Chapter 3
Conservation Strategy (Sections 3.4 and 3.5)

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Acronyms and Abbreviations

BiOps	biological opinions
BMPs	best management practices
Cal Fire	California Department of Forestry and Fire Protection
Central Valley Water Board	Central Valley Regional Water Quality Control Board
CESA	California Endangered Species Act
cfs	cubic feet per second
CM	Conservation Measure
CVP	Central Valley Project
DBW	California Department of Boating and Waterways
DFG	California Department of Fish and Game
DO	dissolved oxygen
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DWR	California Department of Water Resources
DWSC	Deep Water Ship Channel
ELT	early long-term
ESA	federal Endangered Species Act
FAV	floating aquatic vegetation
HCPs	habitat conservation plans
LLT	late long-term
mg/L	milligrams per liter
NCCPs	natural community conservation plans
NGVD	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
NT	near-term
ppt	parts per thousand
Reclamation	U.S. Bureau of Reclamation
ROA	Restoration Opportunity Area
SAV	submerged aquatic vegetation
SRCSD	Sacramento Regional County Sanitation District
SWP	State Water Project
TMDL	total maximum daily load
UC	University of California
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
YBFEP	Yolo Bypass Fisheries Enhancement Plan

Chapter 3
Conservation Strategy (Sections 3.4 and 3.5)

3.4 Conservation Measures

3.4.1 Introduction

This section describes in detail all of the 22 conservation measures proposed for the BDCP. Collectively, these conservation measures, plus the adaptive management and monitoring program described in Section 3.6, comprise the conservation strategy. Important context for all of the conservation measures, including how the conservation measures were developed over the course of several years of planning, is found in Section 3.2, *Methods and Approaches Used to Develop the Conservation Strategy* and in Appendix 3.A, *Background on the Process of Developing the BDCP Conservation Measures*. See Chapter 6, *Plan Implementation*, for the implementation schedule for each conservation measure.

Conservation measures are given numeric codes for easy reference throughout the Plan. The conservation measures are organized hierarchically in the same fashion as the biological goals and objectives. Conservation Measures 1 and 2 are at the landscape scale because they apply to numerous natural communities and covered species. Conservation Measures 3 through 11 each apply to one natural community (i.e., at the natural community scale). Conservation Measures 12 through 21 address other stressors for one or more covered species, so these measures apply at the species-specific level. Conservation Measure 22 addresses avoidance and minimization measures and applies to all previous conservation measures.

3.4.2 Conservation Measure 1 Water Facilities and Operation

*[**Note to Reviewers:** This draft of CM1 describes existing and proposed water facilities. This conservation measure has been extensively revised from the November 2010 working draft, so changes are not shown. This version does not contain a proposal for adaptive limits to water operations; that proposal is still in development and a modified version of CM1 will be released as soon as it is available.]*

3.4.2.1 Introduction and Summary

The primary purpose of *Conservation Measure (CM) 1 Water Facilities and Operation* is to meet or contribute to BDCP biological goals and objectives that are listed below and fully described in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met. Implementation of CM1 will also produce a variety of other important benefits that are not closely tied to the protection and recovery of covered species and natural communities. These include restoring and protecting ecosystem health, water supply, and water quality; reducing State Water Project (SWP) and Central Valley Project (CVP) vulnerability to earthquake and flood hazards; and improving the flexibility of the SWP/CVP in the face of climate change. These benefits are further detailed in the EIR/EIS for the BDCP.

Many of the conservation actions proposed under CM1 provide for the continuation of or reduction in already greatly reduced entrainment levels at existing facilities that are a result of biological opinions (BiOps) issued after BDCP was already underway (Section 1.3.7*, Relationship to Existing Biological Opinions*). CM1 incorporates most of those constraints, but proposes a different approach to management of those constraints, which will be implemented after the new north Delta diversions become operational. This change in management approach is logical, because the new north Delta diversions will allow an array of beneficial flow modifications that are not possible using the existing water management infrastructure in the Delta. These potential benefits are described below (Section 3.4.2.2, *Purpose*), as is the management approach to achieving them (Section 3.4.2.5, *Implementation*).

CM1 will make substantial changes to water operations in the Delta through two major components: construction of new water facilities and operations of both new and existing water conveyance facilities once the new facilities become operational. New facilities construction is summarized in Section 4.1.3, *New Water Facilities Construction*, *Operations, and Maintenance*. Further details on the construction of the new water conveyance facilities are found in the EIR/EIS for the BDCP. Construction of the new Fremont Weir operable gates is also discussed in *CM2 Yolo Bypass Fisheries Enhancement*.

Construction of the new north Delta facilities is part of this conservation measure, because it is a necessary precursor to the operational changes enabled by the new facilities; however, it is not otherwise detailed in this section, which focuses on description of how the new and existing facilities would be operated so as to produce a conservation benefit.

This conservation measure is described in the following sections.

Section 3.4.2.2, *Purpose*, lists the biological goals and objectives that will be supported by CM1 and describes how and why CM1 is expected to support each of those goals and objectives.

Section 3.4.2.3, *Water Facilities*, describes the facilities that will be jointly operated to implement the range of flow conditions achievable under CM1:

- South Delta diversions (existing facilities)
- Delta Cross Channel gates (existing facilities)
- Suisun Marsh salinity control gates (existing facilities)
- North Delta diversions (proposed facilities)
- North Bay Aqueduct intakes (one existing, one proposed facility)
- Fremont Weir operable gates (proposed facilities)

Section 3.4.2.4, *Problem Statement*, describes the basic flow management problem currently faced in the Delta and how existing facilities are used to manage flows. This is followed by a summary of how flow management, using the existing and proposed new facilities, can achieve substantial benefits for Delta ecosystems, including covered species and natural communities. The detailed exposition of those benefits, however, appears in Chapter 5, *Effects Analysis*.

Section 3.4.2.5, *Implementation*, begins by describing the fundamental approach used in CM1, which is to control a group of important flow parameters (e.g., Sacramento River inflow, Suisun Bay outflow) within an adaptive limits context. Thus, to achieve desired conservation benefits, CM1 will limit the volumes of diversion in a manner that allows variation within a specified range, via a specified adaptive management process. It describes the logistical and ecological constraints that operate to set upper and lower bounds to the adaptive limits, and describes how the limits would be applied in practice. This section also addresses the maintenance actions that would be associated with facility operations.

3.4.2.2 Purpose

The primary purpose of CM1 is to meet or contribute to the biological goals and objectives identified in Table 3.4-1. By helping to restore a more natural flow regime and enabling restoration of some attributes of a natural flood disturbance regime, CM1 also provides an indirect contribution to many other goals and objectives that are directly served by habitat protection and restoration actions; these goals and objectives are not specifically listed below, but are addressed in detail in CM2 through CM11. The rationale for each of the goals and objectives listed in Table 3.4-1 is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-1. Biological Goals and Objectives Addressed by CM1 Water Facilities and Operation

Biological Objective	How CM1 Advances Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.6: Maintain or increase life-history diversity of native fishes and a diversity of spawning and rearing conditions for native fishes over time.	Altering flow regimes to more closely resemble those that occurred in the south Delta prior to human flow modification will increase environmental and life-history diversity.
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.2: Promote connectivity between low salinity zone habitats and upstream freshwater habitats, and availability of spawning habitats for covered fish species.	Reduction of the current north-south flow pattern through the Delta and improvement of the ecological value of the migration corridor through the Yolo Bypass will facilitate connectivity and access to spawning habitat.
Objective L3.3: Support the movement of larval and juvenile life stages of covered fish species to downstream rearing habitats.	Flexibility provided by dual conveyance operations allows "pulse flows" to expedite the downstream passage of larval delta and longfin smelt. The Fremont Weir operable gates improve the Yolo Bypass as an alternative, lower-risk juvenile salmonid migration corridor. Use of the north Delta diversions reduces unfavorable north-south flows in the interior Delta that expose outmigrant juveniles to unfavorable habitats and high predation risk. Synergistic effects optimize juvenile Sacramento splittail and salmonid use of restored rearing habitats.
Objective L3.4: Provide flows that support the movement of adult life stages of native fish species to natal spawning habitats.	Use of the north Delta diversions increases attraction flows from the San Joaquin River, thus reducing the incidence of returning adults being exposed to unfavorable habitats and migration delays. The Fremont Weir operable gates and fish passage facilities reduce the likelihood of adult fish stranding.

Biological Objective	How CM1 Advances Objective
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objective L4.1: Avoid and minimize impacts on covered species resulting from BDCP covered activities.	The actions described to address the objectives of Goals L2, L3, and L4 to minimize impacts on covered species resulting from entrainment and other stressors will advance this objective. Additional minimization measures related to facility construction are presented in *CM22 Avoidance and Minimization Measures*.
Objective L4.4: Reduce entrainment, impingement, and salvage losses of covered fish species.	Entrainment and related losses will be reduced in the south Delta by reducing use of the south Delta diversions and by appropriately screening and operating the north Delta diversions.

3.4.2.2.1 Environmental and Life-History Diversity (Objective L2.6)

Operation of the new north Delta diversions is expected to substantially improve flow patterns in the south Delta by reducing exports from the south Delta and timing flows in the north Delta to improve Old River and Middle River positive (i.e., northerly) flows. This partially recreates patterns in physical variables such as salinity regimes and flow patterns in the Delta that more closely resemble conditions under which native resident species evolved. The new north Delta diversions provide flexibility to manage flow patterns to provide appropriate physical cues needed to initiate upstream or downstream migration. By gaining access to more natural flow conditions, covered species have greater opportunity to exhibit the full diversity of life-history strategies latent in their genetic makeup.

3.4.2.2.2 Juvenile Migration and Rearing (Objective L3.3)

Juvenile life stages of all covered fish species use habitat in the Plan Area for both migration and rearing, often with both activities occurring in the same area. Juvenile salmonids, for instance, forage throughout their outmigration, spending up to several months in the Plan Area. Pacific lamprey ammocoetes may forage for many years in the Plan Area before beginning to metamorphose and migrate towards the sea. CM1 supports migration and foraging by juveniles of each of the covered fish species, primarily by four mechanisms: pulse flows, preferred migration corridors, reduced north-south flows, and synergies involving habitat restoration areas.

Proposed bypass flow criteria allow pulse flows that would provide a period of relatively rapid downriver flows in the Sacramento and westward. This would be achieved by minimizing diversions, especially at the Delta Cross Channel and the south Delta diversions, at times that would allow delta and longfin smelt larval transport to foraging habitat in the low salinity zone (noting that migration timing differs for the two species). Expediting their migration in this way would allow them to complete outmigration before they deplete their yolk sac; it also reduces the time during migration that they are exposed to other stressors such as predation. Providing pulse flows requires coordinated timing of both reservoir releases and diversion volumes as described below in Section 3.4.2.5, *Implementation*.

CM1 creates or improves one principal preferred migration corridor, and in concert with *CM16 Nonphysical Barriers*, facilitates others. The principal benefit derives from use of the Fremont Weir operable gates to set the timing, duration, and volume of flows through the Yolo Bypass. Salmonid and green and/or white sturgeon (sturgeon) outmigration through the Yolo Bypass is expected to result in reduced predation stress, because the Bypass is dry much of the year and, therefore, not expected to develop appreciable populations of predatory fish, such as nonnative centrachids, which pose a substantial risk to juvenile salmonids and sturgeon elsewhere in the Delta. Fish that outmigrate through the Yolo Bypass will also be at reduced risk of entrainment. Salmonid, sturgeon, and Sacramento splittail (splittail) rearing in the Yolo Bypass are expected to be highly productive because of the prevalence of shallow-water habitats with abundant benthic organic matter that will support high primary productivity along with high populations of invertebrate detritivores and other macroinvertebrates.

Under current conditions, north-south flows predominate much of the time in channels leading to the south Delta export facilities and in the Delta Cross Channel. Depending on tidal state and hydrologic stage, they can also occur in certain channels hydraulically connected to these waterways. Such artificial flow patterns are thought to attract outmigrating juvenile salmonids to these channels, which leads to increased entrainment at the SWP/CVP pumps and areas of the interior Delta where greater instances of adverse conditions exist. Dual conveyance operations will allow modifying operation of the south Delta diversions, and potentially those of the Delta Cross Channel, so as to reduce the frequency and magnitude of flows causing migrating fish to enter the interior Delta. This, in turn, will allow juvenile outmigrants to follow a downstream course through the estuary and to San Francisco Bay, thereby having a more rapid migration with briefer exposure to predation; it will also reduce the proportion of fish entering the interior Delta, where survival of juvenile Chinook salmon (and presumably other salmonids) is lower (Baker and Morhardt 2001; Brandes and McLain 2001; CALFED 2001; Perry and Skalski 2009; Perry et al. 2010). Reducing the reliance on through-Delta conveyance via the Delta Cross Channel and intakes in the south Delta will also substantially reduce the effects of existing flow anomalies such as weak flows or reverse flows on salmonids in the San Joaquin River system and tributaries, Mokelumne River, and other east-side tributaries. Although there is some increased entrainment exposure for Sacramento River salmonids due to the presence of the new north Delta diversions, these effects are intended to be minimized by fish screen and sweeping and approach velocity criteria, and other operational parameters such as bypass flows.

Restoration actions benefiting fish habitat, such as channel margin habitat enhancement and channel-floodplain reconnections, will preferentially be sited in areas projected for heavier use by covered fish species under the altered CM1 flow conditions. Thus, synergistic benefits may be derived from the coincidence of altered flow benefits with improved habitat condition. For instance, because channel margin enhancement will be targeted to juvenile salmonid migration corridors, there should be a disproportionately higher use of those habitats by migrant juvenile salmon.

Operation of the Fremont Weir operable gates is expected to improve access of splittail, salmonids, and sturgeon to foraging opportunities in existing and future restored inundated floodplain habitat in the Yolo Bypass, as described further under *CM2 Yolo Bypass Fisheries Enhancement*.

3.4.2.2.3 Adult Migration (Objective L3.4)

Operation of the north Delta diversions is expected to reduce reliance on through-Delta conveyance via the Delta Cross Channel and diversions in the south Delta. Locally, this will reduce the occurrence and magnitude of flow changes driven by the south Delta diversions on salmonids and sturgeon in the San Joaquin River system and tributaries, Mokelumne River, and other east-side tributaries. Such artificial flow patterns are thought to confuse the upstream migration cues of adults, reducing the probability that they will enter the east-side tributaries or causing delays in migration.

For salmonids and sturgeon migrating up the Sacramento River, seasonal closure or restriction of Delta Cross Channel gates is expected to maintain operational restrictions set under the BiOps, which provide migration cues for returning adults, and avoid false cues.

Besides these effects, the Fremont Weir operable gates and associated fish ladder and sturgeon ramps are intended to improve passage and reduce delays and stranding of upstream migrating fish that enter the Yolo Bypass.

3.4.2.2.4 Entrainment and Related Losses (Objective L4.4)

Entrainment has long been recognized as a frequently fatal risk associated with the existing south Delta diversions. This risk has been reduced and is partly remediated by existing fish screen and salvage facilities described below under Section 3.4.2.3, *Water Facilities*. Additionally, reductions in exports under the recent requirements of the BiOps have further reduced entrainment risks. Nonetheless opportunities remain to further reduce entrainment and its associated risks, which include stress/injury related to salvage operations, and prescreening and postscreening losses to predation.

The location of the existing south Delta export facilities is within the influence of all covered fish species for at least part of the year. Reducing diversions in the south Delta is expected to reduce the risk of entrainment mortality of salmonids, smelt, splittail, sturgeon and Pacific and river lamprey (lamprey), and the risk of predation mortality of salmonids, smelt, lamprey, and splittail associated with the export facilities. (Fish that do become entrained into Clifton Court Forebay will have predation risk reduced through measures described in *CM15 Predator Control.*)

The new north Delta diversions will be equipped with fish screens designed to minimize the risk of entrainment or impingement for all covered fish species, including relatively weak swimmers such as the delta smelt; moreover, the population centers of resident estuarine species, particularly delta and longfin smelt, are downstream of the reach of the Sacramento River where the north Delta intakes would be installed (Wang 1986; Bennett 2005). These screens will be engineered to provide appropriate approach and sweeping velocity to minimize risk to covered fish species when fish are within the vicinity of intakes. Multiple intakes will reduce the distance fish must travel past each fish screen, allowing individuals to rest between intake locations. There will also be an aggressive predator control program at the north Delta diversion sites, as described in *CM15 Predator Control*. These measures are expected to minimize the contribution to entrainment and predation caused by operation of the north Delta diversions. Use of these diversions, in turn, enables a substantial reduction in entrainment and predation risk associated with the south Delta diversions.

Because the north Delta diversions do not require a fish salvage facility, their operation is expected to reduce or eliminate mortality of covered fish species associated with collection, handling, transport, and release of salvaged fish from the existing export facilities and predation within these facilities.

A new diversion from the Sacramento River, proposed as the North Bay Aqueduct Alternative Intake, would operate in conjunction with the existing North Bay Aqueduct intake at Barker Slough.

The new diversion would be periodically operated to divert water of higher quality than is sometimes available from Barker Slough, and may reduce entrainment for species such as delta smelt that may be more abundant in Barker Slough than in the vicinity of the alternative intake site on the Sacramento River.

3.4.2.2.5 Species-Specific Objectives

*[**Note to reviewers:** Biological goals and objectives for covered fish species have not been finalized. However, the discussion of ecosystem-specific benefits above includes information about benefitted species, as applicable.]*

3.4.2.3 Water Facilities

The water facilities that would be used to perform flow management under CM1 are described below.

South Delta diversions. The existing south Delta diversions (Figure 1-1) occur at the Banks Pumping Plant (SWP) and the Jones Pumping Plant (CVP). Banks Pumping Plant draws water into the Clifton Court Forebay, which is located in the south Delta along Old River. The forebay's intake draws water from three main sources: namely Old River downstream (north) of the intake, Middle River via Grant Line Canal, and Old River upstream of the intake. Jones Pumping Plant does not include a forebay but rather diverts water directly from Old River just upstream of the entrance to Clifton Court Forebay. The pumping plants generally divert all of the water coming from the San Joaquin River through Old River and Grant Line Canal, and draw the remainder of the pumping flow from Old and Middle River channels (north of the intakes) conveying Sacramento River water from the central Delta. The pumping plants often cause net reverse flows (southward) in Old River and Middle River. Each pumping plant has an associated fish facility: the Skinner Fish Protective facility for the Banks Pumping Plant and the Tracy Fish Collection Facility for the Jones Pumping Plant. The two fish facilities contain fish louvers (with 1-inch opening that create a behavioral barrier) that protect some fish from entrainment by the pumps. Those fish are collected and trucked to release points elsewhere in the Delta. The south Delta diversion facilities are described in greater detail in Chapter 4, *Covered Activities and Associated Federal Actions*.

Delta Cross Channel. The Delta Cross Channel is an existing gated diversion channel between the Sacramento River near Walnut Grove, and Snodgrass Slough (Figure 1-1). Flows into the Delta Cross Channel from the Sacramento River are controlled by large radial gates. When the gates are open, water flows from the Sacramento River through the cross channel to Snodgrass Slough and from there to channels of the lower Mokelumne River and into the central Delta. Once in the central Delta, the water is conveyed primarily via Old and Middle Rivers to the Clifton Court Forebay, and then to the pumping plants as described above. Use of the Delta Cross Channel minimizes intake of brackish waters through the pumps by conveying fresh Sacramento River water to the forebay via a route that is little affected by tidal and flow-driven sources of saline water. The Delta Cross Channel is described in greater detail in Chapter 4, *Covered Activities and Associated Federal Actions*.

Suisun Marsh Salinity Control Gates. Suisun Marsh is currently managed largely to provide seasonal freshwater wetland habitat, primarily to support waterfowl habitat and recreation. Wetland managers flood their ponds in early October and drain them after the end of the waterfowl season in January. The Suisun Marsh salinity control gates were originally installed and operated as a tidal pump to reduce salinity within the marsh: the one-way gates were opened on the ebb tide to allow freshwater from upstream to enter the slough and closed on the flood tide to prohibit saline water from entering the slough. Operation of the gates is based on tidal stage and triggered by high salinity readings in the marsh. Gate operation results in a net flow of water from east to west. The salinity control structure (the gates and associated flashboards) alters local hydrodynamics and water quality conditions and can impede the migration and passage of various fish species when operated. The gates are operated, on average, 10 days per year, all during the period of early October through May (Burkhard pers. comm.). Coordination will occur with the Suisun Marsh Charter Group over the term of the BDCP to seek amendments to the Suisun Marsh Plan that will provide for reducing the long-term operation of the Suisun Marsh Salinity Control Gates. This action will allow more water to flow past Chipps Island and will improve access of covered fish species to existing and future restored intertidal marsh habitats.

North Delta diversions. The new north Delta diversions will consist of five intakes located along the Sacramento River between Freeport and Courtland (Figures 4-2, 4-3, and 4-4). Each intake will have a capacity of up to 3,000 cubic feet per second (cfs) and will be fitted with fish screens designed to minimize entrainment or impingement risk for all covered fish species. Diverted waters will be conveyed to a new regulating forebay, and then south to SWP/CVP canals, via a pipeline and tunnel system. Construction of the north Delta diversions will allow great flexibility in operation of both south and north Delta diversions, as well as operation of the Delta Cross Channel. Diversions may be balanced to occur primarily in the north or south Delta, with further changes possible by allocating flow through the Delta Cross Channel. It is thus possible to adjust flow volumes and directions to meet locally or temporally important use by covered fish species, for instance by minimizing cross-Delta flows and reverse flows in Old River or by providing “pulse” flows to move larval delta smelt downstream before their yolk sacs are depleted. The north Delta diversions and conveyance system are described in detail in Section 4.1.3, *New Water Facilities Construction, Operations, and Maintenance*.

North Bay Aqueduct intakes. The existing Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct for delivery in Napa and Solano Counties. A new diversion from the Sacramento River, proposed as the North Bay Aqueduct Alternative Intake, would operate in conjunction with the existing North Bay Aqueduct intake at Barker Slough. The new diversion would be periodically operated to divert water of higher quality than is sometimes available from Barker Slough. The capacity of this facility, however, is too small (approximately 240 cfs) to materially affect streamflow. The North Bay Aqueduct intakes and their operation are described in Chapter 4, *Covered Activities and Associated Federal Actions*.

Fremont Weir operable gates. New operable gates on the Fremont Weir will allow for control of the timing, duration, and frequency of inundation of the Yolo Bypass during periods when the Sacramento River would not otherwise spill over the Fremont Weir into the Yolo Bypass. This will allow planned inundation of the bypass at times and for durations that yield optimum value for spawning, migration, and rearing by covered fish species. These benefits will be further increased by associated actions and projects designed to facilitate salmonid and sturgeon passage through the bypass, minimize stranding risks, and enhance habitat. Construction and operation of the Fremont Weir operable gates and associated actions are described in *CM2 Yolo Bypass Fisheries Enhancement*.

3.4.2.4 Problem Statement

Operations of the south Delta SWP/CVP diversion facilities have been identified as primary factors in altering hydrodynamic conditions within Delta channels and associated fishery habitat (California Department of Water Resources 2006; Baxter et al. 2008). These operations contribute to local changes in water current patterns, water quality, and direct entrainment and losses of fish, macroinvertebrates, nutrients, phytoplankton, and zooplankton from the Delta environment (California Department of Water Resources 2006). The principal existing issues associated with flow management in the Delta, which CM1 is designed to address, include the following.

- Reverse flows in the Old and Middle Rivers.
- Entrainment, salvage, and predation effects of south Delta diversions.
- Delta Cross Channel effects on fish migration.
- Salinity, flow, and habitat in Suisun Marsh.
- Flow modification effects in the Sacramento River.
- Effects of reduced Delta outflows.

These issues are described below.

3.4.2.4.1 Reverse Flows in the Old and Middle Rivers

Most or all of the covered fish species (the juvenile and adult lifestages of Chinook salmon, steelhead, delta smelt, longfin smelt, sturgeon, lamprey, and splittail) are expected to use hydrodynamic cues (e.g., channel flow direction and magnitude) to help guide their movement through the Delta. Reverse flows in Delta channels are thought to provide false attraction to migration cues, resulting in longer migration routes that may expose fish to varied sources of mortality such as predation, exposure to seasonally elevated water temperatures, and increased vulnerability to entrainment at the south Delta diversions.

A variety of other impacts have also been attributed to reverse flows in the Old and Middle Rivers. During the winter months, there is a positive relationship between the magnitude of reverse flows within Old and Middle Rivers and the occurrence of pre-spawning adult delta smelt in SWP/CVP fish salvage (Kimmerer 2008; U.S. Fish and Wildlife Service 2009). Also, particle tracking model simulations predict that planktonic early life stages of covered fish species (e.g., larval delta smelt) face a greater risk of vulnerability to entrainment at the SWP/CVP export facilities when reverse flows within Old and Middle Rivers increase.

Reverse flows within the channels of Old and Middle Rivers are also hypothesized to affect local and regional habitat conditions for covered fish and other aquatic species. Changes in channel velocity and flow patterns affect hydraulic residence time in the area and the production of phytoplankton and zooplankton that are important to the diet of covered fish. Channel velocities, scour, and deposition patterns affect habitat for benthic organisms and other macroinvertebrates. Changes in tidal hydrodynamics, especially channel velocity, affect habitat suitability for covered fish and other aquatic species in the area.

Relationships between the magnitude of reverse flows in Old and Middle Rivers and corresponding changes in salvage of various covered fish, such as juvenile Chinook salmon, steelhead, splittail, longfin smelt, lamprey, and sturgeon, are highly variable. Analyses and evaluations are ongoing to further assess the potential biological benefits of managing the SWP/CVP south Delta diversions based on direct diversion rates or changes in the magnitude of reverse flows in Old and Middle Rivers.

Construction and operation of the new north Delta diversions is expected to greatly reduce the incidence of reverse flow and restore a predominantly east-west flow pattern in the San Joaquin River. The resulting benefits are explained in Section 3.4.2.2, *Purpose*.

3.4.2.4.2 Entrainment, Salvage and Predation Effects of South Delta Diversions

For decades, water has been diverted directly from the south Delta through SWP/CVP facilities to meet agricultural and urban water demands south and west of the Delta. These diversions create an artificial north-south flow of water through the Delta (as opposed to the general east-west flow pattern that existed before the diversions) and, as detailed above, have resulted in the development of reverse flows in major Delta channels that result in entrainment of fish, invertebrates, nutrients, and other organic material. Existing diversion facilities are equipped with louvers that guide juvenile and larger fish into salvage facilities. Salvaged fish are subsequently transported to release locations on the lower Sacramento and San Joaquin Rivers, where there are high concentrations of predators (Miranda et al. 2010). Planktonic eggs, larvae, and small juveniles are not effectively salvaged and do not survive when carried into conveyance facilities. Smelt and juvenile salmonids that are drawn into Clifton Court Forebay are subject to high rates of predation from the large populations of predatory fish that are present there as well as other sources of mortality (Gingras 1997; Clark et al. 2009; Castillo et al. 2009).

Construction and operation of the new north Delta diversions is expected to facilitate substantial reductions in entrainment and associated adverse effects associated with operation of the south Delta diversions. The resulting benefits are explained in Section 3.4.2.2, *Purpose*, subsection *Entrainment and Related Losses (Objective L4.4).*

3.4.2.4.3 Delta Cross Channel Effects on Fish Migration

When the Delta Cross Channel is open, fish move into the interior Delta with Sacramento River water (Brandes and McLain 2001). Survival of juvenile Chinook salmon, and likely other fish species, within the interior Delta is lower than survival in the mainstem Sacramento River (Baker and Morhardt 2001; Brandes and McLain 2001; CALFED 2001; Perry and Skalski 2009; Perry et al. 2010), although it is unknown whether this reduced survival has a population-level effect on Chinook salmon (Manly 2002, 2008).

Current seasonal operations of the Delta Cross Channel gates are designed to minimize the migration of juvenile fish from the Sacramento River into the interior Delta through the Delta Cross Channel during the spring. However, adverse effects of an open Delta Cross Channel operation to anadromous fish, and other fish, occur outside of this closure period. Furthermore, open gates decrease velocities and increase bi-directional flows in the Sacramento River and its tributaries, slowing the migration of covered species and increasing their vulnerability to predation or mortality from poor habitat. Therefore, lengthening the closure period or operating on a tidal or daily cycle may improve survival of salmonids and other covered fish species.

Construction and operation of the new north Delta diversions are not expected to entail substantial changes in the frequency and volume of Sacramento River water flows into the Delta Cross Channel; however, those flows place an operational constraint on the magnitude of adaptive limits discussed below, and are subject to future revision via adaptive management.

3.4.2.4.4 Salinity, Flow, and Habitat in Suisun Marsh

The Suisun Marsh salinity control gates alter local current patterns and tidal hydrodynamics within Montezuma Slough, in large regions of Suisun Marsh, and in the main river channel between the control gate and Suisun Bay (California Department of Water Resources 1999). The gates have formerly been identified as an impediment to migration and passage of species such as Chinook salmon, steelhead, and green sturgeon through Montezuma Slough (Fujimura et al. 2000). For example, operation of the control structure during the late fall in dry years can cause a significant upstream shift in X2 location, potentially increasing the risk of entrainment at the SWP/CVP export facilities for smelt and other species that are situated near the X2 location (Fullerton pers. comm.). These changes in environmental conditions are thought to have resulted in adverse effects on covered species and other aquatic resources within the area.

As levees are breached for tidal restoration under *CM4 Tidal Natural Communities Restoration*, salinity levels may increase through much of Suisun Marsh, complicating the feasibility of discontinuing the operation of the salinity control gates, or eliminating the gates. First, rising salinity could negatively affect the managed wetlands of the remaining waterfowl hunting clubs. Secondly, salinity standards at the Suisun Marsh may have to be revised. Assuming that the Suisun Marsh's current salinity standards are maintained, tidal restoration would likely require increased operation of the salinity control gates (Chappell pers. comm.).

It is expected that the Suisun Marsh salinity control gates would continue to be operated much as they currently are. However, that operation would be subject to modification within the adaptive limits set by CM1 (Section 3.4.2. 5, *Implementation*), and via the BDCP adaptive management process (see Section 3.6.2, *Adaptive Management Process*).

3.4.2.4.5 Flow Modification Effects in the Sacramento River

The Sacramento River is the primary migration corridor and spawning/rearing habitat for Chinook salmon, Central Valley steelhead, sturgeon, and lamprey spawning in the Sacramento River watershed. Further, both delta smelt and longfin smelt are thought to spawn in the lower Sacramento River (Wang 1986; Bennett 2005).

The principal BDCP effects on the mainstem Sacramento River in the Plan Area will be associated with the reductions of flow caused by operation of the new north Delta diversions, which will in almost all respects be an adverse effect. That adverse effect will be minimized by maintaining minimum instream flows past the diversions, which are called "bypass flows." The following considerations were included in the development of the Hood bypass flows.

1. Maintain adequate flows for covered fish species. Of particular interest are flow rates within Sutter and Steamboat Sloughs. These sloughs are existing channels that convey water from the Sacramento River in the general vicinity of Courtland downstream to approximately Rio Vista where they re-enter the lower Sacramento River. Both channels currently have a hydraulic

capacity greater than 500 cfs. Benefits to maintaining adequate flows in Sutter and Steamboat Sloughs include the following.

- Providing an alternative migration route for salmonids (Perry and Skalski 2008) and possibly splittail, sturgeon, and lamprey that circumvents the Delta Cross Channel and Georgiana Slough, thereby reducing the likelihood of covered fish species moving into the interior Delta where they may be exposed to higher predation pressure and entrainment into the south Delta pumps.
- Providing high quality juvenile rearing habitat and adult holding habitat for salmonids, sturgeon, and splittail. Both slough channels support substantially more woody riparian vegetation and greater habitat diversity (e.g., water depths, velocities, in-channel habitat) than is present along the mainstem Sacramento River between Courtland and Rio Vista.
- Providing high quality spawning habitat for splittail during dry periods without floodplain inundation.

Despite these anticipated benefits, Perry and Skalski (2009) and Perry et al. (2010) indicate that survival rates of juvenile Chinook salmon in Sutter and Steamboat Sloughs are highly variable relative to the mainstem Sacramento River. They have found that survival has been higher than, lower than, and similar to survival rates in the mainstem Sacramento River rates. Recent hydrodynamic modeling indicates that substantial habitat restoration in the Cache Slough area (Section 3.4.3.2, *Problem Statement*), in combination with bypass flow requirements for the north Delta diversions, will enhance downstream flows in Sutter and Steamboat Sloughs substantially above those present under current conditions without the north Delta diversion facility (Munevar unpubl. data). Further, the BDCP will enhance channel margin habitat in Sutter and Steamboat Sloughs in part to create habitat that is unfavorable to nonnative predators that may be reducing survival of Chinook salmon, and likely other covered species, in these sloughs. Therefore, in combination with these other conservation measures, maintaining bypass flows is expected to improve survival of salmonids, sturgeon, and splittail in Sutter and Steamboat Sloughs.

2. Maintain transport flows necessary for downstream movement of delta and longfin smelt. Newly hatched larval delta and longfin smelt, called yolk-sac larvae, have a yolk sac attached to them with an oil globule (Wang 1986). The yolk sac provides nourishment for delta smelt larvae for approximately 4 to 6 days (Bennett 2005); this is thought to be similar for longfin smelt. These larvae are very weak swimmers and drift downstream with flows from the Sacramento River to the low salinity zone, where they can find suitable prey. To avoid starvation, this downstream movement must take place before the entire yolk sac is absorbed. Because downstream yolk-sac larval movement is driven nearly entirely by downstream flows, a minimum bypass flow criterion that allows this movement to occur is necessary.
3. Maintain downstream transport of food and organic material. The Sacramento River is used as a major corridor through which food and other organic material from upstream are transported downstream to the Delta and bays. The Delta and bays acquire production from upstream habitats to support their ecosystems.
4. Maintain necessary attraction flows for upstream migration of adult Chinook salmon, steelhead, and sturgeon, including attraction flows through Sutter and Steamboat Sloughs.

5. Minimize tidally driven bidirectional flows near diversion intakes, reducing the exposure duration of covered fish species to predators that will likely reside near intake structures. Unidirectional flows past intakes may also affect local current patterns and hydrodynamics in the vicinity of the screen surface that may affect fish entrainment or impingement, debris loading, effectiveness of fish screen cleaning mechanisms in removing debris from the screen surface, and maintaining a uniform approach velocity within the screen design criterion.

3.4.2.4.6 Delta Outflow Effects

Fishery monitoring studies conducted by California Department of Fish and Game (DFG) (Baxter et al. 1999) suggest that abundances of juvenile life stages of many fish (e.g., starry flounder, splittail, longfin smelt, and striped bass) and macroinvertebrates are correlated with the location of the low salinity zone during the late winter and spring (e.g., February through June [Kimmerer 2004]). For example, longfin smelt juvenile abundance indices increased as the location of X2 moved further downstream (west) within Suisun Bay (Kimmerer 2004). Recent analyses have suggested that previous correlations between X2 location and fish abundance indices have changed, with overall abundance declining (Kimmerer 2004). The changes observed in these relationships have been hypothesized to be the result of the introduction and rapid colonization of Suisun Bay by the filter feeding Asian overbite clam (*Corbula*) and a subsequent reduction in phytoplankton and zooplankton as food supplies for juveniles within Suisun Bay (Kimmerer 2004). Another change in this relationship has occurred since 2001 in conjunction with the pelagic organism decline, although the cause of this change is currently unknown (Baxter et al. 2008).

Factors that may contribute to the relationship between Delta outflow (including X2) and juvenile fish abundance are heavily debated, but may include increased productivity and availability of high quality habitat within Suisun Bay; downstream transport of fish, food, and organic matter; reduced temperature and/or toxics exposure with lower salinity; changes in nutrient composition; inundation of backwater and floodplains with high flows; and the distribution of early life stages of fish into habitats that are located further downstream with decreased vulnerability to direct and indirect effects of south Delta SWP/CVP export operations.

Proposed changes to water operations under CM1 are expected to provide flexibility in managing outflow to benefit covered fish species. Adverse biological effects associated with low or reduced outflows also constitute a limiting factor in setting the adaptive limits, as described below.

3.4.2.5 Implementation

During the initial years of BDCP implementation, flow management will be performed consistent with the current BiOps as amended under court order and any other regulatory or legal constraints that may be imposed in the future. Implementation of flow management under CM1 will be initiated when the new north Delta diversions become operational, thereby enabling joint management of the north and south Delta diversions. This is estimated to occur beginning in year 10 of Plan implementation. This section describes how CM1 would be implemented. Implementation would be administered by the Implementation Office in the manner described in Chapter 7, *Implementation Structure*. Adaptive management and monitoring actions, which are critically important to all conservation measures but especially to CM1, would be implemented as described in Section 3.6, *Adaptive Management and Monitoring Program*, with additional provisions identified below. CM1 implementation is discussed in the following two sections.

- Section 3.4.2.5.1, *Adaptive Limits to Flow Operations*, describes the concept of adaptive limits and how it would be used to determine the location, timing, and volume of water diversions, and thereby to achieve the principal beneficial outcomes of CM1. It also names the limiting flow parameters, assigns values to their limits, and describes the rationale for the selected limits.
- Section 3.4.2.5.2, *Facility Maintenance Actions*, identifies actions needed for facility maintenance.

3.4.2.5.1 Adaptive Limits to Flow Operations

*[**Note to Reviewers:** Although the adaptive limits to flow operations are still in development, certain aspects of the adaptive limits process are known and are summarized here.*

- *The adaptive limits will serve as a kind of contingency or insurance fund, which will allow for adjustments in the operational requirements to respond to uncertainties regarding the efficacy of the BDCP conservation measures.*
- *The adaptive operational limits will be based on consideration of a range in key operating parameters.*
- *The approach is not to specifically identify adaptive limits for each operational parameter, but to identify a block of water that provides significant operational flexibility to respond to biological uncertainty.*
- *Currently, DWR is engaged in a process of evaluating potential adaptive limit endpoints based on this approach. When this effort is complete, CM1 will be reissued with a description of the approach, the range for the limits, the circumstances in which the adaptive management program for water options could be triggered, and adaptive changes to CM1 considered and implemented.]*

3.4.2.5.2 Facility Maintenance Actions

Facility maintenance actions serve to maintain the conservation benefits provided by use of flow management facilities, and thus have conservation value. Facility maintenance actions include periodic cleaning of the diversion screens and episodic in-water work to remove accumulated sediment and debris, which is typically an issue in the aftermath of a high-flow event such as a flood. These actions are further described in Chapter 4, *Covered Activities and Associated Federal Actions*.

3.4.3 Conservation Measure 2 Yolo Bypass Fisheries Enhancement

*[**Note to Reviewers:** One feature of the prior draft CM2 was explicit reference to a Westside Concept. Under Conservation Measure Phasing, page 12, projects identified as (site 12), (site 13), and (site 14) represent adopted goals of the Westside Concept that have been incorporated into this conservation measure, which represents a hybrid of prior proposals]*

Under *CM2 Yolo Bypass Fisheries Enhancement*, the Implementation Office will modify the Yolo Bypass to increase the frequency, duration, and magnitude of floodplain inundation. These actions will improve passage and habitat conditions for splittail, Chinook salmon, sturgeon, lamprey, and possibly steelhead. The modifications, which will include fish passage improvements and flow management facilities, will be implemented in four phases starting with Plan implementation and continuing to approximately 2063. The actions will also provide additional nutrients and water surface area to increase biological productivity, thereby increasing food resources for fish and other aquatic species. This increased productivity and nutrient loading will also benefit other areas, as it is transported downstream.

3.4.3.1 Purpose

The primary purpose of CM2 is to meet or contribute to biological goals and objectives as identified in Table 3.4-2. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementing Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-2. Biological Goals and Objectives Addressed by CM2 Yolo Bypass Fisheries Enhancement

Biological Goal or Objective	How CM2 Advances a Biological Objective
Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.	
Objective L1.3: Restore or create at least 72,809 acres of natural communities, including at least 65,000 acres of tidally influenced natural communities.	Increasing the frequency, magnitude, and duration of inundation in the Yolo Bypass floodplain will enhance primary productivity and the extent of suitable and viable spawning and rearing habitat within the Plan Area. .
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.6: Maintain or increase life-history diversity of native fish species and a diversity of spawning and rearing conditions for native fish species over time.	Increasing frequency of inundation will enhance existing connectivity between the Sacramentoa River and a range of suitable spawning and rearing habitat conditions in inundated areas, thereby increasing habitat diversity and primary productivity.
Objective L2.10: Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways.	Seasonal inundation of floodplain habitat will increase the input of nutrients and terrestrial biota as well as increase aquatic primary and secondary productivity, contributing to an increase in aquatic productivity and food resources for covered fish species.
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objectives L4.3: Manage the distribution of covered fish species to minimize movements into high predation risk areas of the Delta.	Providing flows to attract or direct covered fish species to floodplain habitat less likely to be occupied by nonnative predatory fish will reduce mortality. Providing shallow water with increased productivity will contribute to an increase in growth rates.
Goal GRST2 (Stranding): Improved connectivity that facilitates timely passage and reduces stranding of adult green sturgeon.	
Objective GRST2.1 (Stranding): Reduce stranding of adult green sturgeon at Fremont Weir by 75% over baseline conditions within 15 years of BDCP implementation.	Modifying the Fremont Weir will reduce stranding and passage delays.

Biological Goal or Objective	How CM2 Advances a Biological Objective
Goal WTST2 (Life-History Diversity and Spatial Distribution): Improved habitat connectivity that facilitates timely passage and reduced stranding of adult white sturgeon.	
Objective WTST2.1 (Passage and Stranding): Reduce stranding of adult white sturgeon at Fremont Weir by 75% over baseline conditions within 15 years of BDCP implementation.	CM2 will directly address fish passage delays and stranding at the Fremont Weir.
Goal SAST1 (Spawning and Rearing Habitat): Improved habitat and restored linkages to enhance survival, reproduction, and distribution of Sacramento splittail in the Plan Area.	
Objective SAST1.1 (Spawning and Rearing Habitat): Maintain 5-year running average of splittail index of abundance in the Plan Area of 150% of baseline conditions by providing access to suitable spawning and rearing habitat in the Plan Area within 15 years of BDCP implementation.	Sacramento splittail typically spawn in inundated floodplain and riparian areas within submerged terrestrial vegetation (Moyle 2002). CM2 will directly contribute to providing suitable splittail spawning habitat with suitable inundation frequency, duration, water depths, and submerged vegetation and a range of habitat complexity.
Goal WRCS1 (Abundance and Life-History Diversity): Improved survival (to contribute to increased abundance) of immigrating and emigrating winter-run salmon through the Plan Area.	
Objective WRCS1.1 (Juvenile Survival): Achieve a through-Delta survival rate of juveniles of at least 30% measured as a 4-year running average within 15 years of BDCP implementation.	CM2 will provide suitable rearing habitat and is anticipated to contribute to an increase in the growth of those juvenile witner-run Chinook salmon that occupy the habitat, thereby contributing to an increase in survival, as larger fish generally perform better.
Objective WRCS1.2 (Adult Passage): Limit passage delays in the Yolo Bypass and other anthropogenic barriers and impediments to no more than 36 hours, within 15 years of BDCP implementation.	CM2 will directly address fish passage delays at the Fremont Weir.
Goal SRCS2 (Abundance): Reduce passage delays (to contribute to increased migration and spawning success, and thus abundance) at anthropogenic impediments of adult spring-run migrating through the Delta.	
Objective SRCS2.1 (Migration): Reduce adult passage delays at anthropogenic barriers and impediments that cause median passage times of greater than 36 hours, within 15 years of BDCP implementation.	CM2 will directly address fish passage delays at the Fremont Weir.
Goal SRCS3 (Life-History Diversity and Spatial Distribution): Improved availability of floodplain and channel margin habitat to support spring-run migration and rearing through the Delta.	
Objective SRCS3.1 (Habitat): Increase availability of floodplain habitat by 1,000 acres within 15 years of BDCP implementation, and channel margin habitat by 5 miles within 10 years of BDCP implementation, for spring-run migration and rearing compared to baseline conditions.	CM2 will directly increase the availability of floodplain habitat available to spring-run Chinook salmon.
Goal FRCS2 (Abundance): Reduce passage delays (to contribute to increased migration and spawning success and thus abundance) at anthropogenic impediments of adult fall-run migrating through the Delta.	
Objective FRCS2.1 (Migration): Reduce passage delays at anthropogenic barriers and impediments that cause median passage times of more than 36 hours, within 3 years of BDCP implementation.	CM2 will directly address fish passage delays at the Fremont Weir.

Biological Goal or Objective	How CM2 Advances a Biological Objective
Goal FRCS3 (Life-History Diversity and Spatial Distribution): Improved availability of floodplain and channel margin habitat to support fall-run migration and rearing through the Delta.	
Objective FRCS3.1 (Life-History Diversity and Spatial Distribution): Increase availability of floodplain habitat by 1,000 acres within 15 years of BDCP implementation, and channel margin habitat by 5 miles within 10 years of BDCP implementation, for fall-run migration and rearing compared to baseline conditions.	CM2 will directly increase the availability of floodplain habitat available to spring-run Chinook salmon.

The objective of CM2 is to reduce migratory delays and loss of adult salmon, steelhead, and sturgeon at Fremont Weir and other structures; enhance rearing habitat for Sacramento River Basin salmonids; enhance spawning and rearing habitat for splittail; and improve food sources for delta smelt and other fish species downstream of the bypass. To achieve this, CM2 will modift the Yolo Bypassto increase the frequency, duration, and magnitude of floodplain inundation and to improve fish passage.

Increased frequency of inundation will enhance the existing connectivity between the Sacramento River and floodplain habitat and can result in the increased production of prey, such as zooplankton and dipteran larvae, mobilization of organic material, increased primary production, and increased areas with conditions that are suitable for spawning, egg incubation, and larval stages for fish species such as splittail (if inundation is greater than 30 days). Seasonal flooding in the bypass will occur when it will be most effective at supporting native fish species (i.e., when it is in synchrony with the seasonal timing of naturally occurring hydrologic and seasonal events in the watershed).

Increased magnitude of inundation has the potential to increase primary and secondary aquatic productivity. Flooding increases the volume of water in the photic zone area, allowing increases in biomass of phytoplankton. Increased biomass leads to an increase in the abundance of zooplankton and planktivorous fish. This increase in primary and secondary productivity in the foodweb is realized within the immediate Yolo Bypass area, but because phytoplankton and zooplankton are transported by flow, is also exported downstream.

Increased duration of inundation is expected to increase production of zooplankton and dipteran larvae, mobilization of organic material, and increased primary production. Inundation lasting more than approximately 30 days between March 1 and May 15 is expected to benefit splittail spawning and juvenile production. Short-duration inundation (less than 30 days) is expected to result in only small benefits to juvenile salmon growth when compared to opportunities that extend longer than 30 days (BDCP Integration Team 2009).

Modifications to topography and weirs are expected to improve fish passage and reduce the risk of migration delays and stranding of adult fish. Stranding and predation by birds and fish have also been identified as sources of mortality for juvenile rearing salmon within the floodplain habitat (Sommer et al. 2001b, 2005; BDCP Integration Team 2009). Illegal harvest of covered fish species is also a potential source of mortality that could be exacerbated by existing migration delays, low flows, and stranding caused by shorter inundation periods.

Specifically, this conservation measure will convey the following benefits.

- Provide access to additional spawning habitat for splittail (Sommer et al. 2001a, 2002, 2007, 2008; Moyle 2002; Moyle et al. 2004; Feyrer et al. 2006). Because splittail are primarily floodplain spawners, successful spawning is predicted to increase with increased floodplain inundation.
- Provide additional juvenile rearing habitat for Chinook salmon, splittail, and possibly steelhead (Sommer et al. 2001a, 2001b, 2002, 2007, 2008; Moyle 2002; Moyle et al. 2004; Feyrer et al. 2006). Growth and survival of larval and juvenile fish can be higher in the floodplain compared to those rearing in the mainstem Sacramento River (Sommer et al. 2001b).
- Improve downstream juvenile passage conditions for Chinook salmon, splittail, river lamprey, and possibly steelhead and Pacific lamprey. An inundated Yolo Bypass is used as an alternative to the mainstem Sacramento River for downstream migration of salmonids, splittail, river lamprey, and sturgeon; rearing conditions and protection from predators are believed to be better in this area. Sommer et al. (2003, 2004) found that, other than steelhead and Pacific lamprey, juveniles from all of these species inhabit the Yolo Bypass during periods of inundation. However, the expected increased habitat and productivity resulting from increased inundation of Yolo Bypass are likely to provide some benefits to other covered species, including steelhead and lamprey.
- Improve adult upstream passage conditions of migrating fish using the bypass, such as fall-, late fall-, winter-, and spring-run Chinook salmon; steelhead; sturgeon; and lamprey. An inundated Yolo Bypass is used as an alternative route by upstream migrating adults of these species when Fremont Weir is spilling. Increasing the frequency and duration of inundations will provide these improved conditions for more covered species over longer portions of their migrations. However, the increased use of the bypass could put more fish at risk, if stranding conditions occur when flows are reduced. The overall benefits of providing additional flow in the bypass will be assessed through adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*).
- Increase food production for rearing salmonids, splittail, and other covered species on the floodplain (Sommer et al. 2001a, 2001b, 2002, 2004, 2007, 2008; Moyle 2002; Moyle et al. 2004; Feyrer et al. 2006). During periods when the bypass is flooded, a relatively high production of zooplankton and macroinvertebrates serves, in part, as the forage base for many of the covered fish species (Benigno and Sommer 2008; Moyle et al. 2004).
- Increase the availability and production of food in the Delta, Suisun Marsh, and bays downstream of the bypass, including restored habitat in Cache Slough, for delta smelt, longfin smelt, and other covered species, by exporting organic material and phytoplankton, zooplankton, and other organisms produced from the inundated floodplain into the Delta (Schemel et al. 1996; Jassby and Cloern 2000; Mitsch and Gosselink 2000; Moss 2007; Lehman et al. 2008).
- Increase the duration of floodplain inundation and the amount of associated rearing and migration habitat during periods that the Yolo Bypass is receiving water from both the Fremont Weir and the westside tributaries (e.g., Cache and Putah Creeks).
- Reduce losses of adult Chinook salmon, sturgeon, and other fish species to stranding and illegal harvest by improving upstream passage at the Fremont Weir (*CM17 Illegal Harvest Reduction*).

- Reduce the exposure and risk of juvenile fish migrating from the Sacramento River into the interior Delta through the Delta Cross Channel and Georgiana Slough, by decreasing the number of fish passing through these areas (Brandes and McLain 2001).
- Reduce the exposure of outmigrating juvenile fish to entrainment or other adverse effects associated with the proposed north Delta intakes and the proposed Barker Slough Pumping Plant facilities by passing juvenile fish into the Yolo Bypass upstream of the proposed intakes.
- Improve fish passage, and possibly increase and improve seasonal floodplain habitat availability, by retrofitting Los Rios Check Dam with a fish ladder, or creating another, fish-passable route for water from Putah Creek to reach the Toe Drain.

Increasing the frequency, magnitude, and duration of inundation in the Yolo Bypass floodplain is the largest opportunity for enhancing seasonally inundated floodplain habitat in the Central Valley. The Yolo Bypass floodplain is the only floodplain in the Plan Area that can be managed for habitat and species benefits without the restoration of historic floodplains that have been developed for year-round land uses.

3.4.3.2 Problem Statement

For descriptions of the ecological implications and current condition of the Yolo Bypass fisheries, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* also describes the need for fishery enhancements as a component of the conservation strategies for aquatic communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM2.

3.4.3.2.1 Flow Management in the Yolo Bypass

The Yolo Bypass is the largest contiguous floodplain on the lower Sacramento River. The bypass is a central feature of the Sacramento River Flood Control Project, which conveys floodwaters from the Sacramento and Feather Rivers and their tributary watersheds. Unlike conventional flood control systems that frequently isolate rivers and ecologically essential floodplain habitat, the Yolo Bypass has been engineered to allow Sacramento Valley floodwaters to inundate a broad floodplain.

The primary input to the Yolo Bypass is through the Fremont Weir[1]. Flow pulses in the Sacramento River are first diverted into Sutter Bypass, an 18,000-acre agricultural floodplain with many similarities to the Yolo Bypass; the Sacramento River immediately upstream of Fremont Weir has a relatively low channel capacity (28,250 cfs), so Sutter Bypass flooding is often initiated in modest flow pulses (Sommer et al. 2001b). When the combined flow of Sutter Bypass and the Sacramento and Feather Rivers raises water levels at Fremont Weir to an elevation of 32.8 feet National Geodetic Vertical Datum of 1929 (NGVD), which typically occurs when combined total flow from these sources surpasses 55,000 cfs (Sommer et al. 2001b), flows begin to enter Yolo Bypass. This occurs in

[1] The Fremont Weir, located between river miles 81.7 and 83.4, is a fixed concrete weir constructed by USACE. It is 9,120 feet in length with an earthfill section dividing it into two parts. The crest of the concrete weir section is at elevation 33.5 feet (no vertical datum given), and the crown of the earthfill section is at an elevation of 47.0 feet (no vertical datum given) (U.S. Army Corps of Engineers 1955).

approximately 70% of water years. Complete inundation of the Yolo Bypass floodplain, which is 59,000 acres (92 square miles) approximately doubles the wetted area of the Delta.

Floodwaters entering over Fremont Weir initially flow through scour channels to the Tule Pond, then into the Tule Canal, a perennial channel north of the Sacramento Weir, and the Toe Drain, a perennial channel south of the Sacramento Weir on the eastern edge of the bypass, and then spill onto the floodplain when discharge in the Toe Drain exceeds the channel capacity, at approximately 2,000 to 3000 cfs. The floodplain is considered inundated when the stage of the Toe Drain at Lisbon Weir exceeds just over 8 feet NGVD. In major storm events, additional water enters from the east via Sacramento Weir, adding flow from the American and Sacramento Rivers (Sommer et al. 2001b). Flow also enters the Yolo Bypass from several small west-side streams: Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, and Putah Creek. These tributaries can substantially augment the Sacramento River Basin floodwaters or cause localized floodplain inundation before Fremont Weir spills occur (Sommer et al. 2001b).

Management of the Fremont Weir is considered passive, because the weir is the primary release facility and was designed to overtop at a specific stage and allow inundation of the Yolo Bypass floodplain. No facilities to adjust the flow entering the Yolo Bypass are associated with the Fremont Weir. The Sacramento Weir is a needle dam, the top portion of which is manually operated to selectively change the flow split between the Sacramento River mainstem and the Yolo Bypass.

3.4.3.2.2 Floodplain Habitat

Yolo Bypass is important in terms of agricultural production, wildlife and aquatic habitat, recreation (e.g., waterfowl hunting and bird or wildlife viewing), and educational opportunities. Seasonal inundation of the Yolo Bypass limits the types of crops that can be grown. Orchards and winter crops are not viable, nor are long-term ventures such as alfalfa. Agricultural crops that benefit wildlife include rice (both wild and conventional), tomatoes, corn, millet, wheat, milo, and safflower. Cattle grazing occurs on approximately 8,000 acres of the bypass (California Department of Fish and Game 2008).

Yolo Bypass provides aquatic habitat for 42 fish species, 15 of which are native (Sommer et al. 2001a). The bypass seasonally supports several covered species, including delta smelt (typically found lower in the bypass in the in the Cache Slough area), splittail, steelhead, and spring-run and winter-run Chinook salmon. Typical winter and spring spawning and rearing periods for native Delta fish coincide with the timing of the flood pulse (Sommer et al. 2001b). The majority of the floodplain habitat is seasonally dewatered and is less likely to be dominated by nonnative fish species except in perennial waters. The Yolo Bypass is unique in the Delta in its large size and resistance to nonnative aquatic predators and competitors.

Sommer et al. (2003) noted that floodplain inundation during high-flow years may favor several aquatic species in the estuary. The Yolo Bypass is an important nursery for young fish, and may help to support the foodweb of the San Francisco Estuary. Adult fish use the Yolo Bypass as a migration corridor (i.e., Chinook salmon and sturgeon) and for spawning (i.e., splittail) (Harrell and Sommer 2003).

Physical structures in the bypass such as the Fremont Weir have been identified as impediments and potential barriers to successful upstream passage. Two passage issues exist.

- Passage impediments caused by existing structures when Sacramento River water is flowing over the Fremont Weir into the Yolo Bypass.
- Flow attraction caused by tributary flows and the Cache Slough Complex tidal exchange when no water is flowing over the Fremont Weir and upstream passage is not possible.

3.4.3.2.3 Sacramento Splittail

Sacramento splittail migrate upstream and spawn in seasonally inundated floodplain margin habitat associated with flooded vegetation (Sommer et al. 2001a; Moyle 2002; Moyle et al. 2004). Splittail typically spawn in late winter to spring, depositing adhesive eggs on submerged vegetation and other substrates. After hatching, the larval and early juvenile splittail forage and rear along the inundated floodplain prior to moving downstream into the estuary as waters recede.

Adult splittail spawn in the Plan Area on inundated floodplains of the Yolo Bypass and Sutter Bypass and along the Cosumnes River (Sommer et al. 1997, 2001a, 2002; Crain et al. 2004; Moyle et al. 2004). Limited collections of ripe adults and early stage larvae indicate splittail spawn in shallow water (less than 2 meters deep) over flooded vegetated habitat (cockle burr, other annual terrestrial vegetation, and perennial vegetation like willow) with a detectable water flow (Moyle et al. 2004). Floodplain inundation activates dormant larvae of an aquatic fly (chironomid) that oversummer in floodplain sediment, and that as late stage larva or pupa, is an important food of late stage larval splittail (Kurth and Nobriga 2001). Relatively warm temperatures and an abundance of food allow young splittail to grow and develop rapidly on floodplains, so that they are physically prepared to leave floodplains when water levels recede. Increasing water temperatures and declining water levels may cue floodplain emigration of juvenile splittail.

3.4.3.2.4 Chinook Salmon

Juvenile Chinook salmon can rear in the Yolo Bypass (Sommer et al. 2001a; Moyle 2002; Harrell and Sommer 2003; BDCP Integration Team 2009). Sommer et al. (2001a) noted several benefits for juvenile Chinook salmon that rear in Yolo Bypass as opposed to the mainstem Sacramento River, including the availability of low-velocity habitats, increased food resources, and warmer water temperatures, all of which can result in increased growth rates by reducing energy expenditures, increasing energy inputs, and increasing metabolic rates, respectively.

Results of coded wire tag studies and beach seine and rotary screw trap sampling within the Yolo Bypass showed that, on average, residence time for juvenile salmon in the inundated bypass was approximately 30 days, although substantially shorter (4 days) and longer residence times (greater than 50 days) were also observed. These results suggest that, although a few days of inundation may be sufficient to trigger incubation and emergence of dipteran larvae and stimulate primary production, longer periods of inundation (3 weeks or more) may be required to provide sufficient time for fish such as juvenile Chinook salmon to take advantage of increased prey availability, thereby achieving improved growth rates and size when compared to those continuing to rear in the Sacramento River and the Delta (BDCP Integration Team 2009). It is also possible that these benefits vary among Chinook salmon populations; studies to date have not distinguished between winter-run, spring-run, and fall-run juvenile Chinook salmon rearing in the bypass. However, the timing of bypass inundation, which primarily floods in January and occasionally in December but rarely in November, does correlate well with juvenile fall-run and, to a lesser extent, winter-run Chinook salmon densities in the adjacent reach of the Sacramento River, which are generally greatest between January and April, and November and January, respectively. Their peak emigration rates are closely tied to peaks in Sacramento River flow, which can occur from January 1 until April 15 (BDCP Integration Team 2009; Del Rosario et al. in review).

3.4.3.2.5 Sturgeon

Adult white sturgeon have been observed using the Yolo Bypass as an upstream migration corridor (BDCP Integration Team 2009; Harrell and Sommer 2003), and green sturgeon have been rescued from the Yolo Bypass at the Fremont Weir. Thus, it appears that both use the bypass as a migration route (Sacramento Bee 2011).

Passage issues delay migration and increase the risk of adult mortality. Observations at the Fremont Weir have shown that adult fish are vulnerable to increased legal and illegal harvest when they accumulate in the concrete apron of the weir and in the area immediately downstream of the weir. Efforts are currently underway to identify the design and operation of improved fish passage facilities that would reduce delays and the mortality risk associated with these delays. The design and operations of fish passage facilities will be an integral component of modifications to the Fremont Weir. The levels of mortality or sublethal effects on various species of adult fish (including sturgeon) within the bypass and the relationships between the frequency, magnitude, seasonal timing, or duration of inundation of the floodplain have been identified as a serious problem, but the magnitude of potential adverse effects on adult fish have not been quantified.

3.4.3.2.6 Other Covered Fish Species

Juvenile delta and longfin smelt and sturgeon, while not likely to use the Yolo Bypass as rearing habitat, could benefit directly or indirectly from increased aquatic production exported downstream from the bypass to the Delta and bays. The co-occurrence of suitable food supplies (zooplankton) and various life stages of delta smelt is an important factor affecting delta smelt survival and abundance (Feyrer et al. 2007; Miller 2007). Increased frequency, duration, and area of Yolo Bypass inundation is anticipated to increase aquatic production in the Yolo Bypass or food resources available to fish. Export of these food resources from the bypass to areas downstream is expected to benefit delta and longfin smelt and sturgeon. Although both smelt species also seasonally occur in Yolo Bypass (Sommer et al. 2004), they are unlikely to substantially use habitat beyond the floodplain's perennial channel (e.g., seasonal habitat).

The extent to which juvenile steelhead rear in the Yolo Bypass is unknown, but steelhead smolts may use the bypass to a limited extent. The extent to which steelhead use the Yolo Bypass as a migration corridor and how that affects their migration is unknown, but it is assumed that steelhead do migrate through the Yolo Bypass.

Lamprey may also enter the Yolo Bypass, but the extent is unknown.

3.4.3.2.7 Covered Terrestrial Species

Giant garter snakes in the Yolo Bypass are part of the Yolo Basin/Willow Slough subpopulation addressed in the recovery plan for this species (U.S. Fish and Wildlife Service 1999). This population centers on the western Yolo Bypass levee with the majority of reported occurrences west of the bypass, or along the western side of the interior of the bypass. Possible reasons for the lack of giant garter snakes on the eastern side of the bypass include more frequent and longer duration inundation events due to lower elevations on the east side, and the potential for predation along the Toe Drain.

Giant garter snakes forage and find cover in rice fields, wetlands, and adjacent uplands during their active season (early spring through mid fall) and remain in underground burrows during their hibernation period (mid fall through early spring). Giant garter snakes that have been observed in the Yolo Bypass during their active season could lie dormant in burrows in the bypass during the inactive season; however, the existing flood regime probably either precludes use of the bypass during their inactive period or displaces snakes during flood events.

There is also modeled habitat for Swainson's hawk, sandhill crane, and other covered terrestrial species that would be affected by periodic inundation in the Yolo Bypass. Any take that may result from the change in inundation frequency and extent is not expected to adversely affect the long-term survival or recovery of any covered species, as described in Section 5.3.5, *Integrating Results*.

3.4.3.3 Implementation

3.4.3.3.1 Required Actions

Yolo Bypass fisheries enhancement will be achieved with site-specific projects to construct fish passage improvements and facilities to introduce and manage additional flows for seasonal floodplain habitat. Prior to construction for each project, the preparatory actions will include interagency coordination, feasibility evaluations, site or easement acquisition, modifications to agricultural practices, development of site-specific plans, and environmental compliance. This will include coordination with federal agencies to comply with the existing BiOp.

This conservation measure is evaluated in Appendix 5.D, *Toxics*; Appendix 5.E, *Habitat Restoration*; Appendix 5.F, *Ecological Effects*; and Appendix 5.H, *Construction Effects on Covered Fish*. This information supports Chapter 5, *Effects Analysis*; the effects analysis is necessary to provide incidental take coverage under the BDCP.

3.4.3.3.2 Yolo Bypass Fisheries Enhancement Plan

All of the proposed actions will be evaluated in the forthcoming Yolo Bypass Fisheries Enhancement Plan (YBFEP). The YBFEP will propose a sustainable balance between important uses of the Yolo Bypass such as flood protection, agriculture, endangered terrestrial species habitat, fisheries habitat, the Yolo Natural Heritage Program, and managed wetlands habitat as described in existing state and federal land management plans associated with the Yolo Bypass Wildlife Area and existing conservation easements on private land.

The YBFEP will, with stakeholder and scientist input, further refine CM2 into one or more component projects for which project-specific environmental compliance documentation will be completed. During development of the YBFEP, which will be completed within the first 5 years of Plan implementation, the merits of these alternatives will be evaluated. If the actions are expected to achieve the biological goals of CM2—improve upstream and downstream fish passage, reduce straying and stranding of native fish, increase the availability of floodplain rearing and spawning habitat for covered fish species, and stimulate the foodweb by boosting aquatic productivity—the actions will be further developed and implemented. If the YBFEP evaluation does not support implementation of one or more of the actions, the action will not be implemented. Reasons that implementation may not be supported by the YBFEP include, but are not limited to, that the action will not be effective, is not needed because of the effectiveness of other actions, or will have unacceptable effects on flood control.

Specifically, the YBFEP will address the following elements.

- Evaluate alternative actions to improve passage and reduce stranding, including, but not limited to, physical modifications to the Fremont Weir and Yolo Bypass to manage the timing, frequency, and duration of inundation of the Yolo Bypass (Figure 3.4-1) with gravity flow from the Sacramento River, and to improve upstream fish passage past barriers including Fremont and Lisbon Weirs.
- Identify actions that will be implemented, based on the alternatives evaluation.
- Describe the applicable BDCP biological objectives, performance goals, and monitoring metrics.
- Demonstrate plan compatibility with the flood control functions of the Yolo Bypass as well as habitat management, agricultural uses, and waterfowl hunting.
- Identify specific funding sources from the BDCP funding commitments.
- Discuss regulatory and legal constraints and how the constraints will be addressed.
- Provide an implementation schedule with milestones for key actions.

The BDCP Authorized Entities will consult with the U.S. Army Corps of Engineers (USACE), DFG, National Marine Fisheries Service (NMFS), and USFWS to develop the YBFEP and will also coordinate with Yolo and Solano Counties, affected reclamation districts, other flood control entities, and the Yolo Bypass Working Group. The BDCP Authorized Entities will develop a public outreach strategy before the YBFEP process starts, which will establish a timeline and identify opportunities for stakeholder involvement, including a process by which stakeholder comments will be addressed in—or rejected from—the YBFEP. During implementation of CM2, the BDCP Authorized Entities will coordinate with the USACE, the California Department of Water Resources (DWR), reclamation districts, and other flood control entities, as appropriate, to ensure that fish passage improvements, bypass improvements, and Fremont Weir improvements and operations are constructed in accordance with the YBFEP and are compatible with the flood control functions of the Yolo Bypass.

3.4.3.3.3 Timing and Phasing

*[**Note to Reviewers:** The information below identifies the component projects and studies to be implemented in the near-term, early long-term and late long-term. The component projects and time frame presented below are still in development. The information will be updated when the final component projects and time frames for each are determined.]*

CM2 actions are proposed for implementation in four phases:

- Phase 1: first 5 years of BDCP implementation (corresponds with near-term [NT])
- Phase 2: second 5 years of BDCP implementation (corresponds with NT)
- Phase 3: 2022 to 2026 (corresponds with early long-term [ELT])
- Phase 4: 2027 to 2063 (corresponds with the late long-term [LLT])

These conservation actions will be defined and more fully evaluated in the YBFEP.

Phases 1 and 2: First 10 years of BDCP Implementation (Near-Term)

The following projects will likely be implemented, based on YBFEP evaluation, in the first 10 years of Plan implementation. Site numbers in parentheses correspond with locations on Figure 3.4-1.

- Acceleration of fish rescue and improvements to fish stranding assessments (site 1) (Phase 1).
- Additional hydrologic, water quality, vegetation, sediment, and ecological monitoring stations and studies (site 2) (Phase 1). See detail in Section 3.6, *Adaptive Management and Monitoring Program*.
- Floodplain fish rearing pilot project at Knaggs Ranch, not to exceed 100 acres. This project will incorporate the goal of the Westside Concept[2] (site 3) (Phase 1 or before).
- Fish ladder operations at Fremont Weir. Experiment with different approaches to operating the existing ladder (e.g., removing wooden baffles and monitoring fish passage) (site 4) (Phase 1 or before).
- Experimental sturgeon ramps. Construct and study up to four experimental ramps at the Fremont Weir to test whether they can provide effective passage for adult sturgeon and lamprey from the Yolo Bypass over the Fremont Weir to the Sacramento River when the river overtops the weir by approximately 3 feet (Figure 3.4-2). Feasibility and specific design criteria for the ramps have not yet been determined. Monitoring technologies will be used to collect information on fish passage to evaluate its efficacy at passing adult fishes (site 5) (Phase 1).
- Auxiliary fish ladders at Fremont Weir. Construct up to three sets, each with up to three fish ladders. At least one set will serve the western length of Fremont Weir. Because the Fremont Weir is nearly 2 miles long and is constructed in two distinct lengths, these auxiliary fish ladders will help fish pass the weir regardless of the location they approach it from. Figure 3.4-3 shows a concept for a facility to prevent fish stranding in the western length of Fremont Weir. At least one of the fish ladders will replace, and possibly increase the width of, the existing Fremont Weir fish ladder. Figure 3.4-4 shows a concept for substantially improving the existing fish ladder. At least one multistage, multispecies fishway will be placed adjacent to the main gated seasonal floodplain inundation channel (in its ultimate location) to provide passage when velocities or partially opened gates would otherwise be impassable or provide poor fish passage. Figure 3.4-5 shows a concept for providing multistage, multispecies fish passage. Fish ladder placement will result in positive drainage from the stilling basin, with very little, if any, additional work on the stilling basin (site 6)(Phase 1).
- Fish screens for small Yolo Bypass diversions. If YBFEP determines screening small Yolo Bypass diversions to be an appropriate means to hold existing irrigation practices harmless, construct fish screens on small Yolo Bypass diversions (site 7) (Phase 1).
- New or replacement Tule Canal and Toe Drain impoundment structures and agricultural crossings. Replace agricultural crossings of the Tule Canal and Toe Drain with fish-passable

[2] The term “Westside Concept” has been used to describe a range of ideas for how to: bring water into the Yolo Bypass, bring juvenile fish into the bypass, distribute water through the bypass, manage floodplain habitat and develop opportunities for enhanced water supply in the bypass, and reduce reliance on pumping water from the Delta north through the Toe Drain. The Westside Concept can be understood as either a stand-alone action or an auxiliary action similar to those described in other elements of CM2. This range of ideas will be explored further in the YBFEP, and actions that support the goals of the YBFEP will be incorporated.

structures such as flat car bridges or earthen crossings with large, open culverts. Construct new or replacement operable check-structures to facilitate continued agriculture in the Yolo Bypass while promoting fish passage in season (site 8) (Phase 1).

- Lisbon Weir improvements. Replace the Lisbon Weir with a fish-passable gate structure that maintains or improves the ability to impound water for irrigation (site 9) (Phase 1).
- Lower Putah Creek improvements. Realign Lower Putah Creek to improve upstream and downstream passage of Chinook salmon and steelhead. The action will also include floodplain habitat restoration to provide benefits for multiple species on existing public lands. The realignment will be designed so that it will not create stranding or migration barriers for juvenile salmon (site 10) (Phase 1).
- Upper Putah Creek improvements (outside BDCP Plan Area). Support fish passage, water quality, and spawning habitat improvements in Putah Creek upstream of the Yolo Bypass Wildlife Area and downstream of Solano Diversion Dam (site 11) (Phase 1).
- Evaluate the desirability of improving the water supply for the Yolo Bypass Wildlife Area and implementing other conservation measures to improve Lisbon Weir and provide adult fish passage at Fremont Weir over a broader season. These actions will improve Yolo Bypass Wildlife Area water supply at Lisbon Weir. Other actions not yet fully defined or developed will be considered. These may include a subsidy of Yolo Bypass Wildlife Area pumping costs or procurement of additional water from western tributary sources. Improvements will support wildlife management in the Yolo Bypass Wildlife Area by reducing reverse flows in the Toe Drain and could benefit the aquatic foodweb and downstream fish. This project incorporates goals of the Westside Concept (site 12) (Phase 1).
- Supplemental use of flow through Knights Landing Ridge Cut. Evaluate the desirability of using supplemental flows through Knights Landing Ridge Cut, introduced via redesign of Colusa Basin Drain Outfall Gates, increased operation of upstream unscreened pumps, or other means. If currently unscreened pumps were to be used for more than a pilot period, the pumps would need to be screened or replaced with fish-friendly pumps. This project incorporates goals of the Westside Concept (site 13) (Phases 1 and 2).
- Flood-neutral fish barriers. Construct and test flood-neutral fish barriers to prevent fish from straying into Knights Landing Ridge Cut and the Colusa Basin Drain. These barriers will be most effective when employed in association with attraction flows to a location, such as at Fremont Weir, that is fish-passable and leads to the mainstem Sacramento River. This project incorporates goals of the Westside Concept (site 14) (Phase 2).
- Gated seasonal floodplain inundation channel past Fremont Weir. Modify a section of the Fremont Weir to be able to introduce managed flows to the Yolo Bypass at times when Fremont Weir is not overtopping. The Fremont Weir would continue to passively overtop when the Sacramento River stage exceeds the height of the weir. In Chapter 5, *Effects Analysis*, it is assumed that a section of the Fremont Weir will be lowered to 17.5 feet (NAVD88). Lower elevations may be considered, if necessary, to satisfy inundation targets or fish passage needs. Because the Fremont Weir is perched on the natural levee that bounds the Yolo Basin, including the northern edge of the Yolo Bypass (Figure 3.4-1), it will be necessary to excavate through that area of higher ground to hydraulically connect the Sacramento River to the Yolo Bypass at these lower flow stages (Figure 3.4-6). Thus, the new section of gates will replace the former section of

Fremont Weir, and also extend below it, to govern flows in the channel that will be excavated. The new section of operable gates will allow for controlled flow into the Yolo Bypass when the Sacramento River stage at the weir exceeds approximately 17.5 feet, leaving the remaining portion of Fremont Weir to overtop passively when the Sacramento River stage is higher than the top of the weir (32.8 feet NAVD 88). The seasonal floodplain inundation flows will attract fish migrating upstream. Therefore, the gates and the fishways immediately adjacent to them will be designed so that, when they are operated to provide seasonal floodplain inundation flows, they also provide for the efficient upstream and downstream passage of sturgeon and salmonids to and from the Yolo Bypass into the Sacramento River. If additional work to ensure positive drainage of the entire length of Fremont Weir is required, it will be completed in this step (site 15) (Phase 2).

- Nonphysical or physical barriers to attract juvenile salmon into the Yolo Bypass. If it is deemed necessary to enhance capture of juveniles into Yolo Bypass through the gated seasonal floodplain inundation channel (described above), construct and operate nonphysical or physical barriers in the Sacramento River. Examples of such barriers might include bubble curtains or log booms (site 16) (Phase 2 or ELT).
- Support facilities. Construct associated support facilities (e.g., operations buildings, parking lots, access facilities such as roads and bridges) necessary to provide safe access for maintenance and monitoring (site 17) (Phase 2).
- Levee improvements. Improve levees adjacent to the Fremont Weir Wildlife Area, as necessary, to maintain existing level of flood protection, or to beneficially reuse excavated earth (site 18) (Phase 2).
- Yolo Bypass modifications to direct or restrain flow. Through modeling and further concept development, determine what types of grading; removal of existing berms, levees, and water control structures (including inflatable dams); construction of berms or levees, reworking of agricultural delivery channels; and earthwork or construction of structures to reduce Tule Canal and Toe Drain channel capacities are necessary to improve the distribution (i.e., wetted area) and hydrodynamic characteristics (i.e., residence times, flow ramping, and recession) of water moving through the Yolo Bypass. The action will include modifications that will allow water to inundate certain areas of the bypass to maximize biological benefits and reduce stranding of covered fish species in isolated ponds, minimize effects on terrestrial covered species, including giant garter snake, and accommodate other existing land uses (e.g., wildlife, public, and agricultural use areas). Necessary lands will be acquired in fee-title or through conservation or flood easement (site 19) (Phase 2).

Phase 3: 2022 to 2026 (Early Long-Term)

Final permissions from USACE for construction of component projects directly affecting flood control structures (Fremont Weir, Sacramento Weir, and Colusa Basin Drain Outfall Gates, if affected, as well as project levees) will be received by ELT (Phase 3) at the latest. This will initiate construction contracting and constructing the remainder of the component projects. Full buildout will be completed by the end of ELT (estimated in plan year 10, 11 or 12), and operations of these component projects will begin.

The following project will be implemented in Phase 3.

- Sacramento Weir Improvements. At a minimum, modifications will be made to reduce leakage at the Sacramento Weir and thereby reduce attraction of fish from the Yolo Bypass to the weir where they cannot access the Sacramento River and could become stranded. The YBFEP will review the benefits and necessity of constructing fish passage facilities at the Sacramento Weir to improve upstream adult fish passage and positive drainage to reduce juvenile fish stranding. This action may require excavation of a channel to convey water from the Sacramento River to the Sacramento Weir and from the Sacramento Weir to the Toe Drain, construction of new gates at all or a portion of the weir, and modifications to the stilling basin (site 20) (Phase 3).

Phase 4: 2027 to 2063 (Late Long-Term)

Phase 4 will encompass project operation, monitoring, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*). A matrix of criteria will be developed and tested prior to Phase 4, and operations will be adjusted accordingly. For example, if results of monitoring and studies indicate that shorter or earlier gate operations within the adaptive management range yield equivalent or better fish benefits, operation of the gated channel at Fremont Weir would be reduced. If scientific results indicate that the wetter, later end of the adaptive management range is more effective biologically, operations would shift accordingly.

3.4.3.3.4 Operation Scenarios for Fremont Weir

Proposed modifications to the Fremont Weir will increase the biological benefit of the Yolo Bypass across a range of water-year types, while accommodating other uses of the Yolo Bypass such as management for agriculture, waterfowl, wetlands, and fish. Table 3.4-3 summarizes the operations patterns of the proposed Fremont Weir gated channel (the "notch") to manage the timing, frequency, and duration of inundation of the Yolo Bypass with inflow from the Sacramento River. The intent is to inundate the floodplain during periods of importance to the covered fish species, primarily from mid-November through mid-April, with limited operations outside of this period sufficient to ramp down inundation in such a way as to avoid and minimize potential stranding of native fish but control populations of nonnative fish.

Maintenance of Fremont Weir and Yolo Bypass Improvements

Routine maintenance of the Fremont Weir and Yolo Bypass is also a covered activity. Vegetation maintenance activities may include mowing, discing, livestock grazing, dozing, spraying and/or hand-cutting of young willow groves, cottonwoods, arundo, brush, debris, and young selected oak trees. Trees with a trunk diameter of 4 inches or greater may be pruned up to 6 feet from the ground. Clearing of areas will be done in stripes to open areas for water flow and to avoid islands and established growth. On a nonroutine but periodic basis, sediment will be removed from the Fremont Weir area using graders, bulldozers, excavators, dump trucks, or other machinery. Outside of the new channel, sediment removal of approximately 1 million cubic yards within 1 mile of the weir can be reasonably expected to occur on an average of approximately every 5 years based on recent maintenance history. Primarily inside the new channel, an additional 1 million cubic yards of sediment removal is anticipated every other year as a conservative estimate of sediment management. Where feasible, work will be conducted under dry conditions; if necessary, some dredging may be required to maintain connection along the deepest part of the channel for fish passage. Where agreements can be made with landowners, sediment may be disposed of on properties in the immediate vicinity of the Fremont Weir; it may also be used as source material for levee or restoration projects, or otherwise beneficially reused.

Maintenance activities will extend from the Sacramento River to the Fremont Weir, the Fremont Weir to the southern end of the Yolo Bypass, and along and between the associated levees.

Actions to Reduce Effects on Giant Garter Snake and Other Terrestrial Covered Species

Increased inundation in the Yolo Bypass is anticipated to result in flooding of approximately 963 acres of giant garter snake upland habitat during the hibernation period. Additionally, the reduction in rice lands as a result of spring flooding could diminish the amount of available agricultural aquatic habitat for giant garter snake during the active season. As described in Table 3.4-4, drainage improvements will be made, as needed, to accelerate spring planting and minimize loss of rice lands. Additionally, as described under *CM3 Natural Communities Protection and Restoration*, a giant garter snake preserve with a mosaic of upland and aquatic habitats will be established in and adjacent to the Yolo Basin/Willow Slough subpopulation to reduce effects on giant garter snake that would result from habitat loss in the Yolo Bypass.

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Table 3.4-3. Potential Operations Pattern for Fremont Weir Gated Channel, also known as a "Notch"

		Before Nov 10	Nov 10–Nov 30	Dec 1–Feb 15	Feb 16–Feb 28	March 1–March 23	Mar 24–April 10	April 11–May 15	May 16 or Later
If Fremont Weir does not overtop that water year	**Operations Concept**	**No Fremont Weir operations** except for the minimum in-bank flow required to provide fish passage (**up to 500 cfs,** if appropriate).	Initiate Fremont Weir **flows up to 6,000 cfs, only if harvest is complete or if western tributaries are already flooding.**	Initiate Fremont Weir flows **up to 6,000 cfs.** A change in shallow water habitat distribution is anticipated (i.e., acres available at 0 to 1 foot depth and at 1 to 6 foot depth). As very shallow areas get deeper, new very shallow areas are created, variably offsetting the total amount available for dabbling and wading birds. These changes and tradeoffs will need to be analyzed and managed.	Initiate Fremont Weir flows **up to 6,000 cfs.** A change in shallow water habitat distribution is anticipated (i.e., acres available at 0 to 1 foot depth and at 1 to 6 foot depth). As very shallow areas get deeper, new very shallow areas are created, variably offsetting the total amount available for dabbling and wading birds. These changes and tradeoffs will need to be analyzed and managed.	Initiate Fremont Weir flows **up to 6,000 cfs.** A change in shallow water habitat distribution is anticipated (i.e., acres available at 0 to 1 foot depth and at 1 to 6 foot depth). As very shallow areas get deeper, new very shallow areas are created, variably offsetting the total amount of very shallow areas available for dabbling and wading birds. These changes and tradeoffs will need to be analyzed and managed.	**No Fremont Weir notch operations except ramping down of flows initiated earlier** to in-bank fish passage flow levels of 1,000 cfs or less, by April 10, at a rate that does not increase fish stranding. When natural events drop to 6,000 cfs at the YBY gauge, flows go in-bank approximately 11 days later. Unless natural floods are dominating the system during this time, time-to-drainage should be much less than 11 days from the time notch flows drop to 1,000 cfs. More detail about flow ramping is desirable. It will need to be determined in the YBFEP.	No Fremont Weir notch operations except for in-bank fish passage flows (up to 500 cfs, if appropriate).	**No Fremont Weir operations** except for the minimum in-bank flow required to provide fish passage (**up to 500 cfs,** if appropriate).
						If natural flood event, lasting for a duration of 30-days, has not occurred within 5-7 years during March 1 -May 15, prescribe an inundation regime to meet or exceed a minimum duration of 30 days with small flooding footprint.			
	Estimated notch operation frequency[1] for a portion of the period		0 to very few water years	6–25% of water years	8–14% of water years	11–19% of water years	8–11% of water years	No floodplain inundation flows through Fremont Weir "notch" past April 11 in years Fremont Weir does not overtop	
If Fremont Weir overtops that water year	**Operations Concept**		When upstream flows are available, capture juvenile salmonids in **up to 6,000 cfs** into the bypass and operate to achieve **30-day duration.** Water availability in the river upstream will determine whether full 6,000 cfs flows are passed.	Provide continuity between events with flows **up to 6,000 cfs** to achieve **30- to 45-day duration or longer**.	Provide continuity between events with flows **up to 6,000 cfs** to achieve **30- to 45-day duration or longer**.	After Fremont Weir overtopping stops, extend small flooding footprint in low-yield areas with **up to 6,000 cfs notch flows to achieve at least 30-day duration**, then ramp down to in-bank fish passage flows (up to 500 cfs, if appropriate).			
	Estimated "notch" operation frequency[1] for a portion of the period		11% of water years	64% of water years	58–61% of water years	61% of water years	53–56% of water years	19% of water years	
Total % water years with Potential with-Project for-floodplain habitat operation, by period		0%	11%	69–89%	67–75%	72–81%	61–67%	19%	0%
Historical % of water years with Fremont Weir overflow in these periods, for reference		0%	11%	61%	50%	47%	22%	17%	8%

	Before Nov 10	Nov 10–Nov 30	Dec 1–Feb 15	Feb 16–Feb 28	March 1–March 23	Mar 24–April 10	April 11–May 15	May 16 or Later
Footprint Targets: Conservation easements or fee title will be required for all inundation on agricultural land	**Out-of -bank flows not created by project (zero or negligible).**	**Smaller Inundation**: First flush "notch" operations add **up to 10,000 acres** to existing inundation. Operations piggybacking on overflow events prolong **7,000 to 10,000 acres of inundation**.	**Larger Inundation**: First flush "notch" operations add to existing inundation. Following natural spill events (nonproject flooding, including west-side tributaries or Fremont Weir), operate the notch to prolong duration and provide continuity between events. Natural spill events range considerably. Operations would target **17,000 acres of inundation**. When appropriate flows are not available for "larger inundation," operate the "notch" for "smaller inundation."	**Larger Inundation:** Following natural spill events (nonproject flooding, including west-side tributaries or Fremont Weir), operate the notch to prolong duration and provide continuity between events. Natural spill events range considerably. Operations would target **17,000 acres of inundation**. Ramp larger inundation flows down to the smaller acreage range by February 28. When appropriate flows are not available for "larger inundation," operate the "notch" for "smaller inundation."	**Smaller Prolonged Inundation**: Target **7,000 to 10,000 acres of inundation,** with mitigation of impacts on agriculture.	**Smaller Prolonged Inundation:** Target **7,000 to 10,000 acres,** with mitigation of impacts on agriculture.	**Smaller Prolonged Inundation**: Target **7,000 to 10,000 acres,** with mitigation of impacts on agriculture.	**Out-of-bank flows not created by project (zero or negligible).**

[1] Frequency estimates are based on water years 1968 through 2003, as represented in CALSIM results preproject and the Fremont Weir bar charts summarizing historic overtopping in the Sac River Flood Control System Fact Sheet (California Department of Water Resources 2010). High and low ranges were estimated based on avoidance of very short flow events. Notch operations at river stage 17.5 feet or higher correspond to times when west-side tributaries are also typically contributing flow. Preliminary investigations suggest that very short Fremont Weir "notch" events are unlikely to be met with substantial sustained west-side tributary flow, particularly early in the water year. This may have limiting implications on operations to send more juvenile winter-run salmon into the bypass more often in November, December, and January.

Table 3.4-4. Agricultural, Waterfowl, and Fishery Considerations

		Before Nov 10	Nov 10–Nov 30	Dec 1–Feb 15	Feb 16–Feb 28	Mar 1–April 10	April 11–May 15	May 16 or Later
Fishery Enhancement	**Juvenile Salmonids on Floodplain**		Provide seasonal floodplain habitat for the large emigration of winter-run Chinook salmon that occurs in correlation with the first 400 cubic meters per second pulse flow event of the year (occurred in 22% of years [1997–2010] in November, with November 20 the earliest date.)	Improve availability of floodplain habitat (e.g., food) for all salmonids, particularly **winter-run and spring-run Chinook salmon**. The majority of winter-run are detected upstream of the Fremont Weir from November through February.	Improve availability of floodplain habitat (e.g., food) for all salmonids, particularly **fall-run, spring-run, and winter-run Chinook salmon**. The majority of winter-run are detected upstream of the Fremont Weir from November through February.	Improve availability of floodplain habitat (e.g., food) for all salmonids, particularly **fall-run and Butte Creek spring-run Chinook salmon and steelhead**. Nearly the entire run of Butte Creek spring-run emigrate down Butte Creek past Chico in January and February and continue their emigration through the Sutter Bypass in the following three months depending on flow.	Improve availability of floodplain habitat (e.g., food) for all salmonids, particularly **late fall-run Chinook salmon and steelhead**.	
	Splittail on Floodplain		Accommodate the migration pulse of splittail adults that occurs approximately 1 week following a flow pulse.	Improve conditions for adults staging to spawn and spawning, improving likelihood that splittail eggs and larvae will be present in February and March.		Provide seasonal floodplain habitat for splittail spawning and rearing as water conditions allow.		
	Adult Fish Passage	Improve passage for covered species, particularly adult salmonids and sturgeon through notch or additional fishways.						
Agriculture (conservation easements or fee-title will be required for all inundation on agricultural land)			Late harvest must be complete before notch flows could occur for fish benefits.	No impacts on agriculture during this period. Willows and marsh plants must be managed to allow for subsequent planting.	When out-of-bank flow occurs in the Yolo Bypass during this period, it causes **zero to some yield impacts on affected lands**. Drainage occurs approximately 11 days after flows measured at YBY gauge drop to 6,000 cfs. Create berms to manage and focus flows on low-yield lands to minimize impacts on agriculture. Improve drainage on high-yield lands, as needed, to accelerate planting.	When out-of-bank flow occurs in the Yolo Bypass during this period it causes **some to high yield impacts on affected lands**. Drainage occurs approximately 11 days after flows measured at YBY gauge drop to 6,000 cfs. Create berms to manage and focus flows on low-yield lands to minimize impacts on agriculture. Improve drainage on high yield lands, as needed, to accelerate planting.	May 10 is the final day for planting without yield impacts. Final cessation of Yolo Bypass flows during this period could be too late to allow successful land preparation and planting by June 10, the reported last possible day to plant (with high yield impacts).	Cessation of Yolo Bypass flows by May 15 is too late to prepare land to plant by June 10, the last possible day to plant (with high yield impacts).
Waterbird and Wetland Management		Seasonal wetland flooding begins early September, full flood-up by mid-October. Flood harvested rice fields as early as possible after harvest.	Circulate water in wetlands and maintain optimal levels for foraging (<30 centimeters). Continue flooding of rice fields, harvest typically completed.	Circulate water in wetlands and rice fields to maintain optimal levels for foraging (<30 centimeters).	Maintain wetlands through February and March. Water levels in most rice fields typically drawn down in late February in anticipation of field preparation.	Begin drawdown of flooded seasonal wetlands on April 1 to promote germination of swamp timothy (a forage crop). Later drawdown results in undesirable vegetation. Duck nesting in uplands begins.	Peak nesting period for resident ducks (uplands) and shorebirds (wetlands/rice). Maintain some permanent wetlands for brood/chick habitat. Newly planted rice provides forage and habitat for breeding waterbirds.	Maintain some wetlands for breeding waterbirds and broods. Waterbird nesting increases in rice fields and brood use continues until August. Fallow rice fields (on Yolo Wildlife Area) flooded for migrating shorebirds (July/August).

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3.4.4 Conservation Measure 3 Natural Communities Protection and Restoration

Under *CM3 Natural Communities Protection and Restoration*, the Implementation Office will provide the mechanism and guidance to establish a system of conservation lands in the Plan Area, called a reserve system, by acquiring lands for protection and restoration. Such a system is needed to meet natural community and species habitat protection objectives described in Section 3.3, *Biological Goals and Objectives*. The reserve system will be assembled over the BDCP permit term to accomplish the following aims.

- Protect and enhance areas of existing natural communities and covered species habitat.
- Protect and maintain occurrences of selected plant species with limited distributions.
- Provide sites suitable for restoration of natural communities and covered species habitat.
- Provide habitat connectivity among the BDCP conservation lands, and connectivity to other conservation lands inside and outside the Plan Area.

This section describes the purpose and need for the reserve system, the means by which CM3 will help to meet BDCP biological goals and objectives, and opportunities for protecting and restoring natural communities throughout the Plan Area. This section also describes procedures for land acquisition and restoration planning, including requirements related to the extent of land acquisition, site selection criteria and reserve design, preacquisition surveys, and development of site-specific plans for restoration projects. Additional restoration requirements for each natural community type are provided in CM4 through CM10.

Refer to Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM3. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM3 on covered species will be avoided or minimized.

3.4.4.1 Purpose

The primary purpose of CM3 is to meet or contribute to the biological goals and objectives as identified in Table 3.4-5. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-5. Biological Goals and Objectives Addressed by CM3 Natural Communities Protection and Restoration

Biological Goal or Objective	How CM3 Advances a Biological Objective
Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.	
Objective L1.1: Protect at least 31,000 acres of existing natural communities, focusing on the highest quality natural communities and covered species habitats.	Natural communities will be protected to achieve minimum protection acreage targets (Table 3.3-2). Natural community and species-specific goals and objectives and *CM11 Natural Communities Enhancement and Management* site selection criteria provide parameters and criteria directing the Implementation Office to protect the highest quality natural communities and covered species habitats.
Objective L1.2: Protect sufficient lands for the restoration of natural communities as described in Objective L1.3.	Lands will be secured for restoration to achieve minimum restoration acreage targets for each natural community (Table 3.3-2). Natural community goals and objectives and *CM11 Natural Communities Enhancement and Management* site selection criteria provide parameters and criteria for securing appropriate lands to meet the restoration-related biological objectives.
Objective L1.3: Restore or create at least 72,809 acres of natural communities, including at least 65,000 acres of tidally influenced natural communities.	*CM11 Natural Communities Enhancement and Management* and Section 3.4.4.3.4, *Restoration Project Planning* describe the process for developing site-specific restoration projects to meet this objective. *CM11 Natural Communities Enhancement and Management* also describes the necessary components for site-specific restoration plans to meet this objective. Additional restoration actions are described in the conservation measures related to restoration of each natural community.
Objective L1.4: Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.	The reserve system will be distributed through a majority of the 11 conservation zones, capturing a variety of hydrologic, elevation, soil, slope, and aspect conditions across a diversity of natural communities. Sites will be selected for protection based partially on their potential to preserve natural environmental gradients (Section 3.4.4.3.3, *Siting and Design Considerations*). Restored tidal natural communities will include a gradient ranging from shallow subtidal aquatic, to mudflat, emergent marsh plain, riparian (in suitable locations) and transitional uplands (*Reserve Design Criteria by Natural Community Group*, *Tidal Natural Communities*, below, and under *CM4 Tidal Natural Communities Restoration*). Grasslands and associated vernal

Biological Goal or Objective	How CM3 Advances a Biological Objective
	pool and alkali seasonal wetland complexes will be protected in large, contiguous landscapes encompassing the range of vegetation, hydrologic, and soil conditions that characterize these communities (*Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex*, below).
Objective L1.5: Include sufficient noncultivated upland areas adjacent to restored and protected valley/foothill riparian to provide upland habitat values and refugia from flooding.	When securing lands for riparian restoration, particularly in association with floodplain restoration, sufficient land will be protected to provide upland wildlife habitat and refugia for flooding. Any cultivated lands secured for this purpose will be restored as grassland (*Reserve Design Criteria by Natural Community Group, Seasonally Inundated Floodplain and Riparian Natural Community*, below).
Objective L1.6: Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing protected lands.	When securing lands for restoration or protection, priority will be given to lands adjacent to and between existing protected lands, within and adjacent to each conservation zone (Section 3.4.4.3.3, *Siting and Design Considerations*).
Objective L1.7: To accommodate projected future sea level rise, within the 65,000 acres of tidal restoration include sufficient upland transitional areas adjacent to restored brackish and freshwater tidal emergent wetlands to permit the future upslope establishment of tidal emergent wetland communities; also include additional noncultivated upland to provide habitat and high-tide refugia for native wildlife.	When securing lands for tidal restoration, sufficient lands will be included to accommodate 3 feet of sea level rise (this will be included in the 65,000-acre total). Additional lands will be secured to provide upland wildlife habitat and flood refugia: any cultivated lands secured will be converted to grassland and count toward the 2,000-acre grassland restoration target, and any existing grasslands protected in this area will count toward the 8,000-acre grassland protection target (*Reserve Design Criteria by Natural Community Group, Tidal Natural Communities*, below).
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.1: Allow natural flooding regimes to promote regeneration of desirable natural community vegetation and structural diversity, or implement management actions that mimic those natural disturbances.	Sufficient lands will be acquired and protected to accomplish this objective, as described under *Reserve Design Criteria by Natural Community Group, Seasonally Inundated Floodplain and Riparian Natural Community*, below, and under *CM5 Seasonally Inundated Floodplain Restoration.*
Objective L2.2: Allow natural flooding to promote fluvial processes, such that bare mineral soils are available for natural colonization of vegetation, and cause fresh deposits of sediments (i.e., fine sands and silt).	Sufficient lands will be acquired and protected to accomplish this objective, as described under *Reserve Design Criteria by Natural Community Group, Seasonally Inundated Floodplain and Riparian Natural Community*, below, and under *CM5 Seasonally Inundated Floodplain Restoration.*

Biological Goal or Objective	How CM3 Advances a Biological Objective
Objective L2.3: Allow lateral river channel migration.	Sufficient lands will be acquired and protected to accomplish this objective, as described under *Reserve Design Criteria by Natural Community Group, Seasonally Inundated Floodplain and Riparian Natural Community*, below, and under *CM5 Seasonally Inundated Floodplain Restoration.*
Objective L2.4: Connect rivers and their floodplains to recharge floodplain groundwater from mainstem channels and allow input of large woody debris, leaves, and insects to rivers.	Sufficient lands will be acquired and protected to accomplish this objective, as described under *Reserve Design Criteria by Natural Community Group, Seasonally Inundated Floodplain and Riparian Natural Community,* below, and under *CM5 Seasonally Inundated Floodplain Restoration.*
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	Sites will be selected based on their level of contribution to connectivity between existing protected lands (Section 3.4.4.3.3, *Siting and Design Considerations*). Tidal habitat restoration in Conservation Zone 4 may provide giant garter snake habitat connectivity between the Coldani Marsh/White Slough subpopulation and the Stone Lakes National Wildlife Refuge lands to the north (*Reserve Design Requirements by Species, Giant Garter Snake*, below). Lands in Conservation Zones 1 and 11 will be protected to increase habitat linkages between Suisun Marsh, Jepson Prairie, and the Cache Slough Complex (*Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex*, below). Lands in Conservation Zone 8 will be protected to maintain habitat linkages with protected lands to the south and east, within the East Contra Costa HCP/NCCP area (*Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex*, below).
Goal TPANC1: Tidal perennial aquatic natural community that supports habitats for covered and other native species and that supports aquatic food web processes.	
Objective TPANC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 10,000 acres of tidal perennial aquatic in Conservation Zones 1, 2, 4, 5, 7, and 11 that support aquatic food production and habitat for covered and other native species.	Sufficient lands will be acquired and protected to achieve this objective (Table 3.3-2 and *Reserve Design Criteria by Natural Community Group, Tidal Natural Communities*).

Biological Goal or Objective	How CM3 Advances a Biological Objective
Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.	
Objective TBEWNC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 4,800 acres of tidal brackish emergent wetland in Conservation Zone 11.	This acreage is a subset of tidal marsh restoration target acreage. Sufficient lands will be acquired and protected to achieve this objective. See Table 3.3-2 and *Reserve Design Criteria by Natural Community Group, Tidal Natural Communities.*
Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.	
Objective TFEWNC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 13,900 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.	This acreage is a subset of tidal marsh restoration target acreage. Sufficient lands will be acquired and protected to achieve this objective. See Table 3.3-2 and *Reserve Design Criteria by Natural Community Group, Tidal Natural Communities.*
Goal NFEW/NPANC1: Nontidal marsh consisting of a mosaic of nontidal freshwater emergent perennial wetland and nontidal perennial aquatic natural communities, and providing habitat for covered and other native species.	
Objective NFEW/NPANC1.1: Create at least 400 acres of nontidal freshwater marsh consisting of a mosaic of nontidal perennial aquatic (at least 250 acres) and nontidal freshwater emergent wetland (at least 100 acres) natural communities, with suitable habitat characteristics for giant garter snake and western pond turtle.	Sufficient lands will be acquired and protected to achieve this objective. See Table 3.3-2 and *Reserve Design Criteria by Natural Community Group, Nontidal Aquatic and Wetland Natural Communities*. See also *CM10 Nontidal Marsh Restoration.*
Objective NFEW/NPANC1.2: Of the at least 400 acres of created nontidal freshwater marsh, create at least 200 acres contiguous with habitat occupied by the Coldani Marsh/White Slough garter snake subpopulation in Conservation Zone 2, and at least 200 acres contiguous with habitat occupied by the Yolo Basin/Willow Slough giant garter snake subpopulation in Conservation Zone 4.	Nontidal marsh restoration projects will be located appropriately for achieving this objective. See *Reserve Design Criteria by Natural Community Group, Nontidal Aquatic and Wetland Natural Communities.* See also *CM10 Nontidal Marsh Restoration.*
Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.	
Objective VFRNC1.1: Restore or create 5,000 acres of valley/foothill riparian forest.	See Table 3.3-2.
Objective VFRNC1.2: Protect 750 acres of existing valley/foothill riparian forest in Conservation Zone 7 within the near-term implementation period.	Sufficient lands will be acquired and protected to achieve this objective. See Table 3.3-2 and Reserve *Design Criteria by Natural Community Group, Seasonally Inundated Floodplain and Riparian Natural Community* Also see *CM7 Riparian Natural Community Restoration.*
Objective VFRNC1.3: Restore corridors of riparian vegetation along 20 miles of channel margin in the Sacramento and San Joaquin River systems to provide habitat along important migratory routes for anadromous fish and improve wildlife movement.	Sufficient lands will be protected to achieve this objective. See Table 3.3-2 and *Reserve Design Criteria by Natural Community Group. Seasonally Inundated Floodplain and Riparian Natural Community*. See also *CM6 Channel Margin Enhancement.*

Biological Goal or Objective	How CM3 Advances a Biological Objective
Goal GNC1: Extensive grasslands comprised of large, interconnected patches or contiguous expanses.	
Objective GNC1.1: Protect a minimum of 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 7, 8, and 11.	See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex.*
Objective GNC1.2: Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian and tidal natural communities for wildlife foraging and upland refugia.	See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex*. Also see *CM8 Grassland Natural Community Restoration.*
Objective GNC1.3: Protect stock ponds and other aquatic features within protected grasslands to provide aquatic breeding habitat for native amphibians and aquatic reptiles.	When selecting sites for grassland protection, priority will be given to sites that include aquatic features suitable for supporting native amphibians and aquatic reptiles.
Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.	
Objective ASWNC1.1: Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.	See *Reserve Design Criteria by Natural Community Group, Grasslands, Vernal Pool Complex and Alkali Seasonal Wetland Complex.*
Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.	
Objective ASWNC2.1: Provide appropriate seasonal flooding characteristics for supporting and sustaining alkali seasonal wetland species.	When selecting sites for alkali seasonal wetland protection, priority will be given to sites that include the intact local surrounding watershed to sustain natural drainage patterns and sites that are not threatened by potential artificial flows (e.g., urban or agricultural runoff) from adjacent areas.
Goal VPCNC1: Vernal pool complexes comprised of large, interconnected, or contiguous expanses that represent a range of environmental conditions**.**	
Objective VPCNC1.1: Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the vernal pool recovery plan (U.S. Fish and Wildlife Service 2005).	See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex.*
Objective VPCNC1.2: Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage.	Sufficient lands will be acquired and protected to achieve this objective. See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex*. Also see *CM9 Vernal Pool Complex Restoration.*
Objective VPCNC1.3: Increase the size and connectivity of protected vernal pool complex within the Plan Area and increase connectivity with protected vernal pool complex adjacent to the Plan Area.	See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex.*

Biological Goal or Objective	How CM3 Advances a Biological Objective
Objective VPCNC1.4: Protect the range of inundation characteristics that are currently represented by vernal pools throughout the Plan Area.	See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex.*
Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species.	
Objective MWNC1.1: Protect and enhance at least 1,500 acres of managed wetland in the Grizzly Island Marsh Complex consistent with the salt marsh harvest mouse recovery plan.	Managed wetlands will be protected in the appropriate quantity and location to achieve this objective (*CM11 Natural Communities Enhancement and Management*).
Objective MWNC1.2: Create at least 320 acres of managed wetlands consisting of greater sandhill crane roosting habitat in minimum patch sizes of 40 acres within the greater sandhill crane Winter Use Area in Conservation Zones 3, 4, 5, or 6, with consideration of sea level rise.	Suitable lands for managed wetland creation will be protected in the appropriate quantity and location to achieve this objective, and managed wetland will be created as described in [PLACEHOLDER]
Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.	
Objective CLNC1.1: Protect at least 20,000 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species.	See *Reserve Design Criteria by Natural Community Group, Cultivated Lands.*
Objective CLNC1.2: Annually maintain 4,600 acres of rice lands or similarly functioning habitat for giant garter snake in Conservation Zone 2.	See *Reserve Design Criteria by Natural Community Group, Cultivated Lands.*
Objective CLNC1.3: Target cultivated land conservation to provide connectivity between other protected lands.	See *Reserve Design Criteria by Natural Community Group, Cultivated Lands.*
Objective CLNC1.4: Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur within BDCP conserved cultivated lands, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.	See *Reserve Design Criteria by Natural Community Group, Cultivated Lands.*
Goal RBR1: Suitable habitat available for the future growth and expansion of riparian brush rabbit populations.	
Objective RBR1.1: Of the 750 acres of protected valley/foothill riparian natural community, protect at least 200 acres of suitable riparian brush rabbit habitat (defined in *CM7 Riparian Natural Community Restoration*) that is occupied by the species or contiguous with occupied habitat.	See *Reserve Design Requirements by Species, Riparian Brush Rabbit.*
Objective RBR1.2: Of the 5,000 acres of riparian restoration, restore/create and maintain at least 300 acres of early- to mid-successional riparian habitat that meets the ecological requirements of the riparian brush rabbit and that is within or adjacent to or that facilitates connectivity with existing occupied or potentially occupied habitat.	See *Reserve Design Requirements by Species, Riparian Brush Rabbit.*

Biological Goal or Objective	How CM3 Advances a Biological Objective
Goal RW1: A reserve system that includes suitable habitat available for the future growth and expansion of riparian woodrat populations.	
Objective RW1.1: Of the 5,000 acres of riparian restoration, restore/create and maintain at least 300 acres riparian habitat that meets the ecological requirements of the riparian woodrat (e.g., dense willow understory and oak overstory) and that is adjacent to or facilitates connectivity with existing occupied or potentially occupied habitat.	See *Reserve Design Requirements by Species, Riparian Woodrat.*
Goal GSHC1: Protection and expansion of greater sandhill crane winter range.	
Objective GSHC1.1: Within the at least 20,000 acres of conserved cultivated lands, protect 5,800–7,100 acres of high [0.75 HSU] to very high [1.0 HSU] value habitat for the greater sandhill crane, with at least 30% maintained in very high [1.0] value types in any given year, as defined by this Plan. This protected area will be within the Winter Use Area, will consider sea level rise, and will be within 2 miles of known roosting sites in Conservation Zones 3, 4, and/or 5. Patch size of cultivated lands will be at least 160 acres.	See *Reserve Design Requirements by Species, Greater Sandhill Crane.*
Objective GSHC1.2: To create additional high value greater sandhill crane winter foraging habitat, 10% of the habitat protected under Objective GSHC1.1 will involve acquiring low value habitat and converting it to high or very high value habitat.	See *Reserve Design Requirements by Species, Greater Sandhill Crane.*
Objective GSHC1.3: If greater sandhill crane habitat is removed from within 2 miles of a roost site, of the total protected acres under Objective GSHC1.1, create 1 acre or protect 2 acres of foraging habitat for every acre removed within 2 miles of that roost site.	See *Reserve Design Requirements by Species, Greater Sandhill Crane.*
Objective GSHC1.4: Within the 320 acres of created managed wetland (Objective MWNC1.2), create at least 40 acres of roosting habitat within 2 miles of Winter Use Areas on the Stone Lakes National Wildlife Refuge, and all other roosts within 2 miles of existing traditional roost sites.	Suitable lands for managed wetland creation will be protected in the appropriate quantity and location to achieve this objective, and managed wetland will be created as described in [PLACEHOLDER]
Objective GSHC1.5: If monitoring results indicate that greater sandhill cranes abandon known roost sites as a result of covered activities, create a new roost site of equal size (in addition to the acreage prescribed under Objective MWNC1.1) in the Winter Use Area in Conservation Zones 3, 4, 5, or 6. Create the roost within 2 miles of the affected roost and adjacent to other protected crane foraging habitat.	Suitable lands for managed wetland creation will be protected in the appropriate quantity and location to achieve this objective, and managed wetland will be created as described in [PLACEHOLDER]

Biological Goal or Objective	How CM3 Advances a Biological Objective
Goal SH1: Contribute to the sustainability of the Swainson's hawk population by protecting cultivated lands suitable for Swainson's hawk foraging.	
Objective SH1.1: Within the at least 20,000 acres of conserved cultivated lands, protect 19,800 to 33,700 acres as a matrix of moderate quality [0.5 HSU] Swainson's hawk foraging habitat, at least 30% of which will be managed as very high [1.0 HSU] quality habitat.	Cultivated lands will be protected in the appropriate quantity and location, and with the appropriate composition, to achieve this objective, as described in [PLACEHOLDER]
Goal TRBL1: Improved nesting, nesting-adjacent foraging, and wintering habitat for tricolored blackbirds in the Plan Area.	
Objective TRBL1.1: Protect 50 acres of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat located within 5 miles of high quality foraging habitat in Conservation Zones 1, 2, 8, or 11.	Sufficient lands will be acquired and protected to achieve this objective.
Objective TRBL1.3: Of the cultivated lands protected as covered species habitat, protect 11,400 to 19,000 acres of moderate or higher quality cultivated lands as nonbreeding foraging habitat, 50% of which is of high or very high value.	Sufficient lands will be acquired and protected to achieve this objective.
Objective TRBL1.4: Of the cultivated lands protected as covered species habitat, protect 5,100 to 7,600 acres of high to very high quality breeding-foraging habitat within 5 miles of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat in Conservation Zones 1, 2, 3, 4, 7, 8 or 11.	Sufficient lands will be acquired and protected to achieve this objective.
Goal WBO1: Contribute to the sustainability of the burrowing owl population by protecting cultivated lands suitable for burrowing owl foraging.	
Objective WBO1.1: Of the cultivated lands protected under Objective CLNC1.1, protect at least 1,000 acres in Conservation Zones 1 and 11 that support moderate value burrowing owl habitat and are within 1 mile of high value grassland habitat or occupied moderate value habitat.	Cultivated lands will be protected in the appropriate quantity and location, and with the appropriate western burrowing owl characteristics, as described in [PLACEHOLDER], to achieve this objective.
Goal GGS1: High quality upland and aquatic giant garter snake habitat with buffers from disturbance.	
Objective GGS1.1: Restore or protect existing grasslands adjacent to the 400 acres of restored nontidal marsh to provide sufficient upland refugia and overwintering habitat for giant garter snakes.	See *Reserve Design Requirements by Species, Giant Garter Snake.*
Objective GGS1.2: Protect giant garter snakes on preserve lands from incidental injury or mortality by establishing 200-foot buffers between protected giant garter snake habitat and roads, and establishing giant garter snake preserves at least 2,500 feet from urban areas or areas zoned for urban development.	See *Reserve Design Requirements by Species, Giant Garter Snake.*

Biological Goal or Objective	How CM3 Advances a Biological Objective
Goal GGS2: Expanded range and protected corridors facilitating giant garter snake movement and population connectivity.	
Objective GGS2.1: Of the at least 20,000 acres of cultivated lands to be protected, prioritize protection of lands that establish connectivity between the giant garter snake Coldani Marsh/White Slough and Yolo Basin/Willow Slough subpopulations and the Stones Lakes National Wildlife Refuge.	See *Reserve Design Requirements by Species, Giant Garter Snake.*
Objective GGS2.2: Of the 13,900 acres of tidal freshwater emergent wetland restoration, restore at least 1,500 acres in Conservation Zone 4 to facilitate connectivity, dispersal, and movement of giant garter snakes and contribute to a north-south corridor that includes protected cultivated lands and restored tidal and nontidal wetlands between Coldani Marsh/White Slough and the Stones Lakes National Wildlife Refuge.	See *Reserve Design Requirements by Species, Giant Garter Snake.*
Goal VPC1: Protected occurrences of the rarest covered vernal pool crustacean species.	
Objective VPC1.1: Protect at least one currently unprotected occurrence of conservancy fairy shrimp.	The 600 acres of protected vernal pool complex will include at least one conservancy fairy shrimp occurrence.
Goal VELB1: Promote dispersal and expansion of the valley elderberry longhorn beetle where there are known source populations within the American River and Sacramento River systems.	
Objective VELB1.1: Mitigate for impacts on elderberry shrubs by creating valley elderberry longhorn beetle habitat consistent with the USFWS (1999a) valley elderberry longhorn beetle conservation guidelines and planting elderberry shrubs in high-density clusters.	See *Reserve Design Requirements by Species, Valley Elderberry Longhorn Beetle.*
Objective VELB1.2: Site valley elderberry longhorn beetle habitat restoration within drainages immediately adjacent to or in the vicinity of sites known to be occupied by valley elderberry longhorn beetle.	See *Reserve Design Requirements by Species, Valley Elderberry Longhorn Beetle.*
Goal BRIT/HART1: A reserve system that includes habitat and occurrences for brittlescale and heartscale.	
Objective BRIT/HART1.1: Of the protected alkali seasonal wetland complex, vernal pool complex, and grassland natural community, protect 150 acres of suitable brittlescale and heartscale habitat in Conservation Zones 1, 8, or 11.	See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex* and *Reserve Design Requirements by Species, Plants.*
Goal DBC1: Expand the distribution and increase the abundance of delta button celery populations.	
Objective DBC1.1: Establish two occurrences of delta button celery within the restored floodplain habitat on the mainstem of the San Joaquin River in Conservation Zone 7 between Mossdale and Vernalis.	See *Reserve Design Criteria by Natural Community Group, Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex* and *Reserve Design Requirements by Species, Plants.*
Goal CGB1: A reserve system that includes Carquinez goldenbush occurrences and sustains suitable habitat for this species.	
Objective CGB1.1: Protect at least three unprotected occurrences of the Carquinez goldenbush in Conservation Zones 1 and/or 11.	See *Reserve Design Requirements by Species, Plants.*

3.4.4.2 Problem Statement

For descriptions of the ecological values and current condition of natural communities in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* also describes the need for natural communities protection and restoration as a component of the conservation strategies natural communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM3.

Natural communities in the Plan Area have been lost, fragmented, and degraded primarily as a result of agricultural conversion, flood control, and urban development. The protection and restoration of natural communities will eliminate future loss, fragmentation, and degradation within the reserve system, and natural communities restoration will reverse past loss, fragmentation, and degradation. As shown in Table 3.3-2, there is ample unprotected land available in the Plan Area for acquisition to implement CM3, and to build off of and link existing protected areas within and adjacent to the Plan Area. The following discussion describes existing conditions and natural community protection opportunities in each of the conservation zones. The conservation zones are shown in Figure 3.2-2.

3.4.4.2.1 Conservation Zone 1

Conservation Zone 1 is located north of Suisun Marsh and Portrero Hills. This zone provides opportunities for protecting and restoring grasslands and associated vernal pool and alkali seasonal wetland complex, for tidal marsh restoration at Suisun Marsh, and for cultivated lands protection. Approximately 8% of the conservation zone (4,446 of 54,061 acres) is currently protected, providing opportunities to link the reserve system with existing protected lands. Key protected areas in this zone are Jepson Prairie Preserve and Calhoun Cut Ecological Reserve, south and west of Lindsey Slough.

Conservation Zone 1 includes some of the largest contiguous expanses of grasslands and associated vernal pool complex in the Plan Area. Grasslands and associated vernal pool complex in this zone are located between protected grassland landscapes immediately adjacent to the Plan Area (e.g., Jepson Prairie Preserve) and tidal marsh in the Cache Slough Complex. Grasslands in this zone provide, or have the potential to provide, foraging habitat for the tricolored blackbird, western burrowing owl, Swainson's hawk, and white-tailed kite; upland habitat for the giant garter snake and western pond turtle; breeding and upland habitat for the western spadefoot toad and California tiger salamander; and habitat for the covered vernal pool fairy shrimp and tadpole shrimp species, alkali milk-vetch, San Joaquin spearscale, dwarf downingia, Boggs Lake hedge-hyssop, Heckard's peppergrass, legenere, heartscale, brittlescale, delta buttoncelery, and Carquinez goldenbush.

Sufficient cultivated lands are present in Conservation Zone 1 to achieve a substantial proportion of the overall cultivated lands conservation target acreages established for the Plan Area. Cultivated lands in this zone provide foraging habitat for tricolored blackbird, Swainson's hawk, and other cultivated lands-associated species.

Conservation Zone 1 includes tidal, grassland, and vernal pool restoration opportunities. It includes a portion of the Cache Slough Restoration Opportunity Area (ROA), which is suitable for tidal habitat restoration as described in *CM4 Tidal Natural Communities Restoration*. This zone also contains lands suitable for grassland restoration to increase connectivity among currently fragmented patches of grassland and seasonal wetlands (both within Conservation Zone 1 and with adjacent lands to the southwest that, in turn, connect with Conservation Zone 11) and to provide high-value transitional upland habitat adjacent to restored tidal marsh plain habitats. Additionally, Conservation Zone 1 contains lands that were historically vernal pool complexes and have since been highly degraded, but which are suitable for vernal pool restoration.

3.4.4.2.2 Conservation Zone 2

Conservation Zone 2 consists of the Yolo Bypass and associated lands to the south and west, and overlaps with the Yolo County Habitat Conservation Plan (HCP)/Natural Community Conservation Plan (NCCP) area. Cultivated land is the predominant community type in this zone, thus it provides opportunities for protecting cultivated foraging habitats. This zone also provides opportunities for protecting and restoring grassland and associated seasonal wetlands, and for restoration of tidal and associated riparian habitats and nontidal wetlands. Conservation Zone 2 includes a portion of the Cache Slough ROA, which is suitable for tidal habitat restoration as described in *CM4 Tidal Natural Communities Restoration.*

Approximately 58% (39,700 of 68,904 acres) of Conservation Zone 2 consists of protected lands. Ample opportunities exist to protect cultivated lands and associated natural communities in large blocks connected to existing protected lands, both within this zone and with adjacent lands to the southwest and southeast in Conservation Zones 1 and 4, respectively. Yolo Bypass Wildlife Area and other protected lands owned by DFG are present in the central and northern portions of Conservation Zone 2, while Liberty Island, owned by the Trust for Public Lands, and other lands owned by USACE and the U.S. Bureau of Reclamation (Reclamation) are present at the southern end.

Conservation Zone 2, which hosts the majority of rice and other agriculture in the Plan Area, supports sufficient cultivated lands to achieve a substantial proportion of the overall cultivated lands conservation target acreages established for the Plan Area. These cultivated lands support foraging habitat for tricolored blackbird, Swainson's hawk, giant garter snake, and other cultivated lands-associated species. This zone includes one of two giant garter snake subpopulations in the Plan Area (the Yolo Basin/Willow Slough subpopulation).

3.4.4.2.3 Conservation Zone 3

Conservation Zone 3 is located between the Yolo Bypass and the Sacramento River, and consists primarily of cultivated lands and natural and artificial channels with narrow strips of associated riparian vegetation. This conservation zone provides opportunities to protect foraging habitat for Swainson's hawk and greater sandhill crane. Protection of cultivated lands and associated irrigation channels may also provide opportunities to establish giant garter snake habitat connectivity between the Yolo Basin/Willow Slough subpopulation in Conservation Zone 2 and the Coldani Marsh/White Slough subpopulation in Conservation Zone 4. Only 0.6% (460 of 83,246 acres) of this conservation zone consists of existing protected lands, providing few opportunities for building the reserve system off of existing protected land in this zone.

3.4.4.2.4 Conservation Zone 4

Conservation Zone 4 is located along the eastern edge of the Plan Area, and overlaps with the San Joaquin County Multiple Species HCP area. This conservation zone provides opportunities to restore tidal and associated riparian habitats and nontidal wetlands, and to protect cultivated lands. It includes tidal habitat restoration opportunities in the Cosumnes/Mokelumne ROA, at the confluence of the Cosumnes and Mokelumne Rivers.

Approximately 41% (20,013 of 48,832 acres) of Conservation Zone 4 consists of existing protected lands, so ample opportunities remain in this zone to link the reserve system with existing protected lands. Stone Lakes National Wildlife Refuge and Cosumnes Preserve occupy most of the land in the northern half of Conservation Zone 4. In the central portion of the conservation zone are lands held by The Nature Conservancy, including Bean Ranch, Crump Ranch, Fitzgerald, Beacon Farms, and Cowell Ranch. Lands publicly owned by BLM, the City of Sacramento, and DWR are also present in the central portion of Conservation Zone 4. Woodbridge Ecological Reserve (DFG), White Slough Wildlife Area (DWR), and the City of Lodi water treatment plant are present in the southern half of Conservation Zone 4.

Cultivated lands in Conservation Zone 4 provide habitat for tricolored blackbird, Swainson's hawk, greater sandhill crane, and giant garter snake. This zone contains the Coldani Marsh/White Slough subpopulation of giant garter snake, and provides opportunities for marsh restoration and cultivated lands protection to protect and expand this subpopulation and provide habitat connectivity with giant garter snakes in the Stone Lakes area in Conservation Zone 4.

3.4.4.2.5 Conservation Zone 5

Conservation Zone 5 extends from the central Delta eastward, to encompass lands along the eastern edge of the Plan Area. This zone includes cultivated lands that provide habitat for tricolored blackbird, Swainson's hawk, greater sandhill crane, and giant garter snake. It includes lands suitable for tidal habitat restoration in the West Delta ROA, providing habitat for Mason's lilaeopsis, Suisun Marsh aster, and delta mudwort, and for the creation of sandhill crane roosting sites.

Approximately 25% (30,919 of 123,679 acres) of Conservation Zone 5 consists of existing protected lands, providing opportunities to link the reserve system with existing protected lands. These protected lands include Sherman Island and Twitchell Island, owned by DWR, Staten Island owned by The Nature Conservancy, and Lower Sherman Island and Woodbridge Ecological Reserves owned by DFG. Other protected lands in Conservation Zone 5 includes portions of Stone Lakes National Wildlife Refuge and Cosumnes Preserve, and East Bay Regional Park lands.

3.4.4.2.6 Conservation Zone 6

Conservation Zone 6 encompasses deeply subsided islands of the Delta that are predominately under cultivation and generally support only small, fragmented patches of nonagricultural habitat. The zone provides opportunities for tidal habitat restoration in the West Delta ROA providing habitat for Mason's lilaeopsis, Suisun Marsh aster, and delta mudwort. Cultivated lands in Conservation Zone 6 provide Swainson's hawk foraging habitat and greater sandhill crane foraging and roosting habitats, and thereby provides opportunities for cultivated lands protection to help conserve these species.

Approximately 11% (11,940 of 110,771 acres) of Conservation Zone 6 consists of existing protected lands. These include the Franks Tract State Resource Area owned by California Department of Parks and Recreation, Dutch Slough owned by DWR, and numerous relatively small areas consisting of delta islands owned by DFG and DWR.

3.4.4.2.7 Conservation Zone 7

Conservation Zone 7 is located at the southern end of the Plan Area and includes the San Joaquin and Stanislaus Rivers and their tributaries with associated cultivated lands and natural communities. This zone overlaps with the San Joaquin County Multiple Species HCP area. Conservation Zone 7 provides the best opportunities in the Plan Area for restoring seasonally inundated floodplain. The riparian natural communities in Conservation Zone 7 support riparian brush rabbit and provide suitable habitat for riparian woodrat, least Bell's vireo, Townsend's big-eared bat, yellow-breasted chat, white-tailed kite, Swainson's hawk, and valley elderberry longhorn beetle. Cultivated lands in this zone provide habitat for Swainson's hawk other agriculture-associated covered species.

Only approximately 2% (2,685 of 116,734 acres) of Conservation Zone 7 consists of existing protected lands, providing limited opportunities for building a reserve system off of existing protected lands in this zone. However, opportunities exist to connect with protected lands to the south of the Plan Area, including adjacent San Joaquin National Wildlife Refuge. Protected lands in this zone include portions of San Joaquin National Wildlife Refuge, and several small protected areas including Vernalis Riparian Habitat Preserve (DFG), Dos Reis Preserve (DFG), and lands owned by the City of Stockton, U.S. Department of Defense, and the State Lands Commission.

3.4.4.2.8 Conservation Zone 8

Conservation Zone 8 is in the southwestern portion of the Plan Area and overlaps with the East Contra Costa County HCP/NCCP area. The predominant natural communities in Conservation Zone 8 are grasslands and associated vernal pool and alkali seasonal wetland complexes, which provide habitat for San Joaquin kit fox, tricolored blackbird, western burrowing owl, Swainson's hawk, white-tailed kite, western pond turtle, western spadefoot toad, California red-legged frog, California tiger salamander, covered vernal pool fairy shrimp and tadpole shrimp species, alkali milk-vetch, San Joaquin spearscale, heartscale, brittlescale, delta button celery, and caper-fruited tropidocarpum. Tidal natural communities provide habitat for Mason's lilaeopsis and delta mudwort. Conservation Zone 8 provides opportunities for protecting these natural communities and the associated covered species.

Approximately 9% (3,169 of 35,776 acres) of Conservation Zone 8 consists of existing protected lands. Protected lands in this conservation zone include Clifton Court Forebay (DWR), Byron Conservation Bank (DFG), and lands owned by the State Lands Commission.

3.4.4.2.9 Conservation Zone 9

Conservation Zone 9 is comprised primarily of urban lands (e.g., Brentwood and Discovery Bay are located in this zone); nonurban areas are predominately cultivated lands. Nonagricultural habitats occur in small patches that are disconnected from other natural habitats. Cultivated lands in this conservation zone provide foraging habitat for Swainson's hawk. This conservation zone provides opportunities for protecting cultivated lands.

Approximately 5% (1,631 of 30,426 acres) of Conservation Zone 9 consists of existing protected lands. These include lands owned by East Bay Regional Park District and several relatively small areas owned by the city and county.

3.4.4.2.10 Conservation Zone 10

Conservation Zone 10 encompasses the city of Antioch and consists almost entirely of urban lands. There are few or no protection or restoration opportunities in this zone. This zone has limited existing protected lands (511 of 6,356 acres, or 8% of the conservation zone), including lands owned by East Bay Regional Park District and several relatively small areas owned by the city and county. Antioch Dunes National Wildlife Refuge is in this zone.

3.4.4.2.11 Conservation Zone 11

Conservation Zone 11 is located in the Suisun Marsh area, and predominately consists of tidal natural communities and managed wetlands surrounded by an upland fringe of grasslands and associated vernal pools and alkali seasonal wetlands. The grasslands and associated vernal pools and alkali wetlands provide habitat for the tricolored blackbird, western burrowing owl, Swainson's hawk, white-tailed kite, western spadefoot toad, California tiger salamander, covered vernal pool fairy shrimp and tadpole shrimp species, alkali milk-vetch, San Joaquin spearscale, dwarf downingia, Boggs Lake hedge-hyssop, Heckard's peppergrass, legenere, heartscale, brittlescale, and Carquinez goldenbush. The tidal marsh and managed wetlands provide habitat for the salt marsh harvest mouse, Suisun shrew, Townsend's big-eared bat, tricolored blackbird, Suisun song sparrow, California black rail, California clapper rail, western pond turtle, Suisun thistle, soft bird's-beak, Delta tule pea, Suisun Marsh aster, and Mason's lilaeopsis. Conservation Zone 11 provides opportunities to protect and restore all of these natural communities and to conserve the associated covered species.

Approximately 52% (55,470 of 107339 acres) of Conservation Zone 11 consists of existing protected lands. These include Grizzly Island Wildlife Area (DFG), Hill Slough Wildlife Area (DFG), Rush Ranch (Solano Land Trust), and lands owned by the Department of Defense and the State Lands Commission.

3.4.4.3 Implementation

3.4.4.3.1 Required Actions

The Implementation Office will establish a reserve system that encompasses all BDCP protected and restored natural communities. The reserve system will consist of lands acquired and managed by the Implementation Office (or by entities on behalf of the Implementation Office) and of lands restored and managed by the Implementation Office but owned by others (e.g., public lands on which BDCP restoration actions will occur). The reserve system is not defined by land ownership, but rather by the implementation of conservation measures on that land. See Section 7.3.1, *Implementation of the Habitat Protection and Restoration Conservation Measures*, for more details on the establishment of the reserve system.

The land acquisition commitments for natural communities are presented in Table 3.3-2 in the "Protected by BDCP" column. Acquisition of these lands will also fulfill the acreage requirements for each of the covered species. These commitments represent the minimum extent of land that will be acquired to meet preservation requirements; the actual extent that will be acquired will likely be greater because acquired parcels will include excess amounts of target and nontarget natural communities.

3.4.4.3.2 Land Acquisition

Lands will be acquired through a variety of mechanisms, that will include but will not be limited to the following.

- Purchase in fee title.
- Permanent conservation easements.
- Limited-term conservation easements lands that remain in agricultural production.
- Change of federal or state-owned lands to more protective land use designation.
- Permanent agreements with state, federal, and local agencies (e.g., flood control agencies) that enable the restoration, enhancement, and management of floodplain and channel margin habitats along levees and lands under flood easements.
- Purchase of mitigation credits from approved private mitigation banks.

The Implementation Office may acquire lands in partnership with other conservation organizations or through grants of land from participating entities where such lands will serve to achieve the biological goals and objectives of the Plan. The reserve system will comprise conservation areas (lands that are under direct management of the Implementation Office or an Authorized Entity), lands protected through permanent conservation easements, and cultivated lands covered by limited term conservation easements.

It is anticipated that lands utilized for habitat restoration and enhancement actions will primarily be those that are currently in public ownership or those that are acquired in fee title because restoration and enhancement activities have a high potential to preclude other land uses. Lands acquired for the protection and maintenance of existing habitat functions may be acquired through conservation easements that specify permitted land uses and practices in sufficient detail to maintain the intended habitat functions of the acquired lands, although enhancements may also be implemented on conservation easement lands as opportunities arise. Limited-term conservation easements would be used only to conserve cultivated lands for a specified period when landowners are unwilling to accept a permanent easement. After the easement expires the Implementation Office would be required to replace the conserved cultivated lands with another conservation easement, either short-term or permanent.

3.4.4.3.3 Siting and Design Considerations

Siting Criteria

The Implementation Office will apply, and revise when necessary, the following criteria for evaluating and prioritizing acquisition of lands for achieving habitat protection and restoration targets. Two sets of criteria are presented, each for different groups of natural communities. These criteria apply to all of the natural communities within each group. Additional site selection and reserve design criteria unique to each natural community, conservation zone, and in some cases covered species, are also presented below.

Criteria for evaluating the suitability of lands supporting grasslands and associated vernal pool and alkali seasonal wetland complex are as follows.

- Effectiveness in contributing towards achieving multiple biological goals and objectives.

- Level of benefits the acquisition will provide for covered species.
- Presence and abundance of covered species.
- Presence of uncommon site-specific attributes (e.g., soil types) required by covered species with narrow range of habitat requirements.
- Likely effects of adjacent land uses on the ability to maintain or improve desired ecological functions into the future.
- Habitat patch size relative to the habitat patch size of the covered species intended to benefit from the habitat.
- Opportunities for effectively implementing management actions to enhance ecological functions.
- Level of contribution for maintaining local and regional ecological processes.
- Level of connectivity provided between and among existing preserved areas.
- Level of contribution to preserve natural environmental gradients consistent with Objective L1.4.
- Level of contribution towards establishment of large preserved areas.
- Likely effects of climate change on future ecological functions, and expected resiliency of site to those effects.
- Role in maintaining and complementing the habitat functions of adjoining natural communities for covered and other native species.
- Level of contribution towards protection of a heterogeneous mix of natural communities and native species, including native grasses and forbs.
- Likely contribution toward achieving biological objectives for approved and planned HCPs and NCCPs overlapping or adjacent to the Plan Area.

Criteria for acquiring land for restoring tidal, riparian, nontidal marsh, and seasonally inundated floodplain habitats are as follows.

- Potential for restoration on the site to achieve multiple biological goals and objectives.
- Suitability and cost effectiveness for restoring target habitats.
- Suitability for supporting the restored habitat over time.
- Expected level of management necessary to maintain desired ecological functions into the future.
- Compatibility with adjacent land uses.
- Likely effects of climate change on future ecological functions, and expected resiliency of site to those effects.

The Implementation Office is committed to securing a sufficient acreage of land to achieve the seasonally inundated floodplain, channel margin habitat, and riparian habitat conservation targets described in *CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement,* and *CM7 Riparian Natural Community Restoration.* However, these commitments cannot be tied to specific conservation zones, but rather to the geographies identified in the conservation measures and, therefore, are not described in the conservation zone acquisition requirements.

Reserve Design Criteria by Natural Community Group

In addition to the general site selection criteria described above, more specific reserve design criteria for natural community groups are described below. For the purpose of minimizing redundancy and addressing landscape-scale conservation needs, the design criteria for natural communities are provided below in four groups: tidal natural communities, grasslands and associated vernal pool and alkali seasonal wetland complex, nontidal aquatic and wetland natural communities, and seasonally inundated floodplain and riparian natural community.

Tidal Natural Communities

Lands will be secured to restore at least 65,000 acres of tidal communities, which will include a restored gradient of natural communities ranging from shallow subtidal aquatic, to mudflat, emergent marsh plain, riparian (in suitable locations) and transitional uplands. Transitional uplands will include sufficient land to accommodate future upslope establishment of marsh plain vegetation expected to result from sea level rise.

Sufficient lands will be secured and protected for tidal habitat restoration to meet the following requirements.

- Meet the minimum restoration targets for each ROA as described in *CM4 Tidal Natural Communities Restoration* and achieve the requirement to restore 65,000 acres of tidal habitat throughout the BDCP Plan Area.
- Protect upland natural communities adjacent to tidal habitat restoration sites sufficient to accommodate a 3-foot sea level rise (this acreage to be included within the 65,000-acre tidal habitat restoration target).
- Protect additional adjacent natural communities to provide upland habitat and refugia for covered wildlife species, including salt marsh harvest mouse, Suisun shrew, Suisun song sparrow, black rail, and clapper rail (this acreage to be included within the upland natural community protection targets).

Additional requirements for tidal habitat restoration are provided in *CM4 Tidal Natural Communities Restoration.*

Grasslands and Associated Vernal Pool and Alkali Seasonal Wetland Complex

This community group is comprised of the grassland, alkali seasonal wetland complex, and vernal pool complex natural communities. These natural communities will be secured by the Implementation Office to achieve the following requirements.

- Protect at least 8,000 acres of existing grasslands.
- Protect at least 600 acres of existing vernal pool complex, primarily in core vernal pool recovery areas identified in the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005). Prior to meeting the 600-acre target, a maximum of 300 acres of the vernal pool complex protection also may count toward the 8,000-acre target acreage for grassland protection. After the 600-acre

vernal pool complex target has been met, any additional protected vernal pool complex acreage can be applied to the grassland target.

- Protect at least 150 acres of existing alkali seasonal wetland complex.
- Restore at least 2,000 acres of grasslands as described in *CM8 Grassland Natural Community Restoration.*
- Restore vernal pool complex to achieve no net loss resulting from covered activities as described in *CM9 Vernal Pool Complex Restoration.*
- Protect the range of inundation characteristics that are currently represented by vernal pools throughout the Plan Area.
- Of the 8,750 acres of protected alkali seasonal wetland, complex, vernal pool complex, and grassland natural community, include at least 150 acres that provide heartscale and brittlescale habitat, and at least 100 acres that support delta button celery habitat as specified in *Reserve Design Requirements by Species.*

The Implementation Office will secure lands for restoration based on siting criteria described in *CM8 Grassland Natural Community Restoration* and *CM9 Vernal Pool Complex Restoration.* Most of the grasslands and associated seasonal wetlands will be secured in Conservation Zones 1, 8, and 11, although additional grasslands may be conserved in Conservation Zones 2, 4, and 7. Conservation Zone 1 protection actions will meet the following zone-specific parameters.

- Secure and protect a portion of the 600 acres of existing vernal pool complex to be protected under the BDCP, in the Jepson-Prairie core vernal pool recovery area (U.S. Fish and Wildlife Service 2005).
- Secure and protect a portion of the 150 acres of existing alkali seasonal wetland to be protected under the BDCP.
- Secure and protect at least 2,000 acres of existing grassland (which may include vernal pool complex, up to 300 acres in the Plan Area that will be counted toward both the 600-acre vernal pool complex and the 8,000-acre grassland protection targets).
- Secure and protect lands in large contiguous landscapes that consist of grasslands, vernal pool complex and alkali seasonal wetland complex and encompass the range of vegetation, hydrologic, and soil conditions that characterize these communities in Conservation Zone 1.
- Secure and protect lands, including existing natural communities and restoration lands, to maintain habitat connectivity with protected grassland and vernal pool landscapes immediately adjacent to the Plan Area (e.g., Jepson Prairie Preserve) and with transitional uplands associated with tidal habitats restored in the Cache Slough Complex ROA.

There are no specific protection requirements for grasslands and associated vernal pools or alkali seasonal wetlands established for Conservation Zones 2, 4, or 7. However, protection may occur if there are high-value grassland or seasonal wetland habitats that connect to existing protected grassland landscapes (e.g., Yolo Bypass Wildlife Area in Conservation Zone 2), or existing grasslands adjacent to restored seasonally inundated floodplain in Conservation Zone 7. Grassland restoration may also occur in these areas. In addition, small and fragmented patches of grassland associated with maintained cultivated lands (e.g., vegetated levee slopes) may be protected to serve as upland habitat for giant garter snake and western pond turtle, and as foraging habitat for Swainson's hawk and white-tailed kite.

Protection in Conservation Zone 8 will meet the following zone-specific parameters.

- Secure and protect at least 1,000 acres of existing grassland.
- Secure and protect a portion of the 600 acres of existing vernal pool complex to be protected under the BDCP in the Altamont Hills vernal pool core recovery area.
- Secure and protect a portion of the 150 acres of existing alkali seasonal wetland to be protected under the BDCP.
- Protect lands in large contiguous landscapes of grasslands and associated vernal pool and alkali seasonal wetland complex natural communities that encompass the range of vegetation, hydrologic, and soil conditions characterizing these communities south of Highway 4.
- Protect lands in locations that will maintain connectivity with protected grassland, vernal pool complex and alkali seasonal wetland complex landscapes within and immediately adjacent to the Plan Area, including connectivity with lands that have been protected or may be protected in the future under the East Contra Costa HCP/NCCP.

Protection in Conservation Zone 11 will meet the following zone-specific parameters.

- Secure and protect a portion of the 600 acres of existing vernal pool complex to be protected under the BDCP in the Jepson Prairie core recovery area.
- Secure and protect a portion of the 150 acres of existing alkali seasonal wetland to be protected under the BDCP.
- Secure and protect at least2,000 acres of existing grassland.
- Protect lands along the upland fringe of Suisun Marsh to maintain connectivity with much larger protected (e.g., Jepson Prairie Preserve) and unprotected grassland landscapes that are immediately adjacent to the zone.
- Protect a gradient of natural communities that range from grassland upland communities down slope to existing and restored tidal wetland communities.

Nontidal Aquatic and Wetland Natural Communities

The nontidal aquatic and wetland natural communities group is comprised of nontidal freshwater perennial emergent wetland and nontidal aquatic natural communities. Marsh will be restored within or adjacent to habitats occupied by the Yolo Basin/Willow Slough (Conservation Zone 2) and Coldani Marsh/White Slough (Conservation Zone 4) giant garter snake subpopulations and within larger patches of protected upland and cultivated lands for giant garter snake.

Protection for nontidal aquatic and wetland natural communities restoration in Conservation Zone 2 will meet the following zone-specific parameter.

- Secure lands to restore up to 200 acres of nontidal marsh that functions as aquatic habitat for the giant garter snake, in locations to benefit the Yolo Basin/Willow Slough giant garter snake subpopulation.

Protection for nontidal aquatic and wetland natural communities restoration in Conservation Zone 4 will meet the following zone-specific parameter.

- Secure lands to restore up to 200 acres of nontidal marsh that functions as aquatic habitat for the giant garter snake, in locations to benefit the Coldani Marsh/White Slough giant garter snake subpopulation.

The specific amount of marsh that will be restored will be determined based on results of site-specific habitat assessments of the Yolo Basin/Willow Slough and Coldani Marsh/White Slough subpopulations to determine the extent of marsh restoration needed in each location to maximize conservation benefits for the species.

Additional criteria for siting nontidal aquatic and wetland natural communities are provided under *Reserve Design Requirements by Species, Giant Garter Snake*. Nontidal aquatic and wetland restoration requirements are further described under *CM10 Nontidal Marsh Restoration.*

Seasonally Inundated Floodplain and Riparian Natural Community

As described in *CM7 Riparian Natural Community Restoration,* the BDCP Implementation Office will secure sufficient lands to restore at least 5,000 acres of riparian natural community. Most of the 5,000-acre riparian restoration target will be accomplished within an area of at least 10,000 acres to be secured for seasonally inundated floodplain restoration per *CM5 Seasonally Inundated Floodplain Restoration*.

The BDCP Implementation Office will secure and protect sufficient lands for seasonally inundated floodplain and riparian natural community restoration to meet siting and design requirements specified in *CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement,* and *CM7 Riparian Natural Community Restoration.*

Additionally, the BDCP Implementation Office will secure and protect at least 750 acres of existing riparian natural community in Conservation Zone 7. At least 200 acres of this will consist of occupied riparian brush rabbit habitat, as described in *Reserve Design Requirements by Species, Riparian Brush Rabbit.*

Cultivated Lands

The following criteria will be used to select cultivated lands to be maintained under the Plan.

- Effectiveness in contributing towards achieving multiple biological goals and objectives.
- Proximity to active Swainson's hawk nesting territories.
- Proximity to greater sandhill crane roost sites.
- Potential to support crops that provide high-value Swainson's hawk and/or greater sandhill crane foraging habitat.
- Proximity to habitat occupied by the Coldani Marsh/White Slough and Yolo Basin/Willow Slough giant garter snake populations.
- Opportunities to incorporate riparian corridors into cultivated land preserves.
- Opportunities to protect patches of other high-value habitats, such as oak groves, wetlands, tree and hedgerows, that are interspersed among agricultural fields.

The BDCP Implementation Office will protect cultivated lands as follows.

- Maintain 4,600 acres of rice lands or similarly functioning agriculture to provide habitat for giant garter snake, western pond turtle, tricolored blackbird, white-tailed kite, waterfowl, and migrant shorebirds in Conservation Zone 2.
- Maintain 19,800 to 33,700 acres of nonrice cultivated lands as foraging habitat for Swainson's hawk.
- Select cultivated lands to provide connectivity between other protected lands.
- Maintain small patches of important wildlife habitats associated with BDCP conserved cultivated lands, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant oak groves, riparian corridors, water conveyance channels, grasslands, and wetlands.

Additional siting and design criteria for cultivated lands are provided in *Reserve Design Requirements by Species* for greater sandhill crane and Swainson's hawk.

Reserve Design Requirements by Species

*[**Note to Reviewers**: These species-specific requirements are likely to change as a result of the Terrestrial Technical Team coordination process.]*

Although the conservation needs for most of the BDCP covered species will be met through the natural community and conservation zone criteria described above, the following additional species-specific protection and restoration criteria are necessary to ensure that conservation needs and regulatory standards are met for these key species. These criteria were designed to provide as much flexibility as possible while meeting the conservation needs of the species.

Giant Garter Snake

Habitat protection and restoration to support subpopulations. Nontidal freshwater marsh will be restored in locations to benefit the Yolo Basin/Willow Slough (Conservation Zone 2) and Coldani Marsh/White Slough (Conservation Zone 4) subpopulations of giant garter snake. The restoration acreage will be determined based on results of site-specific habitat assessments of the Yolo Basin/Willow Slough and Coldani Marsh/White Slough (Conservation Zone 4) subpopulations to determine the extent of marsh restoration needed in each location to maximize conservation benefits for the species.

Marsh will be restored within or adjacent to habitats occupied by these subpopulations and within larger patches of protected giant garter snake upland and cultivated lands. The BDCP Implementation Office will consult with species experts and use guidance provided in the giant garter snake recovery plan (U.S. Fish and Wildlife Service 1999b) to determine specific locations and patch sizes, and develop specific restoration design criteria and implementation guidance (e.g., vegetation associations, edge habitat, bank slopes, wetland to upland ratio).

Cultivated lands will be protected within or adjacent to habitat occupied by the Coldani Marsh/White Slough subpopulation of giant garter snake to establish a 1,000-acre preserve for this subpopulation, and additional cultivated lands will be protected within or adjacent to habitat occupied by the Yolo Basin/Willow Slough subpopulation to establish a 1,000-acre preserve for this subpopulation. The Implementation Office will consult with giant garter snake species experts to determine appropriate cultivated land protection in proximity to the existing subpopulations, proximity and connectivity with existing and restored nontidal perennial freshwater emergent wetland, and opportunities for population protection and expansion. The specific parcels of cultivated land conserved may vary among years to the extent that they are secured through limited-term conservation easements.

Habitat protection and restoration to provide connectivity. Habitat connectivity, particularly hydrologic connectivity that supports giant garter snake movement and dispersal, is essential for protection of giant garter snake populations. Cultivated lands will be protected and tidal wetlands will be restored along a north-south corridor in Conservation Zone 4 to enhance connectivity and facilitate giant garter snake movement from the Coldani Marsh/White Slough subpopulation north to the Cosumnes River Preserve and to Stone Lakes National Wildlife Refuge.

Freshwater tidal habitat restoration will include areas in Conservation Zone 4 to facilitate connectivity, dispersal, and movement of giant garter snakes into unoccupied suitable habitat in the Delta.

The Implementation Office will protect a corridor that will comprise contiguous patches of cultivated lands, restored tidal and nontidal wetlands, grassland, vernal pool complex, and other seasonal wetlands. This corridor will extend from the Coldani Marsh/White Slough giant garter snake subpopulation area north to Stone Lakes National Wildlife Refuge, and to the extent possible will also connect to the Cosumnes River Preserve. The corridor will be configured to provide contiguous giant garter snake movement habitat along this north-south corridor. To serve as a movement corridor to meet the needs of the giant garter snake, the width of the corridor may not be less than 3,200 feet in any location.

Greater Sandhill Crane

The BDCP Implementation Office will secure and protect lands to meet the following reserve design requirements for greater sandhill crane.

Cultivated lands for protection will be prioritized based on their ability to support compatible crop types for sandhill crane foraging habitat, including alfalfa fields, native grasslands, irrigated pastures, sudan grass, and cereals such as corn, wheat, barley, rye, oats, milo, and rice. The BDCP Implementation Office will secure and maintain cultivated lands to ensure that at any given time, within a foraging range of 6 kilometers from a roost site, at least 80% of conserved land will be suitable for the greater sandhill crane, allowing for the management of the land (i.e., through crop rotation change and flooding) as needed to ensure the continued value of the land in years to come.

Additional siting and design requirements for greater sandhill crane habitat creation are provided in *CM11 Natural Communities Enhancement and Management.*

[Note to reviewer – additional detail will be provided in next draft to describe the quantity, quality, and location of cultivated lands to be protected for this species.]

Swainson's Hawk

The BDCP Implementation Office will protect 19,800 to 33,700 acres of cultivated lands as foraging habitat for Swainson's hawk, distributed within Conservation Zones 1, 2, 3, 4, and 7. Protection of these lands will meet the following criteria.

- Located within 8 miles of Swainson's hawk foraging flight distance from riparian nesting habitats.
- Can support crops that provide suitable Swainson's hawk foraging habitat (such crops include alfalfa and low-growing row crops; rice crops, except during limited periods, orchards, and vineyards are unsuitable for Swainson's hawk foraging).

*[**Note to reviewer:** additional detail will be provided in next draft to describe the quantity, quality, and location of cultivated lands to be protected for this species.]*

Riparian Brush Rabbit

The BDCP Implementation Office will secure and protect lands to meet the following reserve design requirements for riparian brush rabbit.

- Of the 750 acres of riparian natural community to be protected, protect at least 200 acres of occupied riparian brush rabbit habitat in Conservation Zone 7. Occupied habitat will consist of riparian areas, contiguous with habitat with riparian brush rabbit sightings, or capture events within the last 5 years.
- Of the 5,000 acres protected for riparian restoration, secure and protect sufficient lands to restore 300 acres of early-to-mid-successional riparian habitat that meets the ecological requirements of the riparian brush rabbit and that are within or adjacent to or that facilitate connectivity with existing occupied or potentially occupied habitat.

Riparian Woodrat (San Joaquin Valley)

The BDCP Implementation Office will secure and protect lands to meet the following reserve design requirement for riparian woodrat.

- Of the 5,000 acres protected for riparian restoration, secure sufficient lands to restore 300 acres that meets the ecological requirements of the riparian woodrat (i.e., dense willow understory and oak overstory) and that is within or adjacent to or that facilitates connectivity with existing occupied or potentially occupied habitat.

The ecological requirements for restored riparian woodrat habitat are described in *CM7 Riparian Natural Community Restoration*.

Valley Elderberry Longhorn Beetle

The BDCP Implementation Office will secure and protect lands to meet the following reserve design requirements for valley elderberry longhorn beetle.

- Secure and protect sufficient lands within drainages immediately adjacent to or in the vicinity of known populations of the beetle to mitigate for impacts resulting from BDCP activities consistent with the USFWS (1999a) valley elderberry longhorn beetle mitigation guidelines.

Plants

The BDCP Implementation Office will secure and protect lands to meet the following reserve design requirements for covered plant species.

- Of the 8,750 acres of protected alkali seasonal wetland complex, vernal pool complex, and grassland natural community, protect 150 acres that support heartscale and brittlescale modeled habitat.
- Protect at least one unprotected occurrences of brittlescale in Conservation Zones 1, 8, or 11.
- Protect at least 2 currently unprotected occurrences of alkali milk-vetch in the Altamont Hills or Jepson Prairie Core Recovery Areas (Conservation Zones 1, 8 or 11).
- Protect and/or establish at least 2 currently unprotected occurrences of Heckard's peppergrass in Conservation Zones 1, 8, or 11.
- Protect and/or establish at least 2 unprotected occurrences of San Joaquin spearscale in Conservation Zones 1, 8, or 11.
- Protect at least one unprotected occurrences of Carquinez goldenbush in Conservation Zones 1 and/or 11.

Preacquisition Surveys and Assessments

The BDCP Implementation Office will develop and implement protocols for assessing lands being considered for acquisition. Preacquisition surveys will be conducted by qualified biologists and other qualified scientists or technical experts as appropriate under agreements with the landowners. Surveys will assess the physical and biological attributes of the lands and the extent to which acquisition would meet the BDCP biological goals and objectives and siting and design criteria and considerations described above. Surveys will also identify natural communities and covered species present or potentially present on the lands, for which measures provided in *CM22 Avoidance and Minimization Measures* would apply.

Site-Specific Restoration Plans

Restoration will be implemented consistent with site-specific plans for each project. Each site-specific plan will include the following elements.

- A description of the hydrology, topography, soils/substrate, and vegetation for the existing condition of the site, and the anticipated condition of the restored site.
- Applicable BDCP biological goals and objectives to which the restoration would contribute.
- Success criteria for determining whether the desired condition for the restoration has been met.
- An implementation plan and schedule that describes site preparation, plantings and seeding, and irrigation, as applicable.
- Applicable avoidance and minimization measures as described in Appendix 3.C, *Avoidance and Minimization Measures.*
- A description of maintenance activities and a maintenance schedule to be implemented until success criteria are met.
- A description of contingency measures to be implemented if success criteria are not met within the established monitoring timeframe.

These contingency measures will differ from adaptive management described in Section 3.6, *Adaptive Management and Monitoring Program*. These measures will be site-specific and will be targeted specifically toward meeting the success criteria indicated in the site-specific restoration plan.

3.4.4.3.4 Restoration Project Planning

Restoration project planning will include a conceptual planning phase and a project-specific phase. During the conceptual planning phase, conceptual designs will be developed for the purpose of evaluating alternatives based on the site selection and design considerations described above, and project feasibility will be evaluated. This phase will involve interagency and stakeholder coordination to examine and evaluate restoration opportunities. The conceptual planning phase will result in the identification of site-specific restoration projects.

Once each site-specific restoration project has been identified, the project-specific phase will involve site acquisition, the preparation of a site-specific restoration plan (see *Site-Specific Restoration Plans*, above), and relevant project review and permitting. The restoration construction, monitoring, and management to achieve restoration success criteria will then be implemented consistent with the site-specific restoration plan, and long-term monitoring and management will be implemented consistent with provisions under *CM11 Natural Communities Enhancement and Management* and Section 3.6, *Adaptive Management and Monitoring Program.*

South Delta Restoration Planning

The South Delta Habitat Working Group is currently in the conceptual planning phase, as described above, for land acquisition and natural community restoration in the south Delta. This effort involves coordination with stakeholders, a separate technical working group comprised of agency scientists, and a consultant team of engineers and scientists. Groups participating in the South Delta Habitat Working Group include USACE, DFG, South Delta Water Agency, Contra Costa Water District, San Joaquin County, San Joaquin Council of Governments, San Joaquin County Vector Control, North Delta Water Agency, American Rivers, Ducks Unlimited, PRBO Conservation Science, River Partners, Kern County Water Agency, Metropolitan Water District, Santa Clara Valley Water District, State Water Contractors, Westlands Water District, San Joaquin River Group Authority, River Islands LLC, and the Cities of Lathrop and Stockton.

South Delta Habitat Working Group has identified, in concept-level planning, four south Delta corridors (Figure 3.4-7) for potential implementation of floodplain restoration. The corridors incorporate actions such as levee setbacks, creation of flood bypasses, riparian planting, and channel margin enhancement. This information is currently developed only at a conceptual level of detail, intended for the purpose of evaluating the relative potential benefits that each corridor may be able to provide. Further planning may detail plans in one or more corridors, as appropriate, for restoration as described above for project-level phases.

The initial South Delta Habitat Working Group evaluation uses hydraulic models and a conceptual ecosystem assessment of the corridors to define positive and negative outcomes for species, habitats, water quality, flood conveyance, and flood risk reduction. These outcomes are evaluated using the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) conceptual models and the DRERIP evaluation process, drawing on the expertise of a group of agency and academic scientists and engineers. This evaluation group will subsequently generate conclusions that can guide more focused implementation at locations where relative benefits are high and apparent risks are low. Outcomes that are uncertain will be identified, as will professional disagreements where existing scientific literature or empirical data are lacking. This transparent depiction of the outcomes, identification of uncertainties, and outlining of issues where disagreement may remain will allow subsequent planning and design efforts to concentrate on resolving uncertainty and disagreement through focused research or analysis prior to implementation.

South Delta Habitat Working Group has identified the potential to implement *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration* in Corridors 2, 3, and 4. All of these conservation measures, except *CM4 Tidal Natural Communities Restoration,* could also be implemented in Corridor 1. While assessment and planning are presently limited to conceptual efforts, work to date has shown that the corridors provide substantial opportunities to reestablish channel margin habitat and tidal marsh. These natural communities would be created via actions to set back levees and construct flood bypasses that would provide the ancillary benefit of redistributing flood flows away from river reaches that are more constrained in terms of potential loss of human life and property damage. The results of Phase 1 efforts for the south Delta will be used to guide a more focused effort to plan and implement projects in those locations found to have the highest potential benefits and the lowest flood management risk.

Adaptive Management and Monitoring

Each site will be managed in perpetuity as described in *CM11 Natural Communities Enhancement and Management.* Restoration projects will initially be managed and maintained consistent with the site-specific restoration plans until restoration success criteria have been met, and will henceforth be managed and monitored consistent with the long-term management and adaptive monitoring program, as described in Section 3.6, *Adaptive Management and Monitoring Program*.

3.4.5 Conservation Measure 4 Tidal Natural Communities Restoration

Under *CM4 Tidal Natural Communities Restoration*, the BDCP Implementation Office will provide for the restoration of at least 65,000 acres of tidal perennial aquatic, tidal mudflat, tidal freshwater emergent wetland, and tidal brackish emergent wetland natural communities within the BDCP ROAs (Figure 3.2-2). Tidal natural communities will be restored along a contiguous gradient encompassing shallow subtidal aquatic[3], tidal mudflat, tidal marsh plain[4], and adjoining transitional upland natural communities. The transitional upland areas, which are included in the 65,000-acre total, will accommodate approximately 3 feet of sea level rise in topographic settings, and can function as tidal marsh plain at some future time, if necessary.

The restoration will be phased to develop[5] 14,000 acres within the first 10 years of Plan implementation, 25,000 acres (cumulative) by year 15 of Plan implementation, and 65,000 acres

[3] The shallow subtidal extends approximately from the mean lower low water elevation to 9 feet below the mean lower low water elevation.

[4] Tidal marsh plain extends from the mean lower low water elevation to the mean higher high water elevation.

[5] In achieving these targets the term *developed* means the complete reintroduction of tidal inundation to areas expected to develop as tidal natural communities. These target values represent the areas developed at the points in time identified. Development of fully functioning restored natural communities may take years subsequent to initial tidal inundation through the effects of natural processes on the constructed surface.

(cumulative) by year 40 of Plan implementation. This schedule includes 5 years of success monitoring following completion of restoration construction.

Refer to Chapter 6, *Plan Implementation,* for details on the timing and phasing of CM4. The process for identifying specific lands and planning individual restoration projects is described in *CM3 Natural Communities Protection and Restoration*. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM4 on covered species will be avoided or minimizedRefer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.1.1 Purpose

The primary purpose of CM4 is to meet or contribute to biological goals and objectives as identified in Table 3.4-6. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-6. Biological Goals and Objectives Addressed by CM4 Tidal Natural Communities Restoration

Biological Goal or Objective	How CM4 Advances a Biological Objective
Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.	
Objective L1.3: Restore or create at least 72,809 acres of natural communities, including at least 65,000 acres of tidally influenced natural communities.	Restore 65,000 acres of freshwater and brackish tidal natural communities, as described under Section 3.4.5.3.1, *Required Actions.*
Objective L1.7: To accommodate projected future sea level rise, within the 65,000 acres of tidal restoration include sufficient upland transitional areas adjacent to restored brackish and freshwater tidal emergent wetlands to permit the future upslope establishment of tidal emergent wetland communities; also include additional noncultivated upland to provide habitat and high-tide refugia for native wildlife.	See Section 3.4.5.3.1, *Required Actions.*
Objective L1.8: To accommodate projected future sea level rise, provide potential tidal marsh plain habitat within the anticipated future eastward position of the low salinity zone of the estuary.	See siting and design considerations discussed under West Delta ROA. Restoration in the West Delta ROA will provide tidal marsh plains within the anticipated future eastward position of the low salinity zone of the estuary with sea level rise.

Biological Goal or Objective	How CM4 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.5: Promote water quality conditions within the Delta that help restore native fish habitat.	Restoration of tidal brackish emergent wetland in areas that are currently managed wetlands in Suisun Marsh ROA is expected to reduce periodic low dissolved oxygen events associated with the discharge of waters from lands managed as seasonal freshwater wetlands (Siegel 2007). Suisun Marsh tidal natural communities restoration is also expected to provide cool water refugia for delta smelt.
Objective L2.6: Maintain or increase life-history diversity of native fish species and a diversity of spawning and rearing conditions for native fish species over time.	Tidal natural communities restoration is expected to increase rearing habitat area for Chinook salmon, Sacramento splittail, and possibly steelhead in the Suisun Marsh ROA; Chinook salmon (Sacramento River runs), splittail, green and/or white sturgeonin the Cache Slough ROA; Cosumnes/Mokelumne fall-run Chinook salmon, steelhead, delta smelt, and splittail in the Cosumnes/Mokelumne ROA; Chinook salmon (Sacramento, San Joaquin, and Mokelumne river runs), splittail, and possibly steelhead in the West Delta ROA; and splittail, Chinook salmon produced in the San Joaquin River and other eastside tributaries, and possibly steelhead in the South Delta ROA. Tidal natural communitiesrestoration in West Delta ROA is also expected to improve future rearing habitat areas for delta smelt and longfin smelt within the anticipated eastward movement of the low salinity zone with sea level rise.
Objective L2.9: Provide refuge habitat for migrating and resident covered fish species.	Tidal natural communities restoration in West Delta ROA will accomplish this objective.
Objective L2.10: Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways.	Restoration of tidal natural communities as described in Section 3.4.5.3, *Implementation,* will contribute toward this objective. Restored emergent wetlands are expected to increase local production of organic materials and organisms that support the aquatic food web, and tidal action is expected to transport food resources via tidal channels to fish habitat. Food resources from the Suisun Marsh ROA would be transported to Suisun Bay to benefit rearing salmonids, splittail, and delta and longfin smelt. From Cache Slough ROA resources would be transported downstream of Rio Vista into the Delta and Suisun Marsh to benefit salmonids, splittail, delta smelt, and sturgeon. From the Cosumnes/Mokelumne ROA resources would be transported into the east and central Delta to benefit fall-run Chinook salmon, steelhead, delta smelt, and splittail migrating to and from the Cosumnes and Mokelumne Rivers, and to the east and central Delta to benefit juvenile salmonids, splittail, delta smelt, and sturgeon. Restoration in the West Delta and South Delta ROAs is expected to increase local food production for rearing salmonids and splittail, and increase availability

Biological Goal or Objective	How CM4 Advances a Biological Objective
	and production of food in the western Delta and Suisun Bay by export via tidal flow.
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	Plan and implement tidal natural communitiesrestoration projects consistent with the siting and design considerations for the West Delta ROA. Tidal brackish restoration in the Suisun Marsh and West Delta ROAs will improve connectivity, and provide a continuous reach of tidal marsh and subtidal aquatic natural communities between Yolo Bypass, the Cache Slough Complex, and Suisun Marsh and Suisun Bay.
Objective L3.2: Promote connectivity between low salinity zone habitats and upstream freshwater habitats, and availability of spawning habitats for native pelagic fish species.	The target acreage of tidal natural communitiescreation and the broad distribution of restoration project sites across the ROAs serve to increase connectivity by providing shallow-water rearing and migration habitats across the range of tidal settings in the Delta.
Goal TPANC1: Tidal perennial aquatic natural community that supports habitats for covered and other native species and that supports aquatic food web processes.	
Objective TPANC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 10,000 acres of tidal perennial aquatic in Conservation Zones 1, 2, 4, 5, 7, and 11 that support aquatic food production and habitat for covered and other native species.	See *Required Actions*.
Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.	
Objective TBEWNC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 4,800 acres of tidal brackish emergent wetland in Conservation Zone 11.	See *Required Actions* and *Minimum Restoration Targets*.
Objective TBEWNC1.2: Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them.	Plan and implement tidal natural communities restoration projects consistent with *Required Actions.*
Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.	
Objective TFEWNC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 13,900 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.	See Section 3.4.5.3.3, *Methods and Techniques, Freshwater Tidal Natural Communities Restoration.*
Objective TFEWNC1.2: Restore tidal freshwater emergent wetlands in areas that increase connectivity among protected lands.	Plan and implement tidal natural communities restoration projects consistent with *Required Actions*.

Biological Goal or Objective	How CM4 Advances a Biological Objective
Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.	
Objective TBEWNC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 4,800 acres of tidal brackish emergent wetland in Conservation Zone 11.	See Section 3.4.5.3.3, *Methods and Techniques, Freshwater Tidal Natural Communities Restoration.*
Notes: ROA = restoration opportunity area	

3.4.5.1 Problem Statement

For descriptions of the ecological values and current condition of tidal natural communities in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for tidal natural communities restoration as a component of the conservation strategies for each of the tidal natural communities and associated covered species, based on the existing conditions and ecological values of these resources. The discussion below describes existing conditions and tidal natural communities restoration opportunities in each of the ROAs.

3.4.5.1.1 Suisun Marsh Restoration Opportunity Area

Suisun Marsh ROA encompasses the Suisun Marsh and is at the western end of the Plan Area, in Conservation Zone 11. Suisun Marsh is the largest brackish marsh complex in the western United States. The majority of historic brackish tidal marsh has been lost; only approximately 8,300 acres remain in Suisun Marsh. This loss of tidal marsh has greatly reduced the availability and quality of spawning and rearing habitat for many native species by reducing the input of organic and inorganic material and food resources into adjoining deep water habitats (sloughs and channels) and the downstream bay and estuary. This loss of brackish tidal marsh has also greatly reduced the extent and quality of habitat for native wildlife and plants adapted to the tidal marsh environment, including many of the covered species.

Those areas suitable for tidal natural communities restoration in Suisun Marsh ROA consist of diked wetlands that are managed for waterfowl and experience little natural tidal action. These managed areas are separated from tidal sloughs by gated culverts and other gated structures that control water exchange and salinity. Waterfowl club managers control the timing and duration of flooding to promote growth of food plants for waterfowl. Some of these are managed as perennial wetlands, others are dry-managed during the summer and early fall months, and are then prepared for waterfowl habitat and hunting with a series of flood-drain-flood cycles. The periodic flooding and discharge of managed wetlands can lead to periods of severely low dissolved oxygen (DO) events in adjoining water bodies, which causes acute mortality in at-risk fish species and impairs valuable fish nursery habitat. Co-occurring with these low DO levels are elevated levels of methylmercury, a neurotoxin endemic to the Delta that bioaccumulates in the foodweb and adversely affects fish and wildlife.

The Suisun Marsh ROA provides opportunities for tidal natural communities restoration to accomplish the following objectives.

- Increase rearing habitat area for Chinook salmon, splittail, and possibly steelhead (Healey 1991; Siegel 2007).
- Increase the local production of food for rearing salmonids, and splittail (Kjelson et al. 1982).
- Provide an important linkage between current and future upstream restored habitat, such as Yolo Bypass/Cache Slough with Suisun Marsh/Bay.
- Increase the availability and production of food in Suisun Bay for juvenile and adult delta and longfin smelt by exporting organic material via tidal flow from the marsh plain and phytoplankton, zooplankton, and other organisms produced in tidal channels into the Bay.
- Provide local areas of cool water refugia for delta smelt (Enright pers. comm.).
- Reduce periodic low DO events associated with the discharge of waters from lands managed as seasonal freshwater wetlands that would be restored as brackish tidal habitat (Siegel 2007; Enright pers. comm.).
- Increase the extent of habitat available for colonization by Suisun Marsh aster and soft-bird's-beak.
- Enhance and increase the extent and connectivity of habitat for salt marsh harvest mouse, Suisun shrew, California clapper rail, California black rail, and Suisun song sparrow.

3.4.5.1.2 Cache Slough Restoration Opportunity Area

The Cache Slough ROA includes the southern end of the Yolo Bypass and lands to the west supporting a complex of sloughs and channels in Conservation Zones 1 and 2. The Cache Slough Complex supports multiple covered fish species and may be one of the last areas where delta smelt spawn and rear successfully. The Cache Slough Complex has been recognized as possibly the best functioning existing tidal natural communities area of the Delta. The complex includes Liberty Island, which is likely the best existing model for freshwater tidal natural community restoration in the Delta for native fishes. Additionally, the Cache Slough Complex encompasses a substantial area of land with elevations suitable for freshwater tidal natural community restoration that would involve few impacts on existing infrastructure or permanent crops relative to other areas of the north Delta. The Cache Slough Complex provides an excellent opportunity to expand the natural communities supporting multiple aquatic and terrestrial covered species. Based on existing land elevations, approximately 21,000 acres of public and private lands in the area are potentially suitable for restoration of tidal habitat. Areas suitable for restoration in the Cache Slough ROA include, but are not limited to, Haas Slough, Hastings Cut, Lindsey Slough, Barker Slough, Calhoun Cut, Little Holland, Yolo Ranch, Shag Slough, Little Egbert Tract, and Prospect Island.

Cache Slough ROA provides opportunities for tidal natural communities restoration to accomplish the following objectives.

- In conjunction with floodplain enhancement in the Yolo Bypass, re-establish the ecological gradient from river floodplain to tidal estuary and provide tidal wetland adjacent to open channel habitat that is characteristic of less altered estuaries.
- Reduce bidirectional flows in Steamboat and Sutter Sloughs and the mainstem Sacramento River compared to tidal action under present conditions, thus significantly enhancing movement of

juvenile salmonids through these waterways and potentially reducing their exposure to predators and the risk of impingement from the north Delta conveyance facilities.

- Increase rearing habitat area for Chinook salmon (Sacramento River runs), splittail, and sturgeon (Healey 1991; Brown 2003; Essex Partnership 2009).
- Increase the local production of food for rearing salmonids, splittail, delta smelt, and sturgeon (Kjelson et al. 1982; Siegel 2007).
- Increase the export of food in the Delta downstream of Rio Vista available to juvenile salmonids, splittail, delta smelt, and sturgeon by exporting organic material from the marsh plain and phytoplankton, zooplankton, and other organisms produced in tidal channels into the Delta and Suisun Marsh (Siegel 2007).
- Expand habitat available for colonization by Mason's lilaeopsis, Suisun Marsh aster, delta mudwort, and Delta tule pea.
- Expand habitat for tricolored blackbird, California black rail, and giant garter snake (in locations with a muted tidal range).

3.4.5.1.3 Cosumnes/Mokelumne Restoration Opportunity Area

The Cosumnes/Mokelumne ROA is located in the eastern portion of the Plan Area, in Conservation Zone 4. This ROA consists primarily of cultivated lands and a complex of sloughs and channels at the confluence of the Cosumnes and Mokelumne Rivers, providing an opportunity to create extensive gradients of tidal and nontidal wetlands. This ROA includes important sites of Areas suitable for restoration within the Cosumnes/Mokelumne ROA (Figure 3.2-2) include McCormack-Williamson, New Hope, Canal Ranch, Bract, and Terminous Tracts north of State Highway 12, and lands adjoining Snodgrass Slough, South Stone Lake, and Lost Slough.

The Cosumnes/Mokelumne ROA provides opportunities to accomplish the following objectives.

- Increase rearing habitat area for Cosumnes/Mokelumne fall-run Chinook salmon, steelhead, delta smelt, and splittail (Healey 1991; Brown 2003).
- Increase the local production of food for Cosumnes/Mokelumne fall-run Chinook salmon, steelhead, delta smelt, and splittail migrating to and from the Cosumnes and Mokelumne Rivers (Kjelson et al. 1982; Siegel 2007).
- Increase the availability and production of food in the east and central Delta available to juvenile salmonids, splittail, delta smelt, and sturgeon by exporting organic material from the marsh plain and phytoplankton, zooplankton, and other organisms produced in tidal channels into the Delta (Siegel 2007).
- Increase the extent of habitat available for colonization by side-flowering skullcap, Mason's lilaeopsis, Suisun Marsh aster, and Delta tule pea.
- Expand habitat for tricolored blackbird, California black rail, greater sandhill crane, and giant garter snake (in locations with a muted tidal range).

3.4.5.1.4 West Delta Restoration Opportunity Area

The West Delta ROA consists of multiple small areas where tidal natural communities can be restored in the western Delta, in Conservation Zones 5 and 6. It primarily supports cultivated lands and grasslands in areas that were historically tidal wetlands but have been diked and hydrologically altered, isolating tidal natural communities in the Cache Slough Complex from Suisun Marsh. Areas suitable for restoration include Dutch Slough, Decker Island, portions of Sherman Island, Jersey Island, Bradford Island, Twitchell Island, Brannon Island, Grand Island, and along portions of the north bank of the Sacramento River where elevations and substrates are suitable.

The West Delta ROA provides opportunities for tidal natural communities restoration to accomplish the following objectives.

- Provide a continuous reach of tidal marsh and subtidal aquatic habitat associated with food productivity between current and future restored habitats in the Cache Slough Complex and Suisun Marsh and Bay.
- Provide tidal marsh plain habitat within the anticipated future eastward position of the biologically important low salinity zone of the estuary with sea level rise.
- Increase rearing habitat area for Chinook salmon (Sacramento, San Joaquin, and Mokelumne River runs), splittail, and possibly steelhead (Healey 1991; Brown 2003).
- Improve future rearing habitat areas for delta smelt and longfin smelt within the anticipated eastward movement of the low salinity zone with sea level rise.
- Increase the local production of food for rearing salmonids, splittail, and other covered species (Kjelson et al. 1982; Siegel 2007).
- Increase the availability and production of food in the western Delta and Suisun Bay by exporting organic material via tidal flow from the marsh plain and organic carbon, phytoplankton, zooplankton, and other organisms produced in tidal channels into adjacent open water areas (Siegel 2007).
- Provide an important linkage between current and future upstream restored habitat with downstream habitat in Suisun Marsh and Bay.
- Provide additional refugial habitat for migrating and resident covered species.
- Increase the extent of habitat available for colonization by Mason's lilaeopsis, Suisun Marsh aster, delta mudwort, and Delta tule pea.
- Expand habitat for tricolored blackbird, California black rail, and giant garter snake (in locations with a muted tidal range).

3.4.5.1.5 South Delta Restoration Opportunity Area

The South Delta ROA, located in Conservation Zone 7, consists primarily of cultivated lands and a riverine system including the San Joaquin River and its tributaries. Potential sites for restoring freshwater tidal habitat include Fabian Tract, Union Island, Middle Roberts Island, and Lower Roberts Island. The South Delta ROA provides opportunities for tidal natural communities restoration to accomplish the following objectives.

- Increase rearing habitat area for splittail, Chinook salmon produced in the San Joaquin River and other eastside tributaries, and possibly steelhead (Healey 1991; Brown 2003).
- Increase the local production of food for rearing salmonids, Sacramento splittail, and other covered species (Kjelson et al. 1982; Siegel 2007).
- Increase the availability and production of food in the Delta and Suisun Bay by export from the south Delta of organic material via tidal flow from the new marsh plain and organic carbon, phytoplankton, zooplankton, and other organisms produced in new tidal channels (Siegel 2007).
- In conjunction with dual conveyance operations, support the expansion of the current distribution of delta smelt into formerly occupied habitat areas.
- Increase the extent of habitat available for colonization by Mason's lilaeopsis, delta mudwort, and Delta tule pea.
- Expand habitat for tricolored blackbird, California black rail, greater sandhill crane, and giant garter snake (in locations with a muted tidal range).

3.4.5.2 Implementation

3.4.5.2.1 Required Actions

Tidal natural communities restoration sites will be designed to support natural communities mosaics for sea level rise accommodation including ecological gradient of shallow subtidal aquatic, tidal mudflat, tidal marsh, riparian habitats and transitional upland (within the sea level rise accommodation area), and uplands (e.g., grasslands, cultivated lands above the sea level rise accommodation area), as appropriate to specific restoration sites.

Actions to restore freshwater and brackish tidal natural communities, as appropriate to site-specific conditions, will include the following measures.

- Secure lands, in fee-title or through conservation easements, suitable for restoring tidal habitats and protect sufficient adjacent uplands to accommodate the future upslope establishment of tidal emergent wetland communities with sea level rise, and to provide upland habitat and refugia for native wildlife (*CM3 Natural Communities Protection and Restoration*).
- Design and implement site-specific avoidance and minimization measures consistent with those described in Appendix 3.C, *Avoidance and Minimization Measures*, to minimize effects on covered species.
- Restore tidal wetland using techniques and methods described below (*Methods and Techniques*) to accomplish the following goals.
    - Reestablish tidal connectivity to reclaimed lands and reintroduce tidal exchange to currently leveed former tidelands.
    - Restore and create sinuous and high density dendritic channel networks within the restored marsh plains.
    - Restore tributary stream functions to establish more natural patterns of sediment transport and improve spawning conditions for delta smelt and other covered fish and macroinvertebrates.

- Design levee and dike breaches to maximize the development of tidal marsh plain and minimize hydrodynamic conditions that favor nonnative predatory fish.

Measures to minimize the potential for methylation of mercury in restored tidal natural communities are described in *CM12 Methylmercury Management.*

3.4.5.2.2 Minimum Restoration Targets

Of the 65,000-acre restoration target, 44,400 acres must occur in particular ROAs. The remaining 20,600 acres will be distributed among the ROAs (Figure 3.2-2) consistent with the following minimum restoration targets.

- Restore 7,000 acres of brackish tidal natural community, of which at least 4,800 acres are tidal brackish emergent wetland, in Suisun Marsh ROA.
- Restore 5,000 acres of freshwater tidal natural community in the Cache Slough Complex ROA.
- Restore 1,500 acres of freshwater tidal natural community in the Cosumnes/Mokelumne ROA.
- Restore 2,100 acres of freshwater tidal natural community in the West Delta ROA.
- Restore 5,000 acres of freshwater tidal natural community in the South Delta ROA.

Restoration actions distributed among the ROAs will be implemented at the discretion of the BDCP Implementation Office based on land availability, practicability consideration, the siting and design considerations described below, and opportunities for meeting the biological goals and objectives. Priority will be given to restoration that meets multiple biological goals and objectives for multiple covered species.

3.4.5.2.3 Methods and Techniques

The following general methods and techniques will be used to achieve the purposes of CM4.

- Restoring natural remnant meandering tidal channels.
- Excavating channels to encourage the development of sinuous, high density dendritic channel networks within restored marsh plain.
- Modifying ditches, cuts, and levees to encourage more natural tidal circulation and better flood conveyance based on local hydrology.
- Prior to breaching, recontouring the surface to maximize the extent of surface elevation suitable for establishment of tidal marsh vegetation (marsh plain) by scalping higher elevation land to provide fill for placement on subsided lands to raise surface elevations.
- Prior to breaching, importing dredge or fill and placing it in shallowly subsided areas to raise ground surface elevations to a level suitable for establishment of tidal marsh vegetation (marsh plain).
- Prior to breaching, cultivating stands of tules through flood irrigation for sufficiently long periods to raise subsided ground surface to elevations suitable to support marsh plain and breaching levees when target elevations are achieved.

Freshwater Tidal Natural Communities Restoration

Freshwater tidal natural communities will be restored by breaching or removing levees along Delta waterways. Tidal natural communities restored on deeply subsided Delta tracts and islands may require construction of cross levees or berms to isolate deeply subsided lands from inundation, avoiding the creation of large areas of subtidal natural communities that could favor nonnative predator or competitor species and disfavor covered fish species. Where required, levees or berms will be constructed to prevent inundation of adjacent lands.

Where practicable and appropriate, portions of restoration sites will be raised to elevations that will support tidal marsh vegetation following breaching. Depending on the degree of subsidence and location, lands may be elevated by grading higher elevations to fill subsided areas, importing dredged or fill material from other locations, or planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation. Surface grading will provide for a shallow elevation gradient from the marsh plain to the upland transition habitat. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration activities may be designed and implemented in a manner that accelerates the development of tidal channels within restored marsh plains. Following reintroduction of tidal exchange, tidal marsh vegetation is expected to establish naturally at suitable elevations relative to the tidal range. Depending on site-specific conditions and monitoring results, patches of native emergent vegetation may be planted to accelerate the establishment of native marsh vegetation on restored marsh plain surfaces. A conceptual illustration of restored freshwater tidal natural community is presented in Figure 3.4-8.

Brackish Tidal Natural Community Restoration

The brackish tidal natural communities will be restored by breaching or removing dikes along Montezuma and other Suisun Marsh sloughs and channels and Suisun Bay. Disconnected remnant sloughs will be reconnected to Suisun Bay and remnant slough levees will be removed to reintroduce tidal connectivity to slough watersheds. Tidal natural communities restored adjacent to farmed lands or lands managed as freshwater seasonal wetlands may require construction of dikes to maintain those land uses. Where appropriate, portions of restoration sites will be raised to elevations that would support tidal marsh vegetation.

Depending on the degree of subsidence, location, and likelihood for natural accretion through sedimentation, lands may be elevated by grading higher elevations to fill subsided areas, importing dredged or fill material from other locations, or planting appropriate native vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation prior to breaching dikes. Surface grading will be designed to result in a shallow elevation gradient from the marsh plain to the upland transition habitat. Remnant disconnected tidal channels will be restored if present in restoration sites to accelerate development of marsh functions. Existing tidal channels may also be deepened or widened if necessary to increase tidal flow. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration sites may be graded to accelerate the development of tidal channels within restored marsh plains. Following reintroduction of tidal exchange, tidal marsh vegetation is expected to naturally establish at suitable elevations relative to the tidal range. Depending on site-specific conditions and monitoring results, patches of native emergent vegetation may be planted to accelerate the establishment of native marsh vegetation on restored marsh plain surfaces. A conceptual illustration of restored brackish tidal habitat is presented in Figure 3.4-9.

Because land surface elevations in Suisun Marsh are relatively homogenous, opportunities to provide linkages to upland habitats are limited to restoration sites that are located along the fringe of Suisun Marsh. Dikes constructed to restore tidal natural communities in the interior of Suisun Marsh will be designed with low gradient slopes supporting high marsh and upland vegetation to provide flood refuge habitat. Where appropriate, higher elevation islands of upland habitat within restored tidal habitat may also be created to provide flood refuge for marsh wildlife.

3.4.5.2.4 Siting and Design Considerations

Tidal natural communities restoration sites will be designed to support habitat mosaics and an ecological gradient of shallow subtidal aquatic, tidal mudflat, tidal marsh, transitional upland and riparian natural communities, and uplands (e.g., grasslands, cultivated lands) for sea level rise accommodation, as appropriate to specific restoration sites.

The BDCP Implementation Office will consider the following restoration variables in the design of restored freshwater tidal natural communities.

- Distribution, extent, location, and configuration of existing and proposed restored tidal natural communities areas.
- Potential for improving habitat linkages that allow covered and other native species to move among protected habitats within and adjacent to the Plan Area.
- For tidal brackish restoration, distribution of restored tidal natural communities along salinity gradients to optimize the range and habitat conditions for covered species and food production.
- Predicted tidal range at tidal natural communities restoration sites following reintroduction of tidal exchange.
- Size and location of levee breaches necessary to restore tidal action.
- Cross-sectional profile of tidal natural communities restoration sites (elevation of marsh plain, topographic diversity, depth, and slope).
- Density and size of restored tidal channels appropriate to each restoration site.
- Potential hydrodynamic and water quality effects on other areas of the Delta.

Restoration for tidal natural communities will include the following design considerations.

- **Marsh plain vegetation.** In the Suisun Marsh ROA, restored tidal marsh plains will be dominated by native brackish marsh vegetation (e.g., pickleweed, saltgrass) appropriate to marsh plain elevations, mimicking the composition and densities of historical Suisun Bay brackish tidal marshes. Other ROAs will be vegetated primarily with tules and other native freshwater emergent vegetation to reflect the historical composition and densities of Delta tidal marshes. Following establishment of tidal exchange, restored natural communities will be monitored to assess the establishment of native and invasive nonnative plants. If indicated by monitoring results, the Implementation Office will implement invasive plant control measures to help ensure the establishment of native marsh plain plant species.

- **Hydrodynamic conditions.** Tidal natural communities restoration will be designed, within restoration site constraints, to produce sinuous, high density, dendritic networks of tidal channels that promote effective tidal exchange throughout the marsh plain and provide foraging habitat for covered fish species.
- **Flow velocities.** Marsh channels and levee breaches will be designed to maintain flow velocities that minimize conditions favorable to the establishment of nonnative submerged and floating aquatic vegetation and habitat for nonnative predatory fish.
- **Tidal action.** Following breaching and reintroduction of tidal action to restoration sites, tidal action will begin the natural process of sediment movement and the restored bottom contours will evolve. A discussion of the types of changes expected is provided in Appendix 3.B, *Marsh Evolution* [***Note to Reviewers:*** *Previously Appendix N-4; this appendix is still in preparation*].
- **Environmental gradients.** As determined by site-specific constraints, tidal natural communities restoration actions will be designed to provide an ecological gradient among subtidal, tidal mudflat, tidal marsh plain, riparian, and upland habitats to accommodate the movement of fish and wildlife species and provide flood refuge habitat for marsh-associated wildlife species during high water events. In addition, by protecting higher elevation lands adjacent to restored marsh plains, these areas will be available for future marsh establishment that may occur as a result of sea level rise.
- **Shallow subtidal aquatic habitat.** Restored shallow subtidal aquatic habitat is expected to support, depending on location, delta smelt, longfin smelt, juvenile salmonid rearing, sturgeon, and lamprey habitat. Shallow freshwater subtidal aquatic habitat in some portions of the Delta support large numbers of nonnative predatory fish and extensive beds of nonnative submerged aquatic vegetation that adversely affect covered fish species. In other portions of the Delta, shallow subtidal habitat provides suitable habitat for native species, such as delta smelt in the Liberty Island/Cache Slough area, and does not promote the growth of nonnative submerged aquatic vegetation. Because it may generate habitat for nonnative predators, it is not a goal of the BDCP to restore large areas of shallow subtidal aquatic habitat; rather, shallow subtidal aquatic habitat will result as part of the restoration of freshwater tidal marsh plain where land surface elevations within restoration sites are subsided below elevations that would support tidal marsh vegetation. Tidal natural communities restoration projects will be designed to minimize the establishment of nonnative submerged aquatic vegetation, which may serve as habitat for nonnative predators. Early restoration projects will be monitored to assess the response of nonnative species to restoration designs and local environmental conditions. This information will be used to modify restoration designs and implementation methods, if necessary, over time to further improve habitat conditions for covered fish species. As described in *CM13 Invasive Aquatic Vegetation Control,* the BDCP Implementation Office will actively remove submerged and floating aquatic vegetation in subtidal portions of tidal natural communities restoration sites to reduce the levels of establishment of nonnative predators.

Siting and Design Considerations for Specific Restoration Opportunity Areas

The BDCP Implementation Office will restore tidal natural communities in the Suisun Marsh and South Delta ROAs (Figure 3.2-2) based on the following additional siting and design considerations.

- **Suisun Marsh ROA.** Brackish tidal natural community will be restored in Suisun Marsh ROA in coordination with the Suisun Marsh Habitat Restoration and Management Plan, currently under development. Restored tidal natural communities will be designed to create ecological gradients that support a mosaic of tidal marsh, tide flat, shallow subtidal aquatic, and transitional upland habitats as appropriate to specific restoration sites. The selection and design of restored tidal natural communities in Suisun Marsh will consider potential hydrodynamic and water quality effects of the proposed restoration, including the effects on salinity intrusion, tidal mixing, and Delta salinity.

Hydrodynamic modeling conducted for the Suisun Marsh Restoration Plan (DeGeorge pers. comm.) indicates that restoring tidal natural communities north of Montezuma Slough would shift the low salinity zone westward and restoring tidal natural communities at sites adjacent to Suisun Bay would shift the low salinity zone eastward, potentially adversely affecting delta smelt habitat and water quality in the west Delta. Consequently, implementation of tidal natural communities restoration projects in north and south Suisun Marsh will be sequenced such that these potential effects will be minimized.

- **South Delta ROA.** To maximize benefits associated with restoration of tidal natural communities in the south Delta, tidal natural communities will not be restored until the north Delta diversion facilities become operational. Potential sites for restoring freshwater tidal natural communities include Fabian Tract, Union Island, Middle Roberts Island, and Lower Roberts Island. Sites selected for restoration would be dependent on the location and design of the selected conveyance pathway and operations for the through-Delta component of the dual conveyance facility. Selected sites would be those that would provide substantial species and ecosystem benefits with the selected through-Delta conveyance configuration and most effectively avoid potential adverse effects of south Delta SWP/CVP operations. In conjunction with dual conveyance operations, tidal natural communities restoration in the South Delta ROA will be designed to support the expansion of the current distribution of delta smelt into formerly occupied habitat areas.

3.4.6 Conservation Measure 5 Seasonally Inundated Floodplain Restoration

Under *CM5 Seasonally Inundated Floodplain Restoration*, the BDCP Implementation Office will set back river levees and restore 10,000 acres of seasonally inundated floodplains *CM2 Yolo Bypass Fisheries Enhancement* augments existing flood flows in the Yolo Bypass, while *CM5 Seasonally Inundated Floodplain Restoration* restores floodplains that historically existed in the Plan Area but have been lost as a result of flood control and channelization. These restored floodplains will intentionally be allowed to flood occasionally to provide the benefits described in Section 3.4.6.1, *Purpose*. Restored floodplains will support valley/foothill riparian, nontidal freshwater perennial emergent, and nontidal perennial aquatic natural communities. Restored floodplains can remain in agricultural production as long as such activities are compatible with seasonal inundation and provide a habitat benefit to covered species (e.g., areas for rearing, foraging, and spawning by covered fishes). CM5 actions will be phased, with at least 1,000 acres restored by year 15 and 10,000 acres (cumulative) by year 40 of Plan implementation.

Although seasonally inundated floodplain may be restored along channels in the north, east, and south Delta, the most promising opportunities for large-scale floodplain restoration are in the south Delta along the San Joaquin, Old, and Middle Rivers. *CM 6 Channel Margin Enhancement* and *CM7*

Riparian Natural Community Restoration will be combined with floodplain restoration to provide a broad mosaic of natural communities and ecological functions.

Refer to Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM5. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM5 on covered species will be avoided or minimized.

3.4.6.1 Purpose

The primary purpose of CM5 is to meet or contribute to biological goals and objectives as identified in Table 3.4-7. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-7. Biological Goals and Objectives Addressed by CM5 Seasonally Inundated Floodplain Restoration

Biological Goal or Objective	How CM5 Advances a Biological Objective
Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.	
Objective L1.1: Protect at least 31,000 acres of existing natural communities, focusing on the highest quality natural communities and covered species habitats.	Floodplain restoration will allow the establishment of natural communities in the floodplain, including riparian, fresh emergent wetland, and tidal mudflat.
Objective L1.5: Include sufficient noncultivated upland areas adjacent to restored and protected valley/foothill riparian to provide upland habitat values and refugia from flooding.	Floodplains will be restored with sufficient width to provide a transition from areas adjacent the main channel that are frequently flooded, to more upland areas that seldom flood and typically provide upland habitat values and refugia from most flood events.
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.1: Allow natural flooding regimes to promote regeneration of desirable natural community vegetation and structural diversity, or implement management actions that mimic those natural disturbances.	Floodplain restoration will establish frequent flooding to create periodic vegetation disturbances, resulting in structural habitat diversity by creating a patchwork of vegetation communities at different ages.
Objective L2.2: Allow natural flooding to promote fluvial processes, such that bare mineral soils are available for natural colonization of vegetation, and cause fresh deposits of sediments (i.e., fine sands and silt).	Floodplain restoration will facilitate natural flooding to promote fluvial processes and allow for colonization of native vegetation on floodplain soils.
Objective L2.3: Allow lateral river channel migration.	Floodplains will be restored with sufficient width to allow lateral channel movement through the processes of erosion and deposition.

Biological Goal or Objective	How CM5 Advances a Biological Objective
Objective L2.4: Connect rivers and their floodplains to recharge floodplain groundwater from mainstem channels and allow input of large woody debris, leaves, and insects to rivers.	Floodplain restoration will connect channels with the vegetated floodplain, thus promoting the input of other organic material and insects to rivers.
Objective L2.5: Promote water quality conditions within the Delta that help restore native fish habitat.	Floodplain restoration is expected to improve water quality by allowing sediments and pollutants to filter out of floodwaters.
Objective L2.6: Maintain or increase life-history diversity of native fish species and a diversity of spawning and rearing conditions for native fish species over time.	Secondary or seasonal channels and pools on the restored floodplain will create backwater salmonid and splittail rearing and splittail spawning habitat.
Objective L2.10: Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways.	Floodwaters on the restored floodplain will benefit fish by cycling nutrients and producing abundant plankton and aquatic insects (Jeffres et al. 2008).
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	The restored floodplain and its associated vegetation is expected to establish or enhance habitat linkages along rivers for terrestrial wildlife.

The success of *CM6 Channel Margin Enhancement* and *CM7 Riparian Natural Community Restoration* depends partly on CM5, because those conservation measures will be implemented in restored floodplains. Biological goals and objectives specifically related to CM6 and CM7 are addressed in Section 3.3, *Biological Goals and Objectives.*

3.4.6.2 Problem Statement

For descriptions of the ecological values and current condition of floodplain habitat in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for floodplain habitat restoration as a component of the conservation strategies for terrestrial and aquatic communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM5.

Channel straightening and levee construction have disconnected river channels from their historic floodplains over much of the Plan Area, resulting in the reduction, degradation, and fragmentation of seasonally inundated floodplain and its associated natural communities. The result has been a substantial loss of high-value spawning and rearing habitat for splittail, a decrease in rearing and foraging habitat for salmonids, a decrease in primary productivity and therefore food availability to planktivorous fishes, and a decline in the abundance and distribution of floodplain-associated species, including splittail, Chinook salmon, and slough thistle.

Although some splittail spawning occurs on shallow margins of existing channels every year, floodplains are highly productive and, when inundated, are used more heavily than channel margin habitat for spawning and larval rearing. The isolation of Delta islands and wetlands behind levees has removed or degraded large areas of high-quality juvenile and adult splittail rearing habitat. In the 1960s and 1970s, USACE increased downstream water conveyance and reinforced levees by clearing and installing riprap on levees in the lower Sacramento River. These actions further reduced or eliminated suitable rearing habitat for splittail downstream from the city of Sacramento by substantially reducing the area of shallow channel margin habitat.

Juvenile salmon use natural stream banks, floodplains, marshes, and shallow water habitats as rearing habitat during out-migration. Juvenile Chinook salmon rearing habitat has been compromised by floodplain modifications (Brandes and McLain 2001). This loss of foraging and rearing habitat has contributed to reduction in the abundance and distribution of all anadromous salmonids in the Plan Area.

Several species of plants have also experienced a reduction in abundance and distribution related to the loss of the historic floodplain. Slough thistle is generally found in the portions of channels that flood at high water and on the banks of floodwater conveyance canals and drains (Griggs pers. comm.; Hansen pers. comm.). The reduction in slough thistle occurrence in the Plan Area is likely related to the loss of scour habitat found in and along floodplains. The loss of woody debris and stumps that are typically associated with well-connected floodplain habitat are likely partially to blame for the limited distribution and abundance of side-flowering skullcap, as this species grows on decaying wood along channel banks.

For descriptions of the ecological values and current condition of natural communities within floodplains in the Plan Area, see Chapter 2, *Existing Conditions* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* also describes the need for floodplain restoration as a component of the ecosystem-level conservation strategy and strategies for natural communities and associated with floodplains, based on the existing conditions and ecological values of these resources.

3.4.6.3 Implementation

3.4.6.3.1 Required Actions

Site-specific projects will restore seasonally inundated floodplain. Preparatory actions for each project will include interagency coordination, feasibility evaluations, site or easement acquisition, modifications to agricultural practices, engineering design, development of site-specific plans, and environmental compliance, if necessary, as described in *CM3 Natural Communities Protection and Restoration.*

A conceptual illustration of restored seasonally inundated floodplain with associated channel margin enhancement and riparian restoration is presented in Figure 3.4-10. Because restoration may require modification of levees that serve flood management functions, floodplain habitats will be restored in a manner that maintains flood conveyance capacity. Actions to restore seasonally inundated floodplain habitats may include but are not limited to the following.

- Set levees back along selected river corridors and remove or breach levees thereby rendered nonfunctional.
- Remove existing riprap or other bank protection to allow for channel migration between the set-back levees through the natural processes of erosion and sedimentation. This will reestablish floodplain processes and support creation and maintenance of spawning and rearing habitat.

- Modify channel geometry in unconfined channel reaches or along channels where levees are set back in order to create backwater salmonid and splittail rearing and splittail spawning habitat.
- Expand river floodplain habitat, including creating and expanding new floodway bypasses to restore rearing habitat and splittail spawning habitat.
- Increase the amount of functional floodplain habitat to increase the quantity and quality of rearing habitat for salmonids and sturgeon and spawning habitat for splittail, and to generate food resources for pelagic species.
- Secure lands, in fee-title or through conservation easements, suitable for restoration of seasonally inundated floodplain.
- Selectively grade restored floodplain surfaces to provide for drainage of overbank flood waters such that the potential for fish stranding is minimized.
- Lower the elevation of restored floodplain surfaces or modify river channel morphology to increase inundation frequency and duration and to establish elevations suitable for the establishment of riparian vegetation by either active planting or allowing natural establishment.
- Continue to farm in the floodplain consistent with achieving biological and flood management objectives, engaging in farming practices and crop types that provide high benefits for covered fish species.
- In cases where farming is no longer feasible or compatible with floodplain habitat goals, discontinue farming within the setback levees and allow riparian vegetation to naturally establish on the floodplain or actively plant riparian vegetation.

3.4.6.3.2 Restoration Site Selection and Design Considerations

Restoration sites for seasonally inundated floodplains will be selected based on the following considerations.

- Ability to meet or contribute to the applicable biological goals and objectives.
- Relative importance of the adjacent channel for use by covered species, especially by rearing/migrating juvenile salmonids.
- Estimated timing, frequency and duration of inundation periods relative to the anticipated range of estimated fluvial flow regimes and sea level conditions influenced by climate change and potential management changes (i.e., the San Joaquin River Restoration Program's Restoration Flow Regime).
- Flood conveyance and risk reduction benefits provided relative to other potential restoration sites.
- Compatibility with ongoing agricultural uses.

Restoration designs for seasonally inundated floodplains will consider the following elements.

- **Floodplain topography.** Where appropriate, the topography of restored floodplains will be modified to reduce the risk of fish stranding and to provide topographic variability to increase hydraulic complexity when flooded.

- **Connectivity.** Where suitable landform is present, restored floodplains will be located and designed such that flows exiting the floodplain pass through existing or restored tidal marsh to recreate historic landscape proximity and to provide for connectivity with adjacent uplands that result in transitional habitats and accommodate species movement.
- **Habitat restoration on restored floodplains.** Riparian forest and scrub vegetation will be actively or passively established in restored floodplain areas consistent with floodplain land uses and flood management requirements. Restored floodplains will provide the largest area available to meet the 5,000-acre target for restoration of woody riparian habitat under *CM7 Riparian Natural Community Restoration*, so about 80% of the riparian habitat restoration will occur at these restored floodplain sites. Established woody riparian vegetation will support habitat for riparian-associated covered species and provide cover and hydraulic complexity for covered fish species during inundation periods. Riparian vegetation will also serve as sources of instream woody material for fish habitat, organic carbon in support of the aquatic food web, and macroinvertebrates (e.g., insects) that provide food for covered fish species (*CM7 Riparian Natural Community Restoration*).
- **Land use on restored floodplains.** Restored floodplains may maintain existing agricultural uses that are compatible with the primary goal of restoring habitat for covered fish and wildlife species. To ensure compatibility, farmed floodplains will comply with the following goals.
    - Minimize the use of persistent herbicides and pesticides that are toxic to aquatic organisms.
    - Practices that minimize disturbance of emergent woody vegetation and subsequent forest development.
    - In areas with low risk of methylmercury production, promote cover and hydraulic complexity for fish by providing structure and biomass from residual crop material.
    - Provide sources of organic carbon in support of aquatic foodweb processes during inundation periods by leaving crop waste onsite.

3.4.7 Conservation Measure 6 Channel Margin Enhancement

Under *CM6 Channel Margin Enhancement*, the BDCP Implementation Office will restore 20 linear miles of channel margin habitat by improving channel geometry and restoring riparian, marsh, and mudflat habitats on the inboard side of levees. Linear miles of enhancement will be measured along one side or the other of a given channel segment: if both sides of a channel are enhanced for a length of 10 miles, this will account for a total of 20 miles of channel enhancement. At least 5 miles will be enhanced by year 10 of Plan implementation, and enhancement will then be phased in 5-mile increments at years 20, 25, and 30, for a total of 20 miles at year 30. Based on results of effectiveness monitoring for this conservation measure, the Implementation Office may elect to enhance up to an additional 20 miles of channel margin (for a total of 40 miles) through the adaptive management decision-making process.

This conservation measure provides an overview of and guidelines for implementing channel margin enhancement. Additional information on channel margin enhancement suitable to implementing projects in the field will appear in detailed design and permitting documents for the projects as they are proposed, developed, and permitted.

Refer to Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM6. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM6 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.7.1 Purpose

The primary purpose of CM6 is to meet or contribute to biological goals and objectives as identified in Table 3.4-8. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties to help ensure that these biological goals and objectives are met.

Table 3.4-8. Biological Goals and Objectives Addressed by CM6 Channel Margin Enhancement

Biological Goal or Objective	How CM6 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.4: Connect rivers and their floodplains to recharge floodplain groundwater from mainstem channels and allow input of large woody debris, leaves, and insects to rivers.	Riparian vegetation on channel margins will provide inputs of organic material (e.g., leaf and twig drop) and insects.
Objective L2.5: Promote water quality conditions within the Delta that help restore native fish habitat.	Establishment of riparian vegetation on channel margins will increase the extent of shaded riverine aquatic cover (U.S. Fish and Wildlife Service 2004), which will help reduce water temperatures for covered salmonids.
Objective L2.6: Maintain or increase life-history diversity of native fish species and a diversity of spawning and rearing conditions for native fish species over time.	Removal of bank protection is expected to re-establish floodplain processes and create low-velocity backwater habitats for Sacramento splittial spawning (Sommer et al. 2001a, 2002, 2007, 2008; Moyle 2002; Moyle et al. 2004; Feyrer et al. 2006). Channel margin enhancement is expected to increase the quality and area of rearing habitat for Chinook salmon, sturgeon, and possibly steelhead, by providing expanded nearshore habitat with improved inputs of terrestrial organic matter, insects, and woody material; riparian shade; and underwater cover (Sommer et al. 2001a, 2001b, 2002, 2007, 2008; Moyle 2002; Moyle et al. 2004; Nakano and Murakami 2001; Feyrer et al. 2006).
Objective L2.10: Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways.	Establishment of riparian vegetation on channel margins will provide inputs of organic material (e.g., leaf and twig drop) into channels, resulting in increased production of zooplankton and macroinvertebrates that serve as or support production food for covered fish species. It will also increase the production and export of terrestrial invertebrates into the aquatic ecosystem (Nakano and Murakami 2001) where riparian vegetation is restored adjacent to channels to provide food for covered fish, western pond turtle, and California red-legged frog.

Biological Goal or Objective	How CM6 Advances a Biological Objective
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	Although channel margins will only be enhanced along channels that provide rearing and outmigration habitat for juvenile salmonids, and the riparian vegetation along channel margins will only be established in narrow strips, the riparian vegetation may provide limited opportunities for movement of terrestrial species as an ancillary benefit of channel margin enhancement.
Objective L3.3: Support the movement of larval and juvenile life stages of native fish species to downstream rearing habitats.	Channel margin habitat enhancement is expected to increase connectivity among salmonid rearing and outmigration habitat areas by providing extensive linear patches of nearshore shallow-water foraging and cover habitat.
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objective L4.2: Manage the distribution and abundance of established nonnative predators in the Delta to reduce predation on native covered fish species.	Replacement of riprap levee embankments with shallow-water, natural substrate nearshore habitat is expected to reduce cover for nonnative fish predators, and thereby reduce the risk for predation on native fish.
Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.	
Objective VFRNC1.1: Restore or create 5,000 acres of valley/foothill riparian forest.	Establishment of riparian vegetation along channel margins is expected to contribute approximately 80 acres toward the 5,000-acre objective.
Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.	
Objective TFEWNC1.1: Within the 65,000 acres of tidal restoration, restore or create at least 13,900 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.	Although channel margin enhancement will not result in large patches of emergent wetland, it is expected to result in establishment of emergent wetland around channel margins that will contribute to the 13,900-acre objective.

3.4.7.2 Problem Statement

For descriptions of the ecological values and current condition of channel margins in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for channel margin enhancement as a component of the conservation strategies for terrestrial and aquatic natural communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM6.

Primary Delta channels serve as movement corridors for the covered fish species and support splittail spawning and salmonid, sturgeon, and splittail rearing habitat. Chinook salmon, Central Valley steelhead, and sturgeon use channel margin habitat for rearing and protection from predators; splittail use low-velocity backwater habitats for spawning. Vegetation along channel margins contributes woody material, both instream and on channel banks, to increase instream cover for fish and enhance habitat for western pond turtle.

Channel margins support valley foothill riparian, emergent wetland, and tidal mudflat natural communities. The riparian natural community provides nesting opportunities for Swainson's hawk and white-tailed kite. Although yellow-breasted chat, least Bell's vireo, and western yellow-billed cuckoo also nest in riparian vegetation, they require large, contiguous patches of vegetation therefore channel margin vegetation could provide migratory stop-over habitat for these species. Channel margins that support elderberry shrubs provide habitat for valley elderberry longhorn beetle. Channel margins also provide habitat for western pond turtle, and mudflats along channel margins provide habitat for Suisun Marsh aster, Mason's lilaeopsis, delta mudwort, and Delta tule pea.

Most channels in the Delta are flanked by levees. In these areas, channel margins lack the diversity and complexity of habitat conditions associated with unmodified channels. Because of the riprap armoring on the levees, many channel margins are devoid of vegetation or have only low-quality vegetation for limited numbers of covered species. Without the vegetation along channel margins that would provide shade and nutrient inputs, habitat values for fish in these channels have declined. Both the quality and quantity of riparian, emergent wetland, and tidal mudflat habitat for covered terrestrial species have declined due to construction of channel-margin levees. Channel margin enhancement will improve channel geometry and restore riparian, marsh, and mudflat habitats along levees, contributing to higher survivorship of outmigrating juvenile Chinook salmon and benefiting the covered and other native species associated with these natural communities along channel margins.

3.4.7.3 Implementation

Channel margin enhancement will be achieved by implementing site-specific projects. Prior to enhancement construction (the on-the-ground activities that will put the enhancements in place) for each project, preparatory actions will include interagency coordination, feasibility evaluations, site acquisition, development of site-specific plans, and environmental compliance, as described further in *CM3 Natural Communities Protection and Restoration.* After construction, each project will be monitored and adaptively managed to ensure that the success criteria outlined in the site-specific plan are met. Channel margin enhancement actions will often be implemented in conjunction with seasonally inundated floodplain and riparian habitat restoration conservation measures (CM5 and CM7, respectively).

Channel margin enhancement will be performed only along channels that provide rearing and outmigration habitat for juvenile salmonids. These channels include the Sacramento River between Freeport and Walnut Grove, the San Joaquin River between Vernalis and Mossdale, and Steamboat and Sutter Sloughs (Figure 3.4-11), which are protected by federal project levees; and the salmonid migration channels in the interior Delta, such as the North and South Forks of the Mokelumne River, which are protected by levees not related to federal projects.

*[**Note to Reviewers:** Figure 3.4-11 to show the river channels described is still pending, as is the estimate of the length of channel margin in these areas, which is needed to demonstrate there is sufficient enhancement opportunity. Additional siting and design guidelines will be defined based on actual channel margin enhancement projects that have been completed for other projects.]*

Channel margin enhancement, as appropriate to site-specific conditions, includes but is not limited to the following actions.

- Remove riprap from channel margins where levees are set back to restore seasonally inundated floodplain areas (*CM5 Seasonally Inundated Floodplain Restoration*).
- Modify the outboard side of levees (Figure 3.4-12) or set back levees to create low floodplain benches with variable surface elevations that create hydrodynamic complexity and support emergent vegetation to provide an ecological gradient of environmental conditions.
- Install large woody material (e.g., tree trunks and stumps) into constructed low benches or into existing riprapped levees to provide physical complexity.
- Plant riparian and emergent wetland vegetation on created benches.

These measures will be implemented along channels protected by levees in the Plan Area. Channel margin enhancements associated with federal project levees will not be implemented on the levee, but rather on benches to the outboard side of such levees (Figure 3.4-12).

3.4.7.3.1 Siting and Design Considerations

Channel margin enhancements will be designed to meet the applicable biological goals and objectives. Because channel margin enhancement will modify channels and levees with flood control functions, enhancements will be implemented to maintain or improve flood control functions. The Implementation Office will coordinate channel margin enhancement planning with the flood control planning efforts of the USACE, DWR, the Central Valley Flood Protection Board, and other flood control agencies.

The following elements will be considered in the location and design of enhanced channel margins.

- The length of channel margin that can be practicably enhanced.
- Connectivity with existing channel margins supporting high functioning salmonid rearing habitat.
- The potential for riparian plantings to augment breeding and foraging habitat for riparian covered species, such as Swainson's hawk, yellow-billed cuckoo, least Bell's vireo, tricolored blackbird, and riparian brush rabbit, in proximity to known occurrences.
- The potential to create mudflats near known occurrences of Suisun Marsh aster, Mason's lilaeopsis, delta mudwort, Delta tule pea and side-flowering skullcap, thereby creating opportunities for natural colonization of new habitat for these species.
- The potential cross-sectional profile of enhanced channels (elevation of habitat, topographic diversity, width, variability in edge and bench surfaces, depth, and slope).
- The potential amount and distribution of installed woody debris along enhanced channel margins.
- The extent of shaded riverine aquatic overstory and understory vegetative cover needed to provide future input of large woody debris and to moderate water temperatures to benefit covered fish.

3.4.8 Conservation Measure 7 Riparian Natural Community Restoration

Under *CM7 Riparian Natural Community Restoration*, the BDCP Implementation Office will restore 5,000 acres of riparian forest and scrub in association with *CM4 Tidal Natural Communities Restoration*,*CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement*. Riparian forest and scrub will be restored to include the range of conditions necessary to support habitat for each of the riparian-associated covered species. CM7 actions will be phased, with 2,300 acres restored by year 15 and 5,000 (cumulative) acres restored by year 40 of Plan implementation.

Refer to Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM7. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM7 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.8.1 Purpose

The primary purpose of CM7 is to meet or contribute to biological goals and objectives as identified in Table 3.4-9. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-9. Biological Goals and Objectives Addressed by CM7 Riparian Natural Community Restoration

Biological Goal or Objective	How CM7 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.4: Connect rivers and their floodplains to recharge floodplain groundwater from mainstem channels and allow input of large woody debris, leaves, and insects to rivers.	Riparian community restoration along rivers will increase instream cover through contributions of woody material derived from the riparian forest (U.S. Fish and Wildlife Service 2004), which will provide habitat complexity important for resting and refuge sites used by covered salmonids, and will contribute to creation of thermal refugia.
Objective L2.5: Promote water quality conditions within the Delta that help restore native fish habitat.	Riparian natural community restoration along channels will increase the extent of shaded riverine aquatic cover (U.S. Fish and Wildlife Service 2004), which will help reduce water temperatures for covered salmonids.

Biological Goal or Objective	How CM7 Advances a Biological Objective
Objective L2.10: Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways.	Riparian restoration will provide inputs of organic material (e.g., leaf and twig drop) where riparian forest and scrub is restored adjacent to channels, resulting in increased production of zooplankton and macroinvertebrates that serve as or support production food for covered fish species. It will also increase the production and export of terrestrial invertebrates into the aquatic ecosystem (Nakano and Murakami 2001) to provide food for covered fish, western pond turtle, and California red-legged frog.
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	See Section 3.4.8.3.2, *Siting and Design Considerations,* below.
Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.	
Objective VFRNC1.1: Restore or create 5,000 acres of valley/foothill riparian forest.	See Section 3.4.8.3.2, *Siting and Design Considerations,* below.
Objective VFRNC1.3: Restore corridors of riparian vegetation along 20 miles of channel margin in the Sacramento and San Joaquin River systems to provide habitat along important migratory routes for anadromous fish and improve wildlife movement.	See Section 3.4.8.3.2, *Siting and Design Considerations,* below, and *CM6 Channel Margin Enhancement.*
Goal VFRNC2: Increase structural diversity to include a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian community.	
Objective VFRNC2.1: Restore, maintain and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands.	See Section 3.4.8.3.2, *Siting and Design Considerations, Vegetation Diversity and Structure,* below.
Objective VFRNC2.2: Maintain at least 1,000 acres of early- to mid-successional vegetation with a well-developed understory of dense shrubs.	See Section 3.4.8.3.2, *Siting and Design Considerations, Vegetation Diversity and Structure,* below.
Objective VFRNC2.3: Maintain 500 acres of mature riparian forest in large blocks (which must have a minimum patch size of at least 50 acres each) in Conservation Zones 4 and/or 7.	See Section 3.4.8.3.2, *Siting and Design Considerations, Vegetation Diversity and Structure,* below.
Goal VFRNC3: Maintain or increase native biodiversity that characterizes the valley/foothill riparian community.	
Objective VFRNC3.1: Maintain or increase abundance and distribution of rare and uncommon shrubs characteristic of riparian communities, especially buttonwillow and elderberry bushes.	See Section 3.4.8.3.2, *Siting and Design Considerations, Vegetation Diversity and Structure,* below.

Biological Goal or Objective	How CM7 Advances a Biological Objective
Goal RBR1: Suitable habitat available for the future growth and expansion of riparian brush rabbit populations.	
Objective RBR1.1: Of the 750 acres of protected valley/foothill riparian natural community, protect at least 200 acres of suitable riparian brush rabbit habitat (defined in *CM7 Riparian Natural Community Restoration*) that is occupied by the species or contiguous with occupied habitat.	See Section 3.4.8.3.2, *Siting and Design Considerations, Species-Specific Actions, Riparian Brush Rabbit,* below.
Objective RBR1.2: Of the 5,000 acres of riparian restoration, restore/create and maintain at least 300 acres of early- to mid-successional riparian habitat that meets the ecological requirements of the riparian brush rabbit and that is within or adjacent to or that facilitates connectivity with existing occupied or potentially occupied habitat.	See Section 3.4.8.3.2, *Siting and Design Considerations, Species-Specific Actions, Riparian Brush Rabbit,* below.
Goal RW1: A reserve system that includes suitable habitat available for the future growth and expansion of riparian woodrat populations.	
Objective RW1.1: Of the 5,000 acres of riparian restoration, restore/create and maintain at least 300 acres riparian habitat that meets the ecological requirements of the riparian woodrat (e.g., dense willow understory and oak overstory) and that is adjacent to or facilitates connectivity with existing occupied or potentially occupied habitat.	See Section 3.4.8.3.2, *Siting and Design Considerations, Species-Specific Actions, Riparian Woodrat,* below.
Objective RW1.2: Create high-water refugia in restored sites through the building and/or restoring of high ground habitat on mounds, berms, or levees, so that refugia are no further apart than 20 meters.	See Section 3.4.8.3.2, *Siting and Design Considerations, Species-Specific Actions, Riparian Woodrat,* below.
Goal VELB1: Promote dispersal and expansion of the valley elderberry longhorn beetle where there are known source populations within the American River and Sacramento River systems.	
Objective VELB1.1: Mitigate for impacts on elderberry shrubs by creating valley elderberry longhorn beetle habitat consistent with the USFWS (1999a) valley elderberry longhorn beetle conservation guidelines and planting elderberry shrubs in high-density clusters.	See Section 3.4.8.3.2, *Siting and Design Considerations, Species-Specific Actions, Valley Elderberry Longhorn Beetle,* below.
Objective VELB1.2: Site valley elderberry longhorn beetle habitat restoration within drainages immediately adjacent to or in the vicinity of sites known to be occupied by valley elderberry longhorn beetle.	See Section 3.4.8.3.2, *Siting and Design Considerations, Species-Specific Actions, Valley Elderberry Longhorn Beetle,* below.

3.4.8.2 Problem Statement

For descriptions of the ecological values and current condition of the valley/foothill riparian natural community in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for riparian area restoration as a component of the conservation strategies for natural communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM7.

The valley/foothill riparian community occurs in mostly discontinuous patches throughout the Plan Area and in narrow linear stands in all conservation zones (Figure 3.2-6). This community consists of riparian forest and scrub primarily along channel margins and unfarmed floodplains. The current extent of the valley/foothill riparian community represents a small fraction of its historical extent in the Plan Area (Thompson 1961; The Bay Institute 1998). An estimated 85 to 95% of riparian vegetation throughout California has been lost to human activities such as river and stream channelization, levee building, removal of vegetation to stabilize levees, and extensive agricultural and urban development (Riparian Habitat Joint Venture 2004). Covered activities will result in a net increase in riparian habitat in the Plan Area.

The substantial reduction in the extent, distribution, and diversity of valley/foothill riparian communities that historically occurred along the upper elevational margins of Delta and along natural levees along Delta and Suisun Marsh channels has greatly reduced the use of this natural community as habitat for associated covered and other native species. Most existing levees were not designed to incorporate riparian vegetation that supports habitat for covered fish and wildlife species. Design features of flood control levees such as steep slopes and the use of riprap preclude natural establishment or survival of riparian vegetation. At sites where riparian vegetation becomes established, it is often cleared to maintain the structural integrity of levees and their design flood capacity. These steep and riprap surfaces provide cover for nonnative predatory fish, contributing to increased predation losses of covered fish species. A lack of riparian habitat associated with existing and restored tidal aquatic and marsh habitats limits potential ecological benefits to fish and wildlife by limiting important ecological gradients and ecosystem functions that such ecotones would provide.

The valley/foothill riparian community provides essential habitat for riparian woodrat and riparian brush rabbit, and roosting and foraging habitat for Townsend's big-eared bat. This community provides breeding habitat for tricolored blackbird, Swainson's hawk, and white-tailed kite. The western pond turtle relies on valley/foothill riparian habitat for breeding, foraging, aestivation, and movement. This community provides habitat for foraging, aestivation, and movement for California red-legged frog. Valley elderberry longhorn beetle depends on elderberry shrubs and while the species can occur in nonriparian areas, populations thrive only in riparian habitat. Yellow-breasted chat, least Bell's vireo, and western yellow-billed cuckoo depend on this habitat type for all life-history requirements. Riparian restoration is needed to increase the extent and connectivity of habitat for these species in the Plan Area. It is also needed to increase habitat extent and quality for native riparian plants, including the covered side-flowering skullcap.

Covered fish species that occur in the Plan Area and that rely on ecological attributes of valley/foothill riparian habitat include Chinook salmon, Central Valley steelhead, lamprey, and sturgeon. Splittail use low-velocity backwater habitats for spawning. Salmonids rely on riparian shade and the resulting cooler water temperatures that control basic metabolic processes. Salmonids also benefit from contributions of the riparian community to the aquatic foodweb, in the form of terrestrial insects and leaf litter that enter the water. Riparian vegetation also supports the formation of steep, undercut banks that provide cover for salmonids.

Restoration of valley/foothill riparian habitats will increase the abundance and distribution of associated covered and other native species, improve connectivity among habitat areas within and adjacent to the Plan Area, improve genetic interchange among native riparian-associated species' populations, and contribute to the long-term conservation of riparian-associated covered species. Covered species that will benefit from the implementation of this conservation measure include riparian woodrat, riparian brush rabbit, Townsend's big-eared bat, tricolored blackbird, Swainson's hawk, white-tailed kite, yellow-breasted chat, least Bell's vireo, western yellow-billed cuckoo, western pond turtle, California red-legged frog, valley elderberry longhorn beetle, Delta tule pea, Mason's lilaeopsis, delta mudwort, slough thistle, Suisun Marsh aster, Chinook salmon, Central Valley steelhead, sturgeon, and splittail.

3.4.8.3 Implementation

3.4.8.3.1 Required Actions

The BDCP Implementation Office will restore at least 5,000 acres of valley/foothill riparian natural community by implementing site-specific restoration projects. Prior to construction of each restoration project, preparatory actions will include interagency coordination, feasibility evaluations, site acquisition, development of restoration plans, and potentially additional environmental compliance. Restoration construction for each project will then occur consistent with the site-specific restoration plan, and will be monitored and adaptively managed to ensure that the success criteria outlined in the restoration plan are met. This planning process and preparation process is described further in *CM3 Natural Communities Protection and Restoration*.

The valley/foothill riparian natural community will be restored primarily in association with the restoration of tidal and floodplain areas and channel margin enhancements. Consistent with the riparian biological goals and objectives listed above, the 5,000 acres of restored riparian will include the following actions.

3.4.8.3.2 Siting and Design Considerations

Connectivity

The 5,000 acres of restored riparian natural community must meet numerous requirements for mid- and late-successional stage habitat, and for species habitat, as summarized in Table 3.4-10. Riparian restoration will be prioritized in areas where it will improve linkages to allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area. Some of this connectivity will be accomplished through planting riparian vegetation along channel margins as described in *CM6 Channel Margin Enhancement*. However, channel margin enhancement will consist mostly of narrow riparian bands with limited value for wildlife movement. Therefore, projects that involve restoration of large riparian areas will focus on connecting existing wildlife habitat along riparian corridors to meet the riparian habitat connectivity objective.

Table 3.4-10. Habitat Requirements for Riparian Restoration

*[**Note to Reviewers:** Pending: a small summary table showing the restoration requirements and the overlap among them.]*

Vegetation Diversity and Structure

Species Diversity and Structural Heterogeneity

Restoration projects will incorporate a diversity of native riparian species into planting schemes. This will include the use of uncommon native shrubs characteristic of riparian communities, including but not limited to buttonwillow (*Cephalanthus occidentalis*) and elderberry (*Sambucus* sp.).

Restoration projects will be designed to provide structural heterogeneity with adequate vertical and horizontal overlap among vegetation components. This will be accomplished by selecting plant species for restoration that include herbaceous groundcover, small trees and shrubs to provide under-story and middle-story vegetation, and large trees to provide high canopy over-story vegetation. Riparian restoration projects will also be designed to provide riparian vegetation that overlaps with adjacent channels, freshwater emergent wetlands, and grasslands.

Early- to Mid-Successional Vegetation

The BDCP Implementation Office will restore riparian vegetation with the long-term objective of maintaining at least 1,000 acres (of the 5,000 acre total) of early- to mid-successional vegetation with a well-developed understory of dense shrubs. However, the riparian natural community is structurally dynamic, as flooding and scouring events will remove vegetation and the community will naturally regenerate through a process of succession. *CM5 Seasonally Inundated Floodplain Restoration* will provide the necessary conditions for this dynamic process. Because of this dynamic nature of the riparian natural community, the 1,000 acres of early- to mid-successional vegetation are not expected to be maintained in a single location: rather, the BDCP Implementation Office will ensure that at least 1,000 acres of early- to mid-successional riparian vegetation with a well-developed understory of shrubs are present throughout the BDCP reserve system each year starting in year X. [***Note to Reviewers:*** *initial implementation year to meet this objective has not yet been determined.*] This will be accomplished through a combination of riparian restoration, riparian protection (*CM3 Natural Communities Protection and Restoration*), and if necessary, riparian enhancement and management (*CM11 Natural Communities Enhancement and Management*). At least 300 acres of early to mid-successional riparian vegetation will be located in Conservation Zone 7 within or adjacent to occupied riparian brush rabbit habitat, as described under *Riparian Brush Rabbit*, below.

Late-Successional Vegetation

The BDCP Implementation Office will restore riparian vegetation with the long-term objective of maintaining at least 500 acres of mature vegetation in Conservation Zones 4 and 7. This will include mature trees with a somewhat open canopy, and a high level of structural understory diversity. It will not be a senescent community with a 100% closed canopy in which new growth is suppressed. For additional details on this late-successional riparian vegetation, see *Species-Specific Actions, Riparian Woodrat* and *Western Yellow-Billed Cuckoo* below.

Because of the dynamic nature of the riparian natural community (see *Early to Mid-Successional Vegetation,* above), the 500 acres of late successional vegetation are not expected to be maintained in a single location: rather, the BDCP Implementation Office will ensure that at least 500 acres of late-successional riparian vegetation are present throughout Conservation Zones 5 and 7 at any given point in time. This will be accomplished through a combination of riparian restoration and riparian protection (*CM3 Natural Communities Protection and Restoration*). At least 200 acres of this riparian vegetation will be maintained to provide suitable breeding habitat characteristics for western yellow-billed cuckoo as described below under *Species-Specific Actions.*

Species-Specific Actions

Riparian Brush Rabbit

Of the 750 acres of riparian natural community to be maintained as early to mid-successional vegetation (see *Early to Mid-Successional Vegetation*, above), at least 300 acres will meet the ecological requirements of the riparian brush rabbit, and be located within or adjacent to, or facilitate connectivity with, existing occupied riparian brush rabbit habitat. These 300 acres will have the following components (based on Kelly et al. 2011).

- **Large patches of dense brush composed of riparian vegetation.** Shrub species, such as California blackberry (*Rubus ursinus*), California wild rose (*Rosa californica*), sandbar willow (*Salix exigua*), coyote brush (*Baccharis pilularis*), golden current (*Ribes aureum*), and other shrubs are necessary to provide protection from predators. These shrubs must grow high enough so that they are not completely inundated during flood events, so that foliage remains above the high water mark and can allow the shrubs to survive through flood events.
- **Ecotonal edges of brushy species that transition to grasses and herbaceous forbs.** Herbaceous forbs that remain during both the wet and dry seasons, such as mugwort (*Artemisia californica*), stinging nettle (*Urtica dioica*), and gumplant (*Grindelia camporum*), growing at the edges of riparian shrubs provide dense cover and protection from predators. Additionally, open fields adjacent to dense brush provide foraging areas for riparian brush rabbits. Creeping wild rye (*Leymus triticoides*), or other suitable grasses, will be established in these adjacent fields as this species is flood tolerant and allows for production of tunnel-like rabbit runways that provide good cover. Santa Barbara sedge (*Carex barbarae*) may also be used, although it does not spread as quickly and is not as dense as creeping wild rye.
- **"Scaffolding plants" (dead or alive) to support blackberry plants above flood levels.** Small trees and tall shrubs such as coyote brush can provide scaffolding for blackberry and other climbing plants to allow these plants to climb above flood levels.
- **A tree overstory, if present, that is not closed**. Trees are not an essential component of riparian brush rabbit habitat, but if trees are present, an open tree canopy is necessary because a closed canopy can inhibit growth of a dense understory.
- **Refugia from flooding.** High-ground refugia will be built on mounds or berms to provide refuge during flood events (short- and long-term) and sea level rise (long-term).

Riparian Woodrat

Of the 5,000 acres of riparian natural community to be maintained as late-successional vegetation, at least 300 acres will meet the ecological requirements of the riparian woodrat, and be located within or adjacent to, or facilitate connectivity with, existing occupied or potentially occupied riparian woodrat habitat. These 300 acres will have structure appropriate for nesting and nest building and will include the following components (based on Kelly et al. 2011).

- **Tree canopy.** Trees will consist primarily of oak (*Quercus* sp.) but may also include cottonwood (*Populus fremontii*), sycamore (*Platanus racemosa*), large willows and other large trees that provide opportunities for woodrats to forage in the tree canopy.
- **Large patches of dense shrub understory.** Shrubs may include blackberries, wild rose, small willows, or other native shrub species to provide cover and substrate for nest building.
- **Canopy and understory connected by a mid-story composed of native species.** Mid-story may include small trees, tall shrubs, and vines such as California wild grape, to provide additional cover and facilitate woodrat access to the tree canopy.
- **Refugia from flooding.** High-ground refugia will be built on mounds or berms to provide refuge during flood events (short- and long-term) and sea level rise (long-term).

Valley Elderberry Longhorn Beetle

The loss of any elderberry shrubs resulting from BDCP covered activities will be mitigated through creation of additional valley elderberry longhorn beetle habitat consistent with USFWS guidelines (1999a). Based on these guidelines, shrubs with beetle exit holes are mitigated at a higher ratio than shrubs without any evidence of exit holes. Elderberry shrubs will be planted in large, contiguous clusters with a mosaic of associated natives.

3.4.8.3.3 Restoration Approaches

The approach for each riparian restoration project will differ depending on whether it is associated with floodplain restoration, tidal habitat restoration, or channel margin enhancement. For general restoration techniques and site selection guidelines that apply to all natural communities, see *CM3 Natural Communities Protection and Restoration*.

Riparian Restoration in Restored Floodplains

Valley-foothill riparian restoration in restored floodplains will be consistent with flood control requirements (Figure 3.4-10). This community will actively be restored in some areas, and in other areas it will be allowed to naturally establish and grow where soils and hydrology are appropriate. Large patches of riparian vegetation will be established in contrast to the narrow stringers of riparian vegetation that typically occur along channels and agricultural water conveyance features in much of the Plan Area.

Active restoration involving site preparation and planting of native riparian vegetation (e.g., Fremont cottonwood, Goodings' willow [*Salix gooddingii*], box elder [*Acer negundo*]) will be implemented if site-specific restored floodplain conditions indicate that such plantings will substantially increase the establishment of riparian forest and scrub, and will be necessary in order to achieve the biological goals and objectives and restoration targets for each phase. Restoration sites will be monitored to determine if nonnative vegetation control or supplemental plantings of native riparian vegetation are necessary.

Riparian Restoration in Restored Tidal Habitats

Woody riparian vegetation will be allowed to naturally reestablish along the upper elevation margins of restored tidal marsh habitats in ROAs (Figure 3.2-2 and *CM4 Tidal Natural Communities Restoration*) where soils and hydrology are suitable, including segments of stream channels that drain into restored marshes. Suitable soils for restoration are expected to be most extensive in the Cosumnes/Mokelumne, East Delta, and South Delta ROAs. In these ROAs, riparian vegetation is expected to generally form as a band of variable width depending on site-specific soil and hydrologic conditions between high marsh vegetation and herbaceous uplands.

Soil salinity in the Suisun Marsh ROA and extensive clay soils in the Cache Slough ROA are expected to limit the extent of riparian vegetation that will become established. In these ROAs, riparian vegetation is expected to generally establish in narrow stringers (e.g., along dikes) and in small patches with suitable soil conditions. Where conditions are appropriate, woody riparian vegetation will be planted on new levees that are constructed by the Implementation Office in ROAs to provide for the restoration of tidal natural communities, and as necessary to meet the biological goals and objectives. As described for riparian natural community restoration in floodplains, native riparian vegetation may be planted to initiate establishment of riparian forest and scrub, and restoration areas will be monitored to determine the need for vegetation control and supplemental plantings.

Riparian Restoration on Channel Margins

Where compatible with site-specific channel margin habitat objectives, native woody riparian vegetation will be planted along channel margins on benches outboard of existing levees to enhance covered fish and wildlife species habitat (Figure 3.4-12). Riparian vegetation restored in these locations is expected to form narrow stringers of riparian forest and scrub along enhanced channel margins.

3.4.9 Conservation Measure 8 Grassland Natural Community Restoration

Under *CM8 Grassland Natural Community Restoration,* the BDCP Implementation Office will restore 2,000 acres of grassland natural community in Conservation Zones 1, 8, and/or 11. Actions under CM8 will be phased, with 1,000 acres restored by year 10 and 2,000 acres (cumulative) restored by year 25 of Plan implementation.

Refer to Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM8. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM8 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.9.1 Purpose

The primary purpose of CM8 is to meet or contribute to biological goals and objectives as identified in Table 3.4-11. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-11. Biological Goals and Objectives Addressed by CM8 Grassland Natural Community Restoration

Biological Goal or Objective	How CM8 Advances a Biological Objective
Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.	
Objective L1.5: Include sufficient noncultivated upland areas adjacent to restored and protected valley/foothill riparian to provide upland habitat values and refugia from flooding.	Grasslands will be restored along the upper margins of restored floodplains or adjacent to the outside of levees adjacent to restored floodplain in Conservation Zone 7 to provide upland refugia for riparian brush rabbit.
Objective L1.7: To accommodate projected future sea level rise, within the 65,000 acres of tidal restoration include sufficient upland transitional areas adjacent to restored brackish and freshwater tidal emergent wetlands to permit the future upslope establishment of tidal emergent wetland communities; also include additional noncultivated upland to provide habitat and high-tide refugia for native wildlife.	Grasslands will be restored adjacent to tidal brackish marsh restoration in Conservation Zone 11 to provide upland flood refugia for salt marsh harvest mouse and other native wildlife.
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	Grassland restoration will improve habitat linkages for covered and other native species that use grasslands by locating restoration projects between existing grasslands.
Goal GNC1: Extensive grasslands comprised of large, interconnected patches or contiguous expanses.	
Objective GNC1.2: Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian and tidal natural communities for wildlife foraging and upland refugia.	The restoration of 2,000 acres of grasslands will be prioritized in areas that connected existing fragmented patches of protected grassland.
Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.	
Objective GNC2.1: Restore and sustain a mosaic of grassland vegetation alliances, reflecting localized water availability, soil chemistry, soil texture, topography, and disturbance regimes, with consideration of historical states.	Grassland planting and seeding will be designed to include a mosaic of grassland vegetation alliances to meet this objective. See *Siting and Design Considerations.*
Objective GNC2.2: Increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs.	Grassland restoration will be designed to meet this objective, as described in *Siting and Design Considerations.*
Objective GNC2.3: Increase burrow availability for burrow-dependent species.	Grassland restoration will improve habitat linkages by prioritizing restoration areas between existing grasslands that facilitate movement for broad-ranging animals.

3.4.9.2 Problem Statement

For descriptions of the ecological values and current condition of the grassland natural community in the Plan Area, see Chapter 2, *Existing Conditions*, and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for restoration as a component of the conservation strategies for the grassland community and associated covered species, based on the existing conditions and ecological values of these resources.

Although California native grassland originally covered approximately 25% of the state land area (Barbour et al. 2007; Stromberg 2007), it has been identified as one of the 20 most endangered ecosystems in the United States (Noss et al. 1995). Grasslands in California are now highly fragmented and dominated by nonnative annual grasses and other nonnative plant species.

Grassland habitat is distributed around the upland margin of the Sacramento-San Joaquin Delta and Suisun Bay system, and much has been lost to development and conversion to agriculture. Some BDCP actions will remove grassland natural community. Restoration of grasslands will offset these losses while improving habitat connectivity and increasing the diversity of grassland species. Grassland restoration will increase the extent, connectivity, and quality of grassland habitat available for use by covered and other native species and thus contribute to their conservation. BDCP covered species expected to benefit from restored grasslands include San Joaquin kit fox, salt marsh harvest mouse, riparian brush rabbit, Townsend's big-eared bat, tricolored blackbird, western burrowing owl, greater sandhill crane, Swainson's hawk, white-tailed kite, giant garter snake, western pond turtle, California red-legged frog, western spadefoot toad, California tiger salamander, heartscale, brittlescale, San Joaquin spearscale, Carquinez goldenbush, and caper-fruited tropidocarpum (see Appendix 2.A*, Covered Species Accounts*, for specific life-history requirements met by the grasslands natural community).

3.4.9.3 Implementation

3.4.9.3.1 Required Actions

The BDCP Implementation Office will restore 2,000 acres of grassland in BDCP Conservation Zones 1, 8, and/or 11 by implementing site-specific restoration projects. Prior to construction of each restoration project, preparatory actions will include interagency coordination, feasibility evaluations, site acquisition, development of restoration plans, and potentially additional environmental compliance. Construction of each restoration project will then occur consistent with the site-specific restoration plan, and will be monitored and adaptively managed to ensure that the success criteria outlined in the restoration plan are met. This restoration planning and preparation process is described further in *CM3 Natural Communities Protection and Restoration*.

3.4.9.3.2 Grassland Restoration Approach

Grassland restoration will include converting nongrassland areas (e.g., ruderal or cultivated lands) into grassland, and restoring native grassland in existing degraded, nonnative grasslands. Grasslands restored as a component of vernal pool complexes will also count toward the 2,000-acre minimum restoration area for CM8.

Grassland restoration will increase the extent, distribution, and density of native perennial grasses intermingled with other native species, taking into consideration the limitations of grassland restoration techniques and current knowledge. The historical extent and composition of California native grasslands is unknown, making the goal of restoring grassland to a presettlement condition unrealistic (Barry et al. 2006; Keeley 1993). Furthermore, establishment of native grassland can be difficult and costly (Barry et al. 2006). This is especially the case in areas where soils and other site conditions are not suitable for native grasslands. Many areas presently occupied by nonnative grasslands were likely historically occupied by scrub or chaparral communities: these areas should not be converted to native grassland because the site factors are likely to be unsuitable for supporting native grasses, and establishment of native grassland on such sites would represent type-conversion rather than restoration (Keeley 1993). Grassland restoration projects will therefore carefully consider historical conditions.

Several native grassland restoration projects have been successfully implemented in or near the BDCP Plan Area.

- The Huichica Creek Native Grassland Restoration Project restored approximately 25 acres of an abandoned pasture field located on the Napa-Sonoma Marshes State Wildlife Area into native, perennial grassland. This land originally consisted primarily of introduced, annual grass species, such as harding grass and rip-gut brome, as well as many invasive noxious weeds. The restoration required weed and annual grass removal, seedbed preparation, native plant seeding and post-seeding management.

*[**Note to Reviewers:** Additional information will be added regarding Audubon Bobcat Ranch in Yolo County, Jepson Prairie Restoration, and possibly others.]*

Rather than completely eliminating nonnatives, the grassland restoration will focus on increasing native biodiversity and improving native wildlife habitat functions. The grassland restoration strategy may be adjusted as described in Section 3.6, *Adaptive Management and Monitoring Program*, with the development of new restoration techniques and other pertinent information as it becomes available.

3.4.9.3.3 Siting and Design Considerations

Grassland restoration will be designed and located to support habitat for associated covered species, improve connectivity among existing patches of grassland and other natural habitats, and improve the native wildlife habitat functions of transitional uplands adjacent to BDCP restored tidal and riparian habitats. Restoration will be prioritized where it improves connectivity and increases the habitat functions of existing grassland habitats, including linking or providing wildlife movement corridors to larger habitat areas immediately outside of the Plan Area, or providing upland refugia for wildlife adjacent to emergent wetland and riparian natural communities. The most strategically important areas are listed below.

- Areas where restoration would connect small patches of grasslands in Conservation Zones 1 and 11 with larger expanses of grassland in the Jepson Prairie area.
- Areas where restoration would connect grasslands in Conservation Zone 8 to other high-quality grassland habitat to the west and southwest of the Plan Area, and support the conservation areas assembled for the Eastern Contra Costa County HCP/NCCP and the San Joaquin County HCP.

- Uplands adjacent to restored tidal brackish emergent wetlands in Suisun Marsh, to provide refugia for salt marsh harvest mouse and other wildlife.
- Areas adjacent to riparian brush rabbit and riparian woodrat habitat along the upper margins of restored floodplains that are expected to be flooded infrequently, and along the outside edges of levees adjacent to floodplain restoration.
- Areas adjacent to restored freshwater emergent wetland restored (*CM10 Nontidal Marsh Restoration*), to provide basking sites and upland refugia for giant garter snake.

Grassland restoration will focus on creating a mosaic of grassland vegetation alliances, reflecting localized water availability, soil chemistry, soil texture, topography, and disturbance regimes, with consideration of historic site conditions. Grassland restoration sites will be selected that support appropriate soils and are adjacent to existing high value grassland natural community (i.e., supporting covered species or high biodiversity) (Keeley 1993). Restoration should generally be targeted to parcels with low soil fertility and those that have not been used for intensive crop production. Site conditions (both physical and biological) and land use history are important in developing biologically appropriate management techniques to enhance native grassland alliances (Stromberg and Griffin 1996; Hamilton et al. 2002; Harrison et al. 2003).

Grasslands restored along the upper margins of seasonally inundated floodplain in Conservation Zone 7 will be designed to provide foraging habitat values and upland refugia for riparian brush rabbit. Creeping wild rye (*Leymus triticoides*) is one of the only floodplain grasses native to the Central Valley that can be easily established through grassland restoration: this flood-tolerant grass allows for the formation of tunnel-like rabbit runways, and thus provides good cover for the riparian brush rabbit (Kelly et al. 2011).

Grasslands restored in the wetland-upland transition zone in Suisun Marsh should be at least 100 feet wide (Williams and Faber 2004), taking sea level rise into account. Restoration in this area will establish grassland plant species that provide adequate cover for salt marsh harvest mouse and other native wildlife that may be vulnerable to predation as they seek high ground during extreme high-tide events.

Grasslands restored adjacent to freshwater emergent wetland (*CM10 Nontidal Marsh Restoration*) should provide sufficient cover for giant garter snake. USFWS recommends using a seed mix of at least 20 to 40% native grass seeds such as annual fescue (*Vulpia* spp.), California brome (*Bromus carinatus*), blue wildrye (*Elymus glaucus*), and needlegrass (*Nassella* spp.); 2 to 4% native forb seeds; 5% rose clover (*Trifolium hirtum*); and 5% alfalfa (*Medicago sativa*). USFWS guidelines also indicate that 40 to 68% of the seed mix may consist of nonaggressive European annual grasses such as wild oats (*Avena sativa*), wheat (*Triticum* spp.), and barley (*Hordeum vulgare*) (U.S. Fish and Wildlife Service 1997).

3.4.9.3.4 Restoration Techniques

Grassland sites that have been highly degraded but retain native grassland species may not require extensive seeding or planting but may be restored with improved livestock grazing and removal of invasive weeds through herbicide application, mowing, or hand removal. Treatments will be appropriate for site conditions. If the success of treatments is uncertain, treatments will be applied in test plots and, if found successful, expanded to larger areas.

The following techniques may be applied to grassland restoration projects, although the Implementation Office is not limited to these techniques. Other approaches and techniques may be applied to grassland restoration projects based on the best information available at the time the restoration project is being planned and designed, and approaches that have been proven successful for past restoration projects. See *CM11 Natural Communities Enhancement and Management* for a description of techniques for grazing and invasive plant control to promote establishment of native grassland species in nonnative grasslands.

Sites that have been highly disturbed may require pretreatment before grassland restoration techniques are applied. For example, invasive weeds may need to be removed using a variety of techniques such as livestock grazing, herbicide treatment, tilling, soil removal and treatment (to remove the weed seed bank), or a combination of these or other treatments. Restoration may also require the recontouring of graded land as appropriate.

Native grasses grow better if the seeds are collected from a nearby site (Stromberg and Kephart 2006). Seed sown on grassland restoration sites will be collected from the nearest practicable natural site with similar ecological conditions. Seed nurseries may be established in some of the restored grasslands to produce seed for subsequent restoration projects.

Seeding will be done in fall or early winter after the first rains. Many California native grasses can be successfully started when seeded at about 3 to 4 pounds per acre (Stromberg and Kephart 2006). The seed may be broadcasted using a tractor-mounted or handheld broadcaster, or a seed drill may be used. Plugs may be used rather than seeding in some areas, especially on steep hillsides. Survivorship for plugs is often 95% or better, as the critical time period for native grasses is the seedling stage (Stromberg and Kephart 2006).

Once seedlings are established, the restored grasslands will be managed consistent with long-term, site-specific management plans. Grassland management techniques are described in *CM11 Natural Communities Enhancement and Management*.

3.4.10 Conservation Measure 9 Vernal Pool Complex Restoration

Under *CM9 Vernal Pool Complex Restoration,* the BDCP Implementation Office will restore the vernal pool complex in Conservation Zones 1, 8, or 11 to achieve no net loss of vernal pool acreage from BDCP covered activities. The restored vernal pool complex will consist of vernal pools and swales within a larger matrix of grasslands. The BDCP Implementation Office will select specific restoration sites in Conservation Zones 1, 8, or 11 based on the suitability of available lands for restoration, biological value, and practicability considerations.

Refer to Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM9. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM9 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.10.1 Purpose

The primary purpose of CM9 is to meet or contribute to the biological goals and objectives as identified in Table 3.4-12. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-12. Biological Goals and Objectives Addressed by CM9 Vernal Pool Complex Restoration

Biological Goal or Objective	How CM9 Advances a Biological Objective
Goal VPCNC1: Vernal pool complexes comprised of large, interconnected, or contiguous expanses that represent a range of environmental conditions**.**	
Objective VPCNC1.2: Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage.	This objective will be fully met by implementing CM9, as described in Section 3.4.10.3, *Implementation.*
Goal VPP1: A reserve system that protects vernal pool plant populations.	
Objective VPP1.2: Protect and/or establish at least two currently unprotected occurrences of Heckard's peppergrass in Conservation Zones 1, 8, or 11.	This objective will be met by implementing CM9, as described in Section 3.4.10.3.4, *Establishment of Covered Plant Occurrences.*
Objective VPP1.3: Protect at least two currently unprotected occurrences of San Joaquin spearscale in Conservation Zones 1, 8, or 11.	This objective will be met by implementing CM9, as described in Section 3.4.10.3.4, *Establishment of Covered Plant Occurrences.*

CM9 will also provide benefits beyond those specified as biological goals and objectives. All benefits and goals are described in more detail below.

The purpose of CM9 is to offset loss of vernal pool ecosystem function and ensure no net loss of vernal pool acreage resulting from BDCP covered activities. The federal government (USFWS and other federal resource agencies) has a no net loss policy for wetlands, meaning that wetland losses must be offset by wetland gains and, to the extent possible, ecosystem function (U.S. Fish and Wildlife Service 1994). In addition to meeting this no net loss policy, vernal pool restoration will offset BDCP-related impacts on the vernal pool complex natural community and its associated covered species and help contribute to the recovery of covered species associated with vernal pools (see below for a summary of benefits to covered species and Section 3.3.5, *Species Biological Goals and Objectives*, for a detailed description of benefits of the conservation strategy for each covered species). The restoration will supplement protection of 600 acres of vernal pool complex (*CM3 Natural Communities Protection and Restoration*) to achieve biological goals and objectives for the vernal pool complex natural community and its associated covered species.

3.4.10.2 Problem Statement

For descriptions of the ecological implications and current condition of the vernal pool complex in the Plan Area, see Chapter 2, *Existing Conditions* and Section 3.3, *Biological Goals and Objectives*. Section 3.3 also describes the need for a restoration program as a component of the conservation strategies for vernal pool complex natural communities associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM9.

Restoration of vernal pool complex habitat as described here will offset vernal pool loss resulting from BDCP covered activities and contribute to the recovery of associated vernal pool covered species. Restored vernal pool complex will be built off of the existing reserve system, and in conjunction with protection of 600 acres of existing vernal pool complex, contribute to the establishment of a large, interconnected vernal pool reserve system in the Plan Area. Establishment of a large vernal pool complex reserve system will prevent further habitat fragmentation that can otherwise disrupt hydrologic processes and gene flow. A large, interconnected vernal pool reserve system is also important in order to provide sufficient upland habitat for the protection of vernal pool plant pollinators, provide for dispersal of vernal pool plants and animals, and sustain important predators of herbivores such as rodents and rabbits (U.S. Fish and Wildlife Service 2005). The vernal pool reserve system, including both restored and protected vernal pool complex, will benefit the following vernal-pool-dependent covered species:

- Conservancy fairy shrimp
- Vernal pool fairy shrimp
- Vernal pool tadpole shrimp
- Mid-valley fairy shrimp
- California linderiella
- California tiger salamander
- Alkali milk-vetch
- Legenere
- Heckard's peppergrass
- San Joaquin spearscale
- Boggs Lake hedge-hyssop
- Dwarf downingia

These species depend upon the vernal pool complex natural community.

3.4.10.3 Implementation

3.4.10.3.1 Required Actions

The amount of vernal pool complex restoration will be determined in implementation based on the following criteria.

- If restoration is completed (i.e., restored habitat meets all success criteria) prior to impacts, then 1.0 acre of vernal pool complex will be restored for each acre affected (1:1 ratio).
- If restoration takes place concurrent with impacts (i.e., restoration construction is completed, but restored habitat has not met all success criteria, prior to impacts occurring), then 1.5 acres of vernal pool complex will be restored for each acre affected (1.5:1 ratio).

In either case, the density of wetted area of vernal pool must be the same as or greater than that lost to covered activities to ensure no net loss of wetlands and wetland function. In lieu of restoration, an equivalent amount of vernal pool restoration credit may be purchased at a USFWS- and DFG-approved vernal pool mitigation bank if the bank occurs in the Plan Area and meets the site selection criteria described below.

3.4.10.3.2 Siting and Design Criteria

Vernal pool restoration sites will meet the following site selection criteria.

- The vernal pool restoration site is in Conservation Zone 1, 8, or 11.
- The site has evidence of historical vernal pools based on soils, remnant topography, remnant vegetation, historical aerial photos, or other historical or site-specific data.
- The site supports suitable soils and landforms for vernal pool restoration.
- The adjacent land use is compatible with restoration and long-term management to maintain natural community functions (e.g., not adjacent to urban or rural residential areas).

Acquisition of vernal pool restoration sites will be prioritized based on the following criteria.

- Contribution to establishment of a large, interconnected vernal pool complex reserve system (e.g., adjacency to existing protected vernal pool complex).
- Proximity to known populations of covered vernal pool species.

3.4.10.3.3 Restoration Techniques

The following restoration techniques will be implemented.

- Remnant natural vernal and swale topography will be restored by excavating or recontouring historical vernal pools and swales to natural bathymetry based on their characteristic visual signatures on historical aerial photographs, other historical data, and the arrangement and bathymetry of vernal pools and swales at a reference site.
- The reference site will consist of existing nearby, natural (i.e., unmodified by human activities) vernal pool complex supporting covered vernal pool species.
- To provide for high-functioning habitat, restored vernal pool complex will be vegetated with hand-collected seed from appropriate areas in the same conservation zone. Soil inocula will not be used to establish vernal pool plants and animals in these conservation zones unless the source vernal pools are free of perennial pepperweed, waxy mannagrass, swamp timothy, and Italian ryegrass. These nonnative species establish more rapidly than native species, and create dense populations that are likely to reduce the establishment success of the native plants and also create thatch problems in the vernal pools (see Baraona et al. 2007 for problems of nonnative species thatch buildup due to soil inocula).
- Propagules (cysts) of covered vernal pool invertebrate species will not be introduced into restored vernal pools through the use of soil inocula unless the source vernal pools are free of perennial pepperweed, swamp timothy, and Italian ryegrass. Vernal pool invertebrates are expected to be passively introduced into the restored vernal pools through the movement of other animals from pool to pool.

3.4.10.3.4 Establishment of Covered Plant Occurrences

The BDCP Implementation Office will protect at least two currently unprotected occurrences of Heckard's peppergrass and at least two currently unprotected occurrences of San Joaquin spearscale in Conservation Zones 1, 8, or 11, consistent with Objectives VPP1.2 and VPP1.3. If lands with unprotected occurrences are unavailable for acquisition, plant occurrences will be established in restored vernal pool complex using seed from the same conservation zone as the restored vernal pool complex. The methods for establishing each occurrence, as well as monitoring methods, success criteria, and contingency measures, will be detailed in the site-specific restoration plan.

3.4.10.3.5 Site-Specific Restoration Plans

A site-specific restoration plan will be developed for each vernal pool restoration site. The restoration plan will include the following elements.

- A description of the aquatic functions, hydrology/topography, soils/substrate, and vegetation, for the design reference site, the existing condition of the restoration site, and the anticipated condition of the restored site.
- Success criteria for determining whether vernal pool functions have been successfully restored.
- A description of the restoration monitoring, including methods and schedule, for determining whether success criteria have been met.
- An implementation plan and schedule that includes a description of site preparation, seeding, and irrigation.
- A description of maintenance activities and a maintenance schedule to be implemented until success criteria are met.
- A description of contingency measures to be implemented if success criteria are not met within the established monitoring timeframe.

3.4.10.3.6 Protection and Management

Restoration sites will be acquired, in fee-title or through conservation easements, and protected in perpetuity. Each restoration site will be managed and maintained consistent with the site-specific restoration plan until restoration success criteria have been met, and will henceforth be managed in perpetuity as described in *CM11 Natural Communities Enhancement and Management.*

3.4.11 Conservation Measure 10 Nontidal Marsh Restoration

Under *CM10 Nontidal Marsh Restoration,* the BDCP Implementation Office will restore 400 acres of nontidal freshwater marsh in Conservation Zones 2 and 4. CM10 actions will be phased, with 100 acres restored by year 2 and 400 (cumulative) acres restored by year 8 of Plan implementation.

*[**Note to Reviewers:** The timeline described above may be too aggressive. It may be more feasible to extend the requirement to ca. 100 acres in each 5-year increment, to achieve 400 acres by year 20.]*

Refer to Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM10. Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM10 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.11.1 Purpose

The primary purpose of CM10 is to meet or contribute to biological goals and objectives as identified in Table 3.4-13. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-13. Biological Goals and Objectives Addressed by CM10 Nontidal Marsh Restoration

Biological Goal or Objective	How CM10 Advances a Biological Objective
Goal NFEW/NPANC1: Nontidal marsh consisting of a mosaic of nontidal freshwater emergent perennial wetland and nontidal perennial aquatic natural communities, and providing habitat for covered and other native species.	
Objective NFEW/NPANC1.1: Create at least 400 acres of nontidal freshwater marsh consisting of a mosaic of nontidal perennial aquatic (at least 250 acres) and nontidal freshwater emergent wetland (at least 100 acres) natural communities, with suitable habitat characteristics for giant garter snake and western pond turtle.	The Implementation Office will create 400 acres of nontidal freshwater emergent wetland and nontidal perennial aquatic communities in locations and with habitat components to support giant garter snake and western pond turtle in the Plan Area.
Objective NFEW/NPANC1.2: Of the at least 400 acres of created nontidal freshwater marsh, create at least 200 acres contiguous with habitat occupied by the Coldani Marsh/White Slough garter snake subpopulation in Conservation Zone 2, and at least 200 acres contiguous with habitat occupied by the Yolo Basin/Willow Slough giant garter snake subpopulation in Conservation Zone 4.	See above.

3.4.11.2 Problem Statement

For descriptions of the ecological values and current condition of nontidal marshes in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* also describes the need for restoration as a component of the conservation strategies for nontidal marsh and associated covered species, based on the existing conditions and ecological values of these resources.

The ecological function of nontidal marsh is limited because it occurs in highly fragmented and small patches in the Planning Area and adjacent lands. A substantial reduction in the extent, distribution, and condition of nontidal freshwater perennial emergent wetland communities that historically occurred throughout the Central Valley and along the perimeter of the Delta has reduced the extent and diversity of these communities as habitat for many native species, including the giant garter snake (Gilmer et al. 1982; The Bay Institute 1998).

While there are records of giant garter snake in tidal marshes of the central Delta, the species is known primarily from nontidal marsh in the interior of the Central Valley, including along the eastern perimeter of the Sacramento-San Joaquin Delta. Agricultural conversion and stream channelization have removed nontidal marsh, leading to widespread giant garter snake population declines and restricting extant populations to remaining degraded or suboptimal habitats, such as irrigation channels and rice fields. A lack of nontidal marsh limits the ecological benefits to fish and wildlife by limiting important ecological gradients and ecosystem functions that these habitats would provide, particularly in association with other native habitats including nontidal permanent aquatic, grassland, and riparian habitats. Restoring nontidal marsh to reestablish a more natural ecological gradient and incorporating aquatic, riparian, and upland transitional habitats is expected, along with BDCP conservation of other natural communities, to increase the abundance and distribution of associated covered and other native species, improve connectivity among habitat areas within and adjacent to the Plan Area, improve genetic interchange among native freshwater perennial emergent wetland species' populations, and contribute to the long-term conservation of giant garter snake and other native species. In addition to giant garter snake, covered species associated with nontidal marsh include tricolored blackbird, California black rail, western pond turtle, and greater sandhill crane. However, the nontidal marsh restoration will focus on creating suitable habitat characteristics for giant garter snake and western pond turtle.

3.4.11.3 Implementation

3.4.11.3.1 Required Actions

The Implementation Office will restore at least 400 acres of nontidal freshwater marsh in Conservation Zones 2 and 4. Restored natural communities will be distributed in patches of at least 25 acres and occur in or near occupied giant garter snake habitat within the proposed 1,000-acre giant garter snake preserves designed to enhance the Coldani Marsh/White Slough and the Yolo Basin/Willow Slough giant garter snake populations.

Restored nontidal wetlands will also be designed and managed to support other native wildlife functions, including waterfowl foraging, resting, and brood habitat, and shorebird foraging and roosting habitat. Transitional upland habitat consisting of grasslands will be restored or protected adjacent to restored freshwater emergent wetland, to provide upland habitat for giant garter snake and western pond turtle, and nesting habitat for waterfowl: this will be credited toward the 8,000 acres of grassland to be protected or the 2,000 acres of grassland to be restored.

Project planning and preparation actions for restoration of all natural communities are described in *CM3 Natural Communities Protection and Restoration*. In addition, anticipated actions to restore nontidal freshwater perennial emergent wetland, as appropriate to site-specific conditions, include, but are not limited to the following actions.

- Securing sufficient annual water to sustain habitat function;
- Establishing connectivity with the existing water conveyance system and habitats occupied by giant garter snakes;
- Site preparation, planting of native marsh vegetation, and maintenance of plantings; and
- Control of nonnative plants.

3.4.11.3.2 Siting and Design Considerations

Nontidal marsh restoration will be designed to support the range of habitat conditions necessary for giant garter snake and western pond turtle. Although the restored marsh may provide nesting habitat value for tricolored blackbird, it will not be designed specifically for this species (large, dense patches of emergent vegetation) but will instead provide a mosaic of open water and relatively open emergent vegetation. Once restoration is complete, it will be monitored to determine if subsequent management actions may be required to ensure successful regeneration of native marsh plant species and other appropriate habitat conditions for the target covered species.

Nontidal marsh will be established through conversion of existing cultivated lands to a freshwater marsh-perennial aquatic complex in areas where hydrology and soils are suitable. One of the key principles of successful restoration is ensuring the presence of the processes that create and maintain wetlands (Middleton 1999; Keddy 2000; Mitsch and Gosselink 1993). The most important processes are related to the availability of water and appropriate hydrology to create and maintain hydric soils and plants. Therefore, restoration of perennial wetlands will occur on sites with appropriate hydrology. This may include areas where perennial wetlands historically occurred and have since been drained or severely degraded. Additionally, there may be sites that are currently appropriate for perennial wetlands that did not historically support them because of changing land uses and altered hydrologic flows. It is imperative that perennial wetlands restoration sites be located directly adjacent to or connected to a source of permanent water.

Restoration may include creating wetland topography. Specifically, this may include site grading and creation of depressions to hold water. Grading will establish an elevation gradient to support both open water perennial aquatic habitat intermixed with shallower marsh habitat.

Restored marshes will occur in association with adjacent grassland, pastureland, or cultivated uplands. The restored tidal marsh will consist of a combination of emergent, tule-dominated vegetation and open water, with bank slopes at variable angles. As described in *CM3 Natural Communities Protection and Restoration* and *CM8 Grassland Natural Community Restoration*, grasslands will be protected or restored adjacent to restored nontidal freshwater emergent wetland to provide upland habitat for giant garter snakes and other native wildlife.

Coarse woody debris or anchored basking platforms will be installed in open water areas to improve habitat for western pond turtles (Hays et al*.* 1999). This modification will increase the habitat value in locations with existing western pond turtles and in newly created ponds where it is hoped that new pond turtle populations will establish. These structures may also enhance habitat for native amphibian species.

Marsh vegetation will be allowed to naturally reestablish along the edges of perennial aquatic habitat, but will also be planted as needed to facilitate marsh development and to manage species composition. The choice of plant species for perennial wetland restoration sites will be based on a palette of native wetland plants including freshwater emergent and aquatic species. The palette will be developed during the implementation process. Ideally, the plants will be grown from soil, seed, or plant stock from local wetland sites. In addition, vegetation is expected to evolve after the original planting such that volunteer plants may move into the wetland over time. In some cases, this can include nonnative invasive species that are not desirable in the reserve system. Therefore, restoration plans will address management of nonnative invasions. Additional issues that will be addressed in wetland design include preventing fish from becoming trapped in the ponds if the hydrology source is from a perennial water body that supports fish (e.g., by the use of fish screens or other appropriate devices). The development of marsh vegetation will be monitored to determine if nonnative vegetation needs to be controlled to facilitate the establishment of native marsh vegetation or if restoration success could be improved with supplemental plantings of native species. If indicated by monitoring, nonnative vegetation control measures and supplemental plantings will be implemented.

3.4.12 Conservation Measure 11 Natural Communities Enhancement and Management

Under *CM11 Natural Communities Enhancement and Management,* the BDCP Implementation office will prepare and implement management plans for protected natural communities, and for the covered species habitats that are found within those communities throughout the reserve system. This section describes the enhancement and management actions that will achieve applicable goals and objectives for natural communities and covered species other than fish, and provides management principles, guidelines, and techniques to be applied across the reserve system and for each natural community.

This conservation measure will be implemented upon permit issuance for certain conservation lands. The conservation measure will extend over time to cover new conservation lands as they are acquired (*CM3 Natural Communities Protection and Restoration*). See Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM3 and CM11). Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM11 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program*, for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.12.1 Purpose

The primary purpose of CM11 is to meet or contribute to the biological goals and objectives identified in Table 3.4-14. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-14. Biological Goals and Objectives Addressed by CM11 Natural Communities Enhancement and Management

Biological Goal or Objective	How CM11 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.1: Allow natural flooding regimes to promote regeneration of desirable natural community vegetation and structural diversity, or implement management actions that mimic those natural disturbances.	If natural flooding disturbance is not sufficient to achieve riparian structural objectives, mechanical vegetation management will be implemented as described in *Riparian Vegetation Enhancement and Management*.

Biological Goal or Objective	How CM11 Advances a Biological Objective
Objective L2.7: Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.	Invasive plant and wildlife control will be implemented within the reserve system to reduce competition, predation, and nest parasitism on native species, thereby improving conditions for native biodiversity. Livestock grazing is expected to help maintain or increase native plant diversity, following the management plans described below.
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	Within the reserve system, fences that serve as movement barriers will be removed, and culverts and other crossings will be improved. Thatch will be controlled in grasslands to facilitate movement by amphibians and other native wildlife. See *Reserve System Permeability.*
Goal VFRNC2: Increase structural diversity to include a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian community.	
Objective VFRNC2.1: Restore, maintain and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands.	Where natural processes such as flooding do not maintain structural heterogeneity, active manipulation such as planting or thinning will be implemented. See *Riparian Vegetation Enhancement and Management.*
Objective VFRNC2.2: Maintain at least 1,000 acres of early- to mid-successional vegetation with a well-developed understory of dense shrubs.	Where natural processes such as flooding do not maintain structural heterogeneity, active manipulation such as planting or thinning will be implemented. See *Riparian Vegetation Enhancement and Management.*
Goal VFRNC3: Maintain or increase native biodiversity that characterizes the valley/foothill riparian community.	
Objective VFRNC3.1: Maintain or increase abundance and distribution of rare and uncommon shrubs characteristic of riparian communities, especially buttonwillow and elderberry bushes.	Rare and uncommon shrubs will be planted in riparian areas within the reserve system. See *Riparian Vegetation Enhancement and Management.*
Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.	
Objective GNC2.1: Restore and sustain a mosaic of grassland vegetation alliances, reflecting localized water availability, soil chemistry, soil texture, topography, and disturbance regimes, with consideration of historical states.	Grazing management, prescribed burns, reseeding, and other grassland management techniques as described in *Grassland Vegetation Enhancement and Management* will be implemented to achieve this objective.
Objective GNC2.2: Increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs.	Grazing, prescribed burns, supplemental plantings, and other techniques will be implemented to promote native perennial grasses and other native plant species. See *Grassland Vegetation Enhancement and Management.*

Biological Goal or Objective	How CM11 Advances a Biological Objective
Objective GNC2.3: Increase burrow availability for burrow-dependent species.	Rodent control will be reduced or eliminated within the reserve system. Manage grasslands through grazing, prescribed burns, and other measures to optimize conditions for burrowing mammals. See *Ground-Dwelling Mammals.*
Objective GNC2.4: Increase prey, especially small mammals and insects, for grassland-foraging species.	Rodent control and pesticide use will be reduced or eliminated within the reserve system. Manage grasslands through grazing, prescribed burns, and other measures to optimize conditions for burrowing mammals. See *Ground-Dwelling Mammals.*
Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.	
Objective ASWNC2.1: Provide appropriate seasonal flooding characteristics for supporting and sustaining alkali seasonal wetland species.	Techniques may include invasive plant control, removal of adverse supplemental water sources into reserve (e.g., agricultural or urban runoff), and removing hydrologic barriers to seasonal flooding. See *Hydrologic Function of Vernal Pools, Seasonal Wetlands, and Stock Ponds.*
Goal VPCNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.	
Objective VPCNC2.1: Maintain or enhance vernal pool complexes to provide the appropriate inundation (ponding) characteristics for supporting and sustaining vernal pool species.	Techniques may include invasive plant control, removal of adverse supplemental water sources into reserves (e.g., agricultural or urban runoff), and topographic modifications. See *Hydrologic Function of Vernal Pools, Seasonal Wetlands, and Stock Ponds.*
Objective VPCNC2.2: Maintain and enhance pollination service in the vernal pool complex, especially by native invertebrates including native solitary bees.	Monitoring, pilot experiments and adaptive management will be implemented to achieve this objective. See *Vernal Pool Pollinators.*
Goal RBR1: Suitable habitat available for the future growth and expansion of riparian brush rabbit populations.	
Objective RBR1.2: Of the 5,000 acres of riparian restoration, restore/create and maintain at least 300 acres of early- to mid-successional riparian habitat that meets the ecological requirements of the riparian brush rabbit and that is within or adjacent to or that facilitates connectivity with existing occupied or potentially occupied habitat.	If flooding and other natural processes are not sufficient to sustain suitable habitat characteristics, riparian brush rabbit habitat will be manipulated through plantings and other techniques to achieve this objective. See *Riparian Vegetation Enhancement and Management.*
Objective RBR1.3: Create and maintain high-water refugia in the 300 acres of restored riparian brush rabbit habitat and additional protected lands occupied or with potential to become occupied by riparian brush rabbit, through the building and/or restoring of high ground habitat on mounds, berms, or levees, so that refugia are no further apart than 20 meters.	Created refugia in riparian brush rabbit habitat will be maintained to ensure that their functionality is sustained. See *Riparian Vegetation Enhancement and Management.*

Biological Goal or Objective	How CM11 Advances a Biological Objective
Objective RBR1.4: In protected riparian areas, monitor for and control nonnative predators that impede survival and breeding success of riparian brush rabbits.	Occupied riparian brush rabbit habitat will be monitored for predators, and predators will be trapped if monitoring shows potential adverse predation effects on the species. See *Riparian Nonnative Predator Control.*
Goal RW1: A reserve system that includes suitable habitat available for the future growth and expansion of riparian woodrat populations.	
Objective RW1.1: Of the 5,000 acres of riparian restoration, restore/create and maintain at least 300 acres riparian habitat that meets the ecological requirements of the riparian woodrat (e.g., dense willow understory and oak overstory) and that is adjacent to or facilitates connectivity with existing occupied or potentially occupied habitat.	If flooding and other natural processes are not sufficient to sustain suitable habitat characteristics, riparian woodrat habitat will be manipulated through plantings and other techniques to achieve this objective. See *Riparian Vegetation Enhancement and Management.*
Objective RW1.2: Create high-water refugia in restored sites through the building and/or restoring of high ground habitat on mounds, berms, or levees, so that refugia are no further apart than 20 meters.	Created refugia in riparian woodrat habitat will be maintained to ensure that their functionality is sustained. See *Riparian Vegetation Enhancement and Management.*
Goal TRBL1: Improved nesting, nesting-adjacent foraging, and wintering habitat for tricolored blackbirds in the Plan Area.	
Objective TRBL1.2: Manage protected tricolored blackbird nesting habitat to provide young, lush stands of bulrush/cattail emergent vegetation and prevent vegetation senescence.	Nesting habitat protected for tricolored blackbirds will be managed through mechanical clearing, burning, or other mechanisms as needed to achieve this objective.
Objective TRBL1.3: Of the cultivated lands protected as covered species habitat, protect 11,400 to 19,000 acres of moderate or higher quality cultivated lands as nonbreeding foraging habitat, 50% of which is of high or very high value.	Cultivated lands protected for tricolored blackbirds will be managed to ensure quality characterisitcs necessary to achieve this objective.
Objective TRBL1.4: Of the cultivated lands protected as covered species habitat, protect 5,100 to 7,600 acres of high to very high quality breeding-foraging habitat within 5 miles of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat in Conservation Zones 1, 2, 3, 4, 7, 8 or 11.	Cultivated lands protected for tricolored blackbirds will be managed to ensure quality characterisitcs necessary to achieve this objective.

CM11 will also provide benefits beyond those specified as biological goals and objectives. All benefits and goals are described in more detail below.

3.4.12.2 Problem Statement

Natural communities and covered species habitat in the Plan Area have been degraded as a result of many human-related activities such as flood control and hydrologic alteration, urban and agricultural runoff, and introduction of invasive plant and wildlife species. Enhancement of natural communities and covered species habitat will therefore be necessary to reverse historical trends, and management will be necessary to prevent further degradation in the reserve system. For descriptions of the ecological values and current condition of natural communities in the Plan Area, see Chapter 2, *Existing Conditions*, and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* describes in detail the need for enhancing and managing each natural community as a component of the conservation strategies for these communities and associated covered species, based on the existing conditions and ecological values of these resources.

3.4.12.3 Implementation

*[**Note to Reviewers:** Additional management tools to address fisheries habitat within the reserve system will be added to this section.]*

3.4.12.3.1 Site-Specific Management Plans

The BDCP Implementation Office will prepare and implement management plans for protected natural communities and covered species habitats that are found within those communities. Management plans may be prepared for specific reserves or multiple reserve areas within a specified geographic area that share common management needs (i.e., reserve units). Within 2 years of acquiring parcels, the Implementation Office will conduct surveys to collect the information necessary to assess the ecological condition and function of conserved species habitats and supporting ecosystem processes. Based on the results, the Implementation Office will identify actions necessary to achieve the applicable biological objectives related to management and enhancement of the reserve at the landscape, natural community, and species levels. Management plans will provide the information necessary to guide these habitat enhancement and management actions.

The management plans will include, but not be limited to, descriptions of the following elements.

- The biological goals and objectives to be achieved with the preservation and management of the parcels.
- Baseline ecological conditions (e.g., habitat maps, assessment of covered species habitat functions, occurrence of covered and other native wildlife species, vegetation structure and composition, assessment of nonnative species abundance and effect on habitat functions, occurrence and extent of nonnative species).
- Vegetation management actions that benefit covered communities, habitats, and species and reduce fuel loads as appropriate; are necessary for implementing community conservation measures; and are necessary for implementing species specific conservation measures.
- A fire management plan developed in coordination with the appropriate agencies and to the extent practicable, consistent with achieving the biological objectives of the BDCP.
- Infrastructure, hazards, and easements.
- Existing and adjacent land uses and management practices and their relationship to covered species habitat functions.
- Applicable permit terms and conditions.
- Terms and conditions of conservation easements when applicable.
- Management actions and schedules.
- Monitoring requirements and schedules.

- Established data acquisition and analysis protocols.
- Established data and report preservation, indexing, and repository protocols.
- The adaptive management approach.
- Any other information relevant to management of the preserved parcels.

Management plans will be periodically updated to incorporate changes in maintenance, management, and monitoring requirements as they may occur over the term of the BDCP.

Based on the assessment of existing site conditions (e.g., soils, hydrology, vegetation, occurrence of covered species) and site constraints (e.g., location and size), and depending on biological objectives of the conserved lands, management plans will specify measures for enhancing and maintaining habitat as appropriate.

Management plans will be prepared for each reserve unit within 4 years of acquisition of each unit to allow time for site inventories and identification of appropriate management techniques. During the interim period, management of the reserve will occur using best practices and based on successful management at the same site prior to acquisition or based on management at other similar sites. Management plans will be working documents that are updated and revised as needed to document current best practices. However, all management plans will be formally reviewed and updated by the Implementation Office at least every 5 years to ensure that the BDCP adaptive management and monitoring program (see Section 3.6, *Adaptive Management and Monitoring Program*) and the results of the latest research are being applied to management in each reserve unit.

3.4.12.3.2 Landscape-Scale Enhancement and Management

Management Principles

The following broad management and enhancement principles apply to all enhancement and management activities.

- **Manage at multiple scales.** Biological processes occur at a wide variety of scales across the landscape. Enhancement and management activities will therefore be planned and executed with these multiple scales in mind. For example, the enhancement of covered plant occurrences will likely occur at a relatively small scale due to the small size of many populations. Microhabitats for covered plants such as soil texture, soil depth, rockiness, and nearest neighbor plants will be considered when designing appropriate management techniques. However, other processes operating at larger scales—such as the spread of invasive species, hillside erosion or deposition, and the patterns of wildfires—will also affect plant habitat enhancement. To be successful, management actions will consider and anticipate processes operating at multiple spatial scales.
- **Balance conflicting species needs.** The effects of an enhancement or management action must be evaluated for all covered species before management decisions are finalized. For instance, some pond-dependent covered species can require conflicting habitat conditions. Dense emergent vegetation around pond margins can provide good habitat for tricolored blackbird and California red-legged frog but may not provide appropriate habitat for California tiger salamander or western pond turtle. The large size of the reserve system will allow disparate actions to occur in different places and achieve net benefit for all of the covered species.

- **Account for inherent variability.** Chance events can often exert strong effects on species and natural systems. The most common chance events are associated with weather (e.g., rainfall, temperature, timing of seasons, drought, and the unknown ramifications of global climate change). Other chance events are associated with species populations themselves; these may include reproductive success and dispersal. Such inherently uncontrollable variables and their effects on covered species are best offset by maintaining within the reserve system a variety of microsites, environmental gradients, and management treatments. This ensures that covered species can take advantage of suitable habitat during favorable conditions and find refugia in unfavorable conditions.
- **Mimic natural processes.** Natural processes (e.g., hydrologic regimes, wildfire) create and maintain habitat for covered species. Therefore management actions will focus on defining, maintaining and enhancing these natural processes. If this is not feasible, then the effects of those processes can be duplicated by alternative management actions.
- **Use adaptive management.** Flexibility and adaptation will be embraced in making management decisions and improving restoration and enhancement activities within natural communities. Adaptive management principles (described in Section 3.6, *Adaptive Management and Monitoring Program*) will apply across the range of general principles as well as to the specific management techniques and tools described below.
- **Minimize adverse effects.** Management actions are designed to provide long-term benefits to the covered species. However, some actions may have short-term adverse effects on a subset of covered species (see Chapter 5, *Effects Analysis*). Management actions should be selected or implemented in such a way that minimizes any adverse effects on covered species. See *CM22 Avoidance and Minimization Measures* for details.

Required Actions

On BDCP reserve lands in the Plan Area, the Implementation Office will take the following actions.

- Implement invasive nonnative plant and animal control to benefit covered species and enhance native biodiversity (see *Invasive Plant Control* and *Nonnative Animal Control*, below).
- Avoid or minimize herbicide use in the reserve system (see *Herbicide Application*, below).
- Coordinate with the local vector control districts to avoid and minimize adverse effects on covered species and their habitat that could result from mosquito abatement activities (see *Mosquito Abatement*, below).
- Design and maintain infrastructure to allow wildlife movement throughout the reserve system (see *Reserve System Permeability*, below).
- Implement fire management plans that include measures to avoid and minimize effects on covered species and their habitats during fire management activities on reserves (see *Fire Management*, below).

Guidelines and Techniques

Fire Management

Fire management will be a component of each site-specific management plan. Several natural communities in the Plan Area are adapted to fire and respond positively after a burn (e.g., grasslands, vernal pool complex). Therefore, some wildfires will be allowed to burn naturally to provide periodic disturbances that will benefit natural communities and covered species, within the larger land-use context. The fire management component of each management plan must include a clear decision system to determine when a wildfire will be left to burn and when it must be partially or wholly contained to prevent damage to structures, prevent injuries, or cause excessive disturbance to natural communities. Fire management must also be implemented to minimize adverse effects on natural communities and covered species. Aggressive suppression can damage topsoil or cause excessive erosion, particularly if heavy machinery or chemical treatments are used to create firebreaks or suppress flames.

The fire management component will include coordination with the California Department of Forestry and Fire Protection (Cal Fire) and local fire-fighting agencies on the use of biologically appropriate management response measures for fire events. Fire management for the reserve system should be based, in part and as applicable, on an agreement with USFWS and DFG on fire-fighting techniques. The management plans will include a range of fire response, from full suppression when wildfires compromise public safety and personal property, to less than full suppression in predetermined areas where public safety and personal property is not compromised, and fire-dependent natural communities are present. The plans may include controlled burn and let-burn components. The goal of such components would be to reduce fuel loads and decrease fire intensity while promoting fire-dependent natural community regeneration and a natural successional process where feasible. This approach will protect public safety, personal property, and sensitive natural communities while allowing for persistence of natural processes in fire-adapted natural communities. The management plan will also include coordination with other land management agencies regarding allocation of prescribed burn permits from the Bay Area Air Quality Management District.

The management plans will describe minimum impact suppression tactics (also known as MIST[6]). Many plans using these techniques and plans with low-impact rehabilitation (restoration) techniques have been developed in recent years. The goal of minimum impact suppression tactics is to safely suppress wildfire using environmentally sensitive suppression methods. Examples of minimum impact suppression tactics guidelines and actions that will be implemented include the following.

- Use environmentally sensitive methods (i.e., procedures, tools, equipment) designed to minimize resource damage and reduce costs.
- Give serious consideration to the use of water as a firelining tactic.
- Establish equipment wash stations to remove noxious weed seeds from tires and vehicle undersides prior to their first use in a reserve.

[6] For example, see <http://www.wildfirelessons.net/documents/GB_MIST_Guidelines.pdf> or the National Wildfire Coordinating Group at <www.nwcg.gov>.

- If there is a risk that a hose coming directly from a local unit's cache is contaminated with noxious weed seeds, obtain fresh hose from the regional cache.
- Establish mobilization and demobilization areas outside the reserve to minimize spread of noxious weeds or diseases.
- Consider the use of helibucket with water or foam before calling for airtankers and retardant.

In order to ensure that the management plans are followed during fires, the Implementation Office will develop a wildfire local operating agreement for the reserve system with Cal Fire and with any other firefighting agency that has responsibility for reserve system lands. The operating agreement will ensure that the fire management components are implemented, that minimum impact suppression tactics are used, and that post-fire restoration is carried out. An example of a local operating agreement that has been developed and utilized successfully is the Henry W. Coe State Park agreement with CalFire (California State Parks 2007).

The wildfire local operating agreement will be in place within 4 years of permit issuance. This will allow time for the fire management component of reserve unit management plans to be developed and for the Implementation Office to work closely with Cal Fire to develop the operating agreement. Specifically, the wildfire local operating agreement for the reserve system will serve the following functions, at a minimum.

- Inform the firefighting agencies of reserve system fire policies and sensitive resources.[7]
- Inform the Implementation Office of functions within the Incident Command System (Cal Fire) with respect to wildland fire.
- Be the local working agreement between the Implementing Entity and firefighting agencies for all activities related to wildland fires in the reserve system.
- Designate responsibilities and guidelines for all activities related to wildland fires.
- Allow the Implementation Office to be a resource advisor in the incident command system and an on-site monitor in the event of a wildfire.
- Identify minimum impact suppression tactics during and after wildland fires to ensure the minimum possible environmental impacts.
- Identify biologically appropriate and complete post-fire restoration and rehabilitation responsibilities.

Following a fire, the Implementation Office will initiate remedial measures as described Section 6.3.2, *Changed Circumstances*.

To ensure successful fire management as described in this Plan, the Implementation Office will hire staff with expertise in firefighting and controlled burns using minimum impact fire suppression techniques. Staff with this expertise will also help to ensure clear and frequent communication with Cal Fire, which is essential to proper implementation of these techniques during a wildfire. Staff with this expertise will also help to ensure immediate assessment and possible responses following

[7] The Implementing Entity will update the appropriate local firefighting agencies of sensitive resources in the reserve system as the reserve system grows.

detection of wildfires in the reserve system. For a description of guidelines and techniques for prescribed burns, see the section below on the grassland natural community.

Invasive Plant Control

Some nonnative plants pose a serious threat to ecosystem function, native biological diversity, and many covered plant species. However, many nonnative plants cannot be effectively controlled because of their great abundance, high reproduction rate, and proficient dispersal ability; the high cost of control measures; or unacceptable environmental impacts of control measures. Therefore, control efforts in the reserve system will focus on new infestations that are relatively easy to eradicate or the most ecologically damaging nonnative plants that have effective suppression techniques available.

The Implementation Office will address the control of invasive plants as a component of each site-specific management plan. Control of invasive plants on reserve lands should begin immediately after acquisition if infestations are serious, even if the management plan is not finalized. Efforts to control invasive plans will be evaluated and revised as needed. Formal evaluations and revisions will take place at least every 5 years[8].

The goals of each management plan will be to control the spread of noxious weeds, as defined by the California Department of Food and Agriculture (CDFA), and invasive plants listed by the California Invasive Plant Council (2007) into new areas and to control infestations of noxious and serious weeds. Another important goal will be to distinguish those species for which eradication or control will be the objective and those species that will be addressed through landscape-level management (i.e., large-scale management rather than site-specific treatments). The major elements listed below will be included in each reserve unit management plan.

- An assessment of the nonnative plants likely to be invasive within the reserve unit that includes the following components.
  - Maps and descriptions of the distribution and abundance of nonnative plants.
  - The known or potential effects of nonnative plants on ecosystem function, native biological diversity, sensitive natural communities, and covered species.
  - The means and risk of the spread of nonnative plants to other areas within and outside the reserves.
  - The cost, feasibility, and effectiveness of available control measures for each species.
- An assessment of invasive plants not currently found in the reserves but found nearby or in similar habitats and that might invade the reserves in the future. The assessment will include a description of known or potential effects on ecosystem function, native biological diversity, sensitive natural communities, and covered species.
- The development and application of criteria for establishing invasive plant control priorities.
- The integration and coordination of invasive plant control efforts in the reserve system with the efforts of other ongoing invasive plant control efforts in the Plan Area.

[8] This is the approximate interval at which the list of invasive plants in California is updated by the California Invasive Plant Council.

- A description of methods to control and prevent the establishment of invasive plants and criteria for evaluating the suitability of application of these methods based on site-specific conditions.
- A description of a process by which future invasive plants can be evaluated quickly to determine the best course of action for their effective removal or control.

Development of the invasive plant component of the reserve unit management plans will be coordinated with other major resource management agencies in the study area including DFG, USFWS, operating regional HCPs and NCCPs, and counties with jurisdictions over parks. Because control of many invasive plants in the Plan Area is a regional issue, coordination with these agencies is essential. Coordination could include sharing costs, staff, and equipment and conducting joint management programs to address the regional problem of invasive plants. Management to control invasive plants will be prioritized such that the invasive plants with the greatest effects on covered species are addressed first.

Additional invasive plant control specific to natural communities is described under the natural community sections below.

Herbicide Application

Herbicides may be used judiciously within the reserve system to control or eradicate invasive plants, and may be necessary to control heavy infestations of certain invasive plants (e.g., Transline herbicide is effective in controlling yellow star-thistle). Certified personnel will conduct any herbicide application. Herbicides will be used with great caution, especially near seeps, creeks, wetlands, and other water resources. Herbicide use will be reserved for instances where no other eradication techniques are effective.

Nonnative Animal Control

Feral pigs and cowbirds will be controlled as described below. Bullfrogs and nonnative fish that prey on California red-legged frog and California tiger salamander larvae will be controlled in stock ponds and seasonal wetlands associated with grasslands (see *Grasslands and Associated Seasonal Wetland Natural Communities*). For control techniques for nonnative fish in rivers and creeks in the reserve system and within the Plan Area, see *CM15 Predator Control.* If the Implementation Office determines, through monitoring of covered species populations in the reserve system, that other nonnative predatory species are adversely affecting covered species such as California black rail or California clapper rail, then the establishment and abundance of nonnative predatory species will be controlled with habitat manipulation techniques or trapping.

- **Feral pig control.** Feral pigs have the potential to adversely affect all wetland types in the Plan Area, especially at the western end of the Plan Area where this species is currently known to occur. The impact of rooting activities in ponds, seasonal wetlands, and emergent wetland natural communities may be reduced by fencing, although fencing to exclude feral pigs will need to be built for that purpose and maintained frequently in order to be effective. If fencing is used, it must be constructed so as not to restrict wildlife movement routes or corridors. In cases where livestock access to ponds and surrounding uplands is desired but feral pigs are degrading habitat, a feral pig control program could be initiated to improve pond habitats. Feral pig control has been effective on San Francisco Public Utility Commission land in the adjacent Alameda Creek watershed (Koopman pers. comm.) and in Henry W. Coe State Park (Sweitzer and Loggins

2001; program is on-going). Feral pig control will be focused on parts of the reserve system where the concentrations of feral pigs are high and impacts on native communities have been observed. It would be difficult to census the exact number of feral pigs within the reserve system without an extensive effort. However, rooting disturbance can be monitored. Pig populations will be controlled during the permit term as long as their disturbance (i.e., rooting disturbance) adversely affects the Implementation Office's ability to successfully implement the conservation strategy for BDCP.

- **Cowbird control.** Cowbird trapping has proven successful in reversing downward population trends for avian species such as least Bell's vireo (Kus and Whitfield 2005). However, there is no evidence that cowbirds are currently threatening avian species populations in the Plan Area. If, through population monitoring, a decline of covered bird species susceptible to cowbird parasitism is detected, cowbird population or host species nest monitoring will be instigated to assess whether cowbirds are responsible for this decline. Cowbird trapping or other control methods will be implemented if monitoring determines that cowbirds are responsible for declines in covered bird species in the Plan Area.
- **Least tern predators.** The management of California least tern nesting habitat will include a strategy to control nonnative predators and manage native predators to enhance reproductive success and increase population abundance. This could be achieved through fencing, direct removal of predators, and/or through the design of nesting habitats that minimize access of predators into active colonies, among other approaches.

Mosquito Abatement

Enhancement of pond and wetland habitats must be balanced with the need to minimize mosquito production. Encouraging adequate populations of mosquito predators, such as native frogs, swallows, and bats, offers an approach to mosquito control that is compatible with management for covered species. Wetlands will be designed to reduce mosquito production by minimizing suitable habitat for mosquitoes (primarily *Culex torsalis*) and other human disease vectors, particularly between mid-July and late September or October when mosquito productivity is highest. Any mosquito control activities to be performed on reserve system land will be addressed in the reserve unit management plan in consultation with the local vector control district. The site-specific management plan will detail the nature of mosquito control activities and explain specific measures implemented to avoid and minimize effects on covered species consistent with the BDCP. The Natomas Basin HCP is an example of a local conservation plan that has created and managed extensive wetlands in a successful partnership with a local vector control agency.

Reserve System Permeability

One important measure of the reserve system's success will be the degree to which it allows native wildlife species to move freely within the reserve system and to other habitat outside the reserve system. In landscape ecology, permeability differs from connectivity in that connectivity refers to creating connections between existing large protected areas of species habitat (described in *CM3 Natural Communities Protection and Restoration*), while permeability refers to the relative potential for a species to move across a landscape (Singleton et al. 2002). For example, removal of a fence or other barriers to species movement would increase landscape permeability.

The permeability of the study area will be increased by the actions listed below, where applicable.

- Retrofitting or removing fences that serve as barriers or hazards to wildlife movement.
- Improving culverts and other crossing points under roads to make them more attractive and safer for wildlife.
- Collecting consistent data on wildlife movement throughout the Plan Area to better inform the location and type of structures that will facilitate safe movement.
- Managing grassland vegetation and thatch to facilitate dispersal of amphibians, such as California tiger salamander, for which dense vegetation may hinder movement.

Most fences in the reserve system will remain and will be used for management purposes, such as grazing management. Those that are unnecessary will be removed to increase reserve system permeability. Additional fences may be installed to better manage grazing timing and locations. Most existing roads within the reserve system will be used for management or monitoring purposes, but those that are unnecessary will be removed and decommissioned (i.e., returned to a natural condition) to reduce hazards to wildlife and the erosion potential associated with dirt and gravel roads. Additional roads may be added to establish access for management or monitoring purposes. These access routes will conform to the natural contours of the surrounding landscape and will only be maintained to the extent necessary for access.

Culverts that create a one-way barrier[9] along waterways will be removed or retrofitted to allow movement of fish and aquatic amphibians both upstream and downstream. In most cases, retrofitting involves replacing small obstructive culverts with larger, straight culverts to allow species to move through more readily. In some instances culverts may be replaced with clear-span bridges to increase the habitat quality of the waterway where it flows under the roadway. This approach enhances the habitat (both aquatic and terrestrial) under the roadway for animal movement. In addition, existing culverts or bridges may be enhanced to increase wildlife movement through or under these permanent barriers. For example, fencing could be installed along the roadway to guide wildlife species away from the roadway and through undercrossings.

3.4.12.3.3 Aquatic and Emergent Wetland Natural Communities

The following measures will be implemented to manage and enhance the aquatic and emergent wetland natural communities in the reserve system, including tidal brackish emergent wetland, tidal freshwater emergent wetland, nontidal freshwater perennial emergent wetland, tidal perennial aquatic, and nontidal perennial aquatic. Applicable management and enhancement actions described at the beginning of this conservation measure will also be implemented. Where there are conflicts between the general and community-specific actions, the community-specific actions will be implemented.

Required Actions

The following management actions will be implemented for all emergent wetland communities in the reserve system.

[9] One-way barriers occur when species can move in one direction, but not the other (e.g., fish moving downstream but not upstream).

- Reduce distribution and abundance of invasive plant species that threaten covered species and biodiversity associated with emergent wetland communities (see *Emergent Wetland Invasive Plant Control*).
- Maintain tidal mudflats by reducing distribution and abundance of invasive plant species (see *Maintenance of Tidal Mudflats*).
- Create or maintain upland areas that can serve as refugia during high-tide events (e.g., grassland patches for salt marsh harvest mouse (see *Maintenance of Upland Refugia*).
- Reduce distribution and abundance nonnative wildlife that threatens covered species in emergent wetland communities (see *Nonnative Wildlife Control*).
- Maintain vegetation composition and structure to support appropriate habitat conditions for covered species (see *Vegetation Management*).
- Control human and pet access into wetland areas.
- Limit cattle access to wetland vegetation to the extent necessary to prevent significant deterioration of covered species habitat.

The following additional management actions will be implemented in Suisun Marsh.

- Reduce and then maintain the cover of nonnative invasive plant species such as perennial pepperweed, bull thistle, and annual grasses in Suisun Marsh to levels that do not significantly impact covered species.
- Contribute to the control of seed predators that threaten populations of soft bird's-beak and Suisun thistle (see *Seed Predator Control*).
- Seed banking for Suisun thistle and soft bird's beak *[**Note to Reviewers:** text to come.]*

The following additional management actions will be implemented for the 400 acres of nontidal freshwater perennial emergent wetlands to be restored in the reserve system.

- Manage vegetation density and composition, water depth, and other habitat elements to enhance habitat values for giant garter snakes.
- Maintain upland refugia (islands or berms) within the restored marsh.
- Maintain permanent buffer zones at least 200 feet wide around all restored nontidal freshwater emergent wetland habitats to provide undisturbed (uncultivated) upland cover and aestivation habitat immediately adjacent to aquatic habitat.
- Manage bank slopes and upland buffer habitats to enhance giant garter snake use, provide cover, and encourage burrowing mammals for purposes of creating hibernation sites for giant garter snake.
- Establish seasonal buffer zones around aquatic habitats to reduce disturbance and improve foraging habitat for tricolored blackbirds.

Guidelines and Techniques

Emergent Wetland Invasive Plant Control

Invasive plants in emergent wetlands include perennial pepperweed, fennel, bull thistle, and giant reed (*Arundo donax*): these species can form dense monocultures that eliminate native plants and degrade wildlife habitat. Additionally, some small nonnative annuals, such as barbgrass (*Hainardia cylindrical*) and rabbitsfoot grass (*Polypogon monspeliensis*), affect soft bird's-beak (a hemiparasite) by functioning as ineffective host plants (Grewell 2005).

Perennial pepperweed will be controlled in Suisun Marsh where it threatens habitat for California clapper rail, Suisun thistle, and soft bird's beak, and other covered species. Small nonnative annuals such as barbgrass (*Hainardia cylindrical*) and rabbitsfoot grass (*Polypogon monspeliensis*) will also be controlled in the reserve system, particularly where they threaten soft bird's-beak populations (Grewell 2005). Other invasive plants in emergent wetlands will be controlled as necessary, as described above, to meet the BDCP biological goals and objectives. While methods have been developed to reduce the cover of invasive species in the short-term, there are no long-term control solutions and effective management of invasive species will require an uninterrupted long-term commitment.

Maintenance of Tidal Mudflats

Tidal mudflats occur within a matrix of tidal aquatic and tidal emergent wetland natural communities. These mudflats will be maintained by reducing invasive plant species such as *Spartina alterniflora* that would otherwise diminish the extent or degrade the function of mudflats. See *CM13 Invasive Aquatic Vegetation Control* for treatments, site selection, and other guidelines on the control of submerged and floating nonnative aquatic vegetation.

Maintenance of Upland Refugia

*[**Note to Reviewers:** text to come.]*

Nonnative Wildlife Control

A feral pig control program will be implemented in the Suisun Marsh area using trapping, hunting, or other effective control methods. Other nonnative animals potentially adversely affecting covered species and native biodiversity in emergent wetland communities include brown-headed cowbirds, feral cats, nonnative red foxes, and nonnative rats. Active control programs will be implemented if nonnative animals are found (through population monitoring) to adversely affect covered species populations.

Vegetation Management

Vegetation management is a critical component of optimizing the emergent wetland habitat function for covered species. Emergent wetland vegetation will be managed depending on the site-specific conditions of individual wetlands, and will largely depend on the individual species or group of species targeted for enhancement (or removal in the case of invasive nonnative species). Vegetation management will involve several techniques, often used in concert, to achieve the species composition and habitat structure necessary to benefit covered and other native species.

- **Prescribed burning.** Prescribed burning has been used as a management tool in tidal emergent wetlands in other areas, such as Blackwater National Wildlife Refuge in Maryland and McFadden National Wildlife Refuge in Texas, to favor the growth of vegetation favorable to waterfowl and other wildlife (U.S. Fish and Wildlife Service 2005). Prescribed burns may be used to achieve similar benefits for tidal wetlands in the reserve system, although any plans for prescribed burns must be based on achieving the BDCP's biological goals and objectives and must consider potential adverse effects on covered species. Pilot projects will be implemented to assess the relative benefits and potential adverse effects of prescribed burning prior to implementation of any large-scale prescribed burning plans in emergent wetlands in the Plan Area.
- **Livestock control**. Cattle grazing will be excluded from Suisun thistle and soft bird's-beak habitat. Cattle will also be controlled through exclusionary fencing to protect other sensitive emergent wetland areas. Overgrazing by cattle and rooting by feral pigs can cause trampling of vegetation, soil compaction, development of "cow contours," and bank destabilization. Fencing wetlands has been shown to be a rapid, successful, and cost-effective method of enhancing some wetlands. After fencing, vegetation cover and wetland species diversity can increase substantially in stock ponds and other permanent or near-permanent freshwater wetlands that have been degraded by cattle grazing (Contra Costa Water District 2002). In this Plan, fencing locations and specifications will depend on several factors, including site-specific conditions and the biological objectives that are being addressed.
- **Seed predator control.** *[**Note to Reviewers:** text to come.]*
- **Seed banking.** *[**Note to Reviewers:** text to come.]*

3.4.12.3.4 Riparian Natural Community

This section describes management and enhancement actions that will be implemented in the reserve system specific to the riparian natural community. Applicable management and enhancement actions described at the beginning of this conservation measure will also be implemented. Where there are conflicts between the general and community-specific actions, the community-specific actions will be implemented.

Required Actions

The following measures will be implemented in restored and protected riparian natural community in the Plan Area.

- Manage the structure and composition of restored riparian areas to help meet the objectives established for the riparian natural community, riparian brush rabbit, riparian woodrat, Swainson's hawk, white-tailed kite, and yellow-billed cuckoo (see *Riparian Vegetation Enhancement and Management*).
- Control invasive plant species to maintain or increase native riparian biodiversity (see *Riparian Invasive Plant Control*).
- Control nonnative potential predators on riparian brush rabbit in occupied riparian brush rabbit habitat (see *Riparian Nonnative Predator Control*).
- Enhance and manage stream channels and channel banks associated with the riparian natural community to increase the diversity of microhabitats, improve hydrologic conditions that

support the regeneration of riparian vegetation, and improve habitat functions for aquatic species (see *Stream Channel Enhancement and Management*).

- Limit cattle access to riparian and other wetland vegetation to the extent necessary to prevent significant deterioration of habitat of covered species (see *Livestock Management*).

Guidelines and Techniques

Riparian Vegetation Enhancement and Management

The reserve system must support at least 1,000 acres of early to mid-successional riparian vegetation. The improvements in hydrology in the Delta (*CM1 Water Facilities and Operation*), including increased frequency and duration of pulse flows and bypass flows, are expected to also improve fluvial disturbance to help maintain and enhance this early to mid-successional riparian vegetation in the reserve system. However, if fluvial disturbance is not sufficient to meet this objective, additional enhancement and management described below will be implemented. Additionally, riparian restoration as described in *CM7 Riparian Natural Community Restoration* will include areas restored specifically to meet suitable habitat characteristics for riparian woodrat, riparian brush rabbit, and yellow-billed cuckoo, and active vegetation management may be necessary to sustain these appropriate habitat characteristics. Once these riparian restoration sites have met their success criteria, riparian vegetation management would occur consistent with this conservation measure to maintain and enhance riparian woodland and suitable habitat characteristics for the target covered species.

The riparian management strategy recognizes the spatially and structurally dynamic nature of the riparian natural community. As flooding along rivers results in scouring and fluvial disturbances, vegetation is cleared from some areas that then go through a process from early successional (low, dense shrubs) toward late successional (high, dense canopy) vegetation. Periodic disturbance thus results in a mosaic of vegetation characteristics that shifts over time. As such, early- to mid-successional riparian vegetation is not expected to remain in one location. Instead, this requirement will be met throughout the reserve system as riparian vegetation matures and is disturbed in different locations. Riparian vegetation in the reserve system will be monitored annually to ensure that there are at least 1,000 acres of early- to mid-successional and 500 acres of mature forest throughout the reserve system. Similarly, the 300 acres of suitable habitat for riparian brush rabbit and 300 acres of suitable riparian woodrat habitat may spatially shift over time, as long as it meets the locational criteria for these species. Active vegetation management will only be implemented if necessary to meet the biological objectives for the riparian community and associated covered species.

Structural heterogeneity of riparian vegetation in the reserve system will be maintained and enhanced. Vegetation structure can be defined as the foliage volume (or cover of foliage) by height for a given area (Riparian Habitat Joint Venture 2009). Structural complexity, including understory (low shrubs), midstory (large shrubs and small trees) and overstory (upper canopy formed from large trees) is important to provide habitat requirements for a diversity of wildlife species. Appropriate structure will also be maintained for riparian brush rabbit and riparian woodrat, as described below.

Active vegetation management may include girdling trees, mechanical vegetation removal, plantings, moving sediment and gravel, or other techniques of managing physical processes and vegetation to provide the appropriate vegetation structural characteristics. The Implementation Office will consider the biological needs for fish and other covered species, and apply the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*, when choosing the appropriate vegetation management techniques and applying them to managed sites.

In addition to managing riparian vegetation structure, the Implementation Office will plant rare or uncommon riparian native plant species such as buttonwillow or elderberry shrubs in riparian areas as deemed appropriate to increase native biodiversity and provide important habitat features for certain covered species (e.g., blackberry for tricolored blackbird). The following guidelines also apply to riparian woodland management in specific instances.

- **Riparian woodrat (San Joaquin Valley)**. The 300 acres of suitable riparian woodrat habitat that will be restored, as described in *CM7 Riparian Natural Community Restoration*, will be maintained to sustain appropriate habitat characteristics for this species. Additionally, flood refugia created for riparian woodrat, as described in *CM7 Riparian Natural Community Restoration*, will be monitored and maintained to ensure that they retain their functional value as flood refugia for this species. The habitat characteristics to be maintained for this species are described in *CM7 Riparian Natural Community Restoration*.
- **Riparian brush rabbit.** The 300 acres of suitable riparian brush rabbit habitat that will be restored as described in *CM7 Riparian Natural Community Restoration*, and the 200 acres of existing occupied habitat to be protected as described in *CM3 Natural Communities Protection and Restoration*, will be maintained to sustain appropriate habitat characteristics for this species. The 200 acres of protected occupied habitat may be further enhanced to establish favorable habitat characteristics for riparian brush rabbit. Additionally, flood refugia created for riparian woodrat, as described in *CM7 Riparian Natural Community Restoration*, will be monitored and maintained to ensure that they retain their functional value as flood refugia for this species. Habitat characteristics to maintain for this species are described in *CM7 Riparian Natural Community Restoration*.
- **Riparian invasive plant control.** Invasive plant control in riparian areas will focus on reducing or eliminating those species that threaten habitat values. Himalayan blackberry, giant reed, perennial pepperweed, black locust, and fig are common invasive plant species in the riparian natural community in the Plan Area. The Implementation Office will consider habitat needs for yellow-breasted chat and tricolored blackbird before removing stands of Himalayan blackberry from riparian areas: these species frequently nest in Himalayan blackberry thickets which provide valuable nesting substrate and cover.
- **Riparian nonnative predator control.** Predator control is a key element of the riparian brush rabbit conservation strategy. Nonnative feral predators, such as cats and dogs, can be a threat to riparian brush rabbit populations, particularly where sufficient cover habitat is not available. Control of predators will be particularly important during restoration and relocation efforts until self-sustaining populations are established. Therefore, predation threats by feral predators will be monitored and minimized at all restoration sites through predator control or other management actions.

Stream Channel Enhancement and Management

The BDCP relies primarily on floodplain and channel margin restoration to establish conditions for natural processes to sustain favorable ecological conditions within and adjacent to stream channels.

However, active enhancement and management of stream channels adjacent to the riparian natural community may be necessary to achieve BDCP biological goals and objectives. The following enhancement activities may be included.

- Installation of woody debris in stream channels to create pools to increase the diversity of microhabitats.
- Removal of riprap along channel banks and alteration of stream channel geomorphology to improve hydrologic conditions that support the regeneration of riparian vegetation and improve habitat functions for aquatic species.

Livestock Management

As part of the grazing management program, the Implementation Office will exclude livestock along targeted stream segments in the reserve system using exclusion fencing, off-channel water sources, and other potential actions as needed. Fencing wetlands may not be appropriate in locations where retaining open water for species such as western pond turtle is an objective.

3.4.12.3.5 Grasslands and Associated Seasonal Wetland Natural Communities

This section describes the management strategies for grasslands and associated natural communities, including vernal pool complex, alkali seasonal wetland complex, and other seasonal wetlands. Applicable management and enhancement actions described at the beginning of this conservation measure will also be implemented Where there are conflicts between the general and community-specific actions, the community-specific actions will be implemented.

Required Actions

- Enhance and manage vegetation to reduce fuel loads for wildfires, reduce thatch, minimize nonnative competition with native plant species, increase biodiversity and provide suitable habitat conditions for covered species (see *Grassland Vegetation Enhancement and Management*).
- Manage grasslands to increase the availability of aestivation and nesting burrows for western burrowing owl, California red-legged frog and California tiger salamander; and to increase prey availability for San Joaquin kit fox, Swainson's hawk, white-tailed kite, and other native wildlife predators (see *Ground-Dwelling Mammals*).
- Where appropriate, install artificial nesting burrows or create elevated berms, mounds, or debris piles for western burrowing owl to facilitate use of unoccupied areas (see *Structures for Covered Wildlife*).
- Install perching structures to facilitate use by western burrowing owl, Swainson's hawk, and white-tailed kite (see *Structures for Covered Wildlife Species*).
- Install woody debris in stock ponds to provide cover and basking opportunities for western pond turtle (see *Structures for Covered Wildlife Species*).
- Enhance and maintain hydrology of vernal pool complex and alkali seasonal wetland complex natural communities and stock ponds (see *Hydrologic Functions of Vernal Pools, Seasonal Wetlands, and Stock Ponds.*).

- Control bullfrogs and other nonnative predatory species limiting the abundance of covered amphibians in seasonal wetlands and ponds (see *Bullfrogs and Nonnative Predatory Fish*).
- Enhance and manage vernal pool complexes to sustain suitable conditions for vernal pool pollinators (see *Vernal Pool Pollinators*).

Guidelines and Techniques

Grassland Vegetation Enhancement and Management

Enhancement and management of grasslands in the reserve system will require applying many of the management techniques described below concurrently at different sites and on different spatial and temporal scales to create a mosaic of grassland conditions. This will maximize habitat heterogeneity across the landscape and will tend to increase native biological and structural diversity (Fuhlendorf and Engle 2001). For example, the buildup of dead plant material, or thatch, has been implicated in the suppression of native annual forbs in unmanaged wet grasslands in California (Hayes and Holl 2003). Techniques to reduce thatch (e.g., livestock grazing, prescribed burning, raking) will be applied only where the treatment is expected to benefit native grassland species. Techniques to reduce thatch should be discontinued if they are demonstrated to promote expansion of invasive species or encroachment of nonnative grassland into native grassland areas. These management techniques can also be effective at reducing the overall biomass of nonnative invasive species and increasing the annual success of native grassland species.

Managers must consider the impacts of management treatments on other covered species. For example, if burns occur in grassland habitat, treatments may affect covered plants in both positive and negative ways (Gillespie and Allen 2004); accordingly, it is important to monitor several life stages to determine the net effect of management actions.

Site conditions (both physical and biological) and land use history are important in developing biologically appropriate management techniques to attempt to enhance native grassland alliances (Stromberg and Griffin 1996; Hamilton et al. 2002; Harrison et al. 2003). For example, some species of native grasses may occur primarily on steep north- or east-facing slopes where soil moisture tends to be higher (Jones & Stokes Associates 1989). Management strategies at these sites will differ from sites on more level topography and drier, south-facing slopes.

Guidelines and techniques for grassland vegetation management are described below.

- **Pilot experiments.** To minimize uncertainty about the appropriate management regime necessary to maintain and enhance each grassland type, pilot experiments will be conducted to test the effects of management actions. The experiments will be designed to test a range of reasonable management alternatives under appropriate spatial scales and seasonal weather patterns. Long-term monitoring programs will also include the following three components: experimental plots that generate information describing the long-term trends of management actions, experimental treatments for most likely management alternatives, and appropriate controls.
- **Livestock grazing.** Grazing by livestock and native herbivores is proposed for implementation in the reserve system to enhance grasslands by creating structural diversity and increasing the abundance of native grassland species. The flora of the Plan Area evolved under the influence of prehistoric herbivores, including large herds of deer, elk, antelope, and other grazing animals,

and without the competition from nonnative annuals which dominate much of the study area today. At present, appropriate livestock grazing utilizing cattle, sheep, and goats can be useful for range management, as a vegetation management tool to promote native plants and animals, and to reduce fuel loads for wildfires. One study found that grazing increased the diversity of native plant species on serpentine grasslands but decreased native diversity on nonserpentine grasslands (Harrison et al. 2003). In addition, grazing and ranch land management practice have been demonstrated to benefit California tiger salamander and California red-legged frog. Livestock grazing can be used to manage vegetation for purposes of maintaining and improving habitat conditions for resident plants and animals and to reduce fuel loads for wildfires. Different grazers and different grazing intensities result in different impacts on vegetation. The BDCP Implementation Office will develop an appropriate grazing program for enhancing and maintaining habitat for covered species for each protected area based on site-specific characteristics of the community and covered species, the spatial location of important ecological features in each pasture, the history of grazing on the site, species composition of the site, grazer vegetation preference, and other relevant information. Grazing exclusion should be used as a management alternative where appropriate. Grazing practices in effect in each pasture for the 5 years prior to acquisition should be continued unless there is a specific conservation related need to alter them or site-specific information suggests that alternate management actions would better advance the sites conservation goals. Grazing in certain native grassland communities, however, may need to be reduced to maintain or enhance these communities. Note that midsummer grazing may be effective in controlling exotic grassland plant species because most native perennial grasses would be dormant in summer and not substantially damaged by grazing.

Several factors, including timing, stocking rate, rotation type, and grazing species, may affect the success of a grazing program (Sotoyome Resource Conservation District 2007). These are described below.

- **Timing.** Varying the timing (i.e., seasonal timing, annual timing) of grazing generally produces different effects across the landscape. Short-term winter grazing following burning may help to control exotic grasses as they germinate after winter rains, while mid-summer grazing may promote native perennial grasses because they are dormant at that time and not substantially damaged by grazing. These tradeoffs will need to be considered as site-specific management plans are developed.
- **Stocking rate.** The stocking rate refers to the number of cattle grazing at a given site for a given period of time. The stocking rate will be consistent with known or experimentally derived rates that promote native plants without adversely affecting covered species or causing long-term rangeland degradation.
- **Rotation type.** Rotation of cattle on different pastures within and between years can influence the success of a grazing program. Current rotations will be monitored and only shifted if monitoring results indicate that the lands or covered species are adversely affected under the existing timing.
- **Grazing species.** Different herbivorous species have different preferences and abilities to be selective grazers and therefore have different impacts on vegetation. Management plans will take these differences into consideration.

Effects on all covered species are not quantified or fully understood, and it is possible that in some cases the effects of grazing on some covered plants may be detrimental Potential adverse effects on covered species will be considered when developing grazing plans, and careful monitoring and adaptive management will be implemented to protect covered species and ensure the biological goals and objectives for these species are met.

Livestock grazing will be introduced or continued at some vernal pools, seasonal wetlands and stock ponds associated with grasslands. Allowing limited livestock access to these areas will help maintain their usefulness as habitat for covered species by preventing excessive plant growth that can lead to rapid sedimentation of ponds (U.S. Fish and Wildlife Service 2002). Seasonally limited grazing can be effective at reducing competition for nonnative plant species in seasonal wetlands (Marty 2005). Grazing can eliminate or reduce cover of exotic plants and maintain wetlands and ponds by preventing excessive plant growth when such a technique is consistent with maintaining values for covered species. Grazing rotation and fencing can also reduce erosive impacts from livestock. In some cases it may be necessary to exclude livestock from seasonal wetlands and ponds as described below.

- **Livestock control.** Grazers will be excluded from some sensitive vernal pool, seasonal wetland, ephemeral drainage, and pond areas. Complete or partial exclusion from ephemeral drainages with the appropriate alkaline soils in Conservation Zone 1 and Conservation Zone 11 will be considered in habitats known to have, or have potential to produce with exclusion (due to proximity to a known occurrence), occurrences of Carquinez goldenbush. Portions of stock ponds in Conservation Zone 8 will be fenced to prevent livestock entry, encourage emergent wetland growth, and facilitate California red-legged frog and California tiger salamander use. In addition, targeted studies examining grazing exclusion from specific terrestrial areas may be considered for sensitive plant species. However, small-scale exclusion fences in potentially remote areas are expensive and labor intensive to install and maintain. Therefore, exclusionary fencing will only be considered in areas where monitoring indicates that conservation targets are not being met or detrimental effects of grazing may actually hinder the survival of the species.

  Fencing wetlands may not be appropriate in locations where retaining open water for species such as western pond turtle and California tiger salamander is an objective. In such cases, fencing half of a pond or wetland (split fencing) may accommodate the needs of multiple covered species (U.S. Fish and Wildlife Service 2002).

  Another technique for minimizing livestock impacts on wetlands is to provide grazing animals with supplemental sources of water located in the uplands away from the wetlands.

- **Prescribed burning.** Prescribed burning may be implemented in grasslands to mimic historic disturbance regimes and promote native biodiversity. Fire played an important role in the development of the historic California native grassland community, and fire suppression following European settlement contributed to a loss of native diversity in California grasslands (Barry et al. 2006). Prescribed burning as a strategy to manage grasslands has been studied extensively in California and elsewhere (Harrison et al. 2003; Rice 2005). A review of existing literature in 2004 found that burning has mixed results depending on the starting condition of the ecosystem and on the timing and frequency of the burns (Rice 2005). Research indicates that in order for fire to successfully reduce nonnative and increase native plant cover, burns must be targeted toward the specific system and species conditions.

Prescribed burning in late spring reduces nonnative seed production and increases native perennial grass seedling establishment due to litter removal and reduction of competition (Menke 1992). Additionally, summer burning can benefit grasslands by stimulating native perennial bunchgrasses to fragment into two or more vigorous daughter plants (Menke 1992). A prescribed burning program will be implemented with careful monitoring and adaptive management to ensure that it meets the objective of promoting native biodiversity.

Prescribed burning can be used to mimic short interval fire regimes. Late spring and fall prescribed burning may be used in some grassland areas to increase native species cover in grasslands and reduce the cover of exotic species, repeating treatment on site as needed. Grazing will be used in conjunction with prescribed burns where appropriate to control exotic grasses as they germinate after winter rains.

If burns are implemented in the reserve system as a management tool, considerations will include the blooming and seeding times of the targeted nonnative species, the history of site use, and the likely condition of the native soil seed bank. Fires will be conducted at a time when the seeds of the targeted invasive plants will be destroyed. Single burns are generally unsuccessful at restoring native diversity and cover to grasslands; multiple burns are usually required. Burning can be used in conjunction with grazing or mowing to control infestations of invasive species. If native vegetation on a site has been particularly denuded, supplementary seeding of native species may be required.

In particular, prescribed burning within the reserve system may be an effective tool to eradicate invasive species that are selectively avoided by grazing livestock. An example of this is barbed goatgrass (*Aegilops triuncialis*). Barbed goatgrass is avoided by livestock but can be controlled with prescribed burns that are appropriately timed (just after plants senesce but while seeds are still maturing) and repeated (probably at least 2 or 3 years in succession) (DiTomaso et al. 2001).

- **Mowing.** In some instances, mowing is a reasonable alternative to prescribed burns. Mowing can often be safer and easier to implement on small scales than fire. Like prescribed burning, mowing needs to be timed to target the blooming and seeding cycle of nonnative species. Mowing may be particularly useful and effective as a small-scale treatment in areas that cattle cannot access (such as steep or rocky slopes) or for other site-specific logistical reasons (for example, when removal of vegetation is required at a time other than the grazing timing currently in use). Discing as a management tool in grasslands is not recommended because it often destroys burrows for covered and other native species (e.g., western burrowing owl, San Joaquin kit fox), increases soil erosion, and creates invasion sites for noxious weeds.
- **Seeding native forbs and grasses.** Highly degraded grasslands may need additional input of native seed to restore their functionality. Seeding may include covered plant species. Any seed supplements in native grasslands must use locally derived genetic stock. Where possible, seed sources of covered plants will come from within the same watershed. If no seed source is available from the same watershed, then the seed source will be from as close as possible. Decisions regarding where to introduce seed and from how far away to collect it will be made in light of all available information about the targeted species, the source population, and issues related to maintaining the genetic integrity of existing populations (California Native Plant Society 2001).

To maximize the success of seed addition, pretreatment (e.g., burning 1 year prior to seeding to reduce weed seeds on the surface and in litter) may be required. Recent research conducted on grasslands in Santa Barbara suggests that seedlings of California native forbs can be excellent competitors when enough seeds are present to overcome the dominance in the seed pool of the exotic grasses and forbs (Seabloom et al. 2002). In a 5-year experiment, burning or mowing had no effect on the abundance or the proportion of native forbs without seeding. Targeted studies could test this approach by seeding grasslands with native and locally collected seeds within the reserves.

Ground-Dwelling Mammals

Increasing the density of ground-dwelling native mammals is an important goal of management on grasslands. Ground-dwelling mammals such as California ground squirrel provide a variety of important ecosystem functions and benefits to covered species such as prey for golden eagle, western burrowing owl, and Swainson's hawk and burrows for western burrowing owl, California red-legged frog, and California tiger salamander. Historically, ground squirrel populations were controlled by ranchers and public agencies. Eliminating ground squirrel control measures on the reserve system may be sufficient to increase squirrel populations in some areas. However, some rodent control measures will likely remain necessary in certain areas where dense rodent populations may compromise important infrastructure (e.g., pond berms, road embankments, railroad beds, levees, dam faces). The use of rodenticides or other rodent control measures will be prohibited in reserves except as necessary to address adverse impacts on essential structures within or immediately adjacent to reserves, including recreational facilities incorporated into the reserve system. The Implementation Office will introduce livestock grazing (where it is not currently used, and where conflicts with covered activities will be minimized) in order to reduce vegetative cover and thus encourage ground squirrel expansion and colonization.

Where lands neighboring preserves require ground squirrel management to protect agricultural uses or public health, a buffer zone will be established on reserve land within which ground squirrel colonies will not be encouraged or may be controlled. The width of this buffer will be determined by the reserve manager in consultation with neighboring landowners and BDCP Implementation Office scientists. The buffer width will depend on site conditions, the size and density of the local ground squirrel population, and the intensity of control methods used adjacent to the preserve.

Structures for Covered Wildlife Species

Various types of structures may be installed and maintained within reserves supporting grasslands and associated wetlands to enhance habitat values for covered wildlife species. The location and type of structure to be installed will be based on expected benefits to covered species and likelihood that the species will occupy the enhanced lands.

Grasslands will be enhanced for western burrowing owl in unoccupied areas where suitable burrows or other microhabitat characteristics are lacking. Enhancement actions for this species may include installing artificial nesting burrows or creating elevated berms, mounds, or debris piles to facilitate use of unoccupied areas.

Perching structures may be installed in grasslands to facilitate use by western burrowing owl, Swainson's hawk, and white-tailed kite. Perches will be installed away from areas such as roads that are likely to experience frequent human disturbance.

Coarse woody debris or anchored basking platforms may be installed in stock ponds to improve habitat for western pond turtles (Hays et al. 1999). This modification will be implemented where it will increase the habitat value in locations with existing western pond turtles and where it is hoped that new pond turtle populations will establish. These structures may also enhance habitat for native amphibian species.

Hydrologic Function of Vernal Pools, Seasonal Wetlands, and Stock Ponds

Hydrologic functions to be maintained within vernal pool and alkali seasonal wetland complexes include surface water storage in the pool, subsurface water exchange, and surface water conveyance (Butterwick 1998:52). Aspects of surface water storage such as timing, frequency, and duration of inundation will be monitored, enhanced and managed to benefit covered species. Techniques used to enhance and manage hydrology may include invasive plant control, removal of adverse supplemental water sources into reserves (e.g., agricultural or urban runoff), and topographic modifications.

Repairs may be made to improve water retention in stock ponds that are not retaining water due to leaks and, as a result, not functioning properly as habitat for covered species. Additionally, pond capacity and water duration can be increased (e.g., by raising spillway elevations) to support covered species populations.

In order to retain the habitat quality of stock ponds over time, occasional sediment removal may be needed to address the buildup of sediment that results from adjacent land use or upstream factors. Dredging will be conducted during the non-breeding periods of covered and other native species.

Bullfrogs and Nonnative Predatory Fish

Habitat management and enhancement will include trapping and other techniques to control the establishment and abundance of bullfrogs and other nonnative predators that threaten covered wildlife species in vernal pools, seasonal wetlands, and stock ponds. The Implementation Office will work to reduce and, where possible, eradicate nonnative exotic species that adversely affect native species. These efforts will include prescribed methods for removal of bullfrogs, mosqitofish, and nonnative predatory fish from stock ponds and wetlands within the reserve system.

The Implementation Office will work to reduce, and if possible eradicate, nonnative predators (e.g., bullfrogs, nonnative predatory fish) from aquatic habitat for covered amphibian species through habitat manipulation (e.g., periodic draining of ponds), trapping, hand capturing, electroshocking, or other control methods. Draining ponds, sterilizing or removing subsoil, and removing bullfrogs can be effective at reducing predation by bullfrogs and other invasive species on covered amphibians and reptiles (Doubledee et al. 2003). Some ponds in the reserve system might be retrofitted with drains if the nonnative species populations cannot be controlled by other means. Ponds without drains and that do not drain naturally may need to be drained periodically using pumps. Drainage of stock ponds and other wetlands will be carried out during the summer or fall dry season. Population models predict that draining ponds every 2 years will increase the likelihood that California red-legged frogs will persist in ponds with bullfrogs (Doubledee et al. 2003). The Implementation Office will evaluate water inputs from outside the reserve system to control nonnative fish and other exotic species from entering and establishing populations in ponds and streams within the Plan Area.

Vernal Pool Pollinators

Vernal pool complexes will be managed to sustain appropriate habitat characteristics for solitary bees and other native pollinators of vernal pool plants. The vegetation management techniques described above are expected to result in suitable conditions for supporting vernal pool plant pollinators. However, little information is currently available on microsite conditions or suitable management techniques for these species. The vernal pool management strategy will therefore be adjusted based on new information regarding vernal pool pollinators as it becomes available. Pilot experiments (described above) may also be directed toward determining the appropriate management regime for vernal pool pollinators.

3.4.12.3.6 Cultivated Landscapes and Managed Wetlands

The following management actions, guidelines and techniques apply to cultivated landscapes and managed wetlands. Applicable management and enhancement actions described at the beginning of this conservation measure will also be implemented. Where there are conflicts between the general and community-specific actions, the community-specific actions will be implemented.

Required Actions

The following management actions apply to all conserved cultivated landsdcapes.

- Defer tilling of crops when feasible to increase foraging opportunities for greater sandhill crane (see *Timing and Flooding*).
- Enhance protected lands for wintering sandhill cranes, waterfowl and shorebirds by flooding harvested corn fields during the fall and winter months (see *Timing and Flooding*).
- Maintain uncultivated seasonal or permanent buffers on cultivated landscapes in the reserve system that are adjacent to riparian and wetland habitats, to protect the integrity of the stream corridor and associated riparian vegetation, to promote regeneration of riparian species, and to reduce disturbance of nesting species such as tricolored blackbirds, yellow-breasted chats, and least Bell's vireo (see *Buffers*).
- Maintain water in canals and ditches during the activity period (early spring through mid-fall) for the giant garter snake, western pond turtle, and other covered species using waterways (see *Canals and Irrigation Ditches*).
- Minimize or discontinue pesticide use to reduce negative impacts on wildlife including direct, lethal toxicity, reproductive failures, and other adverse effects (see *Pesticide Use*).
- Retain existing patches of riparian, grassland, and other natural communities and habitat features that occur within the cultivated landscape matrix (see *Associated Features*).
- Retain trees and plant new trees to provide nesting habitat for Swainson's hawk and white-tailed kite (see *Associated Features*).
- Retain, create, and enhance burrowing owl habitat associated with cultivated landscapes in the reserve system (see *Associated Features*).
- Retain and plant hedgerows on cultivated lands to provide refugia for rodents, thus increasing rodent prey populations for the Swainson's hawk and the white-tailed kite (see *Associated Features*).

- Establish and maintain suitable nesting substrate for tricolored blackbird associated with cultivated landscapes in the reserve system (see *Associated Features*).
- Where managed wetlands exist, focus habitat management and enhancement on improving and maintaining site hydrology by grading, excavating, replacing, or installing water control infrastructure (see *Managed Wetlands*).

Results of effectiveness monitoring of enhancement and management actions will provide the information necessary to identify future changes in management of conserved lands to ensure that biological objectives are achieved over the term of the BDCP.

Guidelines, and Techniques

The management of suitable cultivated landscapes within the Plan Area is focused on three components: establishing habitat thresholds for each cultivated land-associated covered species, monitoring of land cultivation patterns to determine the extent to which the needs of each covered species are being met at any point in time, and maintaining appropriate cropping patterns within the reserve system to meet species-specific objectives. In conjunction with protection and creation of edge habitats, the program is designed to sustain and enhance cultivated landscape values while not overly influencing standard agricultural operations. Agricultural productivity and economic viability will be protected while enhancing and maintaining wildlife values across the cultivated landscape in the BDCP reserve system.

Cropping Patterns

Cultivated lands with the highest habitat values for covered and other native wildlife species will be maintained in the reserve system. Cropping patterns will be managed to ensure, on an annual basis, that at least the minimum habitat acreages and quality for each covered species are maintained as described below.

- **Swainson's hawk.** On cultivated lands managed for Swainson's hawk conservation, crop types will be selected and rotated such that sufficient high value foraging habitat is maintained within the agricultural matrix and that meet the requirements for maintaining the target number of habitat acres for this species. To the extent practicable, conserved cultivated lands will focus on the highest value foraging habitat (i.e., alfalfa), but include other crop type rotations and cultivated land uses (e.g., irrigated pastures) in order to meet the habitat requirement.

  *[**Note to Reviewers:** Additional detail will be provided when the Swainson's hawk strategy is further refined.]*

- **Greater sandhill crane.** On cultivated lands managed for greater sandhill cranes, crop types that provide high value foraging habitat will be used in order to meet the target number of habitat units for this species. Managed cultivated lands that provide foraging habitat for cranes will include corn, wheat, alfalfa, and irrigated pasture cover types.

  *[**Note to Reviewers:** Additional detail will be provided when the sandhill crane strategy is further refined. Additional species may also be described when the cultivated lands strategy is further refined.]*

Timing and Flooding

Where feasible, habitat management in areas conserved as foraging habitat for sandhill crane will include deferring the tilling of corn and grain fields until later in the fall to increase the amount and availability of forage for this species. Also where feasible, a portion of corn or grain fields will be left unharvested to increase the quantity of forage available to sandhill cranes (forage gradually becomes available as senescent plant stalks fall over as a result of weathering).

To increase the foraging and roosting value of cultivated lands for greater sandhill cranes, shallow flooding of some corn, grain, and irrigated pastures during fall and winter will also be used. This will also improve foraging conditions for waterfowl and shorebirds.

Buffers

Uncultivated buffers will be maintained on cultivated lands in the reserve system that are adjacent to the riparian natural community. Uncultivated buffers will also be maintained on cultivated lands in the reserve system around canals and ditches that support giant garter snake, to reduce disturbance and possible mortality and to provide upland habitat for the snake during its dormant period. Where feasible, these buffers will extend 200 feet from the edge of the canal or ditch.

Canals and Irrigation Ditches

The Implementation Office will retain or create connectivity of canals and irrigation ditches within and between giant garter snake reserves to facilitate dispersal and other movement of giant garter snake. Emergent vegetation will be maintained in these canals and irrigation ditches within the reserve system to provide escape cover for giant garter snakes.

Pesticide Use

*[**Note to Reviewers:** text to come.]*

Associated Features

The Implementation Office will retain wetlands, riparian communities, grassland edges, ponds, and other natural communities and habitat features that occur within the cultivated lands matrix. Conservation easements on cultivated lands will stipulate that these natural community features will be protected and managed to achieve BDCP biological goals and objectives.

Tree rows, wood lots or other tree groves, and isolated trees will also be retained under conservation easements on cultivated lands to provide nesting habitat for Swainson's hawk and white-tailed kite. Small woodlots may also be planted in field corners or tree rows may be planted along field borders to provide nesting habitat for these species.

Existing hedgerows will be retained and new hedgerows may be planted in association with cultivated lands in the reserve system. Hedgerows are expected to provide refugia for rodents, thus increasing rodent prey populations for Swainson's hawk, white-tailed kite, and western burrowing owl.

Burrowing owl habitat will be created and enhanced in association with cultivated lands in the reserve system. This will involve the retention or creation of grassland edges, levee slopes, berms, or patches that provide opportunities for burrowing owl breeding or wintering burrows. Burrowing owl habitat will also be enhanced along cultivated edges by managing vegetation height, installing perches and artificial nesting structures, where appropriate, and encouraging ground squirrel activity.

Where conditions permit, stands of emergent vegetation, native blackberry, or other native vegetation will be established along ditches and canals to provide suitable nesting substrate for tricolored blackbird. These stands will be located near foraging sites and, where feasible, within the dispersal range of existing tricolored blackbird nesting colonies.

Managed Wetlands

*[**Note to Reviewers:** text to come.]*

3.4.13 Conservation Measure 12 Methylmercury Management

*[**Note to Reviewers:** This measure is focused solely on the problem of methylmercury contamination arising from existing mercury loading caused by natural and historical sources in watersheds tributary to the Delta. Other conservation measures address water and sediment quality issues.]*

Under *CM12 Methylmercury Management*, the BDCP Implementation Office will minimize conditions that promote production of methylmercury in restored areas and its subsequent introduction to the foodweb, and to covered species in particular. This conservation measure will promote the following actions.

- Define design elements that minimize conditions conducive to generation of methylmercury in restored areas.
- Define adaptive management strategies that can be implemented to monitor and minimize actual post-restoration mobilization of methylmercury.

The design elements will be integrated into site-specific restoration designs based on site conditions, community type (tidal marsh, nontidal marsh, floodplain), and potential concentrations of mercury in prerestoration sediments. The adaptive management strategies can be applied where site conditions indicate a high probability of methylmercury generation and effects on covered species.

3.4.13.1 Purpose

The primary purpose of CM12 is to meet or contribute to biological goals and objectives as identified in Table 3.4-15. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementing Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-15. Biological Goals and Objectives Addressed by CM12 Methylmercury Management

Biological Goal or Objective	How CM12 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.5: Promote water quality conditions within the Delta that help restore native fish habitat.	Use of techniques that reduce methylmercury production from restored wetland and aquatic natural communities will reduce the risk of methylmercury entering sediments, water column, or foodweb.
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objective L4.1: Avoid and minimize impacts on covered species resulting from BDCP covered activities.	Use of techniques that reduce methylmercury production from restored wetland and aquatic natural communities will reduce the risk of methylmercury accumulation in covered species, which would otherwise constitute a potential source of sublethal and lethal metabolic effects.

CM12 will also provide benefits beyond those specified as biological goals and objectives. The techniques proposed in this conservation measure are expected to reduce methylmercury production in Delta wetland ecosystems, convert existing methylmercury to less-toxic inorganic mercury, or reduce the potential for methylmercury to enter the foodweb. Each of these outcomes will benefit all wetland communities and the covered species dependent on those communities.

3.4.13.2 Problem Statement

For descriptions of the current condition of methylmercury in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for methylmercury management as a component of the conservation strategies for each of the tidal natural communities and associated covered species.

Mercury is present in sediments and soils throughout the Delta, having been deposited by tributaries and rivers that drain areas of former mining operations in the mountains. The highest concentrations have been reported in Cache Creek and Yolo Bypass and the Mokelumne-Cosumnes River system (Woods et al. 2010). Mercury is also potentially present in sediments of all ROAs throughout the Delta at varying concentrations.

Mercury in an inorganic or elemental form tends to adhere to soils and has limited bioavailability. Mercury may be converted by bacteria to a different form, called methylmercury, which is much more bioavailable and toxic than inorganic forms, and has a strong tendency to bioaccumulate in organisms. The toxicity and tissue concentrations of methylmercury are amplified as it biomagnifies through the foodchain. As a consequence, the filet mercury concentrations of most sportfish in the Delta exceed fish advisory guidelines.

Mercury is converted to methylmercury in a process called methylation by sulfur-reducing bacteria that occur in anaerobic (oxygen-depleted) conditions, such as are often found in wetland soils. Current research has shown that the conversion rate is highest in sediments subjected to periodic wet and drying-out periods, including marshes and floodplains. The multiple influences of environmental parameters on mercury methylation are complex (Windham-Meyers et al. 2010). In general, the highest methylation rates are associated with high tidal marshes with intermittent wetting and drying periods and anoxic conditions that support methylation (Alpers et al. 2008). Therefore, potential effects from mercury in the Plan Area are highly dependent on many factors that must be considered on a site-specific basis, including the following.

- In-place sediment (or flooded soil) concentrations of mercury, methylmercury, and organic compounds.
- The methylation rates of the surface sediments in restored environments.
- Other environmental conditions including pH, salinity, and redox.

Restoration actions proposed in *CM4 Tidal Natural Communities Restoration* will increase the acreage of intermittently wetted areas by converting cultivated lands and other upland areas to tidal, open water, and floodplain habitats, potentially increasing methylmercury production in the Plan Area. Some of this increased production is likely to be taken up by organisms, and to biomagnify through the foodchain. The risks that mercury and methylmercury pose to covered species is discussed in Appendix 5.D, *Toxics*.

3.4.13.3 Implementation

3.4.13.3.1 Required Actions

Project-Specific Mercury Management Plans

For each restoration project under *CM4 Tidal Natural Communities Restoration*, a project-specific mercury management plan will be developed and will incorporate all of the methylmercury management measures discussed below or include an explanation of why a particular measure cannot be incorporated. The plan will include the following components.

- A brief review of available information on levels of mercury expected in site sediments (proximity to sources, existing analytical data).
- An estimation of the relative amounts of mercury expected in site soils.
- A determination if sampling for characterization of mercury concentrations and/or post-restoration monitoring is warranted.
- A plan for conducting the sampling, if characterization sampling is recommended.

CM12 will be developed and implemented in coordination with the mercury total maximum daily load (TMDL) and basin plan amendment currently in preparation by the Central Valley Regional Water Quality Control Board (Central Valley Water Board) (2011). Phase I of the basin plan amendment (effective October 2011) for methylmercury will be underway for the next 7 years, with an additional 2 years to evaluate Phase I results and plan for Phase II. The findings of research conducted under Phase I will be discussed in each of the project-specific mercury management plans and any new information on methylmercury mitigation measures will be considered and reviewed in the plan for application to that specific project.

The BDCP Implementation Office, in conjunction with the mercury TMDL program, will provide for a programmatic quality assurance/quality control (QA/QC) program that will specify sampling procedures, analytical methods, data review requirements, a QA/QC manager, and data management and reporting procedures. Each project-specific plan will be required to comply with these procedures to ensure consistency and a high level of data quality.

Because methylmercury is an area of active research in the Delta, each new project-specific mercury management plan will be updated based on the latest information about the role of mercury in Delta ecosystems or methods for its characterization or management. Results from monitoring of methylmercury in previous restoration projects will also be incorporated into the next project-specific mercury management plan. This program will be developed and implemented within the context of TMDL and basin plan amendment requirements.

3.4.13.3.2 Timing and Phasing

The timing and phasing of implementing CM12 will be contingent upon the timing and phasing of individual restoration projects developed under BDCP.

3.4.13.3.3 Monitoring and Adaptive Management

Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure. Post-construction monitoring of mercury will be mandatory if preconstruction monitoring data show levels of methylmercury exceeding 0.06 nanogram per liter (unfiltered water sample). This is the level developed by the mercury TMDL.

3.4.13.3.4 Minimization and Mitigation Measures

Each project-specific mercury management plan will describe, at a minimum, the application or infeasibility of each of the mitigation measures described in detail in the following paragraphs. At this time, there is no proven method to mitigate methylation and mobilization of mercury into the aquatic system resulting from inundation of restoration areas. The purpose of CM12, the current mercury TMDL, and the basin plan amendment discussed above is to coordinate research and inform future actions concerning mercury methylation and mitigation measures. The mitigation measures described below are meant to provide a list of current research that has indicated potential to mitigate mercury methylation. CM12 is intended to evolve as it is informed by new research results over time.

Characterize Soil Mercury

Mercury concentrations and distribution in soil will be characterized to inform restoration design, post-restoration monitoring, and adaptive management strategies. The amount of mercury that could be converted to methylmercury is directly related to the initial concentrations of mercury in restoration site sediments. Mercury is generally not homogenously distributed in alluvial sediments. Factors determining the distribution of mercury in an area include distance from source areas (tributaries carrying mercury from upland mining areas such as Cache Creek), sediment grain size (mercury preferentially adheres to fine-grained sediments in depositional areas), and distribution of channel versus overbank alluvial deposits. Sampling designs will account for these variables to assess mercury distribution throughout a restoration site. Outcomes of the characterization could include pre-restoration site preparation and remediation, selection and design of appropriate mitigation measures, and design of post-restoration monitoring requirements.

Further mitigation measures and post-construction monitoring will be mandatory if monitoring data show levels of methylmercury exceeding 0.06 nanogram per liter (unfiltered water sample), as developed by the TMDL.

Minimize Microbial Methylation

Conversion of mercury to methylmercury depends on microbial activity in an anoxic environment. By reducing the amount of organic material at a restoration site, aerobic degradation is limited and anoxic conditions are less likely to result. Thus, conditions are not conducive for sulfate-reducing bacteria and associated methylation. Recent research in the Yolo Bypass has demonstrated that methylmercury levels could be reduced by up to an order of magnitude by using livestock grazing to reduce loads of organic matter prior to flooding (Heim et al. in press). It should be noted that this is not appropriate for all, or probably many, restoration areas, but is an area of research that addresses mercury methylation, and should at least be considered. The mechanism involves the removal of organics through livestock grazing, resulting in less likelihood of anoxic conditions conducive to mercury methylation. Wetlands are complex systems that have evolved under anaerobic conditions and have developed communities of organizations that thrive under these conditions. For each area where removal of organic matter is considered, site-specific conditions and restoration objectives will be carefully evaluated to determine if the measure is appropriate and how it should be implemented.

To ensure an aerobic water column and surface sediment layer that will minimize mercury methylation two techniques will be used when feasible. First, water depths will be sufficient to avoid drying. Second, restoration sites will be designed to include shallow ponded areas with extensive open expanses to promote frequent wind-driven oxygenation (e.g., high wind fetch) that will minimize methylation. Emergent or submerged macrophytes will be removed, which also promotes mixing and aeration throughout the water column. Where feasible, ponds will be deep enough to discourage overgrowth by rooted macrophytes yet shallow enough to promote wind mixing and to allow significant light exposure to the mixed water column, which promotes photodegradation (see below).

Design to Enhance Photodegradation

Photodegradation has been identified as an important factor that removes methylmercury from the Delta ecosystem by converting methylmercury to the biologically unavailable, inorganic (nonmethylated) form of mercury. Photodegradation of methylmercury occurs in the photic zone of the water column (the depth of water within which natural light penetrates). At the 1% light level, the mean depth for the photic zone in the Delta was calculated to be 2.6 meters, with measured depths ranging from 1.9 meters to 3.6 meters (Gill 2008; Byington 2007). Gill and Byington also conclude that photodegradation may be most active within the top half-meter of the water column in the Delta. Gill (2008) identified photodegradation of methylmercury as potentially the most effective mercury detoxification mechanism in the Delta. In the methylmercury budgets developed by Woods et al. (2010), Foe et al. (2008), Byington (2007), and Stephenson et al. (2007), photodegradation rates of methylmercury exceed methylmercury production rates from sediment.

Once photodegraded, mercury will either be volatilized to the air (Amyot et al. 1994), hydrologically transported, or will become available for methylation once again. Once methylated, mercury would again be biologically available.

To maximize photodegradation rates, restoration sites will be maintained for as long as feasible at depths that do not exceed the photic zone.

Remediate Sulfur-Rich Sediments with Iron

Mercury is methylated by sulfate-reducing bacteria that live in anoxic conditions found in tidal marsh restoration areas. Adding iron can reduce the activity of sulfide, thereby reducing mercury methylation. Ferrous iron in sediment pore water can decrease the concentration of dissolved sulfide through the formation of iron sulfide and other minerals. Because iron sulfide is the strongest ligand for oxidized mercury under anoxic conditions, the decrease in sulfide activity should result in a decrease in the concentration of soluble inorganic mercury that is available for methylation and, ultimately, for bioaccumulation. Research in laboratories has demonstrated that the addition of ferrous iron to pure cultures of sulfate-reducing bacteria in an anoxic system decreased net mercury methylation by approximately 75% (Ulrich 2011). Iron remediation to reduce methylation will have to be evaluated on a site-by-site basis. The evaluation will consider species-specific and community effects, fate and transport of the chemicals prior to implementation, and the cost/benefit of the remediation.

Cap Mercury-Laden Sediments

Some restoration areas may require application of fill to raise grades to design elevations. At sites where this measure can be implemented, mercury-containing sediments will be covered and will not be in contact with the water column. This will limit methylmercury flux into the water column and exposure to biota. Depending on the depth of the added sediment layer, bioturbation, which mixes surface and near surface sediments, could bring the mercury back up near the sediment/water interface, limiting the effectiveness of this approach. Baseline characterization of mercury in sediments and post-restoration monitoring within the framework of an adaptive management program will be integrated into this measure.

3.4.14 Conservation Measure 13 Invasive Aquatic Vegetation Control

Under *CM13 Invasive Aquatic Vegetation Control*, the BDCP Implementation Office will take actions to control the introduction and spread of invasive aquatic plant species in BDCP aquatic restoration areas that degrade habitat for covered fish species, waterfowl, and rare native plants (e.g., *Sagittaria sanfordii* and *Lilaeopsis masonii*), and enhance habitat for invasive fish species. Invasive Aquatic Vegetation (IAV) includes submerged aquatic vegetation (SAV) and floating aquatic vegetation (FAV). Invasive SAV and FAV negatively affect covered fish species as well as invasive riparian plants such as giant reed (*Arundo donax*) and red sesbania (*Sesbania punicea*).

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM13 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.14.1 Purpose

The primary purpose of CM13 is to meet or contribute to biological goals and objectives as identified in Table 3.4-16. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-16. Biological Goals and Objectives Addressed by CM13 Invasive Aquatic Vegetation Control

Biological Goal or Objective	How CM13 Advances a Biological Objective
Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.	
Objective L1.4: Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.	IAV control helps to reestablish representative environmental conditions with regard to natural community structure, and supports reestablishment of representative gradients.
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.7: Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.	IAV control allows reestablishment of native aquatic vegetation that has been competitively excluded by invasive, nonnative SAV and FAV species.
Objective L2.10: Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways.	IAV control allows greater light penetration in the water column, supporting greater phytoplankton productivity.
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objective L4.2: Manage the distribution and abundance of established nonnative predators in the Delta to reduce predation on native covered fish species.	IAV, especially SAV, provides cover for nonnative predatory fishes, and its control may reduce predation intensity.
Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.	
Objective TPANC2.1: Control invasive plants, including Brazilian waterweed, Eurasian watermilfoil, and other nonnative plant species that adversely affect native fish populations.	IAV control will contribute to a tidal perennial aquatic natural community that supports viable populations of native fish species by reducing IAV and the habitat it provides for nonnative predatory fish.
Goal DTSM2 (Spatial Distribution): Increased spatial distribution of juvenile and pre-spawning adult delta smelt in preferred habitat areas.	
Objective DTSM2.1 (Spatial Distribution): Increase the extent of suitable habitat in the Plan Area by 15,000 acres during the near-term, 22,000 acres during early long-term, and 49,000 acres during late long-term, and expand the distribution of juvenile and pre-spawn adult delta smelt into that habitat.	Areas currently occupied by IAV, especially SAV, are not suitable for delta smelt. Removal of IAV will help to restore suitable habitat conditions.

Biological Goal or Objective	How CM13 Advances a Biological Objective
Goal LFSM1 (Abundance): Increase abundance of longfin smelt within 15 years of BDCP implementation.	
Objective LFSM1.1 (Abundance): Achieve an annual average of the abundance indices from 1987to 2000 per year, within 15 years of BDCP implementation. **Objective LFSM1.2 (Resilience):** During wet years, achieve a Fall Midwater Trawl abundance index ≥ the abundance index predicted based on regression of prior (1987–2000) longfin abundance and outflow.	Removal of IAV in areas that provide suitable rearing and/or spawning habitat for longfin smelt will contribute towards increasing the extent of suitable habitat available to the species.
Goal PRL1 (Rearing Habitat): Suitable larval rearing habitat for Pacific and River lamprey within the Plan Area.	
Objective PRL1.1: Protect and enhance habitat suitable for larval settlement and development within the Plan Area within 15 years of BDCP implementation.	Removal of IAV in areas that provide suitable larval habitat for river and Pacific lamprey helps to restore habitat.
Goal WTST1 (Abundance): Increased abundance of white sturgeon in the Plan Area.	
Objective WTST1.1: Increase the spawner-adult-abundance-to-juvenile-abundance ratio compared to existing conditions within 15 years of BDCP implementation.	Removal of IAV increases the quantity and quality of habitat suitable for some prey resources important to green and white sturgeon.
Goal GRST1 (Abundance): Increased abundance of green sturgeon in the Plan Area.	
Objective GRST1.1 (Abundance): Increase spawner adult abundance-to-juvenile abundance ratio compared to existing conditions.	Removal of IAV increases the quantity and quality of habitat suitable for some prey resources important to green sturgeon.
Notes: IAV = invasive aquatic vegetation; SAV = submerged aquatic vegetation; FAV = floating aquatic vegetation	

CM13 can also provide benefits beyond those specified as biological goals and objectives. Removing IAV from BDCP aquatic habitat restoration areas is expected to maximize the benefit to covered fish species through the following mechanisms.

- IAV is thought to reduce local flow rates and cause suspended solids to precipitate out of the water column, resulting in a localized reduction in turbidity levels (Grimaldo and Hymanson 1999). This reduced turbidity has several consequences for covered species, described below. In addition, reduced turbidity may increase the hunting efficiency of nonnative piscivores (Nobriga et al. 2005).
- Increased turbidity is hypothesized to improve the predator avoidance abilities of delta and longfin smelt (Interagency Ecological Program 2008a; Anderson 2008). A reduction in turbidity is also hypothesized to reduce the foraging ability of delta and longfin smelt (Nobriga and Herbold 2009; Rosenfield 2010), so increasing turbidity levels may increase delta and longfin smelt foraging abilities.
- Dense patches of IAV physically obstruct covered fish species' access to habitat (Interagency Ecological Program 2008a). IAV removal and control would thereby increase access to rearing habitat for juvenile salmon (all races, but primarily fall-run and winter-run Chinook salmon), steelhead (to some extent), and splittail (Anderson 2008).

- IAV, especially nonnative SAV, provides relatively high quality habitat for nonnative piscivores and is spread across large portions of the Delta in or adjacent to significant migration corridors and pelagic and subtidal open water habitat for covered species (Figure 3.4-13). The interior of nonnative SAV stands is good habitat for larval and juvenile centrarchids (Brown and Michniuk 2007), whereas adult striped bass forage immediately outside of the nonnative SAV bed and feed on juvenile Chinook salmon, steelhead, splittail, delta smelt, and longfin smelt (Stevens 1966; Temple et al. 1998; Nobriga and Feyrer 2007, 2008). Thus, nonnative SAV control is expected to contribute to a reduction in suitable habitat for nonnative predatory fish, thereby reducing predation mortality on juvenile salmon, steelhead, and splittail.
- Shading by IAV, both SAV and FAV, may limit light availability for phytoplankton growth. Thus, IAV removal and control may contribute to an increase in food availability for these covered fish species.

3.4.14.2 Problem Statement

For descriptions of the ecological issues and current condition of invasive aquatic vegetation in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for invasive aquatic vegetation control as a component of the conservation strategies for aquatic communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM13.

IAV is thought to adversely affect the Delta ecosystem by providing habitat for nonnative predators of covered fish species (Brown 2003; Nobriga et al. 2005), reducing food abundance and feeding ability of covered fish species by reducing light and turbidity (Brown and Michniuk 2007), and blocking rearing habitat for juvenile salmon and splittail (Interagency Ecological Program 2008a).

Although the historical extent of native SAV and FAV in the Delta ecosystem is unknown, IAV, both SAV and FAV species, have recently colonized large areas of the Delta (Brown 2003; California Department of Fish and Game 2008; Ustin et al. 2008). Of 55,000 acres of the Delta surveyed in 2007, IAV was estimated to cover between 5,500 and 10,000 acres (10 to 18%) (Ustin et al. 2008). The invasive Brazilian waterweed (*Egeria densa*) forms monodominant stands and is by far the dominant species in mixed stands. IAV vegetation frequently contains three other nonnative species: curlyleaf pondweed (*Potamogeton crispus*), Eurasian watermilfoil (*Myriophyllum spicatum*) and Carolina fanwort (*Cabomba caroliniana*) (Ustin et al. 2008; Santos et al. 2011). The most widespread invasive FAV species, water-hyacinth (*Eichhornia crassipes*), was introduced into the Delta over 100 years ago, and severe infestations were present by the 1980s.

The California Department of Boating and Waterways (DBW) Water Hyacinth Control Program, which began in 1982, has been effective in reducing water-hyacinth in Delta waterways by using chemical and mechanical removal methods. DBW has developed and operated the *Egeria densa* Control Program since 2001, in response to Assembly Bill 2193, which amended the Harbors and Navigation Code to designate DBW as the lead agency for the control of Brazilian waterweed in the Delta (California Department of Boating and Waterways 2006, 2008). Initially, the program focused control efforts in a number of locations where Brazilian waterweed impeded navigation, tested a range of mechanical and chemical control techniques, and conducted an extensive suite of toxicology and water quality tests and sampling that were required by the terms of its National Pollution

Discharge Elimination System (NPDES) permit and under BiOps issued by USFWS and NMFS (California Department of Boating and Waterways 2008). In 2006, DBW concluded that, while its current scale of control efforts was locally effective at specific sites, it was not effective at stopping the expansion of Brazilian waterweed in the Delta. DBW proposed expanding the treatment area to sites across most of the legal Delta between 2006 and 2010 and concentrating on Franks Tract between 2006 and 2008 (California Department of Boating and Waterways 2006).

While these two established and dominant IAV species continue to expand into new areas (Department of Boating and Waterways 2006; Interagency Ecological Program 2008b), other IAV species that could threaten the Delta's ecosystem are appearing in the Delta or occur in the watershed of the Delta but have not yet arrived. Hydrilla (*Hydrilla verticillata*) occurs in Clear Lake and is considered such a high threat that it is targeted by CDFA for complete eradication. A very recent invader, South American spongeplant (*Limnobium laevigata*), first recorded in California in 1996, appeared in the Delta in 2007 and again in 2009 and 2010 (California Department of Food and Agriculture 2011). This emerging species is considered sufficiently threatening that responsibility for its control has been given to CDFA's Hydrilla Program, which is aggressively targeting new infestations for eradication efforts (Akers 2010).

3.4.14.3 Implementation

3.4.14.3.1 Required Actions

To implement this conservation measure, the Implementation Office will not only apply existing control methods tested and developed over several years by the DBW *Egeria densa* and Water Hyacinth Control Programs in BDCP aquatic habitat restoration areas (Figure 3.4-14), but will work with DBW to prioritize established *Egeria densa* and water-hyacinth source populations for control that are near or upstream of restoration areas. It is expected that initial implementation actions will occur in year 2 of Plan implementation.

Control methods currently employed by DBW include application of herbicides to control Brazilian waterweed and herbicide and limited mechanical removal to control water-hyacinth. In addition, research is ongoing into biological control methods for these two species to avoid potential negative effects of herbicide application. Different techniques may be needed to control other IAV species besides water-hyacinth and Brazilian waterweed, and the Implementation Office will support research on emerging IAV species to test and develop effective control methods.

BDCP methods of removal will be dictated by site-specific conditions and intended outcome or goal. Application of herbicides or other methods to control IAV will be timed to eliminate or minimize potential negative effects of removal efforts on covered species as described in Section 3.6, *Adaptive Management and Monitoring Program.*

The Implementation Office will partner with existing programs operating in the Delta (including UC Cooperative Extension, CDFA, local Weed management Areas, RCDs, and Cal-IPC) to perform a risk assessment and subsequent prioritization of treatment areas to strategically and effectively reduce expansion of the multiple species of IAV in the Delta. Reduction efforts will target source populations and populations in the most sensitive areas, such as areas adjacent to and upstream of restoration sites. Recognizing that the introduction and spread of potential IAV is a continuing process, the Implementation Office will consider using tools, such as the customizable Weed

Heuristics: Invasive Population Prioritization for Eradication Tool (WHIPPET) (Skurka Darin et al. 2011), to assist in screening and prioritizing specific IAV species and invaded sites for control.

Prevention is a vital component of invasive species control programs, because efforts expended as soon as a potential IAV species is detected can prevent incurring the much greater costs of controlling the species once it has established and spread. South American spongeplant is an excellent example. Small infestations are relatively easy to eradicate, but if the plant is allowed to establish and set seed, the seeds can survive in sediment and the population becomes very difficult to eradicate later. In addition, the tiny seedlings move easily to establish new infestations (Akers 2010).

The Implementation Office will establish an Early Detection and Rapid Response program to monitor and detect potential IAV that can be targeted before becoming problematic. A good example of such a program is CDFA's Hydrilla Eradication Program, which conducts an annual survey of the Delta with the aim of detecting any sign of Hydrilla before it can establish a foothold. The program works in cooperation with county agricultural commissioners and a variety of federal, state, and county agencies including DBW, DWR, and Reclamation. Other early detection programs include those of CDFA's Integrated Pest Control Branch and the Bay Area Early Detection Network. The Implementation Office will also support public education efforts to provide information on IAV species, how they are spread, and the problems they create (see *CM20 Recreational Users Invasive Species Program*).

3.4.15 Conservation Measure 14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels

Under *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, the BDCP Implementation Office will ensure that the Stockton Deep Water Ship Channel (DWSC) DWR Aeration Facility, which is currently operational, will continue to operate as needed during the BDCP permit term in order to maintain the concentrations of DO above target levels during the entire BDCP permit term. The Implementation Office will develop annual work plans in coordination with fish and wildlife agencies,the Central Valley Water Board, and the current aeration facility operating entities that specify the extent of DO improvements to be implemented and will monitor the effectiveness of measures intended to improve DO levels. The Implementation Office will make funding available for the continued long-term operation and maintenance of the aeration facility within 1 year of implementation of the BDCP. The Implementation Office will also coordinate with the Central Valley Water Board to determine water quality standards to be met both as requirements of the TMDL and as part of BDCP goals and objectives, as well as operational triggers related to when to initiate operations and duration of operations.

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM14 on covered species will be avoided or minimized.

3.4.15.1 Purpose

The primary purpose of CM14 is to meet or contribute to biological goals and objectives as identified in Table 3.4-17. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation

Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-17. Biological Goals and Objectives Addressed by CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels

Biological Goal or Objective	How CM14 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.5: Promote water quality conditions within the Delta that help restore native fish habitat.	Ensure DO levels within the Stockton DWSC are at appropriate levels to provide suitable habitat for covered fish species.
Goal SRCS2 (Abundance): Reduce passage delays (to contribute to increased migration and spawning success, and thus abundance) at anthropogenic impediments of adult spring-run migrating through the Delta.	
Objective SRCS2.1 (Migration): Reduce adult passage delays at anthropogenic barriers and impediments that cause median passage times of greater than 36 hours, within 15 years of BDCP implementation.	Operation of the aeration devices at a DO aeration facility in the Stockton DWSC will help reduce passage delays of fall- and spring-run Chinook salmon associated with low DO levels.
Goal FRCS2 (Abundance): Reduce passage delays (to contribute to increased migration and spawning success and thus abundance) at anthropogenic impediments of adult fall-run migrating through the Delta.	
Objective FRCS2.1 (Migration): Reduce passage delays at anthropogenic barriers and impediments that cause median passage times of more than 36 hours, within 3 years of BDCP implementation.	Operation of the aeration devices at a DO aeration facility in the Stockton DWSC will help reduce passage delays of fall- and spring-run Chinook salmon associated with low DO levels.
Goal WTST2 (Life-History Diversity and Spatial Distribution): Improved habitat connectivity that facilitates timely passage and reduced stranding of adult white sturgeon.	
Objective WTST2.1 (Passage and Stranding): Reduce stranding of adult white sturgeon at Fremont Weir by 75% over baseline conditions within 15 years of BDCP implementation.	Operation of the DWR aeration facility in the DWSC will reduce passage delays of white sturgeon associated with low DO levels.
Goal GRST3 (Spatial Distribution): Increased spatial distribution of YOY and juvenile green sturgeon in the Delta compared to existing conditions.	
Objective GRST3.1 (Distribution): Improve water quality parameters and physical habitat characteristics in the Delta.	Operation of the DWR aeration facility in the DWSC will contribute to improved DO conditions.
Notes: DO = dissolved oxygen; DWSC = deep water ship canal; YOY = young of year.	

CM14 will also provide benefits beyond those specified as biological goals and objectives. Increasing DO concentrations in the Stockton DWSC in accordance with TMDL objectives will achieve the following benefits.

- Reduced delay and inhibition of upstream and downstream migration of fall-run Chinook salmon, steelhead, white sturgeon, lamprey, and, once they are reestablished in the San Joaquin River, spring-run Chinook salmon and green sturgeon.

- Reduced physical stress and mortality of fall-run Chinook salmon, steelhead, white sturgeon, and lamprey, and, once they are reestablished in the San Joaquin River, spring-run Chinook salmon and green sturgeon.

3.4.15.2 Problem Statement

For descriptions of the ecological values and current condition of DO in the Stockton DWSC, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for addressing low DO concentrations as a component of the conservation strategies for aquatic communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM14.

As much as 60% of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses. Depleted flows have contributed to higher water temperatures, lower DO levels, and decreased recruitment of gravel and large woody debris. Other factors that have contributed to low DO include dredging to deepen and widen shipping channels, as well as excessive algal and nutrient loading resulting from land use upstream. One aspect of this issue is that periods of low DO concentrations have historically been observed in the San Joaquin River's Stockton DWSC, which is located downstream from Stockton, California (Figure 3.4-15). The majority of these low DO concentrations have been observed in the summer and fall months in a 7.5-mile-long reach upstream of Turner Cut. For example, over a 5-year period starting in August 2000, a DO meter recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). Over the course of this time period, there were 297 days in which violations of the 5 milligrams per liter (mg/L) minimum DO criterion occurred between Channel Point and Turner and Columbia Cuts during the September through May migratory period for salmonids and March through November migratory period for green sturgeon (once they are reestablished) in the San Joaquin River.

Adult fish, including covered fish species migrating upstream in the fall and early winter, encounter lowered DO in the DWSC due to low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed. Currently, migration routes for adult and juvenile covered fish are limited in this section of the San Joaquin River. Fish can migrate through the DWSC, Old River, or Middle River. The DWSC is the most direct route to spawning habitat upstream of Stockton and rearing habitat downstream within the Delta. Besides being the most direct route, the DWSC likely provides fewer potential hazards for migrating covered fish species, such as less exposure to predators and reduced potential for entrainment compared with migration through the Old and Middle Rivers.

Levels of DO below 5 mg/L have been reported to delay or block migratory movements by fall-run Chinook salmon (Hallock et al. 1970). Low DO levels can cause physiological stress and mortality of fish, including Chinook salmon and steelhead (Jassby and Van Nieuwenhuyse 2005) and other aquatic organisms (Central Valley Regional Water Quality Control Board 2007). Once spring-run Chinook salmon are reestablished in the San Joaquin River under the San Joaquin River Settlement Agreement, similar effects could be expected if low DO conditions in the DWSC were to occur during the adult migration period (approximately March through September). In addition, juvenile white sturgeon, which rear in the San Joaquin River, exhibit reduced foraging and growth rates at DO levels below 58% saturation (5.8 mg/L at 15 °C) (Cech and Crocker 2002).

Ultimately, the low DO levels occur when the rate of oxygen depletion in the DWSC exceeds the rate of oxygen recharge or production. Oxygen recharge and production rates decrease primarily due to two causes.

- As the river water flows downstream from the San Joaquin River channel to the DWSC, the channel depth increases from approximately 9 feet to over 35 feet, which in turn restulst in a reduction in flow velocity and thus a reduction in water column mixing as the water depth increases and the water velocity decreases. This reduces the efficiency of oxygen recharge from atmospheric diffusion.
- Oxygen is produced within the water column via photosynthesis, primarily by phytoplankton but also by SAV. The rate of this oxygen production decreases when light levels decrease. Because the water is turbid and the DWSC is deep, a large proportion of the water column is below the photosynthetic compensation depth (the depth at which an organism's oxygen production by photosynthesis balances oxygen consumption by respiration). Thus, photosynthetic rates, per unit water volume per unit time, are lower.

Conversely, the rate of oxygen consumption in the DWSC is maintained or elevated, relative to upstream waters, for several reasons.

- Phytoplankton at depths below the phytosynthetic compensation depth cause net DO depletion because their respiration rate exceeds their photosynthesis rate.
- Nonphotosynthetic organisms respire in the water column. These include fish, invertebrates such as zooplankton, and microorganisms such as bacteria that metabolize ammonia in the water column.
- Nonbiological chemical reactions consume oxygen in oxidation-reduction reactions.

Also, slow water velocities and reduced water column mixing result in stronger contrasts between high and low DO due to diurnal variations in photosynthesis (photosynthesis only occurs during the daylight hours, so DO levels drop through the night).

The low DO concentrations recorded in the DWSC violate the Central Valley Basin Plan water quality objectives for DO, causing a seasonal barrier to salmonid migration through the DWSC (Hallock et al. 1970) and possibly other covered fish species. In January 1998, the State Water Resources Control Board adopted the Clean Water Act Section 303(d) list that identified this DO impairment, and the Central Valley Water Board initiated development of a TMDL to identify factors contributing to the DO impairment and assign responsibility for correcting the low DO concentration (Central Valley Regional Water Quality Control Board 2005; ICF International 2010).

Since the approval of the San Joaquin River DO TMDL Basin Plan Amendment in 2005, two actions have been implemented to alleviate low DO conditions in the DWSC. First, beginning in 2007 the City of Stockton added engineered wetlands and two nitrifying biotowers to the Stockton Regional Wastewater Control Facility to reduce ammonia discharges to the San Joaquin River. This action decreased the ammonia levels in facility effluent from approximately 30 to 35 mg/L to approximately 2 mg/L, thereby reducing biochemical oxygen demand in the DWSC. The ammonia was the biggest oxygen demand in the winter months and because nitrification treatments were initiated, DO concentrations in the DWSC have improve markedly during the winter months. However, other factors continue to contribute to DO depressions, including reduced river velocity through the Stockton DWSC as a result of increased channel capacity, and upstream contributions of organic materials (e.g., algal loads, nutrients, agricultural discharges).

DO concentrations between May and October would continue to be depressed without additional measures and, prior to the Stockton Regional Wastewater Control Facility improvements, would often drop to less than 4 mg/L between June and September (Jones & Stokes 2002). In response to this problem, DWR constructed the Demonstration Dissolved Oxygen Aeration Facility to determine its applicability for improving DO conditions in the DWSC (ICF International 2010). Constructed between 2006 and 2007 at the west (downstream) end of Rough and Ready Island at the Port of Stockton Dock 20, the Aeration AFacility has been maintained and operated for testing purposes by DWR. The aeration facility underwent an individual Section 7 consultation in 2007 (Jones & Stokes 2007). In 2008, demonstration testing began in June and ended in late September. In 2009, testing was not possible until September because of state bond funding issues. Operations testing of flood tide aeration and nighttime aeration was conducted in September 2009. Additional operations testing and DWSC monitoring were conducted during summer 2010. The demonstration phase ended in December 2010, and DWR, the Central Valley Water Board, and several San Joaquin River DO TMDL stakeholders are in the process of securing a short-term (3-5 years) agreement for funding of operations and maintenance responsibilities. The final report produced in 2010 summarized the results of the testing phase and recommended additional engineering and operations changes to improve the effectiveness of adding DO to the SDWSC.

3.4.15.3 Implementation

3.4.15.3.1 Required Actions

Under this conservation measure, the BDCP Implementation Office will ensure continued funding for and operation of the DWR Aeration Facility, and the continued implementation of measures to improve the facility's effectiveness in meeting BDCP biological goals and objectives. The BDCP Implementation Office will coordinate with the CVRWQCB to ensure that the requirements of both BDCP biological goals and objectives and the San Joaquin River DO TMDL are compatible and effectively met. Long-term funding for operations and maintenance has not been secured and there are currently no mandates by the CVRWQCB that require such funding. Under CM14, the BDCP Implementation Office will share in funding the long-term operation and maintenance costs associated with the project, and will consider funding for modifications to the existing DWR Aeration Facility and/or constructing additional aeration facilities to increase DO levels in the Stockton DWSC and potentially implement the above recommendations, which could improve the effectiveness of CM14 beyond the test results and thus provide greater benefit to covered fish species.

3.4.15.3.2 Siting and Design Considerations

The aeration facility consists of two vertical turbine pumps. The pumps convey river water via discharge piping to two U-Tube contactor wells located west of Dock 20 on the adjacent island. Oxygen is injected at the top of each well. The wells are constructed to a depth of approximately 200 feet below grade. Each well is totally contained, including a bottom seal. Oxygenated water flows down the well in a concentric feed pipe and back up the well annular section. Oxygenated water exiting the U-Tube wells is routed through approximately 1,000 feet of piping back to the DWSC, under Dock 20, and 1,000 feet upstream from the pump intakes where a liquid diffuser mounted along the inboard row of piers, away from shipping traffic, discharges the oxygenated water back to the river (Figure 3.4-16). The aeration facility has been successful in field tests by DWR (ICF International 2010). Results suggest that the aeration facility is effective at raising DO levels in much of the channel; however, some recommendations have been put forth (ICF International 2010) based on the successful operational testing of the aeration facility from 2008 to 2010. There are three general recommendations for the future long-term operations of the aeration facility.

- The aeration facility could be a major component of the TMDL implementation plan for achieving the Central Valley Basin Plan DO objective in the DWSC when the river flow and inflow DO and biochemical oxygen demand concentrations would have resulted in low DO conditions. TMDL accounting procedures for identifying the likely causes for low DO conditions in the DWSC could be developed but would have to be accepted by the Central Valley Water Board and by affected stakeholders.
- A long-term monitoring strategy should be developed as part of the TMDL implementation plan to identify periods when the aeration facility should be operated and to confirm that the added DO was sufficient to achieve the DWSC DO objective. The monitoring strategy should include all data needed for the TMDL accounting procedures.
- Several modifications to the aeration facility should be further evaluated to increase the capacity to deliver added DO to the DWSC or to improve the distribution of added DO upstream of the diffuser. For example, the discharge from the two U-Tube wells could be separated, with a second discharge line and diffuser extended 0.5 mile upstream to distribute more of the added DO upstream of the existing diffuser.

3.4.15.3.3 Adaptive Management and Monitoring

Implementation of CM14 will be informed through effectiveness monitoring that will be conducted as described in Section 3.6, *Adaptive Management and Monitoring Program*. Results from monitoring DO levels at various distances from the diffuser(s) will be used to assess the performance of aeration facility operations at achieving the water quality objective. The Implementation Office will use effectiveness monitoring results to determine whether aeration facility operations result in measurable benefits to covered fish species.

Based on a review of performance and effectiveness monitoring results, the Implementation Office will adjust funding levels, aeration facility operations, or other related aspects to improve the performance and/or biological effectiveness of the aeration facility through the BDCP adaptive management process. Such changes will be addressed in annual work plans.

If results indicate that the aeration facility does not substantially and cost-effectively benefit covered fish species, the BDCP Implementation Office, in coordination with the fish and wildlife agencies and the current aeration facility operating entities, may terminate this conservation measure. If terminated, remaining funding will be discontinued and reallocated to augment funding for other more effective conservation measures identified in coordination with the fish and wildlife agencies through the BDCP adaptive management process.

The Implementation Office will also coordinate with the TMDL stakeholder effort whose ongoing efforts will direct what elements BDCP may want to contribute to (i.e., what isn't required under the TMDL but is required to achieve the goals and objectives of BDCP). For example, the Central Valley Water Board is currently discussing whether the current standard of 6.0mg/l is appropriate, or whether a water quality objective of 5.0 mg/l year round is more appropriate. These decisions will affect BDCP, thus the Implementation Office should be a part of these conversations. Additionally, the Implementation Office will also coordinate with the CVRWQCB to discuss operations and triggers for initiating and duration of operations the DWR aerator to meet water quality objectives.

3.4.16 Conservation Measure 15 Predator Control

Under *CM15 Predator Control,* the BDCP Implementation Office will reduce the local effects of predators on covered fish species by conducting predator control at "hot spot" locations (Figure 3.4-17) that have high densities of predators with a disproportionately large adverse effect on covered fish. For actions to control invasive nonnative plants, see *CM13 Invasive Aquatic Vegetation Control*. For actions to prevent the introduction and further spread of nonnative invasive invertebrates, see *CM20 Recreational Users Invasive Species Program.*

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM15 on covered species will be avoided or minimized.

3.4.16.1 Purpose

The primary purpose of CM15 is to meet or contribute to biological goals and objectives as identified in Table 3.4-18. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-18. Biological Goals and Objectives Addressed by CM15 Predator Control

Biological Goal or Objective	How CM15 Advances a Biological Objective
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objective L4.2: Manage the distribution and abundance of established nonnative predators in the Delta to reduce predation on native covered fish species.	CM15 will directly reduce the abundance of established nonnative predators in localized areas of the Delta.
Goal WRCS1 (Abundance and Life-History Diversity): Improved survival (to contribute to increased abundance) of immigrating and emigrating winter-run salmon through the Plan Area.	
Objective WRCS1.1 (Juvenile Survival): Achieve a through-Delta survival rate of juveniles of at least 30% measured as a 4-year running average within 15 years of BDCP implementation.	CM15 will contribute to a reduction in predator density, and, therefore, a reduction in predation of winter-run Chinook salmon, which will contribute toward increasing abundance.
Goal SRCS1 (Abundance): Improved survival (to contribute to increased abundance) of emigrating juvenile spring-run salmon through the Plan Area.	
Objective SRCS1.1 (Juvenile Survival): Achieve a 4-year running average through-Delta juvenile survival rate, which will result in stable or expanding population[1] within 15 years of BDCP implementation.	CM15 will decrease predator density in the Plan Area to achieve a measurable decrease in steelhead and fall-run and spring-run Chinook salmon predation within 15 years of Plan implementation, focusing on localized predator "hot spots."

Biological Goal or Objective	How CM15 Advances a Biological Objective
Goal FRCS1 (Abundance): Improved survival (to contribute to increased abundance) of emigrating juvenile fall-run salmon through the Plan Area.	
Objective FRCS1.1 (Juvenile Survival): Achieve a 4-year running average through-Delta juvenile survival rate, which will result in stable or expanding population[1] within 15 years of BDCP implementation.	CM15 will decrease predator density in the Plan Area to achieve a measurable decrease in steelhead and fall-run and spring-run Chinook salmon predation within 15 years of Plan implementation, focusing on localized predator "hot spots."
Goal STHD1 (Abundance): Improved survival (to contribute to increased abundance) of juvenile steelhead emigrants form the Sacramento River and San Joaquin River systems through the Plan Area.	
Objective STHD1.1 (Juvenile Survival): Achieve a 4-year running average through-Delta juvenile survival rate, which will result in stable or expanding population[1] within 15 years of BDCP implementation.	CM15 will decrease predator density in the Plan Area to achieve a measurable decrease in steelhead and fall-run and spring-run Chinook salmon predation within 15 years of Plan implementation, focusing on localized predator "hot spots."
[1] Through-Delta survival targets to be refined using similar analysis used for San Joaquin River flow objectives recommendations to the State Water Resources Control Board (U.S. Department of Interior 2011). Potential to measure: can be measured (e.g., see papers by Perry and Skalksi 2008; MacFarlane and Norton 2001; Brandes 1996; Newman 2008).	

CM15 will also provide benefits beyond those specified as biological goals and objectives. All anticipated benefits are described in more detail below.

Conducting localized predator control at hot spots in the Delta will reduce local predator abundance, thus reducing localized predation mortality of Chinook salmon (Temple et al. 1998; Lindley and Mohr 2003); steelhead (Temple et al. 1998), splittail (Moyle et al. 2004), and delta smelt (Stevens 1966; Thomas 1967; Moyle 2002); and possibly longfin smelt (Nowak et al. 2004), and sturgeon.

3.4.16.2 Problem Statement

For descriptions of the ecological values and current status of predator populations in the Plan Area, see Chapter 2, *Existing Conditions* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* also describes the need for nonnative predator control as a component of the conservation strategies for the aquatic natural communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM15. Nobriga and Feyrer (2007) found that the diets of three common piscivorous fish found in the Delta (striped bass, largemouth bass and Sacramento pikeminnow) were composed of numerous invertebrate and fish taxa. Each species displayed seasonal shifts in prey selection. In general, most native fish were consumed during spring (March through May) and the highest prey species richness occurred during summer (June through August). Largemouth bass are likely have the highest per capita effect on nearshore fishes, including native fishes. Largemouth bass preyed on a greater diversity of native fishes than the other two piscivores and consumed native fishes later into the season (July versus May).

Striped bass were introduced to the Delta in 1879 (Nobriga and Feyrer 2007). Since 2004, the striped bass population in the San Francisco estuary appears to have declined, from a high of more than 1 million fish in 2005 to approximately 500,000 fish in 2007 (California Department of Fish and Game 2012). The striped bass is the most broadly distributed and abundant large piscivorous fish in the Plan Area, although it tends to not use habitats occupied by aquatic vegetation (Nobriga and Feyrer 2007). Adult striped bass often congregate near screened diversions, feeding on concentrations of small fish, especially salmon. Striped bass are a major cause of mortality of juvenile salmon and other fish found near the SWP diversions of the South Delta.

Striped bass spawn in large, nontidal tributaries. Most spawning occurs in the Sacramento River, from above Colusa (about river kilometer 195) to below the mouth of the Feather River (about river kilometer 125). Spawning bass may also be attracted to large outflows of agricultural return water from Colusa Drain. During wet years, spawning may take place in the Sacramento River portion of the Delta. In the San Joaquin River, successful spawning upstream of the Delta occurs mainly during years of high flow, when the large volume of runoff dilutes salty irrigation wastewater that normally makes up much of the river's flow. In years of lower flow, spawning occurs in the Delta itself. Because of interactions among these factors there are two main spawning areas that include the Delta: the Sacramento River from Isleton to Butte City and the San Joaquin River and its sloughs from Venice Island down to Antioch (Moyle 2002). After spawning, striped bass eggs and larvae are transported to the low-salinity zone of the estuary by river currents. Bass 1 year and older occur throughout the Delta and in adjacent freshwater and marine habitats.

Largemouth bass are a freshwater fish that cannot successfully reproduce in brackish water (Nobriga and Feyrer 2007). Largemouth bass also were introduced to the Delta in the late nineteenth century, although their numbers in the Delta have increased recently (Nobriga and Feyrer 2007). This increase is associated with increasing water clarity and submerged macrophyte abundance in the Delta. The increase in abundance has been sufficient to support a significant sport fishery (Nobriga and Feyrer 2007). Largemouth bass prefer warm, shallow waters of moderate clarity and beds of aquatic vegetation. In the Delta, habitat provided by the invasion of Brazilian waterweed has been one factor supporting the increase in the largemouth bass population. In low-elevation streams of the Central Valley, largemouth bass occur mostly in disturbed areas where there are large, permanent pools with heavy growths of aquatic plants and two to five other nonnative species. In California it is unusual to find largemouth bass in water with salinities much higher than 3 parts per thousand (ppt), and they avoid salinities higher than 5 ppt. Adult largemouth bass are solitary hunters that may either wander widely or remain in a relatively restricted area centered around a submerged rock or branch (Moyle 2002).

The native Sacramento pikeminnow is a freshwater fish, commonly associated with flowing water habitats (Nobriga and Feyrer 2007). Long-term trends in Sacramento pikeminnow abundance are unknown, but the species is common in the Sacramento River basin (Nobriga and Feyrer 2007). The Sacramento pikeminnow is not targeted by a sport fishery in the Delta, but there is a bounty fishery in the upper Sacramento River to reduce predation on emigrating salmonids (Nobriga and Feyrer 2007). Large pikeminnows typically cruise about in pools during the day in loose groups of five to ten fish, although very large individuals may be solitary. Often by midday they become relatively inactive and return to cover, although some still cruising about, feeding on surface insects or benthos. The largest fish emerge from cover as darkness falls, entering runs and shallow riffles to forage on small fish. Peak feeding usually occurs in the early morning for smaller fish or at night for larger fish. Nighttime predation rates at Red Bluff Diversion Dam were apparently enhanced when lights on the dam made prey more visible. The spawning behavior of pikeminnow has not been recorded in detail (Moyle 2002).

Predator-prey dynamics are influenced by many factors, including: spatial and temporal overlap; habitat structure; environmental heterogeneity; community structure; and attributes of predator and prey including size, taxon, life stage, behavior, and numbers (Mather 1998; Nobriga and Feyrer 2007).

Habitat structure and heterogeneity can affect opportunities for encounter and capture by predators. IAV beds appear to provide habitat that is more favorable to nearshore fishes such as largemouth bass and sunfish that can also take advantage of increased water clarity to find prey (Brown 2003; Nobriga et al. 2005; Nobriga and Feyrer 2007). Human-induced habitat changes such as the alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves also provide conditions that both attract predators and disorient small fish such as juvenile salmonids and smelt (Stevens 1966; Decato 1978; Vogel et al. 1988; Garcia 1989). An extreme case of concentrated predation is seen at release points for salvaged fish from the SWP/CVP export facilities, where large aggregations of piscivorous fish and birds gather to prey on the disoriented fish (Miranda et al. 2010).

Habitat features that allow predators to forage more efficiently include structures, dark locations adjacent to light locations, or deep pools that allow them to hide and ambush their prey. Throughout the Plan Area, multiple locations form or may form "hotspots" that attract high densities of predators, such as the following sites or structures.

- Old structures in or hanging over Delta waterways, such as pier pilings or other human-made features.
- Abandoned boats.
- New intake structures related to the north Delta diversions.
- Scour holes (e.g., the deep hole downstream of the Head of Old River in the San Joaquin River and other locations such as in Georgiana Slough).
- The intakes to the SWP/CVP south Delta export facilities, in particular Clifton Court Forebay (SWP).
- Release sites of salvaged fish from the south Delta CVP/SWP facilities.

Operation of any diversion, including new diversions, may increase predation. Because of hydraulics around diversion structures, prey fish become disoriented (by turbidity and light) and predators tend to aggregate at diversion locations (Kratville 2008). Few direct estimates of predation rates and effectiveness are available. Focused studies of marked fish at the south Delta export facility intakes indicate that predation is high around intake structures, especially at Clifton Court Forebay, where striped bass and other predators consume the majority of fish that pass through the forebay gates even before they reach the salvage facility (Gingras 1997; Clark et al. 2009; Castillo et al. in review). The proposed north Delta intakes could create conditions that enhance predation because of changes in hydrodynamics and littoral habitat.

3.4.16.3 Implementation

3.4.16.3.1 Required Actions

The Implementation Office will review fish monitoring data, bathymetry data, and radio and acoustic tagging study results to determine the locations and causes of predator hot spots throughout the Plan Area. Hot spots in which focused predator control will occur are likely to include, but may not be limited to the following locations.

- Old structures in or hanging over Delta waterways, such as pier pilings or other human-made structures that are no longer functional or have been abandoned but affect flow fields or provide shade or overhead cover (target: 10 to 20 structures removed per year).
- Known predator spawning areas where large numbers of predators may be captured and capture of covered fish species may be avoided or minimized.
- Nonproject screened diversions where predators may congregate and forage on covered fish species and other native fish species.
- Boats that have been abandoned throughout the Delta and provide cover for predators (target: five to ten boats removed per year).
- The new intake structures for the north Delta diversions (target: daily focused removal methods when sensitive life-stages of covered fish species are present).
- The deep hole just downstream of the Head of Old River in the San Joaquin River (target: daily focused removal when sensitive life-stages of covered fish species are present. Additional control efforts may be needed in conjunction with operation of nonphysical barriers, as described in *CM16 Nonphysical Fish Barriers*).
- Specific locations in Georgiana Slough, as identified by the fish and wildlife agencies (target: daily focused removal in up to three specific locations when sensitive life-stages of covered fish species are present).
- Specific locations in Sutter and Steamboat Sloughs, as identified by the fish and wildlife agencies (target: daily focused removal of predators in up to two specific locations per slough when sensitive life-stages of covered fish species are present).
- Release sites of salvaged fish from CVP/SWP facilities (target: focused removal at each salvage release site just prior to release when sensitive life-stages of covered fish species are being salvaged).

The Implementation Office will use a variety of methods to control predator populations in hot spots, including removal of predator hiding spots; modification of channel geometry; and targeted removal of predators through beach seining, gill netting, angling and electrofishing when the capture of targeted predators can be maximized and the potential capture of covered fish species can be avoided or minimized. Other focused methods may be dictated by site-specific conditions and the intended outcome or goal. For some predators, such as striped bass, capturing fish during key life-stages may maximize capture of the target predator while avoiding or minimizing capture of covered fish species. For example, it may be most efficient to capture striped bass during their spawning period (typically April through June), when fish are relatively concentrated along 70 kilometers (43 miles) of the Sacramento River. Priority will be given to predator hot spots in areas with high numbers of covered fish, such as major migratory routes or spawning and rearing habitats, and to methods that maximize the capture of predators and minimize the capture of covered fish species. This may require some experimentation with field methods, such as the mesh size of nets; time of day, month, or year; and control sites.

Site-specific control plans will be developed in consultation with the fish and wildlife agencies, and will include expected benefits, methods, and a monitoring design that will provide information necessary to determine the effectiveness of the predator control actions. Initial inventory and screening actions are expected to take 2 years with initial control actions beginning in year 3 of Plan implementation.

3.4.16.3.2 Adaptive Management and Monitoring

Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure.

Monitoring will assess the abundance, distribution, and size of predator species before and immediately after implementation of predator control actions in each hot spot to determine the effectiveness of the action. Changes in survival rates of covered species will be monitored using acoustic tagging studies or similar techniques. An example of such a study is provided by Cavallo et al. (in review). Likewise, monitoring will assess the effectiveness of specific methods in capturing large numbers of predators and minimizing the capture of covered fish species.

The Implementation Office, in consultation with the fish and wildlife agencies, will use results of effectiveness monitoring to determine whether the actions result in measurable benefits to covered fish species, and to identify adjustments to funding levels, methods, or other related aspects of the program that would improve biological effectiveness. Such changes, once approved through the adaptive management decision-making process, will be effected through subsequent annual work plans.

If the results of monitoring indicate that predator control actions do not substantially and cost-effectively benefit covered fish species, the BDCP Implementation Office, in coordination with fish and wildlife agencies, may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the wildlife and fishery agencies through the BDCP adaptive management process.

3.4.17 Conservation Measure 16 Nonphysical Fish Barriers

Under *CM16 Nonphysical Fish Barriers*, the BDCP Implementation Office will improve the survival of outmigrating juvenile salmonids by using nonphysical barriers to redirect juvenile fish away from channels and river reaches in which survival is lower than in alternate routes (Figure 3.4-18). Nonphysical barriers will be installed and operated from October to June or when monitoring determines that salmonid smolts are present in the target areas. Nonphysical fish barriers have not been shown to be effective for other covered fish species; thus, this conservation measure is likely to be applicable only to salmonids. Refer to *Siting and Design Criteria*, below, for further discussion.

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM16 on covered species will be avoided or minimized.

3.4.17.1 Purpose

The primary purpose of CM16 is to meet or contribute to the biological goals and objectives identified in Table 3.4-19. The rationale for each of these goals and objectives is provided in Section

3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-19. Biological Goals and Objectives Addressed by CM16 Nonphysical Fish Barriers

Biological Goal or Objective	How CM16 Advances a Biological Objective
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objectives L4.3: Manage the distribution of covered fish species to minimize movements into high predation risk areas of the Delta.	Nonphysical fish barriers provide a means of diverting covered fish species, primarily salmonids, from waters that pose a high risk of entrainment and/or predation.
Goal WRCS1 (Abundance and Life-History Diversity): Improved survival (to contribute to increased abundance) of immigrating and emigrating winter-run salmon through the Plan Area.	
Objective WRCS1.1 (Juvenile Survival): Achieve a through-Delta survival rate of juveniles of at least 30% measured as a 4-year running average within 15 years of BDCP implementation.	Nonphysical fish barriers will contribute to achieving this objective by encouraging juvenile salmonids to avoid areas of high risk of entrainment and/or predation.
Goal SRCS1 (Abundance): Improved survival (to contribute to increased abundance) of emigrating juvenile spring-run salmon through the Plan Area.	
Objective SRCS1.1 (Juvenile Survival): Achieve a 4-year running average through-Delta juvenile survival rate, which will result in stable or expanding population[1] within 15 years of BDCP implementation.	Nonphysical fish barriers will contribute to achieving this objective by encouraging juvenile salmonids to avoid areas of high risk of entrainment and/or predation.
Goal FRCS1 (Abundance): Improved survival (to contribute to increased abundance) of emigrating juvenile fall-run salmon through the Plan Area.	
Objective FRCS1.1 (Juvenile Survival): Achieve a 4-year running average through-Delta juvenile survival rate, which will result in stable or expanding population[1] within 15 years of BDCP implementation.	Nonphysical fish barriers will contribute to achieving this objective by encouraging juvenile salmonids to avoid areas of high risk of entrainment and/or predation.
Goal STHD1 (Abundance): Improved survival (to contribute to increased abundance) of juvenile steelhead emigrants form the Sacramento River and San Joaquin River systems through the Plan Area.	
Objective STHD1.1 (Juvenile Survival): Achieve a 4-year running average through-Delta juvenile survival rate, which will result in stable or expanding population[1] within 15 years of BDCP implementation.	Nonphysical fish barriers will contriture to achieving this objective by encouraging juvenile salmonids to avoid areas of high risk of entrainment and/or predation.
[1] Through-Delta survival targets to be refined using similar analysis used for San Joaquin River flow objectives recommendations to the State Water Resources Control Board (U.S. Department of Interior 2011). Potential to measure: can be measured (e.g., see papers by Perry and Skalksi 2008a; MacFarlane and Norton 2001; Brandes 1996; Newman 2008).	

3.4.17.2 Problem Statement

For descriptions of the ecological values and current condition of fish barriers in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for nonphysical fish barriers as a component of the conservation strategies for covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM16.

Juvenile salmonids experience low survival rates while migrating through the Delta toward the ocean. Survival rates vary among routes taken through the Delta (Brandes and McLain 2001; Perry and Skalski 2008b, 2009; Holbrook et al. 2009; Perry et al. 2009) as a result of differential exposure to predation, entrainment mortality at state and federal water export facilities and small agricultural diversions, and other factors (San Joaquin River Group Authority 2006; Burau pers. comm.).

Survival for routes through the interior Delta was at most 35% that of survival for fish remaining in the Sacramento River (Perry et al. 2009). Such low probability of survival when migrating through the interior Delta indicates that significant population-level impacts could result if a sizable portion of the salmon population passed through this area. Perry and Skalski (2009) found that 20 to 35% of tagged salmon used Sutter and Steamboat Sloughs during migration, while 27% to nearly 33% of the population entered the interior area. Low survival probabilities and high proportions of the population migrating through the interior Delta combine to significantly reduce salmon survival through the Delta during migration. Physical barriers have been used in the Delta, such as the Delta Cross Channel gates and the rock barrier at the Head of Old River, to prohibit the entry of fish into channels where survival rates are low. Physical barriers are effective at prohibiting entry of salmonids into channels, but they also alter flow dynamics in these channels, likely affecting tidal flows, sediment loads, bathymetry, water supply reliability, potential for noxious algal blooms, toxic concentrations, and other water quality parameters. Operation of nonphysical barriers is predicted to cause smaller changes in the physical configuration of the channel, thus reducing flow-related effects, while improving survival of salmonids by deterring them from entering channels with a higher risk of mortality.

Installation and seasonal operation of nonphysical barriers is hypothesized to improve survival of juvenile salmonids migrating downstream by guiding fish into channels in which they experience lower mortality rates (Welton et al. 2002; Bowen et al. 2009; Bowen and Bark 2010). A nonphysical barrier that induces behavioral aversion using a combination of sound, lights, and bubbles (called a three-component barrier) has shown promising results in laboratory experiments on Chinook salmon emulating the Sacramento River/Georgiana Slough flow split (Bowen et al. 2008) and a field experiment on Atlantic salmon (*Salmo salar*) smolts in the River Frome, UK (Welton et al. 2002). Preliminary evidence suggests that a three-component barrier was effective in deterring acoustically tagged Chinook salmon juveniles from entering the head of Old River during a 2009 pilot study (Bowen et al. 2009). Nonphysical barriers that use only one component, such as sound or light, have demonstrated only limited success in deterring fish during field trials. For example, out of 25 separate single-component sound and light systems placed in 21 different locations in Europe and the United States to affect the behavior of salmonids near water intakes and canals, fewer than 50% were effective in altering fish behavior (U.S. Bureau of Reclamation 2008).

The three-component Nonphysical Barrier Test Project at the divergence of Old River from the San Joaquin River in the Sacramento-San Joaquin Delta successfully deterred 81% of acoustically tagged Chinook salmon smolts from entering Old River (Bowen et al. 2009). However, the protection efficiency (i.e., the relative proportion of smolts successfully going down the San Joaquin River instead of Old River, without being preyed upon) did not differ between barrier-on and barrier-off conditions, because a large proportion of deterred smolts were preyed upon at a scour hole just downstream of the nonphysical barrier. Therefore, the success of CM16 may require the implementation of *CM15 Predator Control* to remove predators from "hot spots" such as a scour hole. In 2010, flows at the Head of Old River-San Joaquin River divergence were substantially higher and resulted in a greatly reduced deterrence efficiency (23%) with the barrier on that was nevertheless statistically highly significantly greater than with the barrier off (0.5%) (Bowen and Bark 2010). Of the smolts not preyed upon within the study area, the protection efficiency was statistically significantly greater with the barrier on (43%) than with the barrier off (26%), meaning fewer fish were preyed upon with the barrier on that with the barrier off.

DWR is undertaking a pilot test study of a similar three-component nonphysical barrier at the divergence of Georgiana Slough from the Sacramento River to deter outmigrating salmonid smolts from entering Georgiana Slough and experiencing higher mortality in the interior Delta (ICF International 2010). Approximately 1,500 acoustically tagged hatchery fish were released upstream of the barrier and monitored for their responses with and without the barrier operating. Analyses are currently being undertaken, but unfortunately results will not be available for this draft. A similar study will be carried out at the same location in spring 2012.

3.4.17.3 Implementation

3.4.17.3.1 Required Actions

The BDCP Implementation Office may install nonphysical barriers at the sites described below. These barriers will achieve their effect using a combination of sound, light, and bubbles, similar to the three-component nonphysical barrier used in the 2009 DWR Head of Old River Test Project (Bowen et al. 2009). Design and permitting for the initial barrier installations will take approximately 2 years, with installation and operation beginning in year 3 of Plan implementation.

3.4.17.3.2 Siting and Design Considerations

The Implementation Office will evaluate the potential for nonphysical barriers to attract predators. Initial studies carried out by Reclamation (2009) indicate that nonphysical barriers may attract predators, such as striped bass; however, it is not clear if predator densities are higher near nonphysical barriers, if certain types of nonphysical barriers may be more attractive to predators (e.g., sound, air and/or light barriers), or how effective certain types/combinations of barriers are at directing covered salmonids away from areas with a high risk of entrainment and/or predation based on site-specific conditions. Further investigations are necessary to determine whether, and under what conditions, nonphysical barriers may be appropriate.

Nonphysical barrier placement locations may include the Head of Old River, the Delta Cross Channel, Georgiana Slough, and possibly Turner Cut and the Columbia Cut (Figure 3.4-19). The Implementation Office may consider other locations in the future if, for example, future research demonstrates differential rates of survival in Sutter and Steamboat Sloughs relative to the mainstem Sacramento River, or in the Yolo Bypass relative to the mainstem Sacramento River. The Implementation Office will be responsible for placement of the nonphysical barriers. Nonphysical barrier placement may be accompanied by actions to reduce local predator abundance, if monitoring finds that such barriers attract predators or direct covered fish species away from potential entrainment hazards but toward predator "hot spots." Barriers will be removed and stored offsite while not in operation (Holderman pers. comm.).

3.4.17.3.3 Adaptive Management and Monitoring

Implementation of this conservation measure by the BDCP Implementation Office will be informed through effectiveness monitoring that will be conducted as described in Section 3.6, *Adaptive Management and Monitoring Program*. The Implementation Office will conduct and review monitoring to assess the effectiveness of nonphysical barriers, including the pilot testing now under way in the Delta. The Implementation Office will use results of effectiveness monitoring to determine whether operations of nonphysical barriers result in measurable benefits to juvenile salmonids and to identify adjustments to funding levels, methods, or other related aspects of the program that would improve the biological effectiveness of the program.

As mentioned previously, uncertainty regarding the potential attraction of predators to nonphysical barriers and the effectiveness of barriers under certain conditions (i.e., in high flow areas, areas with complex bathymetry or cover, or other areas that may have physical conditions that may limit their effectiveness) must be resolved. Such changes, once approved through the adaptive management decision-making process, will be effected through subsequent annual work plans. If results of monitoring indicate that operations of nonphysical barriers do not substantially and cost-effectively benefit covered fish species, the Implementation Office, in coordination with fish and wildlife agencies, may terminate this conservation measure. If terminated, remaining funding will be discontinued from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the fish and wildlife agencies through the BDCP adaptive management process.

Nonphysical fish barriers are not proposed for delta smelt or longfin smelt, because the barriers have not undergone field trials for these species. Previous laboratory-based evidence suggested that, under a nonphysical barrier configuration that was effective in deterring salmon smolts, the nonphysical barrier was not effective in deterring delta smelt (Bowen et al. 2008). Subsequent laboratory studies have shown that significant deterrence of delta smelt by nonphysical barriers may occur, if through-barrier water velocity is sufficiently low to allow avoidance (Bowen pers. comm.). If demonstrated to be effective in deterring delta smelt and longfin smelt and deemed necessary by the fish and wildlife agencies, nonphysical barriers may also be installed at the mouths of Old and Middle Rivers and in Three Mile Slough (if salinity manipulation is not also needed) to deter these species from moving into these channels where the risk of entrainment to the south Delta export facilities is relatively high. The determination of the efficacy of such barriers and whether they are implemented will be made by the Implementation Office and the fish and wildlife agencies in the adaptive management process.

3.4.18 Conservation Measure 17 Illegal Harvest Reduction

Under *CM17 Illegal Harvest Reduction*, the BDCP Implementation Office will reduce illegal harvest of Chinook salmon, Central Valley steelhead, and sturgeon in the Delta, bays, and upstream waterways by funding enforcement actions. The Implementation Office will provide funding over the term of the BDCP to increase the enforcement of fishing regulations in the Delta and bays to reduce illegal harvest of covered salmonids and sturgeon.

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM17 on covered species will be avoided or minimized.

3.4.18.1 Purpose

The primary purpose of CM17 is to meet or contribute to the biological goals and objectives identified in Table 3.4-20. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-20. Biological Goals and Objectives Addressed by CM17 Illegal Harvest Reduction

Biological Goal or Objective	How CM17 Advances a Biological Objective
Goal FRCS4 (Life-History Diversity and Spatial Distribution): Reduced illegal take (to contribute to increased abundance and genetic and life-history diversity) of fall-run adults in the Delta.	
Objective FRCS4.1 (Life-History Diversity and Spatial Distribution): Increase enforcement efforts to reduce illegal take in the Plan Area within 5 years of BDCP implementation.	CM17 will directly address this objective.
Goal GRST1 (Abundance): Increased abundance of green sturgeon in the Plan Area.	
Objective GRST1.1 (Abundance): Increase spawner adult abundance-to-juvenile abundance ratio compared to existing conditions.	CM17 will contribute to a reduction in illegal harvest of green sturgeon, thereby contributing to an increased adult abundance.

CM17 will also provide benefits beyond those specified as biological goals and objectives. Enhanced enforcement on poaching will contribute toward reducing mortality and potentially increasing population sizes of green sturgeon (Beamesderfer et al. 2007; Boreman 1997; California Department of Fish and Game 2007a), white sturgeon (Bay-Delta Oversight Council 1995; Boreman 1997; Schaffter and Kohlhorst 1999; Beamesderfer et al. 2007; California Department of Fish and Game 2007b, 2008a;), Chinook salmon (all races) (Bay-Delta Oversight Council 1995; Williams 2006), and steelhead (California Department of Fish and Game 2007a, 2008a, 2008b; Moyle et al. 2008;).

Spring-run Chinook salmon are thought to experience the greatest benefit because they may be more susceptible to poaching than other runs due to over-summer holding and ease of locating them. Due to the recent establishment of daily bag limits for splittail by the California Fish and Game Commission, it is hypothesized that this conservation measure will also reduce mortality and potentially increase the population size of splittail.

Magnitudes of population-level benefits of this measure are expected to vary inversely with the population size of each covered species (Bay-Delta Oversight Council 1995; Begon et al. 1996; Futuyma 1998; Moyle et al. 2008).

3.4.18.2 Problem Statement

For descriptions of the ecological consequences and current condition of illegal harvests in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* also describes the need for illegal harvest reduction as a component of the conservation strategies for covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM17.

California has the lowest game warden-to-population ratio in the nation with fewer than 200 field wardens for the entire state. Illegal harvest is thought to have substantial effects on sturgeon populations, particularly white sturgeon (Beamesderfer et al. 2007). Illegal harvest of juvenile and adult Chinook salmon and steelhead in the Delta and bays is also common (Delta-Bay Enhanced Enforcement Program 2007).

The DFG Delta-Bay Enhanced Enforcement Program provides a 10-warden squad formed specifically to increase enforcement on poaching of anadromous fish species in the Delta. The program is funded by water contractors through the Delta Fish Agreement. The BDCP Implementation Office will contribute directly to this existing program by expanding its size to improve enforcement against poaching of covered species.

3.4.18.3 Implementation

3.4.18.3.1 Required Actions

The BDCP Implementation Office will provide funds to DFG to hire and equip 17 additional game wardens and five supervisory and administrative staff in support of the existing field wardens assigned to the Delta-Bay Enhanced Enforcement Program. These staff increases will be supported for the duration of the BDCP term. It is expected that it will take 2 to 3 years to achieve the staff increases, with enforcement beginning in year 3 of Plan implementation.

3.4.18.3.2 Monitoring and Adaptive Management

Refer to Section 3.6, *Adaptive Management and Monitoring Program,* for a discussion of monitoring and adaptive management measures specific to this conservation measure. The Implementation Office will coordinate with DFG to adjust enforcement strategies and funding levels through the BDCP adaptive management process as appropriate based on review of Delta-Bay Enhanced Enforcement Program annual reports.

3.4.19 Conservation Measure 18 Conservation Hatcheries

Under *CM18 Conservation Hatcheries*, the BDCP Implementation Office will establish new, and expand existing, conservation propagation programs for delta and longfin smelt. The BDCP Implementation Office will support two programs.

- The development of a delta and longfin smelt conservation hatchery by USFWS to house a delta smelt refugial population and provide a source of delta and longfin smelt for supplementation or reintroduction, if deemed necessary by the fish and wildlife agencies.
- The expansion of the refugial population of delta smelt and establishment of a refugial population of longfin smelt at the University of California (UC) Davis Fish Conservation and Culture Laboratory, to serve as a population safeguard in case of a catastrophic event in natural habitat.

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM18 on covered species will be avoided or minimized.

Refer to Section 3.6, *Adaptive Management and Monitoring Program*, for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.19.1 Purpose

The primary purpose of CM18 is to meet or contribute to biological goals and objectives as identified in Table 3.4-21. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-21. Biological Goals and Objectives Addressed by CM18 Conservation Hatcheries

Biological Goal or Objective	How CM18 Advances a Biological Objective
Goal DTSM1 (Abundance): Increased spawning success and improve the survival of adult and juvenile delta smelt.	
Objective DTSM1.1 (Growth and Health): Achieve a fall mean body length increase of at least 2 mm longer than existing conditions in December as collected in Fall Midwater Trawl (62 mm vs. 60 mm fork length) within 15 years of BDCP implementation.	The creation and expansion of refugial hatchery populations of delta and longfin smelt will ensure *ex situ* conservation of these species, which will contribute to ensuring their continued existence.
Goal LFSM1 (Abundance): Increase abundance of longfin smelt within 15 years of BDCP implementation.	
Objective LFSM1.1 (Abundance): Achieve an annual average of the abundance indices from 1987to 2000 per year, within 15 years of BDCP implementation.	The creation and expansion of refugial hatchery populations of delta and longfin smelt will ensure *ex situ* conservation of these species, which will contribute to ensuring their continued existence.
Objective LFSM1.2 (Resilience): During wet years, achieve a Fall Midwater Trawl abundance index ≥ the abundance index predicted based on regression of prior (1987–2000) longfin abundance and outflow.	The creation and expansion of refugial hatchery populations of delta and longfin smelt will ensure *ex situ* conservation of these species, which will contribute to ensuring their continued existence.
Objective LFSM1.3 (Survival): Increase survival of longfin smelt larvae immediately following yolk-sac absorption within 15 years of BDCP implementation.	The creation and expansion of refugial hatchery populations of delta and longfin smelt will ensure *ex situ* conservation of these species, which will contribute to ensuring their continued existence.

3.4.19.2 Problem Statement

For descriptions of the ecological values and current condition of delta and longfin smelt in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives*, also describes the need for conservation hatcheries as a component of the conservation strategies for covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM18.

The decline of delta smelt has prompted listings under both federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA). USFWS determined that delta smelt warranted listing as a threatened species under the ESA, effective April 5, 1993. The listing decision was based on a substantial reduction in delta smelt abundance in the Bay-Delta estuary in a variety of fishery sampling programs, threats to its habitat, and the inadequacy of regulatory mechanisms to protect delta smelt. The delta smelt was listed as a threatened species under the CESA, on December 9, 1993. On April 7, 2010, USFWS ruled that a change in status from threatened to endangered was warranted but precluded by other higher-priority listing actions (75 *Federal Register* 17667). On March 4, 2009, the California Fish and Game Commission reclassified the delta smelt as endangered under CESA.

Populations of both delta and longfin smelt have experienced dramatic declines in recent years (Interagency Ecological Program 2008a, 2008b). Although a variety of stressors are suspected, there is still no clear understanding of why these populations have declined (Interagency Ecological Program 2008a, 2008b). There is evidence that delta smelt continue to decline and that very low population size could result in an Allee effect (i.e., the reproduction and survival rates of individuals from low populations increasing with population density), causing an even more rapid decline of the species due to factors unique to small populations (Mueller-Solger 2007). As a result, the risk of extinction of delta smelt is hypothesized to be increasing. Longfin smelt abundance has followed a similar trend to delta smelt (Interagency Ecological Program 2008a, 2008b).

Implementation of CM18 would help to reduce the risk of extinction of both species. Artificial propagation and maintenance of refugial populations of delta and longfin smelt are expected to provide the following benefits.

- Provide a safeguard against the possible extinction of delta and/or longfin smelt by maintaining a captive population that has genetic variability reflecting that of wild populations (Lande 1988; Hedrick et al. 1995; Sveinsson and Hara 1995; Carolsfeld 1997; Sorensen 1998; Hedgecock et al. 2000; Kowalski et al. 2006; Turner et al. 2007; Nobriga and Feyrer 2008; Turner and Osborne 2008; Clarke pers. comm.; Essex Partnership 2009).
- Improve the knowledge base regarding threats to and management of delta and longfin smelt by providing an opportunity to study the effects of various stressors on these species in a controlled environment using hatchery-reared specimens instead of wild caught individuals.
- Establish a source population that can be used to supplement delta and longfin smelt populations naturally propagated in the wild (Lande 1988; Deblois and Leggett 1991; Sveinsson and Hara 1995; Carolsfeld 1997; Sorensen 1998; Flagg et al. 2000; Richards et al. 2004; Kowalski et al. 2006; Purchase et al. 2007; Nobriga 2008; Clarke pers. comm.). Such a supplementation, combined with effective habitat restoration and other measures to improve conditions in their natural environment, can contribute to achieving self-sustaining population levels in the wild.

3.4.19.3 Implementation

3.4.19.3.1 Required Actions

The new facility proposed by USFWS will house genetically managed refugial populations of delta and longfin smelt (Clarke 2008). The facility will provide fish to supplement populations in the wild and provide fish stocks for reintroduction, as necessary and appropriate. State-of-the-art genetic management practices will be implemented to maintain close genetic variability and similarity between hatchery-produced and natural-origin fish. The facility will be designed to also provide captive propagation of other species, if necessary, in the future. Due to space limitations, the facility as planned will consist of two sites: a science-oriented genetic refuge and research facility on the edge of the Sacramento River, and a larger supplementation production facility nearby (Clarke pers. comm.) (Figure 3.4-20). The facility will discontinue housing refugial populations of delta and longfin smelt only when these species achieve recovery as defined by USFWS. The specifications and operations of this facility have not been developed. Additional permitting and environmental documentation will be needed to implement this conservation measure once facility designs and funding are available. Because of these challenges, it is expected that design, permitting, and construction of the facility will take approximately 6 years, with the facility becoming operational in year 7 of Plan implementation.

The UC Davis Fish Conservation and Culture Laboratory is in need of additional space and funds to expand the refugial population of delta smelt and establish a refugial population of longfin smelt. The Fish Conservation and Culture Laboratory and the Genomic Variation Laboratory at UC Davis are and will be the primary entities developing and implementing genetic management of the delta smelt refugial population from 2009 through 2015 or longer, and may then play a secondary role by keeping a back-up population(s). Design, permitting, and construction of upgrades to this existing facility are expected to take 3 years, with the upgrades becoming operational in year 4 of Plan implementation.

At both facilities, genetic management practices will be implemented to maintain genetic diversity comparable to that of natural-origin fish, minimize genetic adaptation to captivity, minimize mean kinship, and equalize family contributions. Furthermore, genetic monitoring of populations in the wild will minimize risks such as genetic swamping from the hatchery population, reduction in effective population size, and changes in the census population-to-breeder population ratio over time.

The BDCP Implementation Office will enter into binding memoranda of agreement or similar instruments with USFWS and UC Davis. If and when populations of these species are considered recovered by USFWS, the Implementation Office will terminate funding for the propagation of the species and either fund propagation of a different BDCP covered fish species, if necessary and feasible, or discontinue funds to this conservation measure and reallocate them to augment funding other of conservation measures identified in coordination with the fish and wildlife agencies through the BDCP adaptive management process.

3.4.19.3.2 Monitoring and Adaptive Management

Implementation of this conservation measure by the BDCP Implementation Office will be informed through effectiveness monitoring that will be conducted for this conservation measure as described in Section 3.6, *Adaptive Management and Monitoring Program*. Based on review of performance and effectiveness monitoring results in USFWS and UC Davis annual reports, the Implementation Office, in coordination with fish and wildlife Agencies and UC Davis, will adjust funding levels, hatchery operations, or other related aspects of the conservation measure in a matter that will improve the performance and/or biological effectiveness of the program through the BDCP adaptive management process. Such changes would be incorporated in subsequent annual work plans.

3.4.20 Conservation Measure 19 Urban Stormwater Treatment

Under *CM19 Urban Stormwater Treatment,* the BDCP Implementation Office will provide a mechanism for implementing stormwater treatment measures that will result in decreased discharge of contaminants to the Delta. These measures will be focused on urban areas.

3.4.20.1 Purpose

The primary purpose of CM19 is to meet or contribute to the biological goal and objective as identified in Table 3.4-22. The rationale for this goal and objective is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-22. Biological Goals and Objectives Addressed by CM19 Urban Stormwater Treatment

Biological Goals or Objective	How CM19 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.5: Promote water quality conditions within the Delta that help restore native fish habitat.	Reduction of pollutant loads in stormwater discharges will reduce a substantial source of nonpoint source pollutant loading in Delta tributary watersheds.

Reducing the amount of pollution in stormwater runoff entering Delta waterways will benefit covered fishes through the following mechanisms.

- Increasing aquatic productivity, which will support food abundance for splittail, delta and longfin smelt, sturgeon, steelhead, and Chinook salmon (all races) (Essex Partnership 2009).
- Reducing loads of pesticides and herbicides, which can be toxic to the invertebrates and phytoplankton (Amweg et al. 2006; Weston et al. 2005) that form the base of the food web or are important prey species for covered fish species.
- Reducing sublethal effects (behavior, tissue and organ damage, reproduction, growth, and immune) of toxic contaminants (including metals and pesticides), which will improve the health of splittail, delta and longfin smelt, sturgeon, steelhead, and Chinook salmon (all races).
- Reducing pyrethroids and other chemicals from urban and stormwater, which will improve the health of covered fish species (Weston and Lydy 2010).

DRERIP analysis indicate that actions to reduce the amount of pollution in stormwater runoff entering Delta waterways will be of high benefit to delta smelt, white sturgeon, steelhead, and Chinook salmon (DRERIP 2009).

3.4.20.2 Problem Statement

For descriptions of the ecological challenges and current condition of stormwater runoff in the Plan Area, see Chapter 2, *Existing Conditions*, and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives*, also describes the need for stormwater runoff management as a component of the conservation strategies for natural communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM19.

Stormwater runoff is a leading source of water pollution in the United States and is a large contributor to toxic loads present in the Delta (Weston et al. 2005; Amweg et al. 2006; Werner et al. 2008). As stormwater runoff flows to the Delta, it accumulates sediment, oil and grease, metals (e.g., copper and lead), pesticides, and other toxic chemicals. Unlike sewage, stormwater is often not treated before discharging to surface water. Despite stormwater regulations limiting discharge volumes and pollutant loads, many pollutants enter Delta waterways. Of particular concern for fish species is the overuse of pesticides, some of which can have deleterious effects on the aquatic food chain (Weston et al. 2005; Teh et al. 2005). Pyrethroid chemicals used as pesticides on suburban lawns are of particular concern, and are a delivered to the Delta system by runoff. These chemicals at very low concentrations can have lethal effects on low trophic levels of the food chain (plankton), and mainly sublethal effects on covered fish species (Weston and Lydy 2010).

All major urban centers in the Delta, including Sacramento, Stockton, and Tracy, and multiple smaller cities must comply with National Pollutant Discharge Elimination System (NPDES) MS4 permits to develop and implement a stormwater management plan or program with the goal of reducing the discharge of pollutants to the maximum extent practicable under Section 402(p) of the Clean Water Act. CM19 will be implemented within the context of these comprehensive plans.

3.4.20.3 Implementation

3.4.20.3.1 Required Actions

The BDCP Implementation Office will oversee a program to provide funding for grants to entities such as the Sacramento Stormwater Quality Partnership, and/or counties and cities whose stormwater contributes to Delta waterways (hereafter the *stormwater entities*) under NPDES MS4 stormwater permits, to implement actions from and in addition to their respective stormwater management plans. Proposed actions will be reviewed by technical staff in the BDCP Implementation Office or by outside experts supporting the Implementation Office. Projects will be funded if the BDCP Implementation Office determines that they are expected to benefit covered species. Interagency agreements and program development are expected to take 2 years, with the program becoming operational in year 3 of Plan implementation. Individual actions under the program are expected to take approximately 5 years each to fund, design, permit, and construct.

Examples of stormwater and treatment best management practices (BMPs) that could be funded by this program can be found in the following sources.

- California Stormwater Quality Association stormwater BMP handbooks (1993).
- State stormwater BMP manuals (U.S. Environmental Protection Agency 2012).
- National Menu of Stormwater Best Management Practices (U.S. Environmental Protection Agency 2008).

The list of relevant sources will continue to change, and the BDCP Implementation Office will retain discretion to approve applications proposing use of all known and reasonable treatment methodologies. Some of the types of actions that could be funded under this conservation measure include, but are not limited to those listed below.

- Constructing retention or irrigation holding ponds for the capture and irrigation use of stormwater.
- Designing and establishing vegetated buffer strips to slow runoff velocities and capture sediments and other pollutants.
- Designing and constructing bioretention systems (grass buffer strips, sand bed, ponding area, mulch layer, planting soil, and plants) to slow runoff velocities and for removal of pollutants from stormwater.
- Constructing stormwater curb extensions adjacent to existing commercial businesses that are likely to contribute oil and grease runoff.
- Establishing stormwater media filters to remove particulates and pollutants, such as that located at the American Legion Park Pump Station in Stockton.
- Providing funds for moisture monitors to be installed during construction of sprinkler systems at commercial sites that will eliminate watering when unnecessary.
- Providing support for establishment of onsite infiltration systems in lieu of new storm drain connections for new construction, such as pervious pavement in place of asphalt and concrete in parking lots and along roadways, and downspout disconnections to redirect roof water to beds of vegetation or cisterns on existing developed properties, including residential.

The BDCP Implementation Office will enter into binding memoranda of agreement or similar instruments with stormwater entities receiving grants under this conservation measure to ensure that their project is implemented. Individual stormwater entities will be responsible for conducting the monitoring necessary to assess the effectiveness of BDCP-supported elements of their stormwater management plans. The BDCP Implementation Office, in coordination with the fish and wildlife agencies, will determine the effectiveness of stormwater pollution load reduction activities in achieving covered fish species benefits (Section 3.6, *Adaptive Management and Monitoring*).

3.4.20.3.2 Timing and Phasing

This conservation measure would be in effect over the 50-year BDCP period. The BDCP Implementation Office will advertise and promote this grant program to ensure that the first awards are made within two years of Plan implementation, assuming qualified projects are considered. Allowing a reasonable time for project design and implementation, the first stormwater treatment measures would likely be in place a minimum of 5 years from the beginning of BDCP implementation.

3.4.20.3.3 Adaptive Management and Monitoring

The Implementation Office will provide ongoing review of monitoring, progress, and other relevant reports from the stormwater entities related to the effectiveness CM19 for reducing contaminant loads in stormwater runoff. The Implementation Office will coordinate with the stormwater entities to adjust stormwater pollution reduction strategies and annual funding levels through the BDCP adaptive management process as appropriate based on review of results of effectiveness monitoring and stormwater agency monitoring and other relevant reports.

The BDCP Implementation Office will use results of effectiveness monitoring to determine if reducing stormwater pollution loads results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that will improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and will be included in the subsequent annual work plans.

If the results of monitoring indicate that reducing stormwater pollution loads does not substantially and cost-effectively benefit covered fish species, the BDCP Implementation Office, in coordination with the fish and wildlife agencies, may terminate this conservation measure. If terminated, remaining funding will be reallocated to augment funding for other more effective conservation measures identified in coordination with the fish and wildlife agencies through the BDCP adaptive management process.

The BDCP Implementation Office, in coordination with the fish and wildlife agencies, may discontinue effectiveness monitoring for this measure in future years if monitoring results indicate a strong correlation between reduction in stormwater pollution loads entering the Delta and responses of covered fish species.

3.4.21 Conservation Measure 20 Recreational Users Invasive Species Program

*[**Note to Reviewers:** This is a new conservation measure, but is based upon prior DRERIP work.]*

Under *CM20 Recreational Users Invasive Species Program*, the BDCP Implementation Office will fund actions to reduce nonnative invasive species within the Plan Area. Funding will be provided to implement the DFG Watercraft Inspection Program in the Delta.

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM20 on covered species will be avoided or minimized. Refer to Section 3.6, *Adaptive Management and Monitoring Program*, for a discussion of monitoring and adaptive management measures specific to this conservation measure.

3.4.21.1 Purpose

The primary purpose of CM20 is to meet or contribute to biological goals and objectives as identified in Table 3.4-23. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that these biological goals and objectives are met.

Table 3.4-23. Biological Goals and Objectives Addressed by CM20 Recreational Users Invasive Species Program

Biological Goals or Objective	How CM20 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.7: Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.	CM20 will reduce the introduction and proliferation of nonnative plant species and animals in the Plan Area through implementation of the DFG Watercraft Inspection Program in the Delta.
Goal TPANC1: Tidal perennial aquatic natural community that supports habitats for covered and other native species and that supports aquatic food web processes.	
Objective TPANC2.1: Control invasive plants, including Brazilian waterweed, Eurasian watermilfoil, and other nonnative plant species that adversely affect native fish populations.	CM20 will reduce the potential introduction of new invasive plant species and the spread of existing invasive plant species by ensuring that recreational users of Plan Area waters are not transporting and introducing or distributing invasive plants via watercraft, trailers, or equipment.

CM20 will also provide benefits beyond those specified as biological goals and objectives. Expected benefits of CM20 to ecosystems, natural communities, and covered species are described below.

3.4.21.1.1 Landscape Scale

Cohen and Carlton (1995) recognized 212 introduced species in the San Francisco estuary, of which 69% are invertebrates, 15% are fish and other vertebrates, 12% are vascular plants and 4% are protists. A subset of these introduced species is the initial focus of this conservation measure, although the list of species addressed will evolve over time in response to new species introductions or changes in the distribution and abundance of existing invasive species.

Two nonnative, invasive clams, *Corbicula fluminea* and *Corbula amurensis,* provide an instructive example of the risk of invasive species introductions to the Plan Area. These clams are efficient filter feeders, competing with native species, such as delta smelt, for food resources (Nobriga and Herbold 2009). The introduction of these clams has substantially reduced the estuary's pelagic productivity at all trophic levels, from phytoplankton (Jassby et al. 2002 in Nobriga and Herbold 2009) to fish (Kimmerer 2002 and 2006 in Nobriga and Herbold 2009). So prodigious is the feeding capacity of Corbula that they are able to daily filter up to a dozen times the water column present above them—in areas where the seabed is covered with these invasive clams, all the water in the area passes through a clam every 2 hours. Given this unprecedented rate of filtration, it is not surprising that the entire food web has been altered. The decline of all plankton-feeding pelagic fishes in the Delta is tied to a dramatic shift in the food web. Where most energy and carbon in the system once flowed through plankton and fishes, they now flow through the clam. The filter-feeding clam also feeds on a number of the same plankton species that serve as key forage for delta smelt and other at-risk pelagic fishes. Other invasive bivalves could likewise impair the productivity of Plan Area waters. One example is the Quagga mussel (*Dreissena bugensis*), which has been found in various southern California water bodies, but has not yet been found in the waters of the Plan Area. Implementation of this conservation measure will reduce the risk of an introduction of the Quagga mussel to the Plan Area via recreational watercraft.

Dense stands of nonnative SAV and FAV are thought to reduce local flow rates and cause suspended solids to precipitate out of the water column, resulting in a localized reduction in turbidity levels (Grimaldo and Hymanson 1999). This reduced turbidity has several consequences for covered species, described below. Further, nonnative aquatic vegetation can spread quickly, outcompeting some native aquatic vegetation and reducing the habitat suitability for covered fish species. These impacts have already been caused in the Plan Area by several invasive plants, specifically water-hyacinth and Brazilian waterweed (discussed in greater detail in *CM13 Invasive Aquatic Vegetation Control*). Recreational watercraft are a primary vector for the introduction and spread of aquatic invasive weeds, so this measure will also help to reduce the risk of that occurrence.

Funding for the implementation of the California Aquatic Invasive Species Management Plan is intended to prevent new invasions, minimize effects from established aquatic invasive species, and establish priorities for actions statewide (California Department of Fish and Game 2008). This conservation measure will contribute toward achieving biological objective L2.10 by directly contributing toward the reduction in the introduction and proliferation of nonnative species.

3.4.21.1.2 Natural Communities

Invasive SAV and FAV species compete with native aquatic vegetation and create habitat for other invasive species such as introduced predatory fish. For example, Brazilian waterweed grows in dense stands along the margins of channels and across shallow bays and restricts juvenile fish access to shallow water habitat. It also reduces water velocity, resulting in lower levels of suspended matter in the water column, which increases water clarity and produces better hunting conditions for nonnative ambush predators such as bass and sunfish (Nobriga et al. 2005; Brown and Michniuk 2007). Eurasian milfoil also grows in dense stands and reportedly can out-compete native plants through shading; it also provides habitat for nonnative ambush predators.

Invasive aquatic plants such as Brazilian waterweed and hydrilla (*Hydrilla verticillata*; not yet known to occur in the Delta) are often fragmented and spread by boats and trailers moved between watersheds (Mills et al. 1995). Controlling the introduction of such invasive aquatic plant species, or the further spread of any existing nonnative aquatic plant species, would thereby benefit aquatic natural communities in the Plan Area.

At the natural community level this conservation measure will contribute to achieving biological Objective TPANC2.1, and contribute toward the control of nonnative plants that adversely affect native fish populations by reducing the introduction of new nonnative plants and the proliferation of existing nonnative plants.

3.4.21.1.3 Covered Species

As mentioned previously, invasive aquatic plants and animals that will be addressed by this conservation measure affect covered fish species in several ways, from reducing the expansion of habitat that may be suitable for predators to reducing primary and secondary productivity and the subsequent increase in the availability of food resources to covered fish species. Dense patches of invasive SAV and FAV physically obstruct covered fish species' access to habitat and may cause reduced turbidity in the water column, which impairs the predator avoidance abilities of delta and longfin smelt. These stands of SAV and FAV also provides relatively high-quality habitat for nonnative piscivores such as larval and juvenile centrarchids (Brown and Michniuk 2007; Interagency Ecological Program 2008a). The introduction of nonnative aquatic animals, such as

Corbula, substantially reduced the estuary's pelagic productivity at all trophic levels, from phytoplankton (Jassby et al. 2002 in Nobriga and Herbold 2009) to fish (Kimmerer 2002 and 2006 in Nobriga and Herbold 2009) and it may be that other nonnative aquatic animals such as Corbicula also reduce the estuary's productivity.

The introduction of additional nonnative aquatic species, such as the Quagga mussel, could have further adverse effects on covered fish species and other native aquatic species. Introductions of new nonnative aquatic species may further increase pressure on covered fish species and may also reduce the likelihood of achieving some BDCP biological goals and objectives. For example, to benefit many of the covered fish species, significant creation, restoration, and enhancement of natural communities will be implemented with the intention of increasing primary productivity in the Plan Area to achieve specific biological objectives. The introduction of a new nonnative aquatic species could impair the effectiveness of such restoration actions. Implementation of the DFG Watercraft Inspection Program in the Delta and the California Aquatic Invasive Species Management Plan will reduce the risk of an inadvertent introduction of a nonnative aquatic species in the waters of the Plan Area, as well as reduce the risk of proliferation of existing nonnative aquatic species in the Plan Area. As such, these actions will contribute toward the success of the BDCP biological goals and objectives outlined in Section 3.3, *Biological Goals and Objectives.*

3.4.21.2 Problem Statement

For descriptions of the ecological implications and current condition of aquatic invasive species that have been introduced in the Plan Area, see Chapter 2, *Existing Conditions* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives* also describes the need for a program to address the introduction of invasive species by recreational users as a component of the conservation strategies for the tidal perennial aquatic natural community and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM20.

Invasive SAV and FAV are thought to adversely affect the Delta ecosystem by providing habitat for nonnative predators of covered fish species (Brown 2003; Nobriga et al. 2005), reducing food abundance and feeding ability of covered fish species by reducing light and turbidity (Brown and Michniuk 2007), and impairing access to rearing habitat for juvenile salmon and splittail (Interagency Ecological Program 2008a).

Although the historical extent of native SAV and FAV in the Delta ecosystem is unknown, invasive SAV and FAV species have colonized large areas of the Delta (Brown 2003; California Department of Fish and Game 2008; Ustin et al. 2008). Of 55,000 acres of the Delta surveyed in 2007, SAV was estimated to cover between 5,500 and 10,000 acres (10 to 18%) (Ustin et al. 2008). IAV continue to expand into a greater proportion of channels and new areas (Interagency Ecological Program 2008b). Brazilian waterweed forms monodominant stands and is by far the dominant species in mixed stands, although the SAV vegetation frequently contains a mixture of three other invasive, or potentially invasive, nonnative species: curlyleaf pondweed (*Potamogeton crispus*), Eurasian watermilfoil (*Myriophyllum spicatum*), and Carolina fanwort (*Cabomba caroliniana*) (Ustin et al. 2008; Santos et al. 2011). The most widespread nonnative FAV species, water hyacinth (*Eichhornia crassipes*), was introduced into the Delta over 100 years ago, and severe infestations were present by the 1980s.

3.4.21.3 Implementation

3.4.21.3.1 Required Actions

The BDCP will provide funding to implement the DFG Watercraft Inspection Program in the Delta, which will establish a basic inspection and cleaning checklist for watercraft and a certificate program under which all boats and trailers entering Delta waterways will be required to be inspected and, if free of standing water and organisms, would be given a 7-day certificate. Boats with standing water or organisms will be denied entry to Delta waterways and the boat owners will be required to clean, empty, and dry their watercraft and remove any organisms and standing water that may be present. If organisms are present, the boat owners may be issued a citation and fined. California law makes it illegal to transport nonnative species, even if done unintentionally. Boats will be required to be reinspected prior to being permitted to enter Delta waterways. Multiple inspection stations will be established along major driving routes throughout the Delta. DFG will work to educate the public on inspecting and cleaning watercraft and identifying nonnative bivalves, particularly Quagga and zebra mussels. The "Don't Move A Mussel!" campaign is an example of a public education program in widespread use in western states. Cleaning boats, trailers, equipment, bilge and other exposed surfaces should be done away from a waterway and with high-pressure hot water, preferably 140 °F at the hull, or around 155 °F at the nozzle, which will kill the mussels (California Department of Fish and Game 2009). Since this measure provides funding to support existing actions, implementation will begin in year 1 of Plan implementation; full program development will likely take approximately 3 years.

This measure will complement efforts described under *CM13 Invasive Aquatic Vegetation Control*, but will be focused on the inspection of watercraft entering the Delta waters and preventing the introduction of new or proliferation of existing invasive species, with emphasis on nonnative animals such as the Quagga mussel and the zebra mussel.

3.4.22 Conservation Measure 21 Nonproject Diversions

*[**Note to Reviewers:** This is a new conservation measure, but is based upon prior DRERIP work.*

Under *CM21 Nonproject Diversions,* the BDCP Implementation Office will provide funding for actions that will minimize the potential for entrainment of covered fish species associated with operation of nonproject diversions. *Non-project diversions* are here defined as diversions of the natural surface waters in the Plan Area for purposes other than meeting SWP/CVP water supply needs; most nonproject diversions serve agricultural needs or provide water for waterfowl rearing areas. This action is anticipated to reduce incidental take of all covered fish except lamprey (which are not known to be affected by this stressor) by entrainment or impingement, and also to improve Delta ecosystem health by reducing the diversion of plankton and other nutritional resources into nonproject diversions, thereby benefiting all covered fishes.

Additionally, many of these unscreened diversions will be removed as a result of BDCP restoration activities, which will eliminate the need for many existing diversions by transforming cultivated lands into protected natural community types (*CM3 Natural Communities Protection and Restoration*). The number and size of the diversions that will be eliminated are not precisely known because the affected parcels have not yet been identified and moreover, some existing diversions may be remediated before being incorporated into the BDCP preserve system. Diversions removed via restoration activities are included in the overall diversion remediation commitment specified below in Section 3.4.22.3, *Implementation*.

Refer to Appendix 3.C, *Avoidance and Minimization Measures*, for a description of measures that will be implemented to ensure that effects of CM21 on covered species will be avoided or minimized.

3.4.22.1 Purpose

The primary purpose of CM21 is to meet or contribute to biological goals and objectives as identified in Table 3.4-24. The rationale for each of these goals and objectives is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will seek to address scientific and management uncertainties and help to advance these biological goals and objectives.

Table 3.4-24. Biological Goals and Objectives Addressed by CM21 Nonproject Diversions

Biological Goals or Objective	How CM21 Advances a Biological Objective
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.10: Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways.	Remediation of nonproject diversions reduces the potential for covered fish prey organisms to be diverted into waters where they no longer support covered fish species productivity.
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.3: Support the movement of larval and juvenile life stages of native fish species to downstream rearing habitats.	Remediation of nonproject diversions reduces the potential for fish to be diverted to unsuitable or lethal waters.
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objective L4.1: Avoid and minimize adverse effects on covered species resulting from BDCP covered activities.	Remediation of nonproject diversions is anticipated to reduce incidental take of covered fish species.
Objective L4.4: Reduce entrainment, impingement, and salvage losses of covered fish species.	Remediation of nonproject diversions can avoid or minimize entrainment and impingement, reducing mortality of covered fish attributable to these causes.
Note: Goals and objectives related to increasing abundance by reducing mortality are identified for all fish species. For all fish species except lamprey, those goals and objectives would also be supported by this conservation measure, by the same rationale stated above for Objective L4.4.	

CM21 will also provide benefits beyond those specified as biological goals and objectives. All benefits and goals are described in more detail below.

3.4.22.1.1 Landscape Scale

Remediation of nonproject diversions is anticipated to increase food availability for delta and longfin smelt (Lund et al. 2007, 2008), green sturgeon (Nilo et al. 2006; Wanner et al. 2007), white sturgeon (Brannon et al. 1985; Buddington and Christofferson 1985; Muir et al. 2000), splittail, Chinook salmon (all races), and steelhead through reduced entrainment of phytoplankton and zooplankton from the Delta.

Remediation of nonproject diversions is also anticipated to reduce entrainment mortality by nonproject diversions of covered fish species, including larval and juvenile delta and longfin smelt (Cook and Buffaloe 1998; Nobriga et al. 2004), juvenile green (Cook and Buffaloe 1998; Nobriga et al. 2004) and white sturgeon (Cook and Buffaloe 1998; Nobriga et al. 2004), juvenile splittail (Young and Cech 1996; Sommer et al. 1997, 2007; Cook and Buffaloe 1998; Moyle et al. 2004; Nobriga et al. 2004; Matica and Nobriga 2005), and fry and juvenile Chinook salmon (all races) and steelhead (Cook and Buffaloe 1998; Nobriga et al. 2004).

3.4.22.1.2 Covered Species

Goals and objectives related to increasing abundance by reducing mortality are identified for all fish species. For all fish species except lamprey, those goals and objectives would be supported by this conservation measure, by the same rationale stated above for 3.4.22.1.1, *Landscape Scale*.

3.4.22.2 Problem Statement

For descriptions of the ecological implications and current condition of nonnative predators in the Plan Area, see Chapter 2, *Existing Conditions,* and Section 3.3, *Biological Goals and Objectives*. Section 3.3, *Biological Goals and Objectives,* also describes the need for nonproject diversion management as a component of the conservation strategies for natural communities and associated covered species, based on the existing conditions and ecological values of these resources.

The discussion below describes conditions that will be improved through implementation of CM21.

The project area includes approximately 2,589 nonproject diversions (Figure 3.4-21). The majority divert water to agricultural fields between April to August, depending on the crop. This diversion timing at least partially overlaps with the presence of many covered species in the Delta. Over 95% of these water diversions are not screened to reduce fish entrainment (Herren and Kawasaki 2001). There is potential for significant entrainment of fish (Hallock and Van Woert 1959 as cited in Moyle and White 2002). Limited studies indicate that screens over such diversions have been at least 99% effective in reducing fish entrainment into them, even for larval fish less than 25 millimeters long (Nobriga et al. 2004).

The nonproject diversions are primarily associated with low salinity and freshwater aquatic habitats. Some diversions are associated with habitat used by all covered fish species, so benefits potentially accrue to all species. The relative benefits are likely to vary with respect to local abundance of each covered fish population, with larger benefits to larval and juvenile life-history stages that have low swimming velocity and/or a propensity to move with the flow vector.

The entrainment risk associated with unscreened diversions in the Central Valley has been recognized for many years. In the mid-1990s, Reclamation's Anadromous Fish Screen Program was initiated to address this problem, with primary funding provided through the Central Valley Project Improvement Act restoration fund, although that has been augmented on occasion by other Reclamation and CALFED funds. Currently, Reclamation's Anadromous Fish Screen Program and DFG's Fish Screen and Passage Program are operated jointly, with participation by Reclamation, USFWS, DFG, NMFS, and DWR. These programs have thus far implemented over 30 projects addressing unscreened diversions throughout the Central Valley, with the majority of projects implemented on relatively large diversions along the mainstem Sacramento River.

3.4.22.3 Implementation

This conservation measure will achieve remediation of 100 cfs of diversion capacity per year; this target will be demonstrably met within any 5-year period during the BDCP term, except in the first 5-year period when program initiation actions are occurring. This remediation rate will be achieved by removal of diversions, which will occur as a consequence of transfer of cultivated lands into the BDCP preserve system, and also via remediation projects to be identified and performed in the manner described below.

3.4.22.3.1 Required Actions

The BDCP Implementation Office will provide funding allocated to implementation of this conservation measure, as detailed in Chapter 8, *Implementation Costs and Funding Sources*. This funding will support the following actions.

- Identification and support of a technical team to inventory and prioritize candidate projects. The technical team will include representatives of the BDCP Implementation Office, Reclamation's Anadromous Fish Screen Program, and DFG's Fish Screen and Passage Program. Although the existing Reclamation and DFG programs focus on achieving benefits to anadromous salmonids, the technical team will be charged to develop prioritization criteria that consider potential effects on *all* covered fish species and that assign highest priority to cost-effective projects that maximize expected entrainment reductions.
- Support of all Anadromous Fish Screen Program and Fish Screen and Passage Program objectives, including the following objectives.
    - To provide funding and/or technical assistance for fish screen projects.
    - To conduct and assess fish entrainment monitoring at unscreened diversions.
    - To support and evaluate screen/diversion related research to help determine the following factors.
        - Critical factors resulting in fish losses at water diversions.
        - Potential lower-cost options for minimizing fish losses at diversions such as the use of behavioral devices at some diversions rather than use of more expensive positive barrier screens.
        - Cost-effective improvements to fish screen design.
    - To conduct post-construction monitoring of fish screens to assure the effective operation of installed fish screens.
- Preparation of annual summary reports describing prior year achievements of supported programs.

Interagency agreements and program development, including assembling the technical team and developing and implementing prioritization criteria, are expected to take 2 years, with the program becoming fully operational in year 3 of Plan implementation. Individual actions under the program are expected to take approximately 4 to 8 years each to design, permit, and construct.

Based on performance of the Anadromous Fish Screen Program and Fish Screen and Passage Program during the past 20 years, it is likely that the highest priority projects, at least initially, will address the larger nonproject diversions (more than 100 cfs) located along major channels in the Delta. It is also likely that some smaller diversions will be addressed because of their location in areas hosting relatively large concentrations of covered fish, and that other diversions will be given higher priority because their timing of operations is conducive to high risk of incidental take of covered species. For example, diversions operated during the winter have a higher risk of entraining outmigrant winter-run Chinook salmon than diversions operated only in the late spring and summer.

The following methods will likely be used to address unscreened diversions.

- Removal of individual diversions that have relatively large effects on covered fish species.
- Consolidation of multiple unscreened diversions to a single or fewer screened diversions placed in lower quality habitat.
- Relocation of diversions with substantial effects on covered species from high quality to lower quality habitat, in conjunction with screening.
- Reconfiguration and screening of individual diversions in high quality habitat to take advantage of small-scale distribution patterns and behavior of covered fish species relative to the location of individual diversions in the channel.
- Voluntary alteration of the daily and seasonal timing of diversion operation.

Additional methods may be implemented if the technical team determines it to be appropriate.

This conservation measure does not identify specific candidate projects. Typically, after a project has been identified through the prioritization process, it goes through a multiyear process that includes key project phases of a feasibility study, preliminary design, final design, and construction. There are also significant permitting and environmental compliance requirements that must be met. Upon completion of the project, the diverter becomes the owner of the constructed facilities and is solely responsible for the operation and maintenance of the fish screen.

During conservation measure implementation, working procedures will be similar to those under the existing Reclamation and DFG programs, whereby program leads develop annual work plans, which would be reviewed by the BDCP Implementation Office and the fish and wildlife agencies, that describe activities or capital improvements to be funded by the BDCP over the course of that year. Reclamation and DFG will each be responsible for implementing their work plan and submitting reports to the Implementation Office demonstrating that the work plan has been successfully implemented. Reclamation and DFG will also be responsible for demonstrating the effectiveness of the funded activities to meet biological objectives.

The BDCP Implementation Office and the fish and wildlife agencies will review the reports prepared by Reclamation and DFG to assess program effectiveness and to identify adjustments to funding levels, management practices, or other related aspects of the program that will improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and will be included in subsequent annual work plans.

If program assessments indicate that the Reclamation or DFG fish screen program is not effective in achieving its stated objectives of providing benefits to listed species or their habitats, the BDCP Implementation Office, in consultation with the fish and wildlife agencies, may terminate support for the program. Support will also be terminated either party declines to enter into a memorandum of agreement with the BDCP Implementation Office. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures in accordance with the BDCP adaptive management process (Section 3.6, *Adaptive Management and Monitoring Program*).

3.4.22.3.2 Timing and Phasing

BDCP contributions to funding of this conservation measure would commence in the first year of BDCP implementation and would continue through the BDCP term. Expenditure of these funds would be jointly determined by the BDCP Implementation Office and the Reclamation and DFG program. See Chapter 6, *Plan Implementation*, for details on the timing and phasing of CM21.

3.4.22.3.3 Siting and Design Considerations

Siting and design considerations would be addressed by the BDCP Implementation Office and the technical team as described above.

3.4.22.3.4 Adaptive Management and Monitoring

The BDCP Implementation Office may adjust its strategies for selecting diversions to be relocated or consolidated, modify intake designs, or adjust funding levels through the BDCP adaptive management process based on monitoring results and other relevant information (e.g., monitoring and research conducted by others). If the results of monitoring indicate that screening of nonproject diversions does not substantially and cost-effectively benefit covered fish species, the BDCP Implementation Office, in coordination with the fish and wildlife agencies, may terminate this conservation measure.

3.4.23 Conservation Measure 22 Avoidance and Minimization Measures

Under *CM22 Avoidance and Minimization Measures,* the BDCP Implementation Office will implement measures to avoid and minimize effects on covered species and natural communities that could result from BDCP covered activities. The avoidance and minimization measures that will be implemented through this framework are detailed in Appendix 3.C, *Avoidance and Minimization Measures*. These measures will be implemented for covered activities throughout the BDCP permit term.

3.4.23.1 Purpose

The primary purpose of CM22 is to incorporate measures into BDCP activities that will avoid or minimize direct take of covered species and minimize impacts on natural communities that provide habitat for covered species. This conservation measure helps to satisfy important regulatory requirements of the ESA and NCCPA. The primary focus of these avoidance and minimization measures is to avoid or minimize take of individuals of covered species (i.e., death, injury, harm, or harassment to species) and of high-quality habitat for covered species that may be affected by covered activities. CM22 will also minimize adverse effects on natural communities, critical habitat, and jurisdictional wetlands and waters throughout the Plan Area.

Another important purpose of CM22 is to meet or contribute to the biological goal and objective identified in Table 3.4-25. The rationale for the goal and objective is provided in Section 3.3, *Biological Goals and Objectives*. Through effectiveness monitoring, research, and adaptive management (Section 3.6, *Adaptive Management and Monitoring Program*), the Implementation Office will address scientific and management uncertainties and help to ensure that this biological goal and objective is met.

Table 3.4-25. Biological Goal and Objective Addressed by CM22 Avoidance and Minimization Measures

Biological Goal or Objective	How CM22 Advances a Biological Objective
Goal L4: Reduce mortality of covered species in the Plan Area.	
Objective L4.1: Avoid and minimize adverse effects on covered species resulting from BDCP covered activities.	The Implementation Office will conduct planning surveys during the site-specific planning process and identify appropriate avoidance and minimization measures as described in Appendix 3.C, *Avoidance and Minimization Measures.* Projects will be designed to avoid and minimize effects as described in Appendix 3.C. Preconstruction surveys and construction-related measures will also be implemented, consistent with Appendix 3.C, to avoid and minimize effects during construction activities.

3.4.23.2 Problem Statement

Careful design and implementation of covered activities will help avoid take of covered species, but specific avoidance and minimization measures are also required during implementation to fully meet this requirement. It is the responsibility of the Implementation Office to design and implement projects in compliance with these measures. The discussion below describes conditions that will be improved through implementation of CM22.

ESA (Section 10[a][2][A][ii]) requires that an HCP applicant minimize the impact of take of covered species to the maximum extent practicable. Additionally, California Fish and Game Code (Fish & Game Code) Section 2801(g) describes the NCCP program as providing a planning framework to avoid and minimize impacts on wildlife. The species-specific avoidance and minimization measures meet regulatory requirements for covered species and also contribute to the protection of covered species as required under Fish & Game Code Section 2820(b).

Consistent with Section 7(a)(2) of the ESA, the BDCP must ensure that covered activities do not result in adverse modification of designated critical habitat for federally listed species. Appendix 3.C, *Avoidance and Minimization Measures*, includes measures that are necessary to ensure that future restoration projects are designed and covered activities are implemented to avoid adverse modification of critical habitat.

3.4.23.3 Implementation

3.4.23.3.1 Required Actions

Specific avoidance and minimization measures will be developed for each BDCP project, based on the comprehensive avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*. Identification and implementation of the appropriate avoidance and minimization measures for each project will occur in four phases.

- **Planning surveys and project planning.** Site-specific surveys will be conducted during the project planning phase to identify natural communities, covered species habitat, and covered species for which avoidance and minimization measures apply. Projects will be designed to avoid and minimize impacts as described in Appendix 3.C, *Avoidance and Minimization Measures*. Site-specific surveys and planning for covered activities associated with *CM1 Water Facilities and Operation* have been completed, but surveys will be needed prior to implementation of many other projects.
- **Preconstruction surveys.** Biological surveys may be necessary during the months or weeks prior to project construction, depending on the results of the planning surveys, as specified in Appendix 3.C, *Avoidance and Minimization Measures*. Results of the planning surveys will be used to determine whether additional avoidance and minimization measures would be applied just prior to or during construction (e.g., establishing buffers around kit fox dens or covered bird species nests). Preconstruction surveys may also involve site preparation actions such as collapsing unoccupied burrows.
- **Project construction.** Best management practices and other avoidance and minimization measures will be implemented during project construction as described in Appendix 3.C, *Avoidance and Minimization Measures*. For some activities, as specified in Appendix 3.C, a biological monitor will be present to ensure that the avoidance and minimization measures are effectively implemented. For some species (e.g., California red-legged frog) the biological monitor will relocate individuals from the construction area to specified nearby safe locations.
- **Operation and maintenance.** Some of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures,* apply to long-term operation and maintenance activities, such as operation and maintenance of the water conveyance facilities and ongoing covered species habitat enhancement and management. Appropriate measures will be identified during the project planning phase and implemented throughout the life of the project. Avoidance and minimization measures applicable to long-term enhancement and management will be incorporated into site-specific management plans.

3.4.23.3.2 General Construction-Related Avoidance and Minimization Measures

General avoidance and minimization measures will be implemented prior to and during the construction of the water conveyance facility, construction of utility lines, initiation of restoration activities, and the implementation of other covered activities. The measures listed below are described in detail in Appendix 3.C, *Avoidance and Minimization Measures*.

- Worker awareness training to ensure that personnel on the project sites understand applicable avoidance and minimization requirements.

- Construction monitoring by qualified biologists to ensure that all construction related avoidance and minimization measures are implemented.
- Best management practices to avoid adverse effects such as erosion, sedimentation, contaminant spills, and encroachment of equipment into adjacent lands.

3.4.23.3.3 Avoidance and Minimization of Adverse Effects on Natural Communities

The following avoidance and minimization measures will be implemented when construction activities or other covered activities occur in the vicinity of these natural communities, as detailed in Appendix 3.C, *Avoidance and Minimization Measures*.

- Restore natural communities that are temporarily removed or degraded.
- Avoid and minimize adverse effects on wetlands.
- Avoid and minimize removal and degradation of valley/foothill riparian natural community.

3.4.23.3.4 Avoidance and Minimization of Take of Covered Species

Avoidance and minimization measures specific to each covered species or group of covered species are detailed in Appendix 3.C, *Avoidance and Minimization Measures*. The following types of avoidance and minimization measures will be implemented.

- During the design phase for individual restoration projects, evaluate site-specific conditions and design the projects to avoid particularly sensitive areas (e.g., sandhill crane roost sites) and incorporate other design measures as appropriate to avoid and minimize take of covered species.
- Implement seasonal or timing restrictions for activities in sensitive areas (e.g., to avoid critical times for nesting or dispersal).
- Passively or actively relocating individuals out of construction areas. An example of passive relocation is the installation of one-way doors on burrowing owl burrows and collapsing burrows after verifying no owls are present.

3.4.23.3.5 Avoidance and Minimization of Effects on Critical Habitat

During the planning phase for individual tidal restoration projects, tidal restoration will be designed to avoid areas that are designated as critical habitat for Contra Costa goldfields, vernal pool fairy shrimp, vernal pool tadpole shrimp, California tiger salamander, California red-legged frog, and several covered fish species. Measures will also be implemented to ensure that restoration, enhancement, and other covered activities avoid direct or indirect effects that might adversely modify critical habitat, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

3.4.24 References

3.4.1.1 Introduction

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3.4.24.1 CM1 Water Facilities and Operation

Baker, P. F., and J. E. Morhardt. 2001. Survival of Chinook salmon smolts in the Sacramento-San Joaquin Delta and Pacific Ocean. Pages 163-182 in R. L. Brown, editor. Contributions to the biology of Central Valley salmonids. Fish Bulletin 179: Volume 2. California Department of Fish and Game, Sacramento.

Baxter, R. D., K. Hieb, S. DeLeon, K. Fleming and J. Orsi. 1999. Report on 1980-1995 fish shrimp and crab sampling in the San Francisco Estuary, California. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Technical Report 63. 503 pp.

Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer, and K. Souza. 2008. Pelagic organism decline progress report: 2007 synthesis of results. January 15, 2008. Available at: http://www.fws.gov/sacramento/es/documents/POD_report_2007.pdf.

Bennett W.A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [online serial]. Vol. 3, Issue 2 (September 2005), Article 1.

Brandes P.L. and J.S. McLain. 2001. Juvenile chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: Brown RL, editor. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(2). Sacramento (CA): California Department of Fish and Game. pp 39-136.

CALFED. 2001. Scrutinizing the Delta Cross-Channel. News from the CALFED Bay-Delta Science Program.

California Department of Water Resources. 1999. Biological Assessment: Suisun Marsh Preservation Agreement as Modified by Amendment Three.

California Department of Water Resources. 2006. [citation unresolved]

Castillo G, Morinaka J, Lindberg J, Fujimura B, Hobbs J, Tigan G, Ellison L, Baskerville-Bridges B. 2009. An Experimental Approach to Evaluate Entrainment Losses of Delta Smelt in the South Delta. 2009 State of the Estuary. 9/29-10/1/2009. Oakland, CA

Clark KW, MD Bowen, RB Mayfield, KP Zehfuss, JD Taplin, CH Hanson. 2009. Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay. CA Department of Water Resources. Available at: http://baydeltaoffice.water.ca.gov/ndelta/fishery/documents/2009_clark_et_al_quantification_of_steelhead_pre-screen_loss.pdf

Fujimura R.W., G. Edwards, D. Killam, T.M. Frink, and L. Millett. 2000. Evaluation of adult salmon migration passage at the Suisun Marsh Salinity Control Gates in Montezuma Slough, California. In: JH Eiler et al. (ed.). Biotelemetry 15: Proceedings of the 15th International Symposium on Biotelemetry, Juneau, Alaska USA, May 9-14, 1999. pp. 68-75

Gingras M. 1997. Mark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-Screening Loss to Entrained Juvenile Fishes: 1976-1993. Interagency Ecological Program Technical Report 55 (November 1997).

Kimmerer W. 2004. Open Water Processes of the San Francisco Estuary: From Physical Forcing to Biological Responses. San Francisco Estuary and Watershed Science. Vol. 2, Issue 1 [February], Article 1. Available at: http://repositories.cdlib.org/jmie/sfews/vol2/iss1/art1

Kimmerer W.J. 2008. Losses of Sacramento River Chinook salmon and Delta smelt (Hypomesus transpacificus) to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 6, Issue 2 [June], Article 2.

Manly, B.F.J. 2008. Review of the report an evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies by K.B. Newman. Western EcoSystems Technology Inc. Report Dated July 16, 2008.

Manly 2002 [citation unresolved]

Miranda, J, R. Padilla, J. Morinaka, J. DuBois, M. Horn. 2010. Release site predation study. CA Department of Water Resources. Available at: http://baydeltaoffice.water.ca.gov/announcement/Element2FinalReport5-2010.pdf

Munevar unpubl. data [citation unresolved]

Perry, R.W. and J.R. Skalski. 2008. Migration and survival of juvenile Chinook salmon through the Sacramento-San Joaquin River Delta during the winter of 2006-2007. Technical report submitted to the U.S. Fish and Wildlife Service, Stockton, CA. September 2008.

Perry, R.W. and J.R. Skalski. 2009. Survival and route migration probabilities of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta during the winter of 2007-2008. Final report submitted to the U.S. Fish and Wildlife Service, Stockton, CA. July 15, 2009.

Perry et al. 2010 [citation unresolved]

United States Fish and Wildlife Service. 2009. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP). December 15, 2008. Available at: http://www.fws.gov/sacramento/es/documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf

Wang, J.C.S. 1986. Fishes of the Sacramento-San Joaquin estuary and adjacent waters, California: a guide to the early life histories. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Tech. Rep. 9. Stockton, CA.

Personal Communications

Burkhard, B., Incident Commander, California Department of Water Resources (916-376-9761). Telephone conversation with J-L Cartron, July 22, 2010 regarding functioning of Suisun Marsh salinity control gates and patterns of land use in Suisun Marsh.

Chappell, S. Executive Director, Suisun Resource Conservation District. Telephone conversation with J-L Cartron on 7/22/2010 regarding functioning of salinity gates and patterns of land use at Suisun Marsh, and development and release of the Suisun Marsh Habitat Management, Preservation, and Restoration Plan.

Fullerton, D. 2007. Principal Resource Specialist, MWD, CALFED Brown Bag Seminar: The interaction among turbidity, salinity, and smelt during fall and winter: a work in progress. 11/27/07.

3.4.24.2 CM2 Yolo Bypass Fisheries Enhancement

BDCP Integration Team. 2009. Yolo Technical Study 2.

Benigno, G. M., and T. R. Sommer. 2008. Just add water: sources of chironomid drift in a large river floodplain. Hydrobiologia. 600(1): 297-305.

Brandes, P. L., and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: Brown RL, editor. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(2). Sacramento (CA): California Department of Fish and Game. pp 39-136.

California Department of Fish and Game. 2008. Yolo Bypass Wildlife Area Land Management Plan.

California Department of Water Resources. 2010. Fact Sheet Sacramento River Flood Control Project Weirs and Flood Relief Structures. Flood Operations Branch. Sacramento, CA. 23pp

Crain, P. K., K. Whitener, and P. B. Moyle. 2004. Use of a restored central California floodplain by larvae of native and alien fishes. American Fisheries Society Symposium 39: 125-140.

Del Rosario et al. [citation unresolved]

Feyrer, F., T. Sommer, and W. Harrell. 2006. Managing floodplain inundation for native fish: production dynamics of age-0 splittail (*Pogonichthys macrolepidotus*) in California's Yolo Bypass. Hydrobiologia 573:213-226.

Feyrer, F., T. Sommer, and J. Hobbs. 2007. Living in a dynamic environment: variability in life history traits of age-0 splittail in tributaries of San Francisco Bay. Transactions of the American Fisheries Society 136:1393-1405.

Harrell, W. C., and T. R. Sommer. 2003. Patterns of adult fish use on California's Yolo Bypass floodplain. In P.M. Faber, ed. California riparian systems: Processes and floodplain management, ecology, and restoration. 2001 Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, California. Pages 88-93.

Jassby, A. D., and J.E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems. 10: 323-352.

Kurth, R., and M. Nobriga. 2001. Food habits of larval splittail. Interagency Ecological Program Newsletter 14(3): 40-42.

Lehman, P. W., G. Boyer, M. Satchwell, and S. Waller. 2008. The influence of environmental conditions on the seasonal variation of *Microcystis* cell density and microcystins concentration in San Francisco Estuary. Hydrobiologia 600:187-204.

Miller, W. J. 2007. Testimony before the subcommittee on water and power. Presented at: Extinction is not a sustainable water policy: The Bay-Delta crisis and the implications for California water management. 7/2/2007.

Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands 3rd ed. Wiley & Sons Inc., New York.

Moss 2007 [citation unresolved]

Moyle, P. B. 2002. Inland Fishes of California, Revised and Expanded. University of California Press, Berkeley, California. 502 pp.

Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.

Sacramento Bee. 2011. Helping hands move fish stranded in Yolo Bypass to Sacramento River. By Matt Weiser. April 13. Available: <http://www.sacbee.com/2011/04/13/3548746/helping-hands-move-fish-stranded.html>.

Schemel, L. E., S. W. Hagar, and D. Childers. 1996. The supply and carbon content of suspended sediment from the Sacramento River to San Francisco Bay. In: J.T. Hollibaugh, ed. San Francisco Bay: The Ecosystem. Pacific Division of the American Association for the Advancement of Science, San Francisco, CA. Pages 237-260

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society. 126:961-976.

Sommer, T, B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001b. Floodplain rearing of juvenile Chinook salmon: Evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2):325-333.

Sommer, T., L. Conrad, G. O'Leary, F. Feyrer, and W. Harrell. 2002. Spawning and rearing of splittail in a model floodplain wetland. Transactions of the American Fisheries Society 131:966-974.

Sommer, T. R., W. C. Harrell, M. L. Nobriga, and R. Kurth. 2003. Floodplain as habitat for native fish: Lessons from California's Yolo Bypass. In PM Faber, ed. California riparian systems: Processes and floodplain management, ecology, and restoration. 2001 Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, California. Pages 81-87.

Sommer, T. R., W. C. Harrell, R. Kurth, F. Feyrer, S. C. Zeug, and G. O'Leary. 2004. Ecological patterns of early life stages of fishes in a river-floodplain of the San Francisco Estuary. *In:* F Feyrer, LR Brown, RL Brown, JJ Orsi, eds. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland. Pages 111-123.

Sommer, T. R., R. D. Baxter, and F. Feyrer. 2007. Splittail "delisting": A review of recent population trends and restoration activities. American Fisheries Society Symposium 53:25-38

Sommer T. R., W. C. Harrell, Z. Manteca, and F. Feyrer. 2008. Habitat associations and behavior of adult and juvenile splittail *(Cyprinidae: Pogonichthys macrolepidotus)* in a managed seasonal floodplain wetland. San Francisco Estuary and Watershed Science 6(2): 1-16.

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

3.4.24.3 CM3 Natural Communities Protection and Restoration

U.S. Fish and Wildlife Service. 1999a. Conservation Guidelines for the Valley Elderberry Longhorn Beetle. July 9, 1999. Sacramento Fish and Wildlife Office. Available: <http://www.fws.gov/sacramento/es/documents/velb_conservation.htm>.

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

U.S. Fish and Wildlife Service. 2005. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Available: <http://www.fws.gov/sacramento/es/recovery_plans/vp_recovery_plan_links.htm>.

3.4.24.4 CM4 Tidal Natural Communities Restoration

Brown, L. R. 2003. Will Tidal Wetland Restoration Enhance Populations of Native Fishes? In: Larry R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1 (October 2003), Article 2. Available at: <http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2>.

Essex Partnership. 2009. DRERIP Evaluations of BDCP Draft Conservation Measures. Summary Report. Available: <http://science.calwater.ca.gov/pdf/workshops/workshop_eco_052209_BDCP-DRERIP_Summary_with_Appendices1.pdf>. Accessed: December 9, 2011.

Healey, M. C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). In: Groot C, Margolis L, editors. Pacific salmon life histories. Vancouver (BC): University of British Columbia Press. p 311-394.

Kjelson, M. A., P. F. Raquel, and F. W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary, California. In: Kennedy VS, editor. Estuarine comparisons. Academic Press. New York, NY. p 393-411.

Siegel, S. W. 2007. Starting the Discussion: Foundation concepts and some initial activities to restore ecosystem functions to the California Delta. Technical report prepared for the Delta Vision Blue Ribbon Task Force. First Draft, December 14, 2007. Available at: <http://deltavision.ca.gov/BlueRibbonTaskForce/Feb2008/Item_11_Attachment_2_Ecosystem_Functions.pdf>.

Personal Communications

Enright, C., Senior Engineer, DWR, Telephone conversation with R. Wilder about methyl-mercury and low dissolved oxygen in effluent from managed seasonal wetlands in Suisun Marsh, 8/26/08.

DeGeorge, J. RMA. May 28, 2008—Presentation to the BDCP Conveyance Working Group on Hydrodynamic effects of restoration of tidal habitat in Suisun Marsh: initial evaluation.

3.4.24.5 CM5 Seasonally Inundated Floodplain Restoration

Brandes, P. L., and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: Brown RL, editor. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(2). Sacramento (CA): California Department of Fish and Game. pp 39-136.

Jeffres, C. A., J. J. Opperman, and P. E. Moyle. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. *Environmental Biology of Fishes.* Volume 83, Number 4, 44-458.

Personal Communications

Griggs, Dr. Thomas. Senior Restoration Ecologist, River Partners. Chico, CA. June 1, 2009—Telephone conversation with John Gerlach.

Hansen, Robert. President, Tulare Basin Wildlife Partners.Visalia, CA. June 1, 2009—Telephone conversation with John Gerlach.

3.4.24.6 CM6 Channel Margin Enhancement

Feyrer, F., T. Sommer, and W. Harrell. 2006. Managing floodplain inundation for native fish: production dynamics of age-0 splittail (*Pogonichthys macrolepidotus*) in California's Yolo Bypass. Hydrobiologia 573:213-226.

Moyle, P. B. 2002. Inland Fishes of California, Revised and Expanded. University of California Press, Berkeley, California. 502 pp.

Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.

Nakano, S., and M. Murakami. 2001. Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs. Proceedings of the National Academy of Sciences of the United States of America 98:166-170.

Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001b. Floodplain rearing of juvenile Chinook salmon: Evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2):325-333.

Sommer, T., L. Conrad, G. O'Leary, F. Feyrer, and W. Harrell. 2002. Spawning and rearing of splittail in a model floodplain wetland. Transactions of the American Fisheries Society 131:966-974.

Sommer, T. R., R. D. Baxter, and F. Feyrer. 2007. Splittail "delisting": A review of recent population trends and restoration activities. American Fisheries Society Symposium 53:25-38.

Sommer. T. R., W. C. Harrell, Z. Manteca, and F. Feyrer. 2008. Habitat associations and behavior of adult and juvenile splittail *(Cyprinidae: Pogonichthys macrolepidotus)* in a managed seasonal floodplain wetland. San Francisco Estuary and Watershed Science 6(2): 1-16.

U.S. Fish and Wildlife Service. 2004. Impacts of Riprapping to Aquatic Organisms and River Functioning, Lower Sacramento River, California. 2nd Edition. Available: <www.fws.gov/sacramento/es/animal_spp_account/acctfish.htm>.

3.4.24.7 CM7 Riparian Natural Community Restoration

Kelly, P. A., T. K. Edgarian, M. R. Lloyd, and S. E. Phillips. 2011. Conservation Principles for the Riparian Brush Rabbit & Riparian Woodrat. Endangered Species Recovery Program, California State University, Turlock. 1-4, 7, 8 pp.

Nakano, S., and M. Murakami. 2001. Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs. Proceedings of the National Academy of Sciences of the United States of America 98:166-170.

Riparian Habitat Joint Venture. 2004. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. Version 2.0 California Partners in Flight. Available: <http://www.prbo.org/calpif/pdfs/riparian_v-2.pdf>.

The Bay Institute. 1998. From the Sierra to the Sea: The Ecological History of the San Francisco Bay Watershed.

Thompson, K. 1961. Riparian Forests of the Sacramento Valley, California. Annals of the Association of American Geographers 51: 294-315.

U.S. Fish and Wildlife Service. 1999. Conservation Guidelines for the Valley Elderberry Longhorn Beetle. July 9, 1999.

U.S. Fish and Wildlife Service. 2004. Impacts of riprapping to aquatic organisms and river functioning, Lower Sacramento River, California. 2nd Edition. Available: <www.fws.gov/sacramento/es/animal_spp_account/acctfish.htm>.

3.4.24.8 CM8 Grassland Natural Community Restoration

Barbour, M., T. Keeler-Wolf, and A. A. Schoenherr (eds). Terrestrial Vegetation of California. 3rd Edition. University of California Press, 730 pp.

Barry, S., S. Larson, and M. George.2006. California grasslands, a historical perspective: a guide for developing realistic restoration objectives. *Grasslands.* Winter: 7-11.

Hamilton, J. G., J. R. Griffin, and M. R. Stromberg. 2002. Long-term population dynamics of native *Nassella* (Poaceae) bunchgrasses in central California. *Madroño* 49:274–284.

Harrison, S., B. D. Inouye, and H. D. Safford. 2003. Ecological heterogeneity in the effects of grazing and fire on grassland diversity. *Conservation Biology* 17(3):837–845.

Keeley, J. E. 1993. Assessing Suitable Sites for Grassland Restoration. Pages 277–281 in J. E. Keeley (ed.), *Interface Between Ecology and Land Development in California*. Los Angeles, CA: Southern California Academy of Sciences.

Kelly, P., T. K. Edgarian, M. R. Lloyd, and S. E. Phillips. 2011. Conservation Strategies for Riparian Brush Rabbit and Riparian Woodrat. Endangered Species Recovery Program. Turlock, CA.

Noss, R. F., LaRoe E. T., Scott J. M. 1995. Endangered Ecosystems of the United States: A Preliminary Assessment of Loss and Degradation. (Biological Report 28.) Washington, DC: U.S. Geological Survey. Available: <http://biology.usgs.gov/pubs/ecosys.htm>.

Stromberg, M. R., J. Corbin, and C. D'Antonio. 2007. California Grasslands: Ecology and Management. University of California Press, Berkeley, CA. 390 pp.

Stromberg, M., and J. R. Griffin. 1996. Long-term patterns in coastal California grasslands in relation to cultivation, gophers, and grazing. *Ecological Applications* 6:1189–1211.

Stromberg and Kephart. 2006. [citation unresolved]

U.S. Fish and Wildlife Service. 1997. Guidelines for Restoration and/or Replacement of Giant Garter Snake Habitat. Appendix A to Programmatic Consultation with the US Army Corps of Engineers. 404 Projects with Relatively Small Effects on Giant Garter Snakes within Butte, Colusa, Glenn, Fresno, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter and Yolo Counties, California.

Williams, P., and P. M. Faber. 2004. Design Guidelines for Tidal Wetland Restoration in San Francisco Bay. Prepared for The Bay Institute. December 29.

3.4.24.9 CM9 Vernal Pool Complex Restoration

Baraona, M., T. Ippolito, and W. Renz. 2007. Post-project appraisals of constructed vernal pools in Solano, County, California. Water Resources Center Archives, University of California. Berkeley, CA.

U.S. Fish and Wildlife Service. 1994. Wetlands Policy and Action Plan, 660 FW 1, FWM#157. Division of Habitat Conservation.

U.S. Fish and Wildlife Service. 2005. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Portland, Oregon. xxvi + 606 pages.

3.4.24.10 CM10 Nontidal Marsh Restoration

Gilmer, D. S., M. L. Miller, R. B. Bauer, and J. R. LeDonne. 1982. California's Central Valley wintering waterfowl: concerns and challenges. Transactions of the North American Wildlife and Natural Research Conference. 47: 441-452.

Hays, D. W., K. R. McAllister, S. A. Richardson, and D. W. Stinson. 1999. Washington State Recovery Plan for the Western Pond Turtle. Washington Department of Fish and Wildlife, Olympia, WA. August. Available: <http://www.wdfw.wa.gov/wlm/diversty/soc/recovery/pondturt/wptfinal.pdf>.

Keddy, P.A. 2000. *Wetland Ecology*. Cambridge, UK: Cambridge University Press.

Middleton, B. 1999. Wetland Restoration, Flood Pulsing and Disturbance Dynamics. New York, NY: John Wiley & Sons. 388 pp.

Mitsch, W. J., and J. G. Gosselink. 1993. Wetlands. New York, NY: Van Nostrand Reinhold. 722 pp.

The Bay Institute. 1998. From the Sierra to the sea: the ecological history of the San Francisco Bay-Delta Watershed. The Bay Institute of San Francisco, Novato, CA, USA. Available at: <http://www.bay.org/sierra_to_the_sea.htm>.

3.4.24.11 CM11 Natural Communities Enhancement and Management

Barry, S., S. Larson, and M. George. 2006. California native grasslands: A historical perspective: A guide for developing realistic restoration objectives. *Grasslands* 16:7-11.

Butterwick, M. 1998. The hydrogeomorphic approach and its use in vernal pool functional assessment. Pages 50-55 *in:* C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr. and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, CA. 1998.

California Invasive Plant Council. 2007. California Invasive Plant Inventory Database, Inventory update 2007. Available: <http://www.cal-ipc.org/ip/inventory/weedlist.php?region=CAFP>. Accessed January 5, 2011.

California Native Plant Society. 2001. Guidelines for Landscaping to Protect Native Vegetation from Genetic Degradation. Sacramento, CA.

California State Parks. 2007. Henry W. Coe State Park Wildfire Local Operating Agreement. March. Monterey District California State Parks, Monterey, California.

Contra Costa Water District. 2002. *Los Vaqueros Project 2001 Annual California Red-Legged Frog and Predator Control Monitoring Report*. January. (J&S 01-356.) Brentwood, CA. Prepared with assistance from Jones & Stokes, Sacramento, CA.

DiTomaso, J. M., K. L. Heise, G. B. Kyser, A. M. Merenlender, and R. J. Keiffer. 2001. Carefully timed burning can control barb goatgrass. *California Agriculture* 55:47–53.

Doubledee, R. A., E. B. Muller, and R. M. Nisbet. 2003. Bullfrogs, disturbance regimes, and the persistence of California red-legged frogs. *Journal Of Wildlife Management* 67:424–438.

Fuhlendorf, S. D., and and D. M. Engle. 2001. Restoring heterogeneity on rangelands: ecosystem management based on evolutionary grazing patterns. BioScience Vol. 52, No. 8, 625-632.

Gillespie, I. G., and E. A. Allen. 2004. Fire and competition in a southern California grassland: impacts on the rare forb *Erodium macrophyllum*. *Journal of Applied Ecology* 41:643–652.

Grewell, B. 2005. Population census and status of the endangered soft bird's beak (Cordylanthus mollis ssp. mollis) at Benecia State Recreation Area and Rush Ranch in Solano County, California. Final Report. Solano County Water Agency, Sacramento, CA.

Hamilton, J. G., J. R. Griffin, and M. R. Stromberg. 2002. Long-term population dynamics of native *Nassella* (Poaceae) bunchgrasses in central California. *Madroño* 49:274–284.

Harrison, S., B. D. Inouye, and H. D. Stafford. 2003. Ecological heterogeneity in the effects of grazing and fire on grassland diversity. *Conservation Biology* 17:837–845.

Hayes, G., and K. Holl. 2003. Cattle grazing impacts on annual forbs and vegetation composition in mesic grasslands in California. *Conservation Biology* 17:1694–1702*.*

Hays, D. W., K. R. McAllister, S. A. Richardson, and D. W. Stinson. 1999. Washington State Recovery Plan for the Western Pond Turtle. Washington Department of Fish and Wildlife, Olympia, WA. August. Available: <http://www.wdfw.wa.gov/wlm/diversty/soc/recovery/pondturt/wptfinal.pdf>.

Jones & Stokes. 1989. *Results of Biological Resource Inventories and Habitat Evaluations in the Kellogg Creek Watershed*. February. (JSA 87-031.) Sacramento, CA. Prepared for James M. Montgomery, Consulting Engineers, Inc., and the Contra Costa Water District.

Kus, B. E., and M. J. Whitfield. Parasitism, productivity, and population growth: response of least Bell's vireos (*Vireo bellii pusillus*) and southwestern willow flycatchers (*Empidonax traillii extimus*) to cowbird (*Molothrus* spp.) control. *Ornithological Monographs.* Volume (2005), No 57, 16-27.

Marty, J. T. 2005. Effects of Cattle Grazing on Diversity in Ephemeral Wetlands. *Conservation Biology* 19:1626–1632.

Menke, J. W. 1992. Grazing and fire management for native perennial grass restoration in California grasslands. *Fremontia*. Vol. 20(2):22-25

Rice, P. M. 2005. *Fire as a Tool for Controlling Nonnative Invasive Plants.* Available: <http:// http://www.weedcenter.org/management/control.html>. Accessed: December 28, 2011.

Riparian Habitat Joint Venture 2009. California Riparian Restoration Handbook. Second Edition. July.

Seabloom, E. W., E. T. Borer, V. L. Boucher, R. S. Burton, K. L. Cottingham, L. Goldwasser, W. K. Gram, B. E. Kendall, and F. Micheli. 2002. Competition, seed limitation, disturbance, and reestablishment of California native annual forbs. *Ecological Applications* 13:575–592.

Singleton, P., H. Gaines, L. William, and J. F. Lehmkuhl. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. Res. Pap. PNW-RP-549. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 89 pp.

Sotoyome Resource Conservation District. 2007. *Grazing Handbook: a guide for resource managers in coastal California.* September 2007. Santa Rosa, CA. 76 pp.

Stromberg, M., and J. R. Griffin. 1996. Long-term patterns in coastal California grasslands in relation to cultivation, gophers, and grazing. *Ecological Applications* 6:1189–1211.

Sweitzer, R. A., and R. E. Loggins. 2001. *Wild Pig Management Plan for Henry W. Coe State Park.* Submitted to California Department of Parks and Recreation, Four Rivers District.

U.S. Fish and Wildlife Service. 2002. *Recovery Plan for the California Red-Legged Frog.* U.S. Fish and Wildlife Service, Portland, Oregon. viii + 173 pp.

U.S. Fish and Wildlife Service. 2005. Endangered and Threatened Wildlife and Plants: Designation of Critical Habitat for the California Tiger Salamander, Central Population, Final Rule. Federal Register 70(162):49380–49458. August 23.

Personal Communications

Koopmann, Tim. Range manager. San Francisco Public Utility Commission, San Francisco, CA. July 7, 2003—conversation with Joel Gerwein (Jones & Stokes).

3.4.24.12 CM12 Methylmercury Management

Alpers, C. N., C. Eagles-Smith, C. Foe, S. Klasing, M. C. Marvin-DiPasquale, D. G. Slotton, and L. Windham-Myers. 2008. Mercury Conceptual Model. Sacramento-San Joaquin Delta Regional Ecosystem Restoration Implementation Plan.

Amyot, M., D. J. McQueen, G. Mierle, and D. R. S. Lean. 1994. Sunlight-induced Formation of Dissolved Gaseous Mercury in Lake Waters. *Environmental Science and Technology.* 1994, 28 (13), pp 2366–2371

Byington, A. 2007. Photo-degradation of Methyl Mercury in the Sacramento – San Joaquin Delta Estuary. Thesis Report Presented to Gary Gill to be Submitted to the CALFED Bay-Delta Program for the Project Transport, Cycling and Fate of Mercury and Monomethylmercury in the San Francisco Delta and Tributaries Task 5.1. Central Valley Regional Water Quality Control Board: Central Valley Region. Available: <http://mercury.mlml.calstate.edu/reports/reports/>.

Central Valley Regional Water Quality Control Board. 2011. Sacramento-San Joaquin Delta Methylmercury TMDL. Lat revised: November 9, 2011. Available: <http://www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/delta_hg/>. Accessed: November 11, 2011.

Foe, C., S. Louie, and D. Bosworth. 2008. Methylmercury Concentrations and Loads in the Central Valley and Freshwater Delta. Final Report Submitted to the CALFED Bay-Delta Program for the Project Transport, Cycling and Fate of Mercury and Monomethylmercury in the San Francisco Delta and Tributaries Task 2. Central Valley Regional Water Quality Control Board. Central Valley Regional Water Quality Control Board: Central Valley Region. Available: <http://mercury.mlml.calstate.edu/reports/reports/>. Accessed: September 28, 2011.

Gill, G. 2008. Monomethylmercury Photo-Degredation Studies. Final Report Submitted to the CALFED Bay-Delta Program for the Project Transport, Cycling and Fate of Mercury and Monomethylmercury in the San Francisco Delta and Tributaries Task 5.1. Central Valley Regional Water Quality Control Board. Central Valley Regional Water Quality Control Board: Central Valley Region. Available: <http://mercury.mlml.calstate.edu/reports/reports/>. Accessed: September 28, 2011.

Heim, W. A., M. Stephenson, A. Bonnema, A. Byington, A. Newman, D. Feliz, L. Sousa, and K. Coale (In Press). Methylmercury Concentrations and Exports from Seasonal Wetlands in the Yolo Wildlife Area, California. Final Report.

Stephenson, M., C. Foe, G. Gill, and K. H. Coale. 2007. Transport, Cycling, and Fate of Mercury and Monomethyl Mercury in the San Francisco Delta and Tributaries: An Integrated Mass Balance Assessment and Approach. Calfed Mercury Project Annual Report.

Ulrich, P. D. (2011). Methylmercury Production in Tidal Salt Marsh Sediments and Potential Control Using Iron Amendments. UC San Diego: California Sea Grant College Program. Available: <http://escholarship.org/uc/item/9ms4z5hz>.

Windham-Myers, Lisamarie, M. Marvin-DiPasquale, J. Fleck, C. N. Alpers, J. Ackerman, C. Eagles-Smith, C. Stricker, M. Stephenson, D. Feliz, G. Gill, P. Bachand, A. Brice, and R. Kulakow. 2010. Methylmercury cycling, bioaccumulation, and export from agricultural and non-agricultural wetlands in the Yolo Bypass. San Jose University Foundation and the California State Water Board.

Woods, M., C. Foe, J. Cooke, and L. Stephen. 2010. Sacramento–San Joaquin Delta Estuary TMDL for Methylmercury. California Regional Water Quality Control Board: Central Valley Region.

3.4.24.13 CM13 Invasive Aquatic Vegetation Control

Akers, P. 2010. The California Department of Food and Agriculture Hydrilla Eradication Program Annual Progress Report 2010. CA: Sacramento. Available: <http://www.cdfa.ca.gov/plant/ipc/hydrilla/pdfs/hydrilla2010_annualreport-contents.pdf>. Accessed Feb 2012.

Anderson, L. 2008. Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). 2008b. Administrative Draft Ecosystem Conceptual Model, Aquatic Vegetation Growth. Sacramento-San Joaquin Delta Regional Ecosystem Restoration Implementation Plan. Draft January 18, 2008.

Brown, L. R. 2003. Will Tidal Wetland Restoration Enhance Populations of Native Fishes? In: Larry R. Brown, editor. *Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science*. Vol. 1, Issue 1 (October 2003), Article 2. Available: <http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2>.

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

California Department of Boating and Waterways. 2006. *Egeria densa* Control Program Second Addendum to 2001 Environmental Impact Report with Five-Year Program Review and Future Operations Plan. U.S. Department of Agriculture, Sacramento, CA.

California Department of Boating and Waterways. 2008. *Egeria densa* Control Program Annual Report 2007 Application Season. U.S. Department of Agriculture, Sacramento, CA.

California Department of Food and Agriculture. 2011. [citation unresolved]

California Department of Fish and Game. 2008. California Aquatic Invasive Species Management Plan. January 2008. 136 pp plus appendices. Available: <www.dfg.ca.gov/invasives/plan>. Accessed: May 29, 3008.

Grimaldo L., and Z. Hymanson. 1999. What is the impact of the introduced waterweed *Egeria densa* to the Delta Ecosystem? *Interagency Ecological Program Newsletter* 12(1): 43-45.

Interagency Ecological Program. 2008a. Interagency Ecological Program 2008 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary. Interagency Ecological Program for the San Francisco Estuary, Sacramento, CA.

Interagency Ecological Program. 2008b. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. January 2008. 78 pp. Available: <http://www.fws.gov/sacramento /es/documents/POD_report_2007.pdf>.Nobriga, M. L., and F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in the Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* Vol5 (Article4), Iss2 May 2007.

Nobriga, M., and F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science Vol5 (Article4), Iss2 May 2007.

Nobriga, M. L., and F. Feyrer. 2008. Diet composition in San Francisco Estuary striped bass: does trophic adaptability have its limits? *Environ Biol Fish* (DOI 10.1007/s10641-008-9376-0) 9pp.

Nobriga, M. and B. Herbold. 2009. Sacramento – San Joaquin Delta Regional Ecosystem Restoration Implementation Plan, the little fish in California's water supply: a literature review and life-history conceptual model for delta smelt (Hypomesus transpacificus) for the Delta Regional Ecosystm Restoration and Implementation Plan (DRERIP). 57 pp.

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

Rosenfield, J. A. 2010 Life History Conceptual Model and Sub-Models for Longfin Smelt, San Francisco Estuary Population for the Delta Regional Ecosystem Restoration Implementation Plan

Santos, M. J., L. W. Anderson, and S. L. Ustin. 2011. Effects of invasive species on plant communities: an example using submersed aquatic plants at the regional scale. Biol. Invasions 13:433-457.

Skurka Darin, G. M., S. Schoenig, J. N. Barney, F. D. Panetta, and J. M. DiTomaso. 2011. WHIPPET: A novel tool for prioritizing invasive plant populations for regional eradication. *Journal of Environmental Management* 92(1): 131-139.

Stevens, D. E. 1966. Food habits of striped bass (*Roccus saxatilis*) in the Sacramento-San Joaquin Delta. *California Department of Fish and Game Fish Bulletin* 136, Part 2:68-96.

Temple, R., K. Daily, T. Shrader, and B. Hooton. 1998. Predation Issues: Introduced Fishes. Draft Review. Oregon Department of Fish and Wildlife. Salem, OR. June 17, 1998.

Ustin, S. L., J. A. Greenberg, M. Santos, S. Khanna, E. Hestir, P. Haverkamp, and S. Kefauver. 2008. Mapping Invasive Plant Species in the Sacramento-San Joaquin River Delta Using Hyperspectral Imagery. California Department of Boating and Waterways, Davis, CA.

3.4.24.14 CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels

Cech, J. J., and C. E. Crocker. 2002. Physiology of sturgeon: effects of hypoxia and hypercapnia. *Journal of Applied Ichthyology* 18:320-324.

Central Valley Regional Water Quality Control Board. 2005. Resolution No. R5-2005-0005: Amending the Water Qulity Control Plan for the Sacramento River and San Joaquin River Basins for the Control Program for Factors Contributing to the Dissolved Oxygen Impairment in the Stockton Deep Water Ship Channel.

Central Valley Regional Water Quality Control Board. 2007. The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region. Fourth Edition, Revised October 2007 (with approved amendments). Available: <www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/sacsjr.pdf>.

Hallock, R. J., R. F. Elwell, and D. H. Fry, Jr. 1970. Migrations of Adult King Salmon, *Oncorhynchus tshawytscha*, in the San Joaquin Delta. California Fish and Game 151. Sacramento. 92 p.

ICF International. 2010. Final Report: Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Aeration Facility Project. Prepared for California Department of Water Resources. 96 pp.

Jassby, A., and E. E. Van Nieuwenhuyse. 2005. Low dissolved oxygen in an estuarine channel (San Joaquin River, California): mechanisms and models based on long-term time series. *San Francisco Estuary and Watershed Science*. 3(2).

Jones & Stokes. 2002. City of Stockton Year 2001 Field Sampling Program Data Summary Report for San Joaquin River Dissolved Oxygen TMDL CALFED 2001 Grant. Prepared for the City of Stockton Department of Municipal Utilities.

Jones & Stokes. 2007. California Department of Water Resources Deep Water Shipping Channel Aeration Demonstration Project Biological Assessment for Operations. Sacramento, CA. 128 p.

3.4.24.15 CM15 Predator Control

Brandes PL. 1996. Results of 1996 coded-wire tag smolt survival experiments in the San Joaquin River Delta. Interagency Ecological Program Newlsetter. 9(4):13-16.

Brown, L. R. 2003. Will Tidal Wetland Restoration Enhance Populations of Native Fishes? In: Larry R. Brown, editor*. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science*. Vol. 1, Issue 1 (October 2003), Article 2. Available: <http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2>.

California Department of Fish and Game. 2012. Striped Bass Population Estimate. Available: http://www.dfg.ca.gov/delta/stripedbass/sbpe.asp. Accessed: January 15, 2012.

Castillo, G., et al. In review. Pre-Screen Loss and Fish Facility Efficiency for Delta Smelt at the South Delta's State Water Project, California*.* 49 pp.

Cavallo, B., et al. In press. Effects of predator and Flow Manipulation on Chinook Salmon (*Oncorhynchus tshawytscha*) Survival in an Imperiled Estuary. *Environmental Biology of Fishes.* 25 pp.

Clark, K., et al. 2009. Q*uantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay*. Fishery Improvements Section, Bay-Delta Office, California Department of Water Resources: Sacramento, CA. 119 pp.

Decato 1978 [citation unresolved]

Gingras, M. 1997. Mark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-Screening Loss to Juvenile Fishes: 1976–1993. (Technical Report 55.) September. Interagency Ecological Program for the San Francisco Bay / Delta Estuary. 22 pp.

Kratville, D. 2008. Sacramento–San Joaquin Delta Regional Ecosystem Restoration Implementation Plan, Semi-Final Species Life History Conceptual Model: Sacramento Splittail (Pogonichthys macrolepidotus). Prepared by California Department of Fish and Game, Sacramento, CA.

Lehman, P. W., T. Sommer, and L. Rivard. 2008. The influence of floodplain habitat on the quantity and quality of riverine phytoplankton carbon produced during the flood season in San Francisco Estuary. Aquatic Ecology 42:363–378.

Lindley, S. T., and M. S. Mohr. 2003. Modeling the effect of striped bass (*Morone saxatilis*) on the population viability of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*). Fish Bulletin 101:321–331.

MacFarlane, B.R., and E.C. Norton. 2001. Physiological ecology of juvenile Chinook salmon (Oncorhynchus tshawytscha) at the southern end of their distribution, the San Francisco Estuary and Gulf of Farallones, California. Santa Cruz Laboratory, Southwest Fisheries Science Center, NMFS. Santa Cruz, CA. 14pp.

Mather 1998 [citation unresolved]

Miranda, J, R. Padilla, J. Morinaka, J. DuBois, M. Horn. 2010. Release site predation study. CA Department of Water Resources. Available at: http://baydeltaoffice.water.ca.gov/announcement/Element2FinalReport5-2010.pdf

Moyle, P. B. 2002. Inland Fishes of California, Revised and Expanded. University of California Press, Berkeley, California. 502 pp.

Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.

Newman, K. B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies. Project number SCI-06-G06-299. U.S. Fish and Wildlife Service, Stockton, CA. Available online at http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS_salmon_studies_final_033108.pdf (November 2008)

Nobriga, M., and F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science Vol5 (Article4), Iss2 May 2007.

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

Nowak, G. M., Tabor, R. A., E. J. Warner, K. L. Fresh, and T. P. Quinn. 2004. Ontogenetic shifts in habitat and diet of cutthroat trout in Lake Washington, Washington. North American Journal of Fisheries Management 24:624–635.

Perry, R. W., and J. R. Skalski. 2008. Evaluating wetland restoration projects in the Columbia River estuary using hydroacoustic telemetry arrays to estimate movement, survival, and residence times of juvenile salmonids. Volume XX in the Design and Analysis of Salmonid Tagging Studies in the Columbia Basin. Bonneville Power Administration, Portland, OR.

Stevens, D. E. 1966. Food habits of striped bass (*Roccus saxatilis*) in the Sacramento-San Joaquin Delta. California Department of Fish and Game Fish Bulletin 136, Part 2:68–96.

Temple, R., K. Daily, T. Shrader, and B. Hooton. 1998. Predation issues: introduced fishes. Draft review. Oregon Department of Fish and Wildlife. Salem, OR. June 17, 1998.

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

U.S. Department of Interior 2011 [citation unresolved]

Vogel et al. 1988 [citation unresolved]

3.4.24.16 CM16 Nonphysical Fish Barriers

Bowen, M. D., and R. Bark. 2010. 2010 Effectiveness of a Non-Physical Fish Barrier at the Divergence of the Old and San Joaquin Rivers (CA). Draft. US Department of the Interior, Bureau of Reclamation. September. Technical Memorandum. Technical Service Center. Denver, CO.

Bowen, M. D., L. Hanna, R. Bark, V. Maisonneuve, and S. Hiebert. 2008. Non-Physical Barrier Evaluation, Physical Configuration I. U.S. Department of the Interior, Bureau of Reclamation. Technical Memorandum. Technical Service Center. Denver, CO.

Bowen, M. D., S. Hiebert, C. Hueth, and V. Maisonneuve. 2009. Effectiveness of a Non-Physical Fish Barrier at the Divergence of the Old and San Joaquin Rivers (CA). Reclamation. Technical Memorandum 86-68290-09-05.

Brandes PL. 1996. Results of 1996 coded-wire tag smolt survival experiments in the San Joaquin River Delta. Interagency Ecological Program Newlsetter. 9(4):13-16.

Brandes, P. L., and J. S. McLain. 2001. Juvenile chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: Brown RL, editor. *Contributions to the Biology of Central Valley Salmonids*. *Fish Bulletin* 179(2). Sacramento (CA): California Department of Fish and Game. pp 39-136.

Bureau of Reclamation. 2008. Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment. May 2008.

Holbrook, C. M., R. W., Perry, and N. S. Adams. 2009. Distribution and Joint Fish-Tag Survival of Juvenile Chinook Salmon Migrating through the Sacramento-San Joaquin River Delta, 2008. U.S. Department of the Interior, U.S. Geological Survey. Biological Resources Discipline Report to San Joaquin River Group Authority. Cook, WA.

ICF International. 2010. Biological Assessment of the 2011 Georgiana Slough Nonphysical Barrier Study for USFWS-Managed Species. November. (ICF 00754.10.) Sacramento, CA. Prepared for California Department of Water Resources, Sacramento, CA, Sacramento, CA.

MacFarlane, B.R., and E.C. Norton. 2001. Physiological ecology of juvenile Chinook salmon (Oncorhynchus tshawytscha) at the southern end of their distribution, the San Francisco Estuary and Gulf of Farallones, California. Santa Cruz Laboratory, Southwest Fisheries Science Center, NMFS. Santa Cruz, CA. 14pp.

Newman, K. B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies. Project number SCI-06-G06-299. U.S. Fish and Wildlife Service, Stockton, CA. Available online at http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS_salmon_studies_final_033108.pdf (November 2008)

Perry, R. W., and J. R. Skalski. 2008a. Evaluating wetland restoration projects in the Columbia River estuary using hydroacoustic telemetry arrays to estimate movement, survival, and residence times of juvenile salmonids. Volume XX in the Design and Analysis of Salmonid Tagging Studies in the Columbia Basin. Bonneville Power Administration, Portland, OR.

Perry R. W., and J. R. Skalski. 2008b. Migration and Survival of Juvenile Chinook Salmon Through the Sacramento-San Joaquin River Delta during the Winter of 2006-2007. Technical report submitted to the U.S. Fish and Wildlife Service, Stockton, CA. September 2008.

Perry, R. W. and J. R. Skalski. 2009. Survival and Route Migration Probabilities of Juvenile Chinook Salmon in the Sacramento-San Joaquin River Delta during the Winter of 2007-2008. Final report submitted to the U.S. Fish and Wildlife Service, Stockton, CA. July 15, 2009.

Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. MacFarlane. 2009. Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta. *North American Journal of Fisheries Management.* 30: 142-156.

San Joaquin River Group Authority. 2006. 2005 Annual Technical Report on the Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January 2006. 131 pgs.

U.S. Bureau of Reclamation 2008 [citation unresolved]

U.S. Bureau of Reclamation 2009 [citation unresolved]

U.S. Department of Interior 2011 [citation unresolved]

Welton, J. S., W. R. C. Beaumont, and R. T. Clarke. 2002. The efficacy of air, sound and acoustic bubble screens in deflecting Atlantic salmon, *Salmo salar* L., smolts in the River Frome, UK. *Fisheries Management and Ecology.* 9:11-18.

Personal Communications

Bowen, Mark. Fishery Biologist. Bureau of Reclamation, Denver, CO. October 12, 2010—Conversation with Marin Greenwood, Aquatic Ecologist, ICF, Sacramento, CA).

Burau, J. U.S. Geological Survey. August 20, 2008—Discussion with BDCP Hood Bypass Sub-Group about Delta hydrology.

Holderman, M. Chief, Temporary Barriers Project and Lower San Joaquin. California Department of Water Resources. June 10, 2009—Telephone conversation with R. Wilder regarding the 2009 DWR Head of Old River Non-Physical Barrier Test Project.

3.4.24.17 CM17 Illegal Harvest Reduction

Bay-Delta Oversight Council. 1995. An Introduction to Harvest and Its Effects on Selected Species of Fish of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: Draft briefing paper. California Resources Agency. Sacramento, CA. March 1995.

Beamesderfer, R. C. P, M. L. Simpson, and G. L. Kopp. 2007. Use of life history information in a population model of Saramento green sturgeon. *Environmental Biology of Fishes*. 70:315-337.

Begon, M, J. L. Harper, and C. R. Townsend. 1996. *Ecology: Individuals, Populations and Communities.* 3rd ed. Blackwell Scientific Publications, Oxford, UK.

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. *Environmental Biology of Fishes*. 48:399-405.

California Department of Fish and Game. 2007a. Delta-Bay Enhanced Enforcement Project: Annual Report July 2006-June2007. Sacramento, CA.

California Department of Fish and Game. 2007b. California Steelhead Fishing Report-Restoration Card. Report to the Legislature. Sacramento, CA. July 2007.

California Department of Fish and Game. 2008a. 2007 Sturgeon Fishing Report Card: Preliminary Data Report. Sacramento, CA.

California Department of Fish and Game. 2008b. Central Valley Angler Survey. Sacramento, CA. December 27, 2008.

Delta-Bay Enhanced Enforcement Project. 2007. California Department of Fish and Game. Unpublished report.

Futuyma, D. J. 1998. Evolutionary biology. 3rd ed. Sinauer Associates. Sunderland, MA.

Moyle, P. B., J. A. Israel, and S. E. Purdy. 2008. Salmon, steelhead, and trout in California: status of an emblematic fauna. Report for the Center for Watershed Sciences, University of California, Davis, CA.

Schaffter, R.G. and D.W. Kohlhorst. 1999. Status of white sturgeon in the Sacramento-San Joaquin Estuary. *California Fish and Game 85* (1):37-41.

Williams, J. G. 2006. Central Valley Salmon: A perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science [online serial]. Volume 4, Issue 3 (December 2006), Article 2.

3.4.24.18 CM18 Conservation Hatcheries

Carolsfeld, J., M. Tester, H. Kreiberg, and N. M. Sherwood. 1997. Pheromone-induced spawning of pacific herring. *Horm Behav* 31(3):256-268.

Clarke, B. 2008. USFWS Plans for Captive Propagation Of Delta Smelt. CALFED Science Program Workshop: The Use of Artificial Propagation as a Tool for Central Valley Salmonid and Delta Smelt Conservation, Sacramento, CA, July 14, 2008.

Deblois, E. M., and W. C. Leggett. 1993. Importance of biotic and abiotic regulators of abundance of the intertidal amphipod *Calliopius laeviusculus* (*Amphipoda: Gammaridae*) and assessment of the accuracy and precision of sampling methods for detecting abundance changes. *Marine Biology* 115: 75-83.

Essex Partnership. 2009. DRERIP Evaluations of BDCP Draft Conservation Measures. Summary Report. Available: <http://science.calwater.ca.gov/pdf/workshops/workshop_eco_052209_BDCP-DRERIP_Summary_with_Appendices1.pdf>. Accessed: December 9, 2011.

Flagg, T. A., B. A. Berejikian, J. E. Colt, W. W. Dickhoff, L. W. Harrell, D. J. Maynard, C. E. Nash, M. S. Strom, R. N. Iwamoto, and C. V. W. Mahnken. 2000. Ecological and Behavorial Impacts of Artificial Production Strategies on the Abundance of Wild Salmon Populations: A Review of Practices in the Pacific Northwest. NOAA Technical Memorandum NMFS-NWFSC-XX. Seattle, WA.

Hedgecock, D., V. K. Rashbrook, and P. W. Hedrick. 2000. Effective population size of winter-run Chinook salmon based on microsatellite analysis of returning spawners. *Can J Fish Aquat Sci* 57:2368-2373.

Hedrick, P. W., D. Hedgecock, and S. Hamelberg. 1995. Effective population size in winter-run Chinook salmon. *Conserv Biol* 9(3):615-624.

Interagency Ecological Program. 2008a. Interagency Ecological Program 2008 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary. Interagency Ecological Program for the San Francisco Estuary, Sacramento, CA.

Interagency Ecological Program. 2008b. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. January 2008. 78 pp. Available: <http://www.fws.gov/sacramento /es/documents/POD_report_2007.pdf>.

KowalskI, R. K., P. Hliwa, A. Andronowska, J. Król, G. J. Dietrich, M. Wojtczak, R. Stabiński, and A. Ciereszko. 2006. Semen biology and stimulation of milt production in the European smelt (*Osmerus eperlanus* L.). *Aquaculture* 261(2006):760-770.

Lande, R. 1988. Genetics and demography in biological conservation. *Science* 241:1455-1460.

Mueller-Solger, A. B. 2007. Delta Smelt Count-Down: Famine or Other Foe? Poster presented at the State of the Estuary Conference, Oakland, CA. October 16-18, 2007.

Nobriga, M. 2008. Aquatic Habitat Conceptual Model. Sacramento, CA: Delta Regional Ecosystem Restoration Implementation Plan.

Nobriga, M. L., and F. Feyrer. 2008. Diet composition in San Francisco Estuary striped bass: does trophic adaptability have its limits? *Environ Biol Fish* (DOI 10.1007/s10641-008-9376-0) 9pp.

Purchase, C. F., D. J. Hasselman, and L. K. Weir. 2007. Relationship between fertilization success and the number of milt donors in rainbow smelt *Osmerus mordax* (Mitchell): implications for population growth rates. *Journal of Fish Biology.* 70(3): 934–946.

Richards, J. M., M. J. Hansen, C. R. Bronte, and S.P. Sitar. 2004. Recruitment dynamics of the 1971–1991 year classes of lake trout in Michigan waters of Lake Superior. *North American Journal of Fish Management* 24:475–489.

Sorensen, P. W. 1998. Hormonally derived sex pheromones in goldfish: A model for understanding the evolution of sex pheromone systems in fish. *Biological Bulletin* 183:173-177.

Sveinsson, T., and T. J. Hara. 1995. Mature males of Arctic charr, *Salvvelinus alpinus*, release F-type prostaglandins to attract conspecific mature female and stimulate their spawning behavior.

Turner, T., and M. Osborne. 2008. Management of genetic resources in the federally endangered Rio Grande silvery minnow, *Hybognathus amarus*. CALFED Science Program Workshop – The Use of Artificial Propagation as a Tool for Central Valley Salmonid and Delta Smelt Conservation. July 24, 2008.

Turner, T. F., T. E Dowling, P. C. Marsh, B. R. Kesner, and A. T. Kelsen. 2007. Effective size, census size, and genetic monitoring of the endangered razorback sucker, *Xyrauchen texanus*. *Conservation Genetics* 8:417-425.

Personal Communications

Clarke, R. U.S. Fish and Wildlife Service. February 3, 2009—Conversation with Alison Willy (USFWS) regarding delta smelt refugial hatchery population.

3.4.24.19 CM19 Urban Stormwater Treatment

Amweg, E. L., D. P. Weston, J. You, and M. Lydy. 2006. Pyrethroid insecticides and sediment toxicity in urban creeks from California and Tennessee. Environmental Science and Technology, 40(5):1700-1706.

California Stormwater Quality Association. 1993. Stormwater Best Management Practice (BMP) Handbooks. Available: <http://www.cabmphandbooks.com/>.

Essex Partnership. 2009. DRERIP Evaluations of BDCP Draft Conservation Measures. Summary Report. Final. OSCM 5:Reduce the Loads of Toxic Contaminants in Stormwater and Urban Runoff Scientific Evaluation Worksheet. May 27, 2009.

Teh, S. J., D. F. Deng, I, Werner, F. C. Teh, S. S. O. Hung. 2005. Sublethal toxicity of orchard stormwater runoff contaminated with esfenvalerate and diazinon in Sacramento Splittail (Pogonichthys macrolepidotus) larvae. Marine Environmental Research, 59:203-216.

U.S. Environmental Protection Agency. 2008. National Menu of Stormwater Best Management Practices. Available: < http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm >.

U.S. Environmental Protection Agency. 2012. State Stormwater BMP Manuals. Available: <http://yosemite.epa.gov/R10/WATER.NSF/0/17090627a929f2a488256bdc007d8dee?OpenDocument>.

Werner, I., S. Anderson, S. Larsen, and J. Oram, 2008. Chemical Stressors in the Sacramento-San Joaquin Delta Conceptual Model. Sacramento-San Joaquin Delta Regional Ecosystem Restoration Implementation Plan.

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

Weston, D. P., R. W. Holmes, J. You, and M. J. Lydy. 2005. Aquatic toxicity due to residential use of pyrethroid insecticides. Environmental Science and Technology 39:9778-9784.

3.4.24.20 CM20 Recreational Users Invasive Species Program

Brown, L. R. 2003. Will Tidal Wetland Restoration Enhance Populations of Native Fishes? In: Larry R. Brown, editor*. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science*. Vol. 1, Issue 1 (October 2003), Article 2. Available: <http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2>.

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

California Department of Fish and Game. 2008. California Aquatic Invasive Species Management Plan. January. Available: < http://www.dfg.ca.gov/invasives/plan/>.

California Department of Fish and Game. 2009. Protect your boat, fight quagga and zebra mussels: A guide to cleaning boats and preventing mussel damage. Sacramento, CA. 20pp.

Cohen, A. N., and J. T. Carlton. 1995. Nonindigenous aquatic species in a United States estuary: A case study of the biological invasions of the San Francisco Bay and Delta, University of California Berkeley, Williams College-Mystic Seaport. Available at: http://www.sgnis.org/publicat/cc1.htm.

Grimaldo, L., and Z. Hymanson. 1999. What is the impact of the introduced waterweed *Egeria densa* to the Delta Ecosystem? *Interagency Ecological Program Newsletter* 12(1): 43-45.

Interagency Ecological Program. 2008a. Interagency Ecological Program 2008 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary. Interagency Ecological Program for the San Francisco Estuary, Sacramento, CA.

Interagency Ecological Program. 2008b. Pelagic organism decline progress report: 2007 synthesis of results. January 2008. 78 pp. Available at: http://www.fws.gov/sacramento /es/documents/POD_report_2007.pdf.

Jassby, A.D., J. E. Cloern, and B. E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47:698-712. Cited in Nobriga and Herbold 2009.

Kimmerer, W. J. 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecology Progress Series 243:39-55. Cited in Nobriga and Herbold 2009.

Kimmerer, W. J. 2006. Response of anchovies dampens effects of the invasive bivalve Corbula amurensis on the San Francisco Estuary foodweb. Marine Ecology Progress Series 324: 207-218. Cited in Nobriga and Herbold 2009.

Mills, C. E., and F. Sommer. 1995. Invertebrate introductions in marine habitats: two species of hydromedusae (Cnidaria) native to the Black Sea, Maeotias inexspectata and Blackfordia virginica, invade San Francisco Bay. Mar. Biol. 122: 279-288.

Nobriga, M. F., and B. Herbold. 2009.The Little Fish in California's Water Supply: a Literature Review and Life-History Conceptual Model for delta smelt (Hypomesus transpacificus) for the Delta Regional Ecosystem Restoration and Implementation Plan (DRERIP).

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

Santos, M. J., L. W. Anderson, and S. L. Ustin. 2011. Effects of invasive species on plant communities: an example using submersed aquatic plants at the regional scale. Biol. Invasions 13:433-457.

Ustin, S. L., J. A. Greenberg, M. Santos, S. Khanna, E. Hestir, P. Haverkamp, and S. Kefauver. 2008. Mapping Invasive Plant Species in the Sacramento-San Joaquin River Delta Using Hyperspectral Imagery. California Department of Boating and Waterways, Davis, CA.

3.4.24.21 CM21 Nonproject Diversions

Brannon, E., S. Brewer, A. Setter, H. Miller, F. Utter, and W. Hershberger. 1985. Columbia River white sturgeon (*Acipenser transmontanus*) early life history and genetics study: final report. Project No. 83-316. U. S. Department of Energy. December 1985.

Buddington, R. K., and J. P. Christofferson. 1985. Digestive and feeding characteristics of the chondrosteans. *Environmental Biology of Fishes* 14:31–41.

Cook, L., and L. D. Buffaloe. 1998. Delta agricultural diversion evaluation summary report, 1993-1995. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. Technical Report Number 61. Sacramento, CA.

Hallock, R. J., and W. F. Van Woert. 1959. A survey of anadromous fish losses in irrigation diversions from the Sacramento and San Joaquin Rivers. Calif. Fish and Game, *45* (4): 227–266. As cited in Moyle P.B. and D. White. 2002. Effects of screening diversions on fish populations in the Central Valley: what do we know? Report for the Science Board, CALFED Ecosystem Restoration Program. January 2002.

Herren, J. R., and S. S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. In: R.L. Brown, ed., Contributions to the Biology of Central Valley Salmonids. Volume 2. California Department of Fish and Game. Fish Bulletin 179. pp. 343-355.

Lund, J., E. Hanak, W. Fleenor, R. Howitt, J. Mount, and P. Moyle. 2007. Envisioning Futures for the Sacramento-San Joaquin Delta. Public Policy Institute of California (PPIC). February 2007, 324 pp. ISBN 978-1-58213-126-9.

Lund, J., E. Hanak, W. Fleenor, W. Bennett, R. Howitt, J. Mount, and P. Moyle. 2008. Comparing futures for the Sacramento-San Joaquin Delta. Public Policy Institute of California. Available at: http://www.ppic.org/main/publication.asp?i=810.

Matica, Z., and M. L. Nobriga. 2005. Modifications to an agricultural water diversion to permit fish entrainment sampling. California Department of Fish and Game 91(1):53-56.

Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (Pogonichthys macrolepidotus) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.

Muir, W. D., G. T. McCabe, Jr., M. J. Parsley, and S. A. Hinton. 2000. Diet of first feeding larval and young-of-the-year white sturgeon in the lower Columbia River. *Northwest Science* 74:25-33.

Nilo, P., S. Tremblay, A. Bolon, J. Dodson, P. Dumont, and R. Fortin. 2006. Feeding ecology of juvenile lake sturgeon in the St. Lawrence River System. *Transactions American Fisheries Society* 135:1044–1055.

Nobriga, M. L., Z. Matica, and Z. P. Hymanson. 2004. Evaluating entrainment vulnerability to agricultural irrigation diversions: a comparison among open-water fishes. American Fisheries Society Symposium. 39: 281-295.

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society. 126:961-976.

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

Wanner, G. A., D. A. Shuman, and D. W. Willis. 2007. Food habits of juvenile pallid sturgeon and adult shovel nose sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota. Journal of Freshwater Ecology 22:81-92.

Young P. S., and Cech J. J. Jr. 1996. Environmental tolerances and requirements of splittail. Transactions of the American Fisheries Society 125:664-678.

3.4.24.22 CM22 Avoidance and Minimization Measures

None.

3.5 Important Regional Actions

*[**Note to Reviewers:** This section has been entirely revised from that presented in the November, 2010 draft BDCP; changes are not shown.]*

3.5.1 Introduction

The conservation measures presented in the preceding section comprise a suite of BDCP actions intended to minimize and mitigate the effect of BDCP covered actions on covered species and contribute to the recovery of species and natural communities. However, these are not the only actions that are expected to influence ecosystem health in the Delta. In addition to actions taken pursuant to overlapping and adjacent regional conservation plans described in Chapter 1, a number of other foreseeable actions, outside the scope of the BDCP and not within the control of the Authorized Entities, are likely to have a substantial influence on the health and recovery of the Delta natural communities and the associated species. This section identifies the most important of these related actions:

- Ammonia load reduction
- Hatchery genetic management plans

These actions are described below.

3.5.1.1 Ammonia Load Reduction

3.5.1.1.1 Problem Statement

Ammonia (NH_3) and ammonium (NH_4^+) are common constituents of effluent from wastewater treatment plants having only primary and secondary treatment processes (Jassby 2008). Twenty-three wastewater treatment plants discharge their effluent in or just upstream of the Plan Area. Of these, 11 employ only primary and secondary treatments, currently releasing on average approximately 252 million gallons of effluent into the Delta and Suisun Bay waterways each day. Four of the 11 facilities, with a total average daily flow of 29 million gallons per day, have plans to upgrade to advanced treatment facilities in the near future. The largest wastewater treatment plant in the Delta, the Sacramento Regional County Sanitation District (SRCSD) wastewater treatment plant, released an average of 158 million gallons of treated effluent into the Sacramento River per day during 2001–2005 (Jassby 2008).

Wastewater treatment plants employ primary and secondary treatment processes to meet current waste discharge specifications in their NPDES permits, which are designed to protect beneficial uses and meets the U.S. Environmental Protection Agency (EPA) aquatic criteria for ammonia/um. However, secondary treatment processes commonly result in discharges of ammonia/um at levels that directly or indirectly affect covered fish species in the Delta. Advanced treatment processes, such as bacterial nitrification or constructed wetlands, can be up to 90% efficient at reducing ammonia/um loads in effluent (Wallace et al. 2006; Chan et al. 2008).

Ammonia/um may affect covered fish species both directly and indirectly. Directly, ammonia/um can be toxic to fish (Randall and Tsui 2002), but concentrations measured in the Delta (SWRCB 2008) are well below levels at which the EPA (1999) identifies acute or chronic toxic effects. Modeling and experimental studies have concluded that the residual effects of ammonia/um in SRCSD wastewater treatment plant effluent on aquatic organisms are "less than significant" (Sacramento Regional County Sanitation District 2003). However, Appendix 5 of EPA (1999) reported that some data indicate that un-ionized ammonia can have adverse effects on aquatic life at concentrations as low as 0.001 to 0.006 mg/L. Mean un-ionized ammonia concentrations from 2000–2008 at the two monitoring locations in the Sacramento River immediately downstream of the SRCSD wastewater treatment plant discharge point exceeded the lower end of this range. In addition, there is some evidence that delta smelt and other covered fish species may be more sensitive than EPA aquatic criteria indicate when they are exposed to ammonia/um in combination with other stressors including elevated water temperature, food limitation, and other contaminants or when actively swimming (Eddy 2005). Thus, current ammonia/um concentrations in the Delta may have direct adverse effects on covered fish species.

Ammonia/um is further hypothesized to indirectly affect covered fish species by disrupting the food web. At least three mechanisms of effect have been proposed: disrupting nitrate uptake by phytoplankton, causing toxic effects in invertebrates that serve as prey for covered fishes, and promoting harmful algal blooms.

Elevated concentrations of ammonium ion can disrupt the uptake of nitrate (NO3) by phytoplankton, a phenomenon demonstrated in San Francisco, San Pablo, and Suisun Bays during spring months (Wilkerson et al. 2006; Dugdale et al. 2007). Phytoplankton form the base of the food web from which much of the food energy for the Delta ecosystem is derived (Jassby and Cloern 2000). Therefore, reductions in phytoplankton production may reduce zooplankton productivity, reducing the prey base for covered pelagic fish species, particularly delta and longfin smelt. Juvenile salmonids may also be affected by limited zooplankton abundance, although they primarily consume other organisms. This effect mechanism is hypothetical; preliminary tests in 2008 using Sacramento River water from immediately downstream of the SRCSD wastewater treatment plant discharge point did not find suppressed uptake of nitrate in phytoplankton despite high ammonium concentrations, although nitrate concentrations were low during the testing period (Parker and Dugdale 2008).

Ammonia/um may also have toxic effects on invertebrates that are prey items for covered fish species (Essex Partnership 2009). If food is limiting to delta and/or longfin smelt, a reduction in the abundance of prey could reduce the abundance of these fish species. However, invertebrates are generally less acutely sensitive to ammonia/um than fish. A recent pilot study suggests that, in combination with other chemicals (i.e., pesticides), ammonia/um at elevated levels may reduce the survival of prey species for delta smelt and longfin smelt, *Eurytemora affinis*, although no conclusive evidence was found to support this (Teh et al. 2008).

Finally, high concentrations of ammonium ion may promote blooms of harmful cyanobacteria, *Microcystis aeruginosa*, which produce microcystins that are toxic to covered fish species (Essex Partnership 2009). Lehman (2008) found that *Microcystis* cell density in the Delta correlated best with low flows and high water temperature and secondarily with nutrient concentrations and ratios; however, nutrient concentrations throughout the water column during the study were always at least an order of magnitude higher than limiting levels. Further, Lehman (2008:201) indicated that the *Microcystis* bloom she documented in 2004 "probably did not cause acute toxicity to aquatic food web organisms in the San Francisco Estuary".

In summary, evidence indicates that ammonia/um levels may affect covered fish species by each of these mechanisms, but the frequency, severity, and distribution of such effects are largely unknown.

3.5.1.1.2 Description

In December 2010, a revised NPDES discharge permit was issued to the SRCSD wastewater treatment plant. The permit would require essentially complete removal of ammonia from the discharge by 2020. In an effort to appeal the permit, the SRCSD has filed suit against the State Board over the requirements, but nonetheless is currently proposing to implement improvements in treatment technology that would cut ammonia discharges from the plant in half (Sacramento

Regional County Sanitation District 2012). Since the facility currently accounts for 63% of wastewater discharges in or near the Plan Area (158 million of 252 million gallons per day), even this would substantially reduce ammonia loading to the affected waterbodies, proportionally reducing the potential adverse effects described above.

3.5.1.1.3 Expected Outcomes

The ammonia loading reductions currently proposed by SRCSD would substantially reduce ammonia/um loads in the Plan Area downstream of the SRCSD wastewater treatment plant. Although frequency, distribution, and severity of potential adverse effects of ammonia/um on Plan Area aquatic ecosystems and covered fish species are currently not well understood, it is likely that the reduced loading would also reduce these adverse effects, which likely constitute stressors on phytoplankton and zooplankton productivity, food supply for pelagic fishes, and perhaps food supply for juvenile salmonids. Ammonia loadings also might result in direct physiological effects on some of these fishes; although there is low confidence in this conclusion as very few data are available. In view of these expected outcomes, ammonia loading reductions would tend to favor successful achievement of biological goals and objectives addressing aquatic ecosystem productivity and food supply for juvenile delta smelt, longfin smelt, and salmonids. It may also contribute to survival and growth objectives for these species.

3.4.1.1 Hatchery Genetic Management Plans

3.5.1.1.4 Problem Statement

Hatchery-origin (fish spawned in and released from hatcheries) Chinook salmon and steelhead have a variety of adverse effects on natural-origin (fish spawned in streams) Chinook salmon and steelhead. Among these effects are the following (ICF Jones & Stokes 2010:4–127).

- Effects related to predation, competition, and related changes in ecological relationships between hatchery-origin and natural-origin populations of native species.
- Effects related to non-target harvest, which is the catch of natural-origin fish by fishermen that are attracted to an area because the waters contain hatchery-origin fish.
- Effects related to invasive species and pathogens that may be accidentally introduced during hatchery release operations.
- Effects that arise from interbreeding of hatchery and wild fish, altering the genetic composition of wild populations.
- Effects that arise from accidental or otherwise unauthorized releases of hatchery fish.
- Effects that are caused by anglers during their pursuit of stocked fish.

One of the most significant of these potential hatchery-related effects is the interaction between natural-origin fish and hatchery-origin fish., These interactions, take the form of both competition and predation as well as interbreeding.

The potential for predation and competition between hatchery-origin and natural-origin salmonids depends on the degree of spatial and temporal overlap; differences in size and feeding habitats; migration rate and duration of freshwater residence; and the distribution, habitat use, and densities of hatchery and natural juveniles (Mobrand et al. 2005). Concern has been expressed about the potential for hatchery-reared salmon and steelhead to prey on or compete with wild juvenile Pacific salmonids and the effect this may have on threatened or endangered salmonid populations (Williams 2006). However, there is little evidence that wild salmonids are preyed on by other salmonids in estuarine environments such as the Delta. Numerous studies suggest that salmonids (hatchery or wild) are not significant predators on juvenile salmonids in these environments, but no studies have been designed to specifically investigate predation by hatchery-reared salmonids (Hatchery Scientific Review Group 2004).

The principal mechanisms by which anadromous hatchery and stocking programs may affect the genetic integrity of native fish include the capture of native fish that might otherwise spawn in natural waters, the rearing of fish in artificial channels and ponds that causes a preferential selection for traits beneficial in the hatchery environment but unfavorable for survival in stream habitats, and the interbreeding of fish exhibiting hatchery-selected genetic traits with the wild fish population (ICF Jones & Stokes, pg 4–172). These mechanisms may result in two types of genetic hazards to wild salmon and steelhead populations: loss of genetic diversity within and among populations, and reduced fitness of a population affecting productivity and abundance. Araki et al. (2008) summarized a number of studies that reported a loss of reproductive success ("fitness") of hatchery fish in nature. Araki et al. (2009) further investigated the effects of interbreeding of hatchery fish with wild populations and concluded a loss of fitness of the receiving wild population, suggesting a loss of genetic fitness of the population. Some populations may be more affected than others due to a variety of factors such as the length of exposure to the hatchery environment, the use of non-local stocks in the hatchery brood stock, the degree of habitat fragmentation, the degree of interbreeding, and the reproductive success of hatchery fish in the wild population.

3.5.1.1.5 Description

Hatchery and genetic management plans (HGMPs) are required by NMFS in regulations, called "4(d) rules" because they are required under Section 4(d) of the ESA, which govern permissible incidental take of ESA-listed species of west coast salmon and steelhead via hatchery operations. NMFS uses the information provided by HGMPs to evaluate impacts on ESA-listed salmon and steelhead. Thus, an HGMP is required to describe a hatchery's operations in detail, particularly with regard to actions that serve to minimize potential adverse effects on listed species.

Draft HGMPs have been developed for nearly all Central Valley hatcheries, but none have been approved yet by NMFS. None of the affected hatcheries are located in the Plan Area.

3.5.1.1.6 Expected Outcomes

HGMP implementation is expected to employ a variety of techniques to minimize interactions between natural-origin and hatchery-origin fish. Examples of such techniques include releasing juveniles at times and in locations where there is low potential for predation or competition interactions, and managing broodstock collection and hatchery to minimize genetic effects.

A recent review of the anadromous fish hatchery and stocking programs in the Central Valley recommended adoption of HGMPs at certain California salmon and steelhead hatcheries as an effective way to minimize competition, predation, and genetic interactions between hatchery-origin and natural-origin fish. Nonetheless, the review found that even with implementation of HGMPs, the existing programs would have significant and unavoidable impacts on the Central Valley spring and fall-run Chinook salmon evolutionarily significant units (ESUs) through the mechanism of competition and predation, and also through the mechanism of genetic effects (ICF Jones & Stokes 2010: chapter 4).

3.5.2 References

Araki, H. A., B. Cooper and M. S. Blouin. 2009. Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild. Biology Letters 5(5):621–624.

Araki, H., A. B. Berejikian, M. J. Ford, and M. S. Blouin. 2008. Fitness of hatchery-reared salmonids in the wild. Evolutionary Applications 1:342–355.

Chan S.Y., Y.F. Tsang, L.H. Cui, and H. Chua. 2008. Domestic wastewater treatment using batch-fed constructed wetland and predictive model development for NH3-N removal. Process Biochemistry. 43: 297-305.

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

Hatchery Scientific Review Group. 2004. Hatchery Reform: Principles and Recommendations of the HSRG. Prepared by Lars Mobrand (chair), John Barr, Lee Blankenship, Don Campton, Trevor Evelyn, Tom Flagg, Conrad Mahnken, Robert Piper, Paul Seidel, Lisa Seeb and Bill Smoker. Long Live the Kings, 1305 Fourth Avenue, Suite 810, Seattle, WA 98101.

ICF Jones & Stokes. 2010. Final Hatchery And Stocking Program Environmental Impact Report/ Environmental Impact Statement. Prepared for California Department of Fish and Game and U.S. Wildlife Service. January.

Jassby, A. 2008. Phytoplankton in the upper San Francisco Estuary: recent biomass trends, their causes and their trophic significance. San Francisco Estuary & Watershed Science 6:1-24.

Jassby, A.D. and J.E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems 10: 323-352.

Lehman, P.W., G. Boyer, M. Satchwell, and S. Waller. 2008. The influence of environmental conditions on the seasonal variation of *Microcystis* cell density and microcystins concentration in San Francisco Estuary. Hydrobiologia 600:187-204.

Mobrand, L. E., J. Barr, L. Blankenship, D. E. Campton, T. T. P. Evelyn, T. A. Flagg, C. V. W. Mahnken. L. W. Seeb, P. Seidel, and W. W. Smoker. 2005. Hatchery reform in Washington state: principles and emerging issues. Fisheries 30:11–22.

Parker A. and R. Dugdale. 2008. Progress report – Sacramento algae/NH4 studies. Unpublished report to the State Water Resources Control Board. Nov. 12, 2008.

Randall D.J. and T.K.N. Tsui. 2002. Ammonia toxicity in fish. Marine Pollution Bulletin. 45: 17-23.

Sacramento Regional County Sanitation District. 2012. SRCSD Files Lawsuit Requesting Relief from Wastewater Discharge Permit Requirements. http://www.srcsd.com/pdf/litigation-filed.pdf, accessed 2012.01.24.

———. 2003. Draft Environmental Impact Report for the Sacramento Regional County Sanitation District, Sacramento Regional Wastewater Treatment Plant 2020 Master Plan. Volume 1 – EIR Text.

Teh S.J., M. Lu, F.C. Teh, S. Lesmeister, I. Werner, J. Krause, and L. Deanovic. 2008. Final Report: Toxic effects of surface water in the upper San Francisco Estuary on Eurytemora affinis. Submitted to the San Luis and Delta-Mendota Water Authority.

U.S. Environmental Protection Agency. 1999. 1999 update of ambient water quality criteria for ammonia. EPA 822-R-99-014. December 1999. Available at: http://www.epa.gov/waterscience/criteria/ammonia/99update.pd.

Wallace S., J. Higgins, A. Crolla, C. Kinsley, A. Bachand, and S. Verkuijl. 2006. High-rate ammonia removal in aerated engineered wetlands. Paper presented at the 10th International Conference on Wetland Systems for Water Pollution Control. September 23-29, 2006: Lisbon, Portugal.

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

Williams, J. G. 2006. Central Valley Salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3): Article 2. December.

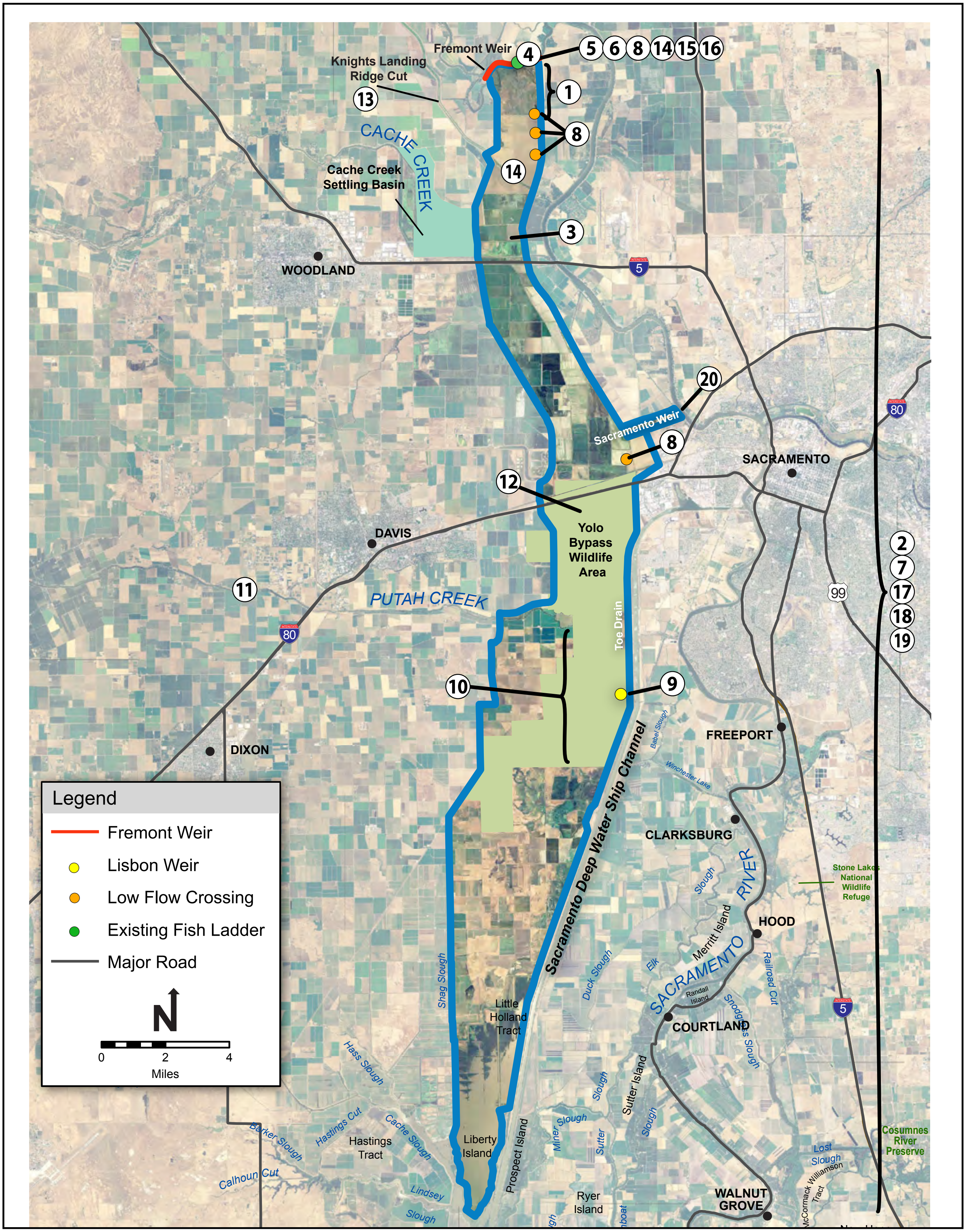

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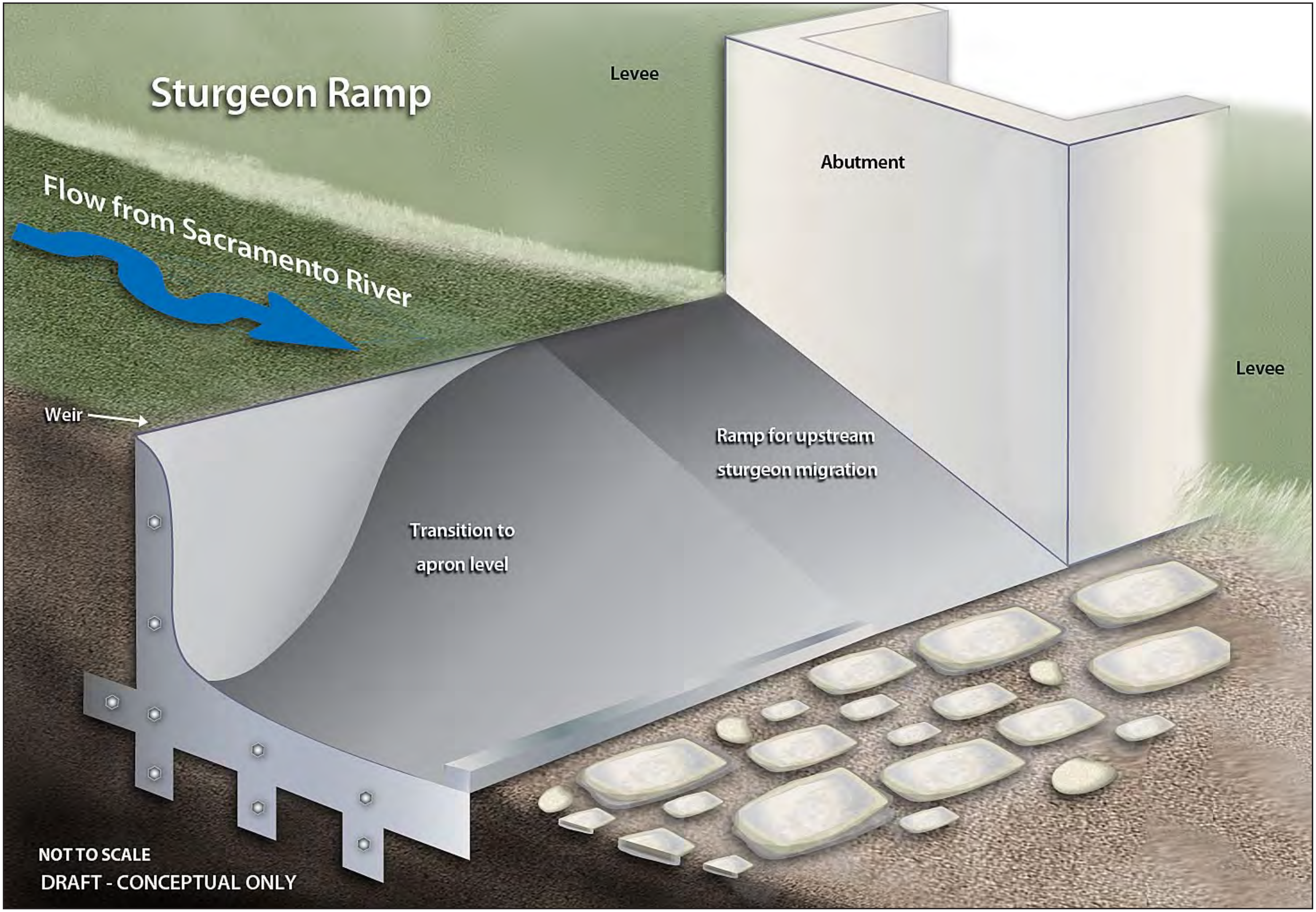
Figure 3.4-1
Yolo Bypass Fisheries Enhancement



Graphics/... BDCP Other Chapters/SAIC Nov 2010 (created: 11/9/10) (Rev. 12/8/11 JD)

Figure 3.4-2
Conceptual Design for Experimental Sturgeon Ramp (CM2)

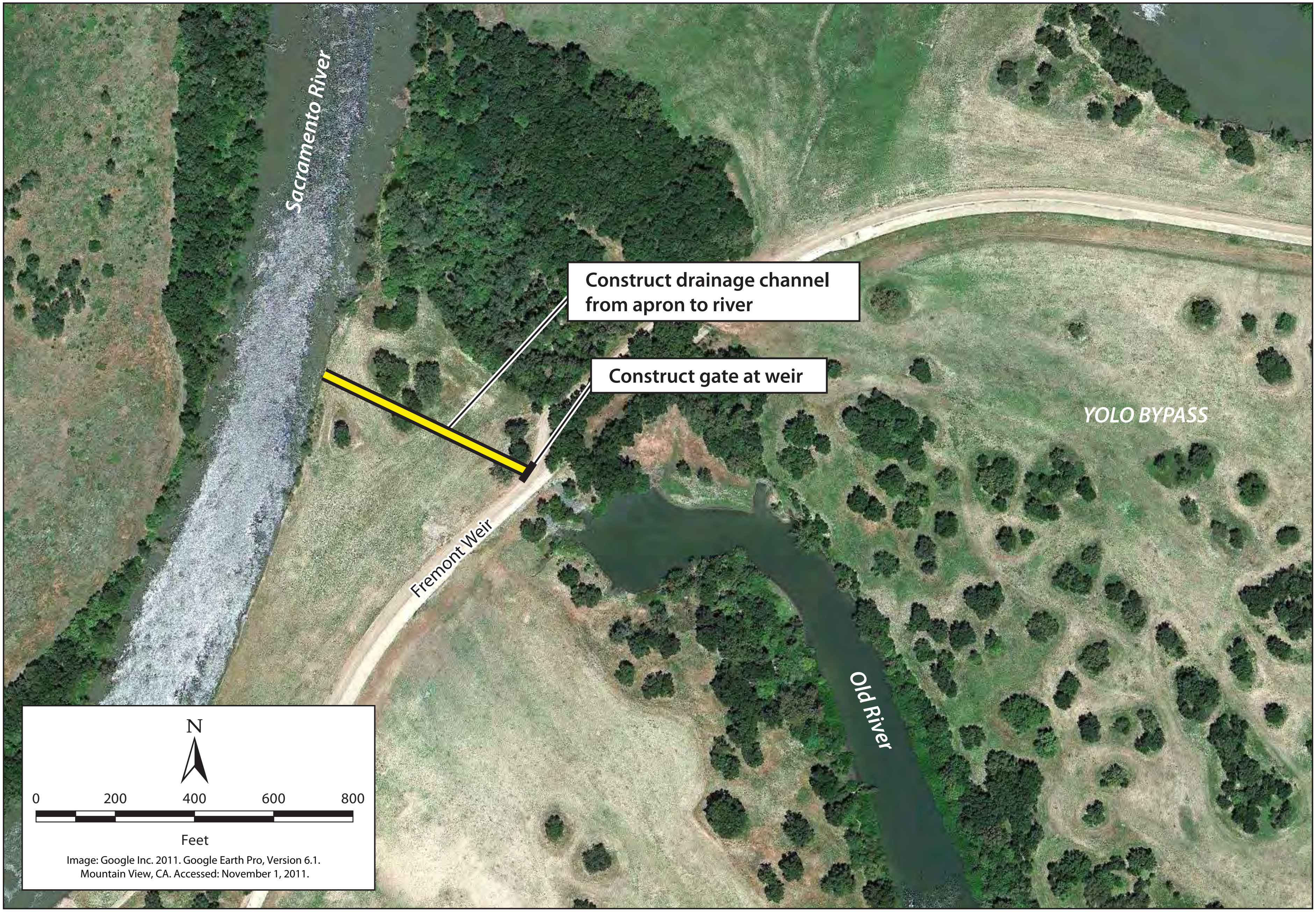


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Figure 3.4-3
Concept for a Facility to Prevent Fish Stranding in the Western Length of Fremont Weir

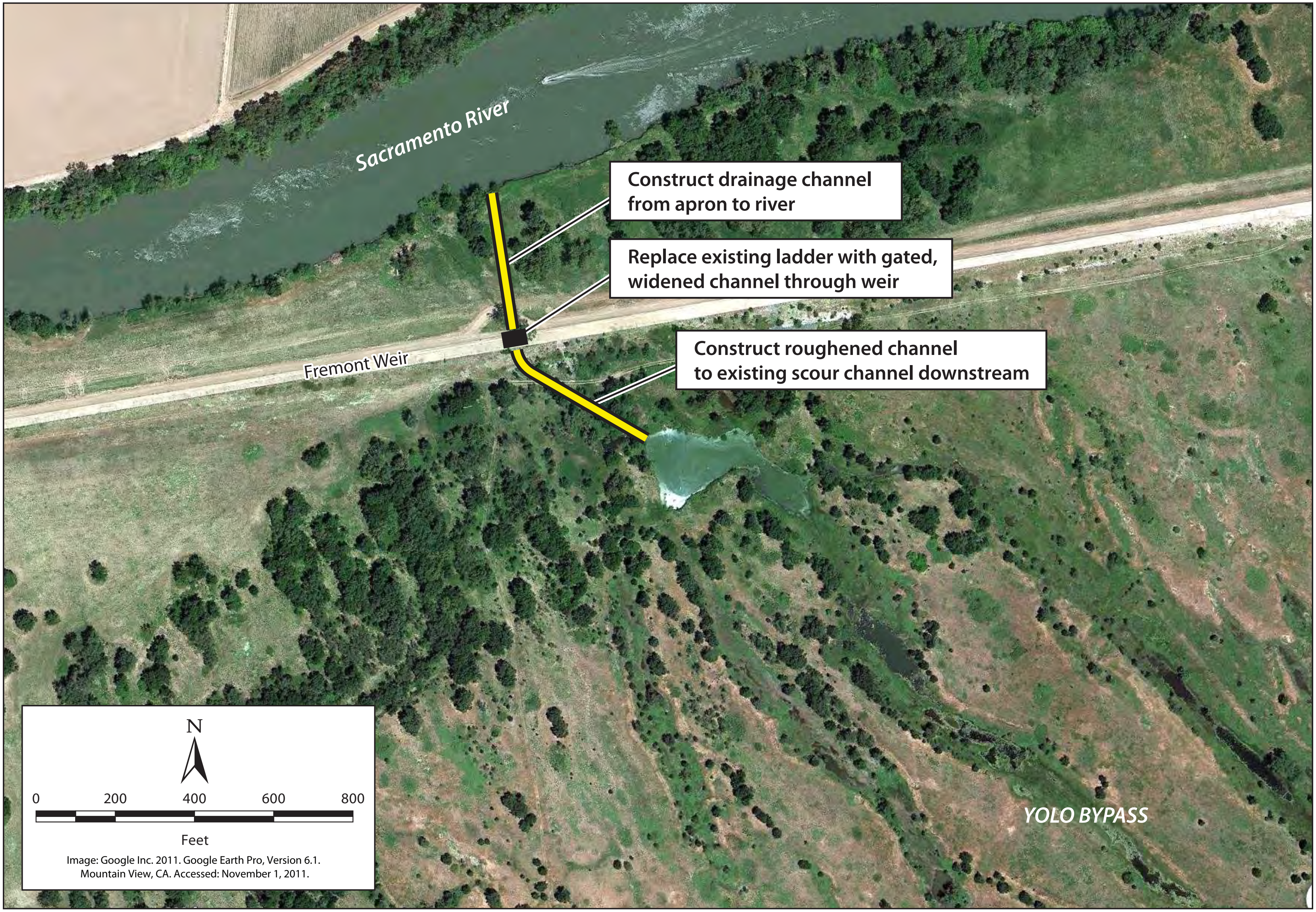

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Figure 3.4-4
Concept for Substantially Improving the Existing Fish Ladder

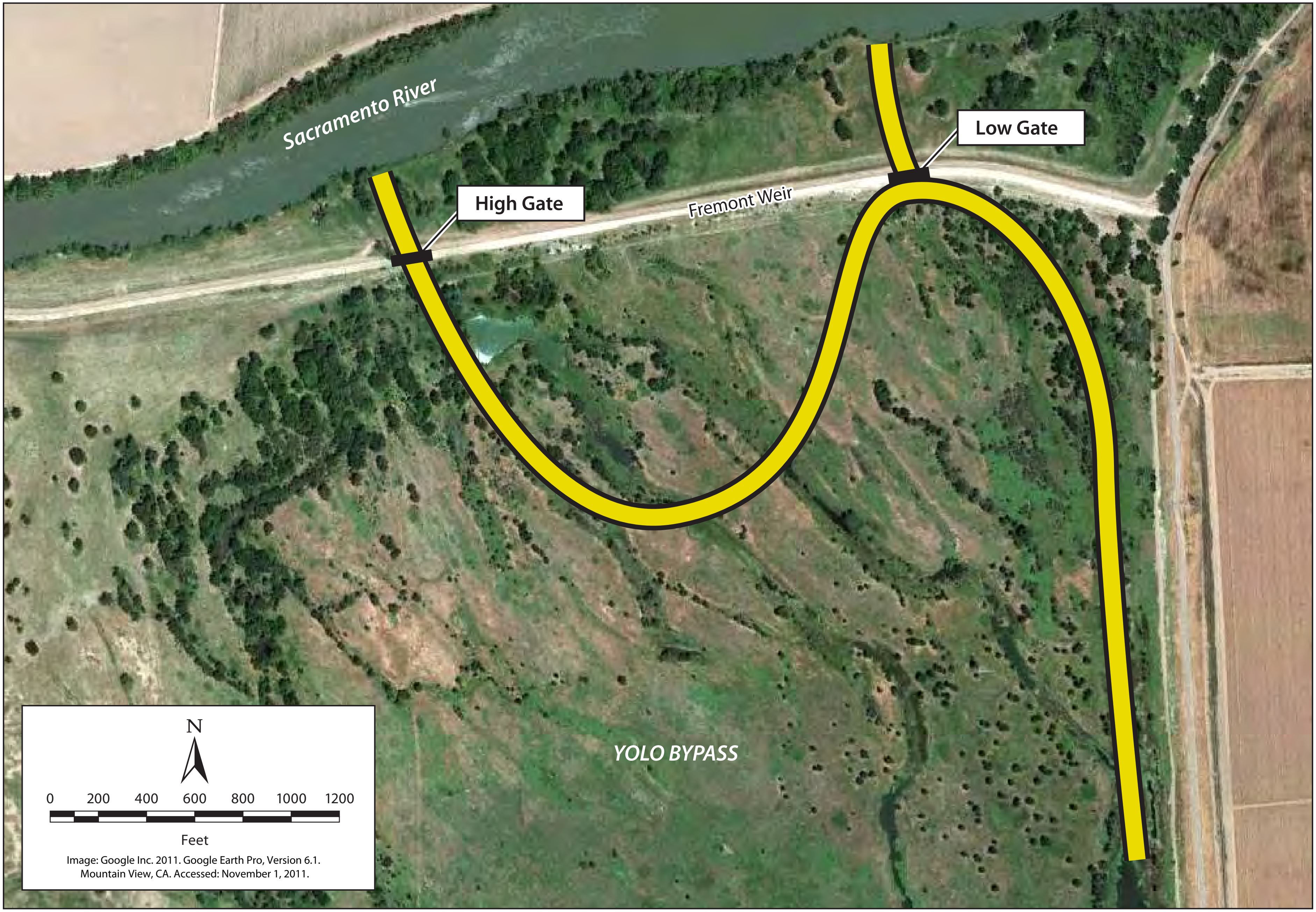

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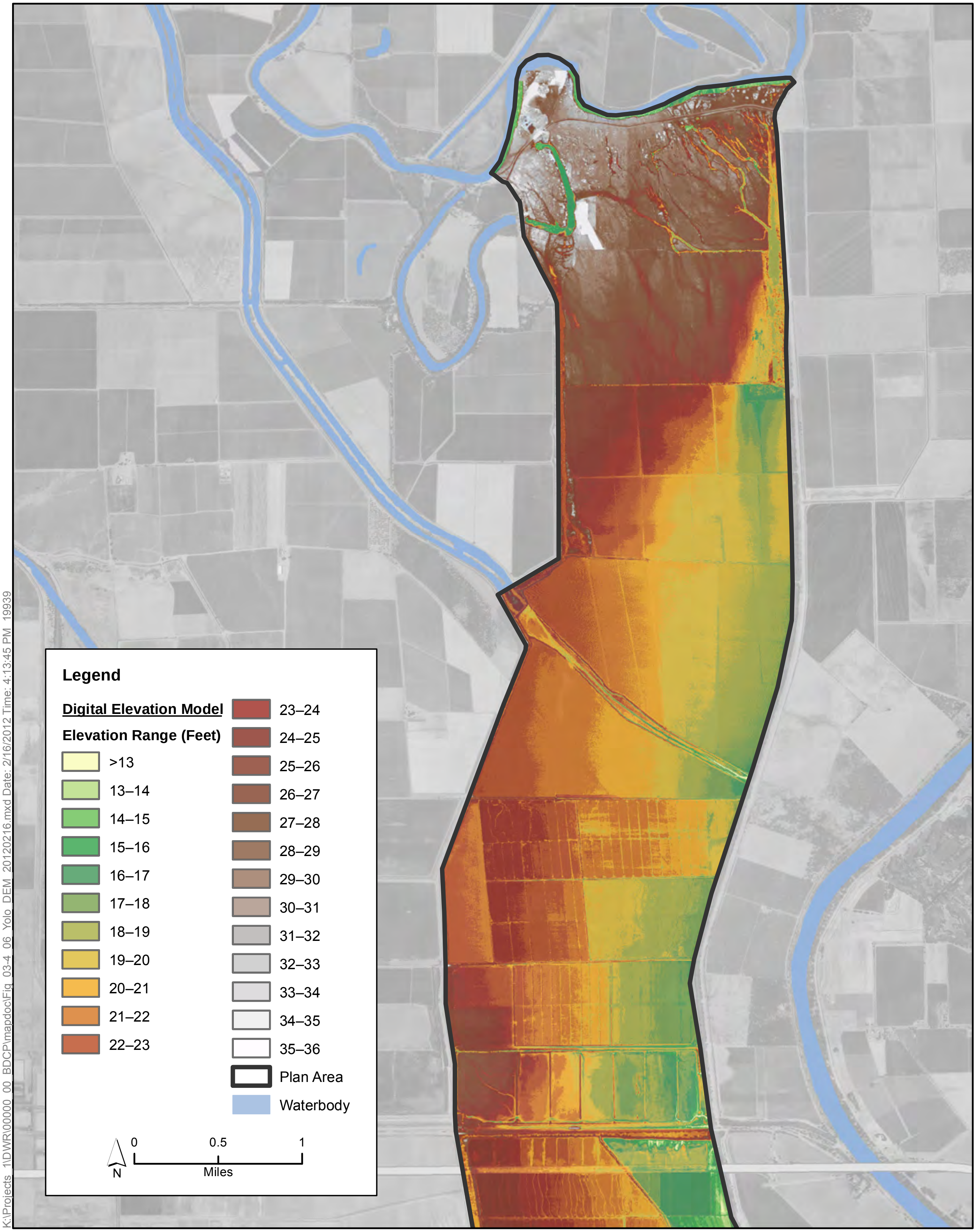
Figure 3.4-5
Concept for Providing Multistage, Multispecies Fish Passage



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Source: Plan Area, DWR 2010; Hydrology, HDR 2011;
Digital Elevation Model, DWR 2006; Aerial Photograph, NAIP 2010.

Figure 3.4-6
Upper Yolo Bypass Digital Elevation Model

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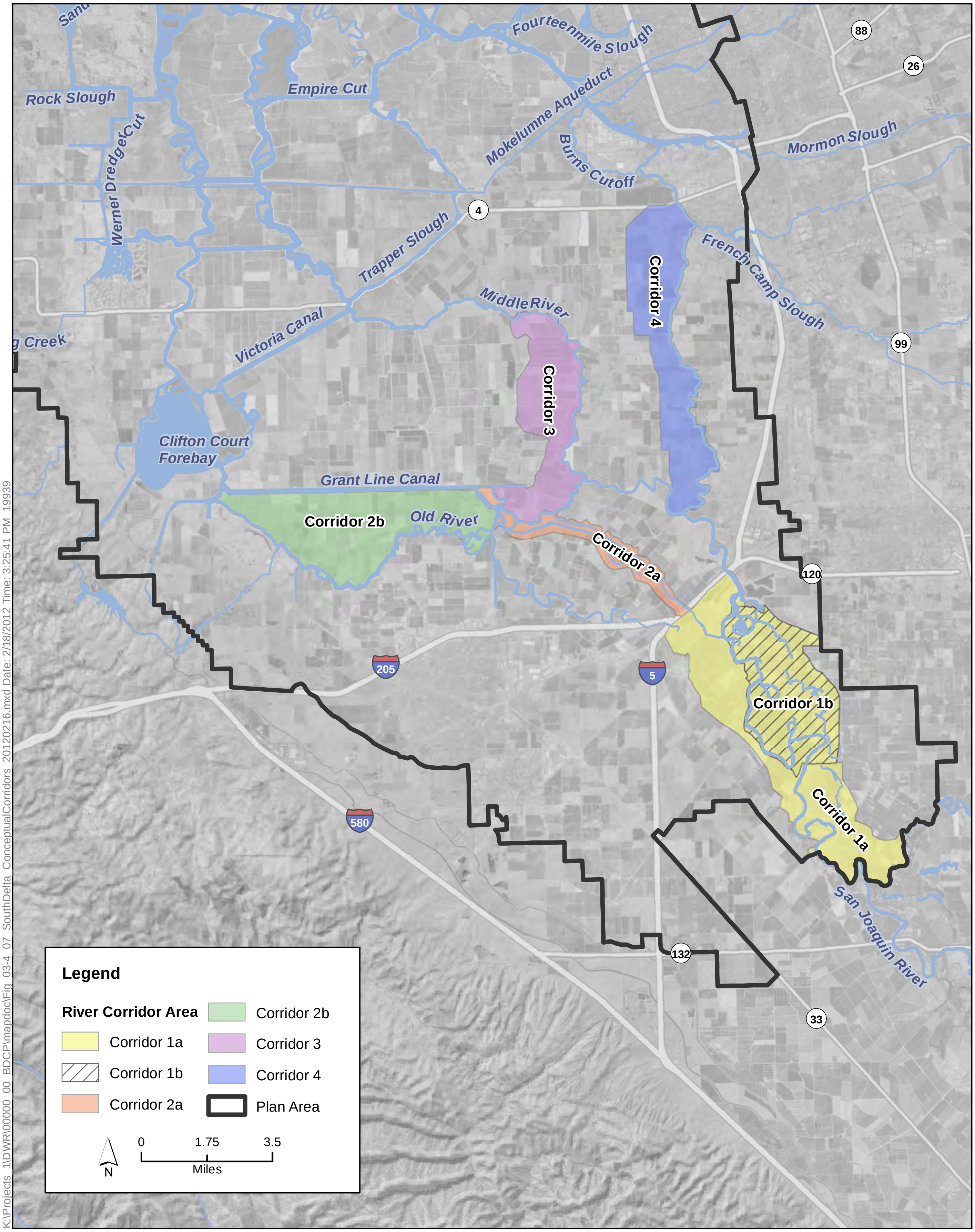

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Sources: River Corridor Areas, ESA PWA 2011; Plan Area, DWR 2010; Aerial Photograph, NAIP 2010.

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Figure 3.4-7
South Delta Conceptual Corridors (For Planning Purposes Only)

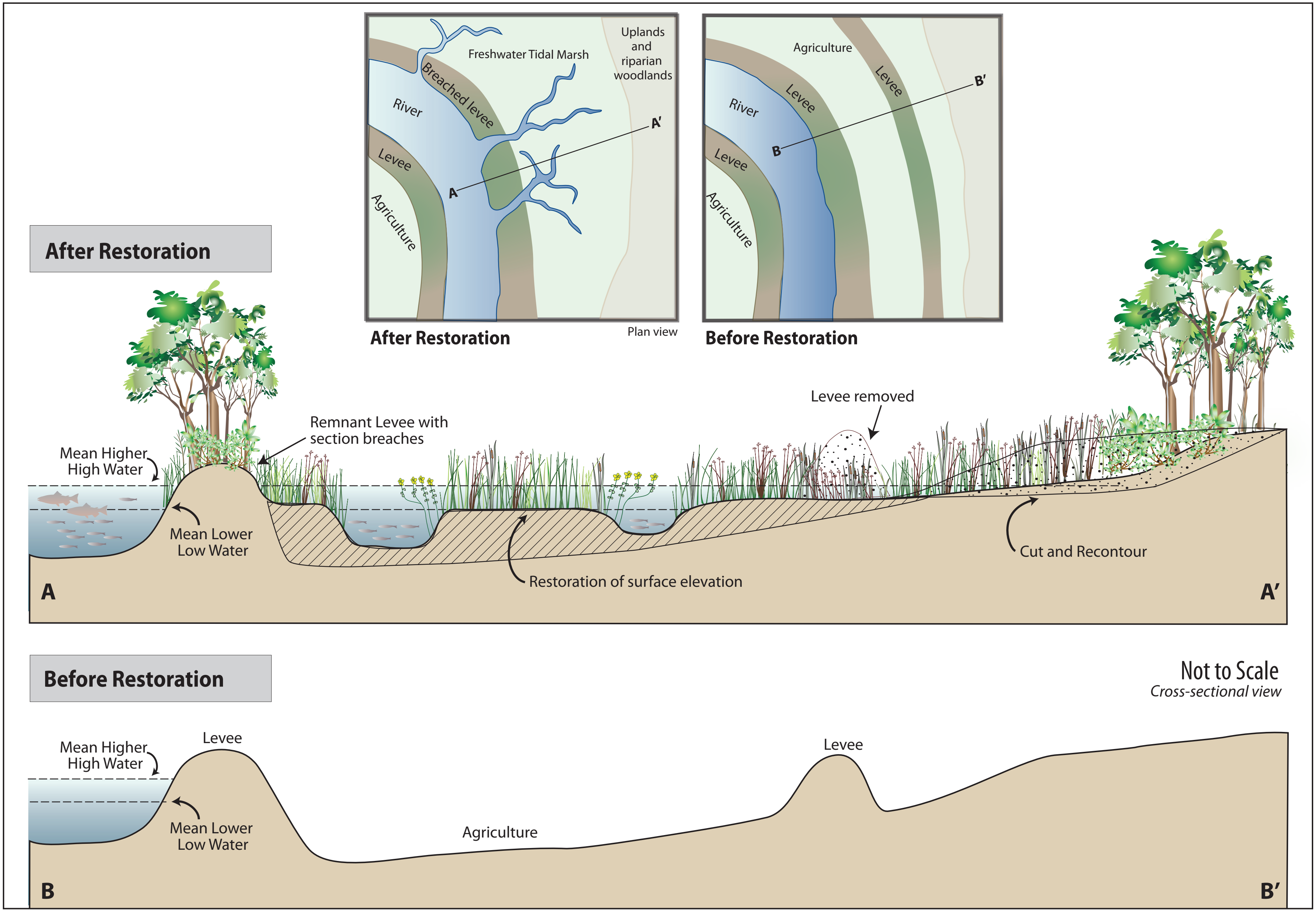

Figure 3.4-8
Conceptual Design for Restored Freshwater Tidal Marsh Habitat

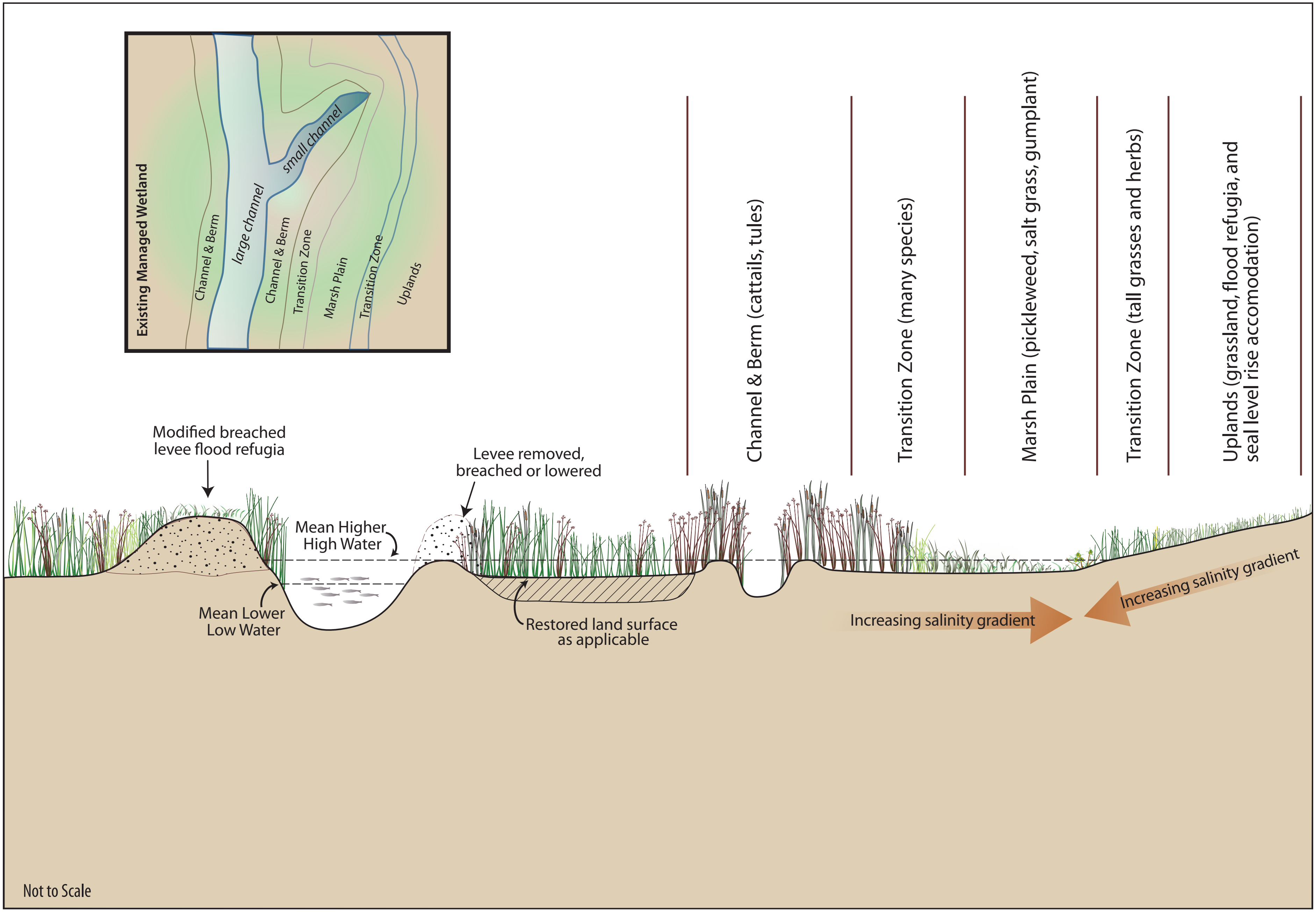

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Figure 3.4-9
Conceptual Design for Restored Brackish Tidal Marsh Habitat (Suisun Marsh ROA)

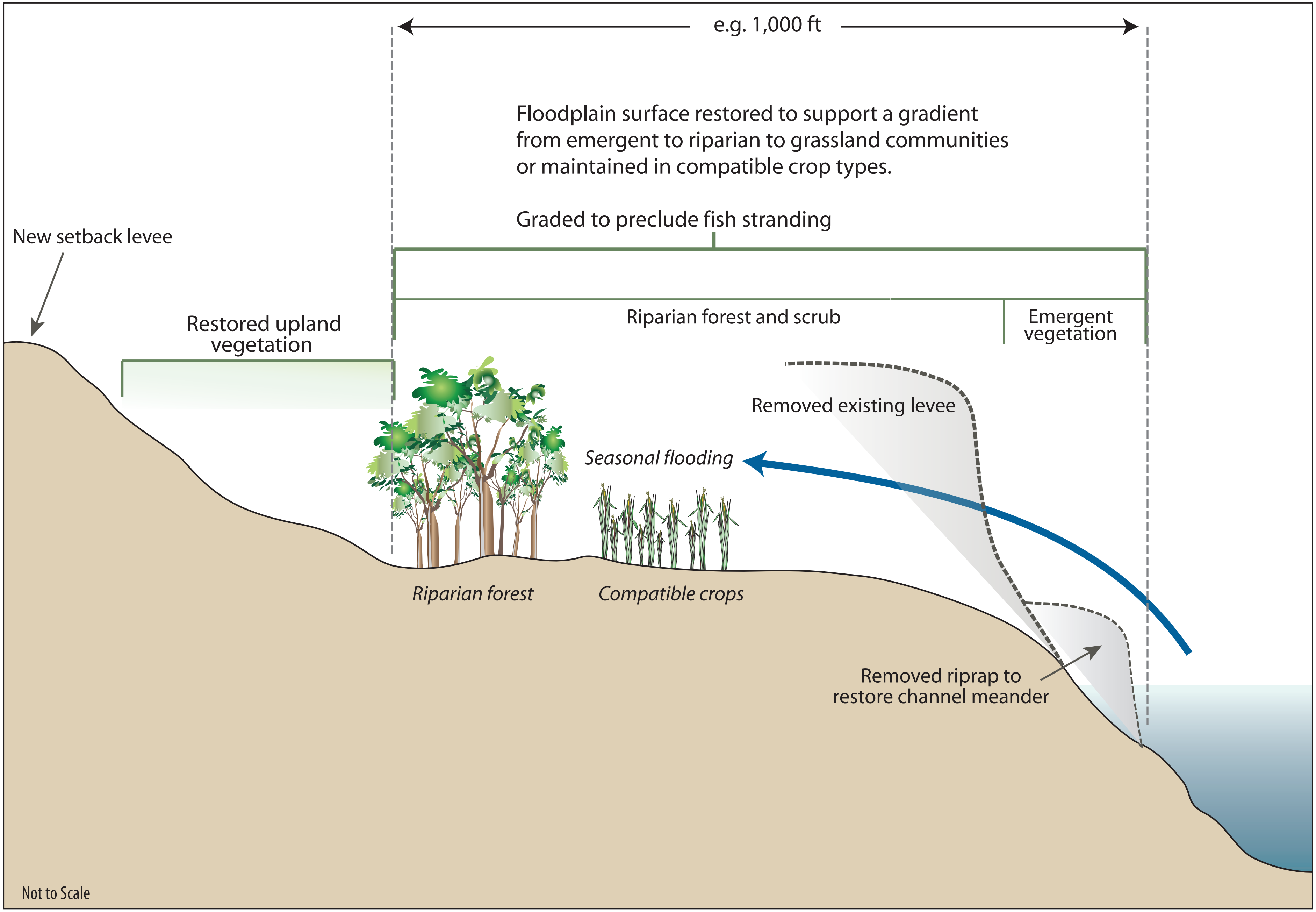

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Figure 3.4-10
Conceptual Design for Restored Seasonally Inundated Floodplain Habitat

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Figure 3.4-11
Channels That Provide Outmigration Habitat for Juvenile Salmonids

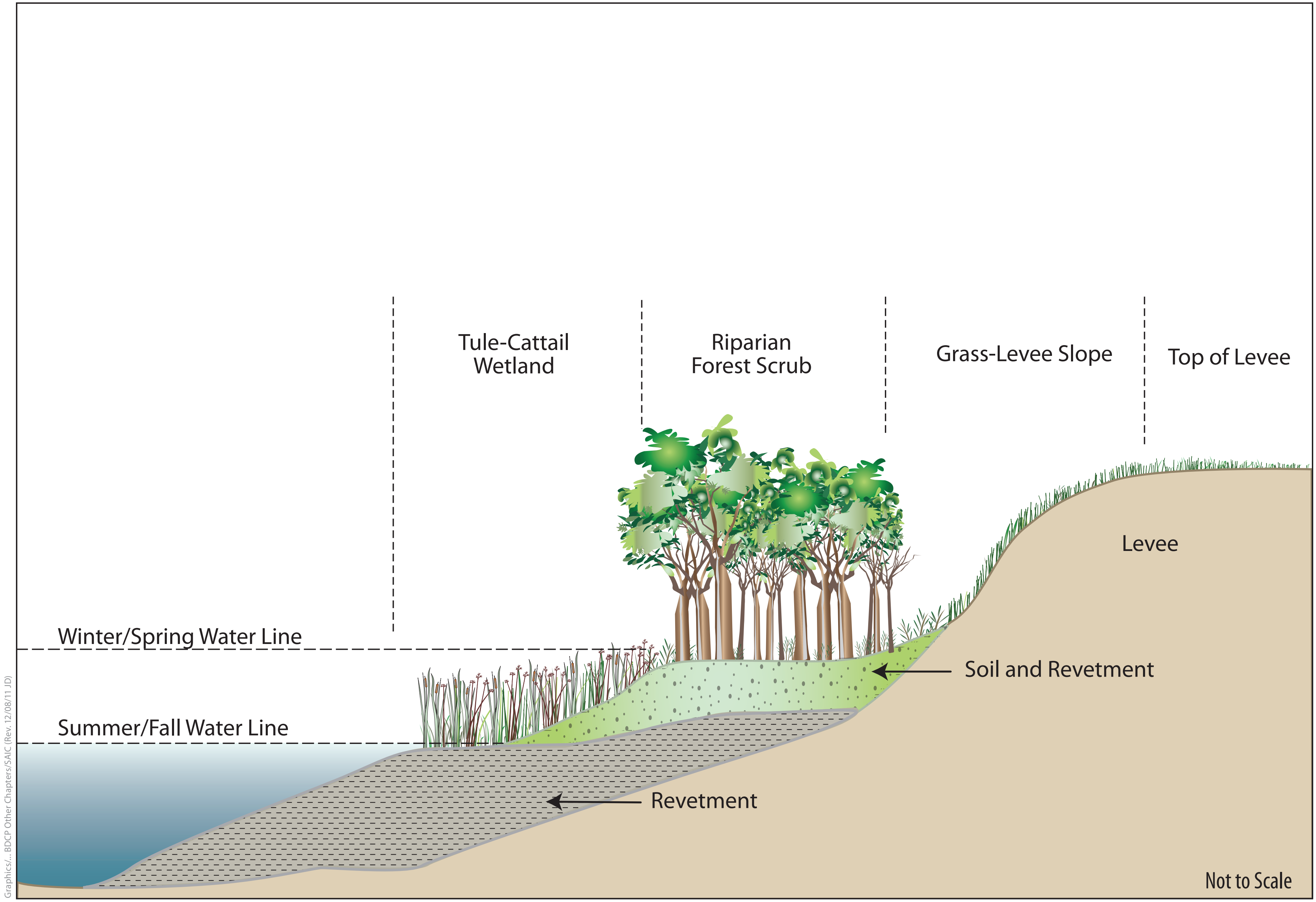
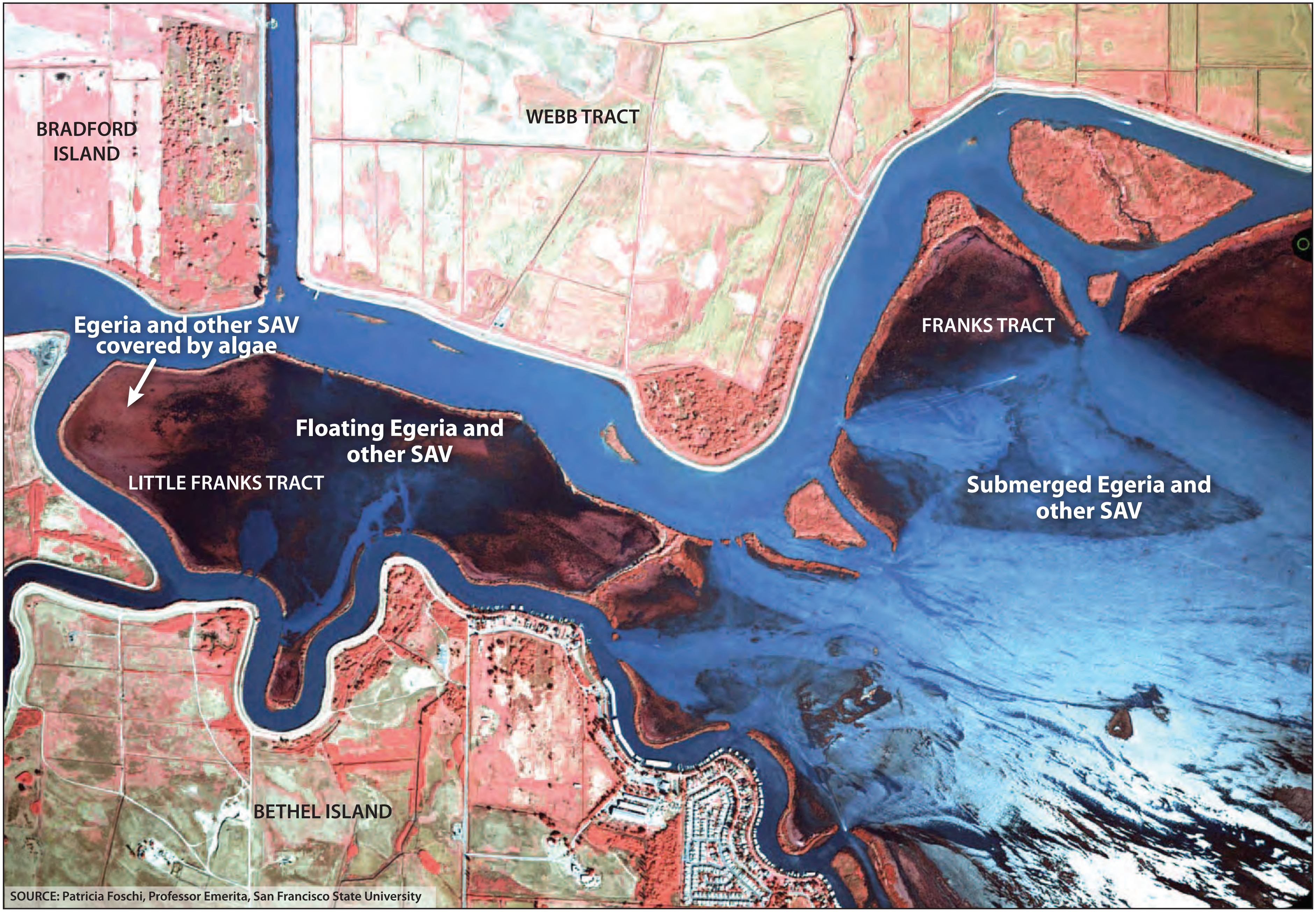
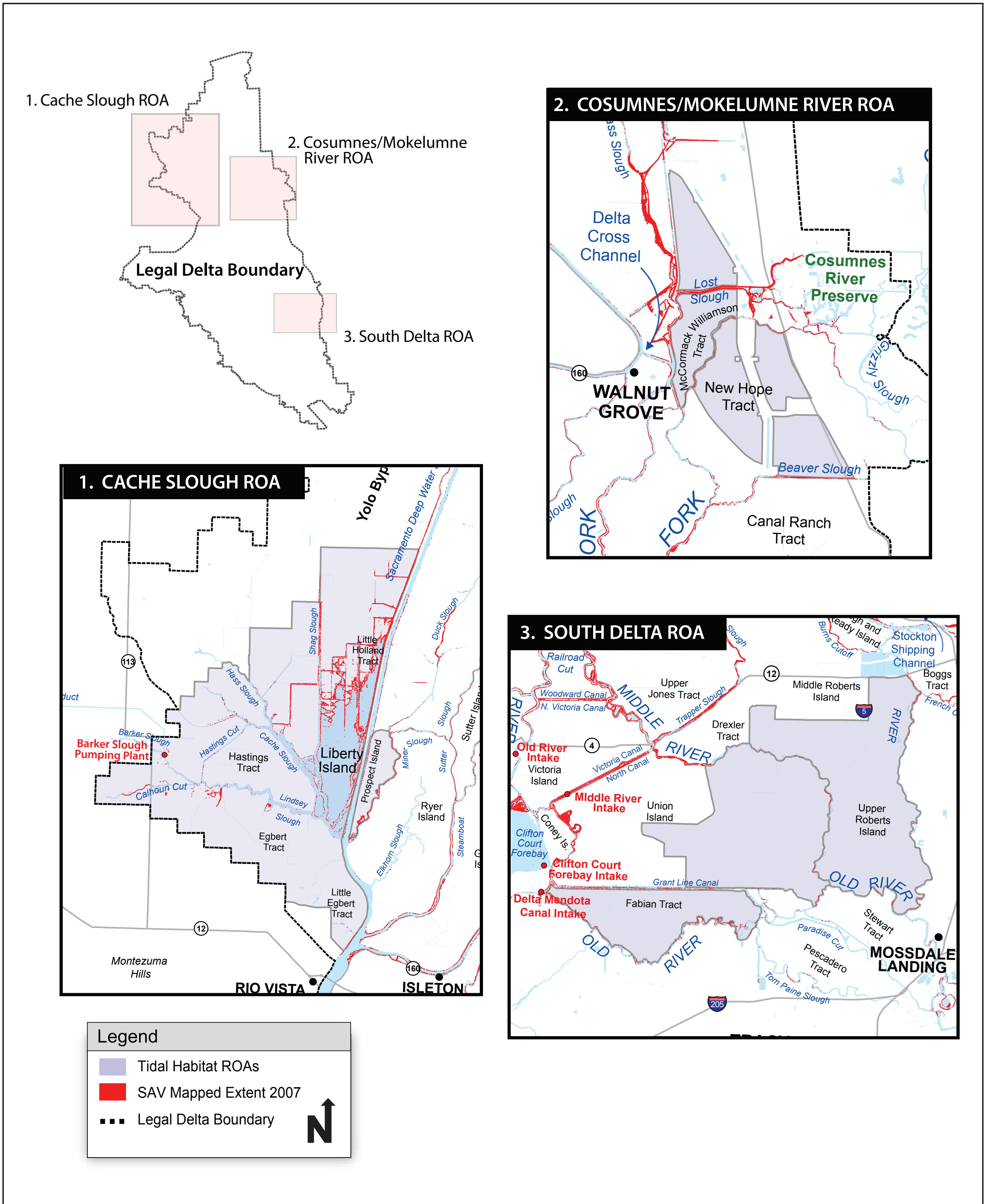


Figure 3.4-12
Cross-Section and Plan View of Typical Restored Channel Margin Habitat



Graphics/... BDCP Other Chapters/SAIC Nov 2010 (created: 11/19/10) (Rev. 12/08/11 JD)

Figure 3.4-13
Examples of Delta Areas with Submerged Aquatic Vegetation (SAV) Infestations



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SOURCE: California Spatial Information Library, 2007; California Department of Fish and Game, 2007; California Department of Water Resources, 2007; Ustin, 2008

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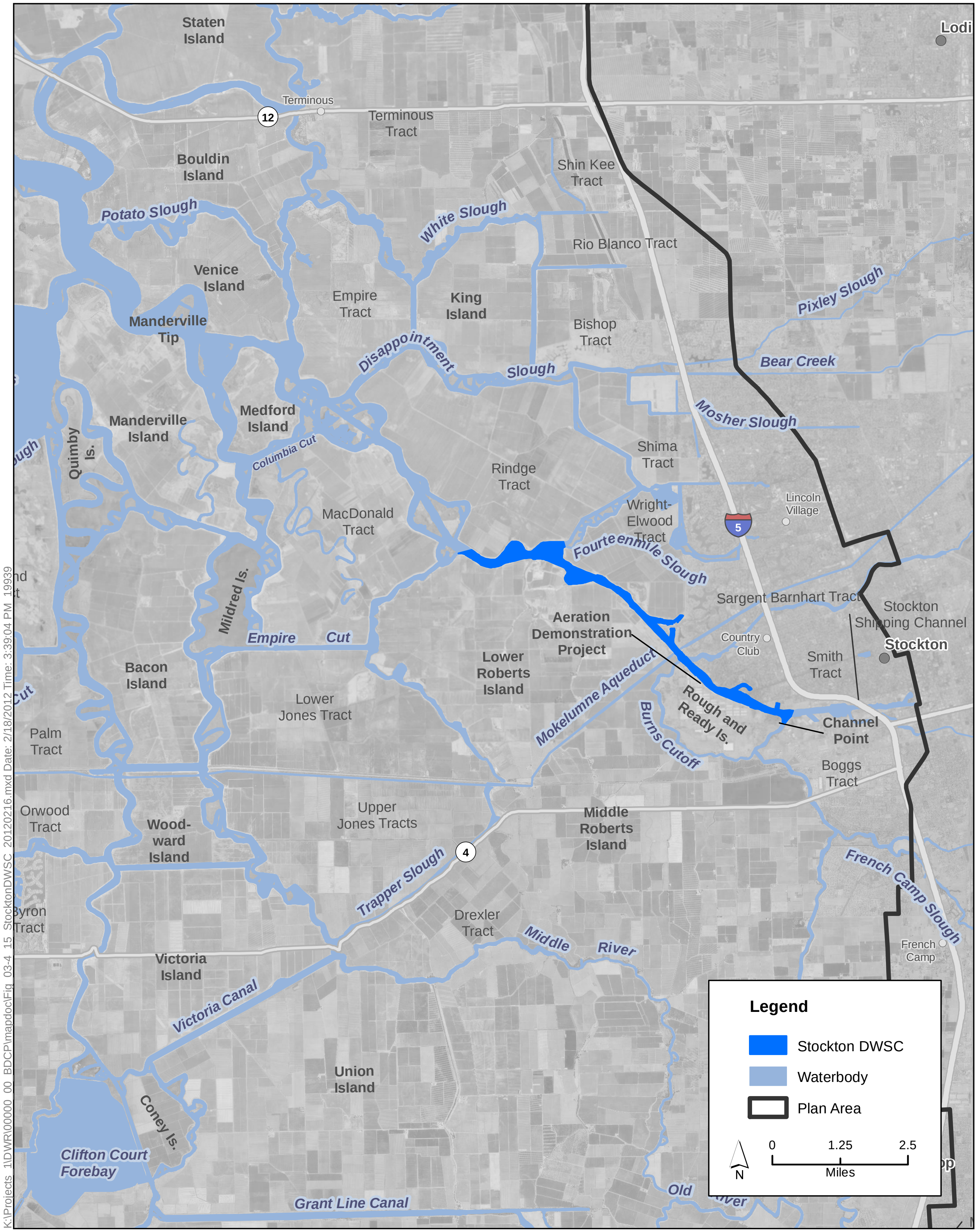
Figure 3.4-14
Overlap of Submerged Aquatic Vegetation in 2007 and Tidal Habitat Restoration Opportunity Areas



Sources: Stockton San Joaquin River Action Area, ICF 2011; Plan Area, DWR 2010; Hydrology, HDR 2011; Cities, U.S. Census Bureau 2010; Aerial Photograph, NAIP 2010.

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Figure 3.4-15
Stockton Deep Water Ship Canal and Aeration Facility Vicinity Map

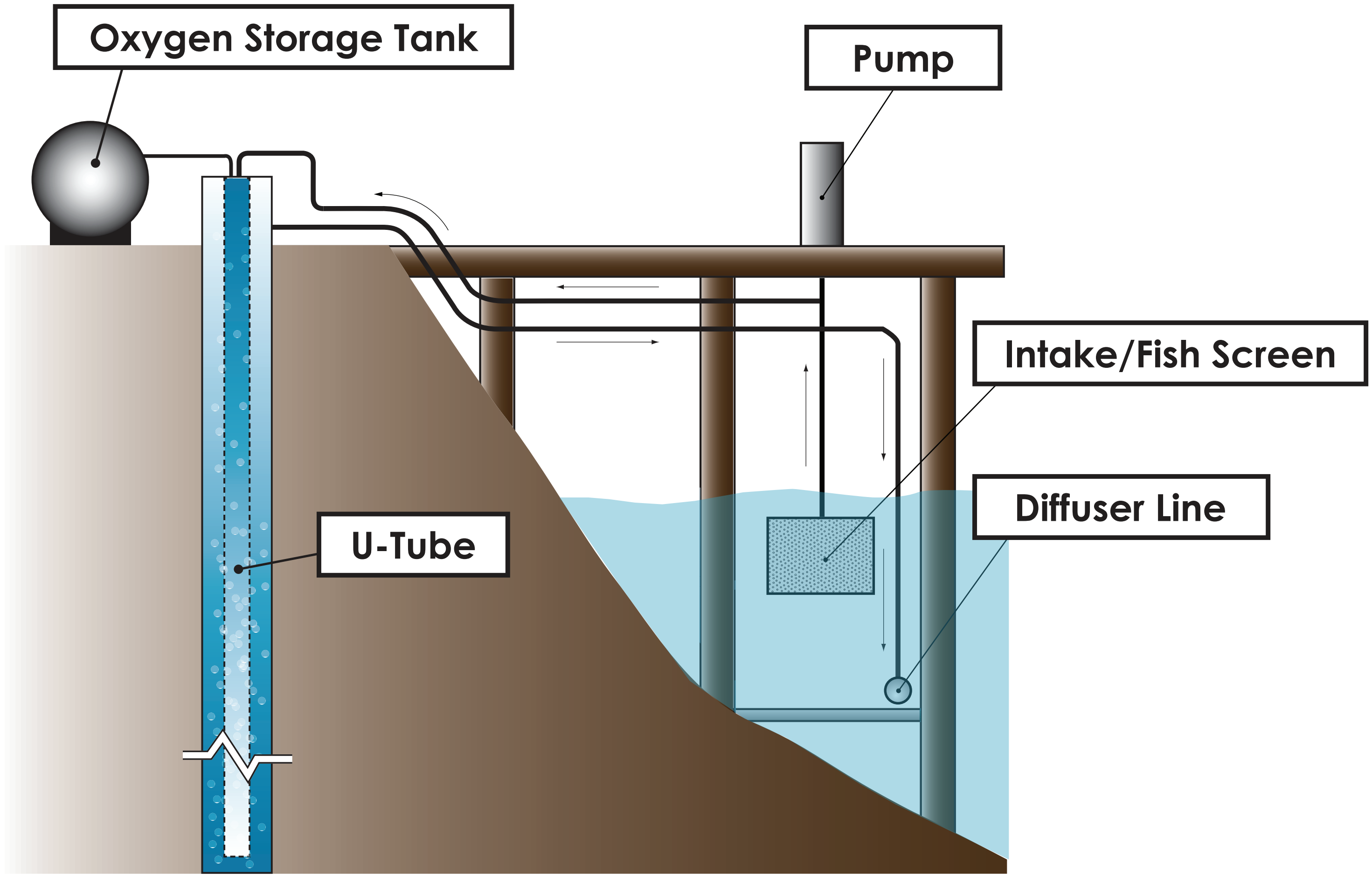

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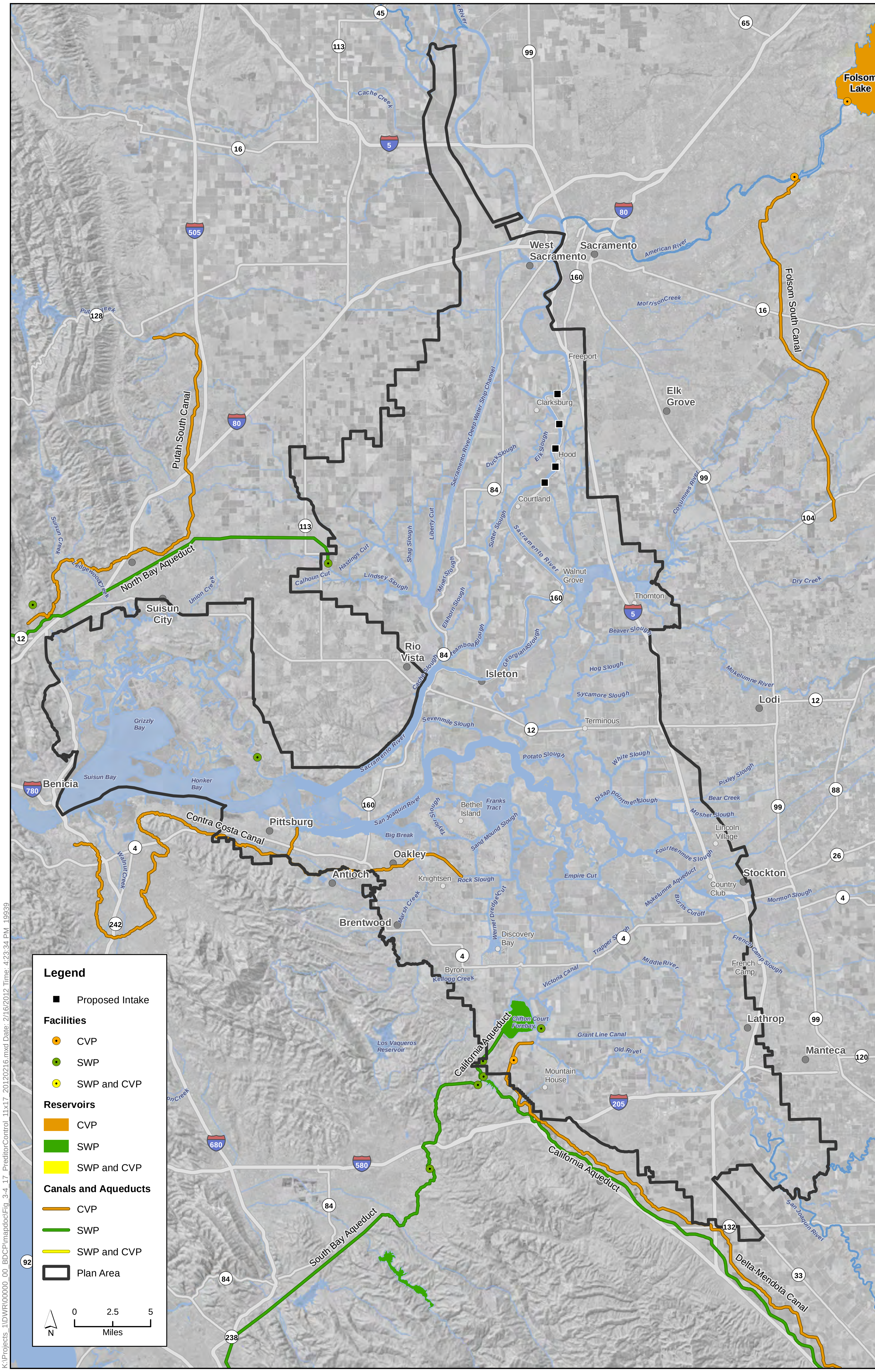
Figure 3.4-16
Schematic of the DWR Demonstration Aeration Facility



Source: Option Features Rev 9a, DWR 2011; DWR Dams and Pumps, DWR 1994; SWP/CVP LAKES, HDR 2011; SWP/CVP Canals and Aqueducts, HDR 2011; Plan Area, DWR 2010; Hydrology, HDR 2011; Cities, U.S. Census Bureau 2010; Aerial Photograph, NAIP 2010.

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Figure 3.4-17
Predator Hot Spots within the Plan Area

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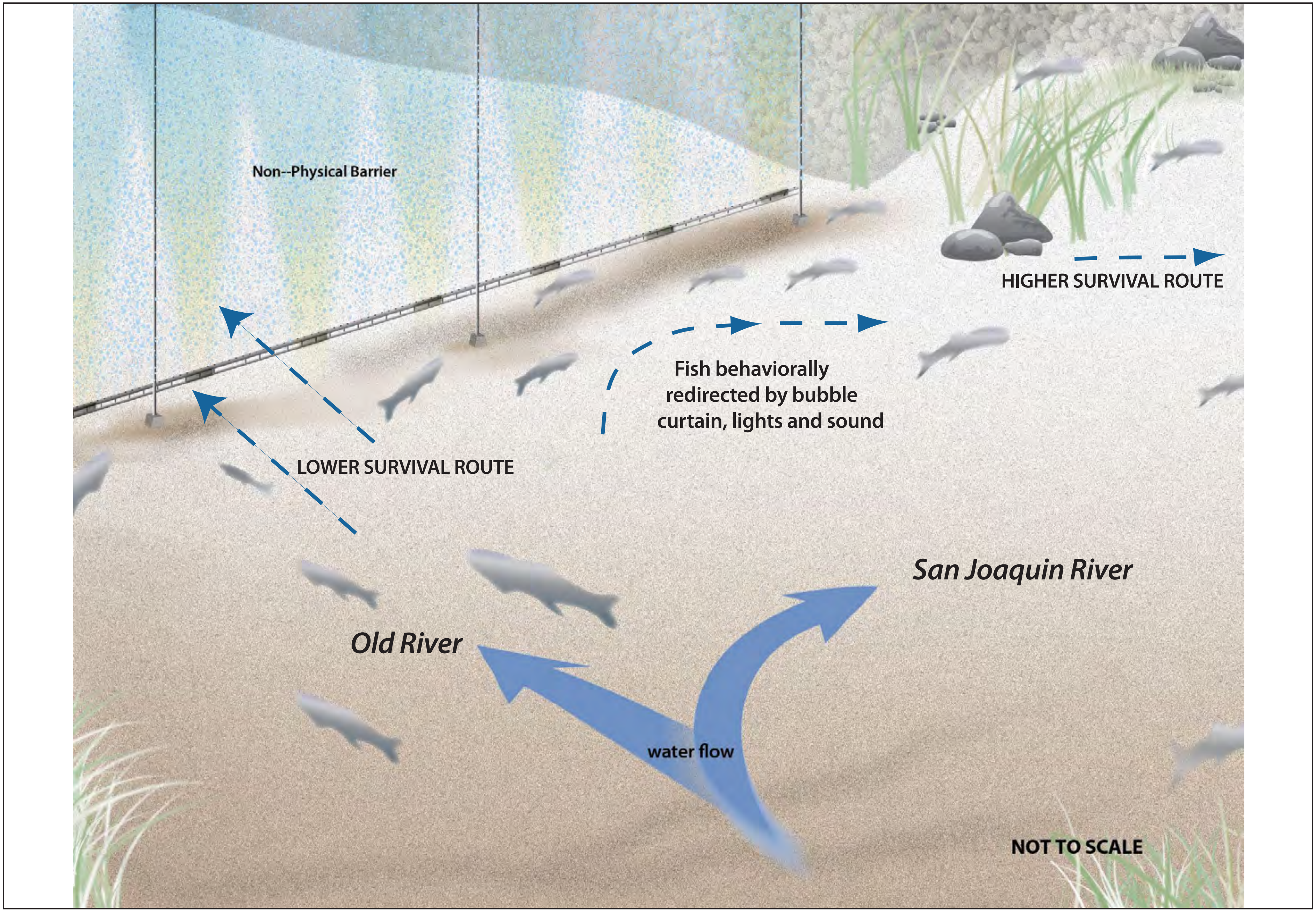

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Figure 3.4-18
Schematic of Nonphysical Fish Barrier

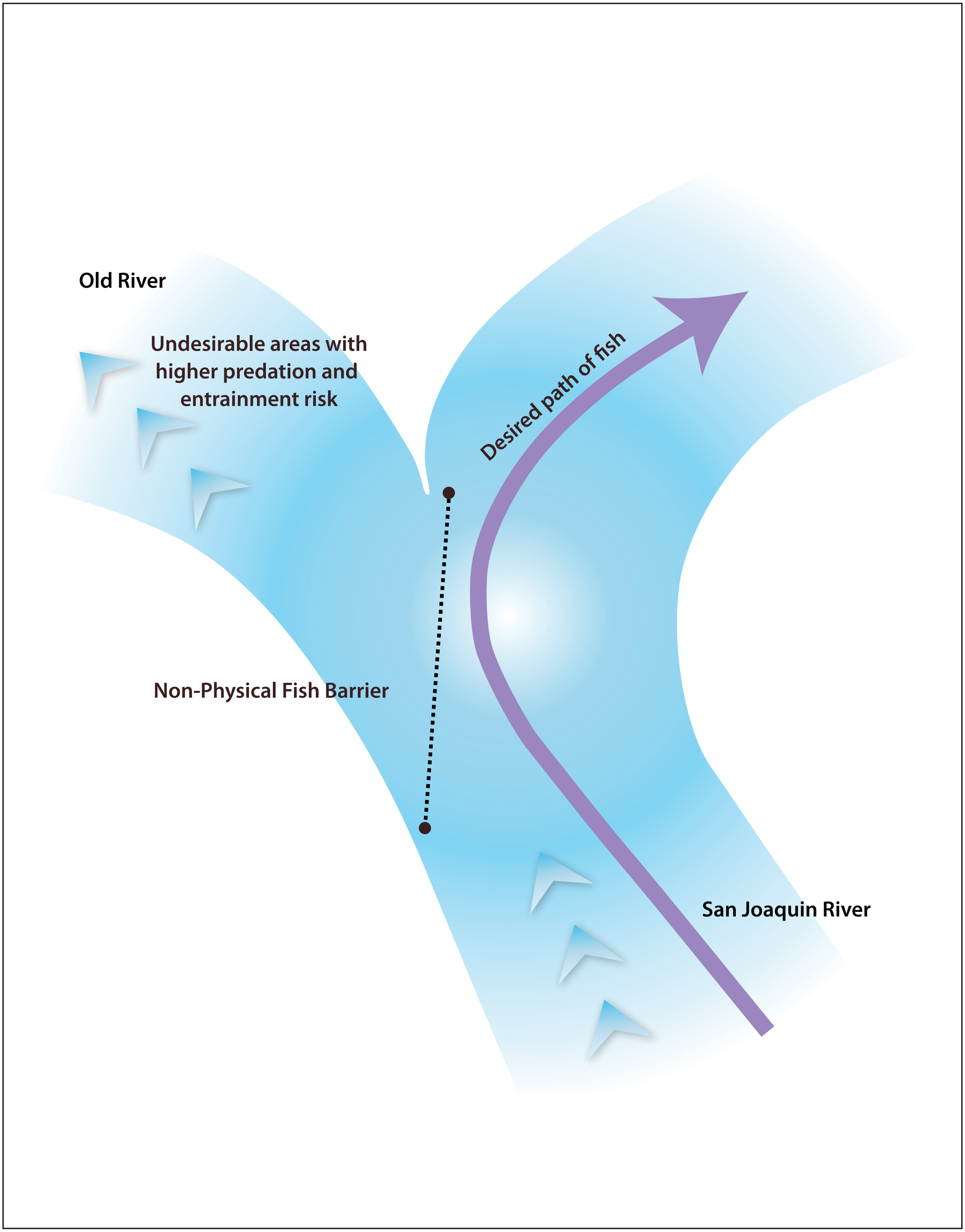

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Figure 3.4-19
Conceptual Location of Nonphysical Fish Barrier

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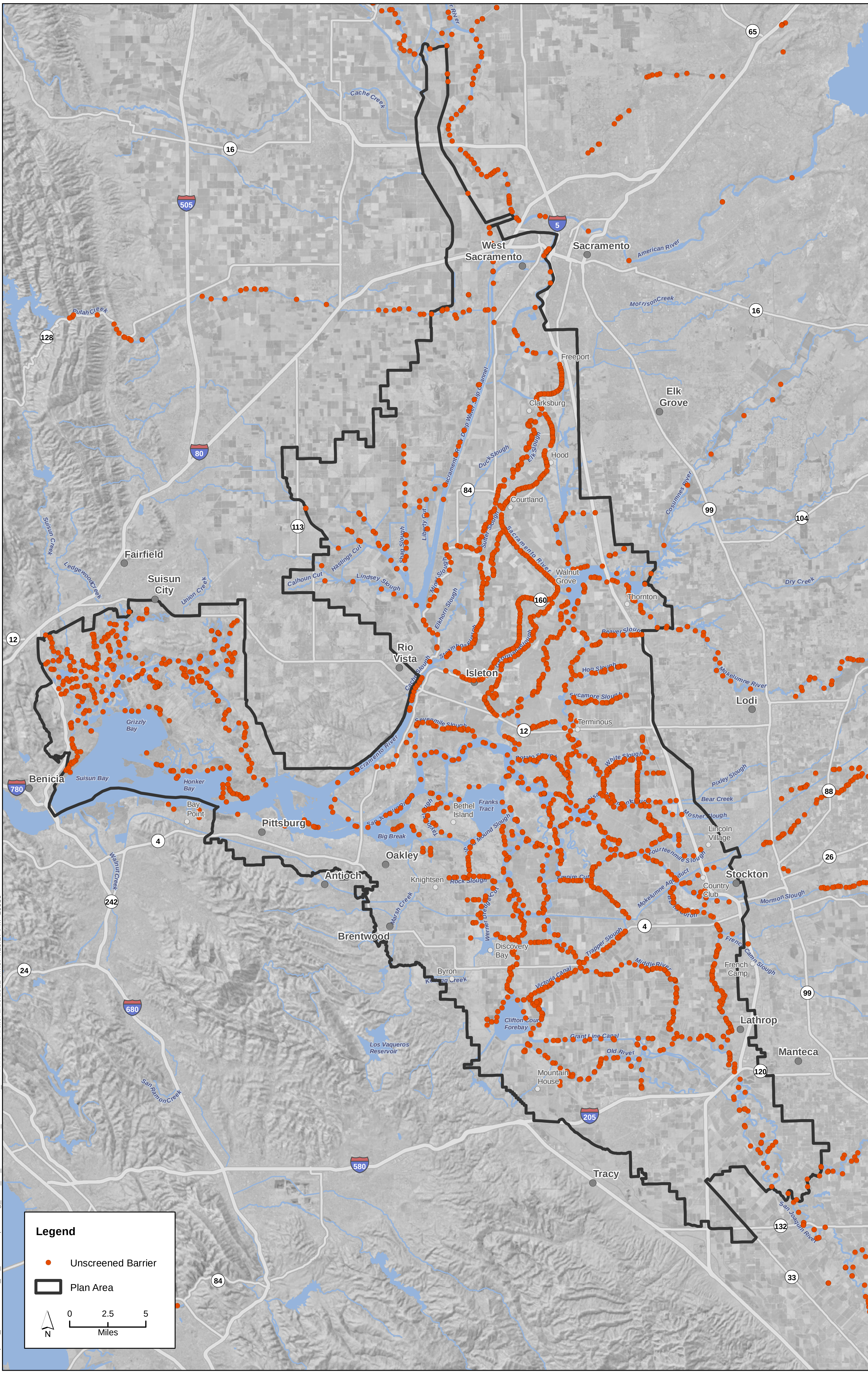
Figure 3.4-20
Potential USFWS Conservation Hatchery Facility Locations



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Sources: Plan Area, DWR 2010; Hydrology, HDR 2010; Barriers, DFG 2011; Aerial Photograph, NAIP 2010

Figure 3.4-21
Unscreened nonproject diversions in the Plan Area

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