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Listed Species

A listed species is a species that is listed as Federally Endangered, Federally Threatened, Federal Candidate, California State Endangered, California State Threatened, California State Rare, California Department of Fish and Game (CDFG) Species of Concern, California Native Plant Society Species Rare/Endangered in California or elsewhere, or California Native Plant Society Species Rare/Endangered in California and more common elsewhere.

Federally Listed Species
Under the Federal Endangered Species Act (FESA), the Secretary of the Interior and the Secretary of Commerce jointly have the authority to list a species as endangered or threatened. FESA defines “endangered” species as any species in danger of extinction throughout all or a significant portion of its range. A “threatened” species is any species that is likely to become an “endangered” species within the foreseeable future throughout all or a significant portion of its range. Additional special-status species include “candidate” species and “species of concern.” ”Candidate” species are those for which the U.S. Fish and Wildlife Service has enough information on file to propose listing as endangered or threatened. “Species of concern” are those for which listing is possibly appropriate but for which the U.S. Fish and Wildlife Service lacks sufficient information to support a listing proposal. A species that has been “delisted” is one whose population has met its recovery goal target and is no longer in jeopardy of extinction.

California Listed Species
Section 2080 of the California Endangered Species Act (CESA) prohibits the “take” of state-listed threatened and endangered species. The CESA defines take as any action or attempt to hunt, pursue, catch, capture, or kill any listed species. If a proposed project may result in “take” of a listed species, a permit pursuant to Section 2080 of CESA is required from the California Department of Fish and Game (CDFG). Take of state-listed species is authorized through Section 2081 through a permit process. Take can also be authorized through Section 2835 with an approved Natural Community Conservation Plan.

California Department of Fish and Game
The CDFG also designates “fully protected” or “protected” species as those that may not be taken or possessed without a permit from the Fish and Game Commission and/or the CDFG. Species designated as fully protected or protected may or may not be listed as endangered or threatened.

Additional Protection

Migratory Birds
The federal Migratory Bird Treaty Act (16 USC Section 703, Supp. I, 1989) prohibits killing, possessing, or trading in migratory birds except in accordance with regulations prescribed by the Secretary of the Interior. This act encompasses whole birds, parts of birds, bird nests, and eggs. Disturbance during the breeding season could result in the incidental loss of fertile eggs or nestlings, or otherwise lead to nest abandonment, and violate the Migratory Bird Treaty Act.

Wetlands
Executive Order 11990 requires federal agencies to take action to minimize the destruction or modification of wetlands by considering both direct and indirect impacts to wetlands that may result from federally funded actions.

Invasive Species
Under Executive Order 13112, projects that occur on federal lands or are federally funded must "subject to the availability of appropriations, and within administration budgetary limits," use relevant programs and authorities to (i) prevent the introduction of invasive species; (ii) detect and respond rapidly to, and control, populations of such species in a cost-effective and environmentally sound manner; (iii) monitor invasive species populations accurately and reliably; and (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded."

14.1 INTRODUCTION

This report provides a detailed description of Building Block 3.2: Tidal Marsh Cache Slough Restoration Alternative. Figure 14-1 provides the flash card for this building block.

14.1.1 Background

The Cache Slough complex is in the northwest Delta at the southern end of the Yolo Bypass. It has many characteristics that would allow restoration and preservation of the area to result in a large, beneficial ecological impact. The complex includes the area surrounding Lindsey, Cache, and Miner sloughs, which drain into the Sacramento River in the Sacramento Deep Water Ship Channel (DWSC). This area is arguably the one most like the historical Delta and contains remnant habitats supporting a large number of listed species. It may be a spawning habitat of the federally threatened Delta smelt. The area is relatively undeveloped and contains several conservation easements and land trusts that have begun to preserve this sensitive area. The area offers one of the most promising sites for large-scale conservation and restoration of tidal marsh and slough ecosystems in the northwestern Delta (Meisler 2002).

14.1.2 Purpose and Scope of Building Block

The purpose of this building block is to create a conceptual preservation/restoration and implementation plan for the Cache Slough Complex to restore the ecology of the region. This building block will identify habitat goals, evaluate methods to reach these goals, and present a cost estimate for implementing the plan. This plan is based on a comprehensive conceptual analysis of proposed general and specific habitat restoration goals presented in a collection of plans by various agencies supporting Delta conservation. These agencies include the Solano Land Trust (SLT); the Bay-Delta Conservation Plan (BDCP); Envisioning Futures for the Sacramento–San Joaquin Delta, Public Policy Institute of California; North Delta Wildlife Refuge, Office of Governor; and Central Valley Joint Venture. Moreover, restoring wetlands of the Yolo Basin is essential in meeting the objectives set out by the U.S. Fish and Wildlife Service (USFWS). The study area includes the Cache Slough Complex, here defined as the area within the 100-year floodplain bordered in the northeast by the Yolo Bypass, including some portion of the bypass area, and Prospect Island on the east.

This analysis develops a concept in which barriers dividing the 100-year floodplain in the Cache Slough Complex could be removed, re-connecting open water, wetland, and upland habitats. The removal of these barriers would increase the acreage and improve the quality of habitat available for numerous species. In this analysis, inventories of species were estimated and reviewed, and the potential for new habitat was assessed. The results included the acreage of habitat that could be created and the number of species that could benefit from expanding and improving the connectivity of the remaining habitat. The analysis presents a “first cut” of the resulting habitats and the species that would be expected to occur. The area is expected to change over time as hydrodynamic and sediment processes alter the landscape, different plant and animal species colonize the area, and vegetation matures.

14.1.3 Objective and Approach

Existing regional habitat goals (e.g., BDCP 2007b), restoration objectives (e.g., Lund et al. 2006; OGSC 2007), and management plans (e.g., Witham 2006) for the Cache Slough area were combined to guide the design of the conceptual restoration plan. The conceptual plan incorporates and expands on existing management plans to include broader habitat goals (Lund et al. 2006) and specifically addresses increasing food supply and suitable spawning habitat area for Delta smelt, as described by the Office of the Governor of California (OGSC 2007). The best available data and expert opinion on existing restoration actions were used to develop a conceptual plan to achieve habitat goals. Published and unpublished data on Delta smelt captured in the Cache Slough area were the basis for estimating the potential of Cache Slough area restoration to increase spawning habitat for Delta smelt.

14.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

The conceptual development of this building block is described below.

14.2.1 Analysis Criteria and Basis of Concept

14.2.1.1 Analysis Criteria: Cache Slough Area Existing Conditions

The Cache Slough area stretches from Barker Slough on the west to Miner Slough on the east. Barker Slough, Lindsey Slough, and Cache Slough are dead-end sloughs. Ulatis Creek feeds Haas Slough. The DWSC and Sutter Slough drain to Miner Slough. The entire Cache Slough Area drains to the Sacramento River at the southern end of the DWSC. Water in the sloughs is fresh, but is tidally influenced and has a tidal range of about 2.6 feet (measured at Cache Slough near Liberty Island), which becomes smaller further upstream in the western sloughs.

The historical Delta consisted of a vast tule marsh; however, 95 percent of the more than 300,000 acres of tidal-freshwater wetlands have been leveed and removed from tidal and floodwater inundation over the last 150 years (Simenstad 2001). Before land reclamation, the Cache Slough complex consisted of tidal marsh, freshwater marsh, and a large lake (Figure 14-2). Land reclamation converted much of the lake into farmland, and extensive levee construction and de-watering converted the tidal marsh plain north of the Cache Slough Complex, leaving the Yolo Bypass floodplain dry unless irrigated or flooded.

Reclaimed land along the sloughs is leveed and riprapped. Calhoun and Hastings Cut are leveed channels in which levees have reconfigured dendritic channel flow into straight lines. Lindsey and Barker sloughs have riparian islands and riprapped levees that have narrow riparian bands in some areas. Diversions from the sloughs irrigate adjacent agricultural land (Figure 14-3). The eastern part of the Cache Slough area is in the Yolo Bypass, including Prospect Island, the northeast portion of Little Egbert Tract, Liberty Island, and Little Holland Tract (YBWG and J&S 2001). The bypass is bordered on the west and east by robust levees that guide floodwaters. Restricted-height levees make these areas function as floodplains during peak flow period. During small floods, floodwaters passing through the lower Yolo Bypass drain into a canal next to the eastern levee wall that flows to Prospect Slough before entering Cache Slough (see Appendix 14C for a detailed description of the function of Yolo Bypass).

Barker Slough hosts the Barker Slough Pumping Plant, which since 1988 has helped supply the North Bay with water via the North Bay Aqueduct. Barker Slough supplies the North Bay Area with water, serving 300,000 people in Napa and Solano Counties, including the cities of Fairfield, Napa, Vacaville, Vallejo, Calistoga, and the Travis Air Force Base. Barker Slough is one of two pumping stations that supply the North Bay area; the other is Cordelia.

The Barker Slough Pumping Plant is operated by the State Water Project. It exports a small amount of water relative to the total amount of water entitlements in the Delta. The State Water Project has an annual entitlement of 4 million acre-feet. The North Bay area is entitled to 1.7 percent of the 4 million acre-feet available through the Delta (68,000 acre-feet). Barker Slough is one of two pumping stations that supply the North Bay area; the other is Cordelia. Barker Slough has nine pumps, which pump at 154 cubic feet per second (cfs) in aggregate. An area's ability to utilize its total annual entitlement depends on rainfall and usage in that year. For example, in 2002 the North Bay used 45 percent of its annual allotment.

This analysis includes an estimate of the monetary value of the Cache Slough Complex. Overall, the Cache Slough Complex has little urban development. The nearest city is Rio Vista, to the south, which is outside of the 100-year floodplain and separated from the complex by Sacramento Flood Control Project levees. Family dwellings are predominant in this area, with a total of 110 compared; only 4 commercial dwellings are present in this area. Minor roads make up the vast majority of the 120 miles of roadways in the area. A significant number of gas fields are present in the Cache Slough area, with 33 miles of standing pipeline and almost 900 oil-gas wells. These facilities add to the value of the property in the area. The southern end of the bypass is used primarily for agriculture, duck hunting (e.g., Hastings Tract), pasture, and managed wetland conservation easements. The Cache Slough Complex Restoration Area currently consists primarily of agricultural land (68 percent of the total acreage), with producers cultivating alfalfa, field crops, grain, orchards, and vineyards (Appendix 14D). Alfalfa is the most abundant crop; it accounts for the largest proportion of annual agricultural revenue. All the agricultural land combined has an estimated production value over $7.4 million per year. Estimated total asset value in Cache Slough exceeds $176 million. Assets included in this estimate encompass civic infrastructures, dwellings, and property for gas and oil production.

The Cache Slough area is believed to be of high ecological value because it is the area of the Delta that is considered to be most like the historical Delta. The area contains remnant riparian and vernal pool habitat and historical dendritic channels of channelized sloughs. Vernal pool and riparian remnant habitats support unique biodiversity in California, and high species richness makes these habitats especially crucial conservation areas.

In particular, this area appears to be a spawning ground for Delta smelt. It is the only area where Delta smelt are observed during spawning in low-water years (Bennett 2005). In high-water years, Delta smelt larvae are also found in Suisun Bay and Napa River (Bennett, written comm., 2007; Bennett 2005). During times of flooding, the Yolo Bypass floodwaters provide important rearing habitat for Sacramento splittail and chinook salmon (T. Sommer, pers. comm., 2007; Feyrer et al. 2006a; Sommer et al. 2005).

Ecologically, the Cache Slough area is a unique place that has been identified as an ideal place for restoration because of the following characteristics:

- Area supports a large number of listed aquatic, plant, bird, and wildlife species, including the Delta smelt.

- Tidal influence is present in the area; this presence reduces the probability of invasion of restored areas by invasive aquatic species, such as Brazilian waterweed (*Egeria densa).*
- Remnant habitats in the area contain sensitive species and high biodiversity.
- Subsidence is low, so re-establishing and expanding existing diverse habitats seems more likely to be successful.
- Cache Slough area connects existing conservation areas, thereby increasing the amount of contiguous habitat and increasing the value of a conserved area.
- Cache Slough area re-establishes the connection between upland and aquatic habitats necessary for many species.
- Little urban development is present in the area.

14.2.1.2 Analysis Criteria: Existing Restoration Plans

Analysis criteria for the restoration plan were obtained from general and specific habitat goals outlined in the following restoration plans for the Cache Slough area:

- Solano Land Trust (Meisler 2002; Witham 2006)
- Bay Delta Conservation Plan.
- Envisioning futures for the Sacramento–San Joaquin Delta, San Francisco, California: Public Policy Institute of California. (Lund et al. 2006)
- North Delta Wildlife Refuge (Foulk 1999; USFWS and DWR 2005)
- Office of Governor (OGSC 2007)
- Central Valley Joint Venture (CVJV 2006)

14.2.1.3 Analysis Criteria: General Restoration Goals

General restoration goals are presented in the restoration plans, including the following:

- More natural channel configuration (Sacramento–San Joaquin Delta Ecological Management Zone)
- Greater amounts of slough (Sacramento–San Joaquin Delta Ecological Management Zone) to support the processes and habitats associated with a productive slough ecosystem (Meisler 2002) (Increasing the number, length, and area of dead-end and open-end sloughs would benefit native fishes, waterfowl, wildlife, and neo-tropical birds [BDCP 2006].)
- Conservation of aquatic, marsh, riparian, vernal pool, and upland perennial grassland supporting at least 29 special-status species (Meisler 2002)
- Maintenance of the agricultural character of the land (Meisler 2002; Witham 2006)
- Greater amounts of permanent and seasonal wetland habitats, which would provide more habitat for fish, waterfowl, and wildlife, and improved aquatic food-web production and water quality (Sacramento-San Joaquin Delta Ecological Management Zone; North Delta National Wildlife Refuge (NDNWR): Foulk 1999; USFWS and DWR 2005; CVJV 2006), including:

- Floodplain habitat: Increasing the amount of floodplain inundated by floodwaters and tides and increasing the amount of shallow water and shorelines would increase tidal aquatic, wetland, and riparian habitats (BDCP 2006; BDCP 2007b).
- Riparian habitat: A large number of listed species, including native fish and wildlife, would benefit from preserving riparian remnant habitat on mid-channel islands and sloughs, and increasing the acreage of riparian habitat on leveed islands (BDCP 2006; BDCP 2007b; Meisler 2002).
- Emergent freshwater wetland and tidal wetland habitats: Increased freshwater emergent wetland habitat for fish, wildlife, waterfowl and sensitive plant species and communities would increase seasonal flooding of leveed lands and flood bypasses, would provide important habitat for shorebirds, waterfowl, raptors (particularly Swainson's hawk), native plants and wildlife, and spawning, rearing, and migration of native fishes (BDCP 2006; BDCP 2007b; OGSC 2007).
- Aquatic habitat (Meisler 2002).
- Perennial grassland habitat: Protecting perennial grasslands is an additional habitat goal (Meisler 2002; Witham 2006).

- Greater connectivity between habitat types along the ecotone from aquatic to upland (aquatic, tidal marsh, riparian, vernal pool and grassland) (Meisler 2002)
  - In particular, mosaics of tidal emergent wetland and shaded riverine aquatic habitat should be restored to provide essential resources for all species, particularly communities or assemblages of species that have declined significantly in the Delta. (North Unit of the Sacramento–San Joaquin Ecological Management Zone).
- Improved fish passage (North Unit of the Sacramento–San Joaquin Ecological Management Zone, which contains the Yolo Bypass and Cache Slough Complex)
- Floodplain modification and improved conveyance of floodwater (NDNWR: Foulk 1999; USFWS and DWR 2005)
- Habitat restoration (North Unit of the Sacramento–San Joaquin Ecological Management Zone, which contains the Yolo Bypass and Cache Slough Complex [CVJV 2006])
- Increased primary and secondary production, which provides food for Delta smelt and other native fish(OGCS 2007)
- Restoration of a landscape corridor stretching between Yolo Basin and Cosumnes Basin (USFWS and DWR 2005)
- Increased number of waterfowl wintering in the Central Valley (Hayes 1999)

14.2.1.4 Analysis Criteria: Specific Restoration Goals

Many available restoration plans specify acreages of habitat or particular species to target for restoration in their goals:

- NDNWR would restore tidally influenced wetland habitats to benefit listed fish species, including winter-run chinook salmon, Delta smelt, and Sacramento splittail as well as migratory waterbirds, neo-tropical migratory songbirds, and other wildlife.

- CVJV (Central Valley): CVJV stated the objective of restoring 110,332[1] acres of wetland habitat in the Central Valley. By April 1, 2003, 65,191 acres (59 percent of the goal) had been restored. However, restoration, has not progressed evenly throughout the region, with some basins (e.g., American, Delta, and Sutter basins) lagging behind the 59 percent increase, and others (e.g., San Joaquin Basin) exceeding the wetland restoration objective (CVJV Implementation Plan [CVJV 2006]).
- CVJV (Yolo Basin): Increased the availability of wetland habitat to meet the food energy needs of migrating waterfowl (CVJV 2006). In 1990, an objective was set to increase wetlands by 9,745 acres. Since that time, 4,254 acres have been restored (44 percent of the objective). Recent studies suggest that 11,558 acres of wetlands are needed to meet 50 percent of duck food energy needs.[2] Currently, 8,558 acres of wetlands are present in the Yolo Basin, leaving a shortage of 3,000 acres. The CVJV has set an annual enhancement objective of 713 acres per year, increasing to 963 acres per year in the future. Once the restoration objectives have been met, the Yolo Basin will require 57,790 acre-feet of water (CVJV Implementation Plan [CVJV 2006]).
- SLT would protect 29 listed species in the Greater Jepson-Prospect Corridor (Witham 2006), 11.4 miles of slough habitat, 614 acres of tule marsh and riparian habitat, 38 acres of mid-channel islands and more than 17,000 acres of one of the largest and most intact vernal pool/perennial grassland complexes in the state of California.
- In 1997, the 3,700-acre Yolo Basin Yolo Bypass Wildlife Area (YBWA) was put under the management of the CDFG. One objective for wetland restoration in the area was to increase the number of wintering waterfowl in the Central Valley to increase population sizes of the following duck species: mallard, northern pintail, American black duck, mottled duck, Gadwall, American wigeon, green-winged teal, blue-winged and cinnamon teal, northern shoveler, Hawaiian duck, Laysan duck, redhead, canvasback, and lesser and greater scaup. (NAWMP 2004). As of 2004, populations were stable or increasing for all of those species, except northern pintail, American black duck, and lesser and greater scaup. In general, populations are currently around 4 million birds, recovering from 2.5 million in 1987, and are approaching the objective of 4.7 million (Hayes 1999).
- OCGS would create spawning habitat for Delta smelt.

14.2.1.5 Basis of Concept: Restoration Actions Considered

The basic strategy for the area is to protect and enlarge remaining habitat and establish connectivity to these areas. Several groups have proposed restoration of a large area in this region. Conservation of habitat corridors has been proposed by the Bay-Delta Conservation Plan and the SLT (Meisler 2002; Witham 2006), and part of the area considered in this building block was considered for a North Delta National Wildlife Refuge by the USFWS (Foulk 1999; USFWS and DWR 2005).

The BDCP (2000) envisions a North Delta Corridor that provides large contiguous habitat corridor that connects the mosaic of tidal marsh, seasonal floodplain, riparian, and grassland

[1] Originally the goal was 120,000 acres, but 9,668 acres were restored before 1990 and removed from the objective.

[2] Currently ducks receive 79 percent of their energy needs from abundant agricultural crops, mainly corn and rice.

habitats in the Yolo Bypass, Cache Slough Complex, Jepson Prairie Preserve, Prospect Island, Little Holland Tract, Liberty Island, and Steamboat Slough.[3] A similar corridor that is slightly smaller in extent has been proposed by the SLT (Meisler 2002; Witham 2006) and guides SLT's acquisition of land and conservation easements. In 1999, the USFWS proposed a North Delta National Wildlife Refuge, which in plans ranged from 9,000 to 45,000 acres. As of 2001, 12,300 acres on Liberty Prospect and Little Holland Tract (Foulk 1999) were available. This plan has recently received renewed interest (USFWS and DWR 2005).

The corridor proposed by SLT is a 13,700-acre corridor along Lindsey and Barker sloughs from Jepson Prairie to Prospect Island and includes Calhoun Cut. The plan involves breaching levees at Calhoun Cut to restore flow to the original South Barker Slough—the original channel before Calhoun Cut. This plan would provide 900 acres of marsh, riparian, vernal pool, and perennial grassland habitat while maintaining land for seasonal livestock grazing. The SLT plan also involves restoration. Other proposed restoration activities involve the reach of Barker Slough between Barker Slough Pumping Plant and the SLT's Jepson Prairie Preserve (Meisler 2002).

The BDCP (2000) proposes several actions to realize the North Delta Corridor: The north Delta corridor would be created through construction of channels as permanent sloughs to connect proposed channel improvements in the Yolo basin, which would feed permanent tidal wetlands along the bypass and connect with existing wetlands within the Yolo Basin Wildlife Area. The sloughs would drain into extensive marsh-slough complexes developed in shallow islands (i.e., Liberty, Little Holland Tract, and Prospect at the lower end of the bypass). Levees would also be removed along the lower DWSC to retain and possibly increase the flood-bearing capacity of the Yolo Bypass. Connections between the DWSC and the new island complexes at Liberty, Little Holland Tract, and Prospect Island would be considered.

The proposed North Delta National Wildlife Refuge would recreate lost wetlands and riparian woodlands by preserving and restoring three Delta islands: Prospect Island, Liberty Island, and Little Holland Tract. This area provides refuge for diverse flora and fauna, including many threatened and endangered species. The formation of this refuge would improve movement of floodwaters from the Yolo Bypass through the north Delta while creating a landscape corridor from the Yolo Basin to the Cosumnes Basin.

The Yolo Basin is recognized valuable habitat along the Pacific Flyway (Kulakow et al. 2005). In 1990, the Central Valley Joint Venture was developed as a partnership to implement the goals of the North American Waterfowl Management Plan. The partnership is administered through the USFWS. Restoring the wetlands of the Yolo Basin is essential in meeting the objectives set forth by the USFWS under jurisdiction of the Migratory Bird Treaty Act (Kulakow et al. 2005; PFC 2007). Under the act, the USFWS, states, and wildlife conservation agencies manage migratory game under coordination of the Pacific Flyway Council.

Several alternatives have been suggested for restoring tidal marsh in the Calhoun Cut Reserve, a 963-acre reserve extending 1.7 miles from State Route 113 to the confluence of Barker Slough and Calhoun Cut. A preliminary study suggested that natural processes of flooding and tidal inundation could be restored at the reserve by removing or breaching levees along the north and

[3] Since the BDCP report was written in 2000, additional conservation easements have been acquired in the area, such as Liberty Farms. This area also includes conservation land at the U.S. Army Corps of Engineers riparian mitigation project at the tip of Cache-Haas, Calhoun Cut Ecological Reserve, and Wilcox Ranch.

possibly south side of Calhoun Cut (Meisler 2002). Alternatively, South Barker Slough could be restored to a functional slough channel by redirecting flow from Calhoun Cut into South Barker Slough (Meisler 2002). Follow-up studies in 2006 proposed three alternatives (PWA et al. 2006) The simplest and least expensive alternative would restore approximately 74 acres of tidal marsh and 0.1 acre of functioning tidal channel by making two breaches and allowing full tidal connection to Calhoun Cut. The second, and preferred, alternative reinstates tidal action to Lindsey Slough. In this alternative, 138 acres of freshwater tidal marsh on Lindsey Slough and 1.9 acres of tidal channel habitat would be restored by making one breach, filling a culvert, and excavating a channel. The third, and most costly, alternative would alter several channels to restore full tidal action to Lindsey Slough while blocking tidal action from Calhoun Cut. This alternative would also establish 138 acres of tidal marsh and 1.9 acres of tidal channel habitat. With no action, 18 acres of marsh habitat are expected to form over 10 years with the natural degradation of berms. The cost of the first phase of the preferred alternative (the second alternative) is estimated at $1,500,000 to $2,000,000 (PWA et al. 2006); the cost estimate in this analysis (Section 14.3) includes the most expensive and least expensive alternatives (PWA et al. 2006).

14.2.2 Analysis Results and Conceptual Layouts

14.2.2.1 Conceptual Layout for Tidal Marsh Restoration Alternative for Cache Slough Area

To examine the potential impacts of the hypothetical Tidal Marsh Restoration Alternative for the Cache Slough area, the following components were included in the analysis of potential ecosystem risks and benefits, the cost estimate, and the estimate of risk reduction:

- The area in the Cache Slough Complex below the 100-year floodplain that is bordered in the northeast by the Yolo Bypass, including some portion of the bypass area, and Prospect Island on the east (Figure 14-3)
- Breaching of levees (included in the cost estimate at the level of detail in which levee stature [i.e., volume of dirt in the levee] was considered)
- Building of levees to maintain or improve flood protection for Rio Vista
- Channeling water to drain over a wide swath of tidal marsh and to encourage marsh channel formation
- Restoring the historical slough channels in Calhoun Cut, Barker Slough, Cache Slough, and Lindsey Slough, as proposed in PWA et al. (2006)
- Preserving and expanding riparian habitat in Barker, Cache, Lindsey, and Miner sloughs
- Removing aboveground structures and stabilizing below-ground structures (“abandonment”)

14.2.2.2 Analysis results

The total acreage involved in the restoration project is 44,900 acres. The majority of the land is in Solano County, with portions of Liberty Island, Prospect Island, Cache-Haas, and Little Holland Tract in Yolo County.

Restoration of the Cache Slough area would create 23,600 acres of floodplain. Tidal marsh would rapidly (in less than 4 years) be established in 7,000 acres and would be established over time (over more than 4 years) in an additional 3,900 acres. The remaining 10,300 acres would become open water habitat and would remain open water habitat for decades, depending on local hydrodynamics and sediment movement processes.

Restoration would preserve habitat for 80 listed species that have been found in the Cache Slough Complex and surrounding U.S. Geological Survey quads (Appendix 14B). As Figure 14-3 shows, the majority of observed occurrences of listed species occur in vernal pool areas or in riparian areas on sloughs. Therefore, restoration would not be expected to destroy habitat, but rather enhance habitat for these species. Listed species in the area include 22 federally threatened and federally endangered species, including wildlife (e.g., clapper rail, salt marsh harvest mouse, and California least tern), plants (seven species), and arthropods (three species). These species may also be listed as California endangered or threatened species. Also, four species are listed as state endangered or threatened and one as rare (but not federally listed), and 15 species are listed as species of concern by CDFG. The rest are plants listed by the California Native Plant Society as rare in California and rare elsewhere or rare in California but common elsewhere.

Species composition in restored habitats may be similar in composition to Liberty Island, which has remained flooded since 1997. A preliminary report of species found at Liberty Island in 2005 (Appendix 14E) shows that breached areas can support a wide range of animal and fish species, including listed species.

14.2.2.3 Existing Restoration Within and Nearby the Cache Slough Area

Of the total restoration area, 12,900 acres are within the Cache Slough Complex or are contiguous with it under conservation easements or restoration plans (Table 14-1). Also, two nearby parcels of land (total of 725 acres) to the west are conserved by mitigation banks (Table 14-1).

The restoration area also connects and expands the Yolo Bypass. The Yolo Bypass, when flooded, creates 60,000 acres of floodplain, doubling the water surface area of the Delta. When flooded, this entire area becomes floodplain habitat that supports native fish and produces primary productivity. Some floodplain habitat in the Yolo Bypass would be converted to open water or tidal wetland habitat. Within the bypass, 20,471 acres are in conservation easements (Table 14-2). The restoration project would connect the 32,900 acres of restored habitat to these conservation easements through the Yolo Bypass floodplain (60,000 acres).

14.2.2.4 Success of Restoration Actions

As part of the results for this building block, we present a summary of the currently available data on the results of various restoration actions and the characteristics that influence the success of restoration actions. The data on this topic are limited, including a preliminary report by the BREACH team (Simenstad et al. 2001) and a study of species colonizing Liberty Island (USFWS DWR 2005). More complete or more recent survey data were not available for Liberty Island; nor has the restoration of Little Holland Tract been monitored (R. Mager, pers. comm., 2007). Currently, the BREACH group planned to start extensive study of restoration at Liberty Island in October 2007 (C. Simenstad, written comm., 2007). The results of these studies will provide better data on the expected outcomes of a tidal marsh restoration strategy for the Cache

Slough area, including colonizing species, community composition of restored sites and change over time, benefits to listed species, changes in primary and secondary productivity, local hydrodynamic and sediment processes, and optimal breach locations.

Habitat Creation: Tidal Wetlands

Restoration of intertidal wetlands in the Delta offers unique challenges due to the high degree of subsidence of leveed islands and the slower rate of post-breach sediment accretion (Simenstad et al. 2001). Creation of tidal wetlands by breaching levees depends on the elevation of land. Simenstad et al. (2001) found that for breached islands in the Delta, rapid (less than 4 years) re-establishment of emergent marsh vegetation occurred if ground elevation was higher (in this case, between mean lower low water [MLLW] + 0.4 meter and mean higher high water, while slow re-establishment of emergent marsh vegetation resulted when elevation was lower (in this case, between MLLW + 0.4 meter and MLLW – 0.6 to 0.8 meter). Habitat remains as open water (no marsh vegetation in 60+ years) if elevation was low (in this case, less than MLLW – 0.6 to 0.8 meter) (Simenstad et al. 2001). Rebuilding intertidal elevations depends greatly on the extent of leveed-island subsidence and the geomorphic region of the Delta and may range from 4 cm/yr^{-1} (subtidal habitats) to 1 cm/yr^{-1} (intertidal habitats), depending largely on the extent of wave and current energy (Simenstad et al. 2001). Formation of dendritic channels, which transport tidal waters into wetlands and which are habitat for fish, can be initiated by digging channels, but expansion and contraction of tidal channels depends on the local hydrodynamic regime of the area. The development of tidal marsh over time at Liberty Island provides an indication of the types of habitats that may develop with breaches of islands in the Cache Slough area. Aerial photos of northern Liberty Island from 2007 and 1937 (not shown) show subtidal open water habitats, floating aquatic vegetation, intertidal marsh, seasonal wetlands, and upland grassland (USFWS and DWR 2005).

Habitat Creation: Floodplain

Inundation of the Yolo Bypass floodplain plays a major role in the success of the Sacramento splittail (Feyrer et al. 2006b), and juvenile salmon reared in Yolo Bypass have been shown to reach larger sizes than juveniles reared in-river (Sommer et al. 2005). Creation of floodplain, which is spawning and rearing habitat for native fish (e.g., chinook salmon, splittail), depends in part on how rapidly floodwaters recede. Fish rely on directional cues to avoid stranding, and more gradual flood recession such as typically occurs in the Yolo Bypass allows most fish to use the floodplain without becoming stranded in water drains. Also, detention basins may strand fish or create perennial ponds that are habitat for exotic fish species (T. Sommer, pers. comm., 2007).

Habitat Creation: Riparian Habitat

Re-establishment of riparian habitat from leveed areas typically involves creation of a setback levee. Removal of riprap, addition of fill to create a riparian bench, and planting is usually required to re-create riparian habitat. Riparian habitat has also emerged at Little Holland Tract (R. Mager, pers. comm., 2007).

Habitat Creation: Native Fish Habitat

Restoring the Delta to its historical state may have unexpected results due to the presence of exotic species in the present-day Delta. For example, restored, historically extensive shallow water habitat becomes primarily dominated by exotic fish, while native fish primarily benefit from restored seasonally inundated wetlands (e.g., floodplains) (Simenstad et al. 2001; Feyrer et al. 2004; Sommer et al. 2005). The benefit to native fish of seasonally flooded tidal marshes (distinct from floodplains) and of open water habitat is currently not well understood. Submerged and floating aquatic vegetation, including introduced species such as water hyacinth and parrot's feather, may dominate subtidal habitats (Simenstad et al. 2001). Sub-tidal habitats are also habitat for exotic fishes that eat native fish. Open water habitat on Liberty Island is occupied by adult and larval Delta smelt and other native fishes; however, exotic fishes dominate species numbers and abundance (USFWS and DWR 2005). Tidal marshes also benefit native fishes, but tend to be dominated by exotic fishes. Tidal marshes next to deep water may also benefit adult Delta smelt, because they tend to be captured in that area (R. Mager, pers. comm., 2007). Networks of small, higher-order sloughs (such as those proposed for restoration in the Cache Slough region) appear to be particularly beneficial for rearing of small and larval native fish species (Matern et al. 2002; Visintainer et al. 2006). Benefits to small native fish from these slough networks are probably related to a combination of low flows, high productivity, and a the relatively low levels of exotic fish predators found in such sloughs.

Creation of habitat that increases the overall population of native fish in spite of being dominated by exotics is beneficial for the conservation of native fishes (Sommer, pers. comm., 2007; Bennett, pers. comm., 2007). Perennial wetlands within the Yolo Bypass floodplain are dominated by exotic fish; however, the bypass is still excellent habitat during flooding for native fishes, such as chinook salmon and splittail (T. Sommer, pers. comm., 2007). Similar trade-offs are also found in the benthic macro-intervertebrate and insect communities in emergent marsh and subtidal habitats that may be dominated by submerged aquatic vegetation/floating aquatic vegetation (Simenstad et al. 2001).

Habitat Creation: Delta Smelt Spawning Habitat

Fish surveys on Liberty Island reveal that Delta smelt adults and larvae are found in restored habitats, particularly in deep-water habitat that is next to tidal marsh habitat (USFWS and DWR 2005) (see Table 14E-2). However, little is known about the location and preferred microhabitat for Delta smelt spawning. Therefore, it is not clear whether the fish spawning habitat is increased by the restoration of these areas. A preliminary meta-analysis (Appendix 14A) of larval and adult Delta smelt surveys in the Cache Slough area suggests that Delta smelt spawning in the Cache Slough area may occur predominantly in the DWSC. This hypothesis could be tested with sampling of larval Delta smelt in the DWSC, which would further inform restoration and preservation efforts of Delta smelt spawning habitat. Further details on the analysis and results are provided in Appendix 14A.

Re-establishing Species Composition

Several studies show that the diversity and density of reference sites are more productive than restored sites (e.g., invertebrates [Simenstad et al. 2001]). However, this conclusion depends on the state of the restored sites, the elevation of the restored sites, and group of species examined.

The composition of species inhabiting a restored site also changes over time. In particular, indicator bird species on a restored site have greater abundance (song sparrow, common yellowthroat) or simply presence (black rail) compared to breached sites (Simenstad et al. 2001) over time. However, overall species richness, diversity, and abundance of all birds showed greater differences by region of the Delta than between reference sites and restored sites (Simenstad et al. 2001).

Increase Primary Productivity

Increases in primary productivity result from increased water residence time found in floodplain tidal marsh and open water. Of the proposed rehabilitation measures, increased use of floodplains probably offers the biggest increases in organic matter sources (Jassby and Cloern 2000). The productivity of intentionally flooded islands would exceed that of adjacent channels because of lower turbidity and shallower mean depth, though vascular plants rather than phytoplankton could dominate if depths are too shallow. Liberty Island produces a fair amount of phytoplankton and also functions as a storage bank for phytoplankton food (T. Sommer, pers. comm., 2007).

14.2.3 Description of Values, Benefits, and Constraints

The primary objective of this building block is to restore tidal inundation to Cache Slough, thereby increasing the connectivity of uplands and waterways, which would increase the quantity and quality of habitat for over 80 listed species. In particular, the building block would provide important spawning habitat for the threatened Delta smelt.

Other benefits and constraints of the building block include:

- A reduction in the long-term costs of levee maintenance
- Halted or reduced island subsidence and a reduction in the risks associated with levee failure
- A potential reduction in salinity intrusion
- A loss in agricultural production
- Environmental risks
- Impacts to infrastructure assets
- Socioeconomic impacts

14.2.3.1 Benefits

Improved Biodiversity

This building block would create a habitat continuum from upland riparian areas to open water. The habitats developed, connected, and protected within this building block would include open water, tidal marsh, floodplain, vernal pools, and grasslands. The provision of this contiguous habitat would increase the abundance and local distribution of at-risk and other native plant and animal species. Preliminary data collected at Liberty Island indicate that in addition to benefiting listed species, including Delta smelt, the area would increase abundance of many native species, including a large number of bird species. Wildlife surveys were not available. Exotic species are also found in restored habitats, with a particularly high number of species and abundance of exotic fish. The building block would also increase the floodplain extent and hence Chinook salmon spawning and rearing habitat. Preservation of existing remnant habitat (e.g., riparian and vernal pool habitat, which supports high biodiversity) and increasing historically abundant habitat types may reduce the risk of extinction of over 80 listed species, increasing the health of the Delta and preserving the rich biodiversity heritage of the state of California.

Conservation in Cache Slough provides a large "bang for the buck" by ecologically benefiting a large number of listed species in a single large habitat area. The idea is to connect approximately 12,000 acres (about a one-third increase) of existing farmland to land that is already protected through easements and covenants.[4]

Reduced Costs for Levee Maintenance

Under the concept presented in this building block, a number of levees would be breached, eliminating the need for ongoing levee maintenance and associated costs. At present, the annual costs to maintain the islands are highly variable for different islands; these costs include dredging, monitoring, earthwork, and rock work; however, the costs have not been quantified. Relative to business as usual, this reduction in levee maintenance costs could represent a financial benefit of the Cache Slough building block.

Halting or Reducing Island Subsidence

The utility of permanently flooded wetlands for halting and reducing subsidence is being investigated in the Delta. The process being examined consists of two components: (1) re-establishing wetlands to slow peat decomposition rates and halt further subsidence and (2) accreting plant biomass in the re-established wetland to reverse subsidence.

Under existing land uses, the mean long-term rate of subsidence for Delta peat islands is estimated at up to 1.0 inch per year. In permanently flooded wetlands, rates of accretion have been estimated at between 0 and 3.6 inches per year,[5] with an average of around 1.6 inches per year (R. Miller, pers. comm., 2007). However, these rates would differ in tidally influenced marsh wetlands, whose rates of accretion are also influenced by local processes, including sediment availability and local hydrology (Simenstad et al. 2001).

The potential production of carbon credits associated with carbon sequestration has not been examined in tidal marshes. Where carbon credits are shown to be "real," they will represent a potential income source for the Cache Slough area.

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[4] Protected land includes that of the U.S. Department of Agriculture (easements), mitigation banks (e.g., Wildlands, Inc.), private land trusts (e.g., Solano Land Trust), U.S. Bureau of Reclamation (Prospect Island), CDFG (Liberty Island), and the U.S. Army Corps of Engineers (riparian mitigation at the tip of Cache-Haas).

[5] Estimated average using 7.5 years of data from Twitchell Island ponds.

Impact on Salinity Intrusion

When a levee breach occurs, the volume of water that floods the islands depends on the current and future amount of island subsidence. Under current land uses, subsidence is estimated to result in a 35 percent increase in island volume by 2050 and 67 percent by 2100 (URS/JBA 2007d). The salinity of the water that floods a breached island depends on the season and the island's location in the Delta. Catastrophic levee breaches increase the water salinity in the Delta and this increase will be larger if the breaching occurs in summer rather than winter. As subsidence continues, the gulp increases and the time to restore equilibrium also increases.

Efforts to reverse subsidence will reduce the volume of saline water flowing from San Francisco Bay into the Delta and therefore will reduce the duration and intensity of the economic and ecological impacts associated with increased salinities.

14.2.3.2 Constraints

Loss of Agricultural Production

The Cache Slough restoration area is composed of about 34,000 acres of land; two-thirds of the total acreage is agricultural land, with producers cultivating alfalfa, field crops, grain, orchards, processing vegetables, and vineyards. Alfalfa is the most abundant land use. Orchards and vineyards are the most lucrative land uses.

A significant constraint to Cache Slough would be the value of agriculture foregone when an island is changed to a wetland. The economic value of this lost production can be measured as the area of different land uses multiplied by the net value (income less variable costs) of production on this land use. For the land uses shown in Table 14-3, if we assume that net annual value of lost agricultural production is equal to 65 percent[6] of income (Table 14-3), the value of lost agricultural production within each island is shown in Table 14-4.

The annual value of agricultural production on the Cache Slough islands is estimated at $7.4 million per year. The capitalized value of this lost production is estimated at over $100 million (discounted at 6 percent over 30 years).

Environmental Risks

Environmental risks include potential invasion by exotic species expanding their geographic range and increasing their population size and hence increasing competition with native species. The tidal action of channels may reduce the invasion by Brazilian waterweed, a common issue in freshwater parts of the Delta. However, Brazilian waterweed has not colonized Liberty Island, a "restored" flooded island within the restoration (Nobriga et al. 2003; Nobriga and Feyrer 2005). A complex trade-off exists between increasing tidal wetlands that are habitat for birds and exotic fish and that also provide primary productivity and increasing seasonal floodplain, which benefits native fish (splittail and chinook salmon). The benefit of seasonally flooded freshwater tidal marsh for native fish is less clear (T. Sommer, pers. comm., 2007).

[6] This percentage is a "rule of thumb" rather than being representative of any one industry.

The restoration plan considered may not be compatible with current land uses in conservation areas, such as preservation of vernal pools in the Cache-Haas Tract and managed wetlands in Liberty farms (proposed to be tidal wetlands). Although floodplain areas could continue to be farmed, tidally inundated areas would preclude farming.

Impacts to Infrastructure Assets

The estimated total asset value in Cache Slough exceeds $176 million dollars (Appendix 14D). Assets considered in this estimation include public infrastructure, dwellings, and property for gas-oil production. Family dwellings are predominant in this area, with a total of 110 compared to only 4 commercial dwellings on-site. Minor roads make up the vast majority of the 120 miles of roadways present. A significant number of gas fields exist in the Cache Slough area, with 33 miles of standing pipeline and almost 900 oil-gas wells. These facilities add to the value of the property in the Cache Slough area.

In developing the conceptual design for the Cache Slough area, some assets are likely to be abandoned, while others may require increased costs to protect them from inundation.

Socioeconomic Impacts

Where substantial land use change is to occur and where people and their livelihoods are affected, considerable social costs can be assumed to occur. It is beyond the scope of this building block to assess the magnitude of these social costs. However, these issues will be addressed through a stakeholder process that could include:

- Guiding principles and agreements for multi-party management of the Lower Bypass
- Mutually beneficial actions with proposed implementation timelines
- Preliminary technical analysis to support the actions considered
- Preliminary regulatory strategies to implement different actions (YBF and CALFED 2005)

14.3 COST ESTIMATE

14.3.1 Construction Considerations

Primary construction considerations include the presence of endangered species during construction, the use of methods of construction that may impact endangered species (e.g., sedimentation, noise,), and time of year to breach levees relative to winter/spring floods.

14.3.2 Cost Estimate

The conceptual-level cost estimate for this building block is presented in Table 14-5. Additional data collection is required to refine costs. These data collection requirements include light detection and ranging (LiDAR) and hydrodynamic modeling of the area to ensure that the current level of flood protection at the borders outside the Cache Slough Complex would be preserved. Additional data are also required to refine the estimate for levee construction costs to protect Rio Vista; a conservative estimate is provided.

Modeling would also be required to refine breach locations and the number of breaches. Total cost for breaches may be over-estimated, because the total number of breaches is based on an existing dataset of smaller tidally inundated areas. The cost estimates do not account for potential reliance on erosional processes to widen breaches, which could reduce the amount of costly earth moving required.

A major cost of the restoration is securing land for conservation. Many alternative approaches are available for preserving and re-storing land, including, but not limited to, conservation easements of various types on private land, flood easements, conservation easements obtained by private mitigation banks, conservation on public lands, and conservation efforts by private land trusts. Various types of conservation and restoration strategies involve different land uses and durations of protection. Conservation and restoration efforts should be coordinated with existing groups, such as the SLT.

The cost estimate for land acquisition may be further altered through floodplain easements. Within the restored area, 19, 829 acres would become floodplain (not including land under conservation easements). This land may necessitate floodplain easements or compensation for lost agricultural yields during floods, rather than land acquisition or conservation easements. The floodplain area could persist in ecologically friendly farming practices, such as those practiced within the current extent of the southern Yolo Bypass. The cost of acquiring floodplain easements is not included in the estimate.

14.4 RISK REDUCTION ESTIMATE

Direct risk reduction includes increasing the available habitat and food supply for many endangered species in the Delta, including Delta smelt. Also, the restoration in this building block would expand the Yolo Bypass floodplain, reducing the hydrostatic pressure on upstream levees, and the risk of levee breach due to flooding overall. Mixed opinions exist about the effect this concept could have on downstream levees. The authors expect a reduction in risk to downstream levees due to the large extent of the Yolo Bypass, but this expectation will need to be substantiated though modeling before a project could proceed. If the results showed that actions would increase flood pressure on downstream levees, such as those that protect Rio Vista, those levees would need to be fortified as part of the project. Flooding of breached islands may also reduce salinity intrusion into the Delta by altering the distribution of the tidal prism throughout the Delta (based on preliminary analysis of the impacts of the Liberty Island breach by Resource Management Associates, Inc. [RMA]; J. DeGeorge, pers. comm., 2007).

14.5 FINDINGS AND CONCLUSIONS

14.5.1 Findings

If implemented, the conservation and restoration of 33,000 acres described in this building block would connect with 12,000 acres of currently conserved or restored areas, resulting in a total contiguous area of habitat of 45,000 acres. Connecting to existing restoration areas creates large areas of restored habitats, which are more beneficial for wildlife. This building block would effectively increase the contiguous preserved area by 37 percent. Tidal restoration of this area would create an additional 24,000 acres of floodplain, 7,000 acres of rapidly establishing tidal marsh, 4,000 acres of slowly establishing tidal marsh, and 10,000 acres of open water habitat. The total acreage of restored habitat is expected to change over time as hydrodynamic, tidal marsh accretion, and sediment deposition processes alter the landscape and as habitat matures over time. Restoration would also connect wetland and upland habitats over this large area, which is critical to several listed species. Some of the restoration actions considered in this building block may also benefit exotic fish species. The habitat value of restored floodplain is directly connected with the operations of the Yolo Bypass and in particular the frequency of flooding.

About 12,000 acres of conservation efforts and public lands currently exist, and mitigation banks and private land trusts are actively conserving the Cache Slough area and the land adjoining and nearby the Cache Slough area. Conservation groups, including private mitigation banks and the SLT, and private landowners may be interested in coordinating efforts to protect and restore the area.

A survey of the existing published and unpublished data on Delta smelt spawning indicates that little is currently known about the preferred spawning microhabitat of the species. Therefore, it is not clear what restoration measures should be taken to increase spawning microhabitat for this species, though many suggest that shallow water gravel may be an ideal habitat. Existing published and unpublished surveys of Delta smelt larvae and adults indicate that even though Delta smelt adults and larvae are found in the Cache Slough area, raw abundances indicate that the most frequently used spawning habitat is upstream in the Sacramento Deep Water Ship Channel (DWSC). Sampling of larval Delta smelt at locations in the DWSC would test this hypothesis. Several surveys indicate that Delta smelt larvae and adults may benefit from the restoration of deep-water habitat in close proximity to tidal marsh. These survey results suggest that the species may benefit from the tidal marsh restoration under consideration in this building block.

14.5.2 Conclusions and Recommendations

In conclusion, this building block could achieve several goals presented by restoration groups for the Cache Slough area, including an increase in a variety of habitat types, which would increase the area for listed species and help increase the health of the overall Delta. In particular, the building block provides high ecological “bang for the buck” by connecting to existing restoration efforts to create large areas of connected habitat to provide greater benefit than un-connected habitat.

Further data collection on the species composition of restored areas at Liberty Island and hydrological processes, sedimentation, primary and secondary production, and water quality factors such as methylmercury and dissolved organic carbon (not discussed in this analysis) would be used to further refine the design and approach of this restoration alternative. Data collection is currently planned at Liberty Island (C. Simenstad, written comm., 2007); however, additional data collection opportunities exist at Little Holland Tract and the U.S. Army Corps of Engineers riparian mitigation site at the tip of Cache-Haas; this information would provide indications of the trajectory of the restoration project through time and the impact of different restoration actions.

These data, along with the data collection discussed in the cost estimate, would further refine the cost estimate and might have the effect of reducing it substantially. High-resolution LiDAR topographic data and detailed hydrodynamic modeling are required to refine the acreage of habitat types created. Hydrodynamic modeling could help evaluate the potential for stimulating the food web through access to open water areas. This modeling could help determine the benefit to species, including juvenile Delta smelt.

Hydrodynamic modeling would also be required to quantify how the concept would modify flood flows. It is essential to ensure that if the concept were to be implemented as a project, flood protection in the areas outside the project boundaries would be maintained or improved.

Methods to prevent the invasion of exotic species are not currently available, but the benefit to native species of fish that would result from increasing open water and tidal marsh habitats may outweigh the negative impacts of invasion and the increase in the abundance of exotic fish by making the native fish more robust and resistant to extinction.

Further study of the locations and microhabitat of the breeding grounds of Delta smelt is required to create additional spawning habitat. Additional efforts should focus on determining spawning microhabitat. We recommend that sites in the DWSC upstream of Cache Slough be added to the 20-millimeter survey to test the hypothesis that current Delta smelt spawning habitat exists upstream of Cache Slough. This information would help inform the appropriate restoration actions for the Cache Slough Complex to increase Delta smelt spawning habitat.

Tables

Table 14-1 Restoration Sites Within, Adjoining, or Nearby the Restoration Area

Connection to Restoration Area	Site Name	Size (Acres)	Habitat Type	Management	Notes	Total Area (Acres)
Within or Adjoining	Liberty Farms	1,128	Managed wetlands	WRP, NRCS	563 acres (1998); 565 acres (2002)	12,884
	Cache-Haas	176	Open water, wetlands	ACOE	Riparian Mitigation	
	Calhoun Cut Ecological Reserve	963	Riparian corridor	CDFG		
	Wilcox Ranch	1,489	Vernal pool habitat	SLT		
	Jepson Prairie	1,566	Vernal pool habitat	SLT		
	Liberty Island	4,566	Open water, wetlands	TPL (2001), CDFG, Wildlands		
	Prospect Island	1,228		USBR		
	Little Holland Tract	1,456		ACOE		
	Eastern Tip of Hastings Tract	152				
	Campbell Ranch Conservation Bank	160		CNLM		
Nearby	Jenny Farm	405		Wildlands, Inc.	Mitigation Bank	725
	Remy Preserve	320		CNLM	Off-site Area	

Note: Additional conservation easements, some for short periods (10–20 years), may be held by the USDA.

ACOE = United States Army Corps of Engineers
CDFG = California Department of Fish and Game
CNLM = Center for Natural Lands Management
NRCS = Natural Resources Conservation Service
SLT = Solano Land Trust
TPL = Trust for Public Lands
USBR = United States Bureau of Reclamation
USDA = United States Department of Agriculture
WRP = Wetland Reserve Program

Table 14-2 Restored Areas in the Yolo Bypass

Connection to Restoration Area	Site name	Size (Acres)	Habitat Type	Management	Notes	Total Area (Acres)
In Yolo Bypass	Vic Fazio Wildlife Area	16,770		CDFG		20,471
	Pope Ranch	391		Wildlands, Inc		
	Bull Sprig Outing Club	119		USFWS (1996)	CE	
	Channel Ranch	191		USFWS (1998)		
	Dawson Duck Club	159		USFWS (1996)	CE	
	Glide In Ranch	852		USFWS (1996)	CE	
	H-Pond Duck Club	479		USFWS (1996)	CE	
	Laurel G Ranch 1	366		USFWS (1996)	Permanent CE	
	Laurel G Ranch 2	122		USFWS (1996)	CE	
	Los Rios Putah Creek	158	Managed wetland	NRCS (2000)	Permanent WRP easement	
	Rising Wing Duck Club	44		USFWS (1998)	CE	
	Saxon Duck Club	480	Managed wetland		CE	
	Skyraker Duck Club	340	Managed wetland		CE	

CE = Conservation Easement
CDFG = California Department of Fish and Game
NRCS = National Marine Fisheries Service
USFWS = United States Fish and Wildlife Services
WRP = Wetland Reserve Program

Table 14-3 Estimated Net Value of Agricultural Production ($/acre)

Land Use	Revenue ($/acre)	Variable Costs (65% revenue)	Net Value ($/acre)
Alfalfa	800	520	280
Field crops	500	325	175
Grain	300	195	105
Orchards	5,900	3,835	2,065
Processing Vegetable	2,900	1,885	1,015
Vineyards	4,200	2,730	1,470

Table 14-4 Estimated Value of Agricultural Production Foregone

URS_ID	Island Name	Area (acres)	Agricultural Production Foregone ($0,000) Annual ($/yr)	Agricultural Production Foregone ($0,000) Capitalized Value NPV (6% over 30 yrs)
88	Cache Haas Tract 1	8,582	$2,395	$32,972
70	Egbert Tract	5,907	$1,476	$20,322
71	Hastings Tract 1	152	$0	$0
81	Hastings Tract	7,185	$735	$10,117
68	Little Egbert Tract	3,248	$935	$12,865
79	Peter Pocket	2,050	$622	$8,568
211	Prospect Island	2,210	$72	$995
69	Egbert Tract East	438	$0	$0
79	Peter’s Pocket West	2,050	$622	$8,568
80	Cache Haas Tract 1 East	1,797	$550	$7,569
		33,619	$7,407	$101,976

NPV = net present value
yr = year

Table 14-5 Conceptual-Level Cost Estimate Summary for the Tidal Marsh Cache Slough Restoration Alternative

Item	Options	Unit cost		Total Amount		Total Cost
		Cost	Unit	Amount	Unit	
Land acquisition						
	Option A: Purchase land[1]	*$10,000*	*acre*	*33,697*	*acre*	*$336,971,207*
	Option B: Acquire conservation easement[2]	*$2,000*	*acre*	*33,697*	*acre*	*$67,394,241*
Levee breaching[3]		$5	cubic yard	689,836	cubic yard	$3,449,180
Levee construction to protect Rio Vista		$21,000,000	mile	1	mile	$21,000,000
Restoration of Lindsey Slough meander at Calhoun Cut[4]						
	Option A	--	--	--	--	*$3,200,000*
	Option B	--	--	--	--	*$400,000*
Dig channels (Tidal Marsh and Yolo Bypass)[5]		$100,000	mile	9	mile	$900,000
Abandonment of existing diversions (siphons, pumps)		$1,000,000	diversion	54	diversions	$54,000,000
Restore riparian habitat						
Removal of rip-rap on exterior levees[6]		$20	cubic feet	24	miles	$50,688,000
Re-vegetation riparian areas		$1,800,000	mile	20	miles	$36,000,000
		SUBTOTAL		**Maximum Options**		**$506,208,387**
				Minimum Options		**$233,831,422**
	MOBILIZATION/DEMOBILIZATION (10%)			Maximum Options		$50,620,839
				Minimum Options		$23,383,142
		SUBTOTAL		**Maximum Options**		**$556,829,226**
				Minimum Options		**$257,214,564**
	CAPITAL CONTINGENCY (30%)			Maximum Options		$151,862,516
				Minimum Options		$70,149,426
		SUBTOTAL		**Maximum Options**		**$708,691,742**
				Minimum Options		**$327,363,990**
	ADMINISTRATION, DESIGN/ENGINEERING, CONSTRUCTION MGT. CONTINGENCY (30%)			Maximum Options		$212,607,523
				Minimum Options		$98,209,197
		GRAND TOTAL		**Maximum Options**		**$921,299,264**
		GRAND TOTAL		**Minimum Options**		**$425,573,187**

All values are in 2007 US dollars.

[1]Standard estimate value used by DRMS Phase II Building Blocks

[2]http://www.calrice.org/a6c2_federal.htm

[3] Assumes 1 breach per 1000 acre-ft and onsite disposal of fill. Three reference cross-sectional levee areas were used to estimate volume of levees of different stature.

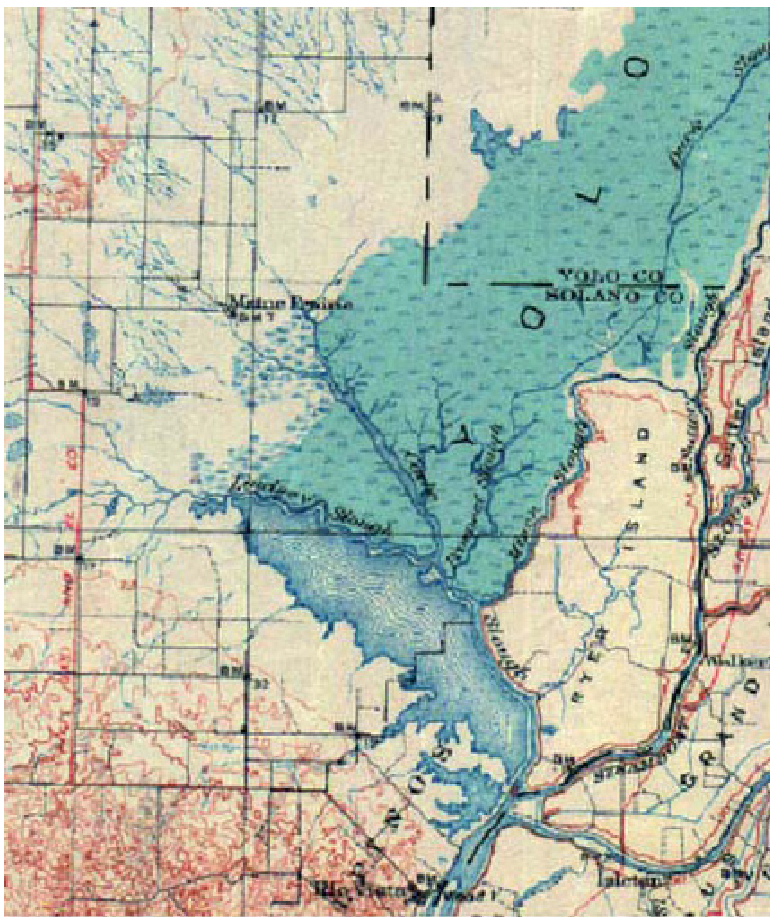
[4] Cost estimates for alternatives from PWA et al. 2006

[5] Assumes a 20 ft by 5ft trench

[6] Assumes removal of riprap on a third of entire length of levees (72 miles), and that the cross-sectional area removed is 20 cubic feet

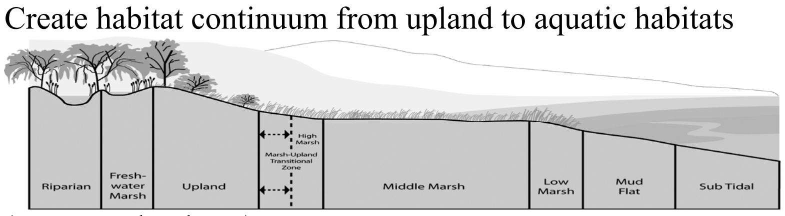
Figures

Historical Wetland Extent (circa 1903-1910; USGS)



Objectives

Create habitat continuum from upland to aquatic habitats



(www.vernalpools.org)

Restore dendritic slough channels for fish habitat

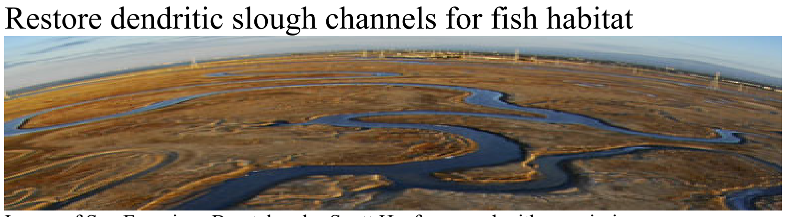
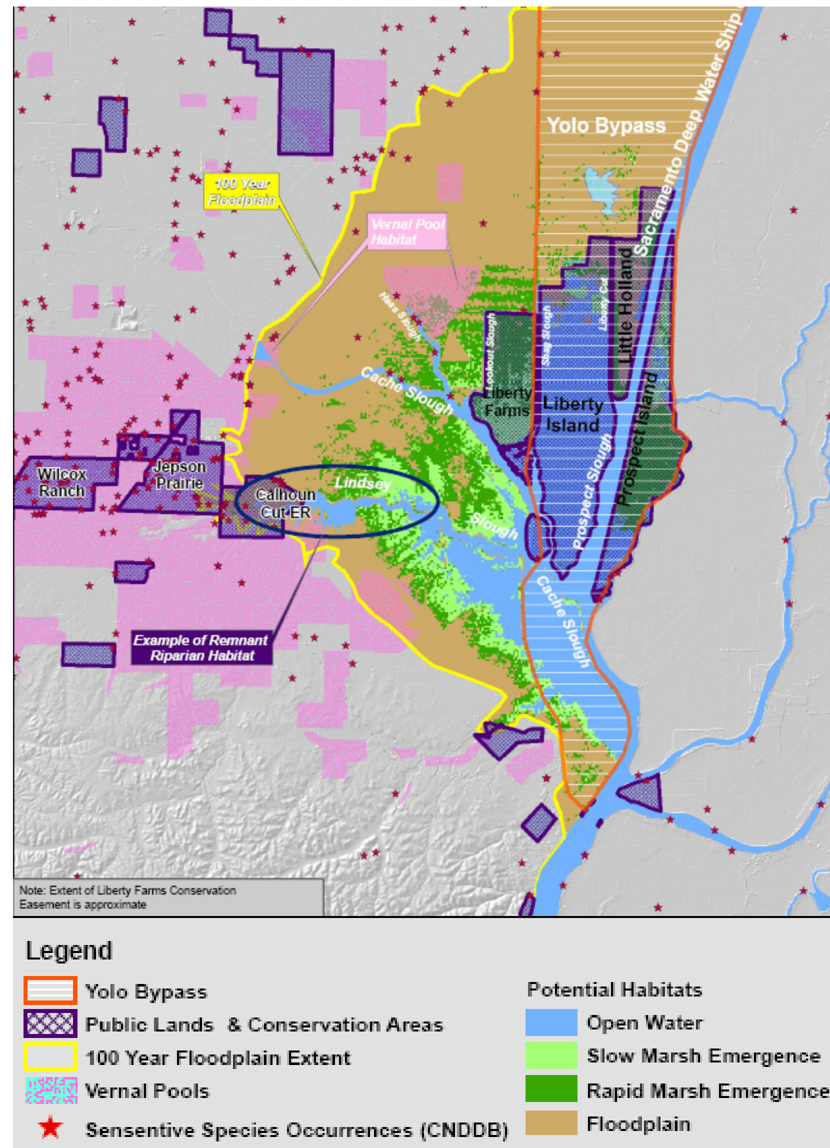


Image of San Francisco Bay taken by Scott Haefner, used with permission

Restore tidal wetlands and riparian habitat

Tidal Marsh Cache Slough Restoration



- The Cache Slough area includes high biodiversity and sensitive habitats, including remnant riparian, vernal pools, and Yolo Bypass floodplain, supporting 80 listed species.
- Preservation and restoration has begun through conservation easements and public lands (purple).
- This restoration alternative will re-establish historical habitat, including tidal marsh, floodplain, and open water.
- The following management plans were used in preparing the building block: Jepson Prairie-Prospect Island Corridor (Solano Land Trust); Bay-Delta Conservation Plan (CALFED); Envisioning Futures (Public Policy Institute of California); North Delta National Wildlife Refuge (USFWS); and Pacific Flyway (Pacific Flyway Council).

Restoration Objectives

- Connect uplands and wetland habitats
- Increase area of habitats supporting listed species, including Delta smelt spawning and rearing habitat[1]

Analysis objective

- Provide the ecological impacts as a basis for stakeholder input to refine the restoration design

Benefits

- Creates large contiguous habitat, including upland, vernal pools, floodplain, tidal marsh, and aquatic habitat through connecting existing restored sites, increasing habitat value for 80 listed species
- Builds on success of multi-use floodplain in Yolo Bypass
- Reduces levee failure and maintenance
- Connects to existing conserved areas, increasing impact
- Restores and creates full channel network to support Delta smelt, juvenile chinook salmon and steelhead, and other native plants and animals that benefit from tule marsh, riparian habitats, and grazing land that border the sloughs
- High potential for restoration success due to relatively high tidal range, historical dendritic channel network, relatively minimal subsidence, and remnant riparian and vernal pool habitat

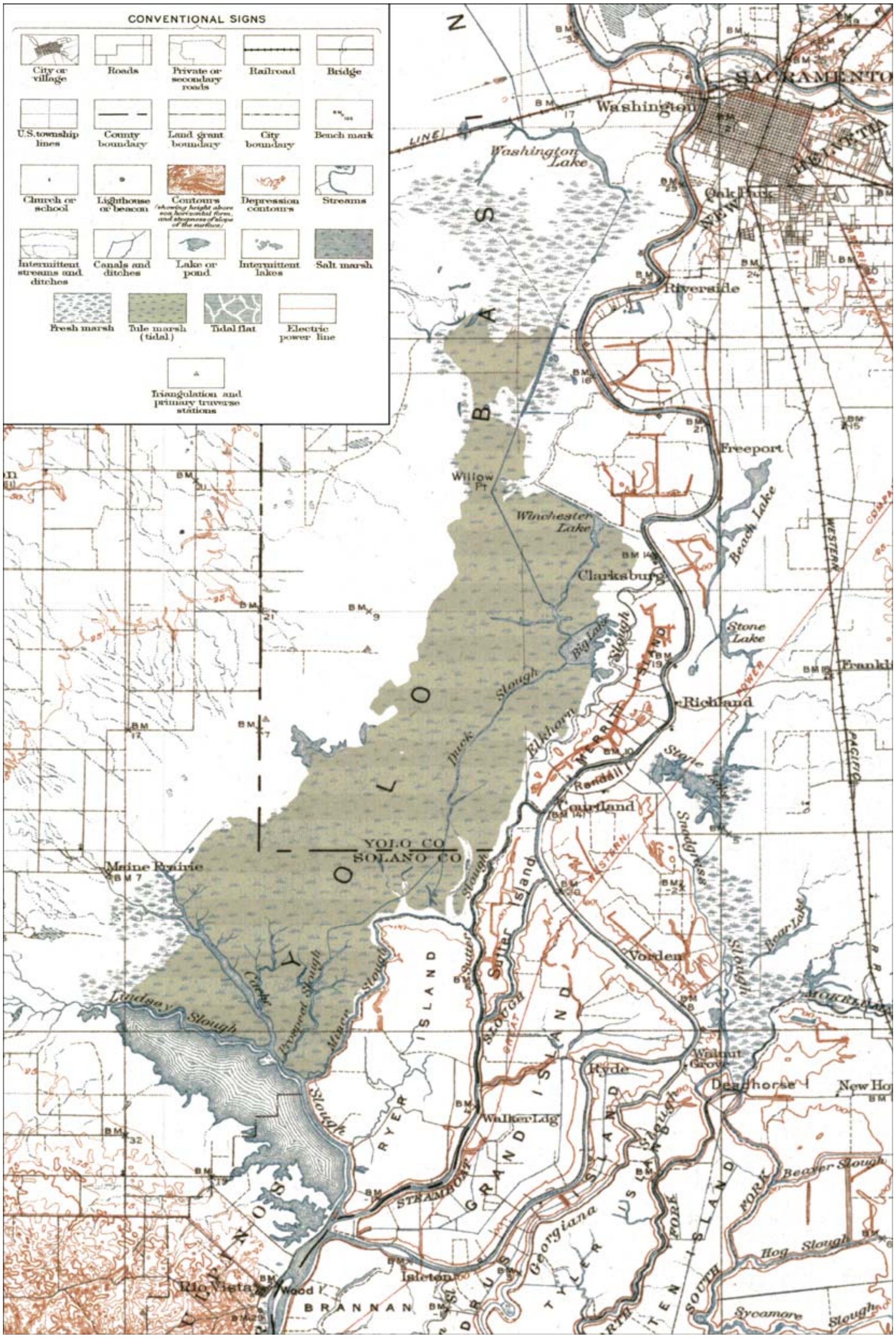
1. Office of the Governor of the State of California, Press Release: Gov. Schwarzenegger Directs Immediate Actions to Improve the Deteriorating Delta, California's Water Supply. July 17, 2007. GAAS:564:07

Analysis of Findings

- Creates and preserves habitat for 80 listed species
- Re-establishes ~32,900 acres of habitat
  - ~7,000 acres of tidal marsh, establishes in > 4 years
  - ~3,900 acres of tidal marsh, establishes in < 4 years
  - ~23,600 acres of floodplain
  - ~10,300 acres of open water
- Connects 12,000 acres of restored habitat as well as preserved remnant riparian and vernal pool habitat, increasing connected habitat 37% (total of ~44,900 acres). In addition, connects 60,000 acres of Yolo Bypass floodplain during flooding.
- Achieves restoration objectives:
  - Re-establishes complex channel and slough network
  - Increases seasonal wetland, marsh, and riparian habitat
  - Increases protected area of vernal pool/perennial grasslands
  - Increases habitat to promote increased abundance and distribution of at-risk and other native plant and animal species

Project Costs

Total project costs = $425 million



Source: U.S. Geological Survey, 1911

Figure 14-2 Cache Slough and Yolo Bypass (1903–1910)

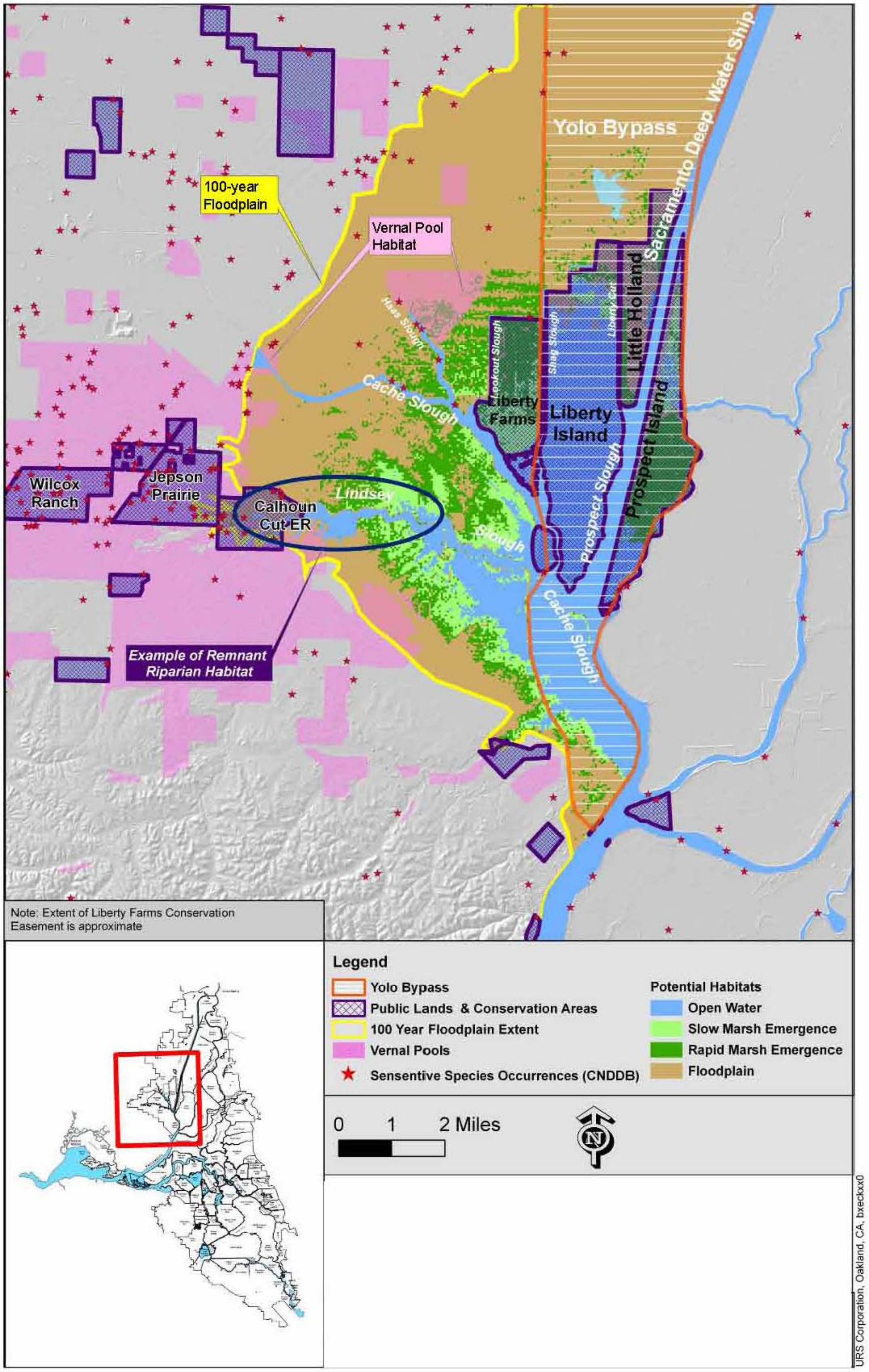


Figure 14-3 Tidal Marsh Cache Slough Restoration Alternative: Project Area

Appendix 14A

Delta Smelt in the Cache Slough Area

Delta smelt are endemic to the San Francisco Estuary and are most commonly found in Suisun Bay, Suisun Marsh, and the Sacramento–San Joaquin River Delta; the Napa River "estuary" may support spawning as well (Hobbs et al. 2005). These fish mature in 1 year at a size of approximately 60–70 millimeters (mm) standard length (SL); a small number of Delta smelt may survive to spawn at 2 years old and these fish can be up to about 120 mm SL at maturity (Bennett 2005). A diffuse migration of larvae from freshwater to brackish water occurs in the early summer and an equally diffuse spawning migration from brackish water to freshwater occurs in the fall and winter (Moyle 2002).

Despite recent significant research efforts on this species, much about its behavior and ecological requirements remains unknown. Finally, it is not necessarily clear that Delta smelt populations are limited by lack of spawning habitat in the Cache Slough region.

14A.1 DELTA SMELT SPAWNING MICROHABITAT

The Cache Slough area (including the Sacramento Deep Water Ship Channel (DWSC) and Miner Slough) is a critical spawning habitat for Delta smelt and is the only location used during dry years (Bennett 2005). However, little is known about spawning locations within the Cache Slough area or the preferred Delta smelt spawning microhabitat. This information is critical to design restoration that protects existing spawning habitat and increases area of spawning habitat. The existing data are reviewed below.

Eggs are broadcast over the bottom in a series of spawns in a single event (Moyle 2002). Delta smelt eggs are demersal and adhesive, sticking by means of a tiny stalk to hard substrates (Wang 1986). Characteristics of suitable spawning microhabitats are largely undocumented; however, data suggest that shallow areas with sand bottoms are likely microhabitat. Moyle (2002) hypothesizes that spawning areas likely contain gravel, sand, or other submerged material that is washed by gentle currents close to the main channel. This hypothesis is supported by laboratory findings that Delta smelt in laboratory fish tanks primarily laid eggs on the bottom of the gel fiberglass-lined tanks and did not shift egg laying to vegetation when vegetation was introduced into the tanks. Furthermore, similar substrates (e.g., gravel) are used by other members of the smelt family (Martin and Swiderski 2001). Recent experiments (described in Bennett 2005) revealed that female Delta smelt deposit their eggs in higher water velocities when offered a choice between flows of 8.8 centimeters per second and 1.4 centimeters per second. Also, L. Grimaldo has recently sampled a large number of young larvae in the southern end of the DWSC next to a series of sandy shoal beaches (W.A Bennett, written comm., July 2007), further suggesting sandy shallow water is ideal spawning microhabitat.

These data suggest that expanding the distribution of sub-tidal slough habitat with gravel or sand substrate in the Cache Slough area may increase available spawning habitat for Delta smelt. However, delineation of restoration actions to increase Delta smelt habitat depends on definitively figuring out whether sandy shoal beaches constitute preferred spawning substrate, and modeling how channel modifications might influence retention (Bennett, written comm., 2007).

Efforts to restore broad, sandy areas in the Cache Slough area may also have detrimental effects for Delta smelt. Broad sandy beach areas are habitat for Delta smelt predators, including inland silversides (*Menidia beryllina*), which can prey on all life stages of Delta smelt, including eggs, and their impact on Delta smelt populations could be substantial (Bennett 2005). Habitat restoration projects in the Cache Slough area must take precautions to prevent supporting a large local predator population in the region.

14A.2 DELTA SMELT LARVAE AND SPAWNING ADULTS IN THE CACHE SLOUGH AREA

Exact spawning areas of Delta smelt have not been documented (Bennett 2005). Nor has the distribution and relative availability of substrate and flow microhabitat characteristics been documented in the Cache Slough area. A preliminary meta-analysis of existing survey data of larval and adult Delta smelt reveal a pattern of distribution within the Cache Slough that may be used to further aid the preservation of existing spawning habitat and shed further light on spawning microhabitat criteria.

Several studies have detected larval and adult Delta smelt when sampling in Cache Slough, the DWSC, and Miner Slough (see Table 14A-1). Areas that Delta smelt use for spawning habitat can be inferred from the presence of young larvae with egg sac (based on the hypotheses that these young larvae have not traveled far from the location where eggs were laid) or the presence of gravid adults. The initial detection of the presence of Delta smelt in the Cache Slough area was from a Delta smelt larva and one ripe adult found in 1988–1991 (Bennett 1993). Subsequent broader sampling (the Striped Bass Egg and Larval Survey, 1992 and 1995, and its successor, the North Bay Aqueduct Larval Survey [NBA], 1996–2004) detected larval Delta smelt throughout the Cache Slough area, including Miner Slough, Lindsey/Barker sloughs, the DWSC, and the confluence of Cache and Haas sloughs. Larval Delta smelt (Table 14A-1) and males and female adults with maturing gonads and fully developed gonads as well as post-spawning fish are regularly found in the immediate vicinity of Cache Slough (the California Department of Fish and Game Spring Kodiak Trawl; Table 14A-2; Kodiak Trawl sampling locations are depicted in Figure 14A-1). The consistent presence of larvae and sexually mature and post-spawning Delta smelt in the vicinity of Cache Slough suggests that these fish spawn in the area and might benefit from increased spawning habitat abundance or quality or both. Although it is possible that Delta smelt are pushed into this area by incoming tides (e.g., into Liberty Island [Nobriga 2007]), Hobbs et al. (2005) demonstrated that larval Delta smelt caught near Cache Slough had a distinctive otolith microchemical pattern consistent with rearing in this area.

Within the Cache Slough area, the largest catches of larval Delta smelt have occurred at the base of Cache Slough (the 20-mm survey has consistently recorded the highest catches April through July; Table 14A-3; the 20-mm survey sampling locations are depicted in Figure 14A-2), which includes the confluence of Cache and Haas sloughs (the Striped Bass Egg and Larval Survey, 1992 and 1995). Similarly, the most consistent returns of sexually mature and post-spawning adults occur in the DWSC, north of the Cache Slough sampling location (Table 14A-2). These data suggest that spawning may occur in the DWSC; further sampling would test this hypothesis.

Delta smelt have also been found in parts of the Cache Slough area restored to tidal inundation. In a survey conducted during one spawning season, Lindberg and Marzuola (1993) found large numbers of sexually mature and post-spawning Delta smelt in a recently flooded island at the intersection of Cache and Shag sloughs and the surrounding area. Surveys of Liberty Island, a flooded island in the southern Yolo Bypass (part of the larger Cache Slough complex) have produced larval Delta smelt (Marshall et al. 2006) and juvenile and adult Delta smelt (Nobriga et al. 2003).

14A.3 INCREASE IN DELTA SMELT FOOD SUPPLY

One restoration goal is to increase the food supply for Delta smelt. This section reviews the data on use of primary and secondary productivity by Delta life history stages, with a focus on the match between the location of food and the life history stages that require food supplementation.

Restoration of shallow-water habitats would be expected to increase available food supplies for larval Delta smelt. Because they create high area-to-volume ratios, shallow sub-tidal waters, inter-tidal marsh, ephemerally inundated terrestrial habitats (e.g., floodplains), and small dendritic slough habitats are each expected be more productive than mainstem rivers or deep-water pelagic habitats (see Sommer et al. 2004 regarding productivity in the nearby Yolo Bypass relative to adjacent river environments). Early-stage larval Delta smelt feed opportunistically on sub-adult calanoid and cyclopoid copepods; larger Delta smelt larvae (10–15 mm SL) feed on adult copepods (Nobriga 2002). Because they have limited swimming abilities at this stage, prey capture is stochastic and probably strongly dependent on prey density (Bennett 2005); thus, increasing primary and secondary productivity in this area would be expected to increase feeding success for larval Delta smelt between first feeding (the yolk sac is almost completely absorbed at lengths between 5–8 mm SL) and the development of the swim bladder and fins (approximately 20 mm SL; Bennett 2005). Increased larval growth rates would be expected to improve larval survival rates and eventual reproductive success. The extent to which larval Delta smelt in the Cache slough region would benefit from additional primary and secondary productivity is not known. Hobbs et al. (2005) indicated that larval Delta smelt from this area grow more rapidly than larvae caught elsewhere in the Delta; however, that finding is based on an extremely small sample collected during 1 year and must be considered preliminary.

In addition to supporting larval Delta smelt growth in the area where restoration occurs, primary and secondary production in these habitats may be exported beyond restoration sites to important nursery areas downstream (e.g., Lehman and Mecum 2006), such as northern Suisun Bay. Because the San Francisco Estuary is relatively unproductive and primary productivity has declined in recent years (Kimmerer 2004) and the growth and survival of Delta smelt juveniles and sub-adults is believed to be limited by food supplies (Hobbs et al. 2006), supplementation of the pelagic food web is likely to benefit Delta smelt populations in general.

Restoration of productive aquatic environments and rearing habitats for larval Delta smelt may have detrimental side effects. Indeed, the balance between population-level costs and benefits of estuarine aquatic habitat restoration projects is still undetermined for many habitats and for most species in this estuary (Brown 2003). For example, floodplain and inter-tidal habitats may act as population sinks for Delta smelt or other native fish species if drainage patterns cause fish to be stranded in inhospitable waters (e.g., Dean et al. 2005; Feyrer et al. 2006a). Non-native predators (such as largemouth bass [*Micropterus salmoides]*) appear to specialize in heavily-vegetated sub-tidal habitats and they may be significant Delta smelt predators. For example, Liberty Island, a “restored” flooded island in the vicinity of Cache slough, was unusual among flooded island habitats studied by Nobriga et al. (2003) and Nobriga and Feyrer (2005) in that it was not colonized by the invasive aquatic weed *Egeria densa* and, possibly as a result, did not support largemouth bass. Other Delta smelt predators inhabit the larger Cache Slough Complex; for example, Nobriga et al. (2003) and Nobriega and Feyrer (2005) regularly detected striped bass (*Morone saxitalis*) and Sacramento pikeminnow (*Ptychocheilus grandis*) in Liberty Island. Restoration activities that increase the number of these predators in the Cache Slough complex could have a detrimental effect on larval Delta smelt production in this area.

Table 14A-1 Data Sources, Methods, and Major Findings of Delta Smelt Sampling in the Cache Slough Area

Name	Contact	Sampling duration	Location (number of sites)	Results	Life stage
20-mm	--	--	Numerous fixed sampling locations throughout the northern San Francisco Estuary between March and July each year. One sampling station located in the Cache Slough Area is of particular interest.	*Delta smelt were regularly detected at the Cache Slough sampling station. The percentage presence of larval Delta smelt at Cache Slough was only exceeded by their frequency of occurrence in the sampling stations near the Sacramento River- San Joaquin Ri	larvae
Bennett, W.A. 1993.	W.A. Bennett (Bodega Bay Marine Lab)	1986-1991	*surveyed for larval fish at two sites in Barker Slough and two sites in Lindsey Slough from 1986, 1988 (n=0),1989 (n=15), 1990 (n=6), 1991(n=75), *adult sampling began in 1991 (data not reported in this document).	In all years the majority of delta smelt were captured in Lindsey Slough.	larvae
GANDA 2001	Robert Aramayl (GANDA)	2001	Barker Slough, Calhoun Cut		larvae
Grimaldo 2007 unpublished	L. Grimaldo (DWR)	2007	Deep-water ship channel	sampled a large number of young larvae in the southern end of the Ship Channel adjacent to a series of sandy shoal beaches	larvae
Hobbs, J.A. et al. 2005	J. Hobbs (Bodega Bay Marine Lab)	May and June 1999	Sampling localities were those of the CDFG 20mm survey on the: Napa River, North Delta (lower Sacramento River; CDFG site 716 at the base of the "Cache Slough Complex"), Central Delta (near the Mokelumne River), South Delta (near the CVP/SWP export fac	1) Delta smelt from the North Bay sampling locality had a significantly different otolith microchemical signature from fish collected at other sites. This indicates a different natal and rearing history for fish in the North Delta as compared to fish else	Juvenile (post-larval)
Kodiak Trawl	--	2002-present	Numerous throughout the Northern Estuary. Sites in Sacramento Ship Channel, at the confluence of Cache-Haas Slough, and in nearby sections of Steamboat Slough, and the lower Sacramento River are of particular interest.	*Maturing, mature, or spawned-out Delta smelt occur regularly in the larger Cache Slough region. *A sampling station in the Sacramento Ship Channel, upstream of Cache-Haas Slough consistently produces male and female maturing, mature, and spawned-out de	pre-spawning, mature, and post-spawning adults
Lindberg, J.C. C. Marzuola, 1993	Joan Lindberg	4 surveys from 31-march through 14-May, 1993	ACOE mitigation site at the junction of Cache Slough and Shag Slough.	Numerous mature and post-spwning Delta smelt were detected in the flooded island at the base of Shag Slough as well as in locations in both Shag and Cache Slough.	Adult
Maeger 1996	R. Mager (DWR)			Data not obtained for this report	larvae
Marshall M., H. Webb, & R, Wilder. 2006.	Rick Wilder (USFWS, now SAIC)	2005-2007	Several locations within Liberty Island sampled by seine and light trap between 2003-2005	Delta smelt larvae occured on Liberty island from 2003-2005 and they were the second most abundant native species detected on that site	larvae
Nobriga et al. 2003	M. Nobriga (DWR; currently Calfed Science Program)	March-October of 2001 and 2003	Decker Island (Sacramento River), Medford Island (San Joaquin River), Sherman Island (confluence), Liberty Island (Yolo bypass), and Mildred Island (East Central Delta)	*Forty delta smelt were captured at Liberty Island during two years of sampling. *Among the different sites sampled, Liberty Island is extreme in the relative lack of SAV (principally Egeria), high turbidity, low overall diversity, and high representation	Juveniles through adults (23mm - 77mm length)
North Bay Aqueduct Larval Survey	Michael Dege (DFG), Kevin Fleming (DFG)	1996-2004 In 1999, only Lindsey Slough sampled continuously	Lindsey Slough (2 sites), Cache Slough at Confluence with Haas Slough (1), Barker Slough (2), Deep-water Ship Channel (1), Miner Slough (2)	*Across these sites, in each year, larval Delta smelt are found earliest in Miner Slough and/or the Ship Channel. *in most years, the sampling location at the confluence of Cache-Haas Sloughs is the last place where larval smelt appear. *in most years, la	larvae
Striped Bass Egg and Larval Survey (DFG)	Kevin Fleming and Michael Dege (DFG)	1992-1994 (identification of larval Osmerids performed during this period but not before)	Numerous. Six (6) sites assessed here, including: 1 on lower Steamboat Slough 1 on lower Sacramento near Iselton 4 in Ship Channel between Cache Slough (to the North) and Sacramento River-proper (to the South) One of these four (site 716) is very near th	The overall pattern of Delta smelt catch is similar across these sites: -fish are caught between early february and early June. They are caught in every sample conducted in 1992 and 1993. More fish are caught in 1994 than in '92 and '93 but they are cau	Larval

Table 14A-2 Presence of Delta Smelt Adult Life Stages in the Northern San Francisco Estuary (Spring Kodiak Trawl)

	711		712		713		715		716		719	
Year	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
2002	1, 2	1,2,3	2		2,3	1	1,2	1,2	1,2	1,2	Not sampled	
2003	1, 2, 3	3	1, 2, 3	2,3	1, 2, 3	1,2,3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3		
2004						2		1, 2, 3	3	2		
2005		3				2, 3	1, 2, 3	1, 2, 3	1	1, 2, 3	1, 2, 3,	1, 2, 3
2006							1	1, 2	1,	2,	1, 2, 3	1, 2, 3
2007							2	1, 2	1,	1,	1, 2, 3	1, 2, 3

Sites are arranged from south to north. Station #716 is at the base of Cache Slough, station #719 is in the upper Sacramento Deep Water Ship Channel. Life stages are depicted for both males (M) and females (F). Life stages correspond to (1) late gonadal development, (2) fully mature (stage V), (3) post-spawning (Stage VI). A life stage was recorded as “present” at a sampling location if any sample caught that life-stage during a given year of sampling.

All life stages were consistently present in sampling of the upper Sacramento Deep Water Ship Channel (station 719) and detection of each life stage became less common as sampling moved south in the channel and the lower Sacramento River.

Table 14A-3 Presence of Larval Delta Smelt as a Percent of Samples in Regions in the Northern San Francisco Estuary

Months	Region (20-mm sampling program sites)									
	Napa	**West Suisun**	**Suisun and Grizzly Bays**	**Suisun Marsh**	**Sacramento & San Joaquin River Confluence**	**Lower Sacramento River**	**Lower Sacramento River Ship Channel**	**Cache Slough**	**Lower San Joaquin**	**Southern & Central Delta**
	340, 341, 343, 344, 345, 346	***405, 411, 4***	***501, 504, 508, 513, 519, 520, 602***	***606, 609, 610***	***703, 704, 801, 804***	***705, 706, 707***	***711***	***716***	***809, 812, 815***	***901, 902, 906, 910, 912, 914, 915, 918, 919***
March*	3.3	0.0	32.4	21.4	45.0	35.3	16.7	**16.7**	16.7	19.3
April	28.3	12.1	45.5	45.5	53.5	37.9	33.3	**55.6**	56.7	62.5
May	41.7	33.3	63.6	72.7	90.9	81.8	36.4	**81.8**	78.8	53.1
June	49.2	33.3	75.3	69.7	93.2	75.8	18.2	**90.9**	75.8	33.3
July	31.4	66.7	82.3	44.4	77.8	66.7	11.1	**77.8**	22.2	2.6
Average	30.8	29.1	59.8	50.8	72.1	59.5	23.1	**64.5**	50.0	34.2

Source**:** CDFG 20-mm survey, 1995 and 2005.

Sampling sites are roughly organized west to east from (left to right).

*Sampling occurred during March in the years 1997 and 2000–2005; samples were conducted during August in two years, but they have not been depicted here.

The frequency of Delta smelt larval detection increased throughout the sampling period in Suisun Bay (including west Suisun, Grizzly and Suisun bays) and decreased after April at sampling stations in the southern and central Delta. In other regions, detection of Delta smelt increased until May or June and then decreased. Delta smelt larvae were detected most frequently among sites at the confluence of the Sacramento and San Joaquin rivers; the one site near Cache Slough produced the second highest overall rate of detection.

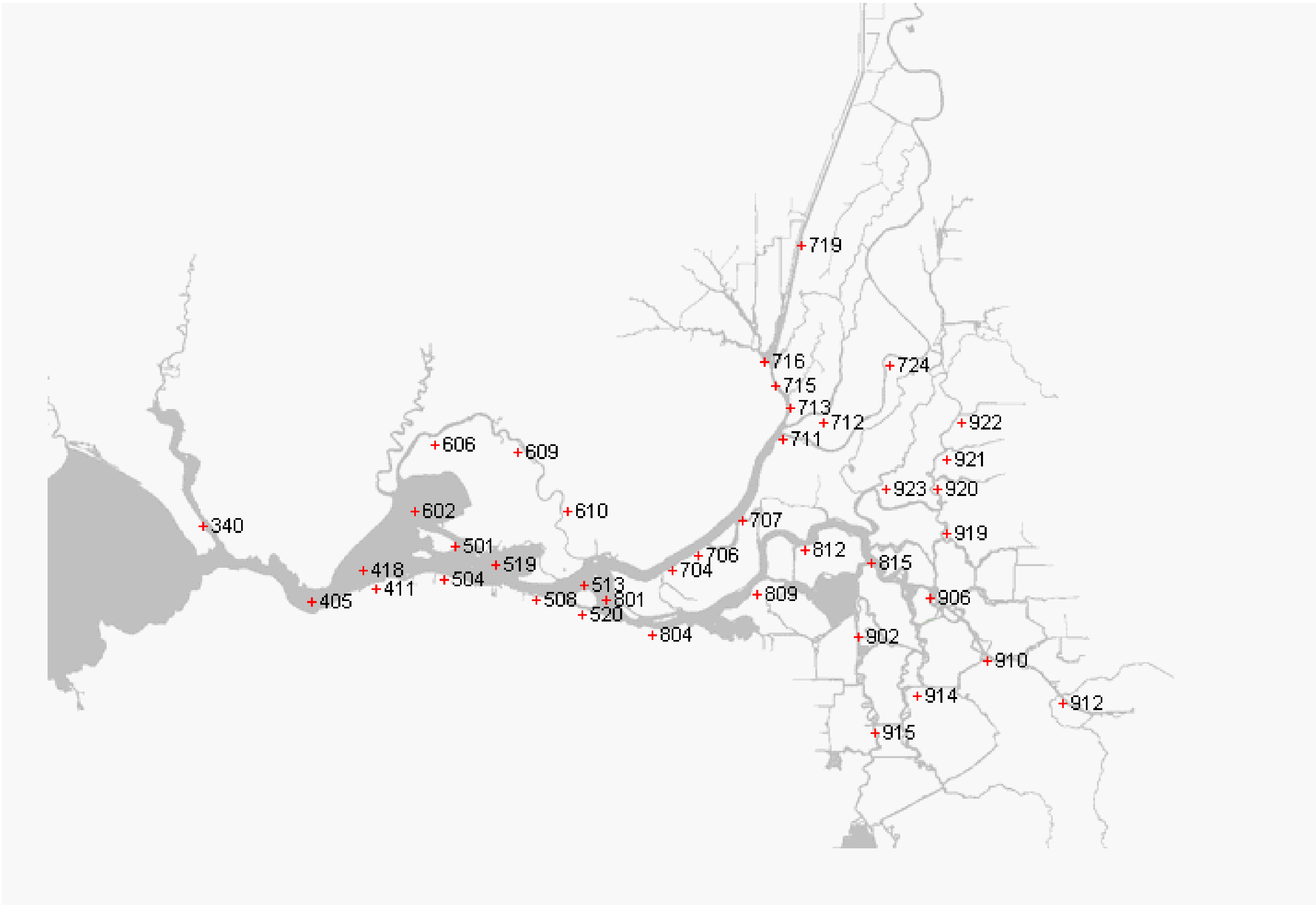


Figure 14A-1 Spring Kodiak Trawl Sampling Stations

Source: http://www.delta.dfg.ca.gov/

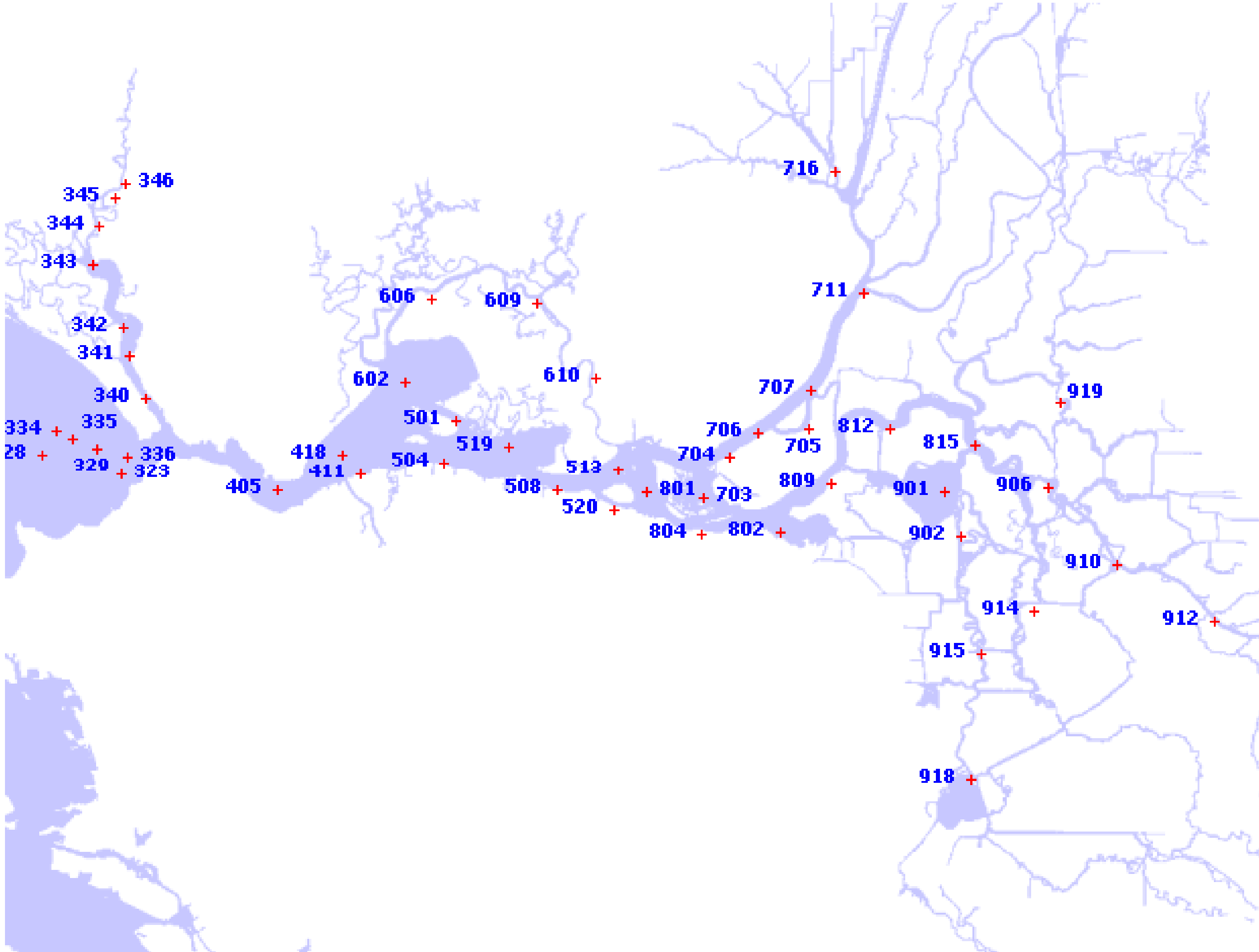


Figure 14A-2 20-mm Survey Sampling Stations

Appendix 14B

Listed Species in the Cache Slough Area

Table 14B-1 Listed Species in the Cache Slough Area

Species Name	Common Name	Status			
		Federal	CA	CDFG	CNPS
Actinemys mamorata	Western pond turtle			SC	
Actinemys marmorata marmorata	Northwestern pond turtle			SC	
Agelaius tricolor	Tricolored blackbird			SC	
Ambystoma californiense	California tiger salamander	T		SC	
Anniella pulchra pulchra	Silvery legless lizard			SC	
Apodemia mormo langei	Lange's metalmark butterfly	E			
Archoplites interruptus	Sacramento perch			SC	
Arctostaphylos Auriculata	Mt. Diablo manzanita				1B.3
Asio Flammeus	Short-eared owl			SC	
Astragalus tener var. *ferrisiae*	Ferris' milk-vetch				1B.1
Astragalus tener var. *tener*	Alkali milk-vetch				1B.2
Athene cunicularia	Burrowing owl			SC	
Atriplex cordulata	Heartscale				1B.2
Atriplex depressa	Brittlescale				1B.2
Atriplex joaquiniana	San Joaquin spearscale				1B.2
Atriplex persistens	Vernal pool smallscale				1B.2
Blepharizonia plumosa	Big tarplant				1B.1
Branchinecta conservatio	Conservancy fairy shrimp	E			
Branchinecta lynchi	Vernal pool fairy shrimp	T			
Buteo regalis	Ferruginous hawk			SC	
Buteo swainsoni	Swainson's hawk		T		
California macrophyllum	Round-leaved filaree				1B.1
Carex comosa	Bristly sedge				2.1

Table 14B-1 Listed Species in the Cache Slough Area

Species Name	Common Name	Status			
		Federal	CA	CDFG	CNPS
Centromadia parryi ssp. *parryi*	Pappose tarplant				1B.2
Charadrius montanus	Mountain plover			SC	
Cirsium hydrophilum var. *hydrophilum*	Suisun thistle	E			1B.1
Coccyzus americanus occidentalis	Western yellow-billed cuckoo	C	E		
Cordylanthus mollis ssp. *hispidus*	Hispid bird's-beak				1B.1
Cordylanthus mollis ssp. *mollis*	Soft bird's-beak	E	R		
Cyptantha hooveri	Hoover's cryptantha				1A
Delphinium recurvatum	Recurved larkspur				1B.2
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle	T			
Downingia pusilla	Dwarf downingia				2.2
Elaphrus viridis	Delta green ground beetle	T			
Eriodonum truncatum	Mt. Diablo buckwheat				1B.1
Erysimum capitatum ssp. *angustatum*	Contra Costa wallflower	E	E		1B.1
Eschscholzia rhombipetala	Diamond-petaled California poppy				1B.1
Fritillaria liliacae	Fragrant fritillary				1B.2
Fritillaria pluriflora	Adobe-lily				1B.2
Geothlypis trichas sinuosa	Saltmarsh common yellowthroat			SC	
Gratiola heterosepala	Boggs Lake hedge-hyssop		E		1B.2
Hesperolinon breweri	Brewer's western flax				1B.2
Hibiscus lasiocarpus	Rose-mallow				2.2

Table 14B-1 Listed Species in the Cache Slough Area

Species Name	Common Name	Status			
		Federal	CA	CDFG	CNPS
Hypomesus transpacificus	Delta smelt	T	T		
Isocoma arguta	Carquinez goldenbush				1B.1
Juglans hindsii	Northern California black walnut				1B.1
Lasiurus cinereus	Hoary bat			SC	
Lasthenia conjugens	Contra Costa goldfields	E			1B.1
Laterallus jamaicensis coturniculus	California black rail		T		
Lathyrus jepsonii var. *jepsonii*	Delta tule pea				1B.2
Legenere limosa	Legenere				1B.1
Lepidium latipes var. *heckardii*	Heckard's pepper-grass				1B.2
Lepidurus packardi	Vernal pool tadpole shrimp	E			
Lilaeopsis masonii	Mason's lilaeopsis		R		1B.1
Limosella subulata	Delta mudwort				2.1
Madia radiata	Showy madia				1B.1
Melospiza melodia maxillaris	Suisun song sparrow				SC
Navarretia leucocephala ssp. *bakeri*	Baker's navarretia				1B.1
Neostapfia colusana	Colusa grass	T	E		1B.1
Oenothera deltoids ssp. *howelii*	Antioch Dunes evening-primrose	E	E		1B.1
Orcuttia inaequalis	San Joaquin Valley orcutt grass	T	E		1B.1
Phalacrocorax auritus	Double-crested cormorant			SC	
Plagiobothrys hystriculus	Bearded popcorn-flower				1B.1
Pogonichthys macrolepidotus	Sacramento splittail			SC	
Potamogeton zosteriformis	Eel-grass pondweed				2.2

Table 14B-1 Listed Species in the Cache Slough Area

Species Name	Common Name	Status			
		Federal	CA	CDFG	CNPS
Rallus longirostris obsoletus	California clapper rail	E	E		
Rana aurora draytonii	California red-legged frog	T		SC	
Reithrodontomys raviventris	Salt-marsh harvest mouse	E	E		
Riparia riparia	Bank swallow		T		
Sagittaria sanfordii	Sandord's arrowhead				1B.2
Scutellaria galericulata	Marsh skullcap				2.2
Scutellaria lateriflora	Blue skullcap				2.2
Sorex ornatus sinuosus	Suisun shrew			SC	
Sternula antillarum browni	California least tern	E	E		
Symphyotrichum lentum	Suisun marsh aster				1B.2
Taxidea taxus	American badger			SC	
Thamnophis gigas	Giant garter snake	T	T		
Trifolium amoenum	Showy Indian clover	E			1B.1
Trifolium depauperatum var. *hydrophilum*	Saline clover				1B.2
Tuctoria mucronata	Crampton's tuctoria or Solano grass	E	E		1B.1

Federal Status: E= Endangered, T= Threatened, C= Candidate
State Status: E= Endangered, T= Threatened, R= Rare
CDFG: SC= Species of Concern
CNPS: 1A= Presumed Extinct, 1B= Rare/Endangered in California or elsewhere,
2= Rare/Endangered in California and more common elsewhere,
3= Need more information,
4= Plants of limited distribution.

Table 14B-2 Special-Status Species in the Jepson Prairie–Prospect Island Corridor

Species Name	Common Name	Status[a]			
		Federal	CA	CNDDB	CNPS
Plants					
Astragalus tener var. *tener*	Alkali milk vetch			1B;323	
Navarettia leucocephala ssp. *bakeri*	Baker's navarettia			1B;233	
Gratiola heterosepala	Boggs Lake hedge-hyssop		SE	1B;122	
Atriplex depressa	Brittlescale				
Neostapfia colusana	Colusa grass	FT	SE	1B;233	
Limosella subulata	Delta mudwort			2;231	
Lathyrus jepsonii var. *jepsonii*	Delta tule pea			1B;223	
Downingia pusilla	Dwarf downingia			2;121	
Fritillaria liliacea	Fragrant fritillary			1B;223	
Atriplex cordulata	Heartscale			1B;223	
Legenere limosa	Legenere			1B;233	
Lilaeopsis masonii	Mason's lilaeopsis		rare	1B;233	
Tuctoria mucronata	Solano grass	FE	SE	1B;333	
Aster lentus	Suisun marsh aster			1B;223	
Atriplex persistens	Vernal pool smallscale			1B;223	
Invertebrates					
Branchinecta conservatio	Conservancy fairy shrimp	FE			G1S1
Elaphrus viridis	Delta green ground beetle	FT			G1S1
Hydrochara rickseckeri	Ricksecker's water scavenger beetle	FSC			G1G2S1S2
Lepidurus packardi	Vernal pool tadpole shrimp	FE			G2G3S2S3
Branchinecta lynchi	Vernal pool fairy shrimp	FT			G2G3S2S3
Amphibians					
Ambystoma californiense	California tiger salamander	FC			G2G3S2S3
Birds					
Athene cunicularia ssp. *hypugea*	Burrowing owl				
Ardea alba	Great egret				G5S4
Charadrius montanus	Mountain plover (wintering)	FPT			G3S2?
Buteo swainsoni	Swainson's hawk		ST		G4S2
Agelaius tricolor	Tri-colored blackbird				G2S2
Fish					
Oncorhynchus tshawytscha	Chinook salmon	FC			G5S2?
Hypomesus transpacificus	Delta smelt	FT	ST		G1S1
Oncorhynchus mykiss	steelhead	FT			G5S2

[a] Abbreviations defined below
[b] Subspecies and ranking unknown

Key to Abbreviations
Endangered Species Act (CESA) Listing Codes
FE Federally listed as Endangered
FT Federally listed as Threatened
FC Federal Candidate Species
FSC Federal Species of Concern (not an official abbreviation)

California Endangered Species Act (CESA) Listing Codes
SE State-listed as Endangered

California Native Plant Society (CNPS) Lists
1A Presumed extinct in California
1B Rare or Endangered in California and elsewhere
2 Rare or Endangered in California, more common elsewhere
3 Plants for which we need more information – Review list
4 Plants of limited distribution – Watch list

California Native Plant Society (CNPS) R-E-D Code
R (Rarity)
1 Rare but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time
2 Distributed in a limited number of occurrences, occasionally more if each occurrence is small
3 Distributed in one to several highly restricted occurrences, or present in such small numbers that it is seldom reported

E (Endangerment)
1 Not endangered
2 Endangered in a portion of its range
3 Endangered throughout its range

D (Distribution)
1 More or less widespread outside California
2 Rare outside California
3 Endemic to California

Natural Diversity Database (NDDB)
Global Ranking
G1 Less than 6 viable element occurrences (EOs) or less than 1000 individuals
G2 6-20 EOs or 1000-3000 individuals
G3 21-100 EOs or 3000-10,000 individuals
G4 Apparently secure; this rank is clearly lower than G3 but factors exist to cause some concern
G5 Population demonstrably secure or ineradicable due to being commonly found in the world

State Ranking
S1 Less than 6 EOs or less than 1000 individuals
S2 6-20 EOs or 1000-3000 individuals
S3 21-100 EOs or 3000-10,000 individuals
S4 Apparently secure within California; this rank is clearly lower than S3 but factors exist to cause some concern (No Threat Rank)
S5 Demonstrably secure to ineradicable within California
*Information from: Meisler 2002.

Appendix 14C

Function of the Yolo Bypass

The Legal Delta contains only the southern half of the Yolo Bypass (south of Interstate 80). The Yolo Bypass was constructed in 1911 under the auspices of the State Reclamation Board. The purpose of the bypass is to protect the Sacramento Valley from flooding by providing a large floodplain for delivering 500,000 cubic feet per second (cfs) of waters from the Sacramento, American, and Feather rivers during periods of high snowmelt and rainfall (Figure 14C-1). During 70 percent of water years, Sacramento River floodwater initially flows onto the northern part of the Yolo Bypass by overtopping the Freemont Weir, which is essentially a short concrete levee. Much less frequently, additional floodwaters from the Sacramento and the American rivers enter the Yolo Bypass through the Sacramento Weir. The Sacramento Weir floodgates are opened when the I-Street gage reaches 27.5 and the flood level is forecast to continue rising, diverting water onto the southern portion of the Yolo Bypass. During large flood events, up to 80 percent of the Sacramento River flows are diverted into the bypass. The southern half of the Yolo Bypass also carries water from four tributaries along its western edge (Cache Creek, Willow Slough, Putah Creek, and Ulatis Creek).

At the southern end of the Yolo Bypass at the “Toe Drain,” large levees with a lot of freeboard are present; these levees have not been breached or overtopped since they were built. The water from the Yolo Bypass is separated from the water in the DWSC along the southern part of the Yolo Bypass (south of Interstate 80) until these waters connect in the Cache Slough area. Floodwaters on the bypass drain to a channel that is maintained as a permanent slough in the Yolo Bypass that discharges (“Toe Drain,” Liberty Cut and Prospect Slough) between Liberty Island and Little Holland Tract. When there is no flooding, water from this channel is diverted to irrigate crops.

Now, predominantly under water, Liberty Island and Little Holland Tract were once reclaimed land ringed by levees. Remnants of these levees remain, especially along the northern portions of the islands. These restricted-height levees prevent flooding at low flood levels, but are designed to flood at higher flood levels to allow the full capacity of the Yolo Bypass to be utilized. Water over-topping these restricted-height levees discharges Yolo Bypass floodwaters into Cache Slough. The levees on these islands are currently breached, allowing freshwater tidal marsh habitats to re-establish.

During floods, water also drains from Cache Slough, but the volume is typically overwhelmed by flow from the Yolo Bypass, resulting in backflow up Cache and Lindsey sloughs. The constriction of the Yolo Bypass where it meets Cache Slough tends to slow drainage from the Yolo Bypass and Cache Slough area.

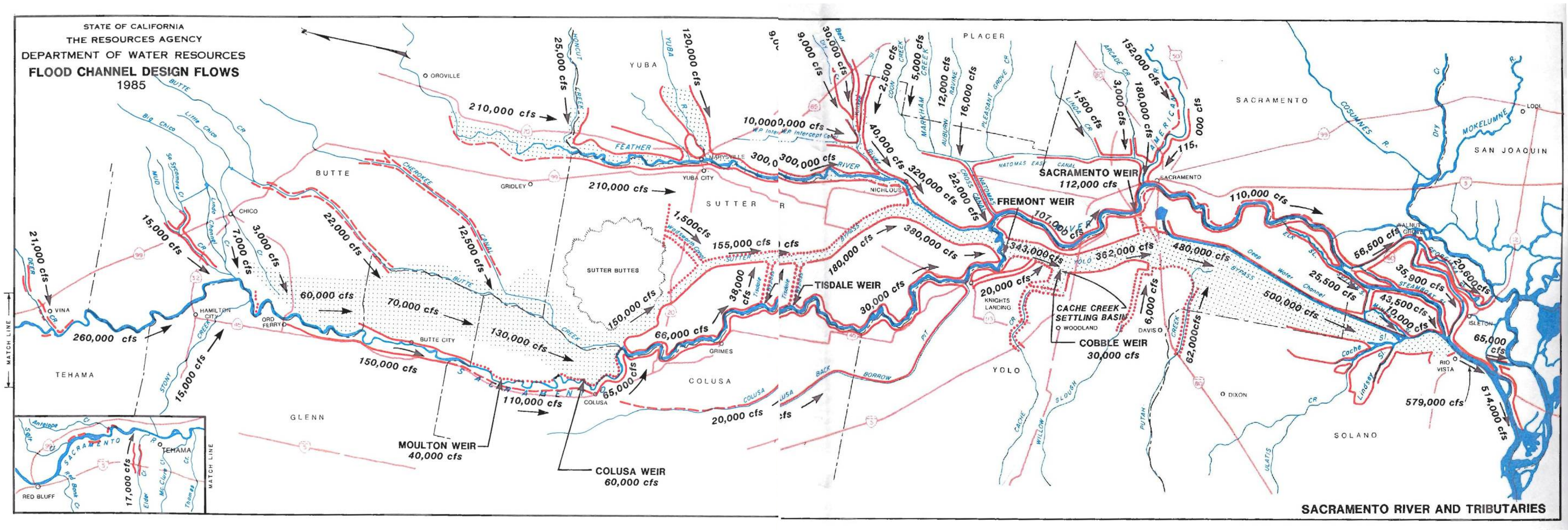


Figure 14C-1 Yolo Bypass

Appendix 14D

Assets in the Cache Slough Area

Table 14D-1 Area of Agricultural Land Use in the Cache Slough Restoration Area

Analysis Zone	Total Area (acres)	Agricultural Land Use								TOTAL Ag Land use	As % Total
		ALFALFA	FIELD CROPS	GRAIN	ORCHARDS	RICE	TOMATO	TRUCK	VINEYARDS		
Cache Haas Tract 1	8,582	4845	1522	321	47			131	346	**7,212**	**84%**
Egbert Tract	5,907	2986	938	198	29			81	213	**4,445**	**75%**
Hastings Tract	7,185	1487	467	98	14			40	106	**2,213**	**31%**
Little Egbert Tract	3,248	1891	594	125	18			51	135	**2,814**	**87%**
Peter Pocket	2,050	1259	395	83	12			34	90	**1,874**	**91%**
Prospect Island	2,210	24	279	131				3		**437**	**20%**
Peter's Pocket West	2,050	1259	395	83	12			34	90	**1,874**	**91%**
Cache Haas Tract 1 East	1,797	1112	349	74	11			30	79	**1,656**	**92%**

Table 14D-2 Value of Agricultural Production

Analysis Zone	Total Area (acres)	Agricultural land use estimated value per acre								
		ALFALFA	FIELD CROPS	GRAIN	ORCHARDS	RICE	TOMATO	TRUCK	VINEYARDS	TOTAL
		$800	*$500*	*$300*	*$5,900*	*$900*	*$2,600*	*$2,900*	*$4,200*	*NA*
Cache_Haas_Tract 1	8,582	$1,357	$266	$34	$96			$133	$509	**$2,395,349**
Egbert_Tract	5,907	$836	$164	$21	$59			$82	$314	**$1,476,388**
Hastings_Tract	7,185	$416	$82	$10	$30			$41	$156	**$735,000**
Little Egbert Tract	3,248	$529	$104	$13	$38			$52	$199	**$934,638**
Peter Pocket	2,050	$353	$69	$9	$25			$35	$132	**$622,427**
Prospect_Island	2,210	$7	$49	$14				$3		**$72,265**
Peter's Pocket West	2,050	$353	$69	$9	$25			$35	$132	**$622,427**
Cache Haas Tract 1 East	1,797	$311	$61	$8	$22			$31	$117	**$549,866**
Total	**33,030**	**$4,162**	**$864**	**$117**	**$295**			**$411**	**$1,559**	**$7,408,360**

Table 14D-3 Assets and Total Asset Values in the Cache Slough Restoration Area

Analysis Zone	Minor Roads	Major Roads	Highways	Transmission lines	Hwy Bridge	Oil - gas wells	Gas Fields	Gas Pipelines	Dwellings - family	Dwellings - other	Commercial	Total Asset Value
	miles	miles	miles	miles	count	count	acres	miles	count	count	count	$
Cache Haas Tract 1	36.9	3.2		3.5	1	104	3,779	9	18	1		**$ 65,883,728**
Egbert Tract	17.5			2.3		140	3,532	7	11	1		**$ 33,602,681**
Hastings Tract 1							45				1	**$ 3,000**
Hastings Tract	9.4			2.2	1	475	41	2	19	2	1	**$ 23,423,010**
Little Egbert Tract	3.7	0.0	1.0		1	29	1,263	3	36	6	2	**$ 21,346,077**
Peter Pocket				0.2		12	600	1	3	1		**$ 2,138,304**
Prospect Island	1.0					11	301		2	1		**$ 1,787,595**
Egbert Tract East	0.8					2	18					**$ 846,756**
Peter's Pocket West	4.8				1	7		1	3			**$ 9,240,504**
Cache Haas Tract 1 East	36.9	3.2		3.5	1	104	3,779	9	18	1		**$ 10,969,095**
Hastings Tract South West	0.1	0.6	0.6	0.5				2				**$ 7,123,638**
Total	**111**	**7**	**2**	**12**	**5**	**884**	**13,357**	**33**	**110**	**13**	**4**	**$ 176,364,387**

Appendix 14E

Species Found at Liberty Island (2005)

Table 14E-1 Bird Species at Liberty Island (2005)

Data in Table 14E-1 are modified from USFWS and DWR 2005.

Family group	Species Name	Common Name	Status			
			Federal	CA	CDFG	CNPS
Gulls and terns	*Sterna caspia*	Caspian tern				
Herons	*Ardea alba*	Great egret				
	Ardea herodias	Great blue heron				
	Botaurus lentiginosus	American bittern				
	Egretta thula	Snowy egret				G5S4
	Nycticorax nycticorax	Black-crowned night-heron				
Pelecaniformes	*Pelecanus erythrorhynchos*	American white pelican				
	Phalacrocorax auritus	Double-crested cormorant				
Rails	*Fulica Americana*	American coot				
	Gallinula chloropus	Common moorhen		ST		G4S2
	Rallus limicola	Virginia rail				
Raptors	*Buteo jamaicensis*	Red-tailed hawk				
	Buteo swainsoni	Swainson's hawk				
	Cathartes aura	Turkey vulture				
	Pandion haliaetus	Osprey				
Shorebirds	*Himantopus mexicanus*	Black-necked stilt				
	Pluvialis dominica	Black-bellied plovers				
	Recurvirostra americana	American Avocet				
	Tringa melanoleuca	Greater yellowlegs				
	--	Sandpiper species				
	--	Dowitcher species				
Songbirds	*Agelaius phoeniceus*	Red-winged blackbird				
	Carpodacus mexicanus	House finch				
	Cistothorus palustris	Marsh wren				
	Corvus brachyrhynchos	American crow				
	Euphagus cyanocephalus	Brewer's blackbird				
	Hirundo rustica	Barn swallow				
	Melospiza melodia	Song sparrow				
	Petrochelidon pyrrhonota	Cliff swallow				
	Tachycineta bicolor	Tree swallow				
Waterfowl	*Anas crecca*	Green-winged teal				
	Anas cyanoptera	Cinnamon teal				
	Anas platyrhynchos	Mallard				
	Anas strepera	Gadwall				

Table 14E-2 Fish Captured at Liberty Island (2005)

Data in Table 14E-2 are modified from USFWS DWR 2005.

Native (N)/ Exotic (E)	Common Name	Capture Method			
		Beach Seine Sampling	Trap Sampling	Larval Sampling	Total
N	Prickly sculpin	0	67	787	854
	Splittail	826	NA[a]	14	840
	Threespine stickleback	4	475	0	479
	Chinook salmon[c]	413	4	0	417
	Delta smelt[c]	26	NA[a]	205	231
	Longfin smelt	0		159	159
	Sacramento pike minnow	49	4	0	53
	Sacramento sucker	20	2	19	41
	Sacramento blackfish	1	1	10	12
	Starry flounder	9	0	0	9
	Pacific staghorn sculpin	2	6	0	8
	Hitch	2	1	1	4
E	Inland silverside	3320	1938	1	5259
	Siberian prawn	3468	NA[b]	0	3468
	Threadfin shad	586	762	4	1352
	Yellowfin goby	484	164	25	673
	Shimofuri goby	24	625	0	649
	Striped bass	356	33	10	399
	American shad	181	71	0	252
	Common carp	7	4	162	173
	White catfish	23	102	0	125
	Black crappie	1	51	0	52
	Bigscale logperch	20	10	17	47
	Western mosquitofish	22	19	0	41
	Tule perch	30	5	0	35
	Cheekspot goby	1	30	0	31
	Fathead minnow	8	3	0	11
	Golden shiner	2	9	0	11
	Black bullhead	0	8	0	8
E	White crappie	0	5	0	5
	Channel catfish	2	2	0	4
	Wakasagi	0	4	0	4
	Chameleon goby	2	1	0	3

[a] Unknown number of individuals collected
[b] High number of individuals collected but numbers not reported
[c] Federal special-status species/candidates