Operations and Maintenance

A variety of management actions to be implemented within restored vernal pool complex may result in localized ground disturbances within San Joaquin kit fox habitat: these activities may include ground disturbance such as removal of nonnative vegetation and road and other infrastructure maintenance activities. Management activities could result in the injury or mortality of San Joaquin kit foxes if individuals are present in work sites or if dens occur in the vicinity of habitat management work sites, but as described in Chapter 3, Section 3.4.7.2.1.2, *Activities with Flexible Locations*, management activities will avoid disturbance of San Joaquin kit fox dens.

6.3.10 Effectiveness Monitoring

On lands protected to benefit San Joaquin kit fox, monitoring will be performed to determine the effectiveness of conservation. Monitoring for San Joaquin kit fox will consist of camera stations baited with a cat food can staked to the ground, on which San Joaquin kit fox will readily deposit scat. For additional details about monitoring see Section 3.4.9.2.3 *Effectiveness Monitoring for Wildlife Species*. Bait stations have potential to alter typical behavior of individual San Joaquin kit fox. As such, effectiveness monitoring for San Joaquin kit fox will be performed by a USFWS approved biologist.

6.3.11 Effects on Critical Habitat

Critical habitat has not been designated for the San Joaquin kit fox

6.3.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of San Joaquin kit fox will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect San Joaquin kit fox in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is conversion of rangeland to urban uses. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of CCF because urbanization within the cities of Brentwood, Pittsburg, Oakley, and Clayton is covered by the East Contra Costa County HCP/NCCP. Urban development outside these incorporated cities (i.e., in the jurisdiction of Contra Costa County) is not covered by the East Contra Costa County HCP/NCCP. Although unlikely to occur due to land use controls, if urban development was proposed in or near the community of Byron it could contribute to a cumulative adverse effect on San Joaquin kit fox in the action area.

Climate change also threatens to modify annual weather patterns. Climate change may result in a loss of San Joaquin kit fox and/or prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat in the action area with the highest likelihood of supporting San Joaquin kit fox is within the East Contra Costa County HCP/NCCP, where large scale conservation efforts will be implemented, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.4 Effects on California Least Tern

Appendix 6.B, *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on terrestrial species. Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.7.6, *Species Habitat Suitability Model*, provides a description of the suitable habitat model for California least tern.

Activities associated with geotechnical exploration, safe haven work areas, the NDDs, tunneled conveyance facilities, CCF modifications, power supply and grid connections, the HOR gate, and RTM storage areas, have the potential to affect California least tern, as described below. Figure 6.4-1 provides an overview of the locations of surface impacts relative to California least tern modeled habitat. See Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* Section 4.A.7.6, *Species Habitat Suitability*, for the definition of suitable California least tern habitat.

Recently, California least terns have been reported nesting at two sites on artificial fill west of the action area: on the eastern edge of Suisun Marsh in the Montezuma Wetland and at the Pittsburg Power Plant in Pittsburg. In addition, there is one nesting record east of the Action Area, where a single pair nested at the Sacramento Regional Wastewater Treatment Plant in 2009 (Conard 2009).

The breeding colonies near the action area are small and exhibit low nesting success compared with those further west and south in San Francisco Bay and in Southern California. In 2010, 23 California least tern pairs and 17 nests were found at the Montezuma Hills site, and only 5 young fledged. California least terns have nested at the Pittsburg Power Plant in Pittsburg with less success. In 2010, Marschalek (2011) documented no breeding pairs at this site. This was the third time in the last 4 years that least terns did not nest at this site. In comparison, 47 California least tern pairs and 47 nests were found at Napa Sonoma Marsh Wildlife Area, and 85 young fledged at that location (see Appendix 4.A.7, *California Least Tern,* for a full species account). For additional detail, see the Status of the Species/Environmental Baseline, Section 4.5.9, *California Least Tern*.

There is no California least tern modeled nesting habitat within the action area; any nesting habitat that may have once been present along the natural shoreline of the Delta has been modified or removed. Surveys will be conducted on occupied nesting habitat as described in Section 3.4.7.3, *Avoidance and Minimization Measures*. Because nesting occurs in the vicinity of the action area, there is some potential for California least tern to forage within the action area. There are 61,751 acres of modeled foraging habitat (open water) in the action area. An estimated 2,268 acres (4% of total modeled habitat in action area) of California least tern modeled habitat will be affected as a result of project implementation. Table 6.4-1 summarizes the maximum affected acreage of California least tern foraging habitat.

Table 6.4-1. Maximum Habitat Loss on Modeled Foraging Habitat for California Least Tern by Activity Type (Acres)

Least Tern Modeled Habitat	Total Modeled Habitat in Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Sites	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Total Maximum Habitat Loss	Geotechnical Exploration	Power Supply and Connection
California Least Tern Habitat	61,751	2	37	34	2,191	3	1	0	2,268	170	9

6.4.1 Geotechnical Exploration

6.4.1.1 Habitat Loss and Fragmentation

Over-water geotechnical exploration activities would occur along the water conveyance tunnel alignment and will not result in any permanent loss of California least tern foraging habitat.

6.4.1.2 Construction Related Effects

Any temporary effects from increased noise at over-water drilling locations are expected to be insignificant due to the distance from known breeding locations (greater than 19 miles). Over-water geotechnical activities are not expected to last more than 60 days in any one location. Because the potential for terns to occur within the vicinity of the tunnel alignment is low, effects on California least tern from geotechnical activities are not anticipated.

6.4.1.3 Operations and Maintenance

There will be no operations and maintenance associated with geotechnical activities.

6.4.2 Safe Haven Work Areas

6.4.2.1 Habitat Loss and Fragmentation

The placement of safe haven work areas is currently unknown because they are constructed "as needed" along the alignment. An estimated 2 acres of modeled California least tern foraging habitat (>0.01% of modeled foraging habitat in the action area) will be removed for the placement of safe haven work areas. Once surface drilling and treatment operations are completed (8 weeks to 24 months), all equipment will be removed and the surface features reestablished. The safe haven work areas will be placed along the tunnel alignment which is area is greater than 25 miles from the nearest breeding colony (Montezuma Wetlands[23]), and there is a very low probability that these areas would be used for foraging by California least tern. In addition, the tern is not limited by foraging habitat and the habitat loss from intake construction comprises less than 0.5% of foraging habitat in the action area.

6.4.2.2 Construction Related Effects

The surface drilling and treatment operation will take from 8 weeks to 24 months. Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from the tunnel alignment to known nesting locations is at least 19 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where construction activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions. Noise or light effects on

[23] The Sacramento Regional Wastewater treatment facility (Bufferlands) is closer to the intake construction location, that site has only supported one successful breeding pair and since 2013 has not supported nesting. As such, this site is not considered a breeding colony. See Section 4.5.9, *California Least Tern*, for more details.

California least tern foraging habitat in the vicinity of the safe haven construction areas are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (the tunnel alignment is at least 19 miles from known breeding locations) as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). No permanent effects on this species from the construction of safe haven work areas are anticipated.

6.4.2.3 Operations and Maintenance

Safe haven work areas will not have any operational capacity. Typical vegetation management will be necessary but effects on modeled California least tern foraging habitat are not anticipated.

6.4.3 North Delta Intake Construction

6.4.3.1 Habitat Loss and Fragmentation

The construction of the north Delta intakes will result in the permanent loss of 37 acres of California least tern modeled foraging habitat (0.06% of modeled foraging habitat within the action area). The impact will occur where intakes 2, 3, and 5 encroach on the Sacramento River's east bank between Clarksburg and Courtland (Figure 6.4-2 through 6.4-4). The intake construction area is greater than 25 miles from the nearest breeding colony (Montezuma Wetlands[24]), and there is a very low probability that these areas would be used for foraging by California least tern. In addition, the tern is not limited by foraging habitat and the habitat loss from intake construction comprises less than 0.5% of foraging habitat in the action area.

6.4.3.2 Construction Related Effects

Construction activities at each intake will include ground clearing and grading, in-water construction of crib walls, in-water pile driving, excavation, and drilling. These activities will require the use of loud, heavy equipment within the construction site as well as along the access roads to the site. Pile driving will create noise and vibration effects. The duration of the effect will be approximately five years as each intake will take approximately five years to construct. Implementation of intake construction at each location will be staggered by approximately six months. Intake 3, the middle intake, will begin construction first; approximately six months later, construction will begin at intake 5, the southernmost intake. Construction at intake 2, the northernmost intake, will begin approximately one year after having begun at intake 5. The result is that construction will overlap at all three sites for approximately four years.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 20 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species

[24] The Sacramento Regional Wastewater treatment facility (Bufferlands) is closer to the intake construction location, that site has only supported one successful breeding pair and since 2013 has not supported nesting. As such, this site is not considered a breeding colony. See Section 4.5.9, *California Least Tern*, for more details.

because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

Noise is the construction-related effect with potential to reach furthest from the project footprint. The standard noise threshold for avian species is 60 dBA (Dooling and Popper 2007). The combined use of the six loudest pieces of construction equipment and pile driving will be no more than 60 dBA at 2,000 feet from the edge of the project footprint. Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the north Delta intakes construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 20 miles) from known breeding locations and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983).

6.4.3.3 Operations and Maintenance

6.4.3.3.1 Operations

6.4.3.3.1.1 Microcystis

The operation of the north Delta intakes have potential to affect streamflows, temperature, and residence times, all variables with potential to affect the occurrence of *Microcystis* blooms. *Microcystis* is a toxic blue-green alga shown to have negative effects on the aquatic foodweb of the Delta (Brooks et al. 2012), with blooms generally occurring from between June to October, when water temperature is 19°C or more. There is potential for some small increase in the frequency of *Microcystis* blooms in the Delta as a result of the operation of the north delta intakes (see Section 6.1.3.5.5 *Microcystis)*, but effects on California least tern are expected to be very small and therefore very difficult to measure. There is only one known, active colony of California least tern’s in the Sacramento-San Joaquin Delta, which on the eastern edge of their known range. This colony is located on the Montezuma wetlands in eastern Suisun Marsh and as of 2013 there were a maximum of 25 breeding pairs and 29 nests with a maximum of four fledglings (Frost 2014). While these nesting birds will forage within the Sacramento-San Joaquin Delta, any incremental effects from potentially slight increases in microcystin concentrations on nesting success would be very difficult to detect given the lack of information regarding the effects of microcystins on California least tern, the existing low reproductive rate of the colony, and the inability to isolate potentially small increases in microcystin as causing an effect distinct from all other potential threats.

6.4.3.3.1.2 Selenium

Selenium exposure has been found to cause reproductive and other physiological effects such as liver lesions, emaciation, developmental abnormalities, etc. in wild aquatic birds that use agricultural drainage water storage areas in the San Joaquin Valley of California (Ohlendorf et al. 2009; Ohlendorf 1986). The selenium concentrations found in these regions are far greater than those found in the Delta today (Presser and Luoma 2006).

A current mass balance of selenium, as a function of source and conveyance, is not available for the San Francisco Estuary (Presser and Luoma 2010). Annual and seasonal variations of selenium concentrations in the Delta and estuary are influenced by discharges in rivers and anthropogenic sources (Presser and Luoma 2006). Water inflow to the Delta comes primarily from the Sacramento and San Joaquin rivers of which the Sacramento River provides the largest water volume contribution and dilution of selenium inputs from other sources. Factors affecting selenium contribution and dilution include total river inflow, water diversions and/or exports, the proportion of the San Joaquin River that is diverted south before entering the estuary, and total outflow of the estuary to the Pacific Ocean (Presser and Luoma 2010).

Selenium contamination in soils and water of the Sacramento Valley is not high and thus not considered a threat in this part of the California least tern's range (Seiler *et al.* 2003). In the San Joaquin River basin, implementation of both regulatory controls and the Grassland Bypass Project, which manages agricultural drainage south and west of the Grassland Ecological Area, have significantly improved water quality in the San Joaquin River and adjacent channels. However, irrigation drainage into Mud Slough and the San Joaquin River results in non-compliance with the selenium water quality objective. Achieving water quality compliance for this segment of the river is not anticipated until 2019 or later. Continued inputs from precipitation runoff from selenium-laden soils, irrigation drainage, and existing riverbed loads still provide inputs of selenium to the Delta where California least tern are potentially exposed to selenium through their diet consisting principally of amphibians and small fish.

There are currently no predictive modeling tools, nor is there an understanding of effects thresholds, that would enable predicting direct effects of dietary selenium exposure on California least tern. However, inferences about the effects of selenium exposure are possible using Delta Smelt as a surrogate for California least tern prey.

In the Delta Smelt effects analysis (Section 6.1, *Effects on Delta Smelt*) DSM2 volumetric fingerprinting was used to estimate the source water contribution of Delta water sources, including the San Joaquin River, that are the primary source of selenium loading to the Delta. Aqueous and Delta Smelt selenium tissue concentrations were modeled at five sites: San Joaquin River at Prisoners Point, Cache Slough at Ryer Island, Sacramento River at Emmaton, San Joaquin River at Antioch, and Suisun Bay at Mallard Island. Modeling results indicated that, of these five sites, the highest proportion of San Joaquin River water and its selenium load (and thus resulting fish tissue selenium) occurred at Prisoners Point. Thus, of the Delta sites modeled for Delta Smelt, Prisoners Point represents the worst-case scenario for selenium exposure.

Results for the PA selenium bioaccumulation modeling for Delta Smelt at Prisoners Point showed increases of as much as twice the modeled tissue concentration, in Delta Smelt foraging at that location. Despite the predicted increases, all but 0.7% of modeled tissue concentrations were below the effects threshold for fish deformities. Based on these modeling results, the PA is unlikely to increase tissue concentrations significantly enough to result in detrimental effects to Delta Smelt. The PA would be expected to have similar effects on fishes with diets and habitat preferences similar to Delta Smelt (e.g., silversides). However, this assumption would not apply to young sunfishes or Sacramento splittail, whose parental diet may include other fish or bivalves that bioaccumulate selenium at substantially higher rate than crustaceans. Our surrogate Delta Smelt tissue modeling also does not represent the risk to California least tern foraging in locations upstream of Prisoners Point with higher San Joaquin River water and selenium contributions, although given the distance to the only active colony, foraging in this area is highly unlikely.

A significant factor in the bioavailability of selenium is water residence time. Biogeochemical modeling suggests that increasing the San Joaquin River discharge could result in increased bioavailable selenium during “low flow” conditions (Meseck and Cutter 2006). Low flow conditions modeled were 70-day residence times. For the PA, residence times were estimated using DSM2-PTM to evaluate the effects of water operations on water quality. Residence time changes under for the PA varied greatly by model site. The highest residence times for the both the NAA and the PA occurred at Grant Line Canal and Old River. The modeling predicted for the PA a 95% percentile, July water residence time of 42.8 days, a reduction of 0.8 days compared to the NAA. Residence time estimates did not meet or exceed the 70-day residence times used in the Meseck and Cutter (2006) biogeochemical modeling that predicted in increased selenium bioavailability. This would suggest that the PA would not result in the same increase of bioavailable, particulate selenium predicted by the hydrologic conditions modeling of Meseck and Cutter (2006).

Thus, using Delta Smelt as a surrogate for California least tern fish prey, selenium bioaccumulation modeling suggests that reductions in fish prey for fish feeding at the same trophic level as Delta Smelt are unlikely to result from the PA. Prey fishes that feed on bivalves or at a higher trophic level may represent an increased risk. Effects of the PA on California least tern, either directly to the bird via increased dietary selenium, or indirectly through reduced fish prey availability, are currently unquantifiable. If risk were increased because of the PA, it would most likely occur for California least tern residing and feeding in the South Delta and the San Joaquin River upstream from Prisoners Point to Vernalis or from California least tern that consumed Sacramento splittail or piscivorous fishes. Given that the only active California least tern colony in the Sacramento-San Joaquin Delta is in Montezuma Wetlands, far from the South Delta, and the fact that California least terns forage on small, top-feeding pelagic fishes such as silversides and topsmelt, the potential for effects from selenium on California least tern is considered so small as to be immeasureable and therefore insignificant.

6.4.3.3.2 Maintenance

Ongoing maintenance activities at the intakes include intake dewatering, sediment removal, debris removal, and biofouling and corrosion removal. These activities will occur from water-based equipment approximately annually. The 60-dBA noise threshold from maintenance activities will not exceed 1,200 feet. Because the intakes are gravity fed, with all pumping being done at the pumping plant at Clifton Court Forebay, no effects from noise will occur as a result of intake operation. Noise, light, or vibration effects on California least tern foraging habitat from operations and maintenance of the north Delta intakes are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 20 miles) from known breeding locations.

6.4.4 Tunneled Conveyance Facilities

6.4.4.1 Habitat Loss and Fragmentation

The tunneled conveyance facilities that would result in 34 acres of impacts on modeled California least tern foraging habitat (0.06% of modeled foraging habitat within action area) include tunnel work areas, vent shafts, tunnel conveyors, access roads, and barge landing (Figures 6.4-5 through 6.4-8). Each of these water conveyance facility structures are located greater than 19 miles from known California least tern breeding locations (Pittsburg Power Plant and Montezuma Wetlands)[25], and there is a very low probability that these areas would be used for foraging by California least tern. In addition, the tern is not limited by foraging habitat and the habitat loss from water conveyance facilities construction comprises less than 0.1% of the foraging habitat in the action area.

6.4.4.2 Construction Related Effects

The duration of active tunnel construction areas is expected to be approximately eight years. See Section 3.2.3, *Tunneled Conveyance*, and Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*, for complete construction activity and timing details.

Construction noise up to 60 dBA (the standard noise threshold for avian species; Dooling and Popper 2007) will occur within 1,200 feet of the footprints for tunnel work areas, tunnel conveyors, and vent shafts. Construction and pile driving noise up to 60 dBA will occur 2,000 feet from the edge of the barge landing construction footprint. Light associated with nighttime activities is also possible.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 19 miles, the potential for birds to occur is very low as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). In addition, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

Noise or light effects on California least tern foraging habitat in the vicinity of the tunneled conveyance facilities construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 19 miles) from known breeding locations. No permanent effects on this species from the construction of the tunneled conveyance facilities are anticipated.

6.4.4.3 Operations and Maintenance

The intermediate forebay and spillway and the pumping plant will require operations and maintenance. Intermediate forebay maintenance includes dredging, control of vegetation and rodents, embankment repairs, and monitoring of seepage flows. Dredging at the intermediate forebay will be infrequent as the sediment storage capacity is designed to last 50 years.

Operations and maintenance related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 19 miles, the potential for birds to occur is very low as the typical foraging habitat for California least tern is within 2

[25] The Sacramento Regional Wastewater treatment facility (Bufferlands) is closer to the intake construction location, that site has only supported one successful breeding pair and since 2013 has not supported nesting. As such, this site is not considered a breeding colony. See Section 4.5.9, *California Least Tern*, for more details.

miles of their colonies (Atwood and Minsky 1983). In addition, if a bird were to forage in a region where dredging activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in open water that could be present under baseline conditions.

Noise or light effects on California least tern foraging habitat in the vicinity of the tunneled conveyance facilities construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 19 miles) from known breeding locations. No permanent effects on this species from the operations and maintenance of the water conveyance facilities are anticipated.

6.4.5 Clifton Court Forebay Modification

6.4.5.1 Habitat Loss and Fragmentation

Clifton Court Forebay (CCF) Modification includes dredging, the expansion of the forebay through the creation of a new embankment, and the creation of a new canal and siphon will impact 2,191 acres of modeled California least tern foraging habitat (3.5% of modeled foraging habitat within the action area). Dredging of the entire forebay to provide additional storage capacity will result in a temporary loss of 1,930 acres of modeled California least tern foraging habitat (Figures 6.4-9 through 6.4-11). The temporary work areas that will support construction activities around CCF will result in 1 acre of modeled habitat loss.

6.4.5.2 Construction Related Effects

Construction activities at Clifton Court Forebay include pile driving, excavation, dredging, and cofferdam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately six years. The duration of dredging is expected to be approximately four years. For complete details on construction activities and phasing, see Section 3.2.5, *Clifton Court Forebay*; for more details on schedule, see Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from CCF to known nesting locations is at least 20 miles, the potential for birds to occur is very low, as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). There is one record, from 1994, of a California least tern foraging in CCF (Yee et al. 1995). However, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

The combined use of the six loudest pieces of construction equipment and pile driving will be no more than 60 dBA at 2,000 feet from the edge of CCF. Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 20 miles) from known breeding locations and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983).

6.4.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the control structures and the siphons. The forebay and the canals will require erosion control, control of vegetation and rodents, embankment repairs, and monitoring of seepage flows. Maintenance of control structures could include roller gates, radial gates, and stop logs. Maintenance requirements for the spillway would include the removal and disposal of any debris blocking the outlet culverts. Dredging may be necessary to remove sediments in the forebays though this is expected to be infrequent as it is designed to hold 50 years of sediment.

Operations and maintenance related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 20 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where dredging activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in open water that could be present under baseline conditions.

Because these activities generate small levels of noise, any potential effect on California least tern would be insignificant and undetectable. Therefore, no noise related effects on California least tern are anticipated from the operations and maintenance associated with the modification of Clifton Court Forebay.

6.4.6 Power Supply and Grid Connections

6.4.6.1 Habitat Loss and Fragmentation

Mapped construction footprints for power supply and grid connections overlap with modeled California least tern foraging habitat in several locations along the alignment (Figure 6.4.1 through 6.4.11, Figure 6.4.13, and 6.4.14). Transmission lines poles or towers would not be placed within open water habitats, and therefore no permanent impacts are expected on California least tern foraging habitat. Based on this method, an estimated 9 acres of modeled California least tern modeled habitat will be temporarily affected as a result of the construction of both temporary and permanent transmission lines, substations, and transmission line relocation (Table 6.4-1).

6.4.6.2 Construction Related Effects

New temporary power lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Temporary substations will be constructed at each intake, at the IF, and at each of the launch shaft locations. To serve permanent pumping loads, a permanent substation will be constructed adjacent to the pumping plants at CCF, where electrical power will be transformed from 230 kV to appropriate voltages for the pumps and other facilities at the pumping plant site. For operation of the three intake facilities, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line-stringing phase; for stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Construction-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than one year at any one location. See Chapter 3, Section 3.2.7.2, *Construction*, for a full description of the construction activities.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 19 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where transmission line construction was occurring, the bird would be expected to avoid the equipment and the construction area. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other structure that could be present under baseline conditions.

Noise or light effects on California least tern foraging habitat in the vicinity of the power supply and grid connection construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 19 miles) from known breeding locations as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983).

6.4.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately ten years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Therefore, operations and maintenance activities for transmission lines will not adversely affect California least tern foraging habitat.

6.4.7 Head of Old River Gate (HOR gate)

6.4.7.1 Habitat Loss and Fragmentation

The construction of the HOR gate will result in the permanent loss of 3 acres (<0.01% of modeled foraging habitat in the action area) of modeled California least tern foraging habitat (Figure 6.4-12). The HOR gate construction area is greater than 35 miles from the nearest breeding colony (Pittsburg Power Plant), and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). Therefore, there is a very low probability that the area around the HOR gate would be used for foraging by California least tern. In addition, the Pittsburg Power Plant nesting location is no longer active. The habitat loss from HOR gate construction comprises less than 0.1% of foraging habitat in the action area.

6.4.7.2 Construction Related Effects

HOR gate construction will include dredging along 500 feet of channel to prepare it for gate construction, which will last approximately 15 days (Section 3.2.10.8, *Dredging and Riprap Placement*). Dredging equipment will be operated from a barge in the channel. It will also include construction of a cofferdam and foundation for the HOR gate, which will require in-water pile driving and will last up to 32 months (3.2.10.11, *Pile Driving*). The installation of the cofferdam will require up to 700 strikes per pile over an estimated 40-day period. The installment of the foundation for the operable barrier will require 15 piles to be set per day with up to 1,050 strikes per pile over an estimated 7-day period.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 35 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

Noise is the construction-related effect with potential to reach furthest from the project footprint. The standard noise threshold for avian species is 60 dBA (Dooling and Popper 2007). The combined use of the six loudest pieces of construction equipment and pile driving will be no more than 60 dBA at 2,000 feet from the edge of the project footprint. Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the HOR gate construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 35 miles) from known breeding locations as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). No permanent effects on this species from the construction of the HOR gate are anticipated.

6.4.7.3 Operations and Maintenance

The new HOR gate will replace the temporary rock barrier that is typically installed at the same location. Because the HOR gate is replacing an existing temporary barrier, no adverse effects to the potentially suitable habitat from hydrological changes are expected.

Periodic maintenance of the HOR gates would occur every 5 to 10 years. Maintenance dredging around the gate would be necessary to clear out sediment deposits. Depending on the rate of sedimentation, maintenance would occur every 3 to 5 years. Noise generated by the service truck nor the dredging machinery will exceed 60 dBA (standard threshold for avian species; Dooling and Popper 2007) at 1,200 feet (See Section 3.3, *Operations and Maintenance of New and Existing Facilities* for further detail).

Operations and maintenance related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 35 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where operations and maintenance activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in open water that could be present under baseline conditions.

Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the HOR gate construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 35 miles) from known breeding locations. No permanent effects on this species from the operations and maintenance of the HOR gate are anticipated.

6.4.8 Reusable Tunnel Material Storage Area

6.4.8.1 Habitat Loss and Fragmentation

Mapped construction footprints for the reusable tunnel material sites overlap with 1 acre (>0.01% of modeled foraging habitat in the action area) of California least tern modeled foraging habitat (Figure 6.4-13 and 6.4-14). The impact will occur from the RTM site west of Clifton Court Forebay along Italian Slough. California least tern is not expected to be foraging at Clifton Court Forebay because it is 20 miles from the nearest nesting site (Pittsburg Power Plant), and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). Therefore, there is a very low probability that these areas around Clifton Court Forebay would be used for foraging by California least tern. In addition, the Pittsburg Power Plant nesting location is no longer active.

6.4.8.2 Construction Related Effects

Each RTM storage area will take five to eight years to construct and fill. RTM areas will be constructed, as needed, depending on location. RTM storage area construction and placement will occur almost continuously through tunnel excavation, approximately 10 years. Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. The movement of the material to another site is not an activity covered in the assessment. For more details about the activities associated with RTM placement see Section 3.2.10.6, *Dispose Soils*.

Noise or light effects on California least tern foraging habitat in the vicinity of the RTM storage area footprints are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 20 miles) from known breeding locations and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983).

6.4.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM storage areas and therefore no effects on California least tern.

6.4.9 Restoration

The placement of restoration sites is currently unknown. However, tidal, non-tidal, and riparian restoration and channel margin enhancement to offset effects on species habitat and wetlands will not result in conversion of modeled California least tern foraging habitat to other habitat types. All restoration sites will be selected by DWR, subject to approval by the jurisdictional fish and wildlife agencies (CDFW, NMFS, USFWS).

6.4.10 Effects on Critical Habitat

Critical habitat has not been designated for the California least tern.

6.4.11 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of California least tern will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect California least tern in the action area when foraging habitat degradation occurs without USFWS authorization; the likelihood of open-water habitat loss is very unlikely. The most likely activity to affect the quality of open-water habitat is unauthorized water pollution and climate change. Poor water quality may decrease prey species density or increase toxin loading such that nesting success and survivorship are affected. Climate change threatens to modify annual weather patterns; it may result in a loss of California least tern prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat near the action area with the highest likelihood of supporting nesting California least terns is within Suisun Marsh area where development is prohibited or highly restricted, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.5 Effects on Western Yellow-Billed Cuckoo

Appendix 6.B, *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Field surveys of the entire action area were not possible because many of the properties are in private ownership. For this reason, GIS-based habitat models were used to identify areas of potential effect. Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.11.7, *Species Habitat Suitability Model*, provides a description of the habitat suitability model for western yellow-billed cuckoo. That model identifies migratory habitat for western yellow-billed cuckoo in the action area. Western yellow-billed cuckoos are not known to nest in the action area, therefore the PA will not affect nesting western yellow-billed cuckoos. The nearest CNDDB nesting occurrence for this species is 43 miles from the location where modeled habitat would be removed by project related activities.

Activities associated with geotechnical exploration, safe haven work areas, north Delta intakes, tunneled conveyance facilities, and power supply and grid connection activities may affect migrating western yellow-billed cuckoos, as described below. Figure 6.5-1 provides an overview of the locations of surface impacts relative to western yellow-billed cuckoo migratory habitat and occurrences. An estimated 33 acres of western yellow-billed cuckoo migratory habitat will be lost as a result of project implementation. There is a total of approximately 11,224 acres of western yellow-billed cuckoo migratory habitat in the action area. Therefore, the loss of 33 acres would result an impact on 0.3% of the migratory habitat in the action area (Table 6.5-1). As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio for a total of 66 acres of riparian creation or restoration.

Table 6.5-1. Maximum Habitat Loss on Habitat for Western Yellow-Billed Cuckoo by Activity Type (Acres)

Western Yellow-Billed Cuckoo Habitat	Total Habitat in Action Area	Permanent Habitat Loss									
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Power Supply and Connection	Geotechnical Exploration	Total Habitat Loss
Total Migratory Habitat	11,224	1	5	11	0	0	12	0	4	0	33

6.5.1 Geotechnical Exploration

Geotechnical exploration sites are currently undetermined but will occur along the tunnel alignment. A USFWS approved biologist will work with the geotechnical exploration team to identify and avoid adverse effects on western yellow-billed cuckoo migratory habitat as described in Section 3.4.7.5.1.2 *Activities with Flexible Locations*. Therefore, geotechnical exploration will not affect western yellow-billed cuckoo.

6.5.2 Safe Haven Work Areas

The placement of safe haven work areas is currently unknown because they are constructed “as needed” along the alignment. Once surface drilling and treatment operations are completed (8 weeks to 24 months), all equipment will be removed and the surface features reestablished.

6.5.2.1 Habitat Loss and Fragmentation

There will be some flexibility in the placement of the safe haven work areas. A USFWS-approved biologist will work with the construction team to minimize suitable western yellow-billed cuckoo habitat (as described in Section 3.4.7.5.1, *Avoidance and Minimization Measures*). An estimated one acre of western yellow-billed cuckoo habitat will be removed for construction of safe haven work areas. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio.

6.5.2.2 Construction Related Effects

Construction activities at the safe haven locations will create noise up to 60 dBA at no more than 1,200 feet from the edge of the construction footprint unless pile driving is required, in which case noise up to 60 dBA could reach up to 2,000 feet from the edge of the construction footprint. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). To minimize this effect, DWR will reduce noise in the vicinity of western yellow-billed cuckoo habitat as described in Section 3.4.7.5.1, *Avoidance and Minimization Measures*. There will still be some potential for noise-related harassment to occur, but the effect, if any, is expected to be small because migratory habitat is not a limiting factor in the delta and cuckoos can shift their locations accordingly. Furthermore, migrating western yellow-billed cuckoos would be in the area for only several days, if present.

Night lighting may also have the potential to affect migrating western yellow-billed cuckoos. While there is no data on effects of night lighting on migration for this species, studies show that migrating birds of other species are attracted to artificial lights and this may disrupt their migratory patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). To minimize this effect, DWR will reduce light in the vicinity of western yellow-billed cuckoo habitat as described in Section 3.4.7.5.1, *Avoidance and Minimization Measures*. There will still be some potential, however, for light-related effects to occur.

6.5.2.3 Operations and Maintenance

Unsited safe haven intervention areas will not have any operational capacity but vegetation management such as mowing and discing and the application of approved herbicides may be necessary. Since this will occur in areas that have already been cleared of riparian vegetation, if any was present, operations and maintenance of safe haven work areas are not expected to affect migrating western yellow-billed cuckoos.

6.5.3 North Delta Intake Construction

6.5.3.1 Habitat Loss and Fragmentation

The north delta intakes will result in the loss of an estimated five acres of western yellow-billed cuckoo habitat (Table 6.5-1; Figures 6.5-2, 6.5-3, and 6.5-4). Fragmentation is not expected to affect migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss of migratory habitat will be offset through riparian creation or restoration at a 2:1 ratio.

6.5.3.2 Construction Related Effects

Construction activities at each intake are described in Section 3.3.6.1, *North Delta Intakes*. These activities will require the use of loud, heavy equipment within the construction site as well as along the access roads to the site. Pile driving will create noise and vibration effects. Noise and lighting associated with north delta intake construction may affect western yellow-billed cuckoo, and these effects will be minimized, as described in Section 6.5.2.2, *Construction Related Effects*.

6.5.3.3 Operations and Maintenance

Ongoing maintenance activities at the intakes include intake dewatering, sediment removal, debris removal, and biofouling and corrosion removal. These activities will occur from water-based equipment approximately annually. Noise and lighting effects from maintenance activities and permanent facility lighting could adversely affect migrating western yellow-billed cuckoos if they use habitat in the vicinity. Permanent and maintenance-related lighting will be minimized as described in Chapter 3, Section 3.4.7.5.1, *Avoidance and Minimization Measures.* Although there may be residual noise and lighting extending into western yellow-billed cuckoo migratory habitat, this is not likely to result in injury of western yellow-billed cuckoos as a result of impairing essential behavioral patterns because migratory habitat is plentiful in the action area and individuals can readily avoid the disturbance during migration.

Because the intakes are gravity fed, with all pumping being done at the pumping plant at Clifton Court Forebay, no effects from noise will occur as a result of intake operation.

6.5.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities include tunnel work areas, vent shafts, the pumping plant and shaft location, a new forebay and spillway, tunnel conveyors, barge unloading facilities, fuel stations, and concrete batch plants (Figures 6.5-1, 6.5-2, 6.5-5, 6.5-8, and 6.5-9).

6.5.4.1 Habitat Loss and Fragmentation

An estimated 11 acres of western yellow-billed cuckoo migratory habitat (0.1% of migratory habitat in the action area) will be removed for tunneled conveyance facility construction (Table 6.5-1). Fragmentation is not expected to be an effect for migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio.

6.5.4.2 Construction Related Effects

Construction activities associated with conveyance facility activities are described in Section 3.2, *Conveyance Facility Construction.* Western yellow-billed cuckoo migratory habitat occurs in the vicinity of the forebay and spillway and may be affected by construction noise and light. Construction noise up to 60 dBA will occur at up to 2,000 feet from the forebay and spillway construction footprint. Light effects from nighttime activities are also possible. Noise and lighting associated with conveyance facility construction may affect western yellow-billed cuckoos as described in Section 6.5.2.2, *Construction Related Effects*.

6.5.4.3 Operations and Maintenance

The intermediate forebay and spillway will require operations and maintenance. Intermediate forebay maintenance includes dredging, control of vegetation and rodents, embankment repairs, and monitoring of seepage flows. As described in Section 6.5.4.1 *Habitat Loss and Fragmentation*, western yellow-billed cuckoo migratory habitat occurs in the vicinity of construction. However, this habitat is greater than 4,000 feet south of the forebay and spillway. Therefore, adverse effects on western yellow-billed cuckoo from operations and maintenance activity noise are not expected.

6.5.5 Clifton Court Forebay Modification

Clifton Court Forebay (CCF) modification includes dredging, the expansion of the forebay through the creation of a new embankment, and creating a new canal and siphon. The CCF modification footprint does not overlap with western yellow-billed cuckoo migratory habitat. Furthermore, there is no migratory habitat in the vicinity of the CCF modification footprint. Therefore, activities associated with CCF modification will not affect western yellow-billed cuckoos.

6.5.6 Power Supply and Grid Connections

6.5.6.1 Habitat Loss and Fragmentation

Mapped construction footprints for the transmission lines will result in loss of up to four acres of western yellow-billed cuckoo migratory habitat (Figures 6.5-1 through 6.5-4 and 6.5-6 through 6.5-9). Fragmentation is not expected to be an effect for migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio.

6.5.6.2 Construction Related Effects

New temporary power lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Construction of new transmission lines will require site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line-stringing phase; for stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Construction-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. Section 3.2.7.2, *Construction*, provides a full description of the construction activities related to transmission line installation. The duration of transmission line construction activities will not be more than one year at any one location.

Western yellow-billed cuckoo migratory habitat occurs in the vicinity of the transmission lines, and may be affected by construction noise and light. Light effects from nighttime activities are also possible. Noise and lighting associated with transmission line construction may affect western yellow-billed cuckoo as described in Section 6.5.2.2 *Construction Related Effects*. For details on the avoidance and minimization measures, see Section 3.4.7.5.1.1 *Activities with Fixed Locations*.

6.5.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately ten years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Loss of habitat associated with the transmission line is counted under permanent habitat loss, therefore vegetation control is not likely to result in any additional effects on western yellow-billed cuckoo.

Migrating western yellow-billed cuckoos may be subject to bird strikes at the transmission lines. However, bird strike diverters will be installed on project and existing transmission lines in a configuration that research indicates will reduce bird strike risk by at least 60% or more, as described in Section 3.4.7.4.1 *Avoidance and Minimization Measures*. With the avoidance and minimization measures in place, and in view of the rarity of migrating western yellow-billed cuckoos in the action area, it is highly unlikely that this species will experience bird strikes at project transmission lines.

6.5.7 Head of Old River Gate

The HOR gate construction footprint does not overlap with western yellow-billed cuckoo migratory habitat. Furthermore, there is no migratory habitat in the vicinity of the HOR gate. Therefore, activities associated with the HOR gate will not affect western yellow-billed cuckoo.

6.5.8 Reusable Tunnel Material

6.5.8.1 Habitat Loss and Fragmentation

An estimated 12 acres of western yellow-billed cuckoo migratory habitat (0.1% of migratory habitat in the action area) will be removed for reusable tunnel material placement (Table 6.5-1; Figures 6.5-2, 6.5-5, 6.5-6, and 6.5-10). Fragmentation is not expected to be an effect for migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the habitat loss will be offset through riparian creation or restoration at a 2:1 ratio.

6.5.8.2 Construction Related Effects

Each RTM storage area will take five to eight years to construct and fill. Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt for long-term on-site storage. The movement of the material to another site is not an activity covered in the assessment. For more details about the activities associated with RTM placement see Section 3.2.10.6, *Dispose Soils*.

Western yellow-billed cuckoo migratory habitat occurs in the vicinity of several RTM sites. Noise and lighting associated with RTM construction may affect migrating western yellow-billed cuckoos as described in Section 6.5.2.2, *Construction Related Effects*.

6.5.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM storage areas and therefore no effects to western yellow-billed cuckoo. While reuse of the RTM is possible, end uses for the material have not yet been identified. It is likely that the material will remain in designated storage areas for a period of years before a suitable end use is identified, and any such use will be subject to environmental evaluation and permitting independent of the PA. Therefore disposition of RTM is assumed to be permanent and future reuse of this material is not part of the PA.

6.5.9 Restoration

6.5.9.1 Habitat Loss and Fragmentation

A USFWS approved biologist will work with DWR and BOR to avoid the loss of suitable habitat. As such, no western yellow-billed cuckoo migratory habitat will be removed to construct restoration sites.

6.5.9.2 Construction Related Effects

Western yellow-billed cuckoo migratory habitat may occur in the vicinity of restoration sites, once they have been located. Noise and lighting associated with RTM construction may affect western yellow-billed cuckoos as described in Section 6.5.2.2, *Construction Related Effects*.

6.5.9.3 Operations and Maintenance

Restoration sites will not have any operational capacity but typical vegetation management will be necessary. Because restoration areas will be sited to avoid adverse effects on western yellow-billed cuckoo migratory habitat, no effects from vegetation management on the species are anticipated.

6.5.9.4 Effects on Critical Habitat

There is no critical habitat for western yellow-billed cuckoo in the action area.

6.6 Effects on Giant Garter Snake

Appendix 6.B, *Terrestrial Effects Analysis Methods,* describes the methods and assumptions used to analyze the effects of the proposed action (PA) on terrestrial species. Section 4.A.12.7 *Species Habitat Suitability Model*, provides a description of the suitable habitat model for giant garter snake. Suitable habitat for giant garter snake is defined in Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* Section 4.A.12.6, *Suitable Habitat Definition.*

Activities associated with geotechnical exploration, safe haven work areas, north delta intakes, tunneled conveyance facilities, Clifton Court Forebay modifications, power supply and grid connections, Head of Old River (HOR) Gate, reusable tunnel material, and habitat restoration activities may affect giant garter snake, as described below. Figure 6.6-1 provides an overview of the locations of surface impacts relative to giant garter snake modeled habitat and occurrences. Section 4.A.12.6, *Suitable Habitat Definition,* for the definition of suitable giant garter snake habitat. There are 88,947 acres (26,328 acres of aquatic habitat and 62,619 acres of upland habitat) of modeled giant garter snake habitat in the action area. An estimated 934 acres (1% of total modeled habitat in action area) of modeled giant garter snake habitat will be lost as a result of project implementation. This includes 243 acres of modeled aquatic habitat (1% of modeled aquatic habitat in action area) and 690 acres of modeled upland habitat (1.1% of modeled upland habitat in action area). Effects from these activities will be described in detail below. Table 6.6-1 and Table 6.6-2 summarize the total estimated habitat loss of giant garter snake modeled habitat.

Table 6.6-1. Maximum Habitat Loss of Modeled Habitat for Giant Garter Snake by Activity Type (Acres)

Giant Garter Snake Modeled Habitat	Total Modeled Habitat in Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Tidal Restoration	Total Maximum Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Aquatic-High	13,598	2	0	29	4	0	27	0	61	0[1]	11
Aquatic-Moderate	12,095	0	0	45	11	0	3	34	94	0[1]	1
Aquatic-Low	635	1	12	18	2	1	53	2	88	0[1]	6
Upland-High	32,216	1	37	34	0	0	81	0	154	28	18
Upland-Moderate	8,357	0	17	75	217	2	75	44	430	63	44
Upland-Low	22,046	1	9	18	2	0	3	74	107	6	6
Aquatic Total	**26,328**	**3**	**12**	**93**	**16**	**1**	**83**	36	243	**0[1]**	**18**
Upland Total	**62,619**	**2**	**62**	**127**	**219**	**2**	**159**	118	690	**98**	**68**
Total	**88,947**	**5**	**74**	**220**	**235**	**3**	**242**	154	934	**98**	**85**

[1] Geotechnical exploration will avoid suitable aquatic giant garter snake habitat, see Chapter 3, Section 3.4.7.6.1, *Avoidance and Minimization Measures*

Table 6.6-2. Maximum Direct Effects on and Conservation of Modeled Habitat for Giant Garter Snake

	Permanent Habitat Loss	Compensation Ratios		Total Compensation	
	Total Maximum Habitat Loss (Acres)	**Protection**	**Restoration**	**Protection[2]**	**Restoration[2]**
Aquatic, High	61	3:1 or 2:1[1]		183 or 122	
Aquatic, Moderate	94	3:1 or 2:1[1]		282 or 188	
Aquatic, Low	88	3:1 or 2:1[1]		264 or 176	
Upland, High	154	3:1 or 2:1[1]		462 or 308	
Upland, Moderate	430	3:1 or 2:1[1]		1,290 or 860	
Upland, Low	107	3:1 or 2:1[1]		321 or 642	
Aquatic Total	**243**	**3:1 or 2:1[1]**		**729 or 486**	
Upland Total	**691**			**2,073 or 1,382**	
TOTAL	**934**			**2,802 or 1,868**	

[1] The 3:1 mitigation ratio will be applied when “in-kind” mitigation is used. In-kind mitigation is that mitigation that replaces a habitat of similar quality, character, and location as that which was lost within the known range of the giant garter snake as described in Section 4.A.11.6, *Suitable Habitat Definition*. DWR will mitigate at a rate of 2:1 for each acre of lost aquatic and upland habitat if the mitigation is created/protected in a USFWS agreed-to high-priority conservation location for GGS, such as the eastern protection area between Caldoni Marsh and Stone Lakes

[2] Compensation can be achieved through restoration or protection. The protection component of habitat compensation will be limited to up to 1/3 of the total compensation.

6.6.1 Geotechnical Exploration

6.6.1.1 Habitat Loss and Fragmentation

The only loss of giant garter snake habitat resulting from geotechnical exploration will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches diameter) and will have no or negligible effects on the giant garter snake.

6.6.1.2 Construction Related Effects

Geotechnical exploration will avoid effects on giant garter snake aquatic habitat but may temporarily affect up to 98 acres of upland habitat during geotechnical exploration. Except for the habitat loss associated with boreholes described above, this temporary effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (2 to 21 days). The operation of equipment during construction could result in injury or mortality of giant garter snakes, if any are present. The potential for this effect will be minimized by confining activities to more than 200 feet from the banks of aquatic habitat if the activity occurs during the active season, confining movement of heavy equipment to existing access roads or to locations more than 200 feet from the banks of potential giant garter snake aquatic habitat, and requiring that all construction personnel receive worker awareness training, as described in Section 3.4.7.6.1.2 *Activities with Flexible Locations.*

6.6.1.3 Operations and Maintenance

There will be no ongoing operations or maintenance associated with geotechnical exploration, therefore no effect on giant garter snake.

6.6.2 Safe Haven Work Areas

6.6.2.1 Habitat Loss and Fragmentation

An estimated 5 acres of giant garter snake habitat (>0.01% of modeled habitat in the action area) will be removed for the placement of safe haven work areas. This loss includes an estimated 3 acres of aquatic habitat (>0.5% of modeled aquatic habitat in action area) and 2 acres of upland habitat (>0.5% of modeled upland habitat in the action area). Table 6.6-2 quantifies the loss of habitat for each habitat value category. Once surface drilling and treatment operations are completed (8 weeks to 24 months), all equipment will be removed and the surface features reestablished.

Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from safe haven work areas. As described in Section 3.4.7.6.1.2 *Activities with Flexible Locations,* workers will confine ground disturbance and habitat removal in the vicinity of suitable habitat to the minimal area necessary to facilitate construction activities.

6.6.2.2 Construction Related Effects

Vehicles and heavy equipment used to clear the construction sites and transport equipment and material could injure or kill giant garter snakes if individuals are present within the construction footprint. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for giant garter snakes to enter the work area. A biological monitor will inspect the construction area prior to and during construction, and if a giant garter snake is encountered during surveys or construction, activities will cease until appropriate corrective measures have been completed, it has been determined that the giant garter snake will not be harmed, or the giant garter snake has left the work area. Additional measures to minimize this effect include limiting vehicle speed in areas outside exclusion fencing to 10 miles per hour within and in the vicinity of giant garter snake habitat where practical and safe to do so, visually checking for giant garter snakes under vehicles and equipment prior to moving them, and checking crevices or cavities in the work area including stockpiles which have been left for more than 24 hours where cracks or crevice may have formed. Equipment will be stored in designated staging areas, and these staging areas will have exclusion fencing where giant garter snakes have potential to occur. For more details on avoidance and minimization measures, see Section 3.4.7.6.1.1, *Activities with Fixed Locations*.

Giant garter snakes could potentially become entangled, trapped, or injured as a result of erosion control measures that use plastic or synthetic monofilament netting in construction areas. As discussed in Appendix 3.F, *General Avoidance and Minimization Measures*, AMM2 *Construction Best Management Practices and Monitoring*, exclusion fencing near giant garter snake habitat will be taut silt fabric (nonmonofilament) 36 inches high with the bottom buried six inches below grade. Exclusion fences will be surveyed daily to ensure they are intact and upright as detailed in Section 3.4.7.6.1.1 *Activities with Fixed Locations*. With these measures in place, the potential for giant garter snakes to be affected in this manner is minimal. Giant garter snakes may be trapped in pipes or other structures used for construction. Workers will inspect any conduits or other features where giant garter snakes may be trapped, and workers will properly contain and remove all trash and waste items generated during construction as detailed in Section 3.4.7.6.1.1, *Activities with Fixed Locations*. With these measures in place, the potential for giant garter snakes to become trapped is minimal.

Giant garter snakes may be injured or killed, or their habitat may be contaminated, as a result of the use of toxic materials during construction. To avoid this effect, all construction equipment will be maintained to prevent leaks of fuel, lubricant, or other fluids, and workers will exercise extreme caution when handling or storing materials. Workers will keep appropriate materials on site to contain and clean up any spills as described in Appendix 3.F, *General Avoidance and Minimization Measures*, AMM5 *Spill Prevention, Containment, and Countermeasure Plan*. With these measures in place, the potential for giant garter snakes to become injured or killed, or their habitat to be contaminated, is minimal.

Construction related light, noise, vibrations, and increased human activity in and near habitat could result in harm and/or harassment of giant garter snakes by interfering with normal activities such as feeding, sheltering, movement between refugia and foraging grounds, and other essential behaviors.

6.6.2.3 Operations and Maintenance

Safe haven work areas will not have any operational capacity and will not have any permanent facilities that will require maintenance. The safe haven shaft will be backfilled after they have fulfilled their purpose.

6.6.3 North Delta Intake Construction

6.6.3.1 Habitat Loss and Fragmentation

An estimated 74 acres of giant garter snake modeled habitat overlaps with the mapped north delta intakes 2, 3, and 5 along the Sacramento River (Figures 6.6-2, 6.6-3, 6.6-4), where land will be cleared for permanent facilities and temporary work areas. The 74 acres of modeled habitat (>0.01% of modeled habitat in the action area) includes 12 acres of aquatic habitat (>0.01% of modeled aquatic habitat in the action area) and 62 acres of upland habitat (>0.01% of modeled upland habitat in action area). Of the estimated 74 acres of modeled habitat to be removed, 47 acres (3 acres of aquatic and 44 acres of upland) will result from construction of permanent facilities such as intake structures and associated electrical buildings and facilities, and permanent access roads. The remaining 27 acres (9 acres of aquatic and 18 acres of upland) of loss will result from use of the work areas, which will last for approximately five years at each intake: because the duration of this effect is greater than one year, this effect will be compensated as if it were a permanent effect. Table 6.6-1 quantifies the loss of habitat for each habitat value category (see Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.11.6, *Suitable Habitat Definition*, for description of high, moderate, and low value habitat categories).

As shown on Figures 6.6-2, 6.6-3, and 6.6-4, the modeled habitat to be lost as a result of intake construction is modeled upland habitat along the Sacramento River. Per the Draft 2015 *Recovery Plan for Giant Garter Snake*, the Sacramento River at the intake locations does not meet the definition of either aquatic habitat or a corridor (U.S. Fish and Wildlife Service 2015). Either the intakes or their construction are likely to obstruct giant garter snake movement in the Sacramento River.

Table 6.6-2 shows the compensation acreage to offset the total loss of giant garter snake habitat, see Table 6.6-2. As described in Section 3.4.7.6.1.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal in the vicinity of suitable habitat to the minimal area necessary to facilitate construction activities.

6.6.3.2 Construction Related Effects

Construction activities at each intake that may affect giant garter snake include ground clearing and grading, construction of the intakes and associated facilities, vehicular use including transport of construction equipment and materials, in-water construction of crib walls, and in-water pile driving. It is unlikely that the in-water activity will affect giant garter snakes because the activities will occur in the Sacramento River, where the species is very unlikely to be present, based on the definitions of aquatic and corridor habitat presented in the Draft 2015 *Recovery Plan for Giant Garter Snake* (U.S. Fish and Wildlife Service 2015).

The duration of construction at each intake facility will be approximately five years. Implementation of intake construction at each location will be staggered by approximately six months. Construction for Intake 3, the middle intake, will begin first; approximately six months later, construction will begin at intake 5, the southernmost intake. Construction at intake 2, the northernmost intake, will begin approximately one year after having begun at intake 5. The result is that construction will overlap at all three sites for approximately four years.

Vehicles and heavy equipment used to clear the construction sites and transport equipment and material could injure or kill giant garter snakes if individuals are present within the construction footprint. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for giant garter snakes to enter the work area. A biological monitor will inspect the construction area prior to and during construction, and if a giant garter snake is encountered during surveys or construction, activities will cease until appropriate corrective measures have been completed, it has been determined that the giant garter snake will not be harmed, or the giant garter snake has left the work area. Additional measures to minimize this effect include limiting vehicle speed to 10 miles per hour within and in the vicinity of giant garter snake habitat where practical and safe to do so, visually checking for giant garter snakes under vehicles and equipment prior to moving them, and checking crevices or cavities in the work area including stockpiles which have been left for more than 24 hours where cracks or crevice may have formed. Equipment will be stored in designated staging areas, and these staging areas will have exclusion fencing where giant garter snakes have potential to occur. These measures are described in detail in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations.* With these measures in place, there is still potential for giant garter snakes to be injured or killed if, for example, vehicles must travel greater than 10 miles per hour and are unable to avoid giant garter snakes or if a snake is able to get through the construction fencing and is undetected by the biological monitor.

Giant garter snakes could potentially become entangled, trapped, or injured as a result of erosion control measures that use plastic or synthetic monofilament netting in construction areas. This effect will be avoided as described in Appendix 3.F, *General Avoidance and Minimization Measures*, AMM2 *Construction Best Management Practices and Monitoring* by prohibiting use of these materials and limiting erosion control materials silt fencing. With these measures in place, the potential for giant garter snakes to be affected in this manner is minimal.

Giant garter snakes may be trapped in pipes or other structures used for construction. To avoid this effect, as described in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations*, workers will inspect any conduits or other features where giant garter snakes may be trapped, and workers will properly contain and remove all trash and waste items generated during construction. With these measures in place, the potential for giant garter snakes to become trapped is minimal.

Giant garter snakes may be injured or killed, or their habitat may be contaminated, as a result of the use of toxic materials during construction. To avoid this effect, all construction equipment will be maintained to prevent leaks of fuel, lubricant, or other fluids, and workers will exercise extreme caution when handling or storing materials. Workers will keep appropriate materials on site to contain and clean up any spills as described in Appendix 3.F, *General Avoidance and Minimization Measures*, AMM5 *Spill Prevention, Containment, and Countermeasure Plan*. With these measures in place, the potential for giant garter snakes to become injured or killed, or their habitat to be contaminated, is minimal.

Construction related effects on aquatic habitat outside the development footprint include decreased water quality during construction activities due to runoff, dewatering, and minor ground disturbance. Construction related water quality effects will be addressed through standard water quality protection measures as described in Appendix 3.F, *General Avoidance and Minimization Measures*, AMM3 *Stormwater Pollution Prevention Plan*, and AMM4 *Erosion and Sediment Control Plan*.

Construction related light, noise, vibrations, and increased human activity in and near habitat could result in harm and/or harassment of giant garter snakes by interfering with normal activities such as feeding, sheltering, movement between refugia and foraging grounds, and other essential behaviors. Construction related light will be minimized to the greatest extent practicable by restricting construction to daytime hours and restricting the use of nighttime lights, when possible, as described in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations*. Noise effects will be minimized as described in Appendix 3.F, *General Avoidance and Minimization Measures*, AMM13 Noise *Abatement*. However, since these measures will only be implemented where practicable, some residual effects resulting from light, noise, vibrations, and human activity are anticipated near giant garter snake habitat. Due to the long-term nature of the activities, giant garter snakes may habituate to these disturbances.

6.6.3.3 Operations and Maintenance

6.6.3.3.1 Maintenance

Ongoing maintenance activities at the intakes include intake dewatering, sediment removal, debris removal, and biofouling and corrosion removal. These activities will occur from water-based equipment approximately annually. These activities are not expected to affect giant garter snake or its habitat because, as stated above, giant garter snakes are not likely to be present in the open water portion of the Sacramento River.

6.6.3.3.2 Operations

6.6.3.3.2.1 Microcystis

The operation of the north Delta intakes has potential to affect streamflows, temperature, and residence times, all off which may affect the occurrence of *Microcystis* blooms. *Microcystis* is a toxic blue-green alga shown to have negative effects on the aquatic foodweb of the Delta (Brooks et al. 2012), with blooms generally occurring from between June to October, when water temperature is 19°C or more. The sensitivity to microcystins, the toxins produced by *Microcystis*, varies by species and life stage (Butler et al. 2009; Schmidt et al. 2013). During *Microcystis* blooms, microcystins may accumulate in tissues of small planktivorous (plankton-eating) fish through the consumption of *Microcystis* or through foodweb transfer, i.e., consumption of prey that have consumed *Microcystis* (Schmidt et al. 2013); to a lesser extent, microcystins may be absorbed directly from the water (Butler et al. 2009). Microcystins are actively absorbed into the tissues and organs of vertebrates, particularly the liver, where they disrupt cellular activity (Butler at al. 2009; Schmidt et al. 2013). Although microcystins have been found in various aquatic organisms, including phytoplankton, zooplankton, crayfish, shrimp, mussel, snail, fish, and frogs, and are known to accumulate in several fish species (Schmidt et al. 2013; Smith and Haney 2006), some research indicates that the toxins may be excreted by the kidneys or metabolized into less toxic forms (Gupta and Guha 2006; Schmidt et al. 2013; Smith and Haney 2006). A study on sunfish found microcystin concentrations decreased after exposure, however, some persisted in organs.

The potential operational effects of the PA on *Microcystis* were assessed using two approaches. First, the frequency of flow conditions conducive to *Microcystis* occurrence (as defined by Lehman et al. 2013) was assessed in the San Joaquin River past Jersey Point (QWEST) and in the Sacramento River at Rio Vista (QRIO), based on DSM2-HYDRO modeling. Second, DSM2-QUAL water temperature modeling (Section 6.1.3.5.2, *Water Temperature*) and DSM2-PTM for estimates of residence time (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.4.3, methods discussion) were used to inform the potential for *Microcystis* occurrence, given the importance of water temperature and the probable importance of residence time (although there are no published relationships between *Microcystis* occurrence and residence time in the Delta). Note that more weight is placed on the analysis based on the published flow conditions at which *Microcystis* occurs (Lehman et al. 2013), because there are no published analyses of the relationship between *Microcystis* occurrence and residence time. Both sets of quantitative analyses (i.e., the flow analysis and the residence time/temperature analysis) focused on the summer/fall (July-November) period because it is during this time of the year that *Microcystis* blooms are likely to occur. Note that other environmental factors, such as nutrients, also affect the abundance of *Microcystis* (Lehman et al. 2014), but these factors are not readily predictable for comparison of the NAA and PA scenarios. This introduces some uncertainty to results based only on flow or residence time/temperature.

The first analysis examined the frequency of years during July-November in which mean monthly flows were within the range at which *Microcystis* has been shown to occur, per Lehman et al. (2013: 155): -240 to 50 m^3/s (approx. -8,500 to 1,800 cfs) for QWEST, and 100-450 m^3/s (approx. 3,500 to 15,900 cfs) for QRIO[26]. This analysis suggested that flow conditions conducive to *Microcystis* bloom occurrence would tend to occur less frequently under the PA than NAA in the San Joaquin River, based on QWEST. For NAA, the percentage of years with QWEST within the range for *Microcystis* occurrence ranged from 89% in October to 98% in August, whereas for PA, the range was from 9% of years in October to 99% of years in August (Table 6.6-3). Neither the NAA nor the PA yielded mean monthly flows below the range noted for *Microcystis* occurrence, whereas for the PA there were substantially more years above the range than for NAA. The results reflected greater mean QWEST flows under the NAA compared to PA, with monthly means under the PA ranging from just under 0 m^3/s (-100 cfs) in August (compared to -168 m^3/s or -5,900 cfs under NAA) to 245 m^3/s (8,600 cfs) in October (compared to 16 m^3/s or 570 cfs under NAA). These results are attributable to less south Delta export pumping under the PA than under the NAA.

[26] The DSM2-HYDRO output locations used for estimating QWEST were RSAN018 + SLTRM004 + SLDUT007; and for QRIO was RSAC101.

Table 6.6-3. Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the San Joaquin River Past Jersey Point (QWEST) Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman et al. 2013).

	NAA				PA			
	Below Range (< -240 m^3/s)	**Within Range (-240 to 50 m^3/s)**	**Above Range (> 50 m^3/s)**	**Mean Flow, m^3/s (cfs)**	**Below Range (< -240 m^3/s)**	**Within Range (-240 to 50 m^3/s)**	**Above Range (> 50 m^3/s)**	**Mean Flow, m^3/s (cfs)**
July	0%	95%	5%	-162 (-5,714)	0%	78%	22%	68 (2,384)
August	0%	98%	2%	-168 (-5,931)	0%	99%	1%	-3 (-103)
September	0%	96%	4%	-128 (-4,531)	0%	52%	48%	191 (6,729)
October	0%	89%	11%	16 (568)	0%	9%	91%	245 (8,637)
November	0%	91%	9%	-39 (-1,391)	0%	53%	47%	178 (6,281)

Implementation of north Delta export pumping under the PA would result in reduced Sacramento River flow compared to the NAA, as reflected in the examination of QRIO (Table 6.6-3). The percentage of years within the range at which *Microcystis* has been noted to occur ranged from 59% in September to 89% in August under NAA, compared to a range from 48% in September to 96% in July for PA (Table 6.6-4). Given that Lehman et al.'s (2013) suggested mechanism for the importance of flow was lower flows leading to sufficiently long residence time to allow *Microcystis* colonies to accumulate into blooms, flows below the range noted for *Microcystis* occurrence by Lehman et al. (100-450 m^3/s) could also be favorable for bloom occurrence, whereas flows above the range may reduce residence time sufficiently to limit bloom formation. The percentage of years in which mean monthly flow was above the range that Lehman et al. (2013) found for *Microcystis* occurrence was less under PA than NAA in July (0%, compared to 10% under NAA), September (0%, compared to 29% under NAA), and November (10%, compared to 16% under NAA). On the basis of differences in QRIO flow, therefore, there could be greater potential for *Microcystis* occurrence in the lower Sacramento River under the PA than NAA. However, this is currently not an area of intense *Microcystis* blooms and if it remains turbid in the future, it is expected that current conditions will continue.

Table 6.6-4. Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the Sacramento River at Rio Vista Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman et al. 2013).

	NAA				PA			
	Below Range (< -100 m^3/s)	**Within Range (-100 to 450 m^3/s)**	**Above Range (> 450 m^3/s)**	**Mean Flow, m^3/s (cfs)**	**Below Range (< -100 m^3/s)**	**Within Range (-100 to 450 m^3/s)**	**Above Range (> 450 m^3/s)**	**Mean Flow, m^3/s (cfs)**
July	5%	85%	10%	702 (24,793)	4%	96%	0%	396 (13,984)
August	11%	89%	0%	462 (16,331)	11%	89%	0%	282 (9,942)
September	12%	59%	29%	754 (26,612)	52%	48%	0%	457 (16,136)
October	15%	84%	1%	420 (14,839)	15%	84%	1%	291 (10,275)
November	7%	77%	16%	769 (27,162)	0%	90%	10%	541 (19,097)

The results of the DSM2-PTM-based residence time analysis presented here focus only on the particle insertion locations upstream (east) of Suisun Bay and Suisun Marsh, because this is where effects of the proposed action (PA) on hydraulic residence time are highest. The effects of the PA on residence time varied by subregion of the Delta. As previously described, there has been no published analysis of the relationship between *Microcystis* occurrence and residence time, so there is uncertainty as to what the differences described here may mean in terms of potential for *Microcystis* occurrence. In the riverine portions of the Sacramento River, residence time is short under both scenarios and so there is little potential for the PA to influence the growth potential of *Microcystis* (Table 6.1-27 and
Table 6.1-28). During summer and fall, residence time in the Sacramento Ship Channel subregion is usually strongly tidally driven, with a relatively minor component of riverine flow, so there is little difference in residence time between NAA and PA (Table 6.1-29). Residence time generally was estimated to be 1-4 days longer under PA than under NAA in the Cache Slough and Liberty Island subregion during July to November (Table 6.1-30); this generally was also true for Rio Vista and the lower Sacramento River in July and August, whereas the residence time in September to November in these subregions generally was similar or slightly lower under PA than under NAA (Table 6.1-31 and Table 6.1-32). As noted in the analysis of QRIO based on Lehman et al. (2013), this is currently not an area of intense *Microcystis* blooms and if it remains turbid in the future, it is expected that current conditions will continue.

In the Lower San Joaquin River and Twitchell Island subregions, residence time generally was greater under the PA than under NAA in July and August, but was similar or less under the PA than under NAA in September to November (Table 6.1-33 and Table 6.1-34). This is in general agreement with the analysis of QWEST that was previously presented: in July and August, QWEST mean values below -5,000 cfs (Table QWEST_microcystis) under NAA reflects high south Delta export pumping that would cause particles to leave the area rapidly (towards the south Delta export facilities) compared to PA. Residence time in the eastern portion of the Delta (San Joaquin River at Prisoners Point and near Stockton, Mokelumne River, and Disappointment Slough) generally was estimated to be greater under the PA (Table 6.1-35, Table 6.1-36, Table 6.1-37, Table 6.1-38), in some cases 4-12 days longer, e.g., Disappointment Slough in July. Substantially greater residence times under the PA also were estimated for Mildred Island, e.g., over 10 days at the 25%–75% percentiles (Table 6.1-39). Increases in residence time were apparent over much of the central/south Delta subregions examined, including Holland Cut (Table 6.1-40), Franks Tract (Table 6.1-41), and Rock Slough and Discovery Bay (Table 6.1-42). Low residence times in Old River and Middle River reflect the relatively short duration before particles are entrained, but lower south Delta export pumping under the PA leads to longer residence times even in these channels, particularly in September–November (Table 6.1-43 and Table 6.1-44). Additional factors increasing residence time in these months under the PA include no export pumping and HOR gate closure during and prior to the fall pulse flow period (Section 3.3.2, *Operational Criteria*, Appendix 5.A, *CALSIM Methods and Results,* Section 5.A.5.2). Considerably increased residence times in Victoria Canal under the PA (compared to NAA) in some months likely reflects the modeled operations of Contra Costa Water District diversions; particles that are entrained relatively quickly by the diversion under the NAA are not moved as quickly in the PA because the Rock Slough diversion is used preferentially, in response to higher EC (Table 6.1-45). Relatively long residence times in the Grant Line Canal and Old River subregion reflect the influence of the south Delta temporary barriers, with similar or longer residence times under the PA in July–August (Table 6.1-46); shorter residence times under the PA in October/November are a result of differing assumptions regarding the fall operations of the HOR gate under the PA compared to the rock barrier under the NAA. In general, there were relatively small differences in residence time for the Upper San Joaquin River subregion (Table 6.1-47).

Table 6.6-5. Summary Statistics of Residence Time (Days) in the Upper Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.4	0.7	0.3 (65%)	0.6	1.2	0.6 (107%)	0.5	0.7	0.3 (57%)	0.5	1.1	0.7 (148%)	0.4	0.8	0.4 (99%)
25%	0.5	1.1	0.7 (135%)	0.6	1.5	0.8 (126%)	0.5	1.0	0.5 (83%)	0.8	1.4	0.7 (87%)	0.6	1.1	0.4 (69%)
50% (median)	0.5	1.2	0.7 (124%)	0.7	1.8	1.1 (164%)	1.2	2.2	1.0 (89%)	1.0	1.7	0.6 (63%)	1.0	1.4	0.4 (45%)
75%	0.8	1.4	0.6 (76%)	1.8	2.0	0.2 (14%)	2.4	2.7	0.4 (15%)	1.6	1.9	0.2 (13%)	1.8	1.7	0.0 (-2%)
95%	2.4	2.7	0.2 (9%)	3.2	3.1	0.0 (-1%)	20.1	11.5	-8.7 (-43%)	2.3	2.3	0.0 (0%)	16.2	10.6	-5.5 (-34%)

Table 6.6-6. Summary Statistics of Residence Time (Days) in the Sacramento River Near Ryde Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	0.4	0.1 (33%)	0.5	0.9	0.4 (69%)	0.5	0.6	0.1 (29%)	0.3	0.6	0.3 (76%)	0.4	0.7	0.3 (85%)
25%	0.5	0.8	0.4 (80%)	0.6	1.1	0.5 (89%)	0.5	0.7	0.2 (33%)	0.6	1.2	0.5 (83%)	0.5	0.9	0.4 (78%)
50% (median)	0.5	1.0	0.5 (89%)	0.7	1.3	0.6 (89%)	0.7	1.5	0.8 (113%)	0.9	1.5	0.6 (65%)	0.8	1.3	0.6 (72%)
75%	0.7	1.2	0.5 (65%)	1.3	1.8	0.5 (40%)	1.7	2.1	0.5 (29%)	1.4	1.7	0.2 (16%)	1.1	1.5	0.4 (32%)
95%	1.8	1.7	-0.1 (-6%)	2.4	2.7	0.2 (10%)	2.5	2.5	0.0 (0%)	2.1	2.3	0.2 (12%)	1.9	1.9	0.0 (-1%)

Table 6.6-7. Summary Statistics of Residence Time (Days) in the Sacramento River Ship Channel Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	43.3	43.4	0.1 (0%)	43.2	43.1	0.0 (0%)	43.2	43.2	0.0 (0%)	42.5	42.5	0.0 (0%)	39.8	39.7	-0.1 (0%)
25%	43.4	43.5	0.0 (0%)	43.3	43.4	0.1 (0%)	43.3	43.3	0.0 (0%)	43.4	43.3	0.0 (0%)	42.3	42.2	0.0 (0%)
50% (median)	43.6	43.6	0.0 (0%)	43.7	43.8	0.1 (0%)	43.7	43.7	0.1 (0%)	43.7	43.6	0.0 (0%)	43.1	43.1	0.0 (0%)
75%	44.0	44.1	0.0 (0%)	44.0	44.1	0.0 (0%)	43.9	44.0	0.0 (0%)	43.9	43.9	0.0 (0%)	44.1	44.0	0.0 (0%)
95%	44.3	44.3	0.0 (0%)	44.2	44.2	0.0 (0%)	44.3	44.3	0.1 (0%)	44.4	44.4	0.0 (0%)	44.3	44.3	0.0 (0%)

Table 6.6-8. Summary Statistics of Residence Time (Days) in the Cache Slough and Liberty Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	20.4	22.5	2.1 (10%)	16.5	19.5	3.0 (18%)	13.1	14.2	1.1 (8%)	11.4	13.8	2.4 (21%)	8.3	9.6	1.3 (15%)
25%	21.3	23.3	2.0 (9%)	17.2	20.8	3.6 (21%)	14.8	17.5	2.7 (18%)	14.6	17.1	2.4 (17%)	11.5	13.1	1.6 (14%)
50% (median)	22.0	23.8	1.8 (8%)	18.3	21.1	2.8 (15%)	16.1	18.7	2.7 (16%)	15.9	18.2	2.2 (14%)	13.4	14.5	1.2 (9%)
75%	22.7	25.1	2.4 (11%)	20.6	22.1	1.5 (7%)	18.2	21.1	2.9 (16%)	17.6	18.6	1.0 (6%)	14.9	15.6	0.7 (5%)
95%	25.8	27.0	1.2 (5%)	22.3	23.7	1.4 (6%)	22.5	22.3	-0.2 (-1%)	19.0	19.5	0.5 (3%)	16.7	16.4	-0.3 (-2%)

Table 6.6-9. Summary Statistics of Residence Time (Days) in the Sacramento River Near Rio Vista Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.4	2.0	0.7 (48%)	5.8	7.4	1.6 (27%)	3.2	1.8	-1.4 (-43%)	3.8	2.7	-1.1 (-29%)	3.6	3.9	0.3 (9%)
25%	6.6	7.7	1.2 (17%)	9.2	9.2	0.0 (0%)	5.0	2.7	-2.3 (-46%)	5.6	5.3	-0.3 (-5%)	5.0	5.3	0.3 (5%)
50% (median)	7.4	11.9	4.5 (60%)	10.4	13.6	3.2 (31%)	7.8	9.0	1.2 (16%)	9.2	8.1	-1.1 (-12%)	6.2	6.6	0.5 (7%)
75%	13.7	14.9	1.1 (8%)	14.7	17.0	2.3 (16%)	15.5	14.7	-0.8 (-5%)	11.9	10.2	-1.7 (-14%)	8.0	9.9	1.9 (24%)
95%	17.3	17.1	-0.2 (-1%)	17.9	19.6	1.7 (10%)	18.9	17.9	-1.0 (-5%)	15.9	14.7	-1.1 (-7%)	12.3	12.1	-0.2 (-2%)

Table 6.6-10. Summary Statistics of Residence Time (Days) in the Lower Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.2	4.7	1.6 (49%)	10.1	12.2	2.1 (21%)	4.8	3.5	-1.3 (-26%)	6.7	6.7	0.0 (0%)	6.1	6.0	-0.1 (-2%)
25%	9.1	12.3	3.2 (35%)	13.5	13.6	0.1 (1%)	7.0	4.4	-2.6 (-37%)	8.8	8.4	-0.4 (-5%)	7.5	7.4	-0.1 (-1%)
50% (median)	12.9	15.0	2.1 (17%)	17.4	18.7	1.3 (8%)	13.4	12.5	-0.9 (-7%)	13.4	12.9	-0.5 (-4%)	10.2	10.8	0.6 (6%)
75%	20.9	21.0	0.2 (1%)	21.7	23.4	1.7 (8%)	22.6	21.2	-1.5 (-6%)	18.4	16.9	-1.5 (-8%)	13.2	14.6	1.4 (11%)
95%	22.4	22.2	-0.2 (-1%)	23.5	24.4	0.9 (4%)	24.3	23.4	-0.9 (-4%)	20.9	20.5	-0.4 (-2%)	18.7	18.4	-0.3 (-1%)

Table 6.6-11. Summary Statistics of Residence Time (Days) in the Lower San Joaquin River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.1	4.6	1.4 (45%)	12.0	12.7	0.7 (6%)	5.5	3.7	-1.8 (-32%)	7.5	6.8	-0.7 (-9%)	7.1	5.2	-2.0 (-27%)
25%	11.3	13.0	1.7 (15%)	15.4	14.2	-1.2 (-8%)	10.4	4.3	-6.1 (-58%)	9.8	7.8	-2.0 (-21%)	9.6	8.1	-1.5 (-15%)
50% (median)	14.1	16.0	2.0 (14%)	17.8	18.3	0.5 (3%)	14.5	11.9	-2.6 (-18%)	13.4	11.5	-1.9 (-14%)	12.2	10.9	-1.3 (-11%)
75%	20.4	21.5	1.1 (5%)	22.4	23.3	1.0 (4%)	22.9	20.7	-2.2 (-10%)	19.9	16.7	-3.2 (-16%)	14.5	15.7	1.2 (8%)
95%	22.7	23.4	0.7 (3%)	24.8	25.2	0.4 (2%)	25.5	24.3	-1.1 (-4%)	22.3	21.0	-1.3 (-6%)	19.3	20.1	0.8 (4%)

Table 6.6-12. Summary Statistics of Residence Time (Days) in the San Joaquin River at Twitchell Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.7	3.1	0.4 (14%)	9.5	12.1	2.6 (27%)	8.1	4.3	-3.8 (-47%)	8.4	5.3	-3.2 (-38%)	7.6	6.0	-1.6 (-21%)
25%	10.2	13.5	3.3 (32%)	10.8	13.6	2.8 (26%)	10.3	5.9	-4.3 (-42%)	12.4	8.0	-4.3 (-35%)	10.6	9.6	-1.0 (-9%)
50% (median)	12.0	16.1	4.1 (35%)	12.6	17.0	4.5 (36%)	11.6	13.3	1.6 (14%)	14.5	11.8	-2.7 (-18%)	12.6	11.8	-0.8 (-6%)
75%	13.6	18.1	4.5 (33%)	19.4	20.4	1.1 (6%)	19.0	20.0	1.0 (5%)	18.2	16.9	-1.4 (-8%)	15.3	15.9	0.6 (4%)
95%	21.0	21.1	0.1 (0%)	23.4	22.2	-1.2 (-5%)	23.0	22.6	-0.4 (-2%)	20.8	20.2	-0.6 (-3%)	18.9	19.7	0.8 (4%)

Table 6.6-13. Summary Statistics of Residence Time (Days) in the San Joaquin River at Prisoners Point from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.7	3.0	0.3 (10%)	4.3	8.4	4.1 (95%)	4.4	5.3	0.9 (20%)	7.5	6.5	-1.0 (-14%)	3.9	6.6	2.7 (68%)
25%	4.9	9.7	4.7 (96%)	5.0	10.5	5.5 (109%)	5.4	7.7	2.3 (43%)	9.8	8.3	-1.5 (-15%)	7.4	8.4	1.0 (14%)
50% (median)	6.0	10.7	4.7 (79%)	6.3	11.0	4.7 (74%)	7.4	11.0	3.7 (50%)	10.7	11.0	0.3 (3%)	8.6	10.6	2.0 (24%)
75%	7.3	12.2	4.9 (66%)	12.5	13.3	0.9 (7%)	10.9	15.0	4.1 (38%)	14.1	14.8	0.7 (5%)	11.1	12.4	1.3 (11%)
95%	13.6	14.8	1.2 (9%)	18.7	16.2	-2.5 (-13%)	16.8	16.7	-0.1 (-1%)	16.5	17.2	0.7 (4%)	14.6	15.0	0.4 (3%)

Table 6.6-14. Summary Statistics of Residence Time (Days) in the North and South Forks Mokelumne River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	4.9	8.7	3.8 (79%)	3.0	6.7	3.7 (126%)	3.9	5.8	1.9 (50%)	6.3	7.5	1.2 (18%)	5.6	5.3	-0.2 (-4%)
25%	12.6	15.6	3.0 (24%)	4.2	8.9	4.7 (112%)	6.7	8.7	2.0 (30%)	9.4	8.7	-0.7 (-7%)	7.1	9.7	2.6 (36%)
50% (median)	20.8	20.8	0.0 (0%)	8.3	11.9	3.6 (44%)	11.4	12.4	1.0 (9%)	10.0	10.7	0.7 (7%)	8.9	10.3	1.4 (16%)
75%	26.1	24.6	-1.5 (-6%)	17.2	17.9	0.7 (4%)	17.0	17.7	0.7 (4%)	13.6	14.0	0.4 (3%)	11.1	12.5	1.3 (12%)
95%	34.2	31.5	-2.7 (-8%)	27.2	20.1	-7.1 (-26%)	24.7	22.2	-2.5 (-10%)	21.5	16.6	-4.9 (-23%)	16.5	14.2	-2.3 (-14%)

Table 6.6-15. Summary Statistics of Residence Time (Days) in the Disappointment Slough Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	12.1	15.5	3.4 (29%)	10.9	18.2	7.2 (66%)	10.8	15.2	4.4 (40%)	13.2	9.5	-3.7 (-28%)	14.7	15.1	0.3 (2%)
25%	17.9	26.7	8.9 (50%)	20.8	20.9	0.1 (1%)	16.8	18.4	1.6 (9%)	15.8	17.8	2.0 (13%)	18.6	17.9	-0.6 (-3%)
50% (median)	25.0	36.9	11.8 (47%)	25.7	29.9	4.2 (16%)	20.6	23.0	2.4 (12%)	19.6	22.9	3.3 (17%)	24.8	21.0	-3.8 (-15%)
75%	34.0	39.4	5.5 (16%)	29.3	33.0	3.8 (13%)	23.3	25.1	1.8 (8%)	23.7	28.7	5.0 (21%)	29.0	29.6	0.7 (2%)
95%	38.2	41.9	3.7 (10%)	34.2	35.6	1.4 (4%)	27.5	29.3	1.8 (7%)	27.5	30.8	3.3 (12%)	34.9	33.2	-1.7 (-5%)

Table 6.6-16. Summary Statistics of Residence Time (Days) in the San Joaquin River Near Stockton Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.3	1.5	0.2 (12%)	3.2	3.9	0.7 (22%)	4.1	4.3	0.1 (4%)	3.0	3.5	0.5 (17%)	2.8	3.1	0.4 (13%)
25%	5.8	7.8	2.0 (35%)	6.5	8.0	1.5 (23%)	5.9	6.8	0.9 (16%)	4.1	5.1	1.0 (25%)	4.4	5.0	0.6 (14%)
50% (median)	13.9	11.7	-2.3 (-16%)	9.7	9.8	0.1 (1%)	6.7	8.6	1.9 (29%)	5.2	6.2	1.1 (21%)	5.7	6.8	1.1 (19%)
75%	18.1	13.0	-5.0 (-28%)	12.1	10.9	-1.1 (-9%)	8.7	9.8	1.1 (13%)	6.4	7.4	1.1 (17%)	7.5	7.6	0.2 (2%)
95%	29.2	23.0	-6.2 (-21%)	15.1	14.4	-0.7 (-5%)	10.0	11.0	1.1 (11%)	8.3	9.0	0.7 (8%)	8.7	9.3	0.6 (7%)

Table 6.6-17. Summary Statistics of Residence Time (Days) in the Mildred Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.0	7.1	4.1 (138%)	1.8	5.0	3.3 (183%)	2.0	7.4	5.4 (270%)	2.9	8.9	6.0 (205%)	2.1	4.1	2.0 (93%)
25%	4.4	15.5	11.1 (255%)	2.2	8.1	5.8 (262%)	3.2	9.2	6.0 (188%)	3.7	11.6	7.9 (215%)	3.0	6.1	3.1 (106%)
50% (median)	6.9	23.4	16.5 (238%)	3.7	9.5	5.9 (160%)	4.7	10.7	6.0 (127%)	5.2	13.0	7.8 (150%)	4.6	13.9	9.3 (205%)
75%	11.1	27.1	16.0 (144%)	13.6	11.9	-1.7 (-12%)	6.9	14.9	8.0 (115%)	9.5	16.5	7.0 (73%)	15.9	15.7	-0.2 (-1%)
95%	25.1	30.0	4.9 (20%)	19.3	19.6	0.3 (2%)	15.4	16.8	1.4 (9%)	21.6	22.6	1.0 (4%)	21.1	21.5	0.4 (2%)

Table 6.6-18. Summary Statistics of Residence Time (Days) in the Holland Cut Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.4	3.8	2.4 (169%)	1.2	3.7	2.4 (198%)	1.5	4.7	3.3 (225%)	2.5	6.5	3.9 (156%)	1.8	3.3	1.5 (81%)
25%	2.0	4.2	2.2 (114%)	1.6	5.1	3.5 (226%)	1.8	5.5	3.7 (208%)	3.4	8.0	4.6 (134%)	2.6	4.0	1.4 (52%)
50% (median)	2.5	4.8	2.3 (95%)	2.4	5.7	3.3 (139%)	3.0	7.5	4.5 (154%)	3.9	8.6	4.7 (123%)	3.3	5.8	2.5 (75%)
75%	3.5	6.0	2.5 (73%)	5.4	6.6	1.1 (21%)	5.7	8.8	3.1 (55%)	5.8	9.1	3.3 (57%)	4.9	8.5	3.7 (76%)
95%	5.6	6.8	1.2 (22%)	9.8	7.8	-2.0 (-21%)	9.7	9.7	-0.1 (-1%)	7.5	9.8	2.3 (31%)	6.9	9.6	2.8 (41%)

Table 6.6-19. Summary Statistics of Residence Time (Days) in the Franks Tract Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	9.4	10.7	1.2 (13%)	10.0	11.1	1.1 (11%)	9.0	8.2	-0.8 (-9%)	9.1	8.6	-0.5 (-5%)	8.1	8.0	-0.1 (-1%)
25%	10.9	12.2	1.3 (12%)	10.9	13.2	2.4 (22%)	10.3	9.4	-0.8 (-8%)	11.1	9.7	-1.5 (-13%)	11.2	10.3	-0.9 (-8%)
50% (median)	11.6	14.4	2.8 (24%)	11.9	16.1	4.3 (36%)	11.8	14.1	2.3 (20%)	13.9	12.5	-1.4 (-10%)	12.3	12.0	-0.3 (-3%)
75%	12.8	16.6	3.8 (30%)	17.0	17.8	0.8 (5%)	16.2	17.4	1.1 (7%)	15.4	13.8	-1.6 (-10%)	14.4	15.1	0.7 (5%)
95%	16.9	17.5	0.6 (3%)	18.0	19.9	1.9 (10%)	18.7	18.5	-0.2 (-1%)	18.6	17.0	-1.7 (-9%)	18.1	18.0	-0.1 (-1%)

Table 6.6-20. Summary Statistics of Residence Time (Days) in the Rock Slough and Discovery Bay Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	4.8	7.4	2.6 (54%)	3.9	8.5	4.6 (119%)	4.7	11.0	6.3 (135%)	5.4	8.4	3.0 (55%)	5.0	6.9	1.9 (37%)
25%	5.6	8.8	3.3 (59%)	5.3	9.7	4.4 (84%)	5.6	14.6	8.9 (159%)	7.3	10.0	2.8 (38%)	5.9	8.2	2.3 (39%)
50% (median)	6.4	10.0	3.7 (57%)	5.7	11.9	6.2 (109%)	6.8	17.5	10.7 (158%)	8.8	15.2	6.4 (72%)	7.5	9.8	2.2 (29%)
75%	7.3	11.4	4.1 (56%)	10.1	15.9	5.9 (58%)	16.6	19.3	2.7 (17%)	12.1	17.1	5.0 (42%)	10.8	12.1	1.3 (12%)
95%	10.7	13.9	3.1 (29%)	19.2	22.3	3.1 (16%)	19.8	25.2	5.4 (27%)	20.6	19.2	-1.4 (-7%)	12.2	13.6	1.5 (12%)

Table 6.6-21. Summary Statistics of Residence Time (Days) in the Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	1.5	1.0 (212%)	0.4	1.4	1.0 (275%)	0.6	1.7	1.1 (199%)	0.6	2.5	1.9 (304%)	0.7	1.3	0.6 (82%)
25%	0.7	1.8	1.1 (164%)	0.6	1.6	1.1 (189%)	0.8	2.5	1.7 (208%)	1.0	3.4	2.3 (228%)	0.9	1.7	0.8 (89%)
50% (median)	1.0	2.3	1.3 (131%)	1.0	2.0	1.0 (102%)	1.1	3.5	2.5 (231%)	1.3	5.9	4.6 (363%)	1.1	1.9	0.7 (64%)
75%	1.4	2.8	1.4 (101%)	2.0	2.5	0.5 (23%)	1.9	6.4	4.5 (243%)	1.7	8.0	6.4 (382%)	1.8	7.2	5.4 (299%)
95%	4.2	3.8	-0.3 (-8%)	4.1	4.8	0.7 (17%)	2.7	12.0	9.3 (347%)	2.4	12.0	9.6 (393%)	2.8	8.6	5.8 (205%)

Table 6.6-22. Summary Statistics of Residence Time (Days) in the Middle River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	0.8	0.3 (62%)	0.4	0.7	0.3 (78%)	0.4	1.1	0.7 (180%)	0.5	1.5	1.0 (196%)	0.4	0.7	0.3 (58%)
25%	0.6	1.1	0.6 (101%)	0.4	0.9	0.5 (114%)	0.4	1.2	0.7 (177%)	0.6	2.0	1.4 (228%)	0.6	0.9	0.3 (51%)
50% (median)	0.7	1.3	0.6 (93%)	0.5	1.0	0.5 (99%)	0.5	1.4	0.8 (155%)	0.7	2.8	2.1 (292%)	0.7	1.1	0.4 (63%)
75%	0.8	1.6	0.8 (100%)	0.9	1.1	0.3 (29%)	0.8	1.6	0.8 (95%)	1.0	7.9	7.0 (727%)	0.8	10.9	10.1 (1,218%)
95%	2.4	4.5	2.1 (88%)	1.9	1.7	-0.2 (-13%)	1.3	2.4	1.1 (84%)	1.2	18.0	16.8 (1351%)	1.1	11.8	10.7 (979%)

Table 6.6-23. Summary Statistics of Residence Time (Days) in the Victoria Canal Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	2.5	2.2 (713%)	0.2	0.5	0.3 (116%)	0.3	0.7	0.4 (170%)	0.3	3.7	3.4 (1082%)	0.3	0.5	0.2 (51%)
25%	0.3	7.4	7.0 (2074%)	0.3	2.2	2.0 (731%)	0.3	4.1	3.8 (1339%)	0.4	5.4	5.1 (1353%)	0.4	0.6	0.2 (57%)
50% (median)	1.3	13.0	11.7 (939%)	4.6	7.6	3.0 (64%)	1.2	7.2	5.9 (480%)	0.6	10.5	9.9 (1734%)	0.6	7.1	6.5 (1052%)
75%	10.0	19.9	9.9 (99%)	14.5	14.2	-0.3 (-2%)	10.6	11.6	1.0 (10%)	3.9	14.7	10.8 (278%)	4.9	11.1	6.2 (126%)
95%	16.8	25.4	8.7 (52%)	26.4	21.1	-5.3 (-20%)	20.4	19.9	-0.5 (-3%)	15.7	17.8	2.1 (13%)	12.3	14.1	1.8 (15%)

Table 6.6-24. Summary Statistics of Residence Time (Days) in the Grant Line Canal and Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.2	3.0	0.8 (35%)	9.3	9.3	-0.1 (-1%)	2.7	6.2	3.4 (125%)	3.6	3.1	-0.5 (-14%)	4.4	5.4	1.0 (23%)
25%	29.3	29.6	0.3 (1%)	20.2	23.5	3.2 (16%)	8.5	10.0	1.5 (18%)	6.7	4.3	-2.4 (-36%)	8.2	8.1	-0.1 (-1%)
50% (median)	38.7	40.0	1.4 (4%)	27.3	29.1	1.8 (6%)	16.9	23.3	6.4 (38%)	13.6	10.1	-3.4 (-25%)	11.8	9.2	-2.7 (-22%)
75%	40.4	41.0	0.6 (1%)	36.2	35.5	-0.7 (-2%)	32.9	35.8	3.0 (9%)	19.5	14.7	-4.8 (-24%)	14.4	11.2	-3.3 (-23%)
95%	42.8	42.0	-0.9 (-2%)	40.8	37.0	-3.8 (-9%)	38.1	38.0	-0.1 (0%)	24.2	24.8	0.6 (3%)	21.2	13.1	-8.0 (-38%)

Table 6.6-25. Summary Statistics of Residence Time (Days) in the Upper San Joaquin River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.2	0.2	0.0 (0%)	0.2	0.2	0.0 (-1%)	0.4	0.4	0.0 (-2%)	0.3	0.3	0.0 (16%)	0.3	0.3	0.0 (-8%)
25%	0.8	0.7	-0.1 (-11%)	0.9	0.8	-0.1 (-16%)	0.7	0.7	-0.1 (-10%)	0.5	0.6	0.1 (23%)	0.4	0.3	0.0 (-6%)
50% (median)	2.0	1.4	-0.7 (-33%)	1.5	1.2	-0.3 (-18%)	1.0	0.8	-0.1 (-13%)	0.6	0.7	0.1 (25%)	0.5	0.5	0.0 (-8%)
75%	3.3	1.8	-1.5 (-46%)	1.9	1.6	-0.3 (-15%)	1.2	1.1	-0.2 (-14%)	0.7	0.8	0.2 (27%)	0.6	0.6	0.0 (-7%)
95%	13.5	6.7	-6.8 (-50%)	2.8	2.4	-0.4 (-15%)	1.5	1.3	-0.2 (-16%)	0.8	0.9	0.1 (18%)	0.6	0.6	0.0 (-1%)

The extent to which giant garter snakes occur within the Delta is unknown, though population concentrations are known to occur along the periphery of the delta in the Yolo Basin-Willow Slough, Yolo Basin Liberty Farms, and Caldoni Marsh-White Slough regions (Figure 6.6-1; Appendix 4.A, *Status of the Species and Critical Habitat Accounts*; U.S. Fish and Wildlife Service 1999). The giant garter snake diet consists primarily of frogs (chiefly American bullfrog [*Rana catesbeiana]*) and western chorus frog [*Pseudacris triseriata*]) and fish, with preference given to frogs (Halsted and Ersan pers. comm). American bullfrog tadpoles eat algae, aquatic plant matter, and some insects. Adult bullfrogs are opportunistic predators, consuming a wide-range of terrestrial and aquatic prey including invertebrates, mammals, birds, fish, reptiles, and amphibians, including other bullfrogs. The western chorus frog has a primarily land-sourced diet of slugs, spiders, isopods, centipedes, earthworms, and insects (Morey 2008), and thus has low potential exposure to microcystin. Bullfrogs forage within the terrestrial and aquatic foodwebs, and may ingest microcystins through the consumption of fish and other aquatic organisms, or through consumption of other bullfrogs.

The streamflow and temperature modeling results suggest there is potential for increased frequency of *Microcystis* blooms during the summer and fall months where giant garter snakes occur in portions of the Sacramento River system in the Delta. *Microcystis* toxicity has been shown to cause deleterious effects on fish and bird species (Butler et al. 2009), but sensitivity to microcystins varies by species and life stage (Table 6.6-3; Butler et al. 2009). The effects of *Microcystis* blooms on giant garter snakes or the prey of giant garter snakes are unknown. Small fish and bullfrogs consumed by giant garter snakes during or after *Microcystis* blooms could be sources of microcystins for giant garter snakes. In the northern portion of the Delta, *Microcystis* blooms are currently not common; if water in this region remains turbid in the future, current conditions are expected to continue.

In the south and central Delta, residence time would be increase under the PA relative to the NAA, which would increase the potential of giant garter snakes exposure to microcystin through the consumption of fish and bullfrogs. This would give greater potential for adverse effects of *Microcystis* under the PA relative to the NAA; however, under the NAA, lower residence time would reflect zooplankton and other food web materials being more susceptible to entrainment because of greater south Delta export pumping, so the overall effect is uncertain; and, as stated previously, the potential effect of *Microcystis* blooms on giant garter snakes is unknown, especially given their preference for American bullfrogs and western chorus frogs.

There is potential for increased occurrence of *Microcystis* blooms in the Sacramento and San Joaquin Delta and therefore increased potential for giant garter snake exposure to microcystins. However, because giant garter snakes preferentially prey upon frogs, which forage in both the terrestrial and aquatic foodweb, and because the effects of current *Microcystis* blooms on giant garter snake are not well understood, the effects of potential increased occurrence of *Microcystis* blooms on giant garter snakes is also unknown.

6.6.3.3.2.2 Selenium

The giant garter snake inhabits marshes, sloughs, ponds, small lakes, low gradient streams, and other waterways and agricultural wetlands, such as irrigation and drainage canals, rice fields and the adjacent uplands (U.S. Fish and Wildlife Service 1999). The extent to which Giant Garter Snakes occur within the Delta is unknown, but it occurs at sites along the San Joaquin River from Vernalis to Sherman Island. The population status of giant garter snake in the Delta is unknown because there is no established monitoring program; current information on their distribution is limited to sporadic sightings.

6.6.3.3.2.2.1 Baseline Exposure

A current mass balance of selenium, as a function of source and conveyance, is not available for the San Francisco Estuary (Presser and Luoma 2010). Annual and seasonal variations of selenium concentrations in the Delta and estuary are influenced by discharges in rivers and anthropogenic sources (Presser and Luoma 2006). Water inflow to the Delta comes primarily from the Sacramento and San Joaquin rivers of which the Sacramento River provides the largest water volume contribution and dilution of selenium inputs from other sources. Factors affecting selenium contribution and dilution include the total river inflow, water diversions and/or exports, the proportion of the San Joaquin River that is diverted south before entering the Estuary, and total outflow of the Estuary to the Pacific Ocean (Presser and Luoma 2010).

Selenium contamination in soils and water of the Sacramento Valley is not high and thus not considered a threat in this part of the giant garter snake's range (Seiler *et al.* 2003). In the San Joaquin River basin implementation of both regulatory controls and the Grassland Bypass Project, which manages agricultural drainage south and west of the Grassland Ecological Area, have significantly improved water quality in the San Joaquin River and adjacent channels. However, irrigation drainage into Mud Slough and the San Joaquin River results in non-compliance with the selenium water quality objective. Achieving water quality compliance for this segment of the river is not anticipated until 2019 or later. Continued inputs from precipitation runoff from selenium-laden soils, irrigation drainage, and existing riverbed loads still provide inputs of selenium to the Delta where GGS are potentially exposed to selenium through their diet consisting principally of amphibians and small fish.

Modification of Delta inflow via construction of the North Delta diversions and water operations changes for the SWP and CVP may interact with selenium fate and transport. Conceptually, exports of San Joaquin River selenium-laden water out of the Delta and into Delta Mendota Canal and California Aquaduct will be reduced under the PA. In addition, less Sacramento River water will be available for dilution of San Joaquin River. Meseck and Cutter (2006) developed a biogeochemical modeling of the estuary to simulate salinity, total suspended material, phytoplankton biomass, and dissolved and particulate selenium concentrations. They modeled an increase in discharge from the San Joaquin River and varying sources of refinery inputs to investigate how it would affect the dissolved and particulate selenium in the San Francisco Bay. They found that when river flow was low (i.e., November, 70-day residence time) total particulate selenium (the bioavailable form) concentrations could increase. These results suggest that bioavailable selenium and associated food web accumulation could increase because of increased San Joaquin River flow and reduced south Delta exports (Meseck and Cutter 2006).

6.6.3.3.2.2.2 Known Effects of Selenium on Snakes and Reptiles

Dietary uptake is the principal route of toxic exposure to selenium in wildlife, including giant garter snake (Beckon et al. 2003). Our current understanding is that selenium does not biomagnify and the majority of food web enrichment occurs at the lowest trophic levels. Scaled reptiles, such as giant garter snake generally do not secrete an albumin layer, as do birds, crocodilians, and turtles (Unrine *et al.* 2006). As a result, selenium may be transported through serum to the egg from the liver as vitellogenin, whereas in birds, crocodilians, and turtles, additional oviductal contributions of selenium occur post-ovulation (Unrine *et al.* 2006, Janz *et al.* 2010). Therefore, a dietary selenium toxicity threshold, rather than an egg concentration threshold, appears appropriate for assessing selenium effects to GGS.

Elevated selenium through diet or maternal transfer to offspring can affect vertebrates when selenium is substituted for sulfur during protein synthesis. Improperly folded proteins and dysfunctional enzymes can result, with consequences including oxidative stress and embryo toxicity. Toxicity thresholds are established by identifying concentrations of selenium that result in an observable effect on an organism (e.g. altered metabolism, mortality, deformity, reproductive failure). No information is available on the toxicity thresholds or indirect effects of selenium for giant garter snake or other snakes. However, information on the risk of selenium exposure on other species may be useful in predicting general effects on giant garter snakes. Laboratory and field study on giant garter snake and terrestrial snakes have documented selenium bioaccumulation from through prey consumption.

A single laboratory study dosed female terrestrial brown house snakes (*Lamprophis falginosus*) with selenium, as selanomethonine, injected into their food items at ~1 (control), 10, and 20 µg/g (dry weight) doses. The investigators selected these dosages because they represented the range of exposures used in prior avian and mammalian studies. No significant effects on survival or reproduction were observed at any dose (Hopkins *et al.* 2004). However, in the two treatment groups selenium was transferred to eggs in concentrations that exceeded all suggested reproduction thresholds for birds and fish (24.25 ±0.49 µg/g dry weight in the 20 µg/g treatment group) (Hopkins *et al.* 2004). No information was available on the consequences of the egg selenium burdens for post-hatch survival.

Wylie et al. (2009) measured selenium and other trace elements in 23 dead giant garter snakes collected from 1995 to 2004 at sites in Colusa National Wildlife Refuge, the Natomas Basin, and other sites in northern California. Giant garter snake liver selenium concentrations ranged from 1.24 to 6.98 µg/g (dry weight) with a geometric mean of 3.06 µg/g. Current science does not provide information about the consequences of these selenium body burdens to the health or survival of individuals or populations of GGS.

6.6.3.3.2.2.3 Effects of the PA

There are currently no predictive modeling tools, nor is there an understanding of effects thresholds, that would enable predicting direct effects of dietary selenium exposure on giant garter snakes. However, inferences about the effects of selenium exposure are possible using Delta Smelt as a surrogate for giant garter snakes' prey.

In the Delta Smelt effects analysis (Section 6.1, *Effects on Delta Smelt*) DSM2 volumetric fingerprinting was used to estimate the source water contribution of the Delta water sources including the San Joaquin River that are the primary source of selenium loading to the Delta. Aqueous and Delta Smelt selenium tissue concentrations were modeled at five sites: San Joaquin River at Prisoners Point, Cache Slough at Ryer Island, Sacramento River at Emmaton, San Joaquin River at Antioch, and Suisun Bay at Mallard Island. Modeling results indicated that, of these five sites, the highest proportion of San Joaquin River water and its selenium load (and thus resulting fish tissue selenium) occurred at Prisoners Point. Thus, of the Delta sites modeled for Delta Smelt, Prisoners Point represents the worst-case scenario for selenium exposure.

Results for the PA selenium bioaccumulation modeling for Delta Smelt at Prisoners Point showed increases of as much as twice the modeled tissue concentration, in Delta Smelt foraging at that location. Despite the predicted increases, all but 0.7% of modeled tissue concentrations were below the effects threshold for fish deformities. Based on these modeling results, the PA is unlikely to increase tissue concentrations significantly enough to result in detrimental effects to Delta Smelt. The PA would be expected to have similar effects on fishes with diets and habitat preferences similar to Delta Smelt (e.g., silversides). However, this assumption would not apply to young sunfishes or Sacramento Splittail whose parental diet may include other fish or bivalves that bioaccumulate selenium at substantially higher rate than crustaceans. Our surrogate Delta Smelt tissue modeling also does not represent the risk to giant garter snake foraging in locations upstream of Prisoners Point that have higher San Joaquin River water and selenium contributions.

Residence times could provide an additional line of evidence in evaluating the risk of selenium effects from the PA. A significant factor in the bioavailability of selenium is water residence time. Biogeochemical modeling suggests that increasing the San Joaquin River discharge could result in increased bioavailable selenium during “low flow” conditions (Meseck and Cutter 2006). Low flow conditions modeled were 70-day residence times.

For the PA, residence times were estimated using DSM2-PTM to evaluate the effects of water operations on water quality. Residence time changes under for the PA varied greatly by model site. The highest residence times for the both the NAA and the PA occurred at Grant Line Canal and Old River sites. The modeling predicted for the PA a 95% percentile, July water residence time of 42.8 days, a reduction of 0.8 days compared to the NAA. Residence time estimates did not meet or exceed the 70-day residence times used in the Meseck and Cutter (2006) biogeochemical modeling that predicted increased selenium bioavailability. This would suggest that the PA and would not result in the same increase of bioavailable, particulate selenium predicted by their hydrologic conditions modeling of Meseck and Cutter (2006).

6.6.3.3.2.2.4 All Life Stages

6.6.3.3.2.2.4.1 Individual-Level

Two modeling efforts suggest the potential for increases in San Joaquin River water and its associated selenium load to the Delta. We lack information about effects thresholds or exposure risk directly to giant garter snake. Using Delta Smelt as a surrogate for giant garter snake fish prey, selenium bioaccumulation modeling suggests that reductions in fish prey for fish feeding at the same tropic level as Delta Smelt are unlikely to result from the PA. Prey fishes that feed on bivalves or at a higher trophic level may represent an increased risk. Project effects on giant garter snake, either directly to the snake via increased dietary selenium, indirectly through reduced fish prey availability are currently unquantifiable. If risk were increased because of the PA, it would most likely occur for giant garter snakes residing and feeding in the South Delta and the San Joaquin River upstream from Prisoners Point to Vernalis or from snakes that consumed Sacramento Splittail or piscivorous fish species.

6.6.3.3.2.2.4.2 Population-Level

There is inadequate information available to assess this risk to giant garter snake individuals or populations from selenium. If giant garter snakes were affected by a selenium increase caused by the PA it would be most likely to occur in the South Delta and the San Joaquin River upstream from Prisoners Point to Vernalis. Giant garter snakes reside in areas of the Delta and lower San Joaquin River (Kesterson and Grasslands Bypass) where selenium has been historically elevated. Population effects were not documented as a result of those historic exposures.

6.6.3.3.2.2.4.3 Effects on Critical Habitat and Habitat

Critical habitat has not been designated for giant garter snake. Based on the result of biogeochemical and particle tracking modeling, increased San Joaquin River inflow increased the potential availability of selenium to the Delta. The magnitude of change in selenium and its bioavailability is highly uncertain.

6.6.4 Tunneled Conveyance Facilities

The water conveyance facilities that overlap with giant garter snake habitat include a tunnel work area, the intermediate forebay and spillway, a road interchange, vent shafts, barge unloading facilities, and access roads.

6.6.4.1 Habitat Loss and Fragmentation

The mapped water conveyance facilities overlap with 220 acres of giant garter snake modeled habitat (0.15% of modeled habitat in action area), including 127 acres of upland habitat (0.2% of modeled upland habitat in action area) and 93 acres of aquatic habitat (0.3% of modeled aquatic habitat in action area). Table 6.6-1 provides the breakdown of habitat loss by habitat quality category.

The 220 acres of giant garter snake habitat to be removed because of conveyance facility construction consists of multiple small areas spread out across the action area, and this loss is not expected to appreciably fragment or isolate patches of giant garter snake habitat in the action area (Figures 6.6-5 through 6.6-12).

As shown on Figures 6.6-5 and 6.6-6 various activities will result in the loss of widely spaced, narrow strips of aquatic habitat consisting of conveyance ditches that have no associated uplands because they are surrounded by regularly disked, non-rice cultivated lands. These activities include two tunnel work areas and the intermediate forebay and spillway.

As shown on Figure 6.6-7, high and low value upland habitat will be removed for a road interchange and high value aquatic habitat will be removed for construction of a concrete batch plant. Construction of a barge unloading facility will remove some aquatic and adjacent upland habitat along Little Potato Slough.

As shown on Figure 6.6-8, construction of two barge unloading facilities will remove upland habitat along the southern edge of Venice Island and the eastern edge of Mandeville Island, and a tunnel work area will remove upland and aquatic habitat on Mandeville Island. An access road between the barge loading facility and the tunnel work area will remove some giant garter snake upland habitat.

As shown on Figure 6.6-9, a barge unloading facility will remove upland habitat on the northern edge of Bacon Island.

As shown on Figure 6.6-11, construction of a barge unloading facility will result in loss of aquatic and upland habitat along the northwestern edge of Victoria Island. Construction of a road interchange will result in the loss of aquatic habitat within a drainage channel and associated upland habitat on Victoria Island.

Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from water conveyance facility construction. As described in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Suitable habitat for giant garter snake is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.12.6, *Suitable Habitat Definition.*

6.6.4.2 Construction Related Effects

Construction activities associated with the conveyance facilities will include short-term segment storage, fan line storage, crane use, dry houses, settling ponds, daily spoils piles, use of power supplies, air, and water treatment. There will also be slurry wall construction at some sites, and associated slurry ponds. RTM handling and permanent spoils disposal will be necessary, as discussed in Chapter 3, Section 3.2.10.6, *Dispose Spoils*. Access routes and new permanent access roads will be constructed for each shaft site. SR 160 provides access to the intermediate forebay and their associated shafts, but for all other shafts, access roads will be constructed (within the existing impact footprint).

Construction of the intermediate forebay first entails excavating the embankment areas down to suitable material, then constructing the embankment, and then building the inlet and outlet shafts (which also serve as TBM launch shafts). Then the interior basin is excavated to design depth (-20 feet), and the spillway is constructed.

To allow time for soil consolidation and pad curing at the tunnel work areas and the intermediate forebay, fill pad construction significantly precedes other work at the shaft site; at the intermediate forebay, for instance, earthwork begins 2.5 years prior to ground improvement, and is then followed by a 9-month period of ground improvement, before the site is ready for construction. The result is that the entire footprint will be cleared very early in the construction schedule. The duration of active tunnel construction is expected to be approximately eight years. The duration of construction activity at the intermediate forebay is expected to be approximately five years. See Chapter 3, Section 3.2.3, *Tunnel Conveyance*, and Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*, for complete construction activity and timing details.

The construction related effects and measures to minimize them are similar to those described above for construction of the intake facilities under Section 6.6.1.2, *Construction Related Effects*.

6.6.4.3 Operations and Maintenance

Permanent water conveyance facilities, including the pumping plant and the intermediate forebay, will require operation and maintenance. Routine maintenance of the tunnel facility will likely include some weed control around the structure which may result in injury or mortality of giant garter snakes. There is also a potential for giant garter snakes to be injured or killed if, for example, vehicles traveling to or from the facilities must travel greater than 10 miles per hour and are unable to avoid giant garter snakes. These effects will be minimized by restricting vegetation control to the active season and confining the use of heavy equipment to outside 200 feet of the banks of potential garter snake habitat unless it is needed for travel to the site as described in Chapter 3, Section 3.4.7.6.1.2, *Activities with Flexible Locations.*

6.6.5 Clifton Court Forebay Modification

6.6.5.1 Habitat Loss and Fragmentation

An estimated 235 acres of giant garter snake modeled habitat overlaps with the mapped Clifton Court Forebay modifications (Figures 6.6-13 through 6.6-16), where land will be cleared for permanent facilities and temporary work areas. The 235 acres of modeled habitat (0.3% of modeled habitat in the action area) includes 16 acres of aquatic habitat (>0.1% of modeled aquatic habitat in the action area) and 219 acres of upland habitat (0.3% of modeled upland habitat in action area). Table 6.6-1 provides a breakdown of habitat loss by habitat value category.

As shown on Figures 6.6-13 through 6.6-16, construction related activities near Clifton Court Forebay will remove upland and aquatic habitat for giant garter snake. These activities include construction of a barge unloading facility, fuel station, and shaft location, which will result in loss of natural wetlands providing aquatic habitat and adjacent upland habitat at the northern end of Clifton Court Forebay. Also, construction of the tunnel conveyor facility and a shaft will remove upland habitat in this area, and construction of the new forebay will remove upland habitat at the southern end of the Clifton Court Forebay. Construction of access roads, a control structure with associated work area, forebay embankment, and canal work areas will result in loss of aquatic and upland habitat on the west side of Clifton Court Forebay.

As shown on Figure 6.6-14, the forebay dredging area and construction of the new forebay, forebay embankment area, and control structure work area will remove upland habitat around Clifton Court Forebay, Old River, and Delta-Mendota Canal.

Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from Clifton Court Forebay modifications. As described in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Suitable habitat for giant garter snake is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.12.6, *Suitable Habitat Definition.*

6.6.5.2 Construction Related Effects

Construction activities at Clifton Court Forebay include vegetation clearing, pile driving, excavation, dredging, and coffer dam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately six years. For complete details on construction activities and phasing, see Chapter 3, Section 3.2.5, *Clifton Court Forebay*, for more details on schedule, see Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*.

The construction related effects and measures to minimize them are the same as described above for construction of the intake facilities under Section 6.6.1.2, *Construction Related Effects.*

6.6.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures, and siphons. The features will are not located in giant garter snake habitat and are not expected to affect the species.

The forebay and the canals will require erosion control. Giant garter snake could potentially become entangled, trapped, or injured as a result of erosion control measures that use plastic or synthetic monofilament netting in construction areas. This effect will be avoided as described in Appendix 3.F, *General Avoidance and Minimization Measures*, AMM2 *Construction Best Management Practices and Monitoring,* by requiring the use of silt fencing. With these measures in place, the potential for giant garter snakes to be affected in this manner is minimal.

The forebay and canals will also require control of vegetation and rodents, and embankment repairs. Maintenance of control structures could include removal or installation of roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the outlet culverts. Use of heavy equipment for maintenance may injure or kill giant garter snakes: these effects and associated minimization measures are as described in Section 6.6.1.2, *Construction Related Effects.* Additionally, removal of vegetation, embankment repairs, and rodent control measures may result in injury or mortality of giant garter snakes, or may degrade habitat by removing cover. These effects will be minimized by restricting vegetation control to the active season, avoiding the use of poison bait, and confining the use of heavy equipment to outside 200 feet of the banks of potential garter snake habitat as described in Section 3.4.7.6.1.2 *Activities with Flexible Locations.*

Maintenance dredging is not expected to be necessary to remove sediments in the forebays.

6.6.6 Power Supply and Grid Connections

6.6.6.1 Habitat Loss and Fragmentation

To conservatively asses temporary impacts from transmission line placement due to the flexibility of the final alignment, a 50-foot wide permanent disturbance area along the transmission line corridor was assumed (see Appendix 6.B, *Terrestrial Effects Analysis Methods*, for additional details about the impact assessment method). Based on this method, an estimated 85 acres (>0.1% of modeled habitat in the action area) of giant garter snake habitat may be temporarily impacted, including 18 acres of aquatic (>0.1% of modeled aquatic habitat in the action area) and 68 acres of upland habitat (0.1% of modeled upland habitat in the plan area), as a result of the construction of both temporary and permanent transmission lines (Table 6.6-1). However, most of the effect from transmission line construction will be temporary. Temporary impacts are incurred from activities that will not last more than one year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas. Permanent habitat loss will result from pole and tower placement. Ongoing vegetation management around the poles and under the lines will be minimal in giant garter snake habitat because aquatic and grassland areas typically do not need to be cleared to maintain transmission line corridors (Figures 6.6-1 through 6.6-5, 6.6-7 through 6.6-27, and 6.6-32).

Because this disturbance is primarily from short-term, temporary effects, specific compensation for the 85 acres of giant garter snake habitat disturbance will be offset by returning these areas to pre-project conditions. Due to the conservative nature of the water conveyance facility impact analysis, and thus the overestimate of mitigation needs, mitigation proposed to compensate for effects from the water conveyance facility are assumed to also provide compensation for the small amount of permanent transmission line effects. As detailed in Chapter 3, Section 3.4.5, *Spatial Extent, Location, and Design of Restoration for Terrestrial Species*, these conservation lands will be sited in locations that provide high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for giant garter snake. As detailed in Section 3.4.1, *Restoration and Protection Site Management Plans*, these conservation lands will be protected and managed for the species.

6.6.6.2 Construction Related Effects

New temporary power lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Temporary substations will be constructed at each intake, at the IF, and at each of the launch shaft locations. To serve permanent pumping loads, a permanent substation will be constructed adjacent to the pumping plants at CCF, where electrical power will be transformed from 230 kV to appropriate voltages for the pumps and other facilities at the pumping plant site. For operation of the three intake facilities, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line-stringing phase; for stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Construction-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than one year at any one location.

The construction related effects and measures to minimize them are the same as described above for construction of the intake facilities under Section 6.6.1.2, *Construction Related Effects.*

6.6.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately ten years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Vegetation control along the transmission line alignment is not expected to adversely affect the giant garter snake because this species typically occurs in open upland areas such as grasslands, and grassland removal is not typically done for transmission line maintenance. Maintenance vehicles could injure or kill giant garter snakes as they travel to and from maintenance sites.

6.6.7 Head of Old River Gate

6.6.7.1 Habitat Loss and Fragmentation

Construction of the HOR gate will result in loss of an estimated 3 acres (>0.01% of modeled habitat in the action area) of giant garter snake habitat, including 1 acre of aquatic habitat (>0.1% of modeled aquatic habitat in the action area) and 2 acres of associated uplands (>0.1% of modeled upland habitat in the action area) (Figure 6.6-28). Table 6.6-1 provides a breakdown of these impacts by habitat value category. Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from construction of HOR gate. As described in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Suitable habitat for giant garter snake is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* Section 4.A.12.6, *Suitable Habitat Definition.*

6.6.7.2 Construction Related Effects

HOR gate construction has two major components: dredging and construction. Dredging to prepare the channel for gate construction will occur along 500 feet of channel, from 150 feet upstream to 350 feet downstream from the proposed barrier. Dredging will occur at a time between August 1 and November 30, lasting approximately 15 days, and will otherwise occur as described in Chapter 3, Section 3.2.10.8, *Dredging and Riprap Placement*. Dredging equipment will be operated from a barge in the channel. Giant garter snakes could be injured or killed by dredging equipment during this activity. As described in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations,* this effect will be minimized by dewatering of habitat prior to construction to encourage giant garter snakes to move out of aquatic habitat, and by installation of construction fencing and monitoring to exclude giant garter snakes from the work area. There is still a chance that giant garter snakes occur in the work areas and be missed by monitors, therefore the potential remains for injury or killing of giant garter snakes in this area.

During HOR gate construction, a cofferdam will be erected to create a dewatered construction area for ease of access and egress. Construction will occur in two phases. The first phase will include construction of half of the operable barrier, masonry control building, operator's building, and boat lock. The second phase will include construction of the second half of the operable barrier, the equipment storage area, and the remaining fixtures, including the communications antenna and fish passage structure. The construction duration is estimated to be up to 32 months. Site access roads and staging areas used in the past for rock barrier installation and removal will be used for construction, staging, and other construction support facilities for the proposed barrier. The construction of the cofferdam and the foundation for the HOR gate will require in-water pile driving, performed as described in Chapter 3, Section 3.2.10.11, *Pile Driving*. Sheet piles will be installed starting with a vibratory hammer, then switching to an impact hammer if refusal is encountered before target depths. Installing the foundation for the operable barrier will require 100 14-inch steel pipe or H-piles to be set with 1 pile driver on site. Approximately 15 piles will be set per day with up to 1,050 strikes per pile over an estimated 7-day period.

The operable barrier construction site has for many years been used for seasonal construction and removal of a temporary rock barrier, and this disturbance at the site renders it less likely that giant garter snakes occur in the area to be affected. If giant garter snakes are present during construction, however, they may potentially be killed or injured by construction equipment or vehicles. These effects and measures to minimize them are as described in Section 6.6.1.2, *Construction Related Effects.* With these measures in place, there is still potential for giant garter snakes to be injured or killed if, for example, if vehicles must travel greater than 10 miles per hour and are unable to avoid giant garter snakes or if a snake is able to get through the construction fencing and is undetected by the biological monitor.

Giant garter snakes may potentially be affected by vibrations from the pile drivers. This could cause giant garter snakes to move out of suitable habitat near construction.

6.6.7.3 Operations and Maintenance

Maintenance of the motors, compressors, and control systems will occur annually and require a service truck. Maintenance dredging around the gate will be necessary to clear out sediment deposits. Dredging around the gates will be conducted using a sealed clamshell dredge. Depending on the rate of sedimentation, maintenance will occur every 3 to 5 years, removing no more than 25% of the original dredged amount. This dredging will have similar effects and be subject to the same minimization measures as those described for dredging in Section 6.6.3.2, *Construction Related Effects.*

6.6.8 Reusable Tunnel Material

6.6.8.1 Habitat Loss and Fragmentation

An estimated 242 acres (0.2% of modeled habitat in the action area) of giant garter snake modeled habitat overlaps with the mapped RTM sites (Figures 6.6-5, 6.6-6, 6.6-7, 6.6-17, and

6.6-29 through 6.6-32), where reusable tunnel material will be placed. The 242 acres of modeled habitat includes 83 acres (0.3% of modeled aquatic habitat in the action area) of aquatic habitat and 159 acres (0.02 acrea of modeled upland habitat in the action area) of upland habitat. Table 6.6-1 quantifies the loss of habitat for each habitat value category.

The habitat to be removed at several RTM sites, and the extent to which RTM placement at each site may fragment the remaining habitat, is described below.

6.6.8.1.1 RTM Site Near Intake 2 (Figure 6.6.2)

The RTM site near Intake 2 overlaps with a strip of giant garter snake upland habitat along Morrison Creek that consists of riparian vegetation. Giant garter snakes tend to use open areas rather than shaded riparian areas for upland habitat. It is therefore unlikely that giant garter snakes use this area frequently if at all. The RTM site will only remove a sliver of the upland habitat in this area and the remaining upland and aquatic habitat along Morrison Creek will remain intact, therefore the RTM placement and storage will not result in fragmentation or isolation of giant garter snake habitat.

6.6.8.1.2 RTM Site South of Lambert Road (Figures 6.6-5, 6.6-17)

The RTM site just south of Lambert Road overlaps with two narrow stretches of drainage ditch providing aquatic giant garter snake habitat, however they are bordered by cultivated lands that are regularly disked and therefore do not provide upland habitat for giant garter snake. Although the aquatic habitat is modeled as moderate value, the lack of associated upland habitat renders it of lower value for the giant garter snake. Furthermore, as shown on Figures 6.6.5 and 6.6-17, the RTM site is south of a large, contiguous block of habitat in the Stone Lakes area and does not fragment this habitat or isolate it from contiguous habitat to the east and south of the RTM site. It may, however, contribute to fragmentation by diminishing the existing string of small habitat patches between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.3 RTM Site on Zacharias Island (Figure 6.6-5)

The RTM site on Zacharias Island overlaps with giant garter snake modeled high value upland habitat along the western edge of the island, adjacent to Snodgrass Slough.

The RTM site is located between giant garter snake habitat along Snodgrass Slough, to the west, and giant garter snake habitat along a tributary to Snodgrass Slough, to the east. Placement of the RTM may impede overland travel of giant garter snakes between these two tributaries, although except during the period of active use of the RTM site, the impediment would not be greater than that imposed by cultivated land, which is not classified as dispersal habitat under the Draft 2015 *Recovery Plan for Giant Garter Snake* (U.S. Fish and Wildlife Service 2015). The RTM site currently consists of cultivated lands that are regularly disked. Connectivity will remain via aquatic habitat, which is connected at the southern tip of Zacharias Island.

6.6.8.1.4 RTM Site, Northernmost Triangular RTM Site (Figures 6.6-6, 6.6-17)

This RTM site overlaps with giant garter snake low value modeled aquatic habitat and adjacent moderate value modeled upland habitat. The aquatic habitat consists of an open borrow pit and the surrounding uplands are sparsely vegetated with riparian species. As shown on Figure 6.6-15, removal of this habitat will reduce the size of a fairly isolated habitat block in this area. The remaining habitat within this block will consist of narrow drainage ditches and associated uplands. As can be seen on Figures 6.6-6 and 6.6-17, the RTM placement will not create any barriers to movement from the remaining habitat, as there is no habitat present immediately to the east of the RTM site. It may, however, contribute to fragmentation by diminishing the existing string of small habitat patches between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.5 RTM Site, Second Triangular RTM Site from the North (Figures 6.6-6, 6.6-30)

This RTM site overlaps with giant garter snake low value modeled aquatic habitat and associated high value modeled upland habitat. The aquatic habitat consists of an open borrow pit and the surrounding uplands are open and sparsely vegetated. As shown on Figures 6.6-6 and 6.6-30, removal of this habitat may contribute to fragmentation by diminishing the existing string of small habitat blocks between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.6 RTM Site North and South of Twin Cities Road (Figure 6.6-30)

This RTM site overlaps with giant garter snake low and high value modeled aquatic habitat and associated high value modeled upland habitat. The aquatic habitat consists of two open borrow pits (one north and one south of Twin Cities Road) and the surrounding uplands are open and sparsely vegetated. As described above, the RTM placement may contribute to fragmentation by diminishing the existing string of small habitat patches between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.7 RTM Site on Bouldin Island (Figure 6.6-7)

This RTM site overlaps with giant garter snake high value modeled aquatic consisting of shallow ponded areas surrounded by regularly disked cultivated lands. As shown on Figure 6.6-20, the RTM placement will remove several isolated patches of giant garter snake habitat, including aquatic habitat associated with regularly disked lands that do not provide suitable upland habitat. The RTM placement in this location will not further isolate the remaining giant garter snake habitat in this area, or block species dispersal.

6.6.8.1.8 RTM West of Clifton Court Forebay (Figure 6.6-32)

This RTM site will result in the removal of a small amount of upland habitat associated with a small, isolated aquatic feature west of Clifton Court Forebay. Most of the upland habitat associated with this aquatic feature will remain.

6.6.8.1.9 Summary of Habitat Loss Resulting from RTM Storage

RTM storage will result in the loss of an estimated 159 acres of upland habitat and 83 acres of aquatic habitat for giant garter snake. There are no known giant garter snake occurrences within the habitat that will be removed, although these areas have not been thoroughly surveyed. Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from RTM placement. As described in Chapter 3, Section 3.4.7.6.1.1, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Suitable habitat for giant garter snake is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* Section 4.A.12.6, *Suitable Habitat Definition.*

6.6.8.2 Construction Related Effects

Each RTM storage area will take five to eight years to construct and fill. RTM areas will be constructed, as needed, depending on location. The RTM storage site at Clifton Court (reach 7) will be the first to be constructed and filled (Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*) with all other RTM storage sites beginning construction within two years. The RTM storage site at Bouldin Island will be the last to begin construction. RTM storage area construction and placement will occur almost continuously during tunnel excavation, approximately 10 years.

Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. The movement of the material to another site is not an activity covered in the assessment. For more details about the activities associated with RTM placement see Chapter 3, Section 3.2.10.6, *Dispose Soils*.

Vehicles and heavy equipment used to clear the RTM sites and transport equipment and material could injure or kill giant garter snakes if individuals are present within the RTM footprint. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for giant garter snake to enter the work area. Other effects related to placement of RTM may include entanglement in erosion control materials, contamination as a result of toxic substances such as fuels, degradation of aquatic habitat from run-off and siltation, and behavioral changes as a result of noise, lighting, or vibration. These effects and measures to minimize them are similar to those described above for construction of the intake facilities under Section 6.6.1.2, *Construction-Related Effects.*

6.6.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to giant garter snake. While reuse of the RTM is possible, future uses for the material have not yet been identified. It is likely that the material will remain in designated storage areas for a period of years before a suitable use is identified, and any such use will be subject to environmental evaluation and permitting independent of the PA. Therefore disposition of RTM is assumed to be permanent and future reuse of this material is not part of the PA.

6.6.9 Restoration

6.6.9.1 Habitat Conversion

Tidal, nontidal, and riparian restoration and channel margin enhancement to offset the effects on species habitat and wetlands will result in conversion of giant garter snake habitat to other habitat types. All restoration sites will be selected by DWR, subject to approval by the jurisdictional fish and wildlife agencies (CDFW, NMFS, USFWS). The acres to be lost as a result of restoration were estimated as described in Appendix 6.B, *Terrestrial Impact Assessment Methods*.

6.6.9.1.1.1 Tidal Restoration

DWR will restore 305 acres of tidal wetlands to benefit delta smelt and other aquatic species to meet habitat restoration requirements. Tidal wetland restoration will include restoration for the loss of wetland types such as emergent wetland and tidal channels. This tidal restoration is likely to occur in the east, north, or west Delta. Potential locations of tidal and wetland restoration include Grizzly Slough, Lower Yolo Ranch, Zacharias Island, and Sherman Island. In the Delta, wetland and riparian habitats are typically restored by the conversion of currently leveed, cultivated land. Such wetland restoration typically involves grading and contouring of the previously cultivated land within the levees, and breaching of the levees in one or more places.

Permanent effects on giant garter snake aquatic habitat are likely to occur when agricultural ditches are modified and flooded as part of the restoration process. The conversion of rice to tidal habitat would be a permanent loss, however, rice is not common the portions of north slough, Cache Slough, or Sherman Island where tidal restoration would likely be placed. Other aquatic features that have potential to occur on cultivated lands converted to wetlands include natural channels and topographic depressions. Tidal aquatic edge habitat where open water meets the levee edge will also be permanently lost in those reaches where the levee is breached. Temporary effects on aquatic edge habitat are also likely to occur during the time of construction, though these effects would not be expected to last more than 2 years. Permanent effects on upland habitat will primarily occur where upland basking habitat (levees) are removed to create tidal connectivity. If small, interior levees exist on the property, these features could be graded to achieve topographical or elevational design requirements, though in many cases, these features are allowed to persist as they foster the formation of mixed plant communities and high-tide refugial habitat for wetland species.

Tidal restoration will result in the loss of an estimated 154 acres of giant garter snake habitat, including an estimated 118 acres of upland habitat and 36 acres of aquatic habitat. Table 6.6-1 provides a breakdown of estimated loss by habitat value category. See Appendix 6.B, *Terrestrial Effects Analysis Methods*, for details about the method used to calculate the effects of tidal restoration to giant garter snake.

6.6.9.1.1.2 Nontidal Restoration

DWR will restore 625 acres of nontidal wetlands to benefit giant garter snake and other species that rely upon nontidal wetlands (e.g., greater sandhill crane). Nontidal restoration for these species may also contribute to mitigation required as compliance with Section 404 of the Clean Water Act. Of the 625 acres that will be restored, 521 acres will be restored to benefit giant garter snake as described in Section 3.4.7.6.2, *Compensation for Effects*, and Section 3.4.7.6.3, *Siting Criteria for Compensation for Effects*; see Table 6.B-6 for a summary of restoration activity by type. The remaining 104 acres of nontidal restoration will benefit the greater and lesser sandhill crane. Nontidal wetland restoration projects for giant garter snake, when constructed, will increase the available, high quality, aquatic and upland habitat for giant garter snake. Habitat loss associated with nontidal wetland restoration projects for giant garter snake is assumed to be temporary and result in a net benefit to the species. Temporary effects will be related to the use and staging of construction equipment on the tops of levees where giant garter snakes are known to bask. There is also potential for canal and ditch aquatic habitat for giant garter snake will be converted to nontidal wetland. These effects on giant garter snakes from nontidal wetland restoration to benefit giant garter snake are expected to be negligible. Adverse effects on giant garter snake from wetland restoration will be avoided to greatest extent practicable as detailed in Chapter 3, Section 3.4.7.6.1, *Avoidance and Minimization Measures.*

6.6.9.1.1.3 Riparian Restoration

DWR will restore 79 acres of riparian natural community to benefit the valley elderberry longhorn beetle and Swainson's hawk. Riparian restoration is likely to occur in the north Delta, Cache Slough, Cosumnes-Mokelumne, or along the Sacramento River. Riparian restoration in this region will likely be accomplished in one of two ways. One way is to reconnect subsided, cultivated lands to flood flows and allow the upland areas (often around the edges of levees) within the parcel to recruit riparian vegetation types, riparian planting will also likely be used to enhance recruitment. Grading could be used in this scenario to increase the amount of area that is at the proper elevations for riparian habitats. Riparian restoration could also be accomplished through levee setbacks. This kind of restoration will require building a new levee behind the existing levee, grading and contouring the existing levee to create the desired habitat types which will likely be a mix of wetland, vegetated edge, and riparian. This kind of riparian restoration will likely occur in a matrix of channel margin enhancement and/or floodplain restoration.

Riparian restoration projects will likely occur on lands that are currently in cultivation. Giant garter snake aquatic habitat in the cultivated regions of Cache Slough, north Delta, Cosumnes-Mokelumne, or the Sacramento River is primarily vegetated edge of tidal habitat or irrigation canals or ditches. Upland habitat in these regions is primarily the tops of levees. For riparian projects where parcels of land are flooded, the primary giant garter snake habitat type that will be lost is the aquatic habitat provided by irrigation canals and ditches. Vegetated tidal edge will be permanently lost wherever levee sections are removed. Canals and ditches will be flooded, at least during some times of the year, and may be graded to increase topographic diversity. Additional vegetated edge could be created on the internal sides of the levees however, these are the regions where riparian restoration will be targeted. Riparian restoration through levee setback may have greater potential to benefit giant garter snake because these types of projects will likely also include channel margin enhancement components that could benefit giant garter snake by restoring sections of vegetated edge habitat.

6.6.9.1.1.4 Channel Margin Enhancement

DWR will enhance approximately 5 miles of channel margins between open water and upland areas to provide improved habitat for migrating salmonids. Channel margin enhancement activities are likely to occur near the intake construction area on the mainstem of the Sacramento River or on one of the nearby connected tidal sloughs (e.g., Steamboat Slough, Elk Slough, or Snodgrass Slough). Channel margin enhancement has the potential to be combined with riparian restoration to meet multiple goals on one restoration site.

Channel margin enhancement will target degraded aquatic edge habitat to improve habitat conditions for migrating salmon and other aquatic species such as delta smelt. Enhanced channel margin sections will seek to replace "hardened", riprap edge habitat with more emergent wetland and riparian habitat. This can be achieved by creating a "bench" of sediment (or other material) at the aquatic edge onto which vegetation can be planted or naturally recruited. This approach to channel margin enhancement is likely to be used to create emergent wetland habitat. More complex channel margin enhancement, where riparian restoration is likely to be a component, will be achieved using levee setbacks.

6.6.9.2 Construction Related Effects

The construction related effects and measures to minimize them are the same as described above for construction of the intake facilities under Section 6.6.1.2, *Construction Related Effects*.

6.6.9.3 Operations and Maintenance

Management activities in restored giant garter snake habitat may affect the species. Management activities may include invasive species control or hydrologic modifications. These management activities would have minimal effect on the species with the implementation of measures defined in Section 3.4.7.6.1.1, *Activities with Fixed Locations*, which would avoid and minimize effects on the species.

6.6.10 Effectiveness Monitoring

On lands protected to benefit giant garter snakes, monitoring to detect the presence of individuals will be performed to determine the effectiveness of conservation. Monitoring for giant garter snakes will consist of trapping surveys to detect presence of individuals. For additional details about monitoring see Section 3.4.9.2.3, *Effectiveness Monitoring for Wildlife Species*. The presence of biologists and trapping activities have potential to alter typical behavior of giant garter snake. As such, effectiveness monitoring for giant garter snake monitoring will be performed by a USFWS approved biologist.

6.6.11 Effects on Critical Habitat

Critical habitat has not been designated for giant garter snake.

6.6.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Potential cumulative effects on giant garter snake in the action area include habitat loss and fragmentation, changes in agricultural and land management practices, predation from introduced and native species, and water pollution. Both habitat loss and fragmentation, and changes in land management practices, could result from conversion of agricultural land to more developed land uses, which is not likely to be extensive due to existing constraints upon land use changes; or from conversion of agricultural land to different crop types having lower habitat suitability, which is not foreseeble. Habitat loss or degradation from agricultural practices is not expected to increase in the forseeable future as agriculture in the Delta is assumed to be fully developed. Predation by an existing introduced native species is likely to be maintained at levels comparable to current conditions; the introduction of new predators or parasites is possible, but not foreseeable; nor are the consequences of such an introduction.

Water pollution effects on the physiology of giant garter snakes or giant garter snake prey could result from a variety of causes, including agricultural practices, increased urbanization, and wastewater treatment plants. The input of pesticides and herbicides associated with agricultural practices are likely to be maintained, because the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects. Water quality effects of urbanization include point and nonpoint-source water quality impairments such as oil, gasoline, herbicides, pesticides, heavy metals, etc., and there is a potential for those effects to further degrade water quality as further urbanization occurs in the action area. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Some of these effects will improve, and others will impair habitat quality for giant garter snake in the action area; their net effect is to approximately maintain current conditions for the foreseeable future.

These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

6.7 Effects on California Red-Legged Frog

Appendix 6.B, *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.10.7 *Species Habitat Suitability Model* provides a description of the suitable habitat model for California red-legged frog.

Activities associated with geotechnical exploration, Clifton Court Forebay modifications, power supply and grid connections, reusable tunnel material, and habitat restoration may affect California red-legged frog, as described below. Figure 6.7-1 provides an overview of the locations of surface impacts relative to California red-legged frog modeled habitat, occurrences, and critical habitat. See Chapter 3, Section 3.4.7.6.1, *Habitat Definition* for the definition of suitable California red-legged frog habitat. There are 3,616 acres of modeled California red-legged frog habitat in the action area, including 118 acres of aquatic and 3,498 acres of modeled upland cover and dispersal habitat. An estimated 58 acres (2% of total modeled habitat in action area) of California red-legged frog modeled habitat will be lost as a result of project implementation, which includes 1 acres of aquatic habitat (2% of modeled aquatic habitat in the action area) and 57 acres of modeled upland cover and dispersal habitat (2% of modeled upland cover and dispersal habitat in the action area). There are 26 linear miles of aquatic habitat in the action area. All activities will avoid California red-legged frog aquatic habitat by at least 300 feet. Table 6.7-1 and Table 6.7-2 summarize the total loss of California red-legged frog modeled habitat under the PA.

Table 6.7-1. Maximum Habitat Loss on Modeled Habitat for California Red-Legged Frog by Activity Type (Acres)

California Red-Legged Frog Modeled Habitat	Total Modeled Habitat in Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Total Maximum Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Aquatic	118	0	0	0	1	0	0	0	1	0	0
Upland Cover and Dispersal	3,498	0	0	0	46	0	0.1	11	57	6	12
Total	**3,616**	**0**	**0**	**0**	**47**	**0**	**0.1**	**11**	**58**	**6**	**12**
Aquatic Habitat (Miles)	26	0	0	0	0	0	0	0	0	0	0

Table 6.7-2. Maximum Direct Effects on and Conservation of Modeled Habitat for California Red-Legged Frog

California Red-Legged Frog Modeled Habitat	Permanent Habit Loss	Compensation Ratios		Total Compensation (Acres)	
	Total Maximum Habitat Loss (Acres)	Protection	Restoration	Protection	Restoration
Aquatic	1	3:1		3	
Upland Cover and Dispersal Habitat	57	3:1		171	
Total	**58**			**174**	

6.7.1 Geotechnical Exploration

6.7.1.1 Habitat Loss and Fragmentation

The temporary loss (6 acres or ~0.1% of all modeled upland habitat in the action area) of California red-legged frog habitat resulting from geotechnical exploration inside the footprint will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches in diameter) and would have no or negligible effects on the California red-legged frog. Geotechnical exploration will avoid loss of California red-legged frog aquatic habitat as described in 3.4.7.7.1.2, *Activities with Flexible Locations*.

6.7.1.2 Construction Related Effects

Geotechnical exploration will avoid effects on California red-legged frog aquatic habitat but may temporarily affect up to 6 acres of modeled upland cover and dispersal habitat inside the footprint. Except for the habitat loss described above, this effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (2 to 21 days). Given the low likelihood of California red-legged frog being present in the areas to be affected, effects on California red-legged frog from geotechnical exploration will be minimal. Construction related actions could injure or kill California red-legged frog if individuals are present, but the potential for this effect will be minimized as described in Chapter 3, Section 3.4.7.6.2.2, *Activities with Flexible Locations*. The operation of equipment during construction could result in injury or mortality of California red-legged frog, if any are present. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored, to minimize the potential for giant garter snake to enter the work area. Additionally, the potential for injuring or killing California red-legged frog during site clearing will be minimized by restricting site clearing in suitable habitat to the dry periods as described in Chapter 3, Section 3.4.7.6.2, *Avoidance and Minimization Measures*.

6.7.1.3 Operations and Maintenance

There will be no ongoing operations and maintenance associated with the geotechnical exploration activities, therefore no effect on California red-legged frog.

6.7.2 Safe Haven Work Areas

Safe haven work areas are not expected to occur in California red-legged frog habitat, therefore this activity is not expected to affect California red-legged frog. If safe haven work areas occur in California red-legged frog habitat, any habitat loss will be compensated at a 3:1 ratio.

6.7.3 North Delta Intake Construction

The north Delta intake construction area does not overlap with California red-legged frog modeled habitat and this activity will not have an adverse effect on the species (Figure 6.7-1).

6.7.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities construction does not overlap with California red-legged frog modeled habitat and will not have an adverse effect on the species (Figure 6.7-1).

6.7.5 Clifton Court Forebay Modification

6.7.5.1 Habitat Loss and Fragmentation

An estimated 47 acres of California red-legged frog modeled habitat overlaps with the mapped Clifton Court Forebay modifications (Figures 6.7-2 and 6.7-3), where land will be cleared for permanent facilities and temporary work areas. The 47 acres of modeled upland cover and dispersal habitat includes 1 acre of aquatic habitat (<1% of modeled aquatic habitat in the action area) and 46 acres of modeled upland cover and dispersal habitat (1% of modeled upland cover and dispersal habitat in the action area) (Table 6.7-1).

Construction of the new forebay will remove aquatic habitat at the southern end of the Clifton Court Forebay. As shown on Figures 6.7-2 and 6.7-3, the forebay dredging area and construction of the new forebay, forebay embankment area, and control structure work area will remove modeled upland cover and dispersal habitat around Clifton Court Forebay and the Delta-Mendota Canal. Nearly all of the affected modeled upland and dispersal habitat would be considered dispersal habitat as it is not located in close proximity to aquatic habitat or known occurrences; modeled aquatic habitat is contiguous to modeled upland cover and dispersal habitat only at a transmission line corridor east of Byron Highway, as shown on Figure 6.7-4.

As described in Chapter 3, Section 3.4.7.6.2.1, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Loss of California red-legged frog habitat will be offset through habitat protection at a 3:1 ratio (Table 6.7-2).

6.7.5.2 Construction Related Effects

Construction activities at Clifton Court Forebay include vegetation clearing, pile driving, excavation, dredging, and coffer dam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately six years. For complete details on construction activities and phasing, see Chapter 3, Section 3.2.5, *Clifton Court Forebay*; for more details on schedule, see Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*. Vehicles and heavy equipment used at the construction site could injure or kill California red-legged frog if individuals are present within the construction footprint. California red-legged from mortality from vehicles and heavy equipment are more likely 24 hours proceeding a rain event and during nighttime construction. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for California red-legged frog to enter the work area. Other effects related to construction may include entanglement in erosion control materials, contamination because of toxic substances such as fuels, degradation of aquatic habitat from run-off and siltation, and behavioral changes as a result of lighting or vibration.

Although measures will be applied to minimize the risk of injuring or killing California red-legged frogs during construction, and to minimize the risk of disrupting behavioral patterns, some potential remains for these effects to occur with all the minimization measures in effect.

6.7.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures and siphons. The features will not be operated in or near California red-legged frog habitat and are not expected to affect the species.

The forebay and canals will require control of vegetation and rodents, and embankment repairs. Maintenance of control structures could include removal or installation of roller gates, radial gates, and stop logs. Maintenance requirements for the spillway would include the removal and disposal of any debris blocking the outlet culverts. Use of heavy equipment for maintenance may injure or kill California red-legged frog: these effects and associated minimization measures are as described in Section 6.7.5.2, *Construction Related Effects.* Additionally, removal of vegetation, embankment repairs, and rodent control measures may result in injury or mortality of California red-legged frog. These effects will be minimized through observance of speed limits where possible, and other measures described in Chapter 3, Section 3.4.7.6.2.1, *Activities with Fixed Locations.*

6.7.6 Power Supply and Grid Connections

6.7.6.1 Habitat Loss and Fragmentation

To conservatively asses impacts from transmission line placement due to the flexibility of the final alignment, a 50-foot wide permanent disturbance area along the transmission line corridor was assumed (see Appendix 6.B, *Terrestrial Effects Analysis Methods*, for additional details about the impact assessment method). Based on this method, an estimated 12 acres (0.3% of all modeled upland habitat in the action area) of California red-legged frog modeled upland cover and dispersal habitat may be temporarily lost as a result of the construction of both temporary and permanent transmission lines (Figures 6.7-2 through 6.7-6 and Table 6.7-1). Temporary impacts are incurred from activities that will not last more than one year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas. Temporary habitat loss will result from pole and tower placement. Ongoing vegetation management around the poles and under the lines will be minimal in California red-legged frog habitat because grassland areas typically do not need to be cleared to maintain transmission line corridors. Transmission line construction will avoid loss of California red-legged frog aquatic habitat as described in 3.4.7.7.1.2, *Activities with Flexible Locations*.

Because this disturbance is primarily from short-term, temporary effects, specific compensation for the 12 acres of California red-legged frog upland habitat disturbance will be offset by returning these areas to pre-project conditions.

6.7.6.2 Construction Related Effects

New temporary power lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Temporary substations will be constructed at each intake, at the IF, and at each of the launch shaft locations. To serve permanent pumping loads, a permanent substation will be constructed adjacent to the pumping plants at CCF, where electrical power will be transformed from 230 kV to appropriate voltages for the pumps and other facilities at the pumping plant site. For operation of the three intake facilities, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line-stringing phase; for stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Construction-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than one year at any one location. See Chapter 3, Section 3.2.7.2, *Construction,* for a full description of the construction activities.

The operation of equipment during construction of the transmission lines could injure or kill California red-legged frog if individuals are present. The construction related effects and measures to minimize them are similar to those described above for reusable tunnel material sites under Chapter 6, Section 6.7.5.2, *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring or California red-legged frog during construction, some potential remains for these effects to occur.

6.7.6.3 Operations and Maintenance

Ongoing vegetation management around the poles and under the lines is expected to be minimal (small scale mechanical mowing and trimming around poles) in California red-legged frog habitat because grassland areas seldom if ever need to be cleared to maintain transmission line corridors.

6.7.7 Head of Old River Gate

The HOR gate construction area does not overlap with California red-legged frog modeled habitat and activities in that area will not have an adverse effect on the species (Figure 6.7-1).

6.7.8 Reusable Tunnel Material

6.7.8.1 Habitat Loss and Fragmentation

An estimated 0.1 acres (>0.1% of modeled upland cover and dispersal habitat in the action area) of California red-legged frog modeled upland cover and dispersal habitat overlaps with the mapped RTM access road where Western Farms Ranch Road meets Byron Highway (Figure 6.7-4, Table 6.7-1). The habitat to be removed is adjacent to cultivated lands and on the east side of Byron Highway, disconnected from the contiguous grassland habitat to the west. As shown in Figure 6.7-1, the RTM site is at the easternmost edge of California red-legged frog modeled habitat in the action area, and therefore will not result in habitat fragmentation or isolation.

The loss of 0.1 acres of modeled upland cover and dispersal habitat will be compensated through protection and management of California red-legged frog habitat at a 3:1 ratio in an area that connects to over 620 acres of existing habitat protected under the *East Contra Costa County HCP/NCCP*. The compensation for the PA will complement the conservation goals of the *East Contra Costa County HCP/NCCP*. See Chapter 3, Section 3.4.7.6.3, *Compensation to Offset Impacts,* for a full description of how protected lands will be sited to provide valuable habitat for this species.

6.7.8.2 Construction Related Effects

The RTM storage area will take five to eight years to construct and fill. All RTM areas will be constructed, as needed, depending on location. RTM storage area construction and placement will occur almost continuously through tunnel excavation, approximately 10 years.

Construction activities at the RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. For more details about the activities associated with RTM placement see Chapter 3, Section 3.2.10.6, *Dispose Soils*.

Vehicles and heavy equipment used to clear the RTM sites and transport equipment and material could injure or kill California red-legged frogs if individuals are present within the RTM footprint. California red-legged from mortality from vehicles and heavy equipment are more likely 24 hours proceeding a rain event and during nighttime construction. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for California red-legged frog to enter the work area. To help minimize the effects to the greatest extent practicable, no construction activities will occur during rain events or within 24-hours following a rain event or during nighttime hours. Other effects related to placement of RTM may include entanglement in erosion control materials, contamination as a result of toxic substances such as fuels, and degradation of aquatic habitat from run-off and siltation, dust, individuals trapped in pipes or other equipment, and falling in trenches or pits one foot or deeper. Additional measures to minimize construction related impacts are discussed in Chapter 3, Section 3.4.7.6.2, *Avoidance and Minimization Measures,* and include using an open-top trailer to elevate materials for onsite storage above ground such as pipes, conduits and other materials that could provide shelter for California red-legged frogs, eliminating the use of plastic monofilament netting (erosion control matting), loosely woven netting, or similar material, implementing dust control measures, and covering trenches and/or pits with wooden planks.

6.7.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to California red-legged frog.

6.7.9 Restoration

6.7.9.1 Habitat Loss and Fragmentation

Restoration activities will avoid effects on California red-legged frog and its habitat with the exception of vernal pool complex restoration, which may result in loss of 11 acres of California red-legged frog upland habitat (0.3% of modeled upland cover and dispersal habitat in the action area). While the exact location of vernal pool restoration is not known, it is likely that it will be in the region directly west, north, or south of CCF where California red-legged frog modeled habitat exists. Although vernal pool restoration in grasslands will result in some loss of California red-legged frog habitat, protection and management of surrounding grasslands associated with the vernal pools is expected to benefit California red-legged frog.

6.7.9.2 Construction Related Effects

Vernal pool restoration will involve use of heavy equipment to excavate areas within grasslands to create topographic depressions. California red-legged frogs could be injured or killed by heavy equipment or struck by vehicles associated with vernal pool construction. Although the AMMs detailed in Section 3.4.7.6.2.1, *Activities with Fixed Locations*, will be applied to minimize the risk of harm to California red-legged frogs during construction, and to minimize the risk of disrupting behavior through noise or lighting, some potential remains for these effects to occur with all the minimization measures in effect.

6.7.9.3 Operations and Maintenance

A variety of management actions to be implemented within restored vernal pool complex may result in localized ground disturbances within California red-legged frog habitat. Ground-disturbing activities such as removal of nonnative vegetation and road and other infrastructure maintenance activities are expected to have minor effects on available California red-legged frog habitat. Management activities could result in the injury or mortality of California red-legged frogs if individuals are present in work sites or if dens occur in the vicinity of habitat management work sites. Noise and visual disturbances could also affect California red-legged frogs use of the surrounding habitat. These effects are expected to be minor, and will be minimized with implementation of the worker awareness training, monitoring, and best management practices described in Chapter 3, Section 3.4.7.6.2, *Avoidance and Minimization Measures*.

6.7.10 Effectiveness Monitoring

On lands protected to benefit California red-legged frog, monitoring to detect the presence of breeding California red-legged frogs will be performed to determine the effectiveness of conservation. Monitoring will include surveying for adult male calls and eye shining. The presence of the biologist and the shining of lights may temporarily alter breeding behavior. As such, effectiveness monitoring for California red-legged frog will be performed by a USFWS approved biologist.

6.7.11 Critical Habitat

California red-legged frog critical habitat occurs in the action area to the west of CCF approximately 0.5 miles from the nearest construction activity area (Figure 6.7-1). Because there is no overlap between the construction footprint and California red-legged frog habitat, no effects on California red-legged frog critical habitat will occur. Future restoration for the project will not result in the adverse modification of California red-legged frog critical habitat.

6.7.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of California red-legged frog will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect California red-legged frog in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is conversion of rangeland to urban uses. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of CCF because urbanization within the cities of Brentwood, Pittsburg, Oakley, and Clayton is covered by the East Contra Costa County HCP/NCCP. Urban development outside these incorporated cities (i.e., in the jurisdiction of Contra Costa County) is not covered by the East Contra Costa County HCP/NCCP. Although unlikely to occur due to land use controls, if urban development was proposed in or near the community of Byron it could contribute to a cumulative adverse effect on California red-legged frog in the action area.

Climate change also threatens to modify annual weather patterns. Climate change may result in a loss of California red-legged frog and/or prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat in the action area with the highest likelihood of supporting California red-legged frog is within the East Contra Costa County HCP/NCCP, where large scale conservation efforts will be implemented, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.8 Effects on California Tiger Salamander

Appendix 6.B, *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Sections 4.A.11.6, *Suitable Habitat Definition,* and 4.A.11.7, *Species Habitat Suitability Model,* define suitable habitat and describe the habitat model for California tiger salamander.

Activities associated with geotechnical exploration, Clifton Court Forebay modification, power supply and grid connections, and habitat restoration may affect California tiger salamander, as described below. Figure 6.8-1 provides an overview of the locations of surface impacts relative to California tiger salamander modeled habitat, occurrences, and critical habitat. There are 12,724 acres of modeled California tiger salamander habitat in the action area. An estimated 57 acres (0.6% of total modeled habitat in action area) of California tiger salamander modeled habitat will be lost as a result of project implementation. Table 6.8-1 and Table 6.8-2 summarize the total estimated habitat loss of California tiger salamander modeled habitat. Only terrestrial cover and aestivation habitat loss is expected to occur; the PA would not entail loss of any aquatic breeding habitat.

Table 6.8-1. Maximum Habitat Loss on Modeled Habitat for California Tiger Salamander by Activity Type (Acres)

California Tiger Salamander Modeled Habitat	Total Modeled Terrestrial Cover and Aestivation Habitat in the Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Total Maximum Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Terrestrial Cover and Aestivation	12,724	0	0	0	46	0	0	11	57	2	7

Table 6.8-2. Maximum Direct Effects on and Conservation of Modeled Habitat for California Tiger Salamander

California Tiger Salamander Modeled Habitat	Permanent Habit Loss	Compensation Ratios		Total Compensation (Acres)	
	Total Maximum Habitat Loss (Acres)	Protection	Restoration	Protection	Restoration
Terrestrial Cover and Aestivation	57	3:1		171	

6.8.1 Geotechnical Exploration

6.8.1.1 Habitat Loss and Fragmentation

The only loss of California tiger salamander habitat resulting from geotechnical exploration will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches in diameter) and their filling would have no or negligible effects on the California tiger salamander.

6.8.1.2 Construction Related Effects

Geotechnical exploration activities will temporarily affect up to 2 acres (>0.1% of modeled terrestrial cover and aestivation habitat in the action area) of modeled California tiger salamander habitat. This effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (2 to 21 days). Given the low likelihood of California tiger salamander being present in the areas to be affected, effects on California tiger salamander from geotechnical exploration will be minimal. Construction related actions could injure or kill California tiger salamander if individuals are present, but the potential for this effect will be minimized as described in Section 3.4.7.7.2.3, *Activities with Flexible Locations.*

6.8.1.3 Operations and Maintenance

There will be no ongoing operations and maintenance associated with the geotechnical activities, resulting in no effect on California tiger salamander.

6.8.2 Safe Haven Work Areas

Safe haven work areas are not expected to occur in California tiger salamander habitat. Activities in these areas will not affect the species.

6.8.3 North Delta Intake Construction

The north Delta intake construction area does not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities construction does not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.5 Clifton Court Forebay Modification

6.8.5.1 Habitat Loss and Fragmentation

An estimated 46 acres (>0.1% of modeled terrestrial cover and aestivation habitat in the action area) of California tiger salamander modeled terrestrial cover and aestivation habitat overlaps with the mapped canal modifications at Clifton Court Forebay (Figure 6.8-2), where land will be cleared for permanent facilities and temporary work areas. The activities that will result in habitat loss include canal construction that will remove terrestrial cover and aestivation habitat at the southern end of the Clifton Court Forebay.

The loss of California tiger salamander terrestrial cover and aestivation habitat will be offset through protection at a 3:1 ratio (Table 6.8-2). As described in Section 3.4.7.7.2.2, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. As detailed in Section 3.4.7.7.4, *Siting Criteria for Compensation for Effects*, these conservation lands will be sited in locations that provide high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for California tiger salamander. As detailed in Section 3.4.7.7.5, *Management and Enhancement*, these conservation lands will be protected and managed for the species in perpetuity.

6.8.5.2 Construction Related Effects

Construction activities at the canal work area south of Clifton Court Forebay include vegetation clearing, excavation, pile driving, dredging, and cofferdam and embankment construction. The duration of construction in this area will be approximately six years. For complete details on construction activities and phasing, see Section 3.2.6, *Connections to Banks and Jones Pumping Plants;* for more details on schedule, see Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*.

Vehicles and heavy equipment used at the construction site could injure or kill California tiger salamanders if individuals are present within the construction footprint. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for California tiger salamanders to enter the work area. Construction activities within 1.3 miles of California tiger salamander aquatic habitat will be minimized during the wet season, October 15 through May 1, to avoid the period when salamanders are most likely to be moving through terrestrial cover and aestivation habitat. Ground disturbing activities in terrestrial cover and aestivation habitat within 1.3 miles of California tiger salamander aquatic habitat or as determined in coordination with the U.S. Fish and Wildlife Service) will cease on days with a 40% or greater forecast of rain from the closest National Weather Service (NWS) weather station, however, ground disturbing work may continue if a USFWS-approved biologist surveys the worksite before construction begins each day rain is forecast and is present during ground disturbing work. Ground disturbing activities may continue after the rain ceases and the work areas is surveyed by the USFWS-approved biologist. If rain exceeds 0.5 inches during a 24-hour period, work will cease until the NWS forecasts no further rain. Modifications to this timing may be approved by USFWS based on site conditions and expected risks to California tiger salamanders as described in Section 3.4.7.7.2, *Avoidance and Minimization Measures*.

Other effects related to construction may include entanglement in erosion control materials, contamination because of toxic substances such as fuels, degradation of aquatic habitat from run-off and siltation, and behavioral changes as a result of lighting or vibration. To prevent California tiger salamander from becoming entangled, trapped, or injured by erosion control structures, erosion control measures that use plastic or synthetic monofilament netting will not be used within areas designated to have suitable California tiger salamander habitat and the perimeter of construction sites will be fenced with amphibian exclusion fencing. For more details on avoidance measures, see Section 3.4.7.7.2, *Avoidance and Minimization Measures*.

Because dusk and dawn are often the times when the California tiger salamander is most actively moving and foraging, to the greatest extent practicable, earthmoving and construction activities will cease no less than 30 minutes before sunset and will not begin again prior to 30 minutes after sunrise within 1.3 miles of California tiger salamander aquatic habitat or as determined in coordination with the US Fish and Wildlife Service. Except when necessary for driver or pedestrian safety, to the greatest extent practicable, artificial lighting at a worksite will be prohibited during the hours of darkness within 1.3 miles of California tiger salamander aquatic habitat or as determined in coordination with the US Fish and Wildlife Service.

Although measures will be applied to minimize the risk of injuring or killing California tiger salamanders during construction, and to minimize the risk of disrupting behavioral patterns, some potential remains for these effects to occur with all the minimization measures in effect.

6.8.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures, and siphons. These features will not be operated in or near California tiger salamander habitat and are not expected to affect the species.

The forebay and canals will need control of vegetation and rodents, and perhaps embankment repairs. Maintenance of control structures could include removal or installation of roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the outlet culverts. Use of heavy equipment for maintenance may injure or kill California tiger salamander: these effects and associated minimization measures are as described in Section 6.8.1.2, *Construction Related Effects*. The possibility of these effects is remote, however, because California tiger salamanders are not likely to be present near the forebay.

6.8.6 Power Supply and Grid Connections

6.8.6.1 Habitat Loss and Fragmentation

To conservatively assess impacts from transmission line placement, a 50-foot wide permanent disturbance area along the transmission line corridor was assumed (see Appendix 6.B, *Terrestrial Effects Analysis Methods* for additional details about the impact assessment method). Based on this method, an estimated 9 acres (>0.1% of modeled terrestrial cover and aestivation habitat in the action area) of California tiger salamander aestivation and cover habitat may be temporarily lost as a result of the construction of temporary transmission lines (Table 6.8-1). Temporary impacts are incurred from activities that will not last more than one year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas. Ongoing vegetation management around the poles and under the lines will be minimal (small scale mechanical mowing and trimming) in California tiger salamander habitat because aquatic and grassland areas typically do not need to be cleared to maintain transmission line corridors.

Because transmission line effects are primarily short-term and temporary, specific compensation for the 7 acres of California tiger salamander habitat (>0.1% of modeled terrestrial and cover habitat in the action area) disturbance will be offset by returning these areas to pre-project conditions.

6.8.6.2 Construction Related Effects

New temporary power lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites.

Construction of new transmission lines will require site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line-stringing phase; for stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Construction-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than one year at any one location. See Section 3.2.7.2, *Construction*, for a full description of the construction activities.

The operation of equipment during construction of the transmission lines could injure or kill California tiger salamander if individuals are present. The construction related effects and measures to minimize them are similar to those described above for construction at the canal work area near Clifton Court Forebay in Section 6.8.5.2, *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring or killing California tiger salamander during construction, and to minimize the risk of disrupting behavior, some potential remains for these effects to occur with all the minimization measures in effect.

6.8.6.3 Operations and Maintenance

Ongoing vegetation management around the poles and under the lines is expected to be minimal in California tiger salamander habitat because aquatic and grassland areas seldom if ever need to be cleared to maintain transmission line corridors. Effects on California tiger salamander from transmission line operations and maintenance, if any, are expected to be negligible.

6.8.7 Head of Old River Gate

The HOR gate construction area does not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.8 Reusable Tunnel Material

The RTM sites do not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.9 Restoration

6.8.9.1 Habitat Loss and Fragmentation

Restoration activities will avoid effects on California tiger salamander and its habitat with the exception of vernal pool complex restoration, which may result in loss of 11 acres of California tiger salamander terrestrial cover and aestivation habitat. While the exact location of vernal pool restoration is not known, it is likely that it will be in the region directly west, north, or south of CCF where California tiger salamander modeled habitat exists. Although vernal pool restoration in grasslands will result in some loss of California tiger salamander habitat, protection and management of surrounding grasslands associated with the vernal pools is expected to benefit California tiger salamander.

6.8.9.2 Construction Related Effects

Vernal pool restoration will involve use of heavy equipment to excavate areas within grasslands to create topographic depressions. California tiger salamanders could be injured or killed by heavy equipment or struck by vehicles associated with vernal pool construction. The types of effects and measures to minimize these effects are as described in Section 6.8.5.2, *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring or California tiger salamander during construction, and to minimize the risk of disrupting behavior through noise or lighting, some potential remains for these effects to occur with all the minimization measures in effect.

6.8.9.3 Operations and Maintenance

A variety of management actions to be implemented within restored vernal pool complex may result in localized ground disturbances within California tiger salamander habitat. Ground-disturbing activities such as removal of nonnative vegetation and road and other infrastructure maintenance activities are expected to have minor effects on available California tiger salamander. Management activities could result in the injury or mortality of California tiger salamanders if individuals are present in work sites or if dens occur near habitat management work sites. Noise and visual disturbances could also affect California tiger salamanders use of the surrounding habitat. These effects are expected to be minor, and will be minimized with implementation of the worker awareness training, monitoring, and best management practices described in Section 3.4.7.7.2, *Avoidance and Minimization Measures*. Furthermore, the management and enhancement of vernal pool complexes are expected to benefit the species.

6.8.10 Effectiveness Monitoring

On lands protected to benefit California tiger salamander, monitoring to detect the presence of California tiger salamanders will be performed to determine the effectiveness of conservation. Monitoring will include dip net surveying for the presence of individuals. The presence of the biologist and dip netting may temporarily alter behavior. As such, effectiveness monitoring for California tiger salamander will be performed by a USFWS approved biologist.

6.8.11 Effects on Critical Habitat

Critical habitat for California tiger salamander occurs in the Jepson Prairie area and overlaps with the action area near to the terminus of Lindsey Slough, west of Rio Dixon Road. There are no water conveyence facility construction activities in this region, however, tidal resotration could occur in the Cache Slough and Lindsey Slough area. Avoidance and minimization measures described in Section 3.4.7.7.2.3.3.2, *Tidal Restoration*, require tidal restoration projects be designed to avoid areas within 250 feet of any of the primary constituent elements (PCEs) of California tiger salamander habitat within the designated critical habitat unit, or some lesser distance if it is determined through project review and concurrence by USFWS that tidal restoration actions will not result in changes in hydrology or soil salinity that could adversely modify these PCEs.

6.8.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of California tiger salamander will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect California tiger salamander in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is conversion of rangeland to urban uses. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of CCF because urbanization within the cities of Brentwood, Pittsburg, Oakley, and Clayton is covered by the East Contra Costa County HCP/NCCP. Urban development outside these incorporated cities (i.e., in the jurisdiction of Contra Costa County) is not covered by the East Contra Costa County HCP/NCCP. Although unlikely to occur due to land use controls, if urban development was proposed in or near the community of Byron it could contribute to a cumulative adverse effect on California tiger salamander in the action area.

Climate change also threatens to modify annual weather patterns. Climate change may result in a loss of California tiger salamander and/or prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat in the action area with the highest likelihood of supporting California tiger salamander is within the East Contra Costa County HCP/NCCP, where large scale conservation efforts will be implemented, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.9 Effects on Valley Elderberry Longhorn Beetle

Appendix 6.B, *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the PA on terrestrial species. Appendix 4.A, *Status of the Species* *and Critical Habitat Accounts*, Section 4.A.14.7, *Species Habitat Suitability Model*, provides a description of the suitable habitat model for valley elderberry longhorn beetle.

Activities associated with safe haven work areas, north delta intakes, tunneled conveyance facilities, Clifton Court Forebay modification, power supply and grid connections, head of Old River gate (HOR gate), reusable tunnel material, and restoration may affect valley elderberry longhorn beetle, as described below. Figure 6.9-1 provides an overview of the locations of surface impacts relative to valley elderberry longhorn beetle modeled habitat and occurrences. See Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.14.6, *Suitable Habitat Definition*, for the definition of suitable valley elderberry longhorn beetle habitat. There are 31,495 acres (15,195 acres of grassland habitat and 16,300 acres of riparian habitat) of modeled valley elderberry longhorn beetle habitat in the action area. An estimated 276 acres (1% of total modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat, which includes 227 acres of grassland habitat and 49 acres of riparian habitat, will be lost as a result of project implementation. Table 6.9-1 and Table 6.9-2 summarize the maximum loss of valley elderberry longhorn beetle habitat and present compensation, respectively.

6.9.1 Geotechnical Exploration

The exact locations of geotechnical exploration activities are not known at this time. As noted in Section 3.4.7.8.2.2, *Activities with Flexible Locations*, preconstruction surveys for elderberry shrubs will be conducted in potential work areas during the planning phase for geotechnical exploration. Geotechnical activities will be planned to fully avoid elderberry shrubs and effects on the species.

6.9.2 Safe Haven Work Areas

6.9.2.1 Habitat Loss and Fragmentation

An estimated 2 acres (>0.1% of modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat will be affected at safe haven work areas. The 2 acres of modeled habitat includes 1 acre of riparian habitat (>0.1% of modeled riparian habitat in action area) and 1 acre of non-riparian habitat (>0.1% of modeled grassland habitat in action area). Because the exact locations of safe haven work areas are not known at this time, it is unknown whether these locations will result in fragmentation of valley elderberry longhorn beetle habitat.

As described in Appendix 6.B, *Terrestrial Effects Analysis Methods*, Table 6.B-10, *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made of the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of the safe haven interventions is estimated to result in direct effects on approximately 7 elderberry shrubs with an estimated total of 140 stems. The actual number of shrubs and stems that will be affected will be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2.1, *Activities with Fixed Locations*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6, *Suitable Habitat Definition.*

Table 6.9-1. Loss of Valley Elderberry Longhorn Beetle Habitat (Elderberry Bushes) by Activity Type (Acres)

Valley Elderberry Longhorn Beetle Habitat	Total Modeled Habitat in the Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Total	Geotechnical Exploration	Power Supply and Connection
Grassland within 200ft	15,195	1	31	57	72	1	65	0	227	52	35
Riparian Habitat	16,300	1	14	19	1	0	14	0	49	11	8
Total Acres Modeled Habitat	**31,495**	**2**	**45**	**77**	**73**	**1**	**79**	**0**	**276**	**63**	**43**
Shrubs	n/a	2	15	23	7	1	19	29	107	0	11[a]
Stems	n/a	20	300	460	140	20	380	581	2,121	0	220[a]

[a] Impacts to shrubs and stems are direct and require transplanting and mitigation. See Section 3.4.7.8.3, *Compensation to Offset Impacts*, for full details on shrubs and stem compensation.

Table 6.9-2. Maximum Shrub and Stem Loss of Valley Elderberry Longhorn Beetle Habitat (Elderberry Bush) and Proposed Compensation (See Chapter 3, Section 3.4.7.8.3, *Compensation to Offset Effects*, for compensation by activity type).

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (25 shrubs, 500 stems)	Greater than or equal to 1 inch, less than 3 inches	280	No	151	1:1	1:1	151	151	
			Yes	129	2:1	2:1	258	516	
	Greater than or equal to 3 inches, less than 5 inches	115	No	62	2:1	1:1	124	124	
			Yes	53	4:1	2:1	212	424	
	Greater than or equal to 5 inches	105	No	57	3:1	1:1	170	170	
			Yes	48	6:1	2:1	291	582	
Riparian (82 shrubs, 1,738 stems)	Greater than or equal to 3 inches, less than 5 inches	1,154[d]	No	413	2:1	1:1	826	826	
			Yes	378	4:1	2:1	1,512	3,024	
	From 3 to 5 inches	300[d]	No	90	3:1	1:1	271	271	
			Yes	115	6:1	2:1	693	1,385	
	Greater than or equal to 5 inches	187[d]	No	90	4:1	1:1	361	361	
			Yes	88	8:1	2:1	701	1,600	
						Total	**5,569**	**9,433**	**15,002**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 107 shrubs occur. Total seedlings/cuttings and associated natives = 15,002

107 transplants plus 1,070 seedlings/cuttings and natives x 1,800 sq ft = 192,600 sq ft = 4.42 acres

13,905 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 2,502,827sq ft = 57.5 acres

Total area = 61.9 acres

Table 6.9-2 shows the compensation for the estimated direct effects to elderberry shrubs from safe haven construction. Table 3.4.-14 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2, *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.2.2 Construction Related Effects

Construction of safe haven interventions will include the use of heavy equipment for ground clearing, grading, excavation, and drilling. Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, which includes having a USFWS-approved biologist present to prevent unauthorized take and to ensure that transplanting measures adhere to the USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*. These guidelines include transplanting shrubs during their dormant season (generally between November and the first two weeks of February), which is when they have lost most of their leaves.

Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, which includes having a USFWS-approved biologist present to prevent unauthorized take and to ensure that transplanting measures adhere to the USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*. These guidelines include transplanting shrubs during their dormant season (generally between November and the first two weeks of February), which is when they have lost most of their leaves.

The operation of equipment during construction in the vicinity of occupied elderberry shrubs could also result in injury or mortality of valley elderberry longhorn beetles if they are actively dispersing between shrubs, which is generally between March 15th to June 15th; or if occupied shrubs are inadvertently damaged by construction activities. These effects will be avoided and minimized as described in Section 3.4.7.8.2, *Avoidance and Minimization Measures* by surveying all areas within 100 feet of construction work areas, setting up barrier fencing and signs around shrubs, training crews on the sensitivity of the habitat and ramifications of violating the Endangered Species Act, and avoiding application of pesticides, herbicides, fertilizers, or other chemicals that could be hazardous to elderberry shrubs within 100 feet of the shrubs.

Temporary construction-related ground disturbances could generate dust that could adversely affect adjacent valley elderberry longhorn beetle habitat. Dust is listed in the valley elderberry longhorn beetle recovery plan as a threat to the species (U.S. Fish and Wildlife Service 1984). However, one study indicated that dust deposition was not correlated with valley elderberry longhorn beetle presence (Talley et al. 2006), although dust was weakly correlated with elderberry stress symptoms (water stress, dead stems, smaller leaves). During times of drought, when elderberry shrubs are under stress, dust deposition could further stress the shrubs, potentially leading to their death. Such a loss of shrubs could adversely affect valley elderberry longhorn beetle (Talley and Hollyoak 2009). The potential effects of dust on valley elderberry longhorn beetle will be minimized by applying water during construction activities or by presoaking work areas that will occur within 100 feet of any potential elderberry shrub habitat.

Exhaust from construction and maintenance vehicles may result in deposition of particulates, heavy metals, and mineral nutrients that could influence the quality and quantity of elderberry shrubs and thereby affect beetle presence and abundance. The results of a study by Talley and Hollyoak (2009) showed no relationship, however, between the distance of the shrubs from highways and the presence or abundance of the beetle. Potential effects from vehicle exhaust will be minimized by implementing measures in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, which include establishing buffers between the shrubs and work areas.

Temporary lighting from construction activities could adversely affect valley elderberry longhorn beetle. The effects of lighting on valley elderberry longhorn beetle are unknown, although insects are known to be subject to heavy predation when they are attracted to night lighting (Rich and Longcore 2006). As identified in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, nighttime construction will be minimized or avoided by DWR, as project applicant between March 15th and June 15th where valley elderberry longhorn beetle is likely to be present. To the greatest extent practicable, artificial lighting at a construction site will be prohibited during the hours of darkness where valley elderberry longhorn beetle is likely to be present. There may, however, be residual effects on the species when it is not practicable to prohibit artificial lighting. Since lighting has not been found to have an adverse effect on this species and is not recognized as a threat to the species (U.S. Fish and Wildlife Service 2014), these effects are not expected to be appreciable.

6.9.2.3 Operations and Maintenance

Operation and maintenance in safe havens is not anticipated to result in any effects on valley elderberry longhorn beetle. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Section 3.4.7.8, *Valley Elderberry Longhorn Beetle*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species during construction.

6.9.3 North Delta Intake Construction

6.9.3.1 Habitat Loss and Fragmentation

An estimated 45 acres (0.13% of modeled habitat in the action area) of valley elderberry longhorn beetle modeled habitat overlaps with the mapped north delta intakes 2, 3, and 5 along the Sacramento River (Figures 6.9-2 through 6.9-4), where land will be cleared for permanent facilities and temporary work areas. The 45 acres of modeled habitat includes 13 acres of riparian habitat (>0.1% of modeled riparian habitat in action area) and 31 acres of grassland habitat (>0.1% of modeled grassland habitat in action area). Of the estimated 45 acres of habitat to be removed, 34 acres (7 acres of riparian and 27 acres of non-riparian) will result from construction of permanent facilities such as intake structures and associated electrical buildings and facilities, and permanent access roads. The remaining 11 acres (6 acres of riparian and 5 acres of non-riparian) of loss will result from use of work areas, which will last for approximately five years at each intake: because the duration of this effect is greater than one year, this effect will be compensated as if it were a permanent effect.

As described in Appendix 6.B, *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As shown in Table 6.9-1, construction of the intakes is anticipated to result in direct effects (permanent and temporary impacts) on approximately 15 elderberry shrubs with an estimated 300 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as described in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6, *Suitable Habitat Definition.*

As seen in Figures 6.9-2, 6.9-3, and 6.9-4, the habitat to be lost as a result of intake construction is along the east shore of the Sacramento River as well as along waterways (ditches, canals, and streams) that drain into the river. Though the impacted areas are relatively narrow (approximately 45 feet wide) they provide continuous modeled habitat along the eastern bank of the Sacramento River and intake construction of them would fragment this habitat. Construction of Intakes 2, 3, and 5 would remove approximately 1.5 miles, 1.4 miles, and 0.8 mile of modeled habitat, respectively along the eastern bank of the river. Considering that valley elderberry longhorn beetle is known to have poor dispersal abilities (Talley et al. 2006), the intakes would create dispersal barriers along the eastern bank of the Sacramento River. There are currently no known records of the species along the Sacramento River south of West Sacramento (California Department of Fish and Wildlife 2015), but surveys for the species in this area may be limited.

Table 6.9-2 shows the compensation for the estimated direct effects to elderberry shrubs from north Delta intakes. Table 3.4-8 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable consistent with USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.3.2 Construction Related Effects

The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Chapter 6, Section 6.9.2.2, *Construction Related Effects*.

The duration of construction at each intake will be approximately five years. Implementation of intake construction at each location will be staggered by approximately six months. Intake 3, the middle intake, will begin construction first; approximately six months later, construction will begin at intake 5, the southernmost intake. Construction at intake 2, the northernmost intake, will begin approximately one year after having begun at intake 5. The result is that construction will overlap at all three sites for approximately four years.

6.9.3.3 Operations and Maintenance

Operation of the intakes is not anticipated to result in any effects on valley elderberry longhorn beetle. Maintenance of the intakes as described in Chapter 3, Section 3.3.6.1, *North Delta Intakes*, would not likely result in effects on valley elderberry longhorn beetle. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Chapter 3, Section 3.4.7.8.2.1, *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.4 Tunneled Conveyance Facilities

6.9.4.1 Habitat Loss and Fragmentation

An estimated 76 acres (0.2% of modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat overlaps with the tunnel conveyance facilities (Figures 6.9-5 through 6.9-11), where land will be cleared for permanent facilities and temporary work areas. The 76 acres of modeled habitat includes 19 acres (0.1% of modeled riparian habitat) of riparian habitat and 57 acres (0.3% of modeled grassland habitat) of non-riparian habitat. Of the estimated 76 acres of habitat to be removed, 62 acres (17 acres of riparian and 45 acres of non-riparian) will result from construction of permanent facilities. The remaining estimated 14 acres (2 acres of riparian and 12 acres of non-riparian) of loss will result from use of tunnel work areas, which will be in use for several years: because the duration of this effect is greater than one year, this effect will be compensated as if it were a permanent effect. Most of the modeled non-riparian habitat affected by access roads consists of areas along existing levee roads that are vegetated in grasses and do not appear to support trees and shrubs.

As described in Appendix 6.B, *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made of the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of the water conveyance facilities is anticipated to result in direct effects (permanent and temporary impacts) on approximately 23 elderberry shrubs with an estimated total of 460 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures.* Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6, *Suitable Habitat Definition.*

Tunneled conveyance facility construction will result in the fragmentation of modeled habitat in some areas. Some of the conveyance facilities (e.g., access roads) result in slivers of adjacent modeled habitat affected that would fragment habitat and others would only affect non-riparian habitat that if occupied shrubs are present in adjacent areas they will already have been somewhat isolated. Some facilities would result in the removal of large areas of habitat or create barriers along stretches of riparian habitat that will result in the fragmentation of habitat and the creation of barriers to dispersal. These areas would include: *Barge Unloading Facility on Zacharias Island* (Figure 6.9-6), which create a small barrier in the riparian habitat along Snodgrass Slough and *Tunnel Conveyor Facility, Fuel Station, and Shaft Locations adjacent to*

Clifton Court Forebay, which would fragment modeled riparian habitat along the north end of Clifton Court Forebay (Figure 6.9-9).

Table 6.9-2 shows the compensation for the estimated direct effects to elderberry shrubs from tunneled conveyance facilities. Table 3.4-11 provides details of how the number of elderberry seedlings and associated native plants were determined. As described in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.4.2 Construction Related Effects

Tunnel conveyance facility construction activities detailed in Chapter 3, Section 3.2, *Conveyance Facility Construction,* include the use of heavy equipment for ground clearing and grading. The effects from water conveyance facility construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Chapter 6, Section 6.9.2.2, *Construction Related Effects.*

6.9.4.3 Operations and Maintenance

Operation and maintenance of the conveyance facilities is not anticipated to result in any effects on valley elderberry longhorn beetle. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Chapter 3, Section 3.4.7.8.2.1, *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.5 Clifton Court Forebay Modification

6.9.5.1 Habitat Loss and Fragmentation

An estimated 73 acres (0.2% of all modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat overlaps with the Clifton Court Forebay facilities (Figures 6.9-12 to 6.9-15) where land will be cleared for permanent facilities and temporary work areas. The 73 acres of modeled habitat includes 1 acre of riparian habitat (>0.1%) and 72 acres (0.3%) of non-riparian habitat, all of which would be permanent impacts. The areas affected are around Clifton Court Forebay and are mostly non-riparian habitat that is mostly vegetated in grasses (Figures 6.9-12 to 6.9-15). Clifton Court Forebay was completely surveyed during the DHCCP surveys between 2009 and 2011. During these surveys, no elderberry shrubs were identified around Clifton Court Forebay.

As described in Appendix 6.B, *Terrestrial Effects Analysis Methods,* Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of Clifton Court Forebay modifications is anticipated to result in direct effects (permanent and temporary impacts) on approximately 7 elderberry shrubs with an estimated total of 140 stems. The actual number of shrubs and stems that will be affected will be determined during preconstruction surveys in suitable habitat as outlined in Chapter 3, Section

3.4.7.8.2, *Avoidance and Minimization Measures.* Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6, *Suitable Habitat Definition.* Although no shrubs were mapped around Clifton Court Forebay during the DHCCP surveys, due to the time between these surveys and project construction there is potential that shrubs could have become established, so for this analysis the modeled habitat there is considered to potentially support elderberry shrubs.

The expansion of Clifton Court Forebay will not fragment any riparian habitat but will fragment some areas of non-riparian habitat along the California Aqueduct. These nonriparian areas, however, appear to only be vegetated with grass.

Table 6.9-2 provides the compensation for the estimated direct effects to elderberry shrubs from Clifton Court Forebay modifications. Table 3.4-12 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2, *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.5.2 Construction Related Effects

Clifton Court Forebay construction activities detailed in Chapter 3, Section 3.2.5.2, *Construction*, include the use of heavy equipment for ground clearing, excavation, and grading and riprap placement. The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Chapter 6, Section 6.9.2.2, *Construction Related Effects.*

6.9.5.3 Operations and Maintenance

Operation of the conveyance facilities is not anticipated to result in any effects on valley elderberry longhorn beetle. Maintenance of Clifton Court Forebay and associated facilities as described in Chapter 3, Sections 3.3.6.3, *Intermediate Forebay,* and 3.3.6.5, *Connections to Banks and Jones Pumping Plants* could result in effects on valley elderberry longhorn beetle. Vegetation maintenance of the forebays and connections to Banks and Jones Pumping Plants could affect valley elderberry longhorn beetle if elderberry shrubs become established in these areas and/or if these activities affect adjacent habitat (e.g., herbicide drift, spills, dust). These potential effects will be avoided and minimized with the implementation of measures identified in Appendix 3.F *General Avoidance and Minimization Measures*, which includes: AMM1 *Worker Awareness Training*, which requires that maintenance staff be trained on the types of sensitive resources located in the project area and the measures required to avoid and minimize effects on these resources; AMM2 *Construction Best Management Practices and Monitoring*, which includes guidance on the use of herbicides; and AMM14 *Hazardous Materials Management*, which requires the development of a hazardous materials management plan and will include appropriate practices to reduce the likelihood of a spill of toxic chemicals and other hazardous materials during maintenance activities.

In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Chapter 3, Section 3.4.7.8.2.1, *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.6 Power Supply and Grid Connections

6.9.6.1 Habitat Loss and Fragmentation

An estimated 43 acres (0.15% of all modeled habitat in the action area) of valley elderberry longhorn beetle modeled habitat overlaps with the transmission lines (Figures 6.9-1 through 6.9-4 and 6.9-6 through 6.9-19), where transmission line construction could remove habitat. The temporary loss of 43 acres of modeled habitat includes 8 acres of riparian habitat (0.1%) and 35 acres (0.1%) of non-riparian habitat.

As described in Appendix 6.B, *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made of the number of shrubs and associated stems that could be affected by construction. As seen in Table 3.4-13, the construction of transmission line is anticipated to result in direct effects (permanent and temporary impacts) on approximately 11 elderberry shrubs with an estimated total of 220 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Chapter 3, Section 3.4.7.8.2.1, *Activities with Fixed Locations*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6, *Suitable Habitat Definition.*

Construction of the transmission lines will most often span areas of modeled habitat, which primarily occur adjacent to waterways; however, for this analysis it is assumed that transmission line construction would result in habitat removal. The corridors used for the GIS analysis were 50 feet wide. Habitat removal along these corridors would cut through areas of modeled riparian habitat throughout the project area, which would create barriers to valley elderberry longhorn beetle dispersal.

Table 6.9-2shows the compensation for the estimated direct effects to elderberry shrubs from transmission line construction. Table 3.4-13 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Chapter 3, Section 3.4.7.8.2.2, *Activities with Flexible Locations,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.6.2 Construction Related Effects

New temporary power lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Temporary substations will be constructed at each intake, at the IF, and at each of the launch shaft locations. To serve permanent pumping loads, a permanent substation will be constructed adjacent to the pumping plants at CCF, where electrical power will be transformed from 230 kV to appropriate voltages for the pumps and other facilities at the pumping plant site. For operation of the three intake facilities, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line-stringing phase; for stringing transmission lines between 230 kV towers, cranes and helicopters will be used. Construction-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than one year at any one location. See Chapter 3, Section 3.2.7.2, *Construction*, for a full description of the construction activities.

Transmission line construction activities detailed in Chapter 3, Section 3.2.7.2, *Construction*, would result in ground disturbance and potential vegetation clearing. The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Chapter 6, Section 6.9.2.2, *Construction Related Effects*.

6.9.6.3 Operations and Maintenance

Operation of the transmission lines would not affect valley elderberry longhorn beetle. Maintenance activities for transmission lines would require the maintenance of vegetation around transmission facilities, which is typically comprised of removal of trees and large shrubs underneath lines and around poles. These activities could result in take of valley elderberry longhorn beetle. As noted in Chapter 3, Section 3.3.6.6, *Power Supply and Grid Connections*, the power providers (PG&E, SMUD, and Western) are responsible for the maintenance of these facilities. As noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Chapter 3, Section 3.4.7.8.2.1, *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species where feasible. The effects analysis, however, assumes all vegetation along the transmission lines will be permanently removed.

6.9.7 Head of Old River Gate

6.9.7.1 Habitat Loss and Fragmentation

Construction of the HOR Gate will result in loss of an estimated 1 acre (>0.1% of modeled habitat in the action area) of valley elderberry longhorn beetle habitat, which consists of non-riparian habitat (see Figure 6.9-20).

As described in Appendix 6.B, *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of the HOR Gate is anticipated to result in direct effects (permanent and temporary impacts) on approximately 1 elderberry shrub with an estimated total of 20 stems. The actual number of shrubs and stems that will be affected will be determined during preconstruction surveys in suitable habitat as outlined in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6, *Suitable Habitat Definition.*

Table 6.9-2provides the compensation for the estimated direct effects to elderberry shrubs from HOR Gate construction. Table 3.4-10 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures*, effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.7.2 Construction Related Effects

HOR Gate construction activities detailed in Chapter 3, Section 3.2, *Conveyance Facility Construction*, include the use of heavy equipment for ground clearing and grading. The effects from these construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Chapter 6, Section 6.9.2.2, *Construction Related Effects.*

6.9.7.3 Operations and Maintenance

The operations and maintenance activities for the HOR gate described in Chapter 3, Section 3.3.6.7 *Head of Old River Gate*, would not result in direct or indirect effects to valley elderberry longhorn beetle because these activities are all within the footprint of the gate and in the wetted portion of the channel where elderberry shrubs would not be found and would not require the use of nighttime lighting, the generation of dust, use of herbicides and other chemicals that could affect adjacent habitat. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Chapter 3, Section 3.4.7.8.2.1, *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.8 Reusable Tunnel Material

6.9.8.1 Habitat Loss and Fragmentation

RTM storage area construction footprints overlap with modeled valley elderberry longhorn beetle habitat at several RTM storage areas (6.9-5, 6.9-12, 6.9-15, and 6.9-20 through 6.9-24). These impacts will be minimized with AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*, which calls for the avoidance of riparian and grassland habitats to the extent practicable. The RTM storage areas near Intake 2, on Zacharias Island, on Bouldin Island, and west of Clifton Court Forebay all have some areas where only slivers of habitat are shown to be affected. Some of these areas likely could be avoided if minor changes were made to the RTM storage footprints. However, for the purposes of this analysis it is assumed that all of these areas would be impacted.

An estimated 79 acres (0.3% of the 26,333 acres of modeled habitat in the action area) of valley elderberry longhorn beetle modeled habitat overlaps with the RTM storage areas. The 79 acres of modeled habitat includes 14 acres of riparian habitat (0.1% of modeled riparian habitat) and 65 acres (0.4% of modeled grassland habitat in the action area) of non-riparian habitat. Based on a review of aerial photos, all of the modeled riparian habitat appears to be suitable for the species and some of the non-riparian habitat appears suitable. The RTM storage area north of Dierssen Road will remove a large patch of modeled habitat for valley elderberry longhorn beetle that is mostly non-riparian habitat. This patch of habitat is relatively isolated from other modeled habitat and thus is not likely to be occupied and is less than optimum for the long-term conservation of the species. The non-riparian habitat in the RTM storage areas on Bouldin Island and west of Clifton Court Forebay appears to be vegetated in grasses with no shrubs, and thus to not be suitable.

As described in Appendix 6.B, *Terrestrial Effects Analysis Methods,* Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the RTM storage areas are anticipated to result in direct effects (permanent and temporary impacts) on approximately 19 elderberry shrubs with an estimated total of 380 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* in Section 4.A.14.6, *Suitable Habitat Definition.*

The use of RTM storage areas will fragment modeled habitat in some areas. Some of the RTM storage areas affect slivers of adjacent modeled habitat and some remove large areas of habitat to cause habitat fragmentation. These areas include:

- the *Second Triangular RTM Storage Area from the North* (Figure 6.9-5), where the removal of a large patch of habitat the remaining habitat immediately west and south of this RTM storage area would become fragmented and more isolated;

- *RTM Storage Area North and South of Twin Cities Road* (Figure 6.9-21), where the loss of modeled habitat will create a barrier between modeled habitat northeast and south of the RTM storage area, making the habitat to the northeast isolated; also a small patch of non-riparian habitat would become isolated along the western boundary of the RTM storage area;

- *RTM Storage Area on Bouldin Island* (Figure 6.9-22 through 6.9-24), where construction of a barge landing will create a gap between modeled habitat to the west and east; and

- *RTM Storage Area West of Clifton Court Forebay* (Figures 6.9-12 and 6.9-15), where the loss of modeled habitat will create a barrier between habitat to the north and south of the RTM storage area; however this habitat consists of grassy levee banks with rip-rap, and thus is not suitable.

Some of these effects could be reduced with the implementation of AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material,* which commits to avoid effects to riparian and grassland habitat to the extent practicable.

Table 6.9-2provides the compensation for the estimated direct effects to elderberry shrubs from RTM storage areas. Table 3.4-9 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.8.2 Construction Related Effects

Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed.

Each RTM storage area will take five to eight years to construct and fill. RTM areas will be constructed, as needed, depending on location. The RTM storage site at Clifton Court (reach 7) will be the first to be constructed and filled (see Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*) with all other RTM storage sites beginning construction within two years. The RTM storage site at Bouldin Island will be the last to begin construction. RTM storage area construction and placement will occur almost continuously through tunnel excavation, approximately 10 years.

The effects from RTM construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Chapter 6, Section 6.9.2.2, *Construction Related Effects.*

6.9.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to valley elderberry longhorn beetle. While reuse of the RTM is possible, end uses for the material have not yet been identified. It is likely that the material will remain in designated storage areas for a period of years before a suitable end use is identified, and any such use will be subject to environmental evaluation and permitting independent of the PA. Therefore disposition of RTM is assumed to be permanent and future reuse of this material is not part of the PA.

6.9.9 Restoration

6.9.9.1 Habitat Loss and Fragmentation

Tidal restoration and channel margin enhancement to offset effects on species habitat and wetlands may result in conversion of valley elderberry longhorn beetle habitat to other habitat types. The acres potentially lost as a result of this restoration were estimated as described in Appendix 6.B, *Terrestrial Effects Assessment Methods*.

6.9.9.1.1 Tidal Restoration

Tidal restoration implemented to offset effects on Delta Smelt and to provide compensation under Section 404 of the Clean Water Act will result in conversion of valley elderberry longhorn beetle habitat to other habitat types. The number of lost stems as a result of this restoration were estimated as described in Appendix 6.B, *Terrestrial Effects Analysis Methods,* Section 6.B.4.3.1.5, *Restoration*. As seen in Table 6.9-1, restoration is anticipated to result in direct effects (permanent and temporary impacts) 29 elderberry shrubs with an estimated total of on 581 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6, *Suitable Habitat Definition.*

Because the exact locations of tidal restoration areas are not known at this time, it is unknown whether these locations will result in the fragmentation of valley elderberry longhorn beetle habitat.

Table 6.9-2provides the compensation for the estimated direct effects to elderberry shrubs from restoration. Table 3.4-15 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Chapter 3, Section 3.4.7.8.2, *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.9.1.2 Channel Margin Enhancement

DWR will enhance 4.6 miles of channel margins between open water and upland areas to provide improved habitat for migrating salmonids. Channel margin enhancement activities are likely to occur near the intake construction area on the mainstem of the Sacramento River or on one of the nearby connected tidal sloughs (e.g., Steamboat Slough, Elk Slough, or Snodgrass Slough). Channel margin enhancement has potential to be combined with riparian restoration to meet multiple goals on one site.

Channel margin enhancement will target degraded aquatic edge habitat to improve habitat conditions for migrating salmon. Enhanced channel margin sections will seek to replace “hardened” riprap edge habitat with more emergent wetland and riparian habitat. This can be achieved by creating a "bench" of sediment (or other material) at the aquatic edge onto which vegetation can be planted or naturally recruited. This approach to channel margin enhancement is likely to be used to create emergent wetland habitat. More complex channel margin enhancement, where riparian restoration is likely to be a component, will be achieved using levee setbacks.

These activities have the potential to affect valley elderberry longhorn beetle habitat but would increase the availability of riparian habitat and improve habitat connectivity along the Sacramento River and nearby connected sloughs.

6.9.9.2 Construction Related Effects

Restoration activities will in some instances include the use of heavy equipment for ground clearing, grading, and excavation. The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Chapter 6, Section 6.9.2.2, *Construction Related Effects.*

6.9.9.3 Operations and Maintenance

Operational requirements for tidal restoration are not expected. Maintenance activities will include non-native plant control which might include mowing and herbicide application. Vegetation control measures will avoid impacts to valley elderberry longhorn beetle as described in Chapter 3, Section 3.4.7.8.5.1, *Levee Maintenance*, and Section 3.4.7.8.5.2, *Weed Control*.

6.9.10 Effectiveness Monitoring

On lands protected to benefit valley elderberry long-horned beetle, monitoring will be performed to determine the effectiveness of conservation. Monitoring for valley elderberry long-horned beetle will consist of shrub and stem surveys. Surveys will include counting the number of exit holes in stems and overall health of the shrub. The presence of biologists may alter typical behavior of individual valley elderberry long-horn beetle. As such, effectiveness monitoring for will be performed by a USFWS approved biologist.

6.9.11 Effects on Critical Habitat

Critical habitat has not been designated for the valley elderberry longhorn beetle.

6.9.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of valley elderberry longhorn beetle will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect valley elderberry longhorn beetle in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is agricultural conversion. Since climate change threatens to modify annual weather patterns, it may result in a loss of valley elderberry longhorn beetle habitat and/or increased numbers of their predators, parasites, and disease.

6.10 Effects on Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Appendix 6.B, *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the PA on terrestrial species. Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Sections 4.A.13.7 and 4.A.14.7 provide descriptions of the suitable habitat model for vernal pool fairy shrimp and vernal pool tadpole shrimp, respectively.

Activities associated with Clifton Court Forebay modifications and reusable tunnel material may affect vernal pool fairy shrimp and vernal pool tadpole shrimp, as described below.

Figure 6.10-1 provides an overview of the locations of surface impacts relative to vernal pool crustacean habitat, occurrences, and critical habitat. See Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Sections 4.A.13.6 and 4.A.14.6 for the definitions of suitable vernal pool fairy shrimp habitat and vernal pool tadpole shrimp habitat, respectively. There are 89 acres of modeled vernal pool fairy shrimp and vernal pool tadpole shrimp habitat in the action area. An estimated 6 acres (7% of total modeled habitat in action area) of vernal pool fairy shrimp and vernal pool tadpole shrimp modeled habitat will be affected as a result of project implementation. Affected habitat and offsetting measures are summarized in Table 6.10-1 and Table 6.10-2 below.

6.10.1 Geotechnical Exploration

There is no vernal pool fairy shrimp or vernal pool tadpole shrimp habitat within or near geotechnical exploration areas, therefore geotechnical exploration activities will not affect vernal pool fairy shrimp or vernal pool tadpole shrimp.

6.10.2 Safe Haven Work Areas

6.10.2.1 Habitat Loss and Fragmentation

There is no habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp within the tunnel alignment, therefore safe haven work areas will not affect vernal pool fairy shrimp or vernal pool tadpole shrimp habitat.

6.10.3 North Delta Diversion Construction

The construction footprint for the NDDs does not overlap with any suitable or potentially suitable habitat and there is no suitable or potentially suitable vernal pool fairy shrimp or vernal pool tadpole shrimp habitat in or within 250 feet of NDD construction, so NDD construction will not affect vernal pool fairy shrimp and vernal pool tadpole shrimp habitat.

Table 6.10-1. Maximum Modeled Habitat Affected for Vernal Pool Crustaceans by Activity Type (Acres)

Total Modeled Habitat in Action Area	Type of Effect	Permanent Habitat Affected								Temporary Habitat Affected	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Total Maximum Habitat Affected	Geotechnical Exploration	Power Supply and Connection
89	Direct	0	0	0	6	0	0	0	6	0	0
	Indirect	0	0	0	0	0	0	0.2	0.2	0	0

Table 6.10-2. Maximum **Affected Habitat for Vernal Pool Crustacean Habitat and Proposed Offsetting Measures**

Proposed Compensation	Direct Effect (Acres)	Indirect Effect (Acres)	Habitat Compensation Ratio		Total Habitat Compensation if all Impacts Occur (Acres)	
			Conservation Bank[1]	Non-bank Site[2, 3]	Conservation Bank[1]	Non-bank Site[2, 3]
Protection (direct and indirect effects)	6	0.2	2:1	3:1	12.4	18.6
Restoration/Creation (direct effects only)	6	NA	1:1	2:1	6	12

[1] Compensation ratios for credits dedicated in Service-approved mitigation banks

[2] Compensation ratios for acres of habitat outside of mitigation banks

[3] Compensation ratios for non-bank compensation may be adjusted to approach those for banks if the Service considers the conservation value of the non-bank compensation area to approach that of Service-approved mitigation banks.

6.10.4 Tunneled Conveyance Facilities

The construction footprint for the tunneled conveyance facilities does not overlap with any suitable or potentially suitable habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp, therefore tunneled conveyance facility construction will not affect vernal pool fairy shrimp or vernal pool tadpole shrimp habitat.

6.10.5 Clifton Court Forebay Modification

6.10.5.1 Habitat Loss and Fragmentation

Modifications of Clifton Court Forebay will affect 6 acres (7% of modeled of vernal pool habitat in the action area) of vernal pool fairy shrimp or vernal pool tadpole shrimp habitat. These effects will occur from the construction of the new forebay, which will affect 5.38 acres of habitat consisting of 0.24 acre of vernal pools and 5.14 acres of alkali seasonal wetlands (Figures 6.10-2 and 6.10-3). The affected vernal pools occur in a cluster of seven pools situated to the south and between the forebay and agricultural fields. There is a CNDDB record of vernal pool fairy shrimp associated with these pools. The affected alkali seasonal wetlands consists of three wetlands, the largest of which is located between the forebay and the aforementioned vernal pools; the other two are located in a narrow strip of land between the forebay and the California Aqueduct.

Table 6.10-2 shows the compensation for direct effects on vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. As seen in this table, directly affected vernal pool crustacean habitat will be mitigated by either purchasing restoration/creation credits at conservation bank (at 1:1) or by restoring/creating habitat at non-bank site approved by the USFWS (at 2:1), and by protecting habitat at either a conservation bank (at 2:1) or at a non-bank site approved by the USFWS (at 3:1). As noted in Chapter 3, Section 3.4.7.9.4.2, *Restoration*, if compensation is not provided at a USFWS-approved conservation bank it shall meet several criteria, in particular showing evidence of historical vernal pools, having suitable soils, and sufficient land to provide supporting uplands. As noted in Chapter 3, Section 3.4.7.9.4, *Siting Criteria for Compensation for Effects*, if protection occurs at a non-bank site, the priority is to protect habitat in the Livermore recovery unit, which is identified as one of the core recovery areas in the *Vernal Pool Recovery Plan* (U.S. Fish and Wildlife Service 2005).

Despite the loss in habitat, the Clifton Court Forebay modifications will not result in the fragmentation of remaining habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp because all the remaining habitat is to the west of Clifton Court Forebay.

6.10.5.2 Construction Related Effects

Construction activities for the Clifton Court Forebay modifications will occur within 250 feet of vernal pool crustacean habitat. As seen in Figure 6.10-2 and 6.10-3, a control structure and the associated temporary work area west of Clifton Court Forebay and a permanent access road, which is the existing Clifton Court Road, occur within 250 feet of vernal pool crustacean habitat. Construction activities occurring within 250 feet of vernal pool crustacean habitat have the potential to result in indirect effects to the habitat through changes in hydrology and changes in water quality. Construction of the control structure[27] will be in the existing canal, which when originally constructed likely disrupted subsurface soils and thus potentially the surrounding hydrology. The construction of the control structure is therefore not likely to alter the supporting hydrology of these wetlands. Construction activities in the adjacent work area will provide access to the area and will include staging materials and equipment. The approximately 100-foot wide work area currently consists of the levee adjacent to the canal, a road on top of the levee road, and work and storage areas. Construction activities have the potential to affect water quality in these wetlands if sediment is transported from the work area during storm events or if there are chemical spills in the work area that could affect groundwater or surface waters during storm events. As noted in Chapter 3, Section 3.4.7.9.2, *Avoidance and Minimization Measures*, staging areas will be designed to be more than 250 feet from vernal pool crustacean habitat; however, access to construction areas and activities that don't have a potential to result in changes to water quality will not be prohibited. Furthermore, potential indirect effects in this area will be further be avoided and minimized with the implementation of measures identified in Appendix 3.F *General Avoidance and Minimization Measures*, which include AMM1, *Worker Awareness Training;* AMM2, *Construction Best Management Practices and Monitoring;* AMM3, *Stormwater Pollution Prevention Plan;* AMM5, *Spill Prevention, Containment, and Countermeasure Plan;* AMM14, *Hazardous Materials Management;* and AMM16, *Fugitive Dust Control.* Other measures specific to the listed vernal pool crustaceans (Chapter 3, Section 3.4.7.9.2, *Avoidance and Minimization Measures*) will also help to minimize indirect effects on these species. These include monitoring by a USFWS-approved biologist to ensure protection of the avoided habitat, fencing around the avoided areas during construction, and training construction personnel on the sensitivity of the species and the importance of avoiding impacts on their habitat

Though Clifton Court Road has been identified as permanent access road, it is an existing paved road the construction of which affected the hydrology of the adjacent alkali seasonal wetland. Repaving this road will not alter the hydrology of the adjacent wetlands; however, repaving could affect water quality in the wetland. These potential effects will be avoided and minimized through the AMMs listed above.

Considering the existing development and land use (existing canal, levee road, and paved access road), the commitment to design final work areas and staging areas to be more than 250 feet from vernal pool crustacean habitat, and the aforementioned AMMs, offsetting measures in the form of habitat protection or restoration are not proposed.

6.10.5.3 Operations and Maintenance

No facilities operations or maintenance activities are expected to occur in habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp. Vernal pool fairy shrimp or vernal pool tadpole shrimp and their habitat could potentially be indirectly affected by maintenance of Clifton Court

[27] Control structures will enable operational decisions about how much water to divert to each PP from each water source (i.e., north or south Delta waters). Control structure designs are shown in Appendix 3.C, *Conceptual Engineering Report*, *Volume 2*, Sheets 88 and 89. Control structures will be constructed in the Middle River/Jones PP canal, NCCF/Jones PP canal, NCCF/Banks PP canal, and SCCF/Bank canal.

Road, but this potential indirect effect will be avoided by implementation of the measures described in Appendix 3.F, *General Avoidance and Minimization Measures*.

6.10.6 Power Supply and Grid Connections

As seen in Figures 6.10-2 and 6.10-3, vernal pool fairy shrimp and vernal pool tadpole shrimp habitat occurs in the areas of proposed permanent transmission lines to the west of Clifton Court Forebay. This habitat consists of alkali seasonal wetlands and vernal pools. As stated in Chapter 3, Section 3.4.7.9.2.2, *Activities with Uncertain Locations*, transmission lines will be designed to fully avoid effects on vernal pool fairy shrimp or vernal pool tadpole shrimp, which includes a minimum 250-foot no disturbance buffer around all vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. Thus, there are no impacts to vernal pool fairy shrimp or vernal pool tadpole shrimp from power supply and grid connections.

6.10.7 Head of Old River Gate

The construction footprint for the HOR gate does not overlap with any suitable or potentially suitable habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp, therefore will not result in impacts to vernal pool fairy shrimp or vernal pool tadpole shrimp habitat.

6.10.8 Reusable Tunnel Material

No habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp occurs within the footprint of RTM storage. Therefore no habitat will be lost due to construction or use of RTM storage areas.

6.10.8.1 Construction Related Effects

Habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp falls within 250 feet of the RTM storage area that is located to the west of Clifton Court Forebay and just east of Byron Highway. This habitat consists of two vernal pools to the south of the RTM storage areas.

Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. The RTM storage area will take approximately five to eight years to construct and fill. RTM storage area construction and placement will occur almost continuously through tunnel excavation, approximately 10 years.

The widening of Western Farms Ranch Road immediately south of the RTM storage area will indirectly affect (ground disturbance and construction activities within 250 feet) 0.2 acre of vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. This habitat consists of two vernal pools that are 25 to 30 feet south of the proposed widening of the Western Farms Ranch Road and as close as 150 feet southeast of the RTM storage area (Figure 6.10-3). Indirect effects on these pools may include changes in water quality, which could include sediment, dust, and construction related chemicals such as fuel, oil, and lubricants entering these pools, and changes to hydrology that support these pools by altering the watershed that supports the pools and/or affecting subsurface soils (i.e., breaking through restrictive soil layers that support pool ponding). Also, the introduction of invasive species could displace native vernal pool vegetation.

These effects will be minimized through general avoidance and minimization measures (AMMs) in Appendix 3.F, *General Avoidance and Minimization Measures,* including *AMM1 Worker Awareness Training; AMM2 Construction Best Management Practices and Monitoring; AMM3 Stormwater Pollution Prevention Plan; AMM5 Spill Prevention, Containment, and Countermeasure Plan; AMM14 Hazardous Materials Management;* and *AMM16 Fugitive Dust Control.* Other measures specific to the listed vernal pool crustaceans (Chapter 3, Section 3.4.7.9.2, *Avoidance and Minimization Measures*) will also help to minimize indirect effects on these species. These include monitoring by a USFWS-approved biologist to ensure protection of the avoided habitat, fencing around the avoided areas during construction, and training construction personnel on the sensitivity of the species and the importance of avoiding impacts on their habitat.

Table 6.10-2 shows the compensation for indirect effects on vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. As seen in this table, indirectly affected vernal pool crustacean habitat will be mitigated by protecting habitat at either a conservation bank (at 2:1) or at a nonbank site approved by the USFWS (at 3:1). As noted in Chapter 3, Section 3.4.7.9.4, *Siting Criteria for Compensation for Effects*, if protection occurs at a non-bank site, the priority is to protect habitat in the Livermore recovery unit, which is identified as one of the core recovery areas in the *Vernal Pool Recovery Plan* (U.S. Fish and Wildlife Service 2005).

6.10.8.2 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to vernal pool fairy shrimp or vernal pool tadpole shrimp, or their habitat.

6.10.9 Restoration

As stated in Chapter 3, Section 3.4.7.9.2.2, *Activities with Uncertain Locations*, restoration sites will be designed to fully avoid effects on vernal pool fairy shrimp and vernal pool tadpole shrimp, including observance of a minimum 250-foot no disturbance buffer around all vernal pool fairy shrimp or vernal pool tadpole shrimp habitat. No habitat will be lost or fragmented by restoration activities.

6.10.10 Effectiveness Monitoring

On lands protected to benefit vernal pool fairy shrimp and vernal pool tadpole shrimp, monitoring to detect the presence of these will be performed to determine the effectiveness of conservation. Effectiveness monitoring for these species will be performed by a USFWS approved biologist.

6.10.11 Effects on Critical Habitat

A designated critical habitat unit for vernal pool fairy shrimp overlaps with a portion of the action area (Figures 6.10-1 through 6.10-3).

Primary constituent elements for vernal pool fairy shrimp are defined as follows (70 Federal Register 46924–46998).

1. Topographic features characterized by mounds and swales and depressions within a matrix of surrounding uplands that result in complexes of continuously, or intermittently, flowing surface water in the swales connecting the pools described below, providing for dispersal and promoting hydroperiods of adequate length in the pools.

2. Depressional features including isolated vernal pools with underlying restrictive soil layers that become inundated during winter rains and that continuously hold water for a minimum of 18 days, in all but the driest years, thereby providing adequate water for incubation, maturation, and reproduction. As these features are inundated on a seasonal basis, they do not promote the development of obligate wetland vegetation habitats typical of permanently flooded emergent wetlands.

3. Sources of food, expected to be detritus occurring in the pools, contributed by overland flow from the pools' watershed, or the results of biological processes within the pools themselves, such as single-celled bacteria, algae, and dead organic matter, to provide for feeding.

4. Structure within the pools described above, consisting of organic and inorganic materials, such as living and dead plants from plant species adapted to seasonally inundated environments, rocks, and other inorganic debris that may be washed, blown, or otherwise transported into the pools, that provide shelter.

The footprints for a proposed transmission line, the RTM site west of Clifton Court Forebay and just east of Byron Highway, and the associated access road (an existing road) overlap with the critical habitat unit for vernal pool fairy shrimp. Only those portions of the designated critical habitat unit that support the primary constituent elements listed above constitute critical habitat for vernal pool fairy shrimp. Areas supporting the primary constituent elements include the depressional wetlands (vernal pool type wetlands) and the surrounding watershed (i.e., 250 feet around the vernal pools). As described in Section 6.10.6, *Power Supply and Grid Connections*, the transmission lines will be designed to avoid vernal pool crustacean habitat, including the vernal pool type wetlands and uplands within 250 feet of the wetlands, thereby avoiding vernal pool fairy shrimp critical habitat. The footprint for the RTM site west of Clifton Court Forebay and just east of Byron Highway will encroach within 250 feet of 0.2 acres of vernal pool type wetlands within the designated critical habitat unit for vernal pool fairy shrimp (Figure 6.10-3). This potentially affects the matrix of surrounding uplands described in constituent element #1, above, as well as potentially affecting overland flow described in constituent element #3, above. Encroachment within 250 feet of vernal pool type wetlands may also affect the transport of materials contributing to vernal pool structure as described in constituent element #4, above.

Although the Clifton Court Forebay construction will bisect the vernal pool fairy shrimp designated critical habitat unit (Figure 6.10-3), there are no primary constituent elements in the southern portion of this unit, therefore the project would not fragment critical habitat for vernal pool fairy shrimp.

Effects on critical habitat within 250 feet of vernal pool type wetlands will be offset through protection at a 2:1 ratio if protection occurs in a USFWS-approved conservation bank, and a 3:1 ratio if protection occurs outside a USFWS-approved conservation bank. Compensation ratios for non-bank compensation may be adjusted to approach those for banks if the USFWS considers the conservation value of the non-bank compensation area to approach that of USFWS-approved conservation banks. For the 0.2 acres of effects within a critical habitat unit, the California Department of Water Resources (DWR) will prioritize protection within designated critical habitat for this species, such as at the Mountain House Conservation Bank.

The PA will not appreciably reduce the conservation value of critical habitat for vernal pool fairy shrimp because no vernal pool type wetlands will be directly lost within critical habitat; effects within 250 feet of the depressional wetlands will be avoided and minimized through measures listed in Chapter 3, Section 3.4.7.9.2, *Avoidance and Minimization Measures* (applicable measures are named in Section 6.10.8.1, *Construction Related Effects*); the vernal pool type wetlands to be indirectly affected through encroachment into the surrounding watershed are in a disturbed area surrounded by roads, ditches, and agricultural lands; and DWR will fully offset adverse effects.

6.10.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of vernal pool fairy shrimp or vernal pool tadpole shrimp will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect vernal pool fairy shrimp or vernal pool tadpole shrimp in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is agricultural conversion. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of Clifton Court Forebay because urbanization in this area is covered by the *East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan (HCP/NCCP)*. Since climate change threatens to modify annual weather patterns, it may result in a loss of vernal pool crustacean habitat.

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6.11.1.1 Personal Communications

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