3.4 CONSERVATION MEASURES

This section presents the BDCP conservation measures that will be implemented by the BDCP Implementation Office to protect and improve the ecological function of natural communities; avoid, minimize, and compensate for impacts on covered species associated with implementation of covered activities; and provide for the conservation of covered species. Collectively the conservation measures are expected to achieve the BDCP biological goals and objectives. As described in Section 3.3, *Biological Goals and Objectives*, conservation measures address conveyance and water operations; protection, enhancement, and restoration of physical habitats that support covered species; and reductions in the effect of other stressors on covered species. Conservation measures were developed to address stressors at three ecological scales: ecosystem, natural community, and species-specific. Ecosystem-level conservation measures are presented in Section 3.4.2, natural community-level and species-specific conservation measures are presented in Sections 3.4.3 and 3.4.4, and avoidance and minimization measures for covered wildlife and plant species are presented in Section 3.4.5.

A summary list of BDCP conservation measures and the biological goals and objectives they serve is provided in Table 3-12. As is demonstrated in Table 3-12, many of the conservation measures address multiple goals and objectives. The following information is provided with each conservation measure, as appropriate, in Sections 3.4.2-3.4.4.

- **Problem Statement.** This section describes the ecological problems that are intended to be addressed by the conservation measure.
- **Hypothesized Benefits.** This section describes the hypotheses that justify the approach reflected in the conservation measure. Uncertainties and risks that could be associated with DRERIP-evaluated conservation measures are described in Appendix F, *DRERIP Evaluation Results*.

Table 3-12. Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives

Goals and Objectives	*Applicable Conservation Measures*
Ecosystem-Level Goals and Objectives	
Goal ECSY1: Protect and restore large landscapes representing a range of physical and biological attributes (e.g., hydrology, soil, and plant associations) necessary to sustain viable populations of covered species, and to preserve native species biodiversity.	
Objective ECSY1.1: Protect 25,000-41,000 acres of existing natural communities that support covered species.	CM3 Natural Communities Protection CM6 Channel Margin Habitat Enhancement
Objective ECSY1.2: Protect a range of environmental gradients (e.g., hydrology, elevation, and soils) across a diversity of natural communities.	CM3 Natural Communities Protection
Objective ECSY1.3: Restore or create up to 65,000 acres of tidally influenced habitat consisting of subtidal, mudflat, tidal marsh, and transitional upland habitat for sea level rise accommodation that supports a gradient of natural communities and habitat for covered species.	CM4 Tidal Habitat Restoration
Objective ECSY1.4: Restore or create up to 10,000 acres of seasonally inundated floodplain and 20 miles of channel margin habitat.	CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Habitat Enhancement
Objective ECSY1.5: Manage protected and restored or created habitats to enhance habitat functions for associated covered and other native species over the term of the BDCP.	CM11 Natural Communities Enhancement and Management
Goal ECSY2: Provide hydrodynamic conditions within Delta waterways that are more reflective of natural patterns of flow within the BDCP Plan Area and Suisun Marsh.	
Objective ECSY2.1: Support the movement of larval and juvenile life stages of native fish species to downstream rearing habitats.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancements CM16 Non-Physical Fish Barriers
Objective ECSY2.2: Support the movement of adult life stages of native fish species to natal spawning habitats.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancements
Objective ECSY 2.3: Promote water quality conditions within the Delta that help restore native fish habitat.	CM12 Methylmercury Management CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels
Objective ECSY2.4: Maintain or increase life history diversity of native fishes and a diversity of rearing conditions for native fishes over time.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancements CM4 Tidal Habitat Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Habitat Enhancement CM7 Riparian Habitat Restoration
Objective ECSY 2.5: Promote greater connectivity between low salinity zone habitats and upstream freshwater habitats, and availability of spawning habitats for native pelagic species.	CM1 Water Facilities and Operation CM4 Tidal Habitat Restoration

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Ecosystem-Level Goals and Objectives	
Goal ECSY3: Provide for connectivity among protected lands to provide for the movement of native organisms among habitat areas and to facilitate genetic exchange among populations.	
Objective ECSY3.1: Protect corridors of habitat that provide linkages among protected habitat areas within and adjacent to the Plan Area.	CM3 Natural Communities Protection
Objective ECSY3.2: Improve habitat corridors that allow covered and other native species to move into protected habitats from adjacent areas and to move among habitat areas within protected lands.	CM3 Natural Communities Protection CM4 Tidal Habitat Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Habitat Enhancement CM7 Riparian Habitat Restoration CM8 Grassland Communities Restoration CM11 Natural Communities Enhancement and Management
Goal ECSY4: Promote ecosystem processes that support natural communities, covered species, other native species, and the habitats of those species.	
Objective ECSY4.1: Maintain and improve disturbance regimes and other processes that support functioning natural communities.	CM4 Tidal Habitat Restoration CM5 Seasonally Inundated Floodplain Restoration CM11 Natural Communities Enhancement and Management
Goal ECSY5: Increase aquatic primary and secondary production in the Delta, Yolo Bypass and Suisun Marsh to increase the abundance and availability of food for native aquatic organisms.	
Objective ECSY5.1: Over the term of the BDCP, increase the abundance and productivity of zooplankton that provide food and support food production for covered fish species in Delta waterways.	CM2 Yolo Bypass Fisheries Enhancements CM4 Tidal Habitat Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Habitat Enhancement
Objective ECSY5.2: Over the term of the BDCP, increase the abundance and productivity of aquatic invertebrate species that provide food and support food production for covered fish species in Delta waterways.	CM2 Yolo Bypass Fisheries Enhancements CM4 Tidal Habitat Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Habitat Enhancement
Goal ECSY6: Reduce the adverse predation effects of non-native species on covered fish species.	
Objective ECSY6.1: Manage the distribution and abundance of established non-native predators in the Delta to reduce predation on native covered fishes.	CM13 Nonnative Aquatic Vegetation Control CM15 Predator Control
Objective ECSY6.2: Manage the distribution of covered fish species to minimize movements into high predation risk areas of the Delta.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancements CM16 Non-Physical Fish Barriers
Goal ECSY7: Protect lands with a sufficient range of habitat conditions to accommodate anticipated shifts in the distributions of covered species and natural communities in response to climate change.	
Objective ECSY7.1: Protect sufficient upland transitional habitat area adjacent to restored brackish and freshwater tidal emergent wetland to permit the future upslope natural establishment of tidal emergent wetland communities with sea level rise.	CM3 Natural Communities Protection CM4 Tidal Habitat Restoration

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Natural Community Goals and Objectives	
Tidal Perennial Aquatic	
Goal TANC1: The expected outcome is tidal perennial aquatic natural community that supports habitats for covered and other native species and that supports aquatic food web processes.	
Objective TANC1.1: Restore or create 10,000 to 20,000 acres of tidal perennial aquatic in the BDCP Restoration Opportunity Areas (Conservation Zones 1, 2, 4, 5, 7, and 11) that supports aquatic food production and habitat for covered and other native species.	CM4 Tidal Habitat Restoration
Goal TANC2: The expected outcome is biologically diverse tidal perennial aquatic natural community that is enhanced for native species and sustained by natural ecological processes.	
Objective TANC2.1: Maintain and enhance the habitat and ecosystem functions of BDCP restored tidal perennial aquatic community for covered and other native species over the term of the BDCP.	CM4 Tidal Habitat Restoration
Tidal Mudflat	
Goal MFNC1: The expected outcome is areas of tidal mudflat that provide foraging habitat for shorebirds and wading birds, and substrates suitable for the natural establishment of BDCP covered plant species.	
Objective MFNC1.1: Restore or create 20 linear miles of edge areas within other natural communities that serve as tidal mudflat substrate and which will support habitat for tidal mudflat-associated species as a component of BDCP restored tidal brackish emergent wetland and tidal freshwater emergent wetland natural communities and channel margin enhancement.	CM4 Tidal Habitat Restoration CM6 Channel Margin Habitat Enhancement
Objective MFNC1.2: Maintain and enhance the habitat and ecosystem functions of BDCP restored tidal mudflat as a component of BDCP restored brackish and freshwater tidal habitat and channel margin enhancement for covered and other native species over the term of the BDCP.	CM1 Water Facilities and Operation CM11 Natural Communities Enhancement and Management
Tidal Brackish Emergent Wetland	
Goal BMNC1: The expected outcome is restored large expanses and interconnected patches of tidal brackish emergent wetland natural community.	
Objective BMNC1.1: Restore or create 3,600 to 4,800 acres of tidal brackish emergent wetland in the Suisun Marsh ROA (Conservation Zone 11).	CM4 Tidal Habitat Restoration
Goal BMNC2: The expected outcome is biologically diverse tidal brackish emergent wetland that is enhanced for native species and sustained by natural ecological processes.	
Objective BMNC2.1: Maintain and enhance the habitat and ecosystem functions of BDCP restored tidal brackish emergent wetland for covered and other native species over the term of the BDCP.	CM11 Natural Communities Enhancement and Management

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	***Applicable Conservation Measures***
Natural Community Goals and Objectives	
Tidal Freshwater Emergent Wetland	
Goal FMNC1: The expected outcome is restored large, interconnected patches of tidal freshwater emergent wetland natural community.	
Objective FMNC1.1: Restore or create 13,900 to 21,600 acres of tidal freshwater emergent wetland in the Cache Slough, West Delta, Cosumnes-Mokelumne, and South Delta ROAs (Conservation Zones 1, 2, 4, 5, 6, and 7).	CM4 Tidal Habitat Restoration
Goal FMNC2: The expected outcome is biologically diverse tidal freshwater emergent wetland that is enhanced for native species and sustained by natural ecological processes.	
Objective FMNC2.1: Maintain and enhance the habitat and ecosystem functions of BDCP restored tidal freshwater emergent wetlands for covered and other native species over the term of the BDCP.	CM11 Natural Communities Enhancement and Management
Nontidal Freshwater Perennial Emergent Wetland	
Goal NWNC1: The expected outcome is nontidal freshwater perennial emergent wetland natural community that supports habitat for covered and other native species.	
Objective NWNC1.1: Create 400 acres of nontidal freshwater marsh (including components of nontidal perennial aquatic and perennial emergent wetland communities) that functions as habitat for the giant garter snake, tricolored blackbird, and western pond turtle within or adjacent to habitat occupied by the Caldoni Marsh/White Slough giant garter snake subpopulation in Conservation Zone 4 and the Yolo/Willow Slough giant garter snake subpopulation in Conservation Zone 2.	CM10 Nontidal Marsh Restoration
Goal NWNC2: The expected outcome is biologically diverse nontidal freshwater emergent wetland communities that are enhanced for native species and sustained by ecological processes.	
Objective NWNC2.1: Maintain and enhance the habitat functions of protected and created nontidal freshwater emergent wetlands for covered and other native species over the term of the BDCP.	CM11 Natural Communities Enhancement and Management
Nontidal Perennial Aquatic	
Goal NANC1: The expected outcome is nontidal perennial aquatic communities that support habitat for covered and other native species. ***Note:*** *The objective for nontidal perennial aquatic community Goal NANC1 is the same as that described under nontidal freshwater emergent wetland Goal NWNC1.*	
Objective NANC1.1: Restore 400 acres of nontidal marsh as per Objective NWNC1.1.	CM10 Nontidal Marsh Restoration
Goal NANC2: The expected outcome is biologically diverse nontidal perennial aquatic communities that are enhanced for native species and sustained by ecological processes.	
Objective NANC2.1: Maintain and enhance the habitat functions of protected and created nontidal open water habitats for covered and other native species over the term of the BDCP.	CM11 Natural Communities Enhancement and Management

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Natural Community Goals and Objectives	
Valley/Foothill Riparian	
Goal VRNC1: The expected outcome is restored large expanses and interconnected corridors of valley/foothill riparian natural community.	
Objective VRNC1.1: Restore or create 5,000 acres of valley/foothill riparian in Conservation Zones 1, 2, 4, 5, 6, 7, and/or 11.	CM7 Riparian Habitat Restoration
Goal VRNC2: The expected outcome is biologically diverse valley/foothill riparian natural community that supports native species and is sustained by natural ecological processes.	
Objective VRNC2.1: Maintain and enhance the habitat and ecosystem functions of BDCP restored valley/foothill riparian and patches of riparian forest and scrub present on BDCP preserved lands over the term of the BDCP.	CM11 Natural Communities Enhancement and Management
Objective VRNC2.2: Establish seasonal buffers around riparian habitats occupied by covered species to minimize disturbance during the breeding season.	CM7 Riparian Habitat Restoration
Objective VRNC2.3: Restore connectivity of valley/foothill riparian corridors along linear watercourses to enhance habitat for covered species and facilitate wildlife movement.	CM7 Riparian Habitat Restoration
Grassland	
Goal GRNC1: The expected outcome is grassland comprised of large interconnected patches or contiguous expanses.	
Objective GRNC1.1: Protect a minimum of 8,000 acres of grassland in Conservation Zones 1, 8, and 11. At least 1,000 acres will be protected in Conservation Zone 8, with the remainder distributed throughout these three Conservation Zones.	CM3 Natural Communities Protection
Objective GRNC1.2: Restore 2,000 acres of grassland to connect fragmented patches of protected grassland.	CM8 Grassland Communities Restoration
Goal GRNC2: The expected outcome is biologically diverse grassland managed to enhance native species and sustained by natural ecological processes.	
Objective GRNC2.1: Restore and sustain a mosaic of grassland vegetation alliances, reflecting local water availability, soil chemistry, soil texture, topography, and disturbance regimes, with consideration of historical states.	CM8 Grassland Communities Restoration
Objective GRNC2.2: Increase the relative cover of native grasses and forbs in native grassland vegetation alliances.	CM8 Grassland Communities Restoration
Objective GRNC2.3: Increase opportunities for wildlife movement through grassland habitat.	CM8 Grassland Communities Restoration
Objective GRNC2.4: Increase burrow availability for burrow-dependent species.	CM8 Grassland Communities Restoration
Objective GRNC2.5: Increase prey, especially small mammals and insects, for grassland-foraging species.	CM8 Grassland Communities Restoration

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Natural Community Goals and Objectives	
Alkali Seasonal Wetland Complex	
Goal AWNC1: The expected outcome is protected alkali seasonal wetland complex natural community that represents a range of environmental conditions and is adjacent to other conserved lands.	
Objective AWNC1.1: Protect 400 acres of alkali seasonal wetland complex natural community in Conservation Zones 1, 8, and/or 11.	CM3 Natural Communities Protection
Goal AWNC2: The expected outcome is biologically diverse alkali seasonal wetland complex natural community with improved native biodiversity, habitat heterogeneity, and the ability to support populations of covered and other native species.	
Objective AWNC2.1: Maintain and, where habitat functions for covered species can be increased, increase the diversity and relative cover of native grasses and forbs.	CM11 Natural Communities Enhancement and Management
Vernal Pool Complex	
Goal VPNC1: The expected outcome is protected vernal pool complex natural community that represents a range of environmental conditions and is adjacent to other conserved lands.	
Objective VPNC1.1: Protect 300 acres of vernal pool complex in Conservation Zones 1, 8, and 11.	CM3 Natural Communities Protection
Goal VPNC2: The expected outcome is restored biologically diverse vernal pool complex natural community with improved native biodiversity, habitat heterogeneity, and the ability to support populations of covered and other native species.	
Objective VPNC2.1: Restore 200 acres of vernal pool complex natural community in Conservation Zones 1, 8, and/or 11 within patches of protected grassland that supports habitat for the western spadefoot toad, California tiger salamander, and the covered vernal pool shrimp and plant species.	CM9 Vernal Pool Complex Restoration
Objective VPNC2.2: Maintain and, where habitat functions for covered species can be enhanced, increase the diversity and relative cover of native grasses and forbs.	CM8 Grassland Communities Restoration CM9 Vernal Pool Complex Restoration
Inland Dune Scrub	
Goal IDSC1: The expected outcome is support for funding of the USFWS management and enhancement of the inland dune scrub natural community on the Antioch Dunes National Wildlife Refuge.	
Objective IDSC1.1: The BDCP will support the funding of the USFWS program for management, enhancement, and monitoring of inland dune scrub natural community on the Antioch Dunes National Wildlife Refuge at an annual amount of $XX.XX for X years.	CM11 Natural Communities Enhancement and Management

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Agricultural Habitats	
Goal ALNC1: The expected outcome is increased habitat functions for covered and other native species that are supported by agricultural land cover types and management practices.	
Objective ALNC1.1: Maintain and protect the functions of 4,600 acres of rice lands as habitat for giant garter snake, western pond turtle, tricolored blackbird, white-tailed kite, waterfowl, and migrant shorebirds in Conservation Zone 2. This objective may be partially or fully achieved by maintaining an equivalent extent of natural or managed lands that support habitat functions similar to rice lands for associated covered and other native wildlife species.	CM3 Natural Communities Protection
Objective ALNC1.2: Maintain and protect the functions of 12,020 to 28,040 acres of non-rice agricultural lands as foraging habitat for Swainson's hawk, white-tailed kite, and tricolored black bird that are located within 8 miles of occupied Swainson's hawk nesting habitat.	CM3 Natural Communities Protection
Objective ALNC1.3: Of the maintained 12,020 to 28,040 acres of non-rice agricultural lands, maintain at least 3,000 acres of pasture that supports moderate-value western burrowing owl foraging habitat. This objective may be partially or fully achieved through preservation of other land cover types that provide moderate-value or greater habitat function for the western burrowing owl.	CM3 Natural Communities Protection
Objective ALNC1.4: Of the maintained 12,020 to 28,040 acres of non-rice agricultural lands, maintain at least 4,800 acres that supports greater sandhill crane foraging habitat within its Winter Use Area and within 2 miles of known roosting sites in Conservation Zones 3, 4, 5 and/or 6.	CM3 Natural Communities Protection
Objective ALNC1.5: Of the maintained 12,020 to 28,040 acres of non-rice agricultural lands and 4,600 acres of rice lands, maintain and protect 1,000 acres within or adjacent to habitat occupied by the Yolo/Willow Slough giant garter snake subpopulation in Conservation Zone 2.	CM3 Natural Communities Protection
Objective ALNC1.6: Of the maintained 12,020 to 28,040 acres of non-rice agricultural lands, maintain and protect 1,000 acres within or adjacent to habitat occupied by the Caldoni Marsh/White Slough giant garter snake subpopulation in Conservation Zone 4.	CM3 Natural Communities Protection
Objective ALNC1.7: Target agricultural land conservation to provide connectivity between other protected lands.	
Objective ALNC1.8: Maintain and protect the small patches of important wildlife habitats associated with agricultural lands that occur within BDCP conserved agricultural lands, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, and wetlands.	CM3 Natural Communities Protection

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Managed Wetland	
Goal MWNC1: The expected outcome is maintenance of the current level of habitat functions provided by existing managed wetlands in the Plan Area through enhancement and restoration of natural communities on BDCP conservation lands, such that those wildlife functions do not preclude achievement of the Central Valley Joint Venture (CVJV) Implementation Plan's waterfowl and shorebird conservation targets for the Delta and Yolo Basin.	
Objective MWNC1.1: Maintain the level of wintering and breeding waterfowl habitat functions currently supported by habitats in the Plan Area through protection, restoration, and management of habitat of equivalent function on BDCP conservation lands.	CM3 Natural Communities Protection CM4 Tidal Habitat Restoration CM8 Grassland Communities Restoration
Objective MWNC1.2: Maintain the current level of migrant shorebird habitat functions currently supported by habitats in the Plan Area through protection, restoration, and management of habitat of equivalent function on BDCP conservation lands.	CM3 Natural Communities Protection CM4 Tidal Habitat Restoration
Goal MWNC2: The expected outcome is biologically diverse managed wetlands that are enhanced for native species.	
Objective MWNC2.1: Maintain and enhance the habitat functions of BDCP managed wetlands present on BDCP preserved lands over the term of the BDCP.	CM11 Natural Communities Enhancement and Management
Other Natural Seasonal Wetland	
Goal ONSW1: The expected outcome is increased habitat functions that support BDCP covered species in other natural seasonal wetland natural community within maintained and protected agricultural habitat areas.	
Objective ONSW1.1: Integrate management of other natural seasonal wetland natural community with management of BDCP maintained and protected agricultural lands to increase habitat functions for covered species.	CM3 Natural Communities Protection
Species-Specific Goals and Objectives *[**Note to Reviewers:** This table will be revised to indlcude the covered fish species pending further development of the covered fish species goals and objectives.]*	
Riparian Woodrat	
Goal RIWR1: The expected outcome is restored and protected habitat for the riparian woodrat.	
Objective RIWR1.1: Of the 5,000 acres of restored valley/foothill riparian, restore and manage 300 acres to meet the ecological requirements of the riparian woodrat in Conservation Zone 7.	CM7 Riparian Habitat Restoration
Riparian Brush Rabbit	
Goal RIBR1: The expected outcome is restored and protected habitat for riparian brush rabbit.	
Objective RIBR1.1: Of the 5,000 acres of riparian restoration, restore and manage at least 300 acres to meet the ecological requirements of the riparian brush rabbit in Conservation Zones 7 or 8.	CM7 Riparian Habitat Restoration
California Least Tern	
Goal CALT1: The expected outcome is an expanded California least tern population in the Plan Area.	
Objective CALT1.1: Create two patches of California least tern nesting habitat during restoration of tidal marsh communities.	CM11 Natural Communities Enhancement and Management

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Species-Specific Goals and Objectives	
Greater Sandhill Crane	
Goal GSHC1: The expected outcome is expansion and protection of greater sandhill crane winter range.	
Objective GSHC1.1: Create 320 acres of seasonally managed greater sandhill crane roosting habitat within Conservation Zones 3, 4, 5, or 6.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Giant Garter Snake	
Goal GGSN1: The expected outcome is high quality upland and aquatic habitat containing a mosaic of features provided for extant giant garter snake populations.	
Objective GGSN1.1: Create functional landscapes on giant garter snake preserves that include a mosaic of restored freshwater marsh intermixed with protected agricultural lands and interconnected water conveyance canals and natural drainages.	CM3 Natural Communities Protection CM4 Tidal Habitat Restoration CM10 Nontidal Marsh Restoration CM11 Natural Communities Enhancement and Management
Goal GGSN2: The expected outcome is protected giant garter snake corridors facilitating movement and linking populations.	
Objective GGSN2.1: Establish connectivity between giant garter snake preserve lands, restored tidal wetlands, and protected agricultural lands in Conservation Zone 4 to facilitate movement into unoccupied portions of the Delta and with the Badger Creek subpopulation.	CM3 Natural Communities Protection CM4 Tidal Habitat Restoration CM10 Nontidal Marsh Restoration CM11 Natural Communities Enhancement and Management
Objective GGNS2.2: Establish a giant garter snake north-south corridor that includes protected agricultural lands and restored tidal and nontidal wetlands between Coldani Marsh/White Slough and the Stone Lakes National Wildlife Refuge.	CM3 Natural Communities Protection CM4 Tidal Habitat Restoration CM10 Nontidal Marsh Restoration CM11 Natural Communities Enhancement and Management
California Red-Legged Frog	
Goal CRLF1: The expected outcome is enhanced breeding California red-legged frog populations in the Plan Area.	
ObjectiveCRLF1.1: Enhance stock ponds in grassland in Conservation Zone 8 through partial livestock exclusion and predator control.	CM11 Natural Communities Enhancement and Management
Lange's Metalmark Butterfly	
Goal LMMB1: The expected outcome is funding support for the USFWS captive breeding and reintroduction program for Lange's metalmark butterfly.	
Objective LMMB1.1: The BDCP will provide funding to support the USFWS program for the captive breeding and release of Lange's metalmark butterfly at an annual amount of $XX.XX for X years.	CM11 Natural Communities Enhancement and Management
Vernal Pool Plant Species **(**Alkali Milk-vetch, San Joaquin Spearscale, Dwarf Downingia, Boggs Lake Hedge-hyssop, Legenere, and Heckard's Peppergrass**)**	
Goal ALMV1: The expected outcome is protected and enhanced alkali milk-vetch populations.	
Objective ALMV1.1: Protect at least 3 unprotected occurrences of alkali milk-vetch in Conservation Zones 1 and/or 11.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective ALMV1.2: Maintain and enhance the habitat functions of preserved alkali milk-vetch habitat over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	***Applicable Conservation Measures***
Species-Specific Goals and Objectives	
Vernal Pool Plant Species **(**Alkali Milk-vetch, San Joaquin Spearscale, Dwarf Downingia, Boggs Lake Hedge-hyssop, Legenere, and Heckard's Peppergrass**)**	
Goal HEPE1: The expected outcome is protected and enhanced Heckard's peppergrass populations.	
Objective HEPE 1.2: Protect at least 2 unprotected occurrences of Heckard's peppergrass in Conservation Zones 1, 8, or 11.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective HEPE1.2: Maintain and enhance the habitat functions of preserved Heckard's peppergrass habitat over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Heartscale and Brittlescale	
Goal HART/BRIT1: The expected outcome is protected and expanded alkali seasonal wetland complex natural community-associated covered species populations.	
Objective HART/BRIT1.1: Of the 400 acres of protected alkali seasonal wetland complex natural community, protect 150 acres that support heartscale and brittlescale habitat.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective HART/BRIT1.2: Protect at least 3 unprotected occurrences of heartscale in Conservation Zones 1 and /or 11.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective HART/BRIT1.3: Protect at least 3 unprotected occurrences of brittlescale in Conservation Zones 1, 8, or 11.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective HART/BRIT1.4: Maintain and enhance the habitat functions of preserved heartscale and brittlescale habitat over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Suisun Thistle and Soft Bird's-Beak	
Goal SUTH1: The expected outcome is protected and expanded Suisun thistle populations.	
Objective SUTH1.1: Protect 3 unprotected occurrences of Suisun thistle in Suisun Marsh in Conservation Zone 11.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective SUTH1.2: Maintain and enhance the habitat functions of preserved Suisun thistle habitat over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Goal SOBB1: The expected outcome is protected and expanded soft bird's-beak populations.	
Objective SOBB1.1: Protect 3 unprotected occurrences of soft bird's-beak in Suisun Marsh in Conservation Zone 11.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective SOBB1.2: Maintain and enhance the habitat functions of preserved soft bird's-beak habitat over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Delta Button-Celery	
Goal DEBC1: The expected outcome is protected and expanded Delta button-celery populations.	
Objective DEBC1.1: Of the 400 acres of protected alkali seasonal wetland complex natural community, protect at least 100 acres that support Delta button-celery habitat.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective DEBC1.2: Maintain and enhance the habitat functions of preserved Delta button-celery habitat over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management

Table 3-12. Terrestrial Conservation Measures that Meet BDCP Conservation Strategy Goals and Objectives (continued)

Goals and Objectives	*Applicable Conservation Measures*
Species-Specific Goals and Objectives	
Contra Costa Wallflower and Antioch Dunes Evening Primrose	
Goal CCWF/ADEP1: The expected outcome is funding support for the USFWS implementation of the propagation and out-planting program for Contra Costa wallflower and Antioch Dunes evening primrose.	
Objective CCWF/ADEP1.1: The BDCP will support the funding of the USFWS program for propagation and out-planting program for Contra Costa wallflower and Antioch Dunes evening primrose at an annual amount of $XX.XX for X years.	CM11 Natural Communities Enhancement and Management
Carquinez Goldenbush	
Goal CAGB1: The expected outcome is protected and expanded Carquinez goldenbush populations.	
Objective CAGB1.1: Protect at least 3 unprotected occurrences of Carquinez goldenbush in Conservation Zones 1 and/or 11.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective CAGB1.2: Maintain and enhance the habitat functions of preserved Carquinez goldenbush habitat over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Caper-Fruited Tropidocarpum	
Goal CFTR1: The expected outcome is protection and expansion of caper-fruited tropidocarpum populations.	
Objective CFTR1.1: Protect occurrences of caper-fruited tropidocarpum that reestablish on BDCP conservation lands.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective CFTR1.2: Maintain and enhance the habitat functions of protected caper-fruited tropidocarpum occurrences over the term of the BDCP.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management
Objective CFTR1.3: Protect and maintain 100 acres of unprotected caper-fruited tropidocarpum grassland habitat in Conservation Zone 8.	CM3 Natural Communities Protection CM11 Natural Communities Enhancement and Management

3.4.1 Development Process

The BDCP conservation measures were developed on the basis of the best available scientific and commercial information, including input of a broad range of technical experts and an extensive body of scientific study and analysis compiled over the past several decades. The conservation measures further reflect the recommendations of independent scientists with extensive knowledge of Delta ecological issues. The conservation measure development process, including descriptions of technical evaluations, is described in Appendix D, *Background on the Process of Developing the BDCP Conservation Measures.* On several occasions, the Steering Committee convened these scientists to provide guidance and insight on a range of issues important to the development of a comprehensive conservation strategy for the BDCP, the recommendations of which are are reflected in many of the conservation measures set out in this section (see Appendix G, *Independent Science Advisors Reports*).

The BDCP conservation measures were initially developed to address the conservation needs of the covered fish species and the aquatic ecosystem by groups of technical experts convened by the Steering Committee. To guide initial development of potential conservation measures, these experts, based on review of the body of relevant scientific information and input from the Fishery Agencies and topical experts, identified important environmental stressors affecting the covered fish species and aquatic ecosystem. The groups then identified the range of potential conservation measures that could reduce or remove the effects of these stressors on the covered fish species. The conservation measure development process was informed through application of several tools and processes described in the following paragraphs. Following development of a range of potential conservation measures, the groups iteratively screened and refined the conservation measures based on evaluations of their likely biological effectiveness and implementability.

A large body of information on the Delta ecosystem and approaches to ecosystem and species conservation has been developed over many years that provided a starting point for the development of the BDCP conservation measures. Important sources of scientific information and conservation approach ideas included the CALFED Bay Delta Program, particularly the Science Program and Ecosystem Restoration Program; the Interagency Ecological Program; two reports on the Delta prepared by the California Public Policy Institute; the Delta Vision Program, various plan and technical documents; and the Delta Risk Management Strategy. Building on this knowledge base, the BDCP conservation measures to address aquatic resources were developed using additional investigations, state-of-the-art physical models, specially developed conceptual models, and expert input from a large number of scientists and resource managers.

At several stages in the development of the conservation measures, interim evaluations where conducted to assess the potential for measures under consideration to improve ecological conditions within the Delta for the covered fish species. Central to these assessments were the conceptual ecological models and detailed evaluation processes that were developed under the CALFED Ecosystem Restoration Program to gauge the likely effect of potential actions on Delta fish and ecosystem processes. This process, known as the Delta Regional Ecosystem Restoration

Implementation Plan (DRERIP) Scientific Evaluation Process, was used to evaluate draft BDCP conservation measures in December 2008-March 2009 (see Appendix F, *DRERIP Evaluation Results*). Under the DRERIP process, potential conservation measures were evaluated individually to assess their benefits and drawbacks without factoring in potential synergies with other actions. To account for interrelationships with other potential measures, the BDCP Synthesis Team was established to review the results of the DRERIP process and identify instances in which combinations of measures would likely provide benefits greater than the sum of the individual measures. The Synthesis Team assessed potential synergies and conflicts between various measures and suggested modifications to the draft conservation measures to improve the overall effectiveness of measures. Based on input from the DRERIP Evaluation and the Synthesis Team, the conservation measures were revised to improve their potential effectiveness.

Following development of draft conservation measures for the aquatic ecosystem and covered fish species, the Steering Committee assembled a team of technical experts to develop conservation measures to address the nontidal natural communities and covered wildlife and plant species. These experts reviewed and refined the draft habitat restoration measures intitially developed to address aquatic resources to ensure that the measures included elements that would also support high functioning habitat for the associated covered wildlife and plant species. Using the best available information, additional conservation measures to protect, enhance, restore, and manage nontidal habitats were developed based on assessments of each covered wildlife and plant species conservation needs. These assessments included consideration for each species distribution within the Plan Area, known species stressors, the extent and distribution of existing protected and unprotected habitat areas, effects of implementing the BDCP actions on each species and their habitats, opportunities to protect and improve habitat corridors, and opportunities to improve habitat connectivity among habitat areas within and adjacent to the Plan Area in accordance with the principles of conservation biology.

3.4.2 Ecosystem-Level Conservation Measures

Ecosystem-level conservation measures include water operations and the spatial distribution of landscape-scale protection and restoration of natural communites to improve the processes and ecological functions supported by the Plan Area's aquatic and terrestrial ecosystems. Water operations are designed to enhance aquatic foodweb processes to improve food abundance and availability and to improve the hydrodynamic and water quality conditions that support the habitat and movement of the covered fish and other native aquatic organisms. Large-scale protection and restoration of connected natural communities are designed to maintain and increase the extent of high functioning habitat areas for the covered and other native wildlife and plant species and that support the movements of covered and other native wildlife. Because these conservation measures will have a systemic effect on ecosystem condtions within the Plan Area, they are designed to complement and guide implementation of the natural community-level conservation measures described in Section 3.4.3, *Natural Community-Level Conservation Measures*.

3.4.2.1 CM1 Water Facilities and Operation

*[**Note to Reviewers:** On January 29, 2010 the BDCP Steering Committee approved, for the purposes of the detailed Effects Analysis, a set of BDCP initial long-term operating criteria. A table of these criteria can be found in the February 11 Steering Committee agenda packet on the BDCP web site. A companion document titled "Aquatic Conservation Measures Proposed for Effects Analysis under BDCP" can also be found in the February 11 agenda packet and describes the steps that were used to develop this set of criteria. These criteria reflected the thinking of the Steering Committee at that time for the purpose of a comprehensive Effects Analysis. The Steering Committee noted that these criteria might become the final criteria or they might be modified based on the results of the Effects Analysis, evaluation of alternatives under CEQA and NEPA, or efforts to optimize them and permit achievement of the ecosystem and water supply goals of the BDCP. The Steering Committee envisioned an iterative process to refine the conservation strategy, including the development of the final set of initial long-term operating criteria and the adaptive range for these criteria.*

An effects analysis has been underway by the SAIC team over the past 10 months and the Steering Committee has been given several presentations on the preliminary results of that analysis. The Effects Analysis continues to be reviewed by the technical staff of the Steering Committee representatives and will be revised as necessary. To date, several issues have been identified that necessitate analysis of potential changes to the initial long-term operating criteria by January 2011. These include:

- *North Delta intake configuration related to predation concerns (in-river vs on-bank)*
- *Spring-run salmon egg mortality on the Sacramento River in the fall*
- *Reduced Sacramento River flows downstream of the north Delta intakes*
- *Refinement of April-May south Delta operations*
- *Winter-spring X2 and outflow effects on longfin smelt*
- *Summer and fall X2 and delta smelt abiotic habitat*

A process has begun to evaluate how modifications to some of the conservation measures, including initial long-term operating criteria, might address some of these issues in a manner that provides a refined approach to fishery protection while being sensitive to the water supply goals. This will lead to an iteration process that will take place for the purpose of describing the final conservation strategy and the initial long-term operating criteria for complete evaluation in the effects analysis. Also, as part of this process, an adaptive range for the operational criteria will be developed.]

This conservation measure provides for significant proposes changes to water operations in the Delta under the BDCP. This conservation measure includes two major components: (1) construction of new water facilities, and (2) operations of new operational control facilities or changes to the operations of existing operational control facilities. The evaluation of proposed new conveyance facilities (or changes to existing facilities) addresses two core issues that are separate and distinct, but are also closely interrelated. The first is the design issue associated with the new facility; that is, whether the new facility itself may enable improvements in flows and hydrodynamics if operated properly, and how to design the facility to achieve those improvements. The second issue is the operational issue; that is, what types of operational parameters would be most appropriate for the new facility to contribute to BDCP goals and objectives. It is important to recognize that these two aspects of proposed new water conveyance facilities are separate and distinct yet also closely joined, and must be evaluated as such.

The proposed new north Delta diversion facility offers an instructive example of this distinction. The appropriateness of the north Delta facility as a major new conservation measure for the BDCP demonstrates how both issues must be addressed together. There is a relatively broad agreement within the fisheries conservation community that a properly operated new north Delta facility will provide substantial benefits for certain listed species over the existing system, for all of the reasons enumerated below. The far more energetic debate focuses on what constitutes the proper operating parameters for the new facility, and less on the design parameters of the north Delta facility itself – although both are essential components of the proposal. Determining the appropriateness of the north Delta facility, therefore, considers the operational parameters that will govern it as much as the reliability of the governance structures that will apply those parameters. Hence, clearly distinguishing the design features from the operational features is important for an accurate appraisal of the merits of the measure overall.

The lower Sacramento River, Delta, and Suisun Bay and Marsh provide habitat for a diverse and complex assemblage of resident and migratory fish and other aquatic organisms. Section 3.2.3 *Development of the Aquatic Resources Component of the Conservation Strategy*, describes the BDCP approach to conservation and outlines the basic principles governing the approach. Several of these principles apply directly to the design of the conservation measure proposed in this section and are, therefore, expanded upon here. Development of water operations conservation measure as part of the BDCP is based, in large part, on the balance of seasonal and interannual variation in hydrologic conditions occurring within the watershed, and seasonal variation in the habitat requirements and geographic distribution of each of the lifestages of the covered fish within the estuary and tributary rivers, as well as many other factors. These include the beneficial interactions between establishing new aquatic habitats and hydrodynamics, a variety of flow-based and other mechanisms affecting the habitat quality and availability for these species and their food supplies, growth, survival, reproduction, and overall population dynamics in response to implementation of conservation measures. In addition, the water operations conservation measure is designed to provide a reliable water supply in a manner that avoids and reduces adverse effects to covered species and their habitat.

The proposed water operations also reflect the fact that the covered fish and other aquatic species have evolved in the Central Valley rivers and Delta. Their life histories are keyed to seasonal changes that naturally occur in flows, water temperatures, and other environmental cues that affect processes such as the seasonal timing of juvenile emigration downstream through the Delta, seasonal timing of reproduction, seasonal patterns in phytoplankton and zooplankton production that are food for covered fish and other aquatic species, seasonal inundation of floodplain habitat, and other important biological mechanisms.

One factor considered in the development of the water operations conservation measure is unidirectional downstream sweeping flows across the new fish screens proposed for the lower Sacramento River as part of long-term dual facility operations. Another consideration is the downstream transport of planktonic fish eggs and larvae, organic material, phytoplankton, and zooplankton from the lower Sacramento River into the Delta and Suisun Bay. A third factor is the consideration of sufficient flows in the lower Sacramento River during the primary migration period for juvenile Chinook salmon, steelhead, and other species (December-June) to reduce the frequency of bidirectional tidal flows in areas like Sutter and Steamboat Sloughs that are thought to reduce migration rates and increase the risk of juvenile fish to mortality from sources such as predation. Another factor that is taken into account is the provision of operations to maintain and improve habitat quality and availability for aquatic species in areas such as the Cache Slough complex, the lower Sacramento River, Delta and the low salinity zone located in the western Delta and Suisun Bay. The long-term water operations described below were developed to meet these and other biological objectives, water supply objectives, and water quality objectives of the BDCP.

In addition to reducing direct entrainment loss as a result of BDCP covered activities, the new water facilities and operations are designed to reduce other sources of harm to listed species, both direct and indirect (e.g. stranding, loss of homing ability, and reduced predation). In addition, implementation will be adaptively managed to optimize benefits to covered species while maintaining water supply reliability (see Section 3.7, *Adaptive Management Program*). Uncertainties concerning these actions will be managed through ongoing monitoring and research under the BDCP monitoring and adaptive management programs.

Water operations in the Delta are an integrated collection of actions that affect flow and water quality. This water facilities and operational conservation measure is closely intertwined with other components of the conservation strategy, including measures that will restore habitat and address other stressors to covered species. For example, the ability of habitat restoration in the south Delta to increase the amount of biological productivity transported to the western Delta and Suisun Bay will be realized only after preferential operation of the north Delta diversion facility over south Delta facilities begins (i.e., long-term operations).

Where applicable, criteria (quantitative values) are identified here for each parameter for specific times of year and specific water year types.

Water Facilities

This section presents an introduction to and summary of the proposed new and existing water facilities operated by the SWP and CVP within and near the Plan Area (Figure 3-52). These facilities include physical control structures such as gates, intakes, and pumps that can modify flows and affect Delta hydrodynamics in the immediate vicinity of the structure and often across large portions of the surrounding Delta. The physical construction and modification of these facilities are described and evaluated separately from the operations of the facilities under the BDCP.

The following is a list of new and existing water facilities and brief description of their functions:

1. North Delta Diversion Facilities and Tunnel/Pipeline – The north Delta diversion facilities will include five new intakes along the Sacramento River between Freeport and Courtland (Figure 3-52). Intakes will be equipped with state-of-the-art positive barrier fish screens to reduce entrainment of fish and will connect to tunnel/pipeline to carry water to a new regulating forebay adjacent and connected to existing south Delta SWP and CVP export facilities. More detail on specific features of the tunnel/pipeline facility is provided in Chapter 4, *Covered Activities*. *[**Note to Reviewers:** The design and location of the new intakes and conveyance facilities to be included in the proposed BDCP have not been determined.]*

2. Fremont Weir Operable Gates – New operable gates on the Fremont Weir will allow for the control of the timing, duration, and frequency of inundation of the Yolo Bypass during periods when the Sacramento River would not currently spill over the Fremont Weir into the Yolo Bypass. Operations for Fremont Weir Operable Gates are described in Section 3.4.2.2. *CM2 Yolo Bypass Fishery Enhancement*.

3. Delta Cross Channel Gates – Delta Cross Channel Gates are existing radial gates that control the flow of Sacramento River water through the Delta Cross Channel into the interior Delta.

4. Montezuma Slough Salinity Control Gate – Existing gate at the eastern opening of Montezuma Slough that controls the flow of fresh and salt water into Montezuma Slough.

5. South Delta Diversions – Two existing diversion facilities, the CVP Jones Pumping Plant and the SWP Banks Pumping Plant, divert water from the south Delta to meet water supply demands outside the Delta.

In addition to the above listed facilities, the existing Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct (NBA) for delivery in Napa and Solano counties. 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.

Near-Term Water Operations

*[**Note to Reviewers**: At this time, BDCP does not have proposed near-term operations.]*

Figure 3-52. Water Operations Facilities in the Delta (Existing and Proposed)

Click here to view figure

Long-Term Water Operations

This section provides descriptions of the long-term water operations for multiple parameters across the Delta. Long-term operations are made possible by facilities constructed during the near-term implementation period (e.g., new north Delta diversions, tunnel/pipeline, and new gates at Fremont Weir). In the long-term implementation period, dual operations of the existing south Delta diversion facilities and the new north Delta diversion facilities will provide greater flexibility to benefit covered fish and water exports not possible during the near-term implementation period. Long-term operations under the dual facility will allow water to be diverted from the lower Sacramento River using state-of-the-art positive barrier fish screens that are expected to substantially reduce the risk of entrainment of covered fish and other aquatic organisms, but will also provide positive benefits resulting from a reduction in the rate of water diversions occurring from the south Delta when covered fish species are present. Long-term water operations described in this section will replace certain near-term water operations once the new north Delta diversions and the new tunnel/pipeline are completed and functional.

Construction and Preferential Operation of a New Water Diversion Facility in the North Delta.

Five new water diversion facilities with 3,000 cfs capacity each (combined 15,000 cfs capacity) will be constructed and operated on the Sacramento River in the north Delta to minimize impacts on fish at the SWP and CVP south Delta diversion facilities. A tunnel/pipeline facility with a 15,000 cfs capacity will be constructed to convey water from the new diversion facilities to the south Delta, where it will join existing SWP and CVP diversion facilities. The capacity of the new facilities will be 15,000 cfs, which is approximately the capacity of existing export pumps at SWP and CVP facilities in the southern Delta. The new tunnel/pipeline will follow a route through the Delta (Figure 3-52). Each new intake will be screened with state-of-the-art positive barrier fish screens and have a pump station, power lines, access roads, and other associated infrastructure.

Five locations for intakes have been identified in the north Delta (Figure 3-52). Selection of locations is based on multiple considerations including, but not limited to, maximizing function and effectiveness of screens; minimizing impacts to in-channel, on-bank, and terrestrial resources; applicable navigational and flood conveyance regulations; channel geometry and bathymetry; location relative to tidal influence and ranges of covered fish; future climate change and sea level rise; and proximity to other infrastructure (e.g., Sacramento Regional Wastewater outfall, existing developed land, and other intakes). Each intake will be engineered to allow variable rate pumping to handle variation in the location of covered fish and tidally-induced flows, as well as sea level rise from climate change. The influence of tides, which could produce reverse or stagnant flows in channels, attenuates upstream such that the most northern intakes are expected to be less influenced by tides than downstream intakes, particularly during higher river flow.

After the comprehensive evaluation of three types of intake/screens structures (on-bank, near-shore, and in-channel screens) for flood control, effects to covered fish species, and feasibility, it was concluded that on-bank structures would best meet these criteria for this reach of the river Fish screens will be designed to NMFS, DFG, and USFWS criteria to include specific screen mesh sizes (1.75 mm open area), a maximum approach velocity of 0.2 feet per second (ft/sec), sweeping velocity of at least two times the approach velocity (0.4 ft/sec), screen cleaning mechanisms, and monitoring systems. Three types of screening materials are currently being investigated: stainless steel, copper-nickel, and plastic. The advantages and disadvantages of each will be considered in the ultimate decision by the Implementation Office of which material to use. Further, with the high risk of invasion into the Delta by quagga and zebra mussels in the future, the use of anti-fouling material or alternative cleaning systems is also being considered.

The tunnel/pipeline will route water through the Delta to a new 600-acre forebay on Byron Tract (Figure 3-52). Water will be conveyed from the five intakes via pipelines to either an intake tunnel or a 750-acre Intermediate Forebay. A 33.5-mile tunnel will convey water from the Intermediate Forebay to the Byron Tract Forebay, where it will tie into existing SWP and CVP facilities.

Although construction of the new north Delta facility and associated infrastructure will be initiated as early as practicable following BDCP authorization, operation of the new facility will not start until and defines the beginning of the long-term implementation period (estimated at implementation year 10). The north Delta diversion facility will be operated in conjunction with, but preferentially to (except during summer months and at other times where necessary to meet the goals of fish conservation and water supply), existing south Delta SWP and CVP diversion facilities to minimize adverse effects on fish in the Delta while maintaining water supply reliability as described in Chapter 4, *Covered Activities*. The quantity and timing of diversions will be affected by specific parameters described in this chapter.

The new intake facilities will be operated to maintain flows in the Sacramento River to meet five primary objectives for flows at and downstream of the new north Delta facilities:

1. Maintain fish screen sweeping velocities,
2. Minimize undesirable upstream transport of water and aquatic resources from downstream channels,
3. Support fish transport to regions of suitable habitat,
4. Minimize predation effects downstream, and
5. Maintain or improve rearing habitat in the north Delta.

These north Delta facilities “bypass flows” represent the rate of flow at which the Sacramento River must pass downstream of the new diversion points. Bypass flows are intended to serve as an operational parameters to limit or otherwise manage water diversions from the new north Delta diversion facilities to minimize and reduce the effects of those diversions on downstream hydrodynamics (e.g., reduce Sacramento River flow downstream of the point of diversion) needed to support functions within and downstream of the river. Bypass flows for the Sacramento River act as an operational criteria in which water diversions will only occur when flows are maintained above the minimum criteria. The minimum bypass flow rates act as restrictions on water diversions during those years and seasons when flow in the Sacramento River is low. To meet water supply goals (see Chapter 4, *Description of Covered Activities*), constraints on the amount of water diverted from north Delta facilities may require commensurate increases in diversions from the south Delta SWP and CVP facilities. To maintain water quality in the south and central Delta during low flow periods on the San Joaquin River in summer months (July-September), existing south Delta pumps will be preferentially operated up to 3000 cfs (see *Delta water quality maintenance* below).

In addition to establishing the minimum bypass flow rates as one set of operating criteria, two additional operating criteria will be implemented in response to low river flow conditions. The first operational condition is preferential operation of the new diversion facilities located the farthest upstream to reduce the effects of low Sacramento River flow on tidal reversal in the vicinity of the diversion (maintain positive downstream flows across the intake structures and reduce the likelihood that larval and juvenile fish will move upstream into the area of potential entrainment/impingement at the diversion). Results of hydrodynamic modeling indicate that a higher level of Sacramento River flow needs to be maintained to avoid tidal flow reversal downstream (e.g., near Walnut Grove) when compared to the flow needed to maintain downstream river flows at more upstream sites. A second operational response to low Sacramento River flow conditions is to implement preferential diversion operations in response to tidal conditions (e.g., divert water during ebb tide stage to maintain sweeping velocity and avoid tidal flow reversal) and then reduce or curtail diversion during the flood tide stage.

Factors considered in developing north Delta diversion bypass flows included:

- Seasonal timing of various life stages of covered fish inhabiting the Sacramento River in the vicinity of the proposed water diversion locations;
- Changes in the biological processes and relationship in response to river flow that occur seasonally (e.g., differences in the biological processes of phytoplankton and zooplankton production between winter-spring and summer-fall);
- The relationship between bypass flows and hydrologic synchrony of flows and environmental cues within the Sacramento River watershed;
- The relationship between river bypass flow rate and constraints on water diversions and water supplies;
- The relationship between downstream transport rate of planktonic particles (simulating larval delta and longfin smelt transport between the upstream spawning areas, such as Cache Slough, and the downstream estuarine habitat where first feeding and juvenile rearing occur) and river flow rate;

- The relationship between river flow and downstream transport of phytoplankton, zooplankton, and organic material;
- The relationship between fall river flows and attraction and migration flows in the mainstem river for adult upstream migration by fall-run and late fall-run Chinook salmon, steelhead, delta and longfin smelt, splittail, and other upstream migrating adults;
- Relationships between river flow rate and juvenile transit time through the lower river (a factor thought to affect vulnerability to predation mortality), juvenile survival rates, and river flow;
- Relationships between river flow and habitat conditions for predatory fish (e.g., largemouth bass, smallmouth bass, pikeminnow, and striped bass) in the river and sloughs;
- The relationship between river flow rate and tidal dynamics (e.g., changes in water velocity and direction in response to flood and ebb tide conditions) and the river flows at various potential diversion locations that maintain a net unidirectional downstream flow over all tidal conditions;
- The relationship between mainstem river flows and seasonal flows into a floodplain habitat such as the Yolo Bypass and the resultant effects on hydrodynamic conditions in the river at the points of diversion;
- The relationship between existing and expanded tidal marsh habitat within the Cache Slough complex and tidal hydrodynamics within the river at various potential points of diversion;
- The relationships between seasonal timing of juvenile winter-run Chinook salmon downstream migration and pulse flows down the lower Sacramento River (del Rosario and Redler 2010); and
- The relationship between river flow, channel geometry, and resulting sweeping velocities across a positive barrier fish screen at each potential diversion location. Sweeping velocity is intended to transport fish downstream in a timely manner to reduce their exposure to entrainment and impingement at the diversion and to help remove accumulated debris from the fish screen surface to maintain approach velocities.

Analysis of seasonal timing of juvenile winter-run Chinook salmon migration (del Rosario and Redler 2010) suggests that pulse flows provide an environmental cue that stimulates the downstream migration of juvenile winter-run Chinook salmon into the Delta and subsequently their migration into coastal marine waters. Pulse flows provide a change in river flow over a short time period and are also typically associated with increases in turbidity and suspended sediments within the water column. Increased turbidity has been identified as an important environmental condition affecting pre-spawning adult delta smelt geographic distribution within the Delta and lower reaches of the Sacramento River. Therefore, bypass operations include provisions for operations in response to seasonal pulse flow events.

Operational Criteria and Adaptive Limits. The north Delta facilities operations and bypass flow requirements will apply in the BDCP long-term implementation period following completion of facilities construction. Specifics on the operational criteria and adaptive range of north Delta facilities bypass flows are provided in Table 3.13. The bypass operations will be based on three parameters "Constant Low Flow Pumping," "Initial Pulse Protection," and "Post-Pulse Operations." Table 3.14 provides post-pulse flows criteria.

To allow for flexible and responsive implementation of the BDCP, several conservation measures include a defined "adaptive range" that establishes the parameters within which a conservation measure may be adjusted to improve its effectiveness or respond to changing biological conditions. Adaptive Ranges are specifically established upper and lower boundaries and limits that govern the scope of changes that can be made to water operations criteria for specific operational parameters under this conservation measure pursuant to the adaptive management program. These adaptive ranges are expected to be included within the bounds of BDCP regulatory authorizations and provide for both flexibility to change operation criteria to improve conservation or water supply performance and limitations to clearly define the confines of the Plan. Adjustments to the water operations criteria set out in the BDCP and reflected in its associated authorizations, and within the adaptive range for water operations described Tables 3-13 and 3-14, may only be conducted through the process identified in Section 3.7.3.2, *Decision Process for Adjusting Water Operations within the Adaptive Range*.

[***Note to Reviewers:*** *Adaptive range limits have not been determined at this time. Tables 3-13 and 3-14 provide "analytical ranges" used in the BDCP Effects Analysis as a step in the process of development of adaptive ranges.]*

> **Problem Statement:** For decades, water has been diverted directly from the south Delta through SWP and CVP facilities to meet agricultural and urban water demands south and west of the Delta. These diversions both require and create an artificial north-to-south flow of water through the Delta (as opposed to the natural general east-to-west flow pattern) and 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 they are subject to high predation pressure (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 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).

Table 3-13. Proposed Long-Term Operational Criteria and Adaptive Range Limits

*[**Note to Reviewers:** Table 3-13 and table 3-14 provide the proposed BDCP long term water operations for evaluation in the BDCP Effects Analysis. The criteria in these tables do not represent criteria agreed to by the Steering Committee; its purpose is for use in the Effects Analysis. These two tables are the same as the tables provided to the Steering Committee in February 2010. The operational criteria identified in these tables are the criteria agreed to by the BDCP Steering Committee on January 29, 2010 as documented in the handout titled: "SAIC Consultant Team Recommendations for Long Term Operations (January 29, 2010 draft D) – revised version based on SC input.]*

North Delta Diversion Bypass Flows		
Objectives include flows of the functional equivalent thereof to (1) maintain fish screen sweeping velocities, (2) reduce upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.		
Analytical Range A Operational Criteria[30]	**Initial Operational Criteria**	**Analytical Range B Operational Criteria[1]**
Constant Low-Level Pumping (Dec-Jun): • Diversions up to 10% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.	**Constant Low-Level Pumping (Dec-Jun):** • Diversions up to 6% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.	**Constant Low-Level Pumping (Dec-Jun):** • Diversions up to 2% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.
Initial Pulse Protection: • No pulse flow protection criteria implemented.	**Initial Pulse Protection:** • Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to pre-pulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (Table 3-6). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement. • If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.	**Initial Pulse Protection:** • No range. (Same as initial operations)
Post-Pulse Operations: • After initial flush(es), go to Level I post-pulse bypass rule (see Table 3-6) until **10** total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until **20** total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.	**Post-Pulse Operations:** • After initial flush(es), go to Level I post-pulse bypass rule (see Table 3-6) until **15** total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until **30** total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.	**Post-Pulse Operations:** • After initial flush(es), go to Level I post-pulse bypass rule (see Table 3-6) until **20** total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 45 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.

[30] Analytical ranges represent the operational range limits for which the Effects Analysis will evaluate operational parameters. These analytical ranges are part of the process of identifying adaptive management ranges. It is expected that the eventual adaptive management range limits would fall within these analytical ranges.

Table 3-13. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

South Delta Channel Flows

Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.

Analytical Range A Operational Criteria

OMR Flows

Old and Middle River flows no less than the values below:

Combined Old and Middle River flows no less than values below* (cfs)					
Month	**W**	**AN**	**BN**	**D**	**C**
Jan	-6000	-6000	-6000	-6000	-6000
Feb	-6000	-6000	-6000	-6000	-6000
Mar	-6000	-6000	-6000	-6000	-6000
Apr	-6000	-6000	-6000	-6000	-6000
May	-6000	-6000	-6000	-6000	-6000
Jun	-6000	-6000	-6000	-6000	-6000
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A
Dec	-7200	-7200	-7200	-7200	-7200

* Values are monthly average for use in modeling. December 20-31 targets are -6000 cfs and are averaged with an assumed background of -8000 cfs for December 1-19.

Initial Operational Criteria

OMR Flows

FWS smelt and NMFS BO's model of adaptive restrictions (temperature, turbidity, salinity, smelt presence)

Table below provides a rough representation of the current estimate of "most likely" operation under FWS and NMFS BO's for modeling purposes.

Combined Old and Middle River flows no less than values below* (cfs)					
Month	**W**	**AN**	**BN**	**D**	**C**
Jan	-4000	-4000	-4000	-5000	-5000
Feb	-5000	-4000	-4000	-4000	-4000
Mar	-5000	-4000	-4000	-3500	-3000
Apr	-5000	-4000	-4000	-3500	-2000
May	-5000	-4000	-4000	-3500	-2000
Jun	-5000	-5000	-5000	-5000	-2000
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A
Dec	-6800	-6800	-6300	-6300	-6100

* Values are monthly average for use in modeling. December 20-31 targets are -5000 cfs (W, AN), -3500 cfs (BN, D), and -3000 cfs (C), and are averaged with an assumed background of -8000 cfs for December 1-19. Values are reflective of the "most likely" operation under the FWS Delta Smelt Biological Opinion. Values for modeling may be updated based on review by fishery agencies.

Analytical Range B Operational Criteria

OMR Flows

- Old and Middle River flows same as proposed Operations during December, January, and June
- Old and Middle River flows no less than -5,000 cfs between July and November

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Analytical Range A Operational Criteria: No Range.

Initial Operational Criteria:

South Delta Export – San Joaquin Inflow Ratio[31]

- Sliding scale for flows above the established OMR to share additional SJR flows between export and environment; export share would increase at higher flows
- Time value of benefit; crediting outside of period in which flows are acquired
- [Note that Conveyance WG/HOTT recommends continuing to evaluate the concept of isolating Old River to address south Delta channel flows.][32]

Analytical Range B Operational Criteria:

South Delta Export – San Joaquin Inflow Ratio

- 50% Feb & Mar
- 25% April & May

[31] The effects of potential increased San Joaquin River inflows on BDCP goals and objectives will be evaluated separately from the BDCP Effects Analysis.

Table 3-13. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

Fremont Weir/Yolo Bypass		
Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.		
Analytical Range A Operational Criteria	**Initial Operational Criteria**	**Analytical Range B Operational Criteria**
No Range.	• Sacramento Weir - No change in operations; improve upstream fish passage facilities • Lisbon Weir - No change in operations; improve upstream fish passage facilities • Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet	No Range.
Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities		No Range.
	Fremont Weir Gate Operations	
December 1-March 30 open the 17.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.	December 1-March 30 (extend to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) open the 17.5 foot and 11.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues, provides seasonal floodplain inundation for food production, juvenile rearing, and spawning) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.	No Range.
Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 25,000 cfs	Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 20,000 cfs but keep 11.5 foot elevation gates open to provide greater opportunity for fish within the bypass to migrate upstream into the Sacramento River; close 11.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 15,000 cfs	No Range.

[32] The concept of isolating Old River to address south Delta channel flows will be evaluated separately from the BDCP Effects Analysis.

Table 3-13. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

<table>
<tr><th colspan="3">Delta Inflow & Outflow</th></tr>
<tr><td colspan="3">Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.</td></tr>
<tr><th>Analytical Range A Operational Criteria</th><th>Initial Operational Criteria</th><th>Analytical Range B Operational Criteria</th></tr>
<tr><td><u>Delta Outflow:</u>
Jul-Jan: Per D-1641
Feb-Jun: Per D-1641*, except no Roe Island triggering
* Current relaxation of Collinsville standard to 4,000 cfs in May and June revised to state when the Eight River Index is 10.0 or less as established on May 1.
** Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions</td><td><u>Delta Outflow:</u>
Jul-Jan: Per D-1641
Feb-Jun: Per D-1641
* Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions</td><td><u>Delta Outflow:</u>
Summer, Winter, and Fall:
Jul-Aug & Dec-Jan: Per D-1641
Sep-Nov: Fall X2 per FWS Smelt BO

Spring:
Feb-Jun: NGO X2-Eight River Index approach in all years (storage off-ramps in all year types will be refined to avoid upstream coldwater storage impacts on all reservoirs).
* Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions
** Continue analysis of NGO watershed unimpaired runoff approach as it relates to PREs and parties outside of BDCP. Carry into “related action” alternative.</td></tr>
<tr><th colspan="3">Delta Cross Channel Gate Operations</th></tr>
<tr><td colspan="3">Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.</td></tr>
<tr><td>No Range.</td><td>Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish)
Dec-Jun: DCC gate closed
Jul-Sep: DCC gate open</td><td>No Range.</td></tr>
<tr><th colspan="3">Rio Vista Minimum Instream Flows</th></tr>
<tr><td colspan="3">Maintain minimum flows for outmigrating salmonids and smelt.</td></tr>
<tr><td>No Range.</td><td>Sep-Dec: Per D-1641
Jan-Aug: Minimum of 3,000 cfs</td><td>No Range.</td></tr>
</table>

Table 3-13. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

Analytical Range A Operational Criteria	Initial Operational Criteria	Analytical Range B Operational Criteria
Operations for Delta Water Quality and Residence Time		
Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.		
Analytical Range A Operational Criteria	**Initial Operational Criteria**	**Analytical Range B Operational Criteria**
No Range.	**Assumptions for analysis:** Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north Oct-Jun: Prefer north delta pumping (real-time operational flexibility)	No Range.
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements		
Existing M&I and ag salinity requirements.		
No Range.	Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.[33]	No Range.

[33] The results of the water quality modeling from the effects analysis will be used to determine if other actions are needed to address water quality issues that may arise, including water quality in the southern and central Delta for both Agricultural and M*I due to the BDCP long-term operations.

Table 3-14. Post-Pulse Operations for North Delta Diversion Bypass Flows

*[**Note to Reviewers:** Table 3-13 and table 3-14 provide the proposed BDCP long term water operations for evaluation in the BDCP Effects Analysis. The criteria in these tables do not represent criteria agreed to by the Steering Committee; its purpose is for use in the Effects Analysis. These two tables are the same as the tables provided to the Steering Committee in February 2010. The operational criteria identified in these tables are the criteria agreed to by the BDCP Steering Committee on January 29, 2010 as documented in the handout titled: "SAIC Consultant Team Recommendations for Long Term Operations (January 29, 2010 draft D) – revised version based on SC input.]*

Level I Post-Pulse Operations

Based on the objectives stated above, it is recommended to implement the following operating criteria:

- Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.

Dec - Apr

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (see main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs
20,000 cfs	no limit	18,400 plus 30% of the amount over 20,000 cfs

Level II Post-Pulse Operations

Based on the objectives stated above, it is recommended to implement the following operating criteria:

- Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.

Dec - Apr

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (see main table)
11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000
15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs
20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs

Level III Post-Pulse Operations

Based on the objectives stated above, it is recommended to implement the following operating criteria:

- Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.

Dec - Apr

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (see main table)
9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000
15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs

Table 3-14. Post-Pulse Operations for North Delta Diversion Bypass Flows (continued)

Level I Post-Pulse Operations

May

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (see separate table)
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs
20,000 cfs	no limit	17,900 plus 20% of the amount over 20,000 cfs

Jun

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (see separate table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs
20,000 cfs	no limit	17,400 plus 20% of the amount over 20,000 cfs

Jul-Sep: 5,000 CFS
Oct-Nov: 7,000 cfs

Level II Post-Pulse Operations

May

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (see separate table)
11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000
15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs
20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs

Jun

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (see separate table)
11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000
15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs

Jul-Sep: 5,000 CFS
Oct-Nov: 7,000 CFS

Level III Post-Pulse Operations

May

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (see separate table)
9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000
15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs

Jun

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (see separate table)
9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000
15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs

Jul-Sep: 5,000 CFS
Oct-Nov: 7,000 CFS

The Sacramento River, in addition to its upstream tributaries, is the primary migration corridor and spawning/rearing habitat for Chinook salmon, Central Valley steelhead, green and white sturgeon, and Pacific and river 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). Important fishery issues with respect to seasonal river flows include: (1) adult Chinook salmon, steelhead, green and white sturgeon, and Pacific and river lamprey attraction flows and upstream migration; (2) juvenile Chinook salmon, steelhead, and Pacific and river lamprey downstream migration and survival; (3) downstream transport of planktonic fish eggs and larvae; (4) downstream transport of food and other organic material; and (5) habitat for both resident and migratory covered fish species within the lower Sacramento River. The importance of river flows to each life stage of the covered fish species varies seasonally depending life history and habitat requirements for each species. Because of the importance of the Sacramento River as a migration route and habitat for covered fish species, maintaining sufficient flows within the river to support this function is an important operational objective for covered fish species.

Hypotheses: Relocation and operation of the primary point of SWP and CVP water diversions from the south Delta to multiple facilities on the Sacramento River between Freeport and Courtland and conveying water through a tunnel/pipeline facility are hypothesized to provide a broad range of benefits to covered fish species, the Delta ecosystem, and water supply if operated according to an appropriate set of operational parameters, which are described as part of this conservation measure. The following hypotheses provide the justification for the relocation of the primary point of diversion:

1. Relocation and operation of the primary point of diversion to the north Delta will substantially reduce entrainment of the larvae of covered fish species by reducing the spatial overlap of diversion intakes and covered fish species. 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. However, 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 could be installed (Wang 1986, Bennett 2005).

2. Equipping facility intakes with state-of-the-art positive barrier fish screens will substantially reduce entrainment and impingement losses of juveniles and adults of covered fish species. These screens will be engineered to provide a maximum approach velocity coupled with a minimum unidirectional sweeping velocity to protect covered fish species when fish are within the vicinity of intakes.

3. Constructing multiple intakes (rather than one or few) along the Sacramento River between Freeport and Courtland will substantially reduce entrainment and impingement losses of juveniles and adults of covered fish species. Multiple intakes will reduce the distance fish must travel past each fish screen, allowing individuals to

rest between intake locations. Early estimates indicated that, if one 15,000 cfs intake were constructed, a single fish screen nearly a mile long will need to be constructed to meet approach and sweeping velocity criteria. This distance would expose fish to screens for longer periods, potentially exhausting them, reducing their swimming ability, and increasing their vulnerability to impingement.

4. Reducing water diversions in the tidal region of the Delta will substantially reduce entrainment and impingement losses of juveniles and adults of covered fish species. Reverse flows associated with tidal oscillations increase the zone of influence of existing diversion facilities in many south Delta channels, potentially increasing the risk of entrainment of covered fish species. Relocating the primary point of diversion farther upstream will reduce the tidal influence on diversions, which will reduce entrainment of covered fish species. Further, for positive barrier fish screens to function properly to minimize fish entrainment and impingement risk, a minimum unidirectional sweeping velocity must be maintained. Opportunities for such velocity improve as tidal influence decreases farther upstream.

5. Relocation and operation of the primary point of diversion to the north Delta will reduce the export of nutrients, phytoplankton, zooplankton, macroinvertebrates, and other organic material from the estuary. The location of existing south Delta diversion facilities is thought to be in an area that exports higher concentrations of nutrients, phytoplankton, zooplankton, macroinvertebrates, and other organic material than will occur with the new proposed reach of the Sacramento River. As a result, the loss of Delta productivity may be lower if water is diverted at north Delta facilities compared to existing south Delta facilities.

6. Improving hydrodynamics within Delta channels will improve fishery and aquatic habitat within the Delta. Existing flow patterns in the Delta have been altered to maintain high water quality in the south Delta for project exports, as well as for local agricultural and other urban water uses. Such alterations include north to south flows through the man-made Delta Cross Channel and reverse flows in Old and Middle Rivers, generating adverse effects on fish and aquatic processes.

7. Relocation and operation of the primary point of diversion to the north Delta will 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 north Delta diversion facility will be designed to avoid altogether the need to salvage fish by constructing in-river or on-river facilities.

8. Relocation and operation of the primary point of diversion to the north Delta will improve water supply reliability and flexibility under conditions of future environmental change. Because of their location, new diversion facilities could withstand predicted future sea level rise in ways that existing diversion facilities will not. Multiple intakes will add flexibility in operations to handle variation in the location of covered fish and tidally-induced flows.

9. Reducing artificial north-to-south through-Delta flows when covered fish are present will increase hydraulic residence time and improve aquatic productivity in the interior Delta. Existing Delta operations promote north-to-south flow of water via the Delta Cross Channel to offset high salinities and lower inflows from the San Joaquin River. By reducing South Delta diversions, less water will move from north to south, resulting in increased residence time of nutrients and organic matter, allowing these materials to be assimilated into the Delta food web.

10. Reducing the reliance on through-Delta conveyance via the Delta Cross Channel and intakes in the south Delta will provide greater opportunity for effective physical habitat restoration and enhancement in the western, eastern, and southern Delta. Decreased south Delta pumping will reduce the export of primary and secondary ecological production that may result from restored habitat, which would other reduce or eliminate the expected benefits of the habitat restoration also proposed by the BDCP. Restoration in these parts of the Delta, as well as Delta-wide hydrodynamic changes expected from a north Delta diversion, will reestablish ecosystem complexity by improving aquatic ecosystem processes, distribution, connectivity, migration, transport, and residence time in ways that the current water conveyance system cannot accommodate.

11. Reducing the reliance on through-Delta conveyance via the Delta Cross Channel and intakes in the south Delta will substantially reduce the effects of existing water projects on salmonids in the San Joaquin River system and tributaries, Mokelumne River, and other east side tributaries. Such artificial flow patterns are thought to entrain outmigrating juvenile salmonids in these channels towards the pumps and confuse the upstream migration cues of adults. Although the potential for adverse effects on Sacramento River salmonids may increase, these effects are predicted to be avoided or minimized by the positive fish screen and sweeping and approach velocity criteria (see #2-4 above) and other operational parameters.

12. Relocation and operation of the primary point of diversion to the north Delta will facilitate the implementation of some other conservation measures focused on non-flow and non-habitat related stressors.

13. Relocation and operation of the primary point of diversion to the north Delta will allow for the emulation of more natural physical patterns (e.g., salinity regimes, flow patterns) and processes in the Delta under which native resident species evolved. For example, a change in the hydrograph could favor native species by providing proper timing of biological processes from physical cues, such as those needed to initiate upstream or downstream migration, and create conditions that disfavor non-native species, such as reduced summer inflows, which are currently higher than would occur naturally.

The following hypotheses provide the basis for maintaining bypass flows past the proposed new north Delta diversions:

1. Maintaining bypass flows will maintain adequate flows in the mainstem Sacramento River and distributaries downstream of the points of diversion 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 maintaining adequate flows in Sutter and Steamboat Sloughs include:

   - 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, etc.) 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; in their studies, 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 (see Section 3.4.3.2), 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 facility north Delta diversion facility (A. Munevar unpubl. data). Further, the BDCP proposes to enhance channel margin habitat in Sutter and Steamboat sloughs in part to create habitat that is unfavorable to non-native 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. Maintaining bypass flows will provide 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) and 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 criteria that allows this movement to occur is necessary.

3. Maintaining minimum bypass flows will provide 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. Maintaining minimum bypass flows will provide necessary attraction flows for upstream migration of adult Chinook salmon, steelhead, and green and white sturgeon, including attraction flows through Sutter and Steamboat Sloughs.

5. Maintaining minimum bypass flows will 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.

Developing bypass flow criteria for the north Delta diversion facilities involved consideration of the seasonal timing of various life stages of covered fish species within the lower Sacramento River, relationships between river flow, water velocity, transport time, and residence time, and the growth, survival, and distribution of various life stages of the covered species.

Adaptive Management Considerations: Results of the biological monitoring would be used adaptively in a variety of ways that include, but are not limited to: (1) changes in diversion operations within a range of adopted diversion parameters that are based on "real-time" monitoring of the occurrence of covered fish in the area; (2) selectively operating diversions based on the geographic distribution of covered fish within the river; and (3) changing diversion operations based on tidal velocity and river flows to increase sweeping velocity and the rate of fish movement past fish screens.

Results of both biological and operational monitoring throughout the Delta could be used within the BDCP adaptive management framework to refine and modify river bypass flow rates. For example, additional information on the actual timing of fish migration downstream within the Sacramento River within a given year could result in modification to the river bypass flows to facilitate migration past the points of diversion and fish screens. The adaptive management ranges provided for operational criteria under this conservation measure (Tables 3-13 and 3-14) provide flexibility to incorporate new knowledge gained through monitoring and research and to respond to changes in the system.

South Delta Diversion Operations and Old and Middle River Flows.

To reduce the impacts of south Delta diversions on covered fish species and the Delta environment, Old and Middle River reverse flows will meet the operational criteria described in Table 3-13. These rivers are subject to reduced or reverse flows as a result of low San Joaquin River inflow, flood tides, and water exports at SWP and CVP facilities. These flow conditions can result in increased risk of entrainment of fish, invertebrates, phytoplankton, and other organic material.

Diversions from the south Delta SWP and CVP facilities will be reduced considerably during wetter periods with dual operation of new north Delta diversion facilities. During wetter periods in the BDCP long-term implementation period, water will be diverted from the south Delta to augment north Delta diversions and may be diverted in appropriate circumstances to improve circulation and maintain water quality conditions in the interior and southern Delta.

Operational Criteria and Adaptive Limits. The operational criteria for south Delta operations and Old and Middle River flows during the BDCP long-term implementation periods are described in Table 3-13.

With operation of north Delta diversion facilities in the long-term implementation period, the existing south Delta SWP and CVP export facilities will be operated as part of a dual conveyance facility and exports from the south Delta will be substantially reduced (the north Delta diversion facilities will be equipped with state-of-the-art positive barrier fish screens and will be the primary point of long-term diversion during wetter periods). The dual export system will be operated to meet water supplies.

> **Problem Statement:** Export operations of the SWP and CVP diversion facilities in the South Delta, in combination with San Joaquin and Sacramento River flows, tidal effects, and substantially reduced inflows into the Delta, have been identified as primary factors in altering hydrodynamic conditions within Delta channels and associated fishery habitat (DWR 2006, Baxter et al. 2008). Export operations of the SWP and CVP pumping plants 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 (DWR 2006).
>
> Although the response of various lifestages of covered species to flows within Old and Middle rivers is dynamic and variable within and among species, there is a positive relationship between the magnitude (average monthly) of reverse flows within Old and Middle rivers and the occurrence of pre-spawning adult delta smelt in SWP and CVP fish

salvage during the winter months (Kimmerer 2008, USFWS 2009c). Further, particle tracking model simulations predict that there is a greater risk that planktonic early lifestages of covered fish species (e.g., larval delta smelt) will be vulnerable to entrainment at the SWP and CVP export facilities when reverse flows within Old and Middle rivers increase. In addition, a number of the covered fish, including 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 movement through the Delta. Reverse flows in Delta channels are thought to contribute to false attraction to migration cues, longer migration routes that may expose fish to sources of mortality such as predation, exposure to seasonally elevated water temperatures and other stressors, and increased vulnerability to entrainment at the SWP and CVP south Delta export facilities.

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 SWP and CVP south Delta exports based on direct diversion rates or changes in the magnitude of reverse flows in Old and Middle rivers.

Hypotheses: Reducing diversions in the South Delta are hypothesized to:

- Reduce the risk of entrainment mortality of salmonids, smelt, splittail, sturgeon and lamprey;
- Reduce the risk of predation mortality of salmonids, smelt, lamprey, and splittail in Clifton Court Forebay; and
- Reduce the risk of entrainment of organic matter and food for salmonids, smelt, splittail, and sturgeon.

Adaptive Management Considerations: Results of biological monitoring will be used within the BDCP adaptive management framework to refine and modify seasonal operations of Old and Middle River flows. The adaptive management ranges provided for operational criteria under this conservation measure (Tables 3-13 and 3-14) provide flexibility to incorporate new knowledge gained through monitoring and research and to respond to changes in the system.

Delta Cross Channel Gate Operations

The Delta Cross Channel gates will be operated during the long-term implementation period to improve fish migration, hydrodynamics (including hydraulic residence time), and food and organic material transport while minimizing changes to water quality for agriculture, municipal, and industrial uses in the interior and southern Delta.

Delta Cross Channel gates are located on the Sacramento River near Walnut Grove (Figure 3-52). The Delta Cross Channel serves as a conveyance facility for water to move from the Sacramento River into the interior Delta. Water quality in the central and south Delta can degrade during low San Joaquin River flows. The Delta Cross Channel was constructed to move higher quality Sacramento River towards the central and south Delta to improve water quality there. Juvenile Chinook salmon, and presumably a number of other fish species, move from the Sacramento River into the interior Delta when the gate is open (Brandes and McLain 2001). Results of survival studies using coded wire tagged and radio tagged fish suggest that survival juvenile Chinook salmon passing into the Delta through the Delta Cross Channel is lower than survival of those migrating down the mainstem Sacramento River (Brandes and McLain 2001, Perry and Skalski 2009, Perry et al. 2010). Based on results of these studies, closure of Delta Cross Channel gates between February 1 and May 20 was established under D-1641 for fish benefits.

Operational Criteria and Adaptive Limits. The operational criteria for the Delta Cross Channel gates during the BDCP long-term implementation period are described in Table 3-13.

Problem Statement: 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 designated by D-1641 are designed to prohibit 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 DCC operation to anadromous fish, and other fish, also occur outside of this closure period. Furthermore, open gates decrease velocities and increase bi-directional flows in the Sacramento River and its distributaries, 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.

Hypotheses: Revised operations of Delta Cross Channel gates are hypothesized to:

- Increase the survival of juvenile Chinook salmon and possibly other covered fish species by: (1) improving downstream migration of fish in the Sacramento River and tributaries, which will reduce their risk to predation and other sources of mortality; and (2) reducing the proportion of fish entering the interior Delta, where survival of juvenile Chinook salmon is lower (Baker and Morhardt 2001, Brandes and McLain 2001, CALFED 2001, Perry and Skalski 2009, Perry et al. 2010). Several hypotheses have been suggested to explain reduced survival of juvenile Chinook salmon in the interior Delta relative to the mainstem Sacramento River, including, but not limited to: (1) increased exposure to unscreened water diversions within the Delta channels; (2) exposure to seasonally elevated water temperatures and potentially toxic contaminants; (3) increased residence time and longer migration routes leading to longer exposure to environmental conditions within the Delta and increased vulnerability to predation mortality; (4) delayed migration as a result of altered hydrologic conditions in Delta channels as a result of SWP and CVP export operations; and (5) direct losses as a result of entrainment, predation, or salvage mortality at the south Delta SWP and CVP export facilities (Baxter et al. 2008).

- maintain sufficient water quality in the south Delta in combination with minimal year-round pumping in the south Delta (see Section 3.4.2.1, CM1). Seasonally elevated water temperatures and an accumulation of toxics can occur in the central and south Delta, likely as a result of high residence times associated with low inflows from the San Joaquin River. These impairments can have lethal and sublethal effects on covered fish species inhabiting the south and central Delta. In addition, modeling results indicate that drinking water quality standards for the south Delta under D-1641 would not be violated under this revised set of operational criteria (A. Munevar pers. comm.).

- Improve the strength of migration cues and avoid false cues for adult migrating steelhead, Chinook salmon, and sturgeon on the Sacramento and San Joaquin Rivers. When the Delta Cross Channel is open, water from the Sacramento River mixes with water from the Mokelumne, Cosumnes, and San Joaquin Rivers, reducing the strength of migration cues to salmonids and sturgeon migrating upstream. Therefore, increasing the duration of Delta Cross Channel closure will allow more anadromous fish below the Delta Cross Channel to directly sense migration cues to upstream habitat, thus increasing the ability to move upstream and reducing delays to spawning; and

- Improve downstream flows and downstream transport of fish eggs, larvae, juveniles, food, and organic material within the Sacramento River into the Delta.

Adaptive Management Considerations: Results of biological monitoring will be used within the BDCP adaptive management framework to refine and modify seasonal operations of Delta Cross Channel gates.

Rio Vista Flows

Sufficient Rio Vista flows will be maintained during the long-term implementation period for the benefit of covered fish species. The lower Sacramento River serves as an important part of the aquatic habitat within the Delta. Diversion of water at new north Delta Diversion Facilities, as well as diversion of water from the mainstem river into side channels (e.g., Delta Cross Channel) or seasonally inundated floodplain habitat (e.g., Yolo Bypass), has a direct effect on flow rates in the Sacramento River at Rio Vista. Identification of a minimum flow requirement at Rio Vista is intended to support fishery and aquatic habitat in the reach of the Sacramento River located between Sacramento and Rio Vista. Flow in the mainstem Sacramento River at Rio Vista is augmented by the flow contribution from Cache Slough, the Yolo Bypass, Sutter and Steamboat Sloughs, and other local tributaries. Minimum river flows at Rio Vista in the fall are included in current regulations (D-1641, biological opinions).

Operational Criteria and Adaptive Limits. The operational criteria for Rio Vista flows during the BDCP long-term implementation periods are described in Table 3-13.

Problem Statement: The Sacramento River, in addition to its upstream tributaries, is the primary migration corridor in the Delta for Chinook salmon, Central Valley steelhead, sturgeon, and lamprey from the Sacramento River basin. In addition, both delta and longfin smelt likely spawn in the lower river in the general vicinity of Rio Vista. Key fishery issues with respect to seasonal river flows at Rio Vista have primarily focused on adult Chinook salmon and steelhead attraction and upstream migration flows during the fall months. The importance of river flows to each of the species and lifestages of covered fish species varies seasonally depending on the life history and habitat requirements of the species.

Hypotheses: Maintaining sufficient flows past Rio Vista is hypothesized to:

- Maintain sufficient attraction and upstream migration flows for adult salmonids, sturgeon, and lamprey in the Sacramento River;
- Maintain sufficient downstream migration of juvenile Chinook salmon, steelhead, and lamprey from the Sacramento River basin;
- Maintain sufficient downstream transport of planktonic fish eggs and larvae;
- Maintain sufficient downstream transport of organic material, phytoplankton, and zooplankton; and
- Provide high quality habitat for both resident and migratory species within the lower river.

Adaptive Management Considerations: Results of biological monitoring will be used within the BDCP adaptive management framework to refine and modify the seasonal river flow criteria at Rio Vista.

Delta Outflows

Sufficient Delta outflows will be maintained during the long-term for the benefit of covered fish species. Delta outflows provide for downstream transport of fish and other aquatic organisms as well as organic material and prey for covered species into the lower reaches of the Delta and Suisun Bay. In balance with upstream salinity intrusion from the bay, Delta outflows also control the location of the low salinity region of the estuary (Baxter et al. 1999, Kimmerer 2004). The abundance of life stages of a number of fish species, including some covered fish species (longfin smelt), has been positively correlated with the location of the low salinity zone (generally measured as X2) within the estuary (Baxter et al. 1999, Kimmerer 2004). Suisun Bay and the western Delta represent important low salinity habitat areas within the estuary. Open water habitat in this region serves as larval and juvenile rearing, adult holding, and foraging habitat for resident and anadromous fish and a wide variety of other aquatic and wildlife species, and as a migration corridor for anadromous species such as salmon, steelhead, sturgeon, and lamprey. Based on the information regarding the relationship between fish abundance and X2 location, the State Water Quality Control Board's D-1641 and the USFWS Biological Opinion include requirements for maintaining the X2 location during the late winter and spring within Suisun Bay.

Operational Criteria and Adaptive Limits. The operational criteria for Delta outflow during the BDCP long-term implementation period are described in Table 3-13.

Problem Statement: Fishery monitoring studies conducted by DFG (Baxter et al. 1999) suggest that abundances of juvenile lifestages 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 (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 (as well as X2 location) 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 X2; inundation of backwater and floodplains with high flows; and the distribution of early lifestages of fish into habitats that are located further downstream with decreased vulnerability to direct and indirect effects of south Delta SWP and CVP export operations.

Hypotheses: Allowing Delta outflow in the adaptable range above is hypothesized to:

- Provide for downstream transport of fish and other aquatic organisms into the lower reaches of the Delta and Suisun Bay;
- Provide sufficient flushing of the Delta to avoid and prolonged exposure to high water temperatures and toxics by covered fish species;
- Provide a suitable location for the low salinity zone; and
- Provide for downstream transport of organic material and prey for covered species into the lower reaches of the Delta and Suisun Bay.

Adaptive Management Considerations: Based on results and analysis of monitoring data, adaptive modifications to management of Delta outflow under the BDCP adaptive management framework could occur by modifying operational criteria by season or water-year type (hydrology) or by addressing other stressors and factors that may affect the survival or abundance of a covered fish species.

Delta Water Quality Maintenance.

Dual conveyance facilities in the Delta will be operated during the long-term implementation period to balance flows and exports for fish protection and water quality for both fish and humans while maintaining water supply reliability. Preferential south Delta operations during summer months when flows in the San Joaquin River are lowest will provide flushing the south and central Delta water with fresh Sacramento River water, thus reducing hydraulic residence time and improving water quality for fish, agriculture, and M&I uses in the south and central Delta.

Considerations regarding dual operations of conveyance facilities include: (1) providing limited flushing for general water quality conditions (reduce residence times) during low San Joaquin River flow periods, (2) maintaining adequate M&I and agricultural salinity in the central and south Delta, and (3) allowing operational flexibility during other periods to operate either north or south Delta diversions based on real-time assessments of benefits to fish, water quality, and operational constraints.

Operational Criteria and Adaptive Limits. The operational criteria for dual conveyance operations, including operations to maintain Delta water quality, during the BDCP long-term implementation periods are described in Table 3-13.

Problem Statement: The balance of fish protection, water supply reliability, and water quality for both fish and humans is dependant, in part, on hydrologic and water quality (e.g., salinity, dissolved oxygen, etc.) conditions occurring within Delta channels, densities of covered fish in the general region of the central and south Delta, and the magnitude of effect of south Delta exports on reverse flows in Old and Middle rivers.

Hypotheses: Dual operation of conveyance facilities in the long-term implementation period according to the operational criteria in Table 3-13 is hypothesized to:

- Reduce entrainment mortality of all covered fish species at south Delta facilities;
- Reduce toxic-related mortality and sublethal effects to all covered fish species in the central and south Delta;
- Reduce the effects of the proliferation of noxious algae, such as Microcystis, in the central and south Delta. Microcystis tends to grow in warm, slowly moving water (Lehman et al. 2008). Microcystis is known to disrupt the food web by being toxic to zooplankton and macroinvertebrates (Resources Agency 2007, Baxter et al. 2008); and
- Reduce the effects of the proliferation of SAV, such as Egeria, in shallow areas of the central and south Delta. Egeria tends to establish and grow at faster rates in warm, slowly moving water (Barko and Smart 1981, Gantes and Caro 2001) (see Section 3.4.3.10 *SAV/FAV Control* for detail on effects to these covered species),

Adaptive Management Considerations: Effectiveness monitoring of water quality parameters, including EC, temperature, selenium, and other toxics as deemed necessary by the BDCP Implementation Office, in central and south Delta before and after preferential south Delta operations begin will inform adaptive management decisions to change pumping rates at the south Delta.

In-Delta Agricultural, Municipal, and Industrial Water Quality Requirements.

In the long-term implementation period, D-1641 North and Western Delta agricultural and municipal and industrial (M&I) standards will be maintained, except that the D-1641 compliance point will be moved from Emmaton to the Three Mile Slough juncture. All water quality requirements contained in the North Delta Water Agency/DWR Contract and other DWR contractual obligations will be maintained.

Operational Criteria and Adaptive Limits. The operational criteria for in-Delta agricultural, municipal, and industrial water quality requirements during the BDCP long-term implementation period are described in Table 3-13.

Problem Statement. Salinity in the Delta is primarily a function of freshwater flowing from tributary rivers and saltwater intrusion from the Pacific Ocean. Areas located downstream such as Suisun Bay and further west are characterized by increasing salinity gradients. The northern and eastern Delta is characterized by primarily freshwater aquatic habitats. The lower San Joaquin River and southern Delta are characterized by low salinity waters, primarily resulting from saline agricultural drainage returns with elevated salt concentrations discharging into the San Joaquin River (DWR et al. 2006). If salinity increases to levels above standards dictated in D-1641, agricultural and M&I use of exported water can be severely limited.

Hypotheses. Maintaining existing D-1641 North and Western Delta agricultural and municipal and industrial (M&I) standards and all water quality requirements contained in the North Delta Water Agency/DWR Contract and other DWR contractual obligations would permit existing agricultural and M&I uses of water in these areas.

Adaptive Management Considerations. Within the BDCP framework of adaptive management, the BDCP Implementing Entity will monitor and adaptively manage salinity in the Delta in response to any adverse impacts resulting from the operational criteria described above

Montezuma Slough Salinity Control Gate Operations.

Coordination will occur with the Suisun Marsh Charter Group over the term of the BDCP to seek amendments to the Suisun Marsh Plan (in development) that will provide for reducing the long-term operation of the Montezuma Slough Salinity Control Gate. 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.

Suisun Marsh is currently managed largely to provide seasonal freshwater wetland habitat, primarily to support waterfowl habitat and recreation. There are approximately 150 waterfowl hunting clubs in the Suisun Marsh, and wetland managers flood their ponds in early October and drain them after the end of the waterfowl season in January. The Montezuma Slough Salinity Control Gate was 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 also results in a net flow of water from east to west. The salinity control structure (the gates and associated flashboards) not only alters local hydrodynamics and water quality conditions but also impedes the migration and passage of various fish species. The gates are operated on average 10 days every year, all during the period of early October through May (B. Burkhard, pers. comm.). Operation of the gates is based on tidal stage and triggered by high salinity readings in the marsh. DWR and USBR are required to meet water salinity standards for the Suisun Marsh established by the SWRCB under D-1641.

Operational Criteria and Adaptive Limits. In the beginning of BDCP implementation, Montezuma Slough Salinity Control Gates will continue to operate in the same way as existing standards. However, as land use changes during the 50 year implementation period, the gates may stay open for longer up to possibly remaining open year-round, as determined through adaptive management (see Section 3.7 *Adaptive Management*).

Problem Statement. The Montezuma Slough Salinity Control Gate has 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). In addition, existing operations of the control structure 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 (DWR 1999). For example, operation of the control structure during the late fall in dry years can cause a significant upstream shift in X_2 location, potentially increasing the risk of entrainment at the SWP/CVP export facilities of smelt and other species that are situated near X_2 location (D. Fullerton pers. comm. 1). 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, 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 could even lead to an increase in the operation of the salinity control gates under the Suisun Marsh Plan (S. Chappell pers. comm.).

Hypotheses: A reduction in operation of the Montezuma Slough Salinity Control Gate is hypothesized to:

- Reduce delays in outmigration of juvenile salmonids and sturgeon by allowing more water and fish to flow past Chipps Island; and
- Improve access of splittail, salmonids, and sturgeon to existing and future restored intertidal marsh habitats in Suisun Marsh.

Adaptive Management Considerations: As land use changes over the period of the Plan, monitoring and adaptive management could be used to alter operations of the salinity control gates.

3.4.2.2 CM2 Yolo Bypass Fishery Enhancement

*[**Note to Reviewers:** Yolo County has proposed specific edits to the content of this conservation measure that will be posted to the BDCP website. These proposed edits will be considered in subsequent versions of this conservation measure developed prior to the release of the public draft of the BDCP in 2011.]*

The purpose of this conservation measure is to improve upstream and downstream fish passage, reduce straying and stranding of native fish, increase availability of floodplain fish rearing and spawning habitat, and stimulate the food web in the Yolo Bypass and to investigate the potential for food web export from the Yolo Bypass to the Delta. The conservation measure requires the preparation and implementation of a Yolo Bypass Fishery Enhancement Plan (YBFEP) that details the specific actions to be implemented to achieve the biological objectives of this measure. Key benefits to covered fish species include reduced migratory delays and loss of salmon, steelhead, and sturgeon at Fremont Weir and other structures; enhanced rearing habitat for Sacramento River Basin salmonids; enhanced spawning and rearing habitat for splittail; and potential improvement of food sources of Delta smelt in habitat downstream of the Bypass. The YBFEP will:

- Evaluate alternative actions to restore 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 3-53) with gravity flow from the Sacramento River, and to improve upstream fish passage past barriers including Fremont and Lisbon Weirs;
- Based on the evaluation, identify the actions, including, but not limited to, the physical modifications to the Fremont Weir and the Yolo Bypass, that will be implemented;
- Describe the YBFEP's biological objectives, performance goals, and monitoring metrics in detail;
- Ensure compatibility with the flood control functions of the Yolo Bypass;
- Identify specific funding sources from the BDCP funding commitments;
- Discuss regulatory and legal constraints and how the constraints will be addressed; and
- Provide an implementation schedule with milestones for key actions.

The BDCP Implementing Entity will consult with the U.S. Army Corps of Engineers, DWR, DFG, NMFS, and USFWS in development of the YBFEP and will coordinate with Yolo and Solano counties, affected reclamation districts, other flood control entities, and the Yolo Bypass Working Group on a wide range of issues during preparation of the YBFEP. During implementation of this conservation measure, the BDCP Implementing Entity will coordinate with the U.S. Army Corps of Engineers, 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 particularly the compatibility with the flood control functions of the Yolo Bypass.

The YBFEP analysis of alternative actions will focus on the construction of physical improvements and modifications from Fremont Weir downstream to the Lisbon Weir to (1) reduce migratory delays and loss of salmonids and sturgeon at Fremont Weir; and (2) enhance seasonal floodplain habitats for salmonids, splittail, and other covered aquatic species. The YBFEP will also evaluate the need for actions that may be necessary to optimize the number of juvenile salmonids entering the bypass when the water is being diverted through the modified Fremont Weir. In addition, a gated channel that could provide flows from the Sacramento River, Colusa Basin Drain, Knights Landing Ridge Cut, or other sources into the Yolo Bypass along the west side will be evaluated.

Figure 3-53. Yolo Bypass Fishery Enhancement Conservation Measure (CM2)

Click here to view figure

All of the actions identified below will be evaluated in the YBFEP. If supported by the evaluation (i.e., would achieve the biological objectives of this conservation measure), all of these actions will be further developed in the YBFEP and implemented. If the YBFEP evaluation does not support implementation of one or more of the actions--because the action would not be effective, is not needed because of the effectiveness of other actions, would have unacceptable effects on flood control, or for other reasons--the action will not be implemented. However, the YBFEP will identify for implementation specific actions that together are sufficient to achieve the biological objectives identified in the YBFEP.

Actions to Reduce Migratory Delays and Loss of Salmonids and Sturgeon at Fremont Weir

1. Fremont Weir Fish Ladder Replacement. The existing Fremont Weir Denil fish ladder will be removed and replaced with new salmonid passage facilities designed to allow for the effective passage of adult salmonids and sturgeon from the Yolo Bypass past the Fremont Weir and into the Sacramento River when the river overtops the weir. Specific design criteria of the ladder have not yet been determined. This facility will incorporate monitoring technologies to allow for collection of information to evaluate its efficacy at passing adult fishes.

2. Experimental Sturgeon Ramps. An experimental ramp(s) will be constructed at the Fremont Weir to allow for the effective passage of adult sturgeon and lamprey from the Yolo Bypass over the Fremont Weir and into the Sacramento River at flows when the new Fremont Weir Fish Ladder will also be operated when the river overtops the weir by approximately 3 feet (Figure 3-54). Specific design criteria of ramps have not yet been determined. This facility will incorporate monitoring technologies to allow for collection of information to evaluate its efficacy at passing adult fishes.

3. Deep Fish Passage Gates and Channel. To enhance adult fish passage through the Fremont Weir, as part of modifications to the Fremont Weir (see action #8, below), a deep fish passage notch will be cut through a much smaller section of the Fremont Weir to an elevation of 11.5 feet (NAVD88). This notch will be fitted with operable "fish passage gates" that will allow controlled flow into the Yolo Bypass when the Sacramento River stage is between 11.5 and 17.5 feet (NAVD88). A "fish passage channel" will be excavated to convey water from the Sacramento River to the new fish passage gates, and from the fish passage gates to the Tule Canal to convey water from the Sacramento River, through the gates, and to the Tule Canal and Toe Drain.

4. Stilling Basin Modification. Modifications will be made to the existing Fremont Weir stilling basin to ensure that the basin drains sufficiently into the deep fish passage channel. Effective drainage of the stilling basin will prevent stranding of juvenile and adult fish that are attracted to pooled water in the stilling basin during drainage of the floodplain.

Figure 3-54. Conceptual Design for Experimental Sturgeon Ramp (CM2)

Click here to view figure

5. Sacramento Weir Improvements. Modifications will be made to reduce leakage at the Sacramento Weir and therefore reduce attraction of fish from the Yolo Bypass to the weir where they are blocked and could become stranded. For comparative analysis purposes, the plan will review the benefits and necessity of constructing fish passage facilities at the Sacramento Weir to reduce juvenile fish stranding and improve upstream adult fish passage. 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 a portion of the weir, and minor modifications to the stilling basin of the weir to ensure proper basin drainage. Specific design criteria of ramps would need to be determined.

6. Tule Canal/Toe Drain and Lisbon Weir Improvements. The YBFEP will include physical modifications to passage impediments, including road crossings and agricultural impoundments in the Tule Canal/Toe Drain to improve fish passage and survival. The plan will evaluate the benefits of replacing three existing structures at the northern end of the Tule Canal with bridges or other structures to allow adult fish passage. Lisbon Weir will be redesigned to improve fish passage while maintaining or improving water capture efficiency for irrigation.

7. Lower Putah Creek Improvements. The YBFEP will include a realignment of Lower Putah Creek. The YBFEP will include a realignment sufficient to improve upstream and downstream passage of Chinook salmon and steelhead in Putah Creek and floodplain habitat restoration to provide benefits for multiple species on existing public lands. This action will be designed so that it will not create stranding or migration barriers for juvenile salmon.

Actions to Increase Seasonal Floodplain Habitats for Salmonids, Splittail, and other Covered Aquatic Species

1. Fremont Weir Modification. The YBFEP will include engineering designs to physically modify the Fremont Weir to manage the timing, frequency, and duration of inundation of the Yolo Bypass with Sacramento River flows. In the BDCP Effects Analysis, it was assumed 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) and fitted with operable gates that will allow for controlled flow into the Yolo Bypass when the Sacramento River stage at the weir exceeds 17.5 feet. Separate operable gates will be designed and operated to provide for the efficient upstream and downstream passage of sturgeon and salmonids to and from the Yolo Bypass into the Sacramento River (as described in action #3 above). The YBFEP will explain how this modification will provide significantly increased acreage of seasonal floodplain rearing habitat with biologically appropriate durations and magnitudes on a return rate of one to three years, depending on water year type.

2. Yolo Bypass Modification. Grading, removal of existing berms, levees, and water control structures, construction of berms or levees, re-working of agricultural delivery

channels, and earthwork or construction of structures to reduce Tule Canal/Toe Drain channel capacities will be conducted to the extent necessary to improve the distribution (e.g., wetted area) and hydrodynamic characteristics (e.g., residence times, flow ramping, and recession) of water moving through the Yolo Bypass. The YBFEP will include modifications that will allow water to inundate in certain areas of the bypass to maximize biological benefits and keep water away from other areas to reduce stranding of covered fish species in isolated ponds, minimize impacts to terrestrial covered species, including giant garter snake, and accommodate other existing land uses (e.g., wildlife, public, and agricultural use areas). If necessary, lands will be acquired, in fee-title and through conservation or flood easements.

3. Westside Option. The YBFEP will include a feasibility study and evaluation of a gated channel to provide flows into Yolo Bypass along the west side. Potential flow sources are the Sacramento River, Colusa Basin Drain or Sacramento River flows through Knights Landing Ridge Cut, or augmentation of other western tributaries. Some modification of the existing configuration of the discontinuous channels along the western edge of the Yolo Bypass may also be required. If effective at meeting biological objectives, this option could be included in the implementation of the conservation measure.

Operational Criteria and Adaptive Limits

The YBFEP will include operational criteria as well as a strategy for adaptive management. The YBFEP will describe how a modified Fremont Weir will be operated to manage the timing and increase the frequency and duration of inundation of a portion of the Yolo Bypass with Sacramento River flows via the Fremont Weir to achieve the biological goals and objectives. The YBFEP will take into account both Weir and tributary inflows.

In the Effects Analysis, inundation timing, frequency, and duration in the Yolo Bypass within the period of December 1 through March 31 (with occasional extension to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) at the reduced weir elevation of 17.5 feet was considered. In evaluating this scenario, target flows into the bypass were between 3,000 and 6,000 cfs. In the Effects Analysis, flow through modified Fremont Weir gates was limited to maximum spills of 6,000 cfs when the Sacramento River was not spilling over the 33 foot crest of the weir. For the Effects Analysis, no management of the gates was assumed to limit lower flows (e.g., <3,000 cfs). The YBFEP will further refine these operational criteria to provide the specific biological objectives, restoration actions, and locations necessary to meet performance goals including habitat attributes, juvenile and adult metrics, and inundation depth and duration criteria. The YBFEP will include criteria for rare situations to limit flooding when, as determined by the BDCP Implementing Entity, inundation could cause more harm than benefit to covered species. Gates will remain closed in such situations

Under existing conditions the Fremont Weir is overtopped and spills into the Yolo Bypass in about 70 percent of years. The proposed notch and gates could increase that frequency to about 75-95 percent of years with a modified weir height of 17.5 feet (NAVD88) compared to the existing weir height of 33 feet (NAVD88). The frequency of Fremont Weir spills of at least 30 days at 3,000 cfs between 1984 and 2007 would double with a modified weir height of 17.5 feet compared to the existing weir height of 33 feet (Table 3-15). Once the targeted duration of inundation is achieved and the river is below the top of the Fremont Weir, the weir gates could be operated to reduce diversion of flow from the Sacramento River to allow for drainage of the Bypass while still allowing for fish passage. The basic flood control functions of the Fremont Weir will not be changed; at flood stage, the weir will overtop as it does currently.

Table 3-15 Number of Floodwater Spills Overtopping the Fremont Weir under Current and Proposed Weir Elevations.

	Events during Water Years 1984-2008[1]		*Events during Water Years 1929-2008*[1]	
	Current Weir[2]	**Proposed Notch**[2]	**Current Weir**[2]	**Proposed Notch**[2]
Less than 30 days	17[3] (10)[4] 42	[3] (20)[4] 48	[3] (29)[4] 13	7[3] (62)[4]
At least 30 days	9 (9)	18 (14)	11 (10)	70 (52)
At least 45 days	4 (4)	11 (11)	5 (5)	46 (41)

[1]Flows between October 1, 1929 and December 31, 1983 have been reconstructed from the hydrologic record

[2]Current weir elevation = 33 ft NAVD88; Proposed weir elevation = 17.5 ft NAVD88.

[3]Number of events with consecutive spills producing at least 3,000 cfs over the Fremont Weir. Assumes no more than a 7-day gap in flooding to count as the same event

[4]Number of water years in which events took place with spills producing at least 3,000 cfs over the Fremont Weir. Water Year is defined as August 1 of the previous year through July 31 of the current year. For example, Water Year 2005 is August 1, 2004 to July 31, 2005.

Problem Statement

The majority of historical floodplain in the Sacramento and San Joaquin River systems have been lost, particularly floodplains that flow directly into the Delta. This loss of floodplains has resulted in a reduction of highly productive rearing habitat for juvenile salmon and spawning and rearing habitat for other native species such as splittail. Loss of floodplain habitat has reduced the seasonal input of organic and inorganic material and food resources into adjoining riverine habitat and the downstream bay and estuary. Inundation of the Yolo Bypass from the Sacramento River is currently limited to times when the Fremont Weir is overtopped, limiting the availability of habitat for covered fish species and inputs to the food web from the Yolo Bypass.

The current configuration of the Yolo Bypass and Fremont Weir creates passage impediments and potential stranding for adult Chinook salmon, steelhead, green and white sturgeon, and river and Pacific lamprey and stranding hazards for juvenile Sacramento splittail, sturgeon, Chinook salmon, and steelhead. First, the Denil fish ladder at the Fremont Weir, designed for adult salmonid passage, is not effective at passing salmon, adult sturgeon and lamprey. Second, the stilling basins immediately downstream of the Sacramento and Fremont weirs have higher stranding rates of juvenile Chinook salmon than do earthen ponds as floodwater recedes (Sommer et al. 2005). Third, there are road crossings and agricultural impoundments in the Tule Canal/Toe Drain that block hydrologic connectivity, and therefore, fish passage. Fourth, the Lisbon Weir, which was built to impound agricultural water in the Toe Drain upstream of the weir, creates a passage impediment for fish at low stage when riprap is exposed or shallowly submerged.

Putah Creek is used for spawning habitat by a small population of Chinook salmon and steelhead. The Los Rios Check Dam, an irrigation impoundment structure, is seasonally removed but remains in place for several months while adult salmon and steelhead are attempting to migrate upstream. The reach of channel downstream of the check dam runs through a straight ditch to the Toe Drain. Putah Creek often breaks through its bank a short distance upstream of the Los Rios Check Dam, requiring periodic road maintenance at the Yolo Bypass Wildlife Area.

Hypothesized Benefits

Modifying the Fremont Weir and its operations and improving fish passage will reduce the adverse effects of stressors related to food availability, habitat availability, passage, harvest, stranding, predation, and entrainment for some of the covered fish species. Specifically, this conservation measure will:

- Create additional spawning habitat for Sacramento splittail (Sommer et al. 2001a, 2002, 2007b, 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;
- Create additional juvenile rearing habitat for Chinook salmon, Sacramento splittail, and possibly steelhead (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). Growth and survival of larval and juvenile fish is higher in the floodplain compared to those rearing in the mainstem Sacramento River (Sommer et al. 2001b);
- Increase downstream juvenile passage of Chinook salmon, Sacramento splittail, river and Pacific lamprey, and possibly steelhead. An inundated Yolo Bypass is used as an alternative to the mainstem Sacramento River for downstream migration of salmonids, splittail, river lamprey, and sturgeon. Sommer et al. (2003, 2004a) found that, other than steelhead and Pacific lamprey, juveniles from all of these species inhabit the Yolo Bypass during periods of inundation. Based on the timing and life history traits of steelhead relative to Chinook salmon, steelhead likely also benefit from inhabiting the Yolo Bypass. Similarly, based on the timing and life history traits of Pacific lamprey relative to river lamprey, Pacific lamprey likely also benefit from inhabiting the Yolo Bypass
- Increase adult upstream passage of fall-, late fall-, winter-, and spring-run Chinook salmon, steelhead, green and white sturgeon, and river and Pacific lamprey. It is thought that an inundated Yolo Bypass is used as an alternative route by upstream migrating adults of these species when Fremont Weir is spilling ;

- Increase food production for rearing salmonids, splittail, and other covered species on the floodplain (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). During periods when the bypass is flooded, there is relatively high production of zooplankton and macroinvertebrates that serve, in part, as the forage base for many of the covered fish species (Benigno and Sommer 2008);
- 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). The co-occurrence of suitable food supplies (zooplankton) and various life stages of delta smelt (e.g., larval and juvenile life stages) has been assumed to be an important factor affecting delta smelt survival and abundance (Feyrer et al. 2007a, Miller 2007b). The relationship between longfin smelt abundance and Delta outflow has experienced two step-declines: one after the invasion of *Corbula* and one during the POD years, although the slope of the relationship has not changed, suggesting that longfin smelt are food-limited (Baxter et al. 2008). Hobbs et al. (2006) found evidence of food limitation in early-stage juvenile longfin smelt, although spatially and temporally variable;
- Increase the duration that the floodplain is inundated 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. When flows in the Sacramento River recede, the Fremont Weir stops spilling, trapping fish downstream of the weir. Many of these fish remain in the shallow water near the weir, providing easy access to illegal harvesters. Under this conservation measure, the Fremont Weir will be modified to reduce stranding when Sacramento River flows recede;
- Reduce the exposure and risk of outmigrating juvenile fish migrating from the Sacramento River into the interior Delta through the Delta Cross Channel and Georgiana Slough, thus decreasing the risk for predation losses (Brandes and McLain 2001);
- Reduce the exposure of outmigrating juvenile fish to entrainment or other adverse effects associated with the intakes of the proposed north Delta water diversion facilities by passing juvenile fish into the Yolo Bypass upstream of the proposed intake locations; and
- 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 and duration of inundation within the Yolo Bypass is the largest opportunity for enhancing seasonally inundated floodplain habitat in the Central Valley . The

Yolo Bypass provides the only opportunity for increasing the frequency and duration of inundation of a floodplain in the Planning Area without restoration of historical floodplain surfaces presently in more highly developed, year-round land uses.

Adaptive Management Considerations

Implementation of this conservation measure by the Management Entity will be informed through effectiveness monitoring that will be conducted as described in Section 3.6, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Results of both biological and operational monitoring in the Yolo Bypass and the mainstem Sacramento River will be used within the BDCP adaptive management framework to refine and modify project structures and operations and fish passage improvements.

Timeline for Implementation

The Yolo Bypass Fishery Enhancement Plan will be completed within 6 months of approval of BDCP. The Plan shall include: (1) specific biological objectives, restoration actions, and locations; (2) specific operational criteria; (3) a timeline with key milestones, (4) performance goals and associated monitoring, including habitat attributes, juvenile and adult metrics, and inundation depth and duration criteria; (5) specific actions to minimize stranding or migration barriers for juvenile salmon; and (6) identification of regulatory and legal constraints that may delay implementation, and a strategy to address those constraints. Construction of capital improvements identified in the Plan will be completed within five years of completion of the Plan.

3.4.2.3 CM3 Natural Communities Protection

This conservation measure provides the mechanism and guidance for the acquisition of lands and the establishment of a system of conservation lands in the Plan Area necessary to meet natural community and species habitat protection objectives established in Section 3.3, *Biological Goals and Objectives*. This system of conservation lands will be built over the term of the BDCP implementation to protect and enhance areas of existing natural communities and covered species habitat, protect and maintain occurrences of selected plant species with very limited distributions, provide sites suitable for restoration of natural communities and covered species habitat, and provide habitat connectivity among the various BDCP conservation land units in the system. This conservation measure describes the overall approach to land acquisition procedures including the extent of land acquisition, a discussion of pre-acquisition surveys, as well as site selection criteria.

Approach to Land Acquisition

The BDCP Implementation Office will establish a system of conservation lands that encompasses all BDCP protected and restored natural communities. Lands may be acquired through the following mechanisms:

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

The BDCP Implementation Office may acquire conservation 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 conservation lands system will be comprised of: 1) conservation areas (lands that are under direct management of the Implementation Office or a Supporting Entity and lands protected through permanent conservation easements); and 2) lands that are covered by limited term conservation easements.

It is anticipated that lands acquired 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 these conservation measures could preclude other land uses. Lands acquired for the protection and maintenance of existing habitat functions may be acquired through conservation easements that specify the range of permitted land uses and practices that will maintain the intended habitat functions of the acquired lands. Limited-term conservation easements may be used to conserve agricultural habitats for a specified period, after which the easement would expire and the Implementation Office will be required to conserve additional habitat to replace the habitat that was protected through the expired conservation easement.

The BDCP habitat conservation target acreage commitments for the natural communities are presented in Table 3-4. Acquisition of these lands will also fulfill the target acreage requirements for each of the covered species for which habitat conservation targets are established (Table 3-5). These targets represent the minimum extent of land that will be acquired; the actual extent that will be acquired will likely be greater because acquired parcels may not be comprised wholly of habitat types that contribute towards achieving conservation target acreage.

Pre-acquisition Surveys and Assessments

The BDCP Implementation Office will develop and implement protocols for assessing physical and biological resources and infrastructure present on lands being considered for acquisition to determine the degree to which they are suitable for achieving habitat protection and restoration objectives. Pre-acquisition surveys would 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, including, but not limited to:

- The extent and quality of existing covered species habitats;
- Connectivity with other habitat areas;
- Presence of covered species;
- Infrastructure supporting existing habitats or necessary to restore habitats;
- Potential constraints to long-term management and maintenance of habitats; and
- Other conservation-related opportunities and constraints.

The BDCP 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. Criteria for evaluating the suitability of lands supporting grassland, alkali seasonal wetland complex, and vernal pool complex include:

- 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 habitat areas;
- Level of contribution for preserving natural environmental gradients;
- Level of contribution towards establishment of large preserve areas;
- Likely effects of climate change on future ecological functions;

- 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;
- Effectiveness in contributing towards achieving multiple biological goals and objectives;
- Likely contribution towards achieving biological objectives for approved and planned HCPs and NCCPs overlapping or adjacent to the Plan Area; and
- Additionally, restoration of vernal pool complex will only be permitted on lands that historically supported vernal pools and that currently support suitable soils for restoration.

Criteria for the selection of agricultural habitats to be maintained under the Plan include:

- Proximity to active Swainson's hawk nesting territories;
- Proximity to greater sandhill crane roost sites;
- Ability to support crops that provide high value Swainson's hawk and/or greater sandhill crane foraging habitat;
- Proximity to habitat occupied by the Caldoni Marsh/White Slough and Yolo Bypass/Willow Slough giant garter snake populations;
- Opportunities to incorporate riparian corridors into agricultural preserves; and
- Opportunities to preserve patches of other high value non-agricultural habitats (e.g., oak groves, wetlands, tree and hedge rows) that are supported among farmed fields.

For acquisition of land for restoring tidal, riparian, nontidal marsh, and seasonally inundated floodplain habitats, the BDCP Implementation Office will develop site selection criteria based on the ability of lands under consideration to:

- Achieve biological goals and objectives;
- Suitability and cost effectiveness for restoring target habitats;
- Suitability for supporting the restored habitat over time; and
- Level of management necessary to maintain desired ecological functions into the future.

Lands acquired for protection of existing habitats must be acquired within the Conservation Zones indicated in Table 3-4 to be credited as contributing towards achieving the biological goals and objectives. Land acquired for restoration of tidal habitat is expected to be located within the ROAs as indicated in CM4 Tidal Habitat Restoration, but may occur elsewhere if suitable lands are available. Seasonally inundated floodplain restoration and channel margin habitat enhancement may be located at appropriate sites within the geographic boundaries indicated in CM6 Channel Margin Habitat Enhancement and CM5 Seasonally Inundated Floodplain Restoration. Riparian habitats are expected to be restored within tidal habitat restoration, channel margin habitat enhancement, and seasonally inundated floodplain restoration sites (see CM7 Riparian Habitat Restoration). The Implementation Office is committed to the acquisition of a sufficient extent 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 Habitat Enhancement*), and CM7 (*Riparian Habitat Restoration*); these commitments, however, are not 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 described below.

The existing extent of unprotected and protected natural communities and their distribution within each of the Conservation Zones are presented in Tables 3-1a through 3-1c.

Conservation Zone 1 Acquisition Requirements

Land acquisition (includes fee title and easement) requirements for Conservation Zone 1 are directed at protecting and restoring grassland and associated seasonal wetlands, acquiring lands necessary for the restoration of tidal and associated riparian habitats, protecting cultivated agricultural foraging habitats, and protecting occurrences of selected plant species with very limited distributions.

Tidal Aquatic and Wetland Natural Communities. Lands sufficient to restore at least 5,000 acres of tidal habitat within the Cache Slough Complex ROA, which includes lands in Conservation Zones 1and 2, will be acquired. Additional lands will be acquired to the extent that additional restoration of tidal habitat is needed in this Conservation Zone to achieve the total conservation target of restoring 65,000 acres of tidal habitat. Restored tidal habitat includes restored gradient of habitats ranging from shallow subtidal aquatic habitat, 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 with sea level rise and will support habitat for grassland associated species. Restored tidal aquatic, marsh plain and associated transitional upland habitats are expected to support habitat for the California black rail; aquatic and possible upland nesting habitat for the California least tern; nesting habitat for the tricolored blackbird; upland and aquatic habitat for the giant garter snake where a narrow tidal range exists; and upland and aquatic habitat for the western pond turtle. The restoration of tidal marsh communities in CZ1 may help achieve the recovery objectives for giant garter snake identified in the giant garter recovery plan (USFWS 1999a). Tidal marsh plain and mudflat habitats are also expected to support substrates suitable for colonization and establishment of Delta tule pea and Suisun Marsh aster, Mason’s lilaeopsis, and Delta mudwort.

Grasslands and Associated Seasonal Wetland Natural Communities. The grassland and associated seasonal wetland community group is comprised of the grassland, alkali seasonal wetland complex, and vernal pool complex natural communities. A portion of the 300 acres of existing vernal pool complex, 400 acres of existing alkali seasonal wetland, and 8,000 acres of existing grassland to be protected under the BDCP will be acquired and protected in Conservation Zone 1. The goal of these acquisitions is to protect lands in large contiguous grassland landscapes that encompass the range of vegetation, hydrologic, and soil conditions that characterize these communities within the Conservation Zone. The extent of existing protected and unprotected grassland, alkali seasonal wetland complex, and vernal pool complex is shown in Figure 3-1a.

Conserved lands will be located to maintain habitat connectivity with protected grassland 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. Specific land acquisition requirements include the protection of at least two occurrences of Heckard's peppergrass. This approach to the conservation of these natural communities will conserve 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 shrimp species, alkali milk-vetch, San Joaquin spearscale, dwarf downingia, Boggs Lake hedge-hyssop, Heckard's peppergrass, legenere, heartscale, brittlescale, Delta button-celery, and Carquinez goldenbush (see details on benefits to each of these species in Section 3.3, *Biological Goals and Objectives*).

These conserved lands will be evaluated and managed to maintain and enhance their existing habitat functions for these species over the term of the BDCP (see Conservation Measure CM11, Natural Communities Enhancement and Management). The protection and restoration of vernal pool complex will help achieve the recovery objectives for Conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, mid- valley fairy shrimp, vernal pool tadpole shrimp, alkali milk-vetch, Boggs Lake hedge-hyssop, and legenere identified in the Vernal Pool Recovery Plan (USFWS 2005).

Some or all of the 2,000 acres of grassland and 200 acres of vernal pool complex to be restored under the Plan may be restored within Conservation Zone 1. Lands that are suitable for the restoration of these habitats as described in Conservation Measures CM9 Vernal Pool Complex Restoration, and CM8 Grassland Communities Restoration will be acquired. Lands acquired for grassland restoration will be located such that they will increase connectivity among currently fragmented patches of grassland and seasonal wetlands and/or provide high value transitional upland habitat adjacent to restored tidal marsh plain habitats. Lands acquired for vernal pool complex restoration will be located on lands that historically supported vernal pools and will be inoculated with seeds of vernal pool plants, and soil inoculum where the donor vernal pools are free of exotic species such as swamp timothy, perennial pepperweed, and Italian ryegrass, collected from vernal pools in Conservation Zones 1 and/or 2. These restored habitats are expected to support habitat for the covered species described above for lands acquired to protect grassland and associated seasonal wetlands.

*Agricultural Lands and Managed Wetlands***.** Agricultural lands will be acquired in Conservation Zone 1 to achieve a substantial proportion of the overall agricultural habitat conservation target established for the Plan Area (Table 3-4). Agricultural lands will be acquired that support foraging habitat for tricolored blackbird, Swainson's hawk, and other agricultural-associated species. These conserved lands will be located within 8 miles of Swainson's hawk foraging flight distances from riparian nesting habitats to ensure that conserved habitats function as foraging habitat for the species. Individual agricultural land acquisitions will be at least 80 acres in size unless high value sites are contiguous or potentially contiguous with other conserved lands; with the intent of creating contiguous agricultural preserves of at least 400 acres. As indicated in CM11 agricultural lands will be managed to provide high value foraging habitat for Swainson's hawk, white-tailed kite, and tricolored blackbird. A portion of the conserved agricultural lands will be maintained as pasture to also meet the foraging habitat requirements of burrowing owl. Other habitat elements on protected agricultural lands (e.g., wetlands, riparian corridors, grasslands, hedgerows, tree rows and groves, and isolated trees) will be retained and enhanced as needed as covered species habitat within the agricultural matrix. The specific parcels of conserved agricultural habitat will vary among years to the extent that they are acquired through limited term conservation easements.

*Plant Species Occurrences***.** Protect and enhance at least 3 occurrences of alkali milk-vetch, brittlescale, and heartscale in Conservation Zones 1, 8, and/or 11. Protect and enhance 2 occurrences of Heckard's peppergrass in Conservation Zones 1, 8, and/or 11. Preserve at least 3 occurrences of Carquinez goldenbush in Conservation Zones 1 and/or 11.

Conservation Zone 2 Acquisition Requirements

Land acquisition (includes fee title and easement) requirements for Conservation Zone 2 are directed at protecting and restoring grassland and associated seasonal wetlands, acquiring lands necessary for the restoration of tidal and associated riparian habitats and nontidal wetlands, and protecting cultivated agricultural foraging habitats.

Tidal Aquatic and Wetland Natural Communities. Lands sufficient to restore at least 5,000 acres of tidal habitat within the Cache Slough Complex ROA, which includes lands in Conservation Zones 1and 2, will be acquired. The criteria for restoring tidal habitat and the anticipated benefits for associated covered species are the same as described above for restoration of tidal habitat in Conservation Zone 1.

*Grasslands and Associated Seasonal Wetland Natural Communities***.** There is no specific acquisition target for grassland and associated seasonal wetlands established for Conservation Zone 2. However, acquisitions 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). Conserved lands will be evaluated and managed to maintain and enhance their existing habitat functions for covered species over the term of the BDCP. In addition, small and fragmented patches of grassland associated with maintained agricultural habitats (e.g., vegetated levee slopes), however, may be protected that will serve as upland habitat for giant garter snake and western pond turtle, and foraging habitat for Swainson's hawk and white-tailed kite. Grassland conservation in Conservation Zone 2 will conserve habitat for the tricolored blackbird, western burrowing owl, Swainson's hawk, white-tailed kite, giant garter snake, and western pond turtle (see details on benefits to each of the species in Section 3.3, *Biological Goals and Objectives*).

*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. Lands will be acquired in Conservation Zone 2 to restore up to 200 acres of nontidal marsh that functions as aquatic habitat for the giant garter snake. Nontidal freshwater marsh will be restored in locations to benefit the Yolo/Willow Slough subpopulation of giant garter snake. The specific amount of marsh that will be restored will be determined based on results of site-specific habitat assessments of the Yolo/Willow Slough and Caldoni Marsh/White Slough (Conservation Zone 4) subpopulations to determine the extent of marsh needed to be restored 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 agricultural habitats. The BDCP Implementation Office will consult with species experts and use guidance provided in the giant garter snake recovery plan (USFWS 1999a) to determine specific locations, patch sizes, and develop specific restoration design criteria and implementation guidance (e.g., vegetation associations, edge habitat, bank slopes, wetland to upland ratio, etc.). In addition to benefiting the giant garter snake, restored tidal marsh habitats are expected to provide nesting habitat for tricolored blackbird and aquatic habitat for the western pond turtle. Increased flying insect production associated with restored marshes relative to the existing upland habitats that will be restored to marsh is expected to improve foraging habitat conditions for the Townsend's Big-eared Bat.

*Agricultural Lands and Managed Wetlands***.** Agricultural lands will be acquired in Conservation Zone 2 to achieve a substantial proportion of the overall agricultural habitat conservation target established for the Plan Area (Table 3-4). Agricultural lands will be acquired that support foraging habitat for tricolored blackbird, Swainson's hawk, giant garter snake, and other agricultural-associated species. A total of 4,600 acres will be maintained in rice or equivalent habitat value to provide habitat for the giant garter snake. Other conserved agricultural lands will be located within 8 miles of Swainson's hawk foraging flight distances from riparian nesting habitats to ensure that conserved habitats function as foraging habitat for the species. Agricultural lands will be managed to provide high value foraging habitat for Swainson's hawk, white-tailed kite, and tricolored blackbird. Other habitat elements on protected agricultural lands (e.g., wetlands, riparian corridors, grasslands, hedgerows, tree rows and groves, and isolated trees) will be retained and enhanced as needed as covered species habitat within the agricultural matrix. Criteria for acquisition of agricultural lands to provide habitat for Swainson's hawk are the same as described above for Conservation Zone 1. A portion of the conserved agricultural lands may also be maintained as pasture to meet the foraging habitat requirements of western burrowing owl.

A portion of the conserved agricultural lands will need to be acquired and maintained within or adjacent to habitat occupied by the Yolo/Willow Slough subpopulation of giant garter snake to establish a 1,000-acre preserve for this subpopulation. The Implementation Office will consult with giant garter snake species experts to determine appropriate agricultural land acquisitions relative to the proximity of the existing subpopulation, proximity and connectivity with existing and restored nontidal freshwater marsh, and opportunities for population protection and expansion. The specific parcels of conserved agricultural habitat will vary among years to the extent that they are acquired through limited term conservation easements.

Conservation Zone 3 Acquisition Requirements

No specific conservation land acquisition targets are identified for Conservation Zone 3. Agricultural lands that support Swainson's hawk and greater sandhill crane foraging habitats, which may be conserved in multiple Conservation Zones to achieve the objectives for these species, may be acquired in Conservation Zone 3. Any acquired Swainson's hawk foraging habitat will be located within 8 miles of its riparian nesting habitat and acquired greater sandhill crane foraging habitat will be located within 2 miles of roosting habitat to ensure that conserved habitats function as foraging habitat for these species.

Conservation Zone 4 Acquisition Requirements

Land acquisition (includes fee title and easement) requirements for Conservation Zone 4 are directed at acquiring lands necessary for the restoration of tidal and associated riparian habitats and nontidal wetlands, and protecting cultivated agricultural habitats.

Tidal Aquatic and Wetland Natural Communities. Lands sufficient to restore at least 1,500 acres of tidal habitat within the Cosumnes/Mokelumne ROA in Conservation Zone 4 will be acquired. The criteria for restoring tidal habitat and the anticipated benefits for associated covered species are the same as described above for restoration of tidal habitat in Conservation Zone 1. The restoration of tidal marsh communities in CZ4 may help achieve the recovery objectives for giant garter snake identified in the giant garter snake recovery plan (USFWS 1999a) by providing additional habitat connectivity between the Caldoni Marsh/White Slough subpopulation and the Stone Lakes National Wildlife Refuge lands to the north and additional connectivity between the Delta and the Badger Creek giant garter snake subpopulation to the east.

Grasslands and Associated Seasonal Wetland Natural Communities. There is no specific acquisition target for grassland and associated seasonal wetlands established for Conservation Zone 4 because high value grassland habitats in the Conservation Zone are currently protected. Small and fragmented patches of grassland associated with maintained agricultural habitats (e.g., vegetated levee slopes), however, may be protected that will serve as upland habitat for giant garter snake and western pond turtle, and foraging habitat for Swainson's hawk and white-tailed kite.

*Nontidal Aquatic and Wetland Natural Communities***.** Lands will be acquired in Conservation Zone 4 to restore up to 200 acres of nontidal marsh that functions as aquatic habitat for the giant garter snake. Nontidal marsh will be restored in locations to benefit the Caldoni Marsh/White Slough giant garter snake subpopulation. The criteria for restoring nontidal marsh and the anticipated benefits for associated covered species are the same as described above for restoration of nontidal marsh in Conservation Zone 2.

*Agricultural Lands and Managed Wetlands***.** Agricultural lands will be acquired in Conservation Zone 4 to achieve a proportion of the overall agricultural habitat conservation target established for the Plan Area (Table 3-4). Agricultural lands will be acquired that support habitat for tricolored blackbird, Swainson's hawk, greater sandhill crane, and giant garter snake. Other habitat elements on protected agricultural lands (e.g., wetlands, riparian corridors, grasslands, hedgerows, tree rows and groves, and isolated trees) will be retained and enhanced as needed as covered species habitat within the agricultural matrix. Criteria for acquisition of agricultural lands to provide habitat for Swainson's hawk are the same as described above for Conservation Zone 1. Protection of agricultural lands in Conservation Zone 4 will also focus on increasing the connectivity of protected lands along the eastern edge of the Plan Area to further facilitate movement and expansion of giant garter snake and other covered species populations between the Stone Lakes National Wildlife Refuge and the Caldoni Marsh/White Slough giant garter snake subpopulation.

A portion of the conserved agricultural land in Conservation Zone 4 will need to be acquired and managed as foraging habitat for the greater sandhill crane to meet the requirements of 4,000 conserved acres within the crane's primary zone. In addition, a portion of the 300 acres of greater sandhill crane managed wetland roosting habitat can be acquired in Conservation Zone 4. Individual agricultural land and managed wetland acquisitions for greater sandhill crane foraging and roosting habitat will be at least 80 acres in size unless high value sites are contiguous or potentially contiguous with other conserved lands. The BDCP Implementation Office will consult with species experts to determine the suitability of potential acquisitions relative to proximity to foraging habitats within the primary zone, and to establish restoration design criteria for crane roosting habitat.

A portion of the conserved agricultural lands will also need to be acquired and permanently maintained within or adjacent to habitat occupied by the Caldoni Marsh/White Slough subpopulation of giant garter snake to establish a 1,000 acre preserve for this subpopulation. The Implementation Office will consult with giant garter snake species experts to determine appropriate agricultural land acquisitions relative to the proximity of the existing subpopulation, proximity and connectivity with existing and restored nontidal perennial freshwater emergent wetland, and opportunities for population protection and expansion. The specific parcels of conserved agricultural habitat will vary among years to the extent that they are acquired through limited term conservation easements.

Conservation Zone 5 Acquisition Requirements

Land acquisition (includes fee title and easement) requirements for Conservation Zone 5 are directed at acquiring lands necessary for the restoration of tidal habitat. Agricultural lands that support Swainson's hawk and greater sandhill crane foraging habitats, which may be conserved in multiple Conservation Zones to achieve the objectives for these species may also be acquired in Conservation Zone 5 if needed to achieve the overall agricultural habitat conservation target (Table 3-4). The extent of subsided lands that may be acquired in Conservation Zone 5, however, is limited to the extent of existing Swainson's hawk and greater sandhill crane foraging habitat located below sea level that would be removed by BDCP actions.

*Tidal Aquatic and Wetland Natural Communities***.** Lands sufficient to restore at least 2,100 acres of tidal habitat within the West Delta ROA will be acquired. The criteria for restoring tidal habitat and the anticipated benefits for associated covered species are the same as described above for restoration of tidal habitat in Conservation Zone 1.

Agricultural Lands. Agricultural lands may be acquired in Conservation Zone 5 to achieve a proportion of the overall agricultural habitat conservation target established for the Plan Area (Table 3-4). Agricultural lands would be acquired that support habitat for tricolored blackbird, Swainson's hawk, greater sandhill crane, and giant garter snake. Other habitat elements on protected agricultural lands (e.g., wetlands, riparian corridors, grasslands, hedgerows, tree rows and groves, and isolated trees) will be retained and enhanced as needed as covered species habitat within the agricultural matrix. Criteria for acquisition of agricultural lands to provide habitat for Swainson's hawk and greater sandhill crane are the same as described above for Conservation Zone 1 and 4, respectively.

In addition, lands necessary to create a portion of the 320 acres of greater sandhill crane roosting habitat can be acquired in Conservation Zone 5. Criteria for acquisition is the same as described above for Conservation Zone 4.

Conservation Zone 6 Acquisition Requirements

No specific conservation land acquisition targets are identified for Conservation Zone 6. This Conservation Zone encompasses deeply subsided islands of the Delta that are dominated by agricultural habitats and generally only support small fragmented patches of non-agricultural habitats. Some tidal habitat restoration could occur in Conservation Zone 6 in the West Delta ROA. Agricultural lands that support Swainson's hawk and greater sandhill crane foraging and roosting habitats, which may be conserved in multiple Conservation Zones to achieve the objectives for these species, may be acquired in Conservation Zone 6. Criteria for acquisition of agricultural lands to provide habitat for Swainson's hawk and greater sandhill crane are the same as described above for Conservation Zone 4. The extent of subsided lands that may be acquired in Conservation Zone 6, however, is limited to the extent of existing Swainson's hawk and greater sandhill crane foraging habitat located below sea level that would be removed by BDCP actions.

Conservation Zone 7 Acquisition Requirements

Land acquisition (includes fee title and easement) requirements for Conservation Zone 7 are directed at acquiring lands necessary for the restoration of tidal and associated riparian habitats, restoration of seasonally inundated floodplains and associated riparian habitat, restoration of riparian habitats specifically to support riparian brush rabbit, and protecting cultivated agricultural habitats.

*Tidal Aquatic and Wetland Natural Communities***.** Lands sufficient to restore at least 5,000 acres of tidal habitat within the South Delta ROA will be acquired. The criteria for restoring tidal habitat and the anticipated benefits for associated covered species are the same as described above for restoration of tidal habitat in Conservation Zone 1. In addition, tidal wetland restoration in Conservation Zone 7 is also expected to benefit the greater sandhill crane by providing potential foraging and roosting habitats and facilitating possible expansion of the species' winter range southward.

*Riparian Natural Community***.** Lands sufficient to restore a substantial portion of the 10,000-acre seasonally inundated floodplain target included within would be most of the 5,000-acre riparian natural community target will be acquired. Floodplain habitat and associated riparian habitat would be restored by setting back levees on major river channels including the San Joaquin, Old, and Middle rivers. Riparian habitat restoration would support habitat for riparian brush rabbit, riparian woodrat, Townsend's Big-eared Bat, yellow-breasted chat, white-tailed kite, Swainson's hawk, and valley elderberry longhorn beetle.

Of the 5,000 acres of restored riparian, 300 acres will be specifically restored to meet the ecological requirements of the riparian brush rabbit and 300 additional acres will be restored to meet the ecological requirements of the riparian woodrat. The BDCP Implementation Office will consult with species experts to determine appropriate restoration locations, minimum patch size, species composition, and to develop other restoration design criteria and implementation guidance.

*Grasslands and Associated Seasonal Wetland Natural Communities***.** There is no specific acquisition target for grassland and associated seasonal wetlands established for Conservation Zone 7. Small and fragmented patches of grassland associated with maintained agricultural habitats (e.g., vegetated levee slopes), however, may be protected that will serve as upland habitat for giant garter snake and western pond turtle, and foraging habitat for Swainson's hawk and white-tailed kite.

*Agricultural Lands and Managed Wetlands***.** Agricultural lands will be acquired in Conservation Zone 7 to achieve a substantial proportion of the overall agricultural habitat conservation target established for the Plan Area (Table 3-4). Agricultural lands will be acquired that support foraging habitat for Swainson's hawk and habitat for other agricultural-associated covered species. Other habitat elements on protected agricultural lands (e.g., wetlands, riparian corridors, grasslands, hedgerows, tree rows and groves, and isolated trees) will be retained and enhanced as needed as covered species habitat within the agricultural matrix. Criteria for acquisition of agricultural lands to provide habitat for Swainson's hawk are the same as described above for Conservation Zone 1. The specific parcels of conserved agricultural habitat will vary among years to the extent that they are acquired through limited term conservation easements.

Conservation Zone 8 Acquisition Requirements

Land acquisition (includes fee title and easement) requirements for Conservation Zone 8 are directed at protecting and restoring grassland and associated seasonal wetlands, and protecting occurrences of selected plant species with very limited distributions. Agricultural lands may also be acquired in this Conservation Zone to provide habitat for Swainson's hawk and other agricultural-associated covered species as described above for Conservation Zone 3.

*Grasslands and Associated Seasonal Wetland Natural Communities***.** At least 1,000 acres of existing grassland will be acquired and protected in Conservation Zone 8; and a portion of the 300 acres of existing vernal pool complex and 400 acres of existing alkali seasonal wetland to be protected under the BDCP will be acquired and protected in Conservation Zone 8. The goal of these acquisitions is to protect lands in large contiguous grassland landscapes that encompass the range of vegetation, hydrologic, and soil conditions that characterize these communities within the Conservation Zone south of Highway 4. Conserved lands will be located to maintain habitat connectivity with protected grassland landscapes within and immediately adjacent to the Plan Area. Protection of these habitat areas will maintain connectivity with lands that have been protected or may be protected in the future under the East Contra Costa HCP/NCCP.

This approach to conservation of these natural communities will conserve habitat for the 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, the covered vernal pool shrimp species, alkali milk-vetch, San Joaquin spearscale, dwarf downingia, Boggs Lake hedge-hyssop, Heckard's peppergrass, legenere, heartscale, brittlescale, Delta button-celery, and caper-fruited tropidocarpum (see details on benefits to each of these species in Section 3.3, *Biological Goals and Objectives*). Protection and management of grasslands and associated seasonal wetlands in Conservation Zone 8 will help achieve recovery plan objectives for the San Joaquin kit fox (USFWS 1998a), the California red-legged frog (USFWS 2002), Conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, mid-valley fairy shrimp, vernal pool tadpole shrimp, alkali milk-vetch, Boggs Lake hedge-hyssop, and legenere (USFWS 2005). These conserved lands will be evaluated and managed to maintain and enhance their existing habitat functions for these species over the term of the BDCP. Following full BDCP implementation, an estimated __ percent of grassland, vernal pool complex, and alkali seasonal wetland remaining in Conservation Zone 8 will be protected.

*Plant Species Occurrences***.** Protect and enhance at least 3 occurrences of alkali milk-vetch, brittlescale, heartscale in Conservation Zones 1, 8, and/or 11. Protect and enhance 2 occurrences of Heckard's peppergrass in Conservation Zones 1, 8, and/or 11. Protect occurrences of caper-fruited tropidocarpum that reestablish in Conservation Zone 8.

Conservation Zone 9 Acquisition Requirements

No specific conservation land acquisition targets are identified for Conservation Zone 9. This Conservation Zone is comprised primarily of urban lands (e.g., Brentwood and Discovery Bay are located in this zone) and non-urban areas are dominated by agricultural habitats. Non-agricultural habitats generally are present in small patches that are fragmented and disconnected from other natural habitats. Agricultural lands that support Swainson's hawk foraging habitat, which may be conserved in multiple Conservation Zones to achieve the objectives for this species, may be acquired in Conservation Zone 9 as described above for Conservation Zone 3.

Conservation Zone 10 Acquisition Requirements

No conservation land acquisition targets are identified for Conservation Zone 10. This Conservation Zone encompasses the City of Antioch and is comprised almost entirely of urban lands.

Conservation Zone 11 Acquisition Requirements

Land acquisition (includes fee title and easement) requirements for Conservation Zone 11 are directed at protection of grassland and associated seasonal wetland habitats, acquiring lands necessary for the restoration of tidal habitats, and protecting occurrences of selected plant species with very limited distributions.

*Grasslands and Associated Seasonal Wetland Natural Communities***.** A portion of the 300 acres of existing vernal pool complex, 400 acres of existing alkali seasonal wetland, and 8,000 acres of existing grassland to be protected under the BDCP will be acquired and protected in Conservation Zone 11. These communities are located along the upland fringe of Suisun Marsh and the goal of these acquisitions is to protect these lands to maintain connectivity with much larger protected (e.g., Jepson Prairie Preserve) and unprotected grassland landscapes that are immediately adjacent to the zone. Specific land acquisition requirements include the protection of at least three occurrences of alkali milk-vetch. This approach is expected to result in conservation of a gradient of natural habitats that range from grassland upland communities down slope to existing and restored tidal wetland communities.

Grassland, vernal pool complex, and alkali seasonal wetland complex communities fringing Suisun Marsh support several rare plant species that will be brought under protection and management through these acquisitions. This approach to conservation of these natural communities will serve to conserve habitat for the tricolored blackbird, western burrowing owl, Swainson's hawk, white-tailed kite, giant garter snake, western pond turtle, western spadefoot toad, California tiger salamander, the covered vernal pool shrimp species, alkali milk-vetch, San Joaquin spearscale, dwarf downingia, Boggs Lake hedge-hyssop, Heckard's peppergrass, legenere, heartscale, brittlescale, and Carquinez goldenbush (see details on benefits to each of these species in Section 3.3, *Biological Goals and Objectives*). These conserved lands will be evaluated and managed to maintain and enhance their existing habitat functions for these species over the term of the BDCP. The protection and restoration of vernal pool complex will help achieve the recovery objectives for Conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, mid- valley fairy shrimp, vernal pool tadpole shrimp, alkali milk-vetch, Boggs Lake hedge-hyssop, and legenere identified in the Vernal Pool Recovery Plan (USFWS 2005). Following full BDCP implementation, an estimated __ percent of grassland, vernal pool complex, and alkali seasonal wetland remaining in Conservation Zone 11 will be protected.

*Tidal Aquatic and Wetland Natural Communities***.** Lands sufficient to restore at least 7,000 acres of tidal habitat, including 3,000 acres of tidal brackish emergent wetland will also be acquired in Conservation Zone 11 within the Suisun Marsh ROA. Restored tidal habitat includes restored gradient of habitats ranging from shallow subtidal aquatic habitat, to mudflat, emergent marsh plain, and transitional uplands. Transitional uplands will include sufficient land to accommodate future upslope establishment of marsh plain vegetation with sea level rise and will support habitat for grassland associated species. Restored tidal marsh plains and mudflats are expected to support 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, Mason's lilaeopsis, and Delta mudwort. Restoration and protection of transitional uplands will provide flood refugia habitat for salt marsh harvest mouse, Suisun shrew, California black rail, and California clapper rail during high water events. Restoration of shallow subtidal aquatic habitat will also support California least tern foraging habitat and aquatic habitat for the western pond turtle.

*Plant Species Occurrences***.** Protect and enhance at least three occurrences of alkali milk-vetch, brittlescale, heartscale in Conservation Zones 1, 8, and/or 11. Protect and enhance 2 occurrences of Heckard's peppergrass in Conservation Zones 1, 8, and/or 11. Protect and enhance 3 occurrences each of Suisun thistle and soft bird's-beak in Suisun Marsh Conservation Zones 11. Preserve at least 3 occurrences of Carquinez goldenbush in Conservation Zones 1 and/or 11.

Inter-Conservation Zone Connectivity

In addition to the spatial distribution requirements among the Conservation Zones for protection of natural communities and covered species, conservation lands will also need to be distributed within and among some Conservation Zones to provide connectivity for some covered species habitats across specific segments within or adjacent to the Plan Area. Specific efforts will focus on two ecological corridors described below. It is expected that the corridors can be established through meeting the natural community conservation targets presented in Table 3-4. Corridor width will follow the recommendations from the *California Essential Habitat Connectivity Project* (DFG/CALTRANS 2010), to the extent that it is practicable and within the natural community conservation targets.

Grassland/Vernal Pool Complex Corridor. Vernal pool complex natural community in Conservation Zones 1 and 11 are situated at elevations that are suitable for serving as upland habitats adjacent to restored tidal habitats and can be protected to build upon existing and planned preserves in Solano County between these conservation zones. Protection of additional vernal pool complex natural community in this area will protect an important connection between Suisun Marsh and the Cache Slough area. Establishing a protected corridor in this area will also facilitate movement of several covered species including California tiger salamander and western spadefoot toad from occupied habitats in the Montezuma Hills and Jepson Prairie into the grassland and vernal pool complex habitats in Conservation Zone 1.

The Implementation Office will explore opportunities through coordination with Solano County to acquire and protect additional lands between Suisun Marsh and the Cache Slough area in order to establish a protected corridor comprised of contiguous patches of grassland, vernal pool complex, tidal wetlands, and other seasonal wetlands.

Giant Garter Snake Corridor. Habitat connectivity, particularly hydrologic connectivity that supports giant garter snake movement and dispersal, is essential for protection of giant garter snake populations, and is a key element of the species' recovery plan (USFWS 1999a). Focusing agricultural land conservation along a north-south corridor within Conservation Zone 4 along with restoration of tidal wetlands in that area, will enhance connectivity and facilitate giant garter snake movement between the Coldani Marsh-White Slough subpopulation north to the Cosumnes River Preserve and to Stone Lakes National Wildlife Refuge.

A corridor will be protected that is comprised of contiguous patches of agricultural, restored tidal and nontidal wetlands, grassland, vernal pool complex, and other seasonal wetlands between the Coldani Marsh/White Slough giant garter snake subpopulation area north to Stone Lakes National Wildlife Refuge and to the extent possible connecting the Cosumnes River Preserve. The corridor will be configured such that there is 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 wide in any location.

Invasive Species Control Program

The BDCP Implementation Office will develop and implement a plan for the control of invasive animal and plant species that could substantially degrade the functions of protected natural communities as habitat for covered and other native species on BDCP lands.

Elements of the plan will include:

- Protocols for periodically surveying for and assessing the abundance of nonnative predators and competitors on BDCP lands;
- Protocols for periodically surveying for and assessing the occurrence and abundance of invasive nonnative plants on BDCP lands;

- A brown-headed cowbird monitoring and control program (see discussion below);
- Methods for assessing degree of biological effect nonnative species have on covered and other native species within BDCP lands;
- Methods for assessing threats of establishment of nonnative animals and plants on lands adjacent to BDCP lands;
- Methods for assessing threats of the spread of nonnative plants from BDCP lands onto adjacent lands;
- A decision-making process for determining the need for implementing management actions to control nonnative species;
- A description of potential nonnative species control methods; and
- A process for developing and implementing monitoring necessary to assess the effectiveness of implemented control methods.

Monitoring and control requirements that may be developed for specific preserve lands will be incorporated into preserve-specific management plans (see CM11 Natural Communities Enhancement and Management).

Examples of nonnative plant species currently of concern include waxy mannagrass, Italian ryegrass, barbed goatgrass, medusahead grass, yellow starthistle, Himalayan blackberry, giant reed, and parrot feather. Animal species that could degrade the habitat functions for covered species include feral domesticated animals (e.g., feral cat predation on ground-nesting birds) and brown-headed cowbirds.

The brown-headed cowbird is a native species that has expanded its range substantially with conversion of historical Central Valley habitats to agriculture. The brown-headed cowbird is a frequent brood parasite of yellow-breasted chats and other native birds and can affect local reproduction of chats. On conserved lands that support nesting yellow-breasted chats, surveys will be conducted to identify and monitor brown-headed cowbird populations, the extent of brood parasitism of yellow-breasted chats, and the reproductive trend of nesting yellow-breasted chats. If it is determined that cowbirds are substantially affecting nesting success of yellow-breasted chats such that local populations are or could decline, cowbird control measures will be implemented to reduce local cowbird populations.

3.4.3 Natural Community-Level Conservation Measures

Natural community conservation measures include the protection, restoration, enhancement, and management of natural communities and the covered species that are dependent upon them. The overarching goal of restoration and protection of natural communities is to create and maintain an ecologically functioning landscape that successfully combines both native and working landscape elements and that meets natural community and species goals and objectives. Natural community conservation measures provide the mechanisms for achieving restoration and protection goals and objectives using the following the guiding principles:

- Restore natural communities such that they contribute to and enhance an ecologically functional landscape;
- Manage and enhance working landscapes (e.g., agricultural lands) such that they protect covered species habitat values and facilitate expansion of covered species populations while maintaining their agricultural production and economic value;
- Emphasize natural ecological gradients and connectivity among and between restored and existing natural communities that provide a range of conditions to provide for shifting or expanding species distributions; and
- Protect, restore, and enhance habitats for covered species such that implementation of the BDCP provides a significant contribution to their long-term conservation in the Plan Area.

3.4.3.1 CM4 Tidal Habitat Restoration

BDCP implementation will provide for the restoration of 65,000 acres of freshwater and brackish tidal habitat within the BDCP ROAs (Figure 3-3). The extent of restored tidal habitat includes a contiguous habitat gradient encompassing restored shallow subtidal aquatic habitat[34], restored tidal mudflat, restored tidal marsh plain habitat[35], and adjoining transitional upland habitat. This upland habitat will accommodate approximately 3 feet of sea level rise that could function as tidal marsh plain at some future time, if necessary. Additional upland habitat, however, would be protected and enhanced to provide habitat for terrestrial species.

Of the 65,000-acre restoration target, 22,000 acres will be distributed among the ROAs as described below in Minimum Restoration Targets for Freshwater Tidal Habitat in ROAs and Minimum Restoration Target for Brackish Tidal Habitat in the Suisun ROA. The remaining 43,000 acres of the target total will be distributed among the ROA's at the discretion of the BDCP Implementation Office based on land availability, biological value, and practicability considerations. The freshwater and brackish tidal habitat restoration targets will be achieved on the following time schedule:

- 14,000 acres developed[36] within the first 10 years of plan implementation;
- 25,000 acres (cumulative) developed by year 15 of plan implementation; and
- 65,000 acres (cumulative) developed by year 40 of plan implementation.

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[34] Restored shallow subtidal habitat extends approximately from the mean lower low water [MLLW] elevation to 9 feet below the MLLW elevation.

[35] Restored tidal marsh plain extends from the MLLW elevation to the mean higher high water [MHHW] elevation.

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

Actions to restore freshwater and brackish tidal habitat, as appropriate to site-specific conditions, will include:

- Acquiring lands, in fee-title or through conservation easements, suitable for restoration of tidal habitats and protecting sufficient adjacent uplands to accommodate 3 feet of future sea level rise;
- Consulting with covered species experts to assist with the design and implementation of avoidance and minimization measures;
- Breaching and lowering levees and dikes to reintroduce tidal exchange to currently leveed former tidelands;
- Reconnecting disconnected remnant sloughs to Suisun Bay and removing remnant slough levees to reintroduce tidal connectivity to slough watersheds;
- Constructing new or enhancing existing levees to provide flood protection for adjacent landowners and protecting existing land use against seepage and erosion of existing levees;
- Constructing new levees to isolate deeply subsided lands from tidal flooding;
- Restoring natural remnant meandering tidal channels;
- Excavating channels to encourage the development of 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;
- Restoring tributary stream functions to establish more natural patterns of sediment transport to improve spawning conditions for delta smelt and other fish and macroinvertebrates;
- Prior to breaching, re-contouring 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; and
- Designing levee and dike breaches to maximize the development of tidal marsh plain and minimize hydrodynamic conditions that favor nonnative predatory fish.

Measures for addressing the potential for methylation of mercury in restored tidal habitats will be addressed through implementation of CM12 Methylmercury Management.

Freshwater Tidal Habitat Restoration

Freshwater tidal habitats will be restored to provide the ecological benefits for covered species described under *Hypothesized Benefits* below. Freshwater tidal habitats will be restored by breaching or removing levees along Delta waterways to reestablish tidal connectivity to reclaimed lands. Tidal habitat 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 habitats that could favor nonnative predator/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 habitat is presented in Figure 3-55.

Restoration variables that will be considered by the BDCP Implementation Office in the design of restored freshwater tidal habitat include:

- Spatial distribution of restored tidal marsh habitats within the Delta;
- Extent, location, and configuration of restored tidal habitat areas;
- Predicted tidal range at tidal habitat restoration sites following reintroduction of tidal exchange;
- Size and location of levee breaches;
- Cross sectional profile of tidal habitat restoration sites (elevation of marsh plain, topographic diversity, depth, and slope); and
- Density and size of restored tidal habitat channels appropriate to each restoration site.

Figure 3-55. Conceptual Design for Restored Freshwater Tidal Marsh Habitat (CM4)

Click here to view figure

Restoration design considerations for freshwater tidal habitat will include the following.

*Marsh Plain Vegetation***.** To provide for high functioning habitat, restored tidal marsh plains 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 habitat 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 habitat 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. Effective tidal exchange is expected to enhance ecological functions that support covered species, including:

- The export of productivity from the marsh plain into adjacent Delta waterways in support of aquatic food web processes;
- Production and export of phytoplankton and zooplankton from tidal channels into adjacent Delta waterways in support of the aquatic food web; and
- Maintenance of cooler localized water temperatures preferred by covered fish species through nocturnal thermal exchange on marsh plains.

Marsh channels and levee breaches will also 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.

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 such the types of changes expected is provided in Appendix N-4 [*marsh evolution document*].

*Environmental Gradients***.** As determined by site-specific constraints, tidal habitat 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 region, 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 habitat restoration projects will be designed to minimize the likelihood of 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 Nonnative Aquatic Vegetation Control, the BDCP Implementation Office will engage in active removal of submerged and floating aquatic vegetation in subtidal portions of tidal restoration sites to reduce the levels of establishment of nonnative predators.

*Minimum Restoration Targets for Freshwater Tidal Habitat in ROAs***.** At a minimum, the BDCP Implementation Office will restore the following amounts of tidal habitat in each of the Delta ROAs (Figure 3-2) as described below.

- **Restore at least 5,000 acres of freshwater tidal habitat within the Cache Slough Complex ROA.** The BDCP Implementation Office will restore a minimum of 5,000 acres of freshwater tidal habitat in the Cache Slough Complex ROA. Areas suitable for restoration include, but are not limited to, Haas Slough, Hastings Cut, Lindsey Slough, Barker Slough, Calhoun Cut, Liberty Island, Little Holland, the Westlands property ("Yolo Ranch"), Shag Slough, Little Egbert Tract, and Prospect Island. The Cache Slough Complex has been recognized as possibly the best functioning existing tidal habitat area of the Delta. The complex includes Liberty Island, which is likely the best existing model for freshwater tidal habitat restoration in the Delta for native fishes. The Complex supports multiple covered fish species and may be one of the last areas where Delta smelt spawn and rear successfully. Restoring the target amount of freshwater tidal habitat within the Cache Slough Complex ROA and protecting associated upland habitat would benefit multiple covered species and the Delta ecosystem. In conjunction with floodplain enhancement in the Yolo Bypass, the habitat restoration in the Cache Slough ROA will re-establish the ecological gradient from river to floodplain to tidal estuary and to provide tidal wetland adjacent to open channel habitat that is characteristic of less altered estuaries. Hydrodynamic modeling indicates that increased tidal exchange in the Cache Slough area resulting from 5,000-10,000 acres of tidal habitat restoration will 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.

Additionally, the Cache Slough Complex encompasses a substantial area of land with elevations suitable for freshwater tidal habitat 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 habitat supporting multiple aquatic and terrestrial covered species. Restoration of freshwater tidal habitat will be designed to support the physical and biological attributes that benefit 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 for restoration would be identified by working with interested landowners.

- **Restore at least 1,500 acres of freshwater tidal habitat within the Cosumnes-Mokelumne ROA.** The BDCP Implementation Office will restore a minimum of 1,500 acres of freshwater tidal habitat in the Cosumnes/Mokelumne ROA. Areas suitable for restoration within the Cosumnes-Mokelumne ROA (Figure 3-2) include McCormack-Williamson Tract, New Hope Tract, Canal Ranch Tract, Bract Tract, Terminous Tract north of State Highway 12, and lands adjoining Snodgrass Slough, South Stone Lake, and Lost Slough. Depending on site-specific conditions, levees may be constructed to avoid inundation of deeply subsided lands.
- **Restore at least 2,100 acres of tidal habitat within the West Delta ROA.** The BDCP Implementation Office will restore a minimum of 2,100 acres of freshwater tidal habitat in the West Delta ROA. The west Delta includes multiple small areas where tidal habitat can be restored. 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 purpose of restoring tidal habitat in the west Delta is to 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 and to 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.
- **Restore at least 5,000 acres of tidal habitat within the South Delta ROA.** The BDCP Implementation Office will restore a minimum of 5,000 acres of freshwater tidal habitat in the South Delta ROA. To maximize benefits associated with restoration of tidal habitat in the south Delta, tidal habitat will not be restored until the north Delta diversion facilities become operational. Potential sites for restoring freshwater tidal habitat 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 habitat restoration in the South Delta

ROA may support the expansion of the current distribution of delta smelt into formerly occupied habitat areas.

Tidal habitat 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 habitats, and uplands (e.g., grasslands, agricultural lands) for sea level rise accommodation, as appropriate to specific restoration sites.

Problem Statement

The majority of historical freshwater tidal marsh in the Sacramento/San Joaquin Delta has been lost. Historically, approximately 350,000 acres of tidal marsh was present in the Delta, of which less than 10,000 acres of freshwater tidal marsh remains. This loss of tidal marsh has greatly reduced the availability and quality of spawning and rearing habitat for many native fish 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 freshwater 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.

Hypothesized Benefits

Restoration of freshwater tidal habitat is hypothesized to provide a range of ecosystem and covered species benefits. These anticipated benefits are described below for the freshwater tidal habitat restoration proposed in each of the ROAs. As described in Chapter 5, *Effects Analysis,* and Appendix F, *DRERIP Evaluation Results*, however, there are a number of uncertainties regarding the level of benefits that may be provided by tidal habitat restored in each of the ROAs as well as risks for adverse consequences. These uncertainties will be addressed through effectiveness monitoring, research, and the adaptive management program (see Sections 3.6 and 3.7).

Restoring freshwater tidal habitat within the Cache Slough ROA is expected to:

- Increase rearing habitat area for Chinook salmon (Sacramento River runs), Sacramento splittail, white sturgeon, and green sturgeon (Healey 1991, Brown 2003, Appendix F, *DRERIP Evaluation Results*);
- Increase the local production of food for rearing salmonids, splittail, delta smelt, green and white 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, white sturgeon, and green 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; and

- Expand habitat for tricolored blackbird, California black rail, and giant garter snake (in locations with a muted tidal range).

Restoring freshwater tidal habitat within the Cosumnes/Mokelumne River ROA is expected to:

- Increase rearing habitat area for Cosumnes/Mokelumne fall-run Chinook salmon, steelhead, delta smelt, and Sacramento splittail (Healey 1991, Brown 2003);
- Increase the local production of food for Cosumnes/Mokelumne fall-run Chinook salmon, steelhead, delta smelt, and Sacramento 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, white sturgeon, and green 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; and
- Expand habitat for tricolored blackbird, California black rail, greater sandhill crane, and giant garter snake (in locations with a muted tidal range).

Restoring freshwater tidal habitat in the West Delta ROA is expected to:

- Increase rearing habitat area for Chinook salmon (Sacramento, San Joaquin, and Mokelumne river runs), Sacramento 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; and
- Expand habitat for tricolored blackbird, California black rail, and giant garter snake (in locations with a muted tidal range).

Restoring freshwater tidal habitat in the South Delta ROA is expected to:

- Increase rearing habitat area for Sacramento 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, 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);
- Increase the extent of habitat available for colonization by Mason's lilaeopsis, Delta mudwort, and Delta tule pea; and
- Expand habitat for tricolored blackbird, California black rail, greater sandhill crane, and giant garter snake (in locations with a muted tidal range).

Adaptive Management Considerations

Implementation of freshwater tidal habitat restoration actions and subsequent management of restored tidal habitats 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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results, likely elements of this measure that could be adjusted through the adaptive management process include considerations for selecting restoration locations and sequencing restoration of tidal habitat among the ROAs; methods for establishing marsh plain vegetation, including the establishment of marsh-associated covered plant species; methods and designs for elevating subsided land surfaces to increase restored marsh plain area; design and location of levee breaches; designs for encouraging the development of a high functioning network of tidal channels; and nonnative vegetation and wildlife control techniques.

Brackish Tidal Habitat Restoration

Brackish tidal habitat will be restored within Suisun Marsh ROA in coordination with the Suisun Marsh Habitat Restoration and Management Plan, currently under development. Brackish tidal habitat will be restored to provide the ecological benefits for covered species described under Hypothesized Benefits below. Brackish tidal habitat will be restored by breaching or removing dikes along Montezuma and other Suisun Marsh sloughs and channels and Suisun Bay to reestablish tidal connectivity to reclaimed lands. Tidal habitat 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 within restoration sites to accelerate development of marsh functions. Existing tidal channels may also be deepened and 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 would be 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 3-56.

Restoration variables that will be considered by the BDCP Implementation Office in the design of restored brackish tidal habitat include:

- Extent, location, and configuration of other existing and proposed restored tidal habitat areas;
- Distribution of restored tidal habitats along salinity gradients to optimize the range of habitat conditions for covered species and food production;
- Predicted tidal range at tidal habitat restoration sites following reintroduction of tidal exchange;
- Size and location of dike breaches;
- Cross sectional profile of tidal habitat restoration sites (elevation of marsh plain, topographic diversity, depth, and slope);
- Density and size of tidal marsh plain channels appropriate to each restoration site; and
- Potential hydrodynamic and water quality effects on other areas of the Delta.

Figure 3-56. Conceptual Design for Restored Brackish Tidal Marsh Habitat (Suisun Marsh ROA) (CM4)

Click here to view figure

Restoration design considerations for brackish tidal habitat include the following.

*Marsh Plain Vegetation***.** To provide high functioning habitat, 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. Vegetated marsh plains will also be expected to filter non-point source pollution from surface or subsurface infiltration that otherwise would flow into Suisun Bay. Following establishment of tidal exchange, restored habitat will be monitored to assess the establishment of invasive nonnative plants. If indicated by monitoring results, the BDCP Implementation Office will implement invasive plant control measures to help ensure the establishment of native marsh plain plant species.

*Hydrodynamic Conditions***.** Restored brackish tidal habitat will be designed to provide hydrodynamic conditions similar to those described for freshwater tidal habitat. In addition to desired biological and ecological attributes, the selection and design of restored tidal habitat in Suisun Marsh will need to consider potential hydrodynamic and water quality effects of the proposed restoration, including the effect on salinity intrusion, tidal mixing, and Delta salinity.

*Environmental Gradients***.** Restored brackish tidal habitat will be designed to provide environmental gradients similar to those described for freshwater tidal habitat. Because land surface elevations within 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 habitat 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.

Minimum Restoration Targets for Brackish Tidal Habitat in Suisun ROA. The BDCP Implementation Office will restore at least the following amount of brackish tidal habitat in the Suisun Marsh ROA.

*Restore at least 7,000 acres of brackish tidal habitat within the Suisun Marsh Restoration Opportunity Area***.** The BDCP Implementation Office will restore a minimum of 7,000 acres of brackish tidal habitat in the Suisun Marsh ROA. Restored brackish tidal habitat will be designed to support the physical and biological attributes described above in Brackish Tidal Marsh Habitat Restoration. Restored tidal habitat 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 Suisun Marsh ROA encompasses a substantial area with elevations suitable for tidal habitat restoration that would have minimal effect on infrastructure or permanent crops relative to other suitable lands within the Delta.

The Suisun Marsh Habitat Restoration and Management Plan (currently under development) will include an evaluation of alternatives, including options that contemplate the restoration of up to

7,000 acres of brackish tidal habitat. Much of Suisun Marsh is currently at elevations that could be restored to tidal habitat.

Hydrodynamic modeling conducted for the Suisun Marsh Restoration Plan (J. DeGeorge pers. comm.) indicates that restoring tidal habitat north of Montezuma Slough would shift the low salinity zone westward and restoring tidal habitat 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 habitat restoration projects in north and south Suisun Marsh will be sequenced such that these potential effects would be minimized.

As described in CM1 *Water Facilities and Operation*, future reoperation of the Montezuma Slough Salinity Control Gate will increase the benefits of restoring brackish tidal habitat in Suisun Marsh by increasing access for covered fish species to existing and restored tidal aquatic habitat within a large area of Suisun Marsh.

Problem Statement

Suisun Marsh is the largest brackish water marsh complex in the western United States. The majority of historical brackish tidal marsh has been lost, of which approximately 8,300 acres remains 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.

Hypothesized Benefits

Restoration of brackish tidal habitat in Suisun Marsh is hypothesized to provide a range of ecosystem and covered species benefits. As described in Chapter 5, *Effects Analysis,* and Appendix F, *DRERIP Evaluation Results*, however, there are a number of uncertainties regarding the level of benefits that may be provided by tidal habitat restored as well as risks for adverse consequences. These uncertainties will be addressed through effectiveness monitoring, research, and the adaptive management program (see Sections 3.6 and 3.7).

Restoring brackish tidal habitat within the Suisun Marsh ROA is expected to:

- Increase rearing habitat area for Chinook salmon, Sacramento splittail, and possibly steelhead (Healey 1991, Siegel 2007);
- Increase the local production of food for rearing salmonids, splittail, and other covered species (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 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;
- Locally provide areas of cool water refugia for delta smelt (C. Enright pers. comm.);
- Reduce periodic low dissolved oxygen events associated with the discharge of waters from lands managed as seasonal freshwater wetlands that would be restored as brackish tidal habitat (Siegel 2007, C. Enright pers. comm.);
- Increase the extent of habitat available for colonization by Suisun marsh aster and soft-bird's-beak; and
- Enhance and increase the extent of salt marsh harvest mouse, Suisun shrew, California clapper rail, California black rail, and Suisun song sparrow habitat.

Adaptive Management Considerations

Implementation of brackish tidal habitat restoration actions and subsequent management of restored brackish tidal habitats 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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results, likely elements of this measure that could be adjusted through the adaptive management process include considerations for selecting restoration locations and sequencing restoration of tidal habitat within Suisun Marsh to maintain desirable salinity gradients; methods for establishing marsh plain vegetation, including the establishment of marsh-associated covered plant species; methods and designs for elevating subsided land surfaces to increase restored marsh plain area; design and location of dike breaches; designs for encouraging the development of a high functioning network of tidal channels; and nonnative vegetation and wildlife control techniques.

3.4.3.2 CM5 Seasonally Inundated Floodplain Restoration

The BDCP Implementation Office will provide for the restoration of 10,000 acres of seasonally inundated floodplain habitat within the north, east, and/or south Delta. Because of the long-lead time needed to plan for and implement floodplain restoration it is not expected that new floodplain would be restored in the first 10 years of Plan implementation. The following are the temporal targets for seasonally inundated floodplain restoration:

- At least 1,000 acres restored by year 15 of plan implementation; and
- 10,000 acres (cumulative) restored by year 40 of plan implementation.

Although seasonally inundated floodplain may be restored along channels in many locations in the north, east, and south Delta, the most promising opportunities for large-scale restoration are in the south Delta along the San Joaquin River, Old River, and Middle River channels based on benefits to covered fish species, practicability considerations, and compatibility with potential flood control projects. Criteria that will be considered in selecting seasonally inundated floodplain restoration sites include:

- Relative importance of the adjacent channel as migration pathways for juvenile salmonids;
- Estimated frequency and duration of inundation periods; and
- Compatibility with flood control programs and level of flood control benefits provided relative to other potential restoration sites.

Actions to restore seasonally inundated floodplain habitats, as appropriate to site-specific conditions, include but are not limited to:

- Acquiring lands, in fee-title or through conservation easements, suitable for restoration of seasonally inundated floodplain;
- Setting back levees along the selected river corridor and removing the existing levees or sections of the existing levees;
- Removing existing riprap along channel banks to allow for channel meander between the set-back levees through the natural processes of erosion and sedimentation;
- Grading restored floodplain surfaces to provide for drainage of over bank flood waters such that the potential for fish stranding is minimized ;
- Lowering the elevation of restored floodplain surfaces to increase inundation frequency and duration and to establish elevations suitable for the establishment of riparian vegetation;
- Discontinuing farming within the setback levees and allowing riparian vegetation to naturally establish on the floodplain;
- Where farming is continued consistent with achieving biological and flood control objectives, engaging in farming practices and crop types that provide high benefits for covered fish species; and
- Actively establishing riparian habitat where necessary to accelerate formation of habitat for specific covered species (see the description of CM7 Riparian Habitat Restoration).

Measures for addressing the potential for methylation of mercury in restored tidal habitats will be addressed through implementation of CM12 Methylmercury Management.

A conceptual illustration of restored seasonally inundated floodplain is presented in Figure 3-57. Because restoration requires modification of levees that serve flood control functions, restored floodplain habitats will be implemented such that flood control functions are maintained or improved.

Figure 3-57. Conceptual Design for Restored Seasonally Inundated Floodplain Habitat (CM5)

Click here to view figure

The BDCP Implementation Office will coordinate floodplain restoration planning with the flood control planning efforts of USACE, DWR, the Central Valley Flood Protection Board, and other flood control agencies to assess the desirability and feasibility for setting back levees in potentially suitable locations. Seasonally inundated floodplain habitat will be designed to support the physical and biological attributes described below in Seasonally Inundated Floodplain Habitat Restoration Concepts and to provide the ecological benefits for covered species described below in Hypothesized Benefits.

Seasonally Inundated Floodplain Habitat Restoration Concepts

Restoration variables that will be considered in the design of restored seasonally inundated floodplain habitat include:

- Modeled timing, duration, interannual frequency, and spatial extent of inundation;
- Connectivity with tidal marsh and channel habitats;
- Accessibility to migrating fish;
- Stranding risk and effects on fish passage;
- Vegetation type and cover;
- Dry season land use (compatible farming practices); and
- Topography and slope.

Restoration design considerations for seasonally inundated floodplain habitat include the following.

*Floodplain Topography***.** Where appropriate, the topography of restored floodplains would be sculpted to reduce the risk for fish stranding by improving drainage and to provide topographic variability to increase hydrodynamic complexity.

*Connectivity***.** Where suitable landform is present, restored floodplains will be located and designed such that flows exiting the floodplain would pass through existing or restored tidal marsh to recreate historical landscape relationships 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 and passively established in restored floodplain areas to the extent consistent with floodplain land uses and flood control requirements. Restored floodplains provide the largest area for meeting the 5,000-acre target for restoration of woody riparian habitat under CM7 Riparian Habitat Restoration, and it is expected that about four-fifths of the riparian habitat restoration will occur at these restored floodplain sites. Established woody riparian vegetation would support habitat for riparian-associated covered species and provide cover and hydrodynamic complexity for covered fish species during inundation periods. Riparian vegetation would 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.

*Land Use on Restored Floodplains***.** Restored floodplains will be managed for ongoing agricultural uses or to support native wildlife habitats. Farmed floodplains will be managed to minimize the use of persistent herbicides and pesticides that are toxic to aquatic organisms and to provide structure and types of residual crop biomass to provide cover and hydrodynamic complexity for fish and provide sources of organic carbon in support of aquatic food web processes during inundation periods.

Problem Statement

Extensive channelization and levee construction has disconnected river channels from their historical floodplains over much of the Central Valley, including the Planning Area, resulting in substantial reduction in the availability of high functioning spawning and rearing habitats that historically support several of the covered fish species. Restoring connectivity of Delta river channels to their historical floodplains will substantially increase the extent of floodplain that can be inundated by overbank flows, thus restoring high functioning spawning and rearing habitat for Sacramento splittail and rearing habitat for salmonids. The restoration of floodplain habitat would allow for establishment of riparian forest and scrub natural community that would support habitat for a large number of covered wildlife and plant species.

Hypothesized Benefits

Restoration of seasonally inundated floodplain habitat is hypothesized to provide the ecosystem and covered species benefits described below. As described in Chapter 5, *Effects Analysis,* and Appendix F, *DRERIP Evaluation Results*, however, there are a number of uncertainties regarding the level of benefits that may be provided by restored floodplain habitats as well as risks for adverse consequences. These uncertainties will be addressed through effectiveness monitoring, research, and the adaptive management program (Sections 3.6 and 3.7).

Restoring seasonally inundated floodplain habitat is expected to:

- Increase spawning habitat for Sacramento splittail by expanding floodplain habitat area and providing in-channel spawning habitat by creating backwaters (Sommer et al. 2001a, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006).
- Depending on the location of restored floodplain, increase rearing habitat for Sacramento and San Joaquin Basin runs of Chinook salmon, Sacramento splittail, and possibly steelhead (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006).

- Increase the production of food for rearing salmonids, splittail, and other covered species (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006).
- Increase the availability and production of food in Delta channels downstream of restored floodplain habitat 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 Delta channels (Mitsch and Gosselink 2000, Moss 2007).
- Increase in nesting habitat for Swainson's hawk and white-tailed kite and habitat for yellow-breasted chat, least Bell's vireo, yellow-billed cuckoo, and valley elderberry longhorn beetle associated with riparian forest and scrub established in floodplain restoration sites.
- Increase in habitat for riparian brush rabbit and riparian woodrat within riparian scrub established in the south Delta restored floodplains (CITATION).
- Increase in habitat area for the establishment of slough thistle and Delta button-celery depending on the location of restored floodplain.

Adaptive Management Considerations

Implementation of seasonally inundated floodplain restoration actions and subsequent management of restored floodplain habitats by the Implementation Office will be informed through effectiveness monitoring that will be conducted for this conservation measure as described in Section 3.6, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results, likely elements of this measure that could be adjusted through the adaptive management process include modifications to floodplain surfaces to increase inundation frequency and duration, reduce the potential for fish stranding, and changes in floodplain vegetation to increase functions related to food production and habitat conditions during periods of inundation.

3.4.3.3 CM6 Channel Margin Habitat Enhancement

The BDCP Implementation Office will provide for the enhancement of 20 linear miles of channel margin habitat in the Delta. This conservation measure is directed at improving habitat conditions for covered fish, wildlife, and plant species along Delta channel banks (as measured along one bank line of channels) by improving channel geometry and restoring riparian, marsh, and mudflat habitats along levees. Channel margin habitat will be enhanced only along channels that serve as important rearing and outmigration habitat for juvenile salmonids. Although channel margin enhancements are intended to provide specific benefits for salmonids, enhancement of these habitats is also expected to improve or restore habitat for other species of covered fish, wildlife, and plants that inhabit channel margin habitats. This measure will be implemented along channels protected by federal Project and/or non-Project levees within the

Plan Area. Channel margin habitat enhancements associated with Project levees will be not be implemented on the levee, but rather on benches to the outboard side of such levees (Figure 3-X [*to come*]). Based on results of effectiveness monitoring for this conservation measure, the BDCP 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. Channel margin habitat enhancement is measured along one side of a channel.

Channel margin enhancement actions will be located along channels that serve as primary rearing and outmigration habitat for juvenile salmonids. These locations include the Sacramento River between Freeport and Walnut Grove, the San Joaquin River between Vernalis and Mossdale, and Steamboat and Sutter Sloughs that are protected by federal Project levees and salmonid migration channels in the interior Delta, such as the North and South Forks of the Mokelumne River, that are protected by non-Project levees. The following are minimum geographic requirements for the 20 miles of channel margin enhancement under this measure:

- At least 5 miles will be located along the Sacramento River between Freeport and Walnut Grove;
- At least 5 miles will be located along the San Joaquin River between Vernalis and Mossdale; and
- The remaining 10 miles will be distributed among the channels described in the preceding paragraph.

The following are the temporal targets for implementation of the 20 miles of channel margin habitat enhancements:

- At least 5 miles enhanced by year 10 of Plan implementation;
- At least 5 miles enhanced by year 20 of Plan implementation;
- At least 5 miles enhanced by year 25 of Plan implementation; and
- At least 5 miles enhanced by year 30 of Plan implementation.

Actions to enhance channel margin habitats, as appropriate to site-specific conditions include, but are not limited to:

- Modifying the outboard side of levees or setting back levees to create low floodplain benches designed with variable surface elevations to create hydrodynamic complexity and that support emergent vegetation to provide an ecological gradient of habitat conditions, and higher elevation benches that support riparian vegetation;
- Planting riparian and emergent wetland vegetation on created benches;
- Installing large woody material (e.g., tree trunks and stumps) could be anchored into constructed low benches or into existing riprapped levees to provide similar habitat functions;

- Removing riprap from channel margins where levees are setback to restore seasonally inundated floodplain habitat under CM5 Seasonally Inundated Floodplain Restoration; and
- Modifying channel geometry in unconfined channel reaches or along channels where levees are setback to restore seasonally inundated floodplain habitat under CM5 Seasonally Inundated Floodplain Restoration, to create backwater salmonid and splittail rearing and splittail spawning habitat.

A conceptual depiction of how channel margin habitat may be enhanced is presented in Figure 3-X [*to come*].

Because channel margin habitat enhancement is expected to require modification of channels and levees that serve flood control functions, channel margin habitat enhancements will be implemented such that flood control functions are maintained or improved. The BDCP Implementation Office will coordinate channel margin habitat enhancement planning with the flood control planning efforts of USACE, DWR, the Central Valley Flood Protection Board, and other flood control agencies to assess the desirability and feasibility for channel modifications. Channel margin habitat enhancements will be designed to support the ecological benefits for covered species described below in *Hypothesized Benefits*.

Restoration variables that will be considered in the location and design of enhanced channel margin habitat include:

- The length of habitat that can be practicably enhanced along channel margins;
- Connectivity with existing channel margin habitats supporting high functioning salmonid rearing habitat;
- The cross sectional profile of enhanced channels (elevation of habitat, topographic diversity, width, variability in edge and bench surfaces, depth, and slope);
- The amount and distribution of installed woody debris along enhanced channel margins; and
- The extent of shaded riverine aquatic overstory and understory vegetative cover needed to provide future input of large woody debris.

Problem Statement

Primary Delta channels serve as movement corridors for the covered fish species and support splittail spawning and salmonid, sturgeon, and splittail rearing habitat. These channels are now leveed and, as such, channel margin habitats lack the diversity and complexity of habitat conditions associated with unmodified channels. Increasing the diversity and complexity of channel margin habitats is expected to increase their function as habitat for covered fish species. Specifically, providing for channel margin habitat complexity along migration corridors for outmigrating juvenile Chinook salmon may increase survivorship through reductions in predation and increases in food availability.

Hypothesized Benefits

Enhancement of channel margin habitat is hypothesized to provide the following ecosystem and covered species benefits. As described in Chapter 5, *Effects Analysis,* and Appendix F, *DRERIP Evaluation Results*, however, there are a number of uncertainties regarding the level of benefits that may be provided by enhancing channel margin habitat as well as risks for adverse consequences. These uncertainties will be addressed through effectiveness monitoring, research, and the adaptive management program (Sections 3.6 and 3.7).

Enhancing channel margin habitats is expected to:

- Increase the quality of rearing habitat area for Chinook salmon, sturgeon, and possibly steelhead (Sommer et al.2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- Reducing the risk for predation on covered fish species by nonnative fish predators;
- Increase the extent of shaded riverine aquatic cover and increase instream cover by through contributions of instream woody material (USFWS 2004);
- Increasing connectivity among salmonid rearing and outmigration habitat areas;
- Provide inputs of organic material (e.g., leaf and twig drop) in support of aquatic foodweb processes;
- Increase production and export of terrestrial invertebrates into the aquatic ecosystem (Nakano and Murakami 2001);
- Create additional spawning habitat for Sacramento splittail by creating low velocity backwater habitats (Sommer et al. 2001a, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006); and
- Create tidal mudflat substrate suitable for the establishment of Suisun Marsh aster, Mason's lilaeopsis, Delta mudwort, and Delta tule pea and coarse woody debris substrate suitable for side-flowering skullcap.

Restoration of riparian forest and scrub that is incorporated into channel margin enhancements is also expected to support habitat for valley elderberry longhorn beetle, Swainson's hawk, white-tailed kite, and potentially, depending on vegetative structure and patch size, yellow-breasted chat and least Bell's vireo. Increasing the extent of large woody material will enhance habitat for western pond turtle.

Adaptive Management Considerations

Implementation of channel margin habitat enhancement actions 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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results, likely elements of this measure that could be adjusted through the adaptive management process include adjusting the design of subsequent channel margin restoration actions to improve habitat functions for covered fish species and increasing the effectiveness of emergent and riparian vegetation establishment techniques.

3.4.3.4 CM7 Riparian Habitat Restoration

The BDCP Implementation Office will restore 5,000 acres of riparian forest and scrub. It is anticipated that riparian forest and scrub will be restored primarily in association with the restoration of tidal and floodplain habitats and channel margin habitat enhancements. The following are the temporal targets for riparian restoration:

- 400 acres restored by year 15 of Plan implementation; and
- 5,000 acres (cumulative) restored by year 40 of Plan implementation.

Anticipated actions to restore riparian forest and scrub, as appropriate to site-specific conditions, include, but are not limited to:

- Acquiring lands, in fee-title or through conservation easements, suitable for restoration of riparian forest and scrub;
- Allowing for the natural establishment of riparian vegetation;
- Site preparation, planting of native riparian vegetation, and maintenance of plantings;
- Irrigation of plantings; and
- Control of nonnative plants.

Patches of restored riparian forest and scrub are expected to support the range of riparian habitat conditions necessary to support habitat for each of the riparian-associated covered wildlife species. Once established, it is expected that restored riparian forest and scrub will be self-sustaining and will be monitored to determine if subsequent management actions may be required to ensure successful regeneration of native riparian plant species.

Riparian Restoration in Restored Floodplains

To the extent consistent with flood control requirements, restored floodplain habitat areas (Figure 3-57 and CM5) will allow for the natural establishment and growth of woody riparian vegetation on portions of restored floodplains that support appropriate soils and hydrology and along channels within restored floodplains. Restored floodplain riparian vegetation is expected to establish in large extensive patches relative to the typically narrow stringers of riparian vegetation that exist along channels and agricultural water conveyance features within much of the Plan Area.

Native riparian vegetation (e.g., Fremont cottonwood, Goodings' willow, box elder) will be planted if site-specific restored floodplain conditions indicate that such plantings will substantially increase the establishment of riparian forest and scrub. Elderberry shrubs will be a component of such plantings to provide habitat for the valley elderberry longhorn beetle. The development of riparian vegetation will be monitored to determine if nonnative vegetation needs to be controlled to facilitate the establishment of native riparian vegetation or if restoration success could be improved with supplemental plantings of native riparian vegetation. If indicated by monitoring, nonnative vegetation control measures and supplemental plantings will be implemented.

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 within ROAs (Figure 3-2 and CM4) 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, West Delta, and South Delta ROAs. In these ROAs, riparian vegetation is expected to generally form as a band of riparian forest and scrub 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 clayey 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 small patches where suitable soil conditions are present. Additionally, where conditions are appropriate woody riparian vegetation will be planted on new levees that are constructed by the BDCP Implementation Office within ROAs to provide for the restoration of tidal habitat. As described for riparian restored in floodplains, native riparian vegetation may 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, including elderberry shrubs, will be planted along channel margins on benches outboard of existing levees (Figure 3-X [to come] and CM6) to enhance covered fish and wildlife species habitat. Riparian vegetation restored in these locations is expected to form narrow stringers of riparian forest and scrub along enhanced channel margins.

Directed Riparian Restoration. At least 300 acres of the 5,000 acres of restored riparian forest and scrub will be located in Conservation Zone 7 and/or 8 (Figure 3-5) within or contiguous with occupied or potentially occupied riparian brush rabbit habitat along the San Joaquin River, Old River, and/or Middle Rivers or suitable tributaries. This restored habitat will be designed and managed to specifically support riparian scrub with an open overstory that includes dense brush and thickets of wild rose, wild grape, and blackberry that supports this species habitat. An additional 300 acres will be restored in similar locations within Conservation Zone 7 to provide suitable habitat for the riparian woodrat. This restored habitat will be designed and managed to specifically support riparian habitat that includes a moderately dense midstory of willow scrub and an overstory of valley oak.

Problem Statement

Substantial reduction in the extent, distribution, and condition of Valley/foothill riparian communities that historically occurred along the upper elevational margins of the Delta and along natural levees along Delta and Suisun Marsh channels has reduced the extent and diversity of valley/foothill riparian habitats for associated covered and other native species. Most existing levees were not designed (e.g., steep banks, rip-rap) to incorporate riparian vegetation that support habitat for covered fish and wildlife species and have created increased habitat for nonnative predatory fish and thus contribute to increased predation losses of covered fish species.

A lack of riparian habitat associated with existing and restored tidal aquatic and marsh habitats limits the ecological benefits to fish and wildlife by limiting important ecological gradients and ecosystem functions that a full suite of these habitats would provide. Restoring Valley/foothill riparian habitats to establish a more natural ecological gradient extending from shallow subtidal aquatic to 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 Planning Area and Suisun Bay, improve genetic interchange among native riparian-associated species' populations, and contribute to the long-term conservation of riparian-associated covered species.

Hypothesized Benefits

Restoration of valley/foothill riparian forest and scrub is hypothesized to provide the following ecosystem and covered species benefits described below. As described in Appendix F, DRERIP Evaluations, however, there are a number of uncertainties regarding the level of benefits that may be provided by restored riparian habitats as well as risks for adverse consequences. These uncertainties will be addressed through effectiveness monitoring, research, and the adaptive management program (Sections 3.6 and 3.7).

Restoring valley/foothill riparian forest and scrub is expected to:

- 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 phytoplankton, zooplankton, and macroinvertebrates that serve as or support production food for covered fish species;
- Increase the extent of shaded riverine aquatic cover and increase instream cover where riparian forest and scrub is restored adjacent to channels through contributions of instream woody material (U.S. Fish and Wildlife Service 2004);
- Increase in the production and export of terrestrial invertebrates into the aquatic ecosystem (Nakano and Murakami 2001) where riparian forest and scrub is restored adjacent to channels;
- Increase the extent of riparian brush rabbit, riparian woodrat, Swainson's hawk, white-tailed kite, yellow-breasted chat, and valley elderberry longhorn beetle habitat; and
- Increase the extent of least Bell's vireo, western yellow-billed cuckoo, and riparian woodrat for potential future occupancy by these species through future expansion of their range; and
- Create coarse woody debris substrate suitable for side-flowering skullcap.

<u>*Adaptive Management Considerations*</u>

Implementation of riparian restoration actions and subsequent management of restored riparian habitats 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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results, likely elements of this measure that could be adjusted through the adaptive management process include riparian vegetation establishment methods, locations selected for restoration of riparian forest and scrub, and post-restoration management actions that may be need to be implemented to ensure that intended habitat functions of restored riparian habitats are maintained over time.

3.4.3.5 CM8 Grassland Communities Restoration

The BDCP Implementation Office will provide for the restoration of 2,000 acres of grassland within the BDCP CZs 1, 8, and/or 11 (Figure 3-6). The restored grassland habitat will be designed and located such that it supports habitat for associated covered species, improves connectivity among existing patches of grassland and other natural habitats, and improves the native wildlife habitat functions of transitional uplands adjacent to BDCP restored tidal habitats. Opportunities for improving connectivity and increasing the habitat functions of existing grassland habitats include linking or providing wildlife movement corridors to much larger habitat areas immediately outside of the Plan Area. The most strategically important areas are a connection between CZs 1 and 11 in the Jepson Prairie area and connecting BDCPs CZ 8 to other high quality grassland habitat to the west and southwest of the Plan Area.

Anticipated actions to restore grassland habitat, as appropriate to site-specific conditions, will include, but not be limited to:

- Acquiring lands, in fee-title or through conservation easements, that have site characteristics (e.g., soils, proximity to high value habitat areas) that support restoration of high functioning grassland high value habitat.
- Restoring grassland by sowing native species using a variety of techniques that include seed drilling, native hay spreading, and plugs as appropriate. Seed sown on the sites will be from collections or increases from seed collected at the nearest practicable natural site with similar ecological conditions. Restoration actions my require the recontouring of graded land as appropriate and should generally be targeted to parcels with low soil fertility and which have not been used for intensive crop production. These areas could also function as seed nurseries to produce seed that could be planted on other portions of the site.
- Potentially restoring grazing grassland habitat to modify its vegetation; this is a complex management problem if the grassland contains native bunchgrasses, geophytes, vernal pool complex, or alkali seasonal wetland complex and will require site and pasture specific solutions like those described in CM9 Vernal Pool Complex Restoration.

Problem Statement

Implementation of BDCP actions will result in the removal of grassland natural community. Restoration of grasslands, therefore, is necessary to ensure that the current habitat functions supported by affected grasslands for associated covered and other native species are maintained.

Hypothesized Benefits of BDCP Actions

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. Restoration of grassland habitat will increase the extent and quality of grassland habitat available for use by covered and other native associated species and thus contribute to their conservation. BDCP covered species predicted 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 A, Covered Species*, for specific life history requirements met by the grasslands natural community).

Adaptive Management Considerations

Implementation of grassland habitat restoration actions will be informed through effectiveness monitoring that will be conducted for this conservation measure as described in Section 3.6 *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results and data compiled from other sources, likely elements of this measure that could be adjusted through the adaptive management process include considerations for selecting restoration locations; methods for establishing and maintaining the desired plant species in restored grasslands, and nonnative vegetation control techniques.

3.4.3.6 CM9 Vernal Pool Complex Restoration

The BDCP will provide for the restoration of 200 acres of vernal pool complex within Conservation Zones 1, 8, and/or 11 (Figure 3-6). The extent of restored vernal pool complex will include a matrix of grassland or alkali seasonal wetland complex in which vernal pools, swales, and saturated alkaline soil areas are adjacent or interspersed and which are found in habitat gradients that vary by Conservation Zone and include tidal freshwater or tidal brackish emergent wetlands, adjoining transitional upland habitat, grassland, alkali seasonal wetlands, and agriculture. The 200 acres will be distributed in Conservation Zones 1, 8, and 11 in a manner that will achieve conservation objectives for associated covered species. The BDCP Implementation Office will select specific restoration sites within these Conservation Zones based on the suitability of available lands for restoration, biological value, and practicability considerations.

Anticipated actions to restore vernal pool complex habitat, as appropriate to site-specific conditions, include but are not limited to:

- Acquiring lands, in fee-title or through conservation easements, suitable for restoration of vernal pool complex habitat;
- Restoring remnant natural vernal and swale topography 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 on the arrangement and bathymetry of natural reference vernal pools and swales;
- Restoring and maintaining natural hydrology by removing impediments to natural runoff such as roads, berms, field drains, storm drains, etc.;
- Restoring and maintaining natural hydrology by removing non-natural supplemental sources of surface water originating from flood irrigation, drainage and irrigation canal turnouts, impermeable surfaces, leaking stock ponds, culverts, etc.;
- Restoring and maintaining natural salt and suspended clay concentrations in vernal pool water;

- Significantly reducing or preventing the deposition of substances that increases the fertility of the habitat such as manure, runoff from cattle or sheep congregation areas, runoff from dairies, etc.;
- Controlling the cover of invasive nonnative plant species such as perennial pepperweed, swamp timothy, Italian ryegrass, etc.;
- Adjusting livestock grazing regimes in vernal pool complexes to improve habitat functions of vernal pools for covered and other native vernal pool species;
- Preventing the introduction of the propagules of invasive species during restoration, maintenance, outreach, and other activities that occur on the site; and
- Hand collecting seed and vernal pool invertebrates from the vicinity of the vernal pools to be restored will be used to establish native species. Soil inoculum should not be used to establish vernal pool plants and animals in these Conservation Zones unless the source vernal pools are free of perennial pepperweed, swamp timothy, and Italian ryegrass which 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 Barona et al. 2007 for problems of nonnative species thatch buildup due to soil inoculum).

Restored vernal pool complex habitat will be designed and managed to provide the ecological benefits for covered species described under the Hypothesized Benefits section below. Habitat will be restored on sites that historically supported vernal pool complex, thus ensuring that soil types that support vernal pools are present.

Restoration variables that will be considered by the BDCP Implementation Office in the design of restored vernal pool complex habitat include:

- The spatial distribution of existing restored vernal pool complex habitat within the Delta;
- The distribution of soils that historically supported vernal pool complex;
- An analysis of historical aerial photography, survey records, or other information and vernal pool and swale restoration will be limited to the visual signatures indicated in that data and contoured using bathymetry data from similar vernal pools in the same Conservation Zone; and
- The predicted tidal range adjacent to tidal habitat restoration sites in Conservation Zone 1 and 11.

Restoration design considerations for vernal pool complex habitat will include the following:

Vernal Pool Complex Vegetation. To provide for high functioning habitat, restored vernal pool complex will be vegetated with hand collected seed from appropriate areas within the same Conservation Zone as the planned restoration action. Soil inoculum will not be used unless the source vernal pools are free of perennial pepperweed, swamp timothy, and Italian ryegrass.

However, prior to any seed collection actions occurring, where physical restoration actions such as excavation are undertaken to restore the hydrology of vernal pool complex habitat, the hydrographs, inundation depths, and water chemistry (particularly salt and boron concentrations) of the restored vernal pool complex will be compared with reference vernal pool complex habitat in the same areas. Following establishment of restored habitat will be monitored to assess the establishment of invasive nonnative plants. If indicated by monitoring results, the BDCP Implementation Office will implement invasive plant control measures to help ensure the establishment of native vernal pool plant species.

Vernal Pool Complex Invertebrates. Propagules of covered vernal pool invertebrate species may be introduced into the restored vernal pools through the movement of individuals. Introductions will not be made through the use of soil inoculum unless the source vernal pools are free of perennial pepperweed, swamp timothy, and Italian ryegrass.

Hydrological Conditions. Vernal pool complex habitat restoration will be designed based on the historical patterns of vernal pools and swales present on the restoration site as indicated by aerial photography and vernal pool bathymetry will be based on natural undisturbed vernal pools in the same area.

Problem Statement

Implementation of BDCP actions will result in the removal of vernal pool complex. Restoration of vernal pool complex, therefore, is necessary to ensure that the current habitat functions supported by affected vernal pools for associated covered and other native species are maintained.

Hypothesized Benefits

Restoration of vernal pool complex habitat will increase the extent of habitat for vernal pool complex-dependent covered species.

Adaptive Management Considerations

Implementation of vernal pool complex habitat restoration actions and subsequent management of restored vernal pool complex habitats 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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results and data compiled from other sources, likely elements of this measure that could be adjusted through the adaptive management process include considerations for selecting restoration locations within the distribution of vernal pool complex habitat among CZs 1 and 8, methods for restoring and maintaining the necessary hydrology and water chemistry, methods for establishing the desired species in the habitat, and nonnative vegetation and wildlife control techniques.

3.4.3.7 CM10 Nontidal Marsh Restoration

The BDCP will provide for the restoration of 400 acres of nontidal freshwater marsh within Conservation Zones 2 and 4 (Figure 3-4). Restored habitat will be distributed in patches of at least 25 acres and associated with occupied giant garter snake habitat within the proposed 1,000-acre giant garter snake preserves designed to enhance the Caldoni 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. Restored habitat will include preserved transitional upland habitat to provide upland habitat for giant garter snake and western pond turtle, and nesting habitat for waterfowl.

Though not a conservation target, patches of existing nontidal freshwater perennial emergent wetland present on lands acquired to protect other natural communities will also be protected and enhanced to improve habitat functions and values for covered and other native species.

Anticipated actions to restore nontidal freshwater perennial emergent wetland, as appropriate to site-specific conditions, include, but are not limited to:

- Acquiring lands, in fee-title or through conservation easements, suitable for restoration of nontidal freshwater perennial emergent wetland;
- Securing sufficient annual water to sustain habitat function;
- Creating complex habitat with open water and edge habitats, tule-dominated vegetation, bank slopes with variable angles, adjacent upland with open canopy and elevational gradient to promote mammal burrows and higher elevation refugia;
- Establishing connectivity with the existing water conveyance system and habitats occupied by giant garter snakes;
- Allowing for the natural establishment of marsh vegetation;
- Site preparation, planting of native marsh vegetation, and maintenance of plantings; and
- Control of nonnative plants.

Patches of restored nontidal freshwater perennial emergent wetland are expected to support the range of habitat conditions necessary to support habitat for each of the nontidal freshwater perennial emergent wetland-associated covered wildlife species. Once established, it is expected that restored nontidal freshwater perennial emergent wetland will be self-sustaining and will be monitored to determine if subsequent management actions may be required to ensure successful regeneration of native marsh plant species.

Nontidal freshwater perennial emergent wetland will be established where soils and hydrology are suitable through conversion of existing agricultural lands to a freshwater marsh-perennial aquatic complex. Restored marshes will also occur in association with adjacent grassland, pastureland, or cultivated uplands. Grading will be required to establish an elevation gradient to support both open water perennial aquatic habitat intermixed with shallower marsh habitat. 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 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.

Problem Statement

The ecological function of nontidal freshwater perennial emergent wetland is limited because it occurs in highly fragmented and small patches within the Planning Area and adjacent lands. Associated with nontidal permanent aquatic and riparian communities, 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 nontidal freshwater perennial emergent wetland habitats 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 within the Central Delta, the species is known primarily from nontidal freshwater perennial emergent wetland within 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 freshwater perennial emergent wetlands, 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 freshwater perennial emergent wetland 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 freshwater perennial emergent wetland to re-establish 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.

Hypothesized Benefits

Restoring nontidal freshwater perennial emergent wetland is expected to:

- Provide essential marsh and aquatic habitat for giant garter snake and western pond turtle;
- Enhance the Caldoni Marsh-White Slough and Yolo Basin-Willow Slough giant garter snake populations by increasing the extent and quality of available habitat;
- Provide nesting habitat for tricolored blackbird; and
- Increase the spatial extent and distribution of habitat available to associated covered and other native wildlife and will increase the diversity and complexity of the mosaic of habitats supported in the Plan Area and adjacent lands.

Adaptive Management Considerations

Implementation of nontidal freshwater perennial emergent wetland restoration actions and subsequent management of restored marsh habitats 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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on analysis of monitoring results, likely elements of this measure that could be adjusted through the adaptive management process include marsh vegetation establishment methods, locations selected for restoration of nontidal freshwater perennial emergent wetland, and post-restoration management actions that may need to be implemented to ensure that intended habitat functions of restored nontidal freshwater perennial emergent wetland are maintained over time.

3.4.3.8 CM11 Natural Communities Enhancement and Management

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. Management plans will provide the information necessary to guide habitat enhancement and management actions necessary to achieve the biological objectives established for the conserved lands addressed by each plan. Within two years of acquisition of conserved parcels, the Implementation Office will conduct surveys to collect the information necessary to assess the level of ecological condition and function of conserved species habitats and supporting ecosystem processes. Based on results of the assessment, the Implementation Office will identify habitat enhancement actions to be implemented to enhance habitat functions for the target covered species and any subsequent ongoing management actions that are necessary to maintain habitat functions over time. Survey data will also collect the information necessary to establish base ecological conditions from which the effectiveness of enhancement and management measures can be evaluated through subsequent effectiveness monitoring.

The content of management plans will include, but not be limited to, a description of:

- The biological goals and objectives to be achieved with the preservation and management of the parcels;
- Base 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;
- The incorporation of 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 land uses and management practices and their relationship to covered species habitat functions;
- Applicable permit terms and conditions;
- Terms and conditions 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; and
- 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 Actions

Listed below are enhancement and management actions for the natural communities described in Section 3.3.2.2, *Natural Community Goals and Objectives*. The application of these or other management actions will depend on site-specific conditions and targeted biological values. Specific management actions will be included in each site-specific management plan described above. Management actions are designed to meet the biological goals and objectives of each natural community and covered species.

Tidal Aquatic and Wetland Natural Communities

Approximately 65,000 acres of tidal habitat restoration is planned for the Plan Area. This includes 7,000 acres of brackish tidal habitat in the Suisun Marsh ROA in Conservation Zone 11 and approximately 14,000 acres of freshwater tidal habitat distributed among 4 ROAs, including 5,000 acres in the Cache Slough ROA in Conservation Zones 1 and 2; 1,500 acres in the Cosumnes/Mokelumne ROA in Conservation Zone 4; 2,100 acres in the West Delta ROA in Conservation Zones 5 and 6; and 5,000 acres in the South Delta ROA in Conservation Zone 7. This restoration will create and protect substantial habitat for several covered species including salt marsh harvest mouse, Suisun shrew, California clapper rail, California black rail, Suisun song sparrow, California least tern, Mason's lilaeopsis, Suisun Marsh aster, Delta tule pea, Delta mudwort, and soft bird's-beak. Tidal wetland restoration in Conservation Zones 4, 5, 6, and 7 is also expected to provide additional habitat for tricolored blackbird, greater sandhill crane, and giant garter snake. The following measures will be implemented to manage and enhance the tidal wetland conservation lands.

- Create or maintain upland areas that can serve as refugia during high tide events (e.g., grassland patches for salt marsh harvest mouse);
- Create two nesting habitat areas consisting of gravel or sandy elevated mounds for California least terns along the margins of tidal perennial aquatic natural community areas on BDCP lands. The BDCP Implementation Office will collaborate with species experts to determine appropriate locations, materials, and dimensions of created sites.
- Restore brackish marsh habitats in a sequenced manner to minimize disturbance to adjacent habitats;
- Maintain habitat connectivity and corridors for species' movement between restored sites and restored and existing habitats;
- Maintain appropriate habitat patch sizes for covered species. The BDCP Implementation Office will consult with species experts to determine appropriate patch sizes and other elements of restoration design relevant to covered species;
- Nonnative predatory species are an important stressor for several covered species (e.g., California black and clapper rails). The establishment and abundance of nonnative predatory species will be controlled with habitat manipulating techniques or trapping;

- Where California least terns or tricolored blackbirds are found nesting, and to the extent feasible, protect and establish appropriate buffer zones around occupied sites to minimize disturbance;
- Reduce and then maintain the population size of feral pigs in Suisun Marsh to levels at which their rooting impacts on tidal marsh plain vegetation does not significantly impact covered species;
- Exclude cattle grazing from Suisun thistle and soft bird's-beak habitat;
- 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;
- Conduct research to determine if fire is beneficial for tidal marsh management and its effects on covered communities and species; and
- Conduct research to determine effective methods for increasing the extent of Suisun thistle and soft bird's-beak in Suisun Marsh.

*[**Note to reviewers:** Additional management tools to address fisheries habitat will be added to this section.]*

Nontidal Aquatic and Wetland Natural Communities

In association with the development of two 1,000 acre preserves for the giant garter snake, 400 acres of nontidal freshwater marsh will be restored. A portion of the 400 acres will be restored to support the protection and expansion of the Yolo/Willow Slough subpopulation in Conservation Zone 2 and a portion will be restored to support the protection and expansion of the Caldoni Marsh/White Slough subpopulation in Conservation Zone 4. The BDCP Implementation Office, through consultation with species experts will determine the number of acres that will be restored in each area based on the level of existing protection and available habitat, and restoration opportunities. The marsh restoration, which will include both emergent wetland and open water habitats, will be coordinated with acquisition of agricultural lands that will make up the 1,000 acre preserves. It is expected that agricultural lands within the preserves, in additional to providing the water conveyance system that will be managed as suitable giant garter snake aquatic habitat and adjacent upland habitat, will also provide suitable foraging habitat for Swainson's hawk, white-tailed kite, and tricolored blackbird. It is also expected that the restored nontidal wetland will provide habitat for nesting tricolored blackbirds and aquatic and cover habitat for western pond turtle. Management plans will be prepared for the Coldani Marsh/White Slough and the Yolo/Willow Slough giant garter snake preserves to guide nontidal wetland restoration activities and associated agricultural land management. The Implementation Office will consult with species experts to develop these plans that will describe site selection, configuration and channel design, water management, vegetation composition, and long-term management of the preserves. The following measures will be addressed in the management plans and implemented to manage and enhance the nontidal wetland and associated giant garter snake preserves.

- Vegetation density and composition, water depth, and other habitat elements will be managed to enhance habitat values for giant garter snakes;
- Upland refugia (islands or berms) will be created and maintained within the restored marsh;
- Permanent buffer zones at least 200 feet wide will be established around all developed wetland habitats to provide undisturbed (uncultivated) upland cover and aestivation habitat immediately adjacent to aquatic habitat;
- Bank slopes and upland buffer habitats will be managed to enhance giant garter snake use, provide cover, and encourage burrowing mammals for purposes of creating aestivation sites for giant garter snake;
- Establish seasonal buffer zones around aquatic habitats to reduce disturbance and improve foraging habitat for tricolored blackbirds;
- Control human and pet access into wetland areas;
- Nontidal and wetland communities may be dominated by bullfrogs and other nonnative predatory species limiting the abundance of covered amphibians and reptiles. Habitat management and enhancement will include trapping and other techniques to control the establishment and abundance of nonnative predators; and
- Limit cattle access to wetland vegetation to the extent necessary to prevent significant deterioration of habitat of covered species.

Riparian Natural Community

Over 5,000 acres of riparian scrub and woodland will be restored in the Plan Area. The majority is expected to develop in Conservation Zone 7 associated with the San Joaquin, Old, and Middle River systems, but riparian habitat will also develop in other Conservation Zones in association with tidal habitat, floodplain, and channel margin restoration. Restored valley/foothill riparian is expected to provide substantial habitat for several riparian-associated covered species. Yellow-breasted chat, least Bell's vireo, riparian brush rabbit, and riparian woodrat will benefit from the establishment of willow scrub and early successional riparian habitats that are expected to develop in association with tidal habitat and floodplain restoration; yellow-billed cuckoo, Swainson's hawk, and white-tailed kite will benefit from the future development of cottonwood-willow forest; and Swainson's hawk and white-tailed kite will benefit from all mature riparian habitats that provide suitable nesting structure. Nesting habitat for Swainson's hawk and white-tailed kite is expected to develop in association with tidal habitat and floodplain restoration and from the restoration of planted riparian habitats along channel margins. Riparian brush rabbit and riparian woodrat will also benefit from directed riparian restoration along channel margins. The following measures include those that will apply to all conserved riparian communities and where noted others apply to lands acquired to manage species-specific values.

- Control nest parasitism (e.g., through cowbird trapping);

- Control the establishment and abundance of nonnative predatory species (e.g., bullfrogs);
- Plant native plant species to improve habitat functions for covered and other native species (e.g., blue elderberry for valley elderberry longhorn beetle, willows for yellow-breasted chat);
- Establish buffers along riparian habitats to minimize the disturbance affects to nesting covered species;
- Establish uncultivated buffers adjacent to riparian habitats to protect the integrity of the stream corridor and associated riparian vegetation and to promote regeneration of riparian species;
- Manage the structure and composition of restored riparian areas to meet the habitat objectives established for riparian brush rabbit, riparian woodrat, Swainson's hawk, white-tailed kite, yellow-breasted chat, least Bell's vireo, and yellow-billed cuckoo;
- Install woody debris in stream channels to create pools to increase the diversity of micro-habitats;
- Where appropriate, remove riprap along channel banks and alter stream channel geomorphology to improve hydrologic conditions that support the regeneration of riparian vegetation and improve habitat functions for aquatic species;
- Prepare a restoration plan for the restoration of 300 acres of riparian habitat for the riparian brush rabbit and 300 acres for the riparian woodrat. Consult with species experts to determine appropriate location, species composition, structure, and patch size, and to develop management guidelines;
- Within riparian brush rabbit restoration areas, create upland refugia (i.e., bunny mounds) to provide protection against flooding. Consult with species experts to determine appropriate location, size, and composition.
- Establish and implement a nonnative species control program to control species such as Himalayan blackberry, giant reed, perennial pepperweed, black locust, and fig where their presence is undesirable; and
- Limit cattle access to riparian and other wetland vegetation to the extent necessary to prevent significant deterioration of habitat of covered species.

Grasslands and Associated Seasonal Wetland Natural Communities

Over 10,000 acres of grassland, vernal pool complex, and alkali seasonal wetland will be protected or restored in Conservation Zones 1, 8, and 11 to support and protect San Joaquin kit fox, Swainson's hawk, white-tailed kite, tricolored blackbird, California red-legged frog, California tiger salamander, and western spadefoot toad populations. The following measures include those that will apply to all conserved grassland communities and where noted others apply to lands acquired to manage species-specific values.

- 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 experimental plots that generate information describing the long term trends of management actions, and include experimental treatments for most likely management alternatives, and appropriate controls.
- Where appropriate, manipulate topography or manage vegetation to attract ground squirrels and other small mammals to: (1) increase the availability of aestivation and nesting burrows for California red-legged frog and California tiger salamander; and (2) increase prey availability for San Joaquin kit fox, Swainson's hawk, white-tailed kite, and other native wildlife predators.
- Reduce rodent control (e.g., poisoning, hunting, and trapping), where appropriate, in conserved grasslands. Note that rodent control measures will likely remain necessary in certain areas where dense rodent populations may compromise important infrastructure (e.g., levees, pond berms, road embankments, and water conveyance structures).
- Fence portions of stock ponds in Conservation Zone 8 to prevent livestock entry, encourage emergent wetland growth, and facilitate California red-legged frog and California tiger salamander use.
- Develop management protocols for stock ponds (e.g., seasonal draining) in Conservation Zone 8 grassland habitats to control bullfrogs and predatory fish and facilitate use by California red-legged frogs and California tiger salamanders.
- Protect grassland movement corridors between aquatic and upland California red-legged frog and California tiger salamander aestivation sites.
- Where lands neighboring preserves require ground squirrel management to protect agricultural uses or public health, establish a buffer zone in the preserve within which ground squirrel colonies will not be encouraged or may be controlled. The width of this buffer will be determined by the preserve 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.
- Where appropriate, install artificial nesting burrows or create elevated berms, mounds, or debris piles for western burrowing owl to facilitate use of unoccupied areas.
- Install perching structures to facilitate use by western burrowing owl, Swainson's hawk, and white-tailed kite.
- For vernal pool complex and alkali seasonal wetland complex, restore and maintain natural hydrology and eliminate supplemental sources of water and structures that increase or decrease the duration of natural vernal pools. If grazed, provide grazing

animals with supplemental sources of water located in the uplands away from vernal pools.

- 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. BDCP 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 immediate need to alter them or site specific data is acquired through scientific studies 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.
- 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.
- Herbicide application may be necessary to control heavy infestations of nonnative plants and re-seed with native species.
- Any seed supplements in native grasslands must use locally derived genetic stock. To maximize the success of seed addition, pretreatments (e.g., burning one year prior to seeding to reduce weed seeds on the surface and in litter) can be utilized.

Inland Dune Scrub

The BDCP Implementation Office will support ongoing efforts to manage and enhance inland dune scrub and to reestablish dune scrub-associated covered species populations through the following actions:

- Support the funding of the USFWS program for management, enhancement, and monitoring of inland dune scrub natural community at the Antioch Dunes National Wildlife Refuge at an annual amount of $XX.XX for X;
- Provide funding to support the USFWS program for the captive breeding and release of Lange's metalmark butterfly at an annual amount of $XX.XX for X years; and

- Support the funding of the USFWS program for propagation and out-planting programs for Contra Costa wallflower and Antioch Dunes evening primrose at an annual amount of $XX.XX for X years.

No acquisition of lands to protect inland dune scrub natural community is proposed.

Agricultural Lands and Managed Wetlands

Agricultural lands will be acquired and managed to support and protect Swainson's hawk, white-tailed kite, greater sandhill crane, tricolored blackbird, and giant garter snake populations. Between 12,000 and 28,000 acres of non-rice agricultural lands and 4,600 acres of rice lands are included in the conservation strategy and that will be managed to provide value to targeted covered species. Agricultural land acquisition is expected to occur throughout the Plan Area, but primarily in Conservation Zones 1, 2, 4, 5, and 7. The following measures include those that will apply to all conserved agricultural lands and where noted others apply to lands acquired to manage species-specific values.

- Minimize or discontinue pesticide use to reduce negative impacts on wildlife including direct, lethal toxicity, reproductive failures, and teratogenic effects.
- Retain hedgerows, wetlands, riparian communities, grassland edges, ponds, and other natural communities and habitat features that occur within the agricultural matrix.
- Retain tree rows, wood lots or other tree groves, and isolated trees to provide nesting habitat for Swainson's hawk and white-tailed kite.
- Retain or create grassland edges, levee slopes, berms, or patches that provide opportunities for burrowing owl breeding or wintering burrows.
- Enhance burrowing owl habitat along agricultural edges by managing vegetation height, installing perches and artificial nesting structures, where appropriate, and encouraging ground squirrel activity.
- Plant hedgerows on agricultural preserves to provide refugia for rodents, thus increasing rodent prey populations for both the Swainson's hawk and the white-tailed kite.
- Plant small woodlots in field corners or tree rows along field borders to provide nesting habitat for Swainson's hawk and white-tailed kite.
- On agricultural 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 units for this species. This will ensure that Swainson's hawk agricultural foraging value is consistently maintained during the term of the BDCP. To the extent practicable, conserved agricultural lands will focus on the highest value foraging habitat (i.e., alfalfa), but include other crop type rotations and agricultural land uses (e.g.,

irrigated pastures) in order to meet the habitat unit requirement (see species model in Appendix A, *Covered Species Accounts*).

- On agricultural land managed for greater sandhill cranes, crop types will be used that provide high value foraging habitat in order to meet the target number of habitat units for this species. Managed agricultural foraging habitat for cranes will include corn, wheat, alfalfa, and irrigated pasture cover types.
- To increase the value of agricultural lands for sandhill cranes, where feasible, habitat management will include deferment of the tilling of corn and grain fields until later in the fall to increase the amount and availability of forage for sandhill cranes. 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 would gradually become available as senescent plant stalks fall over as a result of weathering).
- To increase the foraging and roosting value of agricultural 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.
- Create and manage two greater sandhill crane roost sites located within Conservation Zones 4, 5, and/or 6. Management actions will include 1) establishing appropriate seasonal wetland vegetation that supports crane roosting habitat; 2) incorporating upland berms situated throughout the seasonal wetland; and 3) maintaining water levels that support crane roosting habitat during the crane winter season. The BDCP Implementation Office will consult with species experts to develop specific design and management criteria for crane roost sites.
- Enhance roosting habitat for greater sandhill cranes by controlling public use.
- Establish seasonal or permanent buffers around riparian and wetland habitats to reduce disturbance of nesting tricolored blackbirds, yellow-breasted chats, and least Bell's vireo.
- Establish upland buffers around canals and ditches that support giant garter snake to reduce disturbance and possible mortality.
- 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.
- Maintain and enhance emergent vegetation in irrigation and other water conveyance canals to provide basking and escape cover for giant garter snakes.
- Where managed wetlands exist, habitat management and enhancement will focus on improving and maintaining site hydrology by grading, excavating, replacing, or installing water control infrastructure.
- On agricultural lands within the giant garter snake preserves (Yolo-Willow subpopulation and Caldoni Marsh-White Slough subpopulation), and other conserved agricultural land

that potentially supports giant garter snake, retain or create connectivity of the water conveyance system to facilitate dispersal and other movement of giant garter snakes.

- To enhance protected lands for wintering waterfowl and shorebird use, where feasible flood harvested corn fields during the fall and winter months.

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.

3.4.4 Species Level Other Stressor Conservation Measures

[***Note to Reviewers***: *The text of this section of Chapter 3, including the other stressors conservation measures described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementation Office will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, state and federal agencies, and the public.*]

This section describes BDCP conservation measures that address other factors potentially affecting covered fish species. These factors, collectively titled "Other Stressors," go beyond issues associated with water operations and physical habitats to address toxic contaminants, other water quality issues (e.g., dissolved oxygen), non-native species, hatcheries, harvest, and non-project diversions that are individually and collectively affecting the productivity of the Delta. As discussed more fully in the Introduction (Section 3.1) and the Methods and Approaches Used to Develop the Conservation Strategy (Section 3.2), the inclusion of these measures into the BDCP reflects the comprehensive nature of the approach to conservation that underlies the BDCP.

A number of these conservation measures address activities that are not currently within the direct control of the BDCP Implementation Office and therefore are proposed to be implemented through agreements with third parties. These agreements will establish reliable mechanisms for the execution and success of these measures by those third parties. In instances where a third party is proposed to implement the conservation measure funded by the BDCP, the BDCP Implementation Office will enter into binding Memoranda of Agreement (MOA) or similarly binding instruments with the third party. These MOAs will describe respective roles and obligations for funding and implementing conservation measures as identified through the process described in each conservation measure. Specific elements of the MOA will describe:

- the specific activities or improvements that would be funded by BDCP;
- the preparation of annual work plans for these activities and improvements;
- the expected benefits of the action for covered species and the aquatic ecosystem;
- the performance metrics that will be measured to verify that the action being implemented has the expected benefit;

- provisions for monitoring, reporting, and documenting work performed; and
- provisions for modifying or terminating MOAs.

The third party will develop annual work plans, acceptable to the BDCP Implementation Office and the fish and wildlife agencies, that describe activities or capital improvements to be funded by BDCP over the course of that year. The third party will be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that work plans have been successfully implemented. The third party will also be responsible for demonstrating the effectiveness of the funded activities to meet objectives as specified in the MOA.

The BDCP Implementation Office and the fish and wildlife agencies will review progress or other relevant reports prepared by the third party 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 the subsequent annual work plans.

3.4.4.1 CM12 Methylmercury Management

*[**Note to Reviewers:** This completely revised version of CM12 Methylmercury Management was provided to the Steering Committee on November 18, 2010, and the Steering Committee has not had the opportunity to review it at this time.]*

The purpose of this conservation measure is to minimize the potential for habitat restoration actions, implemented under the BDCP (CM4 *Tidal Habitat Restoration*, CM5 *Seasonally Inundated Floodplain Restoration*, and CM6 *Channel Margin Habitat Enhancement*), to increase the bioaccumulation of methylmercury in covered and other native species. It is also intended to reduce potential negative effects of methylmercury on important native species that maintain natural communities through herbivory, physical disturbance activities, predator-prey interactions, and other species interactions, or through species regulation of ecosystem processes.

The BDCP Implementation Office will:

1) Conduct pre-acquisition surveys to characterize the mercury content in the soil and other factors that could lead to high rates of methylation in potential habitat restoration areas;
2) After evaluating site characteristics and site conservation goals, prepare habitat restoration designs using measures that, to the extent practicable, will minimize the bioaccumulation of methylmercury in covered and other native species;
3) Conduct monitoring, to the extent practicable, to provide data that will enable the Implementation Office to track the effects of the restoration actions on the bioaccumulation of methylmercury in covered and other native species; and

4) Implement adaptive management actions when monitoring data indicate it is necessary, to the extent practicable, to reduce the bioaccumulation of methylmercury in covered and other native species resulting from tidal habitat and floodplain restoration actions.

The Implementation Office will coordinate with DWR, DFG, the Central Valley Regional Water Quality Control Board (CVRWQCB), and other entities to identify and implement methods for minimizing the methylation of mercury in BDCP restoration areas and the bioaccumulation of methylmercury in covered and other native species.

Problem Statement

There are high concentrations of mercury in the Plan Area due to the continual transport and deposition of historical gold and mercury mining sediment through Delta tributaries. In aquatic systems, anaerobic organisms transform mercury from an inorganic state to a bioavailable and toxic form of mercury (methylmercury). The consumption and bioaccumulation of methylmercury may cause adverse effects to BDCP covered fish and wildlife species. Methylmercury bioaccumulates within individuals and biomagnifies in higher food chain level consumers (CVRWQCB 2010). Biomagnification results in approximately four-fold increases in tissue concentration with each prey-to-predator step up the food chain (Marvin-DiPasquale et al. 2007). As a result, toxic effects of methylmercury are manifested strongly in upper trophic level organisms.

Most of the covered fish species are exposed to methylmercury primarily through the consumption of pelagic prey, and secondarily through direct exposure to high concentrations in the water column; although the latter is substantially lower than the former (Alpers et al. 2008). In addition to their pelagic food web exposure, white sturgeon, North American green sturgeon, and Sacramento splittail are most likely to be affected by high methylmercury concentrations in benthic prey. These fish species are long lived and thereby may accumulate high levels of methylmercury.

Wildlife may be affected by consuming fish or other aquatic organisms that have bioaccumulated methylmercury, or by consuming tidal marsh vegetation that contains methylmercury. Patterns of methylmercury concentration in tidal marsh plant species are complex, as are the grazing dynamics of the wildlife that feed on tidal marsh plants. These factors make it difficult to predict the effects tidal marsh and floodplain restoration actions may have on wildlife species.

Effects of dietary methylmercury on fish include, but are not limited to, endocrine and reproductive problems, liver necrosis, brain lesions, and altered behavior that can result in an increased risk of predation. Bioaccumulation rates in fish may depend on a number of environmental factors in addition to methylmercury concentrations in the water column and/or prey (Alpers et al. 2008); these include growth rate (e.g., seasonality with respect to methylation cycles and/or varied prey availability), foraging in habitats (e.g., preferences can result in foraging in areas with increased propensity for methylation), and food web structure (e.g., temporal and spatial variability in trophic transfer linkages).

High concentrations of methylmercury also have negative effects on birds and terrestrial wildlife (Wolfe et al. 1998). Deleterious effects on bird species from methylmercury consumption include reproductive impairment and reduced juvenile survival (Heinz 1979, Evers et al. 2004, Albers et al. 2007, Ackerman et al. 2008). Methylmercury consumption effects on mammals include anorexia, ataxia, and death (O'Connor and Nielsen 1981, Wren et al. 1987).

Methylmercury is produced by the bacterial mediated chemical synthesis of inorganic mercury with an organic compound under fluctuating oxidation/reduction conditions. Inorganic mercury is widely distributed throughout the Delta, both from mercury mining in the Coast Range and as a legacy from the gold-mining in the Sierras where mercury was used in the mining process. Conditions most conducive to the methylation of mercury typically occur at shallow depths within inundated sediments but can also occur in anaerobic open water. Methylmercury can be lost to the atmosphere through de-methylation or be buried deeply in sediment. Net methylation, the balance between methylation and de-methylation, is controlled by an extensive set of chemical and biological factors which are not well understood, limiting the ability of current science to predict changes resulting from tidal habitat and floodplain restoration. Even less is known about how methylmercury enters the benthic and pelagic food webs and the rates at which enters. It is also not well understood how or if methylmercury is transferred between the benthic and pelagic food webs.

While the data are still being refined and augmented, the general pattern in the Plan Area is that the total mercury and methylmercury of the sediment are not tightly correlated with methylmercury content in fish and clam tissue. Sentinel species tissue concentrations in the Dutch Slough area are among the lowest in the Plan Area despite high sediment concentrations (Grassetti Environmental Consulting 2008). Perhaps the best available data are from the Blacklock dike breach restoration site in Suisun Marsh from 2006-2009 which shows that tissue concentrations of methylmercury in inland silverside (a fish) decreased in adjacent Nurse Slough despite the continual increase of methlymercury in the sediment (M. Stephensen unpublished data). Additionally, the amount of methylmercury generated by existing land use activities is highly variable with waterfowl management actions in Suisun Marsh generating more methylmercury in managed wetlands than is generated in tidal marsh habitat (USDI et al. 2010).

Methods for minimizing methylation in sediments are being developed and include capping mercury-containing sediment with uncontaminated sediment (as at the Montezuma Wetlands Restoration Project) and the addition of ferrous iron or activated carbon granules to the sediment. Continued transport of contaminated sediment into and within the Plan Area would likely limit the effectiveness of capping, and the addition of chemicals is experimental and would likely be limited to relatively small areas.

Hypothesized Benefits

Through the use of appropriate site selection protocols, design measures, construction techniques, and management actions, tidal habitat and floodplain restoration is hypothesized to:

- Minimize adverse effects of methylmercury on white sturgeon, North American green sturgeon, and Sacramento splittail;
- Minimize, and potentially reduce, adverse effects of methylmercury on covered wildlife such as salt marsh harvest mouse, Suisun shrew, and California least tern in Suisun Marsh as a result of the conversion of managed wetlands to tidal wetlands;

Adaptive Management Considerations

Implementation of this conservation measure will be informed through effectiveness monitoring that will be conducted as described in Section 3.6, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Results from the long-term monitoring of sentinel species and covered species tissue concentrations of methylmercury and of sediment concentrations of methylmercury will be used to assess the effects of tidal habitat and floodplain restoration on achieving the methylmercury management objective. Effectiveness monitoring results will be used to determine whether tidal marsh and floodplain restoration actions increase tissue concentrations of methylmercury in sentinel and covered fish and wildlife species.

The following four types of monitoring and research actions could be implemented to inform the adaptive management program: (1) quantification of existing mercury and methylmercury sources; (2) remediation of mercury source areas; (3) quantification of ecological and human health effects of methylmercury in the system; and (4) testing of possible management approaches. Many of these action areas are being addressed by ongoing efforts through regional agencies, research institutions, and stakeholders, such as characterization of mercury and methylmercury in sediment and biota throughout the Plan Area, evaluation of solutions for the Cache Creek Settling Basin, research on methylmercury flux and bioaccumulation in various Delta environments, and pilot studies on management approaches such as application of ferrous iron amendments.

3.4.4.2 CM13 Nonnative Aquatic Vegetation Control

The BDCP Implementation Office will control the growth of Brazilian waterweed (*Egeria densa*), water hyacinth (*Eichhornia crassipes*), and other nonnative submerged and floating aquatic vegetation (SAV and FAV) in BDCP tidal habitat restoration areas (Figure 3-58). To implement this conservation measure, the Implementation Office will apply existing methods used by the Department of Boating and Waterways (DBW) *Egeria densa* and Water Hyacinth Control Programs. Control methods currently employed by DBW include application of herbicides and mechanical removal. BDCP methods of removal will be dictated by site-specific conditions and intended outcome or goal. Application of herbicides or other means to control SAV/FAV will be timed to eliminate or minimize potential negative effects of SAV/FAV removal on covered species.

Figure 3-58. Overlap of Submerged Aquatic Vegetation in 2007 and Tidal Habitat Restoration Opportunity Areas (CM13)

Click here to view figure

Problem Statement

Although the historical extent of native SAV and FAV in the Delta ecosystem is unknown, invasive SAV and FAV species have recently colonized large areas of the Delta (Brown 2003, DFG 2008a, Ustin et al. 2008) and are continuing to expand into a greater proportion of channels and new areas (IEP 2008b). The widest spread nonnative FAV species, water hyacinth, was introduced into the Delta over 100 years ago, and severe infestations were experienced by the 1980s. The majority of the surface cover of SAV detected through the recent use of airborne hyperspectral imagery is Brazilian waterweed, although the SAV vegetation frequently contains a mixture of three invasive nonnative species: Brazilian waterweed, *Potamogeton crispus* (curlyleaf pondweed), and *Myriophyllum spicatum* (Eurasian watermilfoil) (Ustin et al. 2008). Of the 55,000 acres of the Delta surveyed in 2007, SAV cover has been estimated to be between 5,500 and 10,000 acres (Ustin et al. 2008). Nonnative SAV and FAV are thought to cause multiple negative effects on the Delta ecosystem, including 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 (IEP 2008a).

The DBW Water Hyacinth Control Program, which began in 1982, has been effective in reducing hyacinth from Delta waterways by using chemical and mechanical removal methods. DBW has developed and operated the *Egeria densa* Control Program since 2001 in response to AB 2193, which amended the Harbors and Navigation Code to designate DBW as the lead agency for the control of Brazilian waterweed in the Delta (DBW 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 permit and under biological opinions issued by USFWS and NOAA Fisheries (DBW 2008). In 2006, DBW concluded that its current approach was not effective at stopping the expansion of SAV in the Delta and proposed expanding the treatment area to sites across most of the legal Delta between 2006-2010 and concentrating on Franks Tract between 2006-2008 (DBW 2006).

Hypothesized Benefits

Removing nonnative SAV and FAV from tidal habitat restoration areas is hypothesized to provide benefits to covered fish species through the following mechanisms:

1. Reducing predation mortality on juvenile salmon, steelhead, and splittail by reducing habitat for nonnative predatory fish (see Appendix F, *DRERIP Evaluation Results*). 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 3-59). The interior of SAV stands is good habitat for larval and juvenile centrarchids (Brown and Michniuk 2007), whereas

adult striped bass forage immediately outside of the SAV bed and feed on juvenile Chinook salmon, steelhead, splittail, delta smelt, and longfin smelt (Stevens 1966, Temple et al. 1998, Nobriga and Feyrer 2007b, 2008);

2. Reducing predation mortality of delta smelt by increasing turbidity levels (IEP 2008a, Appendix F, *DRERIP Evaluation Results*). 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). Increased turbidity is hypothesized to improve the predator avoidance abilities of delta and longfin smelt. In addition, improved turbidity may reduce the hunting efficiency of nonnative piscivores (Nobriga et al. 2005);

3. Increasing food consumption by delta and longfin smelt by increasing turbidity levels. SAV and FAV are thought to reduce local flow rates and cause suspended particles to precipitate out of the water column, resulting in a localized reduction in turbidity levels (Grimaldo and Hymanson 1999). A reduction in turbidity is hypothesized to reduce the foraging ability of delta and longfin smelt;

4. Increasing rearing habitat for juvenile salmon (all races), steelhead, and splittail (Appendix F, *DRERIP Evaluation Results*). Dense patches of SAV and FAV physically obstruct covered fish species' access to habitat (IEP 2008a) that would become available with SAV and FAV removal and control; and

5. Increasing food availability for all covered fish species near removal locations by increasing light levels below vegetation. Phytoplankton growth is hypothesized to be light-limited in the Delta (Cole and Cloern 1984). The presence of SAV/FAV is more light-limiting for phytoplankton growth, through shading, than anticipated increases in water turbidity resulting from SAV/FAV removal. The reduction in light levels near nonnative SAV and FAV are thought to reduce local growth of phytoplankton, which can affect the local abundance of zooplankton that forms the food base for covered fish species near patches of SAV and FAV.

Adaptive Management Considerations

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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. The Implementation Office will monitor the effectiveness of BDCP-funded elements of the nonnative aquatic vegetation control in successfully controlling SAV and FAV. The Implementation Office will adjust control strategies and funding levels through the BDCP adaptive management process as appropriate based on review of program reports.

Figure 3-59. Examples of Delta Areas with Submerged Aquatic Vegetation (SAV) Infestations (CM13)

Click here to view figure

The Implementation Office will use results of effectiveness monitoring to determine if controlling SAV and FAV 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 would improve the biological effectiveness of the program. 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 removing and controlling SAV and FAV does not substantially and cost-effectively benefit covered fish species, the Implementation Office, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management

3.4.4.3 CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels

The purpose of this conservation measure is to maintain dissolved oxygen concentrations above levels that impair covered fish species in the Stockton Deep Water Ship Channel during periods when covered fish species are present. The BDCP Implementation Office will operate and maintain an oxygen aeration facility in the Stockton Deep Water Ship Channel to increase dissolved oxygen concentrations between Turner Cut and Stockton to meet Total Maximum Daily Load (TMDL) objectives established by the Central Valley Regional Water Quality Control Board (CVRWQCB) (2005) (above 6.0 mg/L from September 1 through November 30 and above 5.0 mg/L at all times). The existing aeration facility will be modified as necessary and, if necessary, additional aerators and associated infrastructure would be added to optimize oxygen delivery to the river, contingent upon results of an ongoing demonstration project conducted by DWR and effectiveness monitoring during implementation.

The Implementation Office will be responsible for developing annual work plans in coordination with Fishery Agencies that specify the extent of dissolved oxygen improvements to be implemented and will be responsible for monitoring the effectiveness of dissolved oxygen enhancement measures in improving dissolved oxygen levels.

Problem Statement

The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the State Water Resources Control Board because of low dissolved oxygen concentrations during late summer and early fall (CVRWQCB 2005). The combination of low flows, high loads of oxygen-demanding substances (algae from upstream, effluent from the City of Stockton Regional Wastewater Control Facility, and other unknown sources), and channel geometry contribute to low oxygen levels in the Stockton Deep Water Ship Channel (CVRWQCB 2005). The Stockton Deep Water Ship Channel often fails to meet water quality objectives established by the Regional Board for dissolved oxygen (CVRWQCB 2007). The 7.5-mile low dissolved oxygen area of the ship channel creates a barrier for upstream migration of adult fall-run

Chinook salmon and Central Valley steelhead on the mainstem of the San Joaquin River (Hallock et al. 1970). Further, low dissolved oxygen levels can cause physiological stress on and mortality of fish, including Chinook salmon and steelhead (Jassby and Van Nieuwenhuyse 2005), and other aquatic organisms (CVRWQCB 2007). Once spring-run Chinook salmon are re-established in the San Joaquin River under the San Joaquin River Litigation Settlement, dissolved oxygen sags in the Deep Water Ship Channel will likely have similar effects on this run if sags were to occur during their adult migration period (expected to be approximately March-September). In addition, juvenile white sturgeon, which rear in the San Joaquin River, exhibit reduced foraging and growth rates at dissolved oxygen levels below 58 percent saturation (5.8 mg/l at 15 °C) (Cech and Crocker 2002).

One potential solution to dissolved oxygen sags in the Stockton Deep Water Ship Channel, a dissolved oxygen aeration system, has been installed and is currently undergoing field testing by DWR. Results suggest that the aeration facility is effective at raising dissolved oxygen levels in much of the channel. Long-term funding for operations and maintenance has not yet been secured and there are currently no mandates by the CVRWQCB that require contributors to the sag to fund the project. Under this conservation measure, the BDCP would share in funding the long term operation and maintenance costs associated with the project.

Hypothesized Benefits

Increasing dissolved oxygen concentrations in the Stockton Deep Water Ship Channel in accordance with TMDL objectives is hypothesized to result in:

- Reduced delay and inhibition of upstream and downstream migration of fall-run Chinook salmon, steelhead, white sturgeon, river and Pacific lamprey, and, once they are re-established in the San Joaquin River, spring-run Chinook salmon (Hallock et al. 1970); and
- Reduced physical stress and mortality of fall-run Chinook salmon, steelhead, white sturgeon, river and Pacific lamprey, and, once they are re-established in the San Joaquin River, spring-run Chinook salmon.

Adaptive Management Considerations

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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Results from monitoring of dissolved oxygen levels at various distances from the diffuser(s) will be used to assess the performance of the facilities 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 review of performance and effectiveness monitoring results, the Implementation Office will adjust funding levels, oxygen diffuser methods, or other related aspects that will improve the performance and/or biological effectiveness of the project through the BDCP adaptive management process as appropriate. Such changes will be effected through the BDCP adaptive management process and would be included in the subsequent 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 Fishery 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 Fishery Agencies through the BDCP adaptive management process.

3.4.4.4 CM15 Predator Control

The purpose of this conservation measure is to reduce local effects of predators on covered fish species by conducting focused predator control in high predator density locations. The BDCP Implementation Office will reduce the local effects of predators on covered fish species by conducting focused predator control using a variety of methods in locations in the Delta that are known to have high densities of predators ("hot spots").

The Implementation Office will examine existing fish monitoring data, bathymetry data, and radio and acoustic tagging study results to determine the locations and causes of predator hot spots throughout the Delta (Figure 3-X [to come]). Locations of hot spots in which focused predator control will occur include:

1. Old structures in or hanging over Delta waterways, such as pier pilings or other man-made structures, that are no longer functional or have been abandoned but affect flow fields or provide shade (target: 10-20 structures removed per year);
2. Boats that have been abandoned throughout the Delta (target: 5-10 boats removed per year);
3. New intake structures of the North Delta Diversions (target: daily focused removal when sensitive lifestages of covered fish species are present);
4. The deep hole just downstream of the Head of Old River in the San Joaquin River (target: daily focused removal when sensitive lifestages of covered fish species are present. Additional control efforts may be needed in conjunction with operation of non-physical barriers, as described in CM16);
5. Specific locations in Georgiana Slough, as identified by Fishery Agencies (target: daily focused removal in up to 3 specific locations when sensitive lifestages of covered fish species are present);

6. Specific locations in Sutter and Steamboat sloughs, as identified by Fishery Agencies (target: daily focused removal of predators in up to 2 specific locations per slough when sensitive lifestages of covered fish species are present); and
7. Release sites of salvaged fish from CVP/SWP facilities (target: weekly focused removal at each salvage release site when sensitive lifestages 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, targeted removal of predators, and/or other focused methods as dictated by site-specific conditions and the intended outcome or goal. Preference for which hot spots to address will be given to areas of high overlap with covered fish species, such as major migratory routes or spawning and rearing habitats.

Site-specific control plans will be developed in consultation with the Fishery Agencies, and will include expected benefits, methods, and a monitoring design that will provide information necessary to determine the effectiveness of the action.

Problem Statement

Although a natural part of the estuarine ecosystem, predation in the Delta has been identified as a stressor to BDCP covered fish species (Appendix F, *DRERIP Evaluation Results*). Habitat for fish predators generally consists of a specific suite of attributes that allow them to forage more efficiently, such as dark locations adjacent to light locations or deep pools that allow the predator to hide and ambush their prey. There are multiple locations in the Delta that contain these physical attributes and attract predatory fish that prey upon covered fish species.

Hypothesized Benefits

Conducting localized predator control at hot spots in the Delta using a variety of control methods is expected to 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), Sacramento splittail (Moyle et al. 2004), and delta smelt (Stevens 1966, Thomas 1967, Moyle 2002); and possibly longfin smelt (Nowak et al. 2004), green sturgeon (J. Israel pers. obs.), and white sturgeon.

Within the Columbia River system, a predator removal program was investigated in the 1980's for the control of juvenile salmonid predators benefiting from the existence of multiple hydropower dams located along this system. The principle predators for juvenile salmonids within the Columbia River are the northern pikeminnow (*Ptychocheilus oregonensis*), and two nonindigenous species: smallmouth bass (*Micropterus dolomieu*) and walleye (*Sander vitreus*). Northern pikeminnow greater than ~10 inches were considered the primary predator of juvenile salmonids in slower moving portions of the Columbia River (i.e., near hydropower facilities).

The program, designed to reduce predation rates in these areas utilizing a bounty program, net fisheries, professional fishers, and fishing areas adjacent to hatcheries, was initiated in 1990. The bounty program targets the removal of 10 to 20 percent of the larger pikeminnow to control size classes that have the greatest juvenile salmonid predation rates, while still maintaining a sustained pikeminnow population. By maintaining a sustained pikeminnow population, the program was designed to avoid compensatory responses of other juvenile salmonid predators in the system (smallmouth bass and walleye) filling the void created by pikeminnow removal. Through the first 16 years of the program there were no indications of compensatory responses. In 2006, however, there were possible indications of localized compensatory responses, although there is insufficient data to determine whether there is a system-wide compensatory response (Takata et al. 2007, Van Dyke 2010).

Prior to the initiation of this program, Beamesderfer et al. (1996) estimated that approximately 16.4 million juvenile salmonids of the estimated 200 million downstream migrants were consumed by northern pikeminnow in the Columbia system. Another study estimated that northern pikeminnow accounted for 10 to 20 percent of juvenile salmonid mortality (as cited in Young 1997). Predation rates are greatest in the vicinity of each of the eight Columbia and Snake River reservoirs ("pools"). Within the John Day pool, it was estimated that a northern pikeminnow exploitation rate of 10 to 20 percent could reduce their predation on juvenile salmonids by 50 percent (as cited in Young 1997). From 1990 through 2008, the Northern Pikeminnow Sports Reward Fishery removed 3.3 million reward-sized (≥9 inches) northern pikeminnow from the Columbia system. From 1991-1998, system-wide exploitation rates of northern pikeminnow averaged 11.7 percent (Hankin and Richards 2000). The removal program estimates northern pikeminnow predation has been reduced by 37 percent (Northern Pikeminnow Sports Reward Fishery 2009). Although the program does not provide an estimated annual number of juvenile salmonids "spared" due to predator removal, model estimates for a reduction of 50 percent predation rate range from 5.2 to 8.2 million juvenile salmonids annually (Hankin and Richards 2000).

Adaptive Management Considerations

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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Monitoring will consist of assessing the abundance, distribution, and size of predator species before and immediately after implementation of predator control actions in each hot spot to determine the performance of the action. In addition, potential changes in survival rate of covered species will be monitored using acoustic tagging studies where possible or similar techniques.

The Implementation Office, in consultation with the Fishery 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 its biological effectiveness. 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 the action does not substantially and cost-effectively benefit covered fish species, the BDCP Implementation Office, in coordination with Fishery 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 Fishery Agencies through the BDCP adaptive management process.

3.4.4.5 CM16 Non-Physical Fish Barriers

The purpose of this conservation measure is to improve the survival of outmigrating juvenile salmonids by using non-physical barriers to re-direct them away from channels in which survival is lower (Figure 3-60). The BDCP Implementation Office will install non-physical barriers at the junction of channels with low survival of outmigrating juvenile salmonids to deter fish from entering these channels[37]. Non-physical barrier placement locations will include the Head of Old River, the Delta Cross Channel, Georgiana Slough, and could possibly include Turner Cut, Columbia Cut, the Delta Mendota Canal intake, and Clifton Court Forebay (Figure 3-61). Other locations may be considered in the future by the Implementation Office 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. Non-physical barriers will include a combination of sound, light, and bubbles similar to the three-component non-physical barrier used in the 2009 DWR Head of Old River Test Project (Bowen et al. 2009). Non-physical barriers will be installed and operated during October to June or when Fishery Agencies monitoring determines that salmonid smolts are present in the areas when barriers are to be installed. Non-physical barrier placement may also be accompanied by methods to reduce local predator abundance described in CM15 above if monitoring finds that barriers attract predators. Barriers will be removed and stored off-site while not in operation (M. Holderman pers. comm.).

Problem Statement

Juvenile salmonids experience low survival rates while migrating through the Delta towards the ocean. Survival rates vary among routes taken through the Delta (Brandes and McLain 2001, Perry and Skalski 2008, 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 (SJRGA 2006, J. Burau pers. comm.).

[37] Previous evidence suggests that, under a non-physical barrier configuration that was effective in deterring salmon smolts, the non-physical barrier was not effective in deterring delta smelt (Bowen et al. 2008). It is currently not known whether this was a result of the configuration (e.g., sound frequency) of the non-physical barrier or the poor swimming ability of delta smelt that was swamped by high flows (Bowen et al. 2008). Reclamation is currently studying whether there are sound frequencies that deter delta smelt (M. Holderman pers. comm.). If demonstrated to be effective in deterring delta smelt and longfin smelt and deemed necessary by the Fishery Agencies, non-physical barriers could 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 survival is thought to be lower when present, as determined by Fishery Agencies monitoring.

Figure 3-60. Schematic of Non-Physical Fish Barrier (CM16)

Click here to view figure

Figure 3-61. Conceptual Location of Non-Physical Fish Barrier (CM16)

Click here to view figure

Survival for routes through the interior Delta was at most 35 percent that of survival for fish remaining in the Sacramento River (Perry et al. 2010). 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 19.8 to 34.5 percent of tagged salmon used Sutter and Steamboat sloughs during migration, while 26.7 percent to nearly one-third 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 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. However, operation of non-physical 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.

Hypothesized Benefits

Installation and seasonal operation of non-physical barriers is hypothesized to improve survival of juvenile salmonids migrating downstream by guiding fish into channels in which they experience higher survival rates (Welton et al. 2002, Bowen et al. 2009). The three component non-physical 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). In addition, preliminary evidence suggests that the 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). Non-physical barriers that utilize 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 percent were effective in altering fish behavior (USBR 2006). The three-component Non-physical Barrier Test Project at the confluence of Old River and the San Joaquin River in the Sacramento-San Joaquin Delta has demonstrated greater success, successfully deterring 81.4 percent of tagged Chinook salmon smolts from entering Old River compared to conditions without the barrier operating that deterred 25.4 percent of tagged salmon smolts (Bowen et al. 2009). Sound is known to affect the behavior of salmonids (Vanderwalker 1967, Knudsen et al. 1992, 1994).

Adaptive Management Considerations

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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. The Implementation Office will conduct and review monitoring to assess the effectiveness of using non-physical barriers. The Implementation Office will use results of effectiveness monitoring to determine whether operations of non-physical 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. Uncertainty regarding the potential attraction of predators to non-physical barriers and the effectiveness of barriers in higher flow areas 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 non-physical barriers do not substantially and cost-effectively benefit covered fish species, the Implementation Office, in coordination with Fishery 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 Fishery Agencies through the BDCP adaptive management process.

3.4.4.6 CM17 Hatchery and Genetic Management Plans

[**Note to Reviewers**: *SAIC is in discussion with hatchery coordinators to determine the funding needs for this conservation measure. This measure will be updated as new information becomes available via continued coordination.*]

The purpose of this conservation measure is to develop and implement hatchery and genetic management plans to minimize the potential for genetic and ecological impacts of hatchery-reared salmonids on wild salmonid stocks. The BDCP Implementation Office will minimize potential adverse effects of hatchery-reared salmonids on wild salmonid stocks by supporting the accelerated development and implementation of Hatchery and Genetic Management Plans (HGMPs) for all state Chinook salmon and steelhead hatcheries in the Central Valley. HGMPs would be implemented to reduce adverse ecological and genetic effects of hatcheries on wild fish and to be consistent with conservation and protection for listed fish species.

The Implementation Office will provide funding to:

- Expand and finalize steering groups for each hatchery HGMP process, in part to aid in determining hatchery function;
- Support DFG staff and DFG contractors to prepare HGMPs under DFG and NMFS direction;

- Staff a DFG HGMP Coordinator, a position dedicated to coordinating HGMPs from beginning through implementation. HGMP implementation and adaptive management will be an ongoing task for the life of each hatchery;
- Staff hatcheries sufficiently to carry out changes necessary to meet ESA requirements, including providing regional support for fishery biologists at each hatchery;
- Improve efforts to minimize several categories of hatchery impacts including trucking, inter-basin egg transfers, genetic stock management, monitoring (especially hatchery natural proportions and impacts of hatcheries on natural stocks), and conservation hatcheries; and
- Provide support for staffing and analysis associated with a genetic parental-based tagging system.

Funding of these efforts will be higher during development of the plans and should decline as plans are completed. The BDCP Implementation Office will enter into binding Memoranda of Agreement or similar instruments with DFG as described in Section 3.4.4, *Species Level Other Stressors Conservation Measures*.

Problem Statement

Hatchery-reared Chinook salmon and steelhead are believed to have negative effects on wild Chinook salmon and steelhead, including competition for space and food as juveniles and for spawning habitat as adults. Fish reared in hatcheries can be selected for traits that are different from those in nature, such as those that allow them to survive in an artificial, contained environment (e.g., fast growth, large size). This could result in reduced genetic isolation of hatchery fish from wild fish. It is thought that these hatchery fish outcompete their smaller wild-reared conspecifics (individuals of the same species) for food and space in natural waterways (Williams 2006). Also, as adults, straying by hatchery-reared salmon into natural spawning grounds may lead to competition for spawning habitat and genetic introgression, where offspring of wild salmon are “genetically polluted” with hatchery-selected genes, thereby reducing the fitness of wild population (ISAB 2003, Goodman 2005, Hey et al. 2005).

To address these concerns, hatcheries have begun reforming their management practices to minimize the effects that hatchery fish may have on wild fish. HGMPs serve as the foundation of hatchery management and reform to minimize genetic and ecological impacts to wild fish. HGMPs are developed to devise and evaluate practices of a hatchery to ensure the hatchery contributes to the conservation and recovery of listed salmonids.

Although required, the development of HGMPs in Central Valley hatcheries has been slow to date. The following provides a summary of the status of the progress made toward completion of HGMPs at Central Valley hatcheries (M. Lacy pers. comm.):

- Nimbus Hatchery - Draft HGMPs for both fall Chinook salmon and winter steelhead have been completed. Updates and minor revisions were made during 2008 to initial drafts. Reclamation and DFG staff are currently reviewing subsequent drafts.
- Feather River Hatchery - Draft HGMPs for spring and fall Chinook salmon and Central Valley steelhead were completed in late 2008. DWR is reviewing the spring Chinook salmon draft HGMP; fall Chinook salmon and steelhead HGMPs are both still in development by consultant staff. Updates and DWR comments are being incorporated into all drafts as appropriate.
- Mokelumne River Hatchery - A revised draft HGMP for the steelhead program was completed at the end of 2008 and has been reviewed by hatchery staff. A draft HGMP for the fall Chinook salmon is 50 percent complete.
- Merced River Hatchery - There has been no progress towards beginning work on this HGMP.
- Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery - All of the necessary HGMP information for Coleman and Livingston Stone National Fish Hatcheries are contained in the 2001 Biological Assessment (plus a subsequent addendum for Section 10 coverage for winter Chinook and amendments to respond to operational changes at Coleman National Fish Hatchery) submitted to NMFS. The Biological Opinion, including updates to the BA, is in process.

Hypothesized Benefits

Accelerating the development and implementation of HGMPs at Central Valley hatcheries is hypothesized to:

- Improve the genetics and fitness of wild salmonids (ISAB 2003, Goodman 2005, Hey et al. 2005); and
- Reduce competition for rearing and spawning habitat and food with hatchery-reared salmonids (Flagg et al. 2000, Goodman 2005).

Adaptive Management Considerations

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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. The Implementation Office will review annual reports or other relevant reports to assess the performance of the HGMP teams in the accelerated development and implementation of HGMPs. The Implementation Office will coordinate with the individual hatcheries to adjust HGMP strategies and funding levels through the BDCP adaptive management process as appropriate, based on review of performance monitoring results and other relevant reports.

The Implementation Office will use effectiveness monitoring results to determine whether HGMP development and implementation results in measurable benefits to covered fish species and to identify adjustments to funding levels or other related aspects of the program that would 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 results of review indicate that HGMP development and implementation does not substantially and cost-effectively benefit covered fish species, the Implementation Office, in coordination with Fishery 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 Fishery Agencies through the BDCP adaptive management process.

3.4.4.7 CM18 Illegal Harvest

The purpose of this conservation measure is to reduce illegal harvest of Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon in the Delta, bays, and upstream waterways. The BDCP 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. The BDCP Implementation Office will provide funds to DFG to hire and equip 17 additional Game Wardens and 5 supervisory and administrative staff in support of the existing field wardens assigned to the Delta-Bay Enhanced Enforcement Program over the term of the BDCP.

The DFG Delta-Bay Enhanced Enforcement Program (DBEEP) is a 10-Warden squad that was formed specifically to increase enforcement on poaching of anadromous fish species in Bay-Delta waterways. The program is funded by water contractors through the Delta Fish Agreement. The BDCP would contribute directly to this existing program by expanding its size to improve enforcement against poaching of covered species.

The BDCP Implementation Office will enter into Memoranda of Agreement or similar binding instruments with DFG as described in Section 3.4.4, *Species Level Other Stressors Conservation Measures*.

<u>Problem Statement</u>

California has the lowest Game Warden to population ratio in the nation with fewer than 200 field wardens for the entire state. The Delta is a particular hot spot for poaching because of the large number of sport fish, particularly gravid female white sturgeon, whose roe are used for caviar (Lt. L. Schwall, pers. comm.). Illegal harvest is thought to have high impacts on sturgeon populations, particularly white sturgeon (Beamsderfer et al. 2007). Illegal harvest of juvenile and adult Chinook salmon and steelhead in the Delta and bays is also common (DBEEP 2007).

Hypothesized Benefits

It is hypothesized that enhanced enforcement on poaching will reduce mortality, and potentially increase population sizes, of green sturgeon (Beamesderfer et al. 2007, DFG unpublished, Boreman 1997, D. Tanner pers. comm., DFG 2007b, Appendix F, *DRERIP Evaluation Results*); white sturgeon (Bay-Delta Oversight Council 1995, Boreman 1997, Schaffter & Kohlhorst 1999, Beamesderfer et al. 2007, DFG 2007b, DFG 2008c, M. Gingras pers. comm., Z. Matica pers. comm., CDFG unpubl. data, Appendix F, *DRERIP Evaluation Results*); Chinook salmon (all races) (Bay-Delta Oversight Council 1995, Williams 2006); and steelhead (DFG 2007b, DFG 2007c, DFG 2008d, Moyle et al. 2008, Appendix F, *DRERIP Evaluation Results*). Spring-run Chinook salmon are hypothesized to experience the greatest benefit because they are more susceptible to poaching than other runs due to over-summer holding and ease of locating them (Appendix F, *DRERIP Evaluation Results*). Due to the recent establishment of daily bag limits for Sacramento splittail by the Fish and Game Commission, it is hypothesized that this conservation measure will also reduce mortality and potentially increase 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).

Adaptive Management Considerations

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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. 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 DBEEP annual reports.

3.4.4.8 CM19 Conservation Hatcheries

The purpose of this conservation measure is to establish new and expand existing conservation propagation programs for delta and longfin smelt. The BDCP Implementation Office will support: (1) the development of a delta and longfin smelt conservation hatchery by the 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 Fishery Agencies; and (2) the expansion of the refugial population of delta smelt and establishment of a refugial population of longfin smelt at the University of California, Davis Fish Conservation and Culture Laboratory to serve as a population safeguard in case of a catastrophic event in the wild.

The new facility proposed by the USFWS will house genetically-managed refugial populations of delta and longfin smelt (Clarke 2008). Further, the facility will provide fish to supplement the wild population and provide fish stocks for reintroduction, as necessary and appropriate. State-of-the-art genetic management practices will be implemented to avoid hatchery-produced fish becoming genetically different from wild fish. The facility will be designed with the ability to add 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 (B. Clarke pers. comm.) (Figure 3-62). Specific rules will be established to discontinue housing refugial populations of delta and longfin smelt at the hatchery if and when populations of these species are considered recovered by the Fishery Agencies.

In addition, the UC Davis Fish Conservation and Culture Laboratory (FCCL) 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 FCCL and the Genomic Variation Laboratory (GVL) at UC Davis are and will be, the primary entities developing and implementing genetic management of the delta smelt refugial population over the period 2009-2015 or longer and may then play a secondary role in keeping a back-up population(s).

At both facilities, genetic management practices will be implemented to maintain wild genetic diversity, minimize genetic adaptation to captivity, minimize mean kinship, and equalize family contributions. Furthermore, genetic monitoring of wild populations will proceed to 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 the USFWS and University of California, Davis similar to that described in Section 3.4.4, *Species Level Other Stressors Conservation Measures*. In addition, if and when populations of these species are considered recovered by the Fishery Agencies, the Implementation Office will terminate funding for the propagation of the species and either fund propagation of an additional BDCP covered fish species, if necessary and feasible, or deobligate funds to this conservation measure and reallocate them to augment funding other conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

Problem Statement

Populations of both delta and longfin smelt have dramatically declined recently (IEP 2008a, b). Although a variety of stressors are suspected, there is not a clear understanding of why these populations have declined (IEP 2008a, b). There is evidence that delta smelt continue to decline and that very low population size could result in an Allee effect causing an even more rapid decline of the species (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 (IEP 2008a, b).

Figure 3-62. Potential USFWS Conservation Hatchery Facility Locations (CM19)

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Hypothesized Benefits

Artificial propagation and maintenance of refugial populations of delta and longfin smelt are hypothesized to:

- Provide a safeguard against the possible extinction of delta and/or longfin smelt by maintaining a captive population that is genetically similar to the wild population (Lande 1988, Hedrick et al. 1995, Sveinsson & Hara 1995, Carolsfeld 1997, Sorensen 1998, USFWS 2003, Hedgecock et al. 2000, Kowalski et al. 2006, Turner et al. 2007, Nobriga 2008, Turner & Osborne 2008, B. Clarke, pers. comm., Appendix F, *DRERIP Evaluation Results*);
- Improve the knowledge base regarding threats to and management of delta and longfin smelt by increasing the ability to study the effects of various stressors on these species using hatchery-reared specimens (Appendix F, *DRERIP Evaluation Results*); and
- Contribute to increasing population sizes of delta smelt (Lande 1988, Deblois & Leggett 1991, Sveinsson & Hara 1995, Carolsfeld 1997, Sorensen 1998, USFWS 2003, Flagg et al. 2000, Richards et al. 2004, Kowalski et al. 2006, Purchase et al. 2007, Nobriga 2008, B. Clarke, pers. comm.) and longfin smelt (Sveinsson & Hara 1995, Carolsfeld 1997, Sorensen 1998, USFWS 2003, Flagg et al. 2000, Richards et al. 2004, Kowalski et al. 2006, Nobriga 2008) to self-sustaining levels in the wild when combined with effective habitat restoration and other measures to improve conditions in their natural environment.

Adaptive Management Considerations

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, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Based on review of performance and effectiveness monitoring results in USFWS and UC Davis annual reports, the Implementation Office, in coordination with Fishery Agencies and UC Davis, will adjust funding levels, hatchery operations, or other related aspects that will improve the performance and/or biological effectiveness of the program through the BDCP adaptive management process as appropriate. Such changes will be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

3.4.5 Avoidance and Minimization Measures

As required by Section 10 of the ESA, the BDCP includes avoidance and minimization measures that will be implemented by the BDCP Implementation Office to avoid and minimize adverse impacts of covered activities on the covered species. Careful design and implementation of covered activities will help avoid take of covered species, but specific avoidance and minimization measures may be required during implementation to fully meet this requirement. It