TABLE OF CONTENTS

Tables

Figures

TABLE OF CONTENTS

Appendices

8.1 INTRODUCTION

Analyses have shown that a significant seismic event could destabilize levees protecting islands in the Sacramento–San Joaquin River Delta (Delta). Levee failures could result in inundation of the islands, which could cause an intrusion of San Francisco Bay (bay) water (gulp) of higher salinity into the Delta. This higher-salinity water would replace, supplement, and mix with the freshwaters that flood the breached islands.

This discussion of Building Block 1.6, Armored "Pathway" (Through-Delta Conveyance), includes background information, describes conceptual development of the building block, and provides cost estimates, risk reductions, findings, and conclusions. An overview of the building block is presented on Figure 8-1.

8.1.1 Background

Through-Delta facilities were first studied in the late 1950s and were proposed by the Department of Water Resources (DWR) in 1960 as the single-purpose Delta Water Project (later referred to as the Waterway Control Plan). This alternative proposed such actions as enlarging Delta channels, closing channels, and constructing siphons, as well as moderate releases of water from upstream storage reservoirs for salinity control to improve movement of Sacramento River water to pumps in the South Delta. DWR formulated a similar concept in a plan proposed in 1983 under "Alternatives for Delta Water Transfer." Another through-Delta facility proposal was the North Delta Program, which addressed north Delta flooding issues in addition to improving conveyance capacity of north Delta channels to reduce reverse flow and salinity intrusion.

Previous forms of this building block were considered in the 1950s and 1960s as variants of the Biemond Plan, in the 1980s as the Orlob Plan, and in the 1990s by the California Bay-Delta Authority (CALFED) as various through-Delta alternatives.

8.1.2 Purpose and Scope of Building Block

The purpose of this building block is to evaluate the concept of a north-to-south freshwater corridor along Middle River that uses modifications of existing Delta infrastructure while reducing the potential for seismic disruptions of water supply.

The scope of this building block includes reviewing the geotechnical data, developing hydraulic analyses and system operation, developing construction methodologies, and estimating construction cost. A summary of the collected data and findings is presented in this section.

8.1.3 Objective and Approach

The objective is to confirm the engineering feasibility of this building block and develop the conceptual details, assess the risk reduction benefits, and make a preliminary cost estimate.

The approach is to review existing documentation, gather new information (i.e., current land uses, equipment), and present findings and conclusions.

8.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

8.2.1 Analysis Criteria and Basis of Design

The armored pathway (through-Delta conveyance) concept was developed to move freshwater from the Sacramento River to the State Water Project and Central Valley Project intake facilities located in the south Delta. A significant quantity of freshwater enters the Delta annually from the Sacramento River (approximately 21 million acre-feet [MAF], on average). Most Sacramento River flows are discharged to San Francisco Bay. The water that is used in the Delta and exported by the various larger diversions (including the state and federal water projects near Tracy) finds its way to the diversion sites through several complex routes using various Delta channels.

In this building block, it is desired to redirect a larger portion of the Sacramento River flows southward through Middle River (armored pathway). Note that no increase in the amount of exports is assumed. This building block focuses mainly on the armored pathway. In normal times (without levee breaches), the armored pathway being considered here will lower export salinity and should also improve water quality throughout the Delta.

However, the main objective behind the armored pathway is the ability to quickly reestablish freshwater conveyance to the project pumps in the advent of a major disruption to the Delta levees and the resulting salinity impacts that could result. The statewide impacts are the greatest in a prolonged disruption of the state's water supply. If the time required for reestablishing water exports can be significantly reduced, much of those impacts can be avoided.

8.2.1.1 Analysis Criteria

Solutions for the Delta typically revolve around three central issues: water quality and export reliability, in-Delta land and assets preservation, and ecosystem protection and enhancement. The armored pathway (through-Delta conveyance) building block is primarily a semi-isolated freshwater conveyance corridor; however, the project contains design elements that address all three central issues. This analysis will focus principally on the engineering feasibility of the water conveyance with additional discussion of related benefits.

8.2.1.2 Basis of Design

The design is based on a significant seismic event in Northern California that destabilizes multiple levees protecting islands in the Delta. The subsequent levee failures would result in inundation of some Delta islands, causing saltwater intrusion into the southern and eastern Delta, and displacing the freshwater that is normally in the Delta channel.

The design concept is to restore freshwater Delta conveyance through a semi-isolated corridor from the Sacramento River near the town of Hood to the Clifton Court Forebay in the south Delta. High-salinity waters in the channels and flooded islands after a seismic event would be separated from the conveyance route by seismic-resistant setback levees and by barrier gates located on specific sloughs crossing Middle River. Freshwater from the Sacramento River would be diverted to the new corridor to flush out any saline water that has intruded and to allow exports to resume. The building block includes an inlet structure located near the town of Hood, the seismic–resistant setback levees, and salinity control barriers on various channels across Middle River. The design elements addressed here include:

- Evaluating Delta water quality in the event of levee failure
- Evaluating Sacramento River water quantity
- Developing concepts for inlet facilities and fish protection
- Developing seismic- and flood-resistant setback levees
- Evaluating environmental impacts and benefits
- Evaluating barrier gate equipment and installation requirements
- Estimating preliminary costs

The conceptual alignment and facility locations are shown on Figure 8-1.

8.2.2 Analysis Results

The analysis results are presented in the following order: evaluation of Delta water quality after a significant seismic event, availability of Sacramento River water, and the specific features of the building block considered.

8.2.2.1 Delta Water Quality

As noted above, concern exists that a significant seismic event could destabilize multiple levees protecting islands in the Delta. The subsequent levee failures would result in inundation of the Delta islands and cause a gulp of bay water of high salinity content to intrude into the Delta, replacing and polluting the freshwater resource.

Studies have been conducted to examine the severity of the gulp caused by multiple island inundations and the methods that could be used to restore water quality. The Delta Risk Management Strategy (DRMS) Phase 1 Risk Analysis (URS/JBA 2008h) considered the full range of potential seismic and flood events and developed modeling capability to assess salinity impacts, repair operations, and time requirements to reestablish water supply operations, assuming present "business-as-usual" (BAU) conditions.

The DRMS model was developed from the Resource Management Associates (RMA) Bay-Delta Model, which simulates flow and water quality transport in the San Francisco Bay, Sacramento–San Joaquin River Delta (ranging from the tidal boundary at the Golden Gate to Freeport on the Sacramento River and Vernalis on the San Joaquin River). The RMA model uses finite-element computational methods and represents the embayments and major river sections. The DRMS analytical capabilities extended the model to address upstream reservoir operations in response to a Delta emergency, and streamlined the model structure so it could be used to analyze a large variety of events rapidly. The DRMS modeling capability includes assessments of statewide economic costs and impacts.

The Metropolitan Water District of Southern California (MWD) recently commissioned a study on Delta emergency preparedness (MWD 2007) to further evaluate salinity intrusion into the Delta as exacerbated by catastrophic levee failures and what could be done to improve recovery.

The MWD analysis uses one example of a major levee breach event and considers various new emergency response capabilities and procedures. The analysis was performed using the RMA Bay-Delta Model. The special accomplishment of the MWD study was to consider new uses of barriers and gates to manage the cross-Delta flows in the period after a major levee breach with salinity intrusion. The MWD study did not consider alterations to the Delta channels, such as widening cross sections or deepening channels to increase capacity.

Hydrodynamic modeling of multiple levee failures indicates significant salinity intrusion in the central and southern Delta soon after a seismic event. Also, the saltwater intrusion is difficult to displace with San Joaquin River flows, which average 4 MAF annually. An extended period of saltwater intrusion in the south Delta would significantly limit (or prohibit) the State Water Project (SWP) and Central Valley Project (CVP) from delivering freshwater to their customers.

The MWD study simulations included redirecting Sacramento River water through the eastern Delta (Middle River corridor) using the installation of barrier gates. The model indicated that the mitigation efforts, such as through-Delta conveyance facilities, would substantially improve performance over BAU conditions.

The CVP constructed the Delta Cross Channel in the early 1950s to improve water quality in the central and southern Delta. Water diverted through the Delta Cross Channel and Georgiana Slough aids in flushing salt out of the central Delta and re-establishing the "freshwater pool" at the San Joaquin River near the Mokelumne River and Potato Slough.

Setting up barriers to block the landward migration of higher-salinity waters was used during the 1976–1977 drought to limit the dispersion of salts due to tidal mixing. The same concept is used with the armored pathway by constructing salinity gates to block saline water from entering the channel and the south Delta during a potential collapse of multiple levees. This will also allow the channel to be flushed of saline water and used to reestablish exports more quickly. If non-potable water reaches the south Delta, within flooded islands, it can be very difficult to evacuate, and isolation becomes an important strategy. The problem was evident in the June 1972 failure of Brannan-Andrus Island. During that event, south Delta pumping continued during the initial intrusion of saline water into the central Delta, drawing further salt into the south Delta channels. The SWP shut down for a month while the CVP pumped an estimated 50,000 tons of salt into the San Joaquin Valley to clear the channels.

8.2.2.2 Sacramento River Water Availability

The available water to send into the armored pathway would be dictated by the seasonal flows available in the Sacramento River, as managed by the state and federal water projects using their upstream reservoirs. Figure 8-2 provides a chart showing flow variations between 2001 and 2006. The figure indicates that a minimum flow of approximately 10,000 cubic feet per second (cfs) is usually maintained in the river. Diversions into the armored pathway corridor would need to be regulated by flow control gates so as not to divert too much flow from the Sacramento River and not to flood the Mokelumne River, Middle River, and adjacent sloughs. It is anticipated that diverted amounts would simply reroute the waters needed to support the same amount of pumping that occurs under present conditions.

8.2.2.3 Alignment and Bathymetry

The alignment considered for the armored pathway building block is shown on Figure 8-1. The existing features along the alignment are presented in Table 8-1. The existing sloughs and rivers were evaluated to determine flow capacity and dredging requirements (if necessary). The bathymetry was evaluated to determine average depth along the alignment length for each slough and river. Alignment lengths and widths were scaled off of aerial photographs at the approximate mid-point. The slough and river measurements can vary greatly, but these measurements are sufficient for the present conceptual-level planning activities.

8.2.2.4 Operational Analysis

The operation of the armored pathway building block was evaluated to determine the potential corridor capacities and subsequent canal and levee cross sections. Three different canal capacities were evaluated. It is understood that the same total volume of water will be diverted under three different flow rates: 5,000, 10,000, and 15,000 cfs. The difference in operation is that normal diversion activities will occur for a longer period with a facility with a capacity of 5,000 cfs as compared to a facility with a capacity of 15,000 cfs. In case of a major levee breach event, diversions at capacity would likely be required for some period to flush intruded salinity from the pathway and reestablish exports. The ability to do this would depend on the availability of freshwater upstream.

8.2.2.5 Inlet Facilities and Fish Control

Diverting flows from the Sacramento River would require control of several factors, including debris, sedimentation, and fish. Debris and sedimentation can be controlled by incorporating maintenance features in the inlet facility. However, fish protection and control are important features of concern to many stakeholders.

Many effective design ideas are available for fish screening, and improvements in the science are continual. Applicable research and technology developments are monitored carefully by the local federal and state agencies and private consultants who would participate in further development of fish screen designs. Good initial resources for the fish screen design criteria include:

- National Marine Fisheries Service, Southwest Region, Fish Screening Criteria for Anadromous Salmonids, January 1997
- State of California, Department of Fish and Game, Fish Screening Criteria, June 19, 2000

Fish screens are addressed as a separate building block (Building Block 3.3, Install Fish Screens) in Section 15.

8.2.2.6 Levee Design

This building block envisions improved levees that are both flood resistant and seismic resistant. It is also desired that the new levees incorporate features to promote environmental habitat. Setback levees meet the critical design criteria for controlling foundation and embankment resistance to seismic forces, and providing habitat restoration as discussed below. The purpose of seismically upgrading the levees along Middle River is to ensure that the levees along the armored through-Delta conveyance channel will survive a seismic event and hence continue to allow freshwater to flow to the export pumps. Among the design criteria used to develop the upgraded cross sections are (1) the upgraded levee deformation goal is less than 1 foot when these levees are subjected to a 200-year earthquake and (2) the levees should not experience excessive damage or breach. Also, a static factor of safety of 1.4 is used on both the waterside and the landside.

Subsurface conditions under the levees in the Delta have been previously characterized (DRMS Phase 1) at 100-foot intervals in terms of the thickness of the organic soils and the liquefaction characteristics of the saturated loose sand immediately beneath the organic soil layer. A screening of the levees and foundation conditions by 100-foot increments was used to define the differing conditions along the armored pathway. After considering the above screening and the subsurface conditions in the Delta, 10 discrete improvement categories were developed (defined by foundation conditions), as shown in the list below. Based on these ten categories, ten seismic-resistant setback levee parametric cross sections were developed for the discrete conditions mapped along the armored pathway.

Organic Soil Thickness (feet)	Liquefiable Sand Layer with $(N_1)_{60\text{-}cs} < 20$	Non-Liquefiable Sand Layer with $(N_1)_{60\text{-}cs} > 20$
0	SL 0	SD 0
10	SL 10	SD 10
20	SL 20	SD 20
30	SL 30	SD 30
40	SL 40	SD 40

Notes: SL stands for loose sand, and SD stands for dense sand. The digits after the letters indicate the thickness of the organic deposits. $(N_1)_{60\text{-}cs}$ stands for the corrected standard penetration test (SPT) blow count for the sand deposits below the peat layer.

Based on these subsurface conditions within each reach, three seismic-resistant setback levee design concepts were developed. These three concepts cover the following cases: (1) the areas with no peat in the foundation, (2) the areas with 10 feet or less of peat thickness, and (3) the areas with more than 10 feet of peat thickness. The areas with 10 feet or less of peat can be over-excavated and replaced with engineered backfill. The areas with more than 10 feet of peat will be treated in place by soil improvement methods. For this last case, the cost of excavation and replacement becomes less competitive than foundation treatment. Foundation treatment could consist of deep soil mixing, jet grouting, stone columns, or other appropriate techniques to mitigate the potential liquefaction of the loose saturated sands. Conceptual designs for these three conditions are presented on Figure 8-3.

For the seismic-resistant setback levee upgrade, an allowance for essentially non-structural, planting fill between the original levee and the setback levee was included to create conditions suitable for various types of plantings. Planting and plant maintenance costs (based on the recent experience on the 2006/2007 DWR emergency levee repairs [see URS 2007a]) were used to develop these estimates. Appendix 8A discusses some of the features and benefits of the habitat restoration along the waterside bench of the seismic-resistant setback levee.

The seismic-resistant setback levees would result in a significant reduction of seismic-induced deformations, in particular for levees composed of liquefiable materials or located over liquefiable materials. The reduction in the probability of failure under seismic loading was estimated by comparing the annual frequency of failure of the existing levees (3 to 5 percent mean annual frequency of failure; see results in the DRMS Phase 1 Risk Analysis Report [URS/JBA 2008h]) to that of the same levees after having been seismically upgraded to the 200-year earthquake (0.5 percent mean annual frequency of failure). The risk reduction of levee failure along the armored pathway would range from 80 to 90 percent. The level of reduction varies based on the seismic vulnerability of the existing levees.

8.2.3 Geometric Description of Improvement

The armored pathway building block has six main components:

- Inlet facility and fish screen on the Sacramento River near Hood
- Dredging of the alignment
- Seismic-resistant setback levees along the alignment
- Restoration of the 115 miles of riparian habitat on the levees
- Corridor and SRAH
- Barrier gates
- Two minor bridges over Snodgrass Slough

Each component is discussed below.

8.2.3.1 Intake Facility

An intake facility would be constructed on the Sacramento River south of the town of Hood and adjacent to Snodgrass Slough. The facility would have three main functions: controlled diversion of water, protection of fish, and control/removal of sediments. A location map of the intake facility under consideration is shown in Figure 8-4.

The facility would start with a debris boom and trash rack on the Sacramento River side, followed by the fish screens. For this building block, we anticipate vertical screens, with a fish bypass mechanism at the apex of each screen. In general, the fish are directed up the screens to a trough and then back out to the river. The water passes through the screens. An example of a vertical fish screen from Redlands Canal near Grand Junction, Colorado, is shown on Figures 8-5 and 8-6. A critical design consideration will be the maximum velocity of the water approaching the screens so that the fish can manage the planned avoidance route and be directed back to the river unharmed.

Flow from the Sacramento River and velocity in the slough would be regulated using radial arm gates similar to those at the Delta Cross Channel, as shown on Figure 8-7. The intake facility structure and gates would be designed to match Sacramento River high-flow stage and adjacent embankment elevations. This design feature would prevent uncontrolled flood waters from inundating Snodgrass Slough.

The intake facility would also house sedimentation control and removal components. The Sacramento River is naturally heavy with suspended solids, and provisions should be made at the intake facility to limit the amount of sediments entering Snodgrass Slough. This limitation can be accomplished through energy dissipation (stilling) of the waters entering the facility and incorporation of a sediment trap (sump). During low-flow periods in the summertime, the radial arm gates can be closed and sediments removed from the trap.

8.2.3.2 Dredging

Dredging activities are considered in Snodgrass Slough to provide a conduit from the Sacramento River to the main existing corridor near the Delta Cross Channel.

Additional dredging may be necessary in the downstream sloughs and rivers, depending on the capacity selected (5,000, 10,000, or 15,000 cfs).

A preliminary design for the corridor cross section is shown on Figure 8-8, and the dimensions are given in Table 8-2.

Corridor cross sections were determined from the continuity equation ($Q=V*A$, where Q = flow, V = velocity, and A = area). This relationship is important because it shows how the corridor cross section impacts velocity, which must be kept at less than 1.5 feet per second to minimize erosion. More detailed analyses of velocities under the influence of tidal flood and ebb flows will be needed and may require some enlargement of cross sections.

For this example, the corridor heights have all been set at 20 feet, which is reasonable for the existing corridor bathymetry and suitable for developing conceptual-level estimates. Further analysis should be conducted to best-fit the desired capacity to existing slough and river dimensions and thereby minimize dredging quantities and optimize the setback levee design concept. In the final design, it is likely the corridor cross section will change continuously along the corridor alignment.

8.2.3.3 Setback Levees

Levee improvements are anticipated from Snodgrass Slough to Clifton Court Forebay. The islands and tracts adjacent to the corridor being considered and the levee lengths and costs are identified in Table 8-3.

8.2.3.4 Riparian Benches

The armored pathway building block would reduce the risk of saltwater contamination of the Sacramento/San Joaquin Delta water exports in the event of a catastrophic levee failure. Strengthened setback levees are combined with salinity gates to control the flow of saltwater from intersecting sloughs in an approximately 50-mile-long north-south corridor from the Sacramento River to Clifton Court Forebay. Setback levees will increase riparian habitat in the Delta, and this habitat may be used by listed species. The salinity gate installation and operation might obstruct passage of listed species of anadromous fish, but operation procedures can be established to prevent a significant impact. A discussion of the ecological background for setback levees, riparian habitat, and fish passage is provided in Appendix 8A.

8.2.3.5 Barrier Gates

Barrier gates are considered in the southern Delta to isolate pathway freshwater from water with higher salinity content. Air-powered inflatable bladder–type gates were selected for this building block. Gates would be installed at slough crossings to create a continuous barrier along the armored pathway alignment. Gates are considered at seven locations adjacent to Staten Island, Bouldin Island, Venice Island, Bacon Island, Woodward Island, and Victoria Island. The gate locations are shown on Figure 8-1, and a section view of the inflatable barrier gate under consideration is shown on Figure 8-9.

8.2.3.6 Bridges at Snodgrass Slough

There are two road crossings of Snodgrass Slough with culverts: one at Lambert Road and the other at an unnamed unpaved farm access road. This building block anticipates their replacement with bridges over the armored pathway corridor.

8.2.4 Description of Benefits

Many benefits can be realized under the armored pathway building block. The primary benefit is available in the context of a major levee breach emergency—the ability to reestablish freshwater conveyance to the central and south Delta and to the state and federal project pumps near Tracy more rapidly than under current conditions. Other benefits include water quality and environmental habitat improvements, which are discussed below.

8.2.4.1 Reduced Disruption to Water Supplies

Presently, levee breaches on multiple islands within the Delta could disrupt CVP and SWP Delta pumping and might reduce south-of-Delta CVP and SWP deliveries. With the semi-isolated armored pathway, freshwater through the Delta can be reestablished more quickly and hence the consequences of such a disturbance will be decreased.

8.2.4.2 Reliable Water Supplies to Agriculture

In cases where south-of-Delta CVP and SWP deliveries are reduced, growers and districts will adjust operations to minimize income losses. In regions with developed groundwater pumping capacity, growers and districts will substitute groundwater subject to physical and economic limits. In some cases, groundwater substitution will eliminate the shortage. In other cases, the shortage will remain. In the latter type of cases, available water supply will be rationed. Rationing could take many forms and would be locally determined. However, it is reasonable to assume that within relatively confined geographic regions supplies will be directed, either by executive decision or through economic incentives, first to permanent crops, second to high-value row crops, and third to forage and pasture.

At the level of the individual farm, the farmer must decide at the time the project water delivery reduction is announced which crops already in the ground to continue producing and which crops not yet in the ground to move forward with. The farmer's choices will be guided by expected returns to production. For example, the farmer could choose to abandon crops in the ground to make water available for crops not yet planted if this would minimize the loss of farm income.

8.2.4.3 Reliable Water Supplies to Urban Users

The methodology used for DRMS to assess the economic consequences of a disruption to urban users consists of the following three-step process:

1. Determine the urban water agencies likely to be affected by levee failure in the Delta.
2. Collect the data necessary to estimate the level of shortage in affected agencies.
3. Estimate the cost of shortage for each agency.

The total risks estimated for urban water users represented one of the greatest risks assessed during the DRMS Phase 1 overall risk assessment.

8.2.4.4 Water Quality

The raw water quality of the Sacramento River is better than that of the San Joaquin River. In particular, the Sacramento River has lower total organic compounds and bromide levels. Also, the flushing action of Sacramento River water injected further east into the Delta will keep Delta salinity level lower and other quality measures higher. For potable water uses, this benefit is likely to be realized in both lower water treatment costs and higher consumer satisfaction.

8.2.4.5 Reduced Likelihood of Levee Breach

The seismic-resistant setback levees would reduce the likelihood of a breach along the armored pathway corridor alignment, but it should be noted that this building block does not include full levee replacement for any islands or tracts. The primary purpose of the improved levees is to protect and isolate the freshwater pathway.

8.2.4.6 Improved Biodiversity – Green Space

The seismic-resistant setback levees are designed to incorporate the existing levees, which will be modified to create environmental habitats. The existing levees will be breached at approximately 1,000-foot intervals to allow tidal flows to reach the inner areas between the new and old levees in places or graded as sloping beaches to create tidal and upper benches. The breach provides a corridor to the inner levee areas for aquatic species. The existing levees will also be vegetated to increase the riparian forests similar to those that once bordered the Delta waterways. A detailed discussion of the environmental impacts of this building block can be found in Appendix 8A.

8.2.4.7 Minimized Land Use Impact

The armored pathway building block uses the existing Delta configuration to meet the improvement goals. By using existing sloughs and rivers, less land is needed to accomplish freshwater conveyance, as opposed to other building blocks (e.g., the Isolated Conveyance Facility [see Section 9]). Although the setback levees may require a wider channel than presently exists, the loss of agricultural land is minimized and the new right-of-way requirement would be smaller.

8.2.4.8 Reduced Island Subsidence

A potential benefit associated with this building block is reduced island subsidence through the re-use of dredged materials recovered during canal construction.

8.3 COST ESTIMATE

8.3.1 Item Descriptions

This section briefly describes the key items in this building block:

- Intake Facility – The intake facility is sized for 15,000 cfs and contains debris booms, trash racks, fish screens radial arm gates, and a sedimentation basin. For this building block, the cost item does not include fish screens. Those costs are approximately $200 million and are considered in Section 15, as part of building block 3.3. The costs elements are combined in Scenario 2.
- Dredging - Dredging activities are assumed to be conducted from barges and the soils disposed on adjacent islands and tracts. The item is priced by the mile.
- Bridges – Two small, two-lane county roads crossing Snodgrass Slough are assumed. The preliminary size is 50 feet wide by 500 feet long.
- Setback Levees – Setback levees are designed to withstand significant seismic events and large floods. The work includes removal of peat soils or in situ improvement of the foundation under the new fill material, compacting or foundation improvements (e.g., deep soil mixing, jet grouting) of loose sands, and placing of levee fill material.
- Riparian Benches – The new setback levees and existing levees will be vegetated to restore riparian habitat along the alignment.
- Barrier Gates – The barrier gates considered for this building block are inflatable dam–style gates, manufactured by Obermeyer.

8.3.2 Cost Estimate Table

Table 8-4 shows the cost estimate for this building block.

8.3.3 Cost Resources

Costs were determined by analyzing other similar projects and manufacturer information, including:

- Building Block 1.7, Isolated Conveyance Facility Alternatives (discussed in Section 9)

- Value Engineering Study of a Through-Delta Facility, conducted by Strategic Value Solutions, Inc., for DWR in March 2007 (DWR 2007b)
- Projects implemented by Obermeyer Gates, Inc.

8.3.4 Operation Cost

Operation and maintenance activities at the intake facility include machine upkeep and removal/disposal of collected sediments. The fish screens will need to be evaluated for effectiveness and adjusted accordingly. The barrier gates will require regular maintenance to ensure that they are in good working condition when needed. A need will exist for maintenance and operations staffing, general support equipment, and electricity to operate screens and gates, including auxiliary power from emergency generators. The levees will also require regular inspection to evaluate their condition and occasional repairs to sections subjected to erosion or containing unwanted vegetation.

Upstream reservoir operations may be used to enhance the flushing of salts out of the Delta. Changed reservoir operations will impact lake and stream recreational uses, but the exact nature of these changes has not been determined.

For this building block it is assumed that 10 staff members will be needed to maintain the facilities. The salary and overhead costs are combined and set at $100,000/year for a total of $1 million/year.

Supplies (e.g., vehicles, energy, tools, and other miscellaneous equipment) have not been considered. Losses and depreciation have also not been considered.

8.4 RISK REDUCTION ESTIMATE

The armored pathway building block will improve the reliability of the levee reaches that define it. These levee reaches, which will be seismically upgraded, will have a much lower probability of failure due to seismic events—perhaps lower by 80 percent or more than the present levees. This increase in the reliability of the levees that define the armored pathway, coupled with the installation of barriers across the identified sloughs, would significantly reduce the likelihood of long disruptions of water exports.

8.5 FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The armored pathway building block consists of six main components:

- Inlet facility on the Sacramento River near Hood
- Dredging of the alignment
- Seismic-resistant setback levees along the alignment
- Restoration of the riparian habitat on the levees
- Barrier gates
- Two minor bridges at Snodgrass Slough

The preliminary cost estimate is $5.7 billion in 2007 dollars for 15,000 cfs, $4.6 billion in 2007 dollars for 10,000 cfs, and $3.5 billion in 2007 dollars for 5,000 cfs.

The armored pathway (through-Delta conveyance) building block provides a reasonable way to maintain freshwater delivery in the south Delta. The design is feasible from an engineering perspective and minimally intrusive to the community. Many benefits would accrue, including improved recovery from major levee breaches, improved reliability of normal water delivery, improved water quality, and improved riparian habitat.

Additional evaluation is necessary in several areas:

- Determining the optimum location, design and fish screening requirements of the inlet facility on the Sacramento River
- Evaluating the organic soils and subsurface sands along the alignment to determine levee design parameters and better estimate costs
- Considering alternative levee designs to lower costs (e.g., a seismically damageable but repairable design that would still substantially accomplish the pathway isolation function)
- Identifying economical sources of levee material
- Conducting further hydrodynamic modeling of this alternative, both under normal (non-breach) conditions to evaluate the adequacy of the channel cross sections for conveying desired flows and under-levee breach conditions to evaluate the activities and time required to reestablish freshwater flow in the pathway for a wide variety of failure scenarios (Simulation of levee disruption scenarios may indicate that a bypass or tunnel under the San Joaquin River may be required.)
- Developing construction methods

Tables

Table 8-1 Existing Features Along Alignment

Alignment Description	Depth (feet)	Length[1] (miles)	Width (feet)
Snodgrass Slough	6	11	350
Dead Horse Cut	6	0.8	250
South Mokelumne River	16	10.3	300
Little Potato Slough	16	2.1	250
Little Connection Slough	20	4.5	600
Stockton Deep Water Ship Channel – Crossing	40+	-	-
Columbia Cut	9	1.6	500
Latham Slough	20	5.3	700
Middle River	20	7.9	400
Victoria Canal/North Canal	15	4.8	500
Clifton Court Forebay	6	-	-

[1] Reflects canal length along centerline; total length is approximately 50 miles.

Table 8-2 Preliminary Cross-Section Dimensions

Flow-Q (cfs)	Velocity-V (fps)	Area-A (sf)	Height-h(ft)	Base-b (ft)	Top-a (ft)
5,000	1.0	5,000	20	190	310
10,000	1.25	8,000	20	340	460
15,000	1.5	10,000	20	440	560

cfs = cubic feet per second
fps = feet per second
ft = foot (feet)
sf = square foot (feet)

Table 8-3 Improved Levee Locations and Lengths

Location	Length (Miles)
Staten Island	13
New Hope Tract	3.2
Canal Ranch	3
Brack Tract	2.5
Dead Horse Island	0.8
Tyler Island	9.5
Bouldin Island	4.7
Terminous Tract	5.9
Empire Tract	4.4
Venice Island	2.5
Medford Island	3.7
McDonald Tract	6.2
Mandeville Island	2.3
Bacon Island	7.8
Lower and Upper Jones Tract	8.8
Woodward Island	8.9
Orwood Tract	2.3
Victoria Island	15.1
Byron Tract	6
Union Island	4.3
Drexler Tract	1.3
Total	**115**

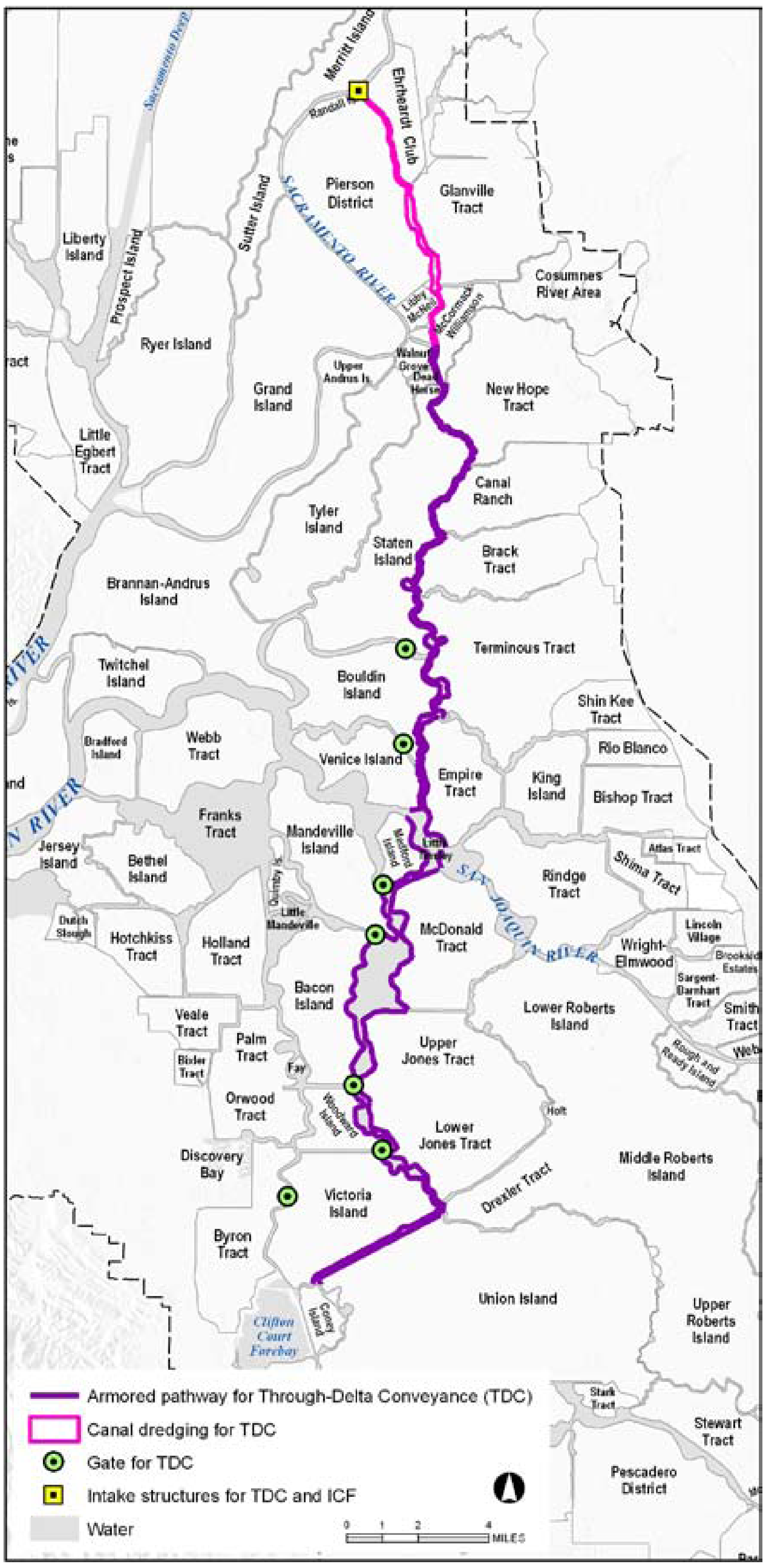
Table 8-4 Cost Estimate for Building Block 1.6, Armored "Pathway" (Through-Delta Conveyance), 15,000 cfs

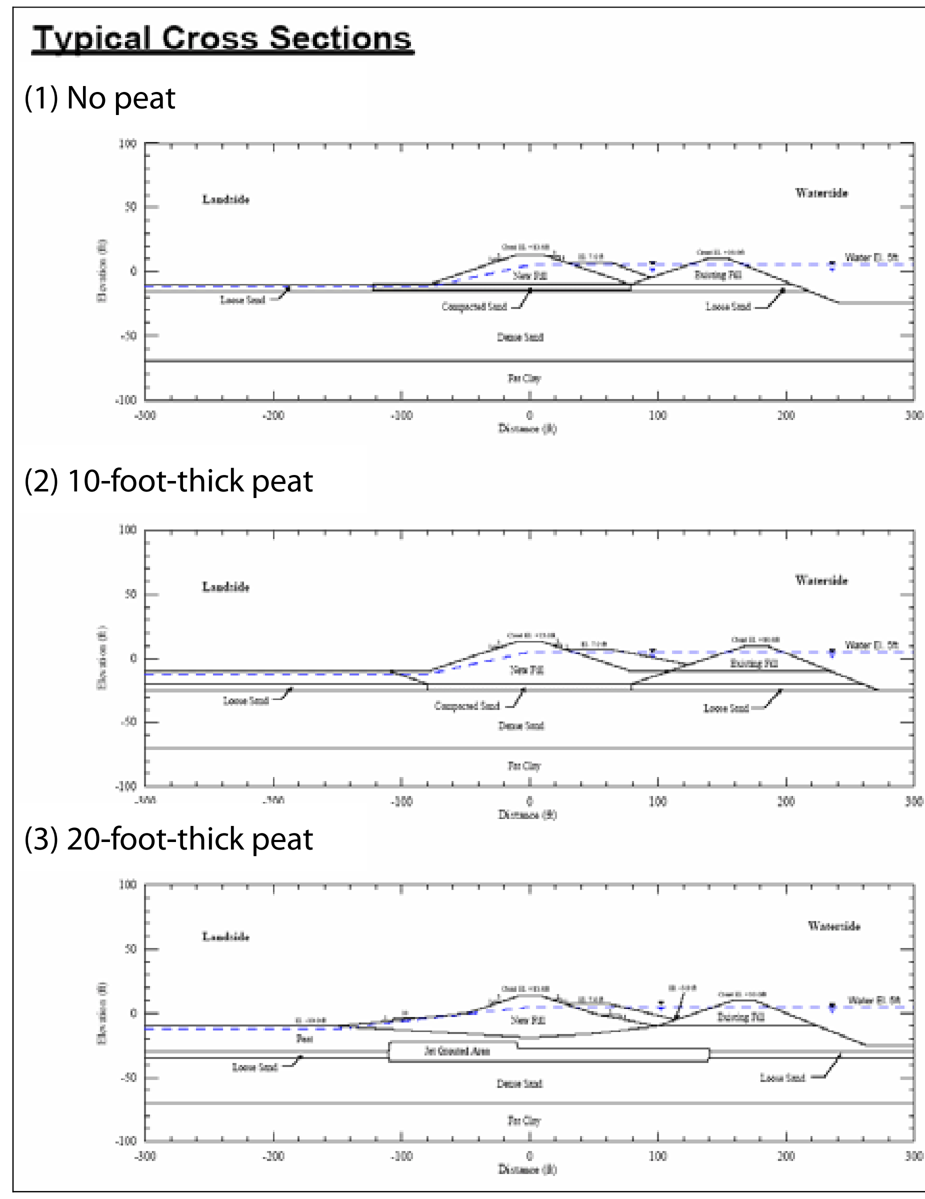
Item	Description	Quantity	Unit	Unit Price	Total
1	Intake Facility	1	LS	$200M	$200M
2	Dredging	57.5	Mile	$4M	$230M
3	Bridges	2	EA	$10M	$20M
4	Setback Levees	115	Mile	$38M	$2.33B
5	Riparian Benches & Plantings	115	Mile	$5.0M	$324M
6	Barrier Gates	7	EA	$20M	$140M
				Subtotal	$3.24B
	Mobilization/Demobilization	5%			$162M
				Subtotal	$3.40B
	Eng., Admin., Legal, CM	30%			$1.02B
				Subtotal	$4.43B
	Contingency	30%			$1.33B
				Total[1]	**$5.76B**

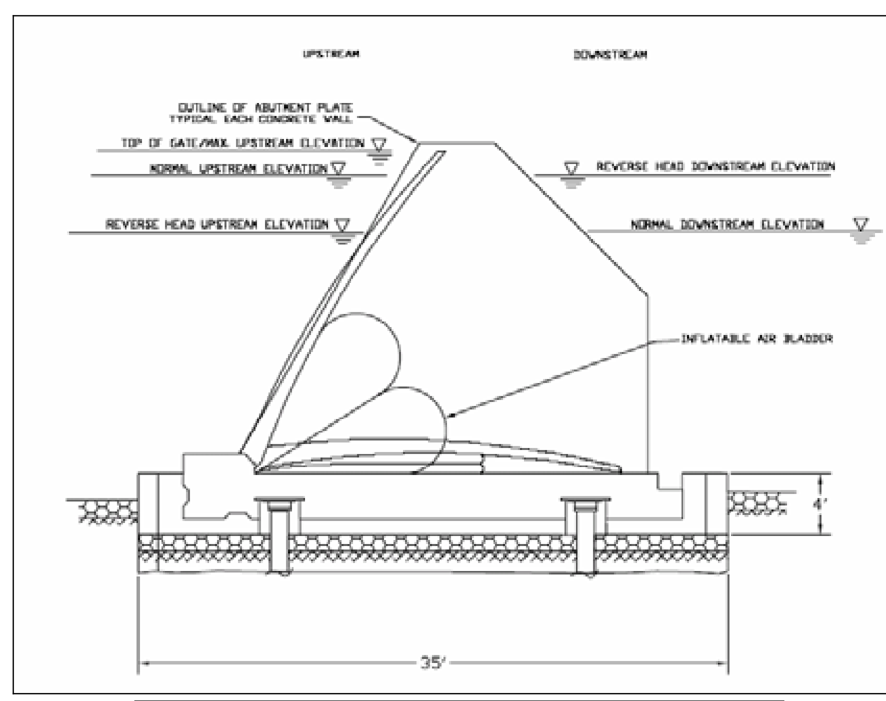
[1] Approximately 90 percent of the cost is for seismic-resistant setback levees.

B = billion
cfs = cubic feet per second
CM = construction management
EA = each
LS = lump sum
M = million

Figures







Typical Barrier Gate

PROJECT INFORMATION

- Capacity = 15,000 cfs
- Corridor Length = 48 miles
- Seismic-Resistant Setback Levees = 115 miles
- Barrier Gates = 7
- Siphon at Old River
- Intake and Fish Screen at Sacramento River

PROJECT BENEFITS

- Keeps Salinity Levels Low After Major Disruption to Delta Levees
- Maintains Water Quality
- Reduces Risk of Export Interruption Somewhat; May Require a Tunnel under San Joaquin River or a Large Flow Control Structure
- Protects Agricultural Areas Adjacent to Improved Levees
- Fish Screens Protect Fish at Intake
- Increases Habitat Area in Riparian Zones (115 miles)
- Seismic-Resistant Levees
- Barrier Gates Could be Used for Improving Water Quality

PROJECT LIMITATIONS

- Dredging Required
- Land Acquisition for Larger Conveyances
- Reduced Flow in the Sacramento River
- No Risk Reduction for Fish Entrainment
- Larger Fish Screen Costs
- Not Very Efficient During Periods of Major Damage to Delta Levees
- Saltwater Intrusion Through San Joaquin River, Particularly During the Dry Season
- Construction Impacts
- Additional Maintenance Cost to Keep up with Sea-Level Rise (115 miles of levees)

PROJECT COSTS

- 15,000 cfs Facility = $5.7 billion
- 10,000 cfs Facility = $4.6 billion
- 5,000 cfs Facility = $3.5 billion

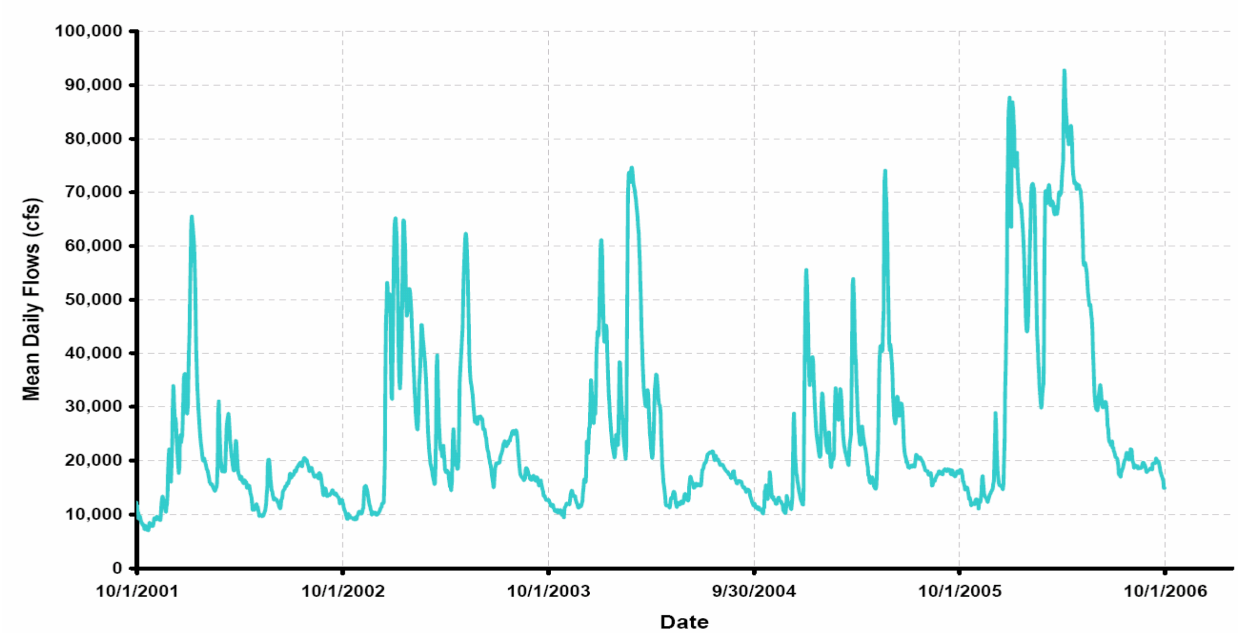


Figure 8-2 Historical Flows in the Sacramento River

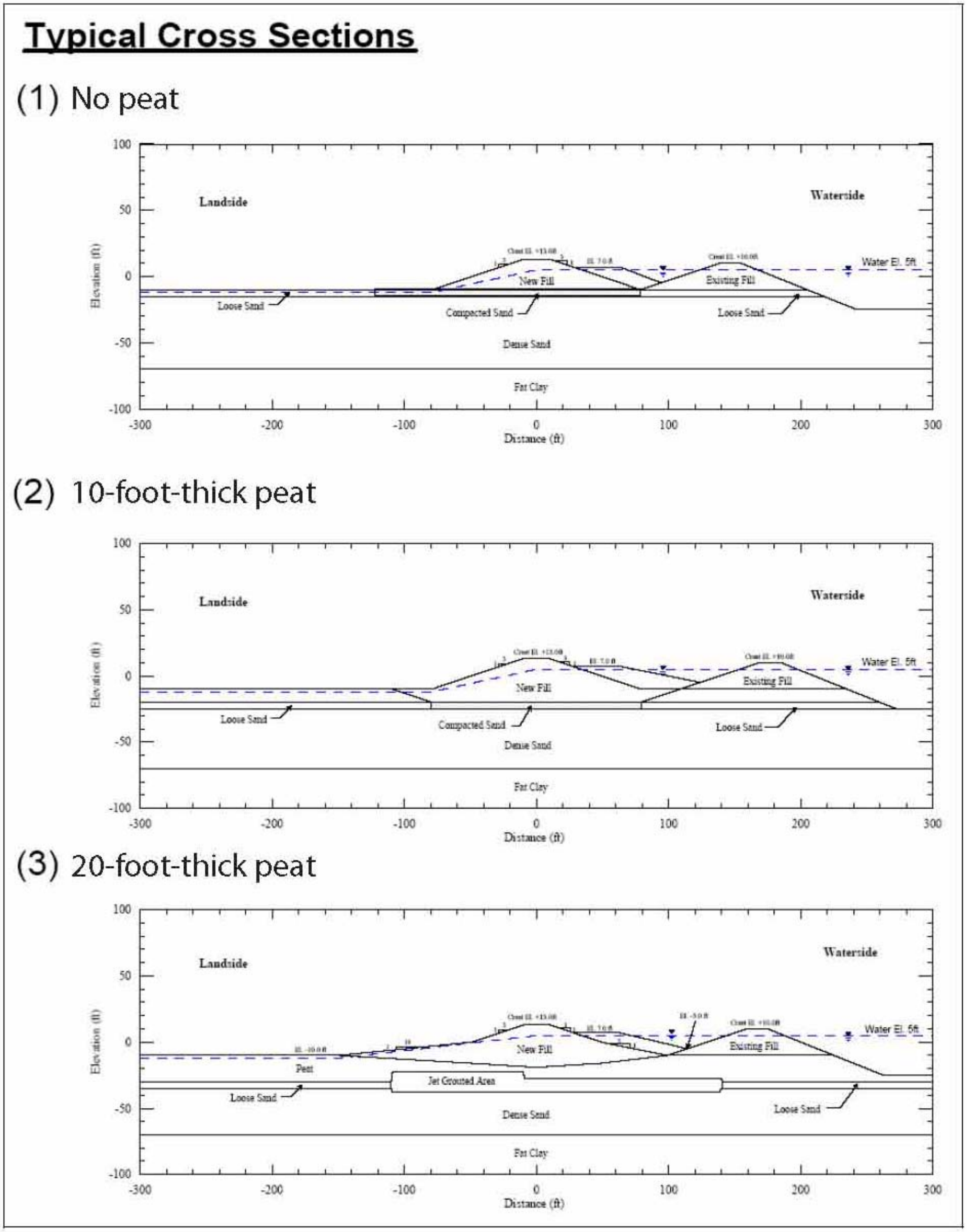


Figure 8-3 Seismic-Resistant Setback Levees

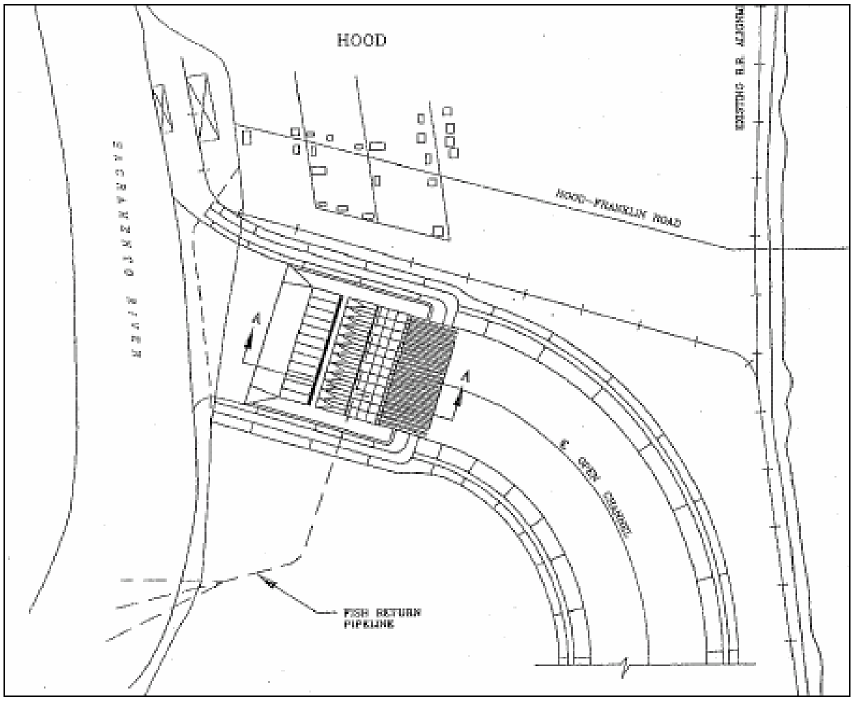


Figure 8-4 Location Map of Intake Facility

Figure 8-5 Redlands Canal Fish Screen (1) (Courtesy: U.S. Fish and Wildlife Service)

Figure 8-6 Redlands Canal Fish Screen (2) (Courtesy: U.S. Fish and Wildlife Service)

Figure 8-7 Delta Cross Channel Radial Arm Gates (Courtesy: United States Bureau of Reclamation)

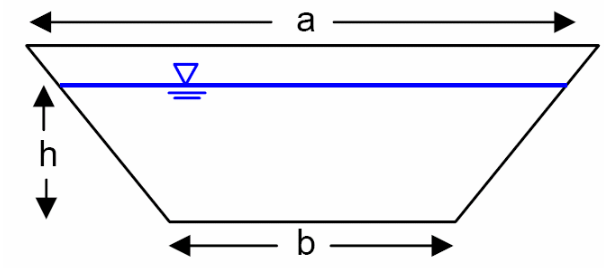


Figure 8-8 Preliminary Corridor Cross Section

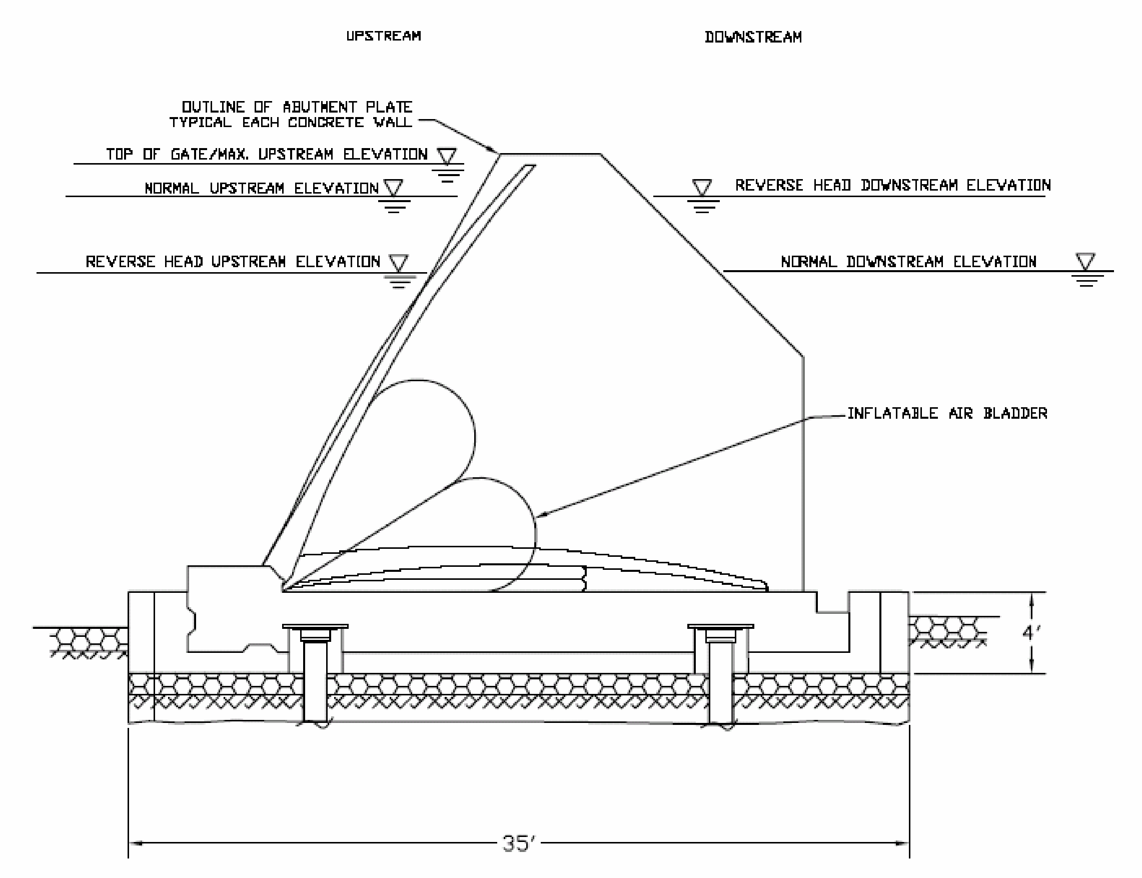


Figure 8-9 Inflatable Barrier Gate

Appendix 8A
Environmental Impact of Armored Pathway

Table of Contents

Table of Contents

Tables

Figures

Attachments

Acronyms

EFH	essential fish habitat
GIS	Geographic Information System
HRG	Habitat Restoration Group
JSA	Jones and Stokes Associates, Inc.
PRBO	Point Reyes Bird Observatory
SAV	submerged aquatic vegetation
SRA	shaded riverine aquatic (habitat)
URS	URS Corporation
USFWS	U.S. Fish and Wildlife Service

8A.1 INTRODUCTION

8A.1.1 Background

Building Block 1.6: Armored "Pathway" (Through-Delta Conveyance) proposes to reduce the risk of saltwater contamination of the Sacramento–San Joaquin River Delta (Delta) water exports in the event of a catastrophic levee failure. Strengthened setback levees are combined with salinity gates to control the flow of saltwater from intersecting sloughs in an approximately 50-mile-long, north-south corridor from the Sacramento River to the Clifton Court Forebay. Setback levees will increase riparian habitat in the Delta, which may be used by listed species. The salinity gate installation and operation may periodically obstruct passage of listed species of anadromous fish. The ecological background for the setback levees, riparian habitat, and fish passage is provided below.

8A.1.1.1 Setback Levees

Setback levees involve the creation of a vegetated riparian bench that recreates the riparian zones occurring in the Delta before levee construction for land reclamation. Setback levees contrast with typical levee designs that involve heavy riprap on the channel sides and removal of trees, primarily due to concerns that large trees may remove sections of the levee wall as a result of windfall, and dense understory vegetation, which can make levee inspections difficult. The Bay-Delta Conservation Plan Conservation Work Group identified "extensive in-Delta levee setbacks" as a "conservation strategy alternative" for improving Delta health and functionality (BDCP 2007). In particular, the California Department of Water Resources lists the following reasons for developing Delta setback levees:

- Reduce maintenance and repair by removing constrictions
- May stabilize channel reach from chronic erosion
- Reduce flood potential downstream
- Reduce water surface elevation at flood stage
- Reduce danger and consequences of levee failures
- Provide larger river floodplain for river meander
- Preserve habitat for riparian species
- Improve fish habitat and fisheries

8A.1.1.2 Riparian Habitat

Vegetation on levees creates riparian habitat, which is the ecosystem between aquatic and upland vegetation that is at least periodically influenced by flooding (Mitsch and Gosselink 1993). Riparian areas are some of the most productive wildlife habitats and have high value as fish and wildlife habitat (USFWS 1989). Loss of historical areas of riparian woodland is high (98 percent of riparian woodland in the Sacramento River Basin since 1850) compared to loss of wetland habitat (67 percent of the wetland vegetation in San Francisco Bay was removed by 1946).

Comparative figures have not been calculated for the Delta, but are probably similar (Whitlow et al. 1979). Historical distribution of riparian vegetation is presented in Figure 8A-1.[1]

Riparian zones have increased species richness (number of species in an area) and density (Anderson and Ohmart 1984; Robertson 1988) and the habitat value (species diversity and density of individuals) of adjacent cropland (Hahnke and Stone 1978). Riparian habitats often have a rich diversity of plant species and unique structural diversity, with several canopy layers of vegetation (Bentrup and Hoag 1998). Plant composition and structure is regulated by the frequency, magnitude, duration, and seasonal timing of flooding, and subsurface conditions and can include hardwood trees and woody species (such as willows), forbs, grasses, and grass-like species (Bentrup and Hoag 1998). The full value of riparian habitat for many species requires adjacent habitats, including riparian freshwater marsh, saltwater brackish water marsh, and transitional uplands, which are together referred to as the riparian corridor or riparian zone (HRG and JSA 1994).

The riparian zone influences several elements of fish habitat, including temperature, cover, and food (Reeves and Roelofs 1982 in USFWS 1989). Riparian trees shade the adjacent shallow water, and this shade moderates water temperature and may keep temperatures within the requirements of the fish. Streamside vegetation creates critical habitat for small fish by slowing the water movement along the margins of larger streams, providing cover from predators, and providing food in the form of terrestrial organisms that are easier to capture than many aquatic drift organisms (USFWS 1989). Streamside vegetation supplements the aquatic foodweb that eventually supports fish biomass by contributing food items such as benthic macro-invertebrates, detritus from leaves, herbaceous vegetation (which is consumed as soon as it is deposited), and large woody debris, which provides long-term food reserves (Bentrup and Hoag 1998).

Riparian systems provide breeding and foraging habitat for resident birds (see Figure 8A-2) and are productive habitats for migrating birds (USFWS 1989). According to the Riparian Bird Conservation Plan (PRBO 2004), riparian habitat in the Bay-Delta supports six listed bird species and six focal species for conservation. The listed species are Swainson's hawk (*Buteo swainsoni*), yellow warbler (*Dendroica petechia brewsteri*), willow flycatcher (*Empidonax traillii*), tricolored blackbird (*Agelaius tricolor*), yellow-breasted chat (*Icteria virens)*, and least Bell's vireo (*Vireo bellii pusillus*); the focal species for conservation are spotted sandpiper (*Actitis macularia*), warbling vireo (*Vireo gilvus*), tree swallow (*Tachycineta bicolor*), Wilson's warbler (*Wilsonia pusilla*), black-headed grosbeak (*Pheucticus melanocephalus*), and blue grosbeak (*Passerina caerulea*). Riparian habitat is critical to river otters (*Lutra Canadensis*) and beavers (*Castor Canadensis*) as well as various pheasant species when fields are bare in the winter (Mall and Rollins 1972). Amphibians and reptiles use the full width of the riparian zone for forage, cover, and migration corridors. Therefore, complex riparian habitat may benefit sensitive species of concern, including the western pond turtle (*Clemmys marmorata marmorata*) and the foothill yellow-legged frog (*Rana boylii)*, and threatened/endangered species, such as the California tiger salamander (*Ambystoma californiense*)and the California red-legged frog (*Rana draytonii*) (HRG and JSA 1994).

[1] Historical distribution of riparian vegetation map was created using Geographic Information System (GIS) information by overlaying historical vegetation data gathered by Kuchler (1977) with historical Delta channels from geologic maps in Atwater (1982).

8A.1.1.3 Fish Passage

Listed species of anadromous fish, including chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), green sturgeon (*Acipenser medirostris*), and Delta smelt (*Hypomesus transpacificus*), use Delta waterways as they migrate to and from freshwater spawning grounds upstream and brackish habitats further downstream. Salinity gates would be placed to prevent the flow of saltwater into the freshwater corridor. Installation of the gates (which may require cofferdams) and their operation during the time of upstream and downstream migration may obstruct major migration arteries to the San Joaquin River used by listed anadromous fish species.

8A.1.2 Purpose and Scope of Building Block

Ecologically, the purpose of the building block is to create a 50-mile riparian corridor as part of the armored pathway (through-Delta conveyance). The riparian corridor would re-establish rare riparian habitat in the Delta.

This appendix describes the ecological impacts of the building block, including the benefits of a 50-mile riparian corridor to listed species and the impacts of construction and operation of salinity gates on listed fish species (Section 8A.2). The report also describes the characteristics of high-value riparian habitat and presents a vegetated levee design that incorporates these characteristics (Section 8A.3). A cost estimate is presented in Section 8A.4. Section 8A.5 presents the risk reduction impacts, and Section 8A.6 presents the findings, conclusions, and recommendations.

8A.1.2.1 Objectives and Approach

Objectives
The objectives of the riparian corridor are to increase rare riparian habitat in the Delta and to benefit the many Delta species that rely on riparian habitat. The ultimate goals are to increase population sizes, reduce the risk of extinction to listed species, and increase the overall ecological health of the Delta.

Approach
To design a riparian corridor that achieves these goals, the consulting team first evaluated:

- Habitat expansion of listed riparian species resulting from a 50-mile-long riparian corridor in a north-south alignment through the Sacramento–San Joaquin River Delta
- Disruption of waterway use by listed anadromous fish because of construction and operation of salinity gates

Second, the characteristics of high-value riparian habitat are discussed and a setback levee vegetation design is presented that provides high-value habitat to listed species.

8A.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

8A.2.1 Analysis Criteria and Basis of Design

The analysis criteria and basis of design are presented below.

8A.2.1.1 Methodology for Assessing Ecological Impacts of Setback Levees

The ecological benefits of the setback levee design for listed riparian species were evaluated in a manner inspired by an unpublished paper by Westhoff and Hester (2007). The current distribution of riparian trees (obtained from Westhoff and Hester 2007) was combined with the location of the proposed setback levee corridor in a Geographic Information System (GIS) format. URS Corporation (URS) senior wildlife biologist S. Leach selected the species that benefit from riparian habitat from the listed species that occur in the Sacramento–San Joaquin River Delta region in the California Natural Diversity Database (July 2007). GIS figures were compiled using U.S. Geological Survey topographic quadrangle maps containing observations of the listed species overlain with the existing riparian habitat and the proposed setback levee corridor. The maps were examined to evaluate the impact of the corridor on connecting the range or expanding the spatial extent of the habitat of each riparian species.

8A.2.1.2 Methodology for Assessing the Ecological Impacts of Salinity Gate Construction and Operation

The use of waterways by listed species that may be obstructed by salinity gates were obtained from maps of critical habitat and essential fish habitat (EFH). The time of year in which waterways would be used for migration or by fish is presented. These data may be used to determine a time of year to construct salinity gates that would not impede fish passage.

8A.2.1.3 Characteristics of High-Value Riparian Habitat

The functional values of riparian habitat to fish and wildlife include the following:

- Diverse habitat structures in riparian areas (aquatic, marsh, riparian [hardwoods, shrubs]) and upland) provide food, shelter, and corridors for animal movement and juvenile dispersal, which support wildlife diversity (Bentrup and Hoag 1998). For example, Figure 8A-2 illustrates use of different habitats in the riparian corridor by bird species.
- High foliage density and diversity in the vertical and horizontal dimensions are among the variables most frequently associated with high avian densities and species diversity in riparian zones along the lower Colorado River (Anderson and Omar 1985 in USFWS 1989).
- Riparian trees that shade the adjacent shallow water control water temperature and keep it within fish temperature requirements for spawning.
- Streamside vegetation creates critical habitat for small fish and food sources for benthic macrofauna.

Many riparian species rely on particular species of riparian vegetation. In particular, cottonwoods and willow are critical to songbirds (Whitlow et al. 1979). Attachment 8A-1 lists plant species that benefit riparian birds. The federally threatened valley elderberry longhorn beetle relies on a sole host plant, the elderberry tree (*Sambucus* spp.), which is associated with riparian forest. The federally endangered riparian brush rabbit's habitat includes riparian areas dominated by willow thickets (*Salix* spp.), California wild rose (*Rosa californica*), Pacific blackberry (*Rubus vitifolius*), wild grape (*Vitis californica*), Douglas' coyote bush (*Baccharis douglasii*), and various grasses.

8A.2.1.4 Design Methodology for Setback Levees

Plant species were selected based on vegetation designs that comply with agency standards for self-mitigating vegetation for the Sacramento River emergency levee repairs project (URS 2007a).These designs take into account a number of parameters. The plant species were selected for suitability of use on levees (e.g., widely spaced clean-barked deciduous trees, compact thornless shrubs, and reducing vegetation favorable for Beechy ground squirrel while maintaining vegetation for other wildlife (Whitlow et al. 1979). The Beechy ground squirrel makes tunnels that contribute to the weakening of levee walls and boils (in which water boils up on the landside of the levee. These boils must be addressed immediately so that they do not reduce the structural integrity of the levee wall and cause a levee breach. Plant species were further selected on the basis of typical inundation frequency. Plants that provide forage or cover for native wildlife were preferred. URS wildlife biologists S. Leach and C. Stewman identified plant species and characteristics that would increase the habitat value of a riparian zone for listed riparian species in the Delta and a list of riparian plants that benefit birds that rely on riparian habitat (Attachment 8A-1).

Plant density and elevations for planting various species were based on the vegetation designs that comply with agency standards for self-mitigating vegetation for the Sacramento River emergency levee repairs (URS 2007a). A less-dense planting design called “simple” is used in the cost estimate. The same plant species would be used along the entire armored levee pathway; no changes in species composition of the vegetation along the 50-mile-long, north-south length of the armored corridor are expected.

8A.2.2 Analysis Results and Design Layouts

The Westhoff and Hester map (2007) of current riparian habitat indicates that the center of the Delta is relatively devoid of riparian trees; in contrast, riparian trees are extensive in the north Delta and a smaller patch is present in the south Delta. The riparian corridor would effectively connect the riparian habitat in the north Delta and the south Delta. The riparian corridor would provide habitat connecting the ranges of nine listed riparian species (Figures 8A-3a and 8A-3b). The riparian corridor would expand the current range extent of 19 listed riparian species (Figures 8A-4a and 8A-4b). The riparian corridor would provide different types of benefits for listed species, including an increase in habitat (particularly for plants), increased foraging, enhanced breeding/nesting territory, and increased shelter and cover (Table 8A-1). Detailed benefits for listed species are described in Section 8A.3.2.

8A.2.2.1 Waterway Obstruction

Salinity control gates (salinity gates) would be placed along waterways south of the San Joaquin River and the Stockton Deep Water Ship Channel in the south Delta. Construction may involve erecting cofferdams to block the waterway during construction of the tunnels in which the siphons will be placed. These cofferdams may obstruct migration, juvenile rearing, spawning, and holding by salmonids and use by native fish.

The salinity gates are on Old River, Middle River (two salinity gates), Latham Slough, and Connection Slough. Both the San Joaquin River and these waterways lead to the following salmonid spawning grounds: Calaveras River, Stanislaus River, Tuolumne River, and Merced River. In the event that the salinity gates are in operation and their associated waterways are obstructed, the San Joaquin River would offer an unobstructed route for fish to reach these spawning grounds. However, emigrating juvenile fish have limited swimming abilities relative to adults and they may not be able to locate alternative emigration routes when faced with construction of salinity gates or salinity gates in operation. The area in which the gates occur is designated as EFH for the listed ESUs Central Valley fall-run chinook salmon (utilized for migration, holding, and rearing) and Central Valley late fall-run chinook salmon (utilized for holding and rearing), and is within the critical habitat designated for the listed Central Valley steelhead (likely utilized for migration, holding, and rearing). Adults of the listed Central Valley spring-run and winter-run chinook salmon do not currently migrate through waterways affected by salinity gate construction, but they may enter and leave these waterways during upstream migrations and early juvenile emigrants may rear in or near these waterways.

- Central Valley fall-run chinook salmon spawn and rear in the Calaveras River and Mokelumne River and use the San Joaquin River for migration to spawning grounds in upstream tributaries and juvenile rearing. Creation of setback levees north of the San Joaquin River would affect the emigration route and probable rearing grounds of fall-run chinook salmon spawned in east-side tributaries to the Delta (and potentially for fall-run and other runs from other natal rivers and streams). Shallow riparian habitat created on setback levees under this building block may provide additional rearing habitat for these fish, but this habitat may also encourage the spread of invasive submerged aquatic vegetation (SAV) plant species and the non-native predatory fish species that utilize this SAV. Adult migration of fall-run chinook salmon is from July to December, spawning takes place from late-September to early-January, and juvenile emigration occurs from December to June.
- Sacramento River late fall-run chinook salmon may use Middle River and the San Joaquin River opportunistically, as they occasionally spawn in the Calaveras River. Juveniles would be expected to emigrate through these same waterways and some rearing and growth may occur during emigration. Adult migration occurs from October to March, and juvenile emigration occurs from late-August to March.
- The endangered Sacramento winter-run chinook salmon may use the Calaveras River for opportunistic/intermittent spawning, holding, and rearing. Lindley et al. (2007) are dubious that fish identified as winter-run are accurately identified; they suggest these fish are more likely to be late-fall run chinook salmon. As a result, winter-run spawning in the Calaveras River remains speculative. Adult migration for winter-run chinook salmon occurs from December to early July, spawning occurs from late April to mid-August, and juvenile emigration occurs from July through April.
- The threatened Central Valley spring-run chinook salmon no longer spawn in the Mokelumne, Cosumnes, Calaveras, or San Joaquin rivers; however, they once probably spawned in the headwaters of each of these streams (Yoshiyama et al. 2000), and their future persistence may depend on restoration of this run to San Joaquin tributaries where snow-melt run-off is expected to persist under current global-warming scenarios (Lindley et al. 2007).
- The threatened Central Valley steelhead enter freshwater throughout the year, regularly from July through March, and most commonly from August through October. They hold in the Delta and main stems of major rivers until tributary flows are high enough for spawning (Moyle 2002). Spawning begins as early as October and ends as late as June but is more common from December through April. This evolutionarily significant unit has the longest freshwater migration of any winter-run steelhead (NOAA 1998). No EFH has been

designated for the Central Valley steelhead. The locations of the proposed armored pathway (Through-Delta Conveyance) fall within the critical habitat of the Central Valley steelhead. Steelhead spawn in the Sacramento River and its tributaries, the Mokelumne River, the Calaveras River, and other tributaries of the San Joaquin River.

All juvenile salmonids emigrating from the Central Valley pass through the Delta. Diversion of a significant amount of freshwater flow from the Sacramento River into the northern Delta above the Delta Cross Channel gates may increase the number of emigrating salmonid juveniles that are drawn from the Sacramento River into the central and southern Delta. Even if the new diversion is well-screened, reduced flows in the lower Sacramento River may not produce an adequate directional signal for emigrating juvenile chinook salmon. Direct and indirect mortality of salmonid juveniles is expected to increase in the interior Delta compared with those fish that move directly from the northern to western Delta. Similarly, the diversion of Sacramento River water into the interior Delta may alter the olfactory and tactile signals used by migrating adult salmon as they try to locate their natal spawning grounds. Such changes may lead to migration delays and could decrease spawning migration success. Also, as juvenile fish emigrate they may migrate up waterways other than their natal streams and rear in these watersheds. As a result, juveniles of each of the five distinct populations of Central Valley salmonids may experience direct impacts from the construction proposed in each of the waterways involved in this building block.

- The threatened southern distinct-population segment of green sturgeon may migrate through each of the waterways relevant to this building block. They are known to migrate through the Delta and they are known to spawn in the Sacramento River. Whereas spawning has not been documented in the San Joaquin River or its tributaries, NOAA Fisheries considered it likely that they historically spawned in the San Joaquin River and its major tributaries.[2] It is possible that these fish spawn currently or spawned historically in the Mokelumne, Calaveras, or San Joaquin rivers and their upstream tributaries. Also, emigrating juvenile or adult sturgeon may pass through or forage in any of the areas affected by this building block.
- Construction of setback levees and construction and operation of salinity control gates under this building block may also impact the spawning and rearing of federally and state-threatened Delta smelt. Sloughs scheduled for seismic-resistant setback levees under this building block encompass two sampling stations (#906 near Medford Island and #919 near Bouldin Island). During the years 1995–2005, sampling at these locations produced larval Delta smelt in 0–24 percent and 0–21 percent of samples annually, respectively. Salinity control gates are proposed for Latham Slough and Middle River in the vicinity of Mildred Island and for Old River in the vicinity of Victoria Island. The 20-mm survey detects larval Delta smelt in this area at sampling stations #914 and #915; at both of these sites, larval smelt were detected at 0–16 percent of samples annually. These results suggest that in some years at least, Delta smelt spawn and/or rear in or near the waterways considered in this building block and that construction activities and active management of hydrologic and salinity patterns in these areas may negatively impact Delta smelt during those years.
- Longfin smelt (*Spirinchus thaleichthys*) also occur in the region impacted by the proposed setback levees. Spawning runs of this species-of-special-concern carry some adults into

[2] Federal Register / Vol. 70, No. 65 / Wednesday, April 6, 2005 Pages 17386-17401.

freshwater sections of the Sacramento and San Joaquin rivers. Although larvae have been less common in the San Joaquin River than in the Sacramento River in recent years, longfin smelt larvae have been caught at California Department of Fish and Game 20-mm sampling stations in and upstream of the area impacted by construction of the armored pathway (Through-Delta Conveyance). Indeed, whereas, Moyle (2002) lists the upstream range of this species on the San Joaquin River as Medford Island, larval longfin smelt have been caught upstream near Rough and Ready Island on several occasions since 2000. These occurrences suggest that spawning and rearing may occur in or near the area potentially impacted by setback levee operations and changed hydrodynamics in the area impacted by this building block. Also, to their potential direct impacts, construction and operation of salinity control gates in this area would be expected to alter hydrodynamics in the Delta and these altered hydrodynamics may impact spawning, survival, and transport of larval longfin smelt to the brackish waters where they live through most of their life cycle.

Several other commercially, recreationally, and ecologically important fish species, including striped bass (*Morone saxatilis*), threadfin shad (*Dorosoma petenense*), and Sacramento splittail (*Pogonichthys macrolepidotus*) may migrate through the San Joaquin River corridor on their way to or from spawning grounds on the San Joaquin River or its tributaries. Adults and juveniles may experience delays during construction or operation of salinity control gates; these delays would likely result in reduced spawning success for adults and increased mortality for juveniles as they become entrained behind or attempt to migrate around salinity control gates. Also, these species spawn in the waterways north of the San Joaquin River, and their juveniles would be impacted (potentially in negative or positive ways) by habitats created on setback levees in this area.

8A.3 GEOMETRIC DESIGN OF IMPROVEMENT

Cross sections of the setback levee are shown in Figure 8-3 in the main text for Section 8. Agricultural fill creates a riparian bench during August mean high water (MHW) + 2 feet and creates shallow water habitat to a maximum depth of 6 feet. Planting zones (areas with the same plant species and density design) are also depicted by number. In the riparian bench, trees are only planted in the location where agricultural fill is greater than 5 feet above the structural levee. The fill is graded so the depth of the shallow water habitat varies to create dead-end sloughs, which increase the variety of elevations and habitats.

8A.3.1 Setback Levee Vegetation Design

Planting zones (areas with the same plant species and density) are described from the existing levee to the island interior. Existing habitat on the channel-side of the levee would not be disturbed, and the interior-side of the existing levee would be planted with native shrubs and riparian trees. The planting schedule (Table 8A-2) lists plant species and planting densities for each planting zone.

The existing levees (in contrast with the proposed setback levees) would be breached approximately every 1,000 feet to allow water to flow into the designed riparian channels. Breach locations would be chosen to avoid listed plant species growing on the channel-side of the levee. Erosion would likely widen breaches over time. Interior to the existing levee would be a channel (approximately 6 feet below mean sea level) that would remain wetted over the tidal cycle to prevent fish stranding. The soil would be graded so the channels form dead-end sloughs, which would also function as seasonal floodplain habitat. The subtidal area will not be planted. Woody material would create fish habitat. The intertidal zone will not be planted, but rapid colonization by cattails and tules would be expected. The intertidal zone slopes up to a riparian bench at MHW + 2 feet, which would be planted with flood-tolerant trees and shrubs. The upper slope of the levee would be hydroseeded with a variety of herbaceous native plants.

8A.3.2 Description of Benefits and Constraints

8A.3.2.1 Benefits

The ecological benefits are as follows:

- Riparian corridors support a large number of listed species, including fish, insects, reptiles, birds, and mammals. Increases in area of both riparian and marsh habitat are required in the Delta.
- The armored pathway goes through the center of the Delta, which is devoid of trees. Adding riparian corridors along the length of the pathway would connect two bodies of riparian habitat in the north and south of the Delta. Riparian corridors would increase the ability of listed species, such as the rare plant species California hibiscus, Mason's lilaeopsis, and Delta mudwort, to spread and increase in population size. The range of several listed species associated with riparian habitat is disjoined in the center of the Delta. Re-establishing riparian corridors would increase the habitat area and may reconnect populations, which could decrease the probability of species loss from reduced genetic diversity associated with low population size.
- Long-term benefits are expected as trees mature because avian abundance and diversity varies according to the age of the riparian canopy (Nur et al. 2005). For example, Swainson's hawk requires mature trees for nesting and roosting.
- The creation of riparian corridors will create large amounts of upland transition zones that support many species and that have been dramatically reduced because of levees.
- Shallow-water habitat ending in dead-end sloughs may also benefit the giant garter snake, which has been recently recorded in drainage channels in Yolo Bypass (S. Leach, pers. comm., 2007).
- Shaded riverine aquatic (SRA) habitat typically provides rearing habitat for juvenile fish, and therefore may have little benefit for native listed fish species. Most listed species are anadromous fish, and they typically do not stop in the Delta to rear but continue up to freshwater tributaries. Steelhead salmon could benefit from SRA as they travel through the Delta, but SRA is more beneficial upstream. Depending on the bottom substrate, these shallow water areas could provide spawning habitat for Delta smelt and might support juvenile rearing. This habitat could also benefit green sturgeon by providing detritus inputs that support desired food sources, including mollusks. Estuarine habitats are used by chinook salmon in the Pacific Northwest; however, Central Valley chinook salmon appear to move through the Delta rather quickly, experiencing minimal in-Delta growth. In-Delta shallow-water riparian habitat may be of little use to Central Valley chinook salmon because of high water temperatures, degraded water quality, and abundant predators in the Delta. Indeed, creation of shallow-water riparian habitats may serve to extend emigration paths and residence times in the Delta and increase in-Delta mortality as a result. The location of the

proposed building block and its north-south orientation does not serve to facilitate juvenile chinook salmon emigration to brackish water; chinook salmon that use this habitat will experience increased exposure to mortality sources in the Delta, including entrainment at water diversions. Steelhead salmon may potentially use the shallow areas created by this building block for juvenile rearing during outward migration. Steelhead emigrate earlier in the year than spring- and fall-run chinook salmon, when water temperatures are cooler. They also emigrate at a larger size than chinook salmon and are more competent swimmers. Thus, they may be less susceptible to in-Delta mortality sources than chinook salmon.

- Floodplain habitat may provide spawning opportunities for Sacramento splittail. This species has been the subject of intensive research because of its former status as a federally protected species under the Endangered Species Act. Sacramento splittail rely on floodplain habitats for spawning; adults live in shallow brackish waters of the northern estuary. Juveniles and adults migrate through and feed in the Delta.

8A.3.2.2 Constraints

The ecological constraints of the building block include the following:

- Construction and operation of the salinity gates may impair the passage of migrating chinook and steelhead salmon. Gates may be in place for up to 6 months while the salinity regime in the Delta is reestablished after a catastrophic levee failure.

If permanently inundated habitat areas were to be formed, these are likely to be colonized and dominated by SAV (e.g., *Egeria densa*). This domination may be likely because high densities of SAV (principally *Egeria densa*) occur in the center of the setback levee corridor, at Mildred and Medford islands compared to sites on the Sacramento River (Sherman Island, Liberty Island, and Decker Islands [Norbriga and Feyrer 2005; Norbriga et al. 2003]). Exotic SAV tend to harbor exotic fishes, such as the centrarchidae basses (which include the largemouth bass, smallmouth bass, and sunfish but not striped bass). These are major fish predators and would adversely affect native fish species. If the permanently flooded areas have shallow sloping sandy banks that remain clear of SAV, they could become dominated by the invasive inland silverside (*Menidia beryllina*). Inland silversides are an opportunistic fish predator and are also incredibly effective at filtering phyto- and zooplankton out of the water column. An increase in the population of inland silversides would also adversely affect native fishes, through predation and competition.

8A.4 COST ESTIMATE

8A.4.1 Construction Considerations

The time of year of the construction of salinity gates should avoid the migration of listed species of fish through the waterways.

8A.4.2 Cost Estimate Tables

The summary cost estimate for the vegetation design of setback levees utilizing a self-mitigating design is presented in Table 8A-3, and a design with less dense plantings is presented in Table 8A-4.

8A.5 RISK REDUCTION ESTIMATE

8A.5.1 Discussion of Potential Indirect Risk Reductions in the Context of the Scenarios

Creating a riparian corridor through the Delta would increase habitat for a number of terrestrial endangered species, including plants, insects, mammals, reptiles, and birds. The riparian corridors may provide limited benefit to listed species of fish, many of which are anadromous and may not use spawning habitat provided by the corridors. Exotic fish may use the corridor for spawning. Creating riparian corridors may reduce the risk of extinction of listed terrestrial species through increased habitat size.

This building block could potentially increase the risk to listed species of anadromous fish in the event of a catastrophic levee failure that would result in the operation of gates obstructing waterways used for migration.

8A.6 FINDINGS AND CONCLUSIONS

8A.6.1 Findings

The ranges of nine listed species have the potential to be reconnected by the proposed riparian corridor, and 19 species may benefit from expanded habitat, increased foraging, nesting/breeding, and shade and cover. Construction and operation of salinity gates may obstruct the migration of listed fish species, including chinook and steelhead salmon. The impact of construction may be minimized by constructing gates at times of year when anadromous listed fish are not using the waterways for migration. Shallow-water riparian habitat may be colonized by exotic fish, but floodplain habitat may benefit native fish species.

8A.6.2 Conclusion and Recommendations

Setback levees may provide a corridor of rare riparian habitat that may connect populations and ranges of listed terrestrial species. The proposed changes would connect riparian tree corridors in the north and south Delta and reestablish their historical extent. Reconnecting riparian zones would further increase the habitat value for listed species. Increasing the habitat, nesting, foraging, and cover for listed species may reduce the probability of species extinction. Benefits for listed fish species are variable, and the operation of salinity gates may constrain fish migration, depending on the timing of construction and operation.

Tables

Table 8A-1 Listed Riparian Species Depicted in Figures 8A-3 and 8A-4

Habitat benefits generated by setback levees	Species name	Common name	Habitat Improvements: Expands habitat range of special status plants	Increased Foraging	Enhances Breeding/ Nesting Territory	Increased Shelter/Cover
Connect Ranges	*Agelaius tricolor*	Tricolored blackbird			x	x
	Antrozous pallidus	Pallid bat		x	x	x
	Carex comosa	Bristly sedge	x			
	Coccyzus americanus occidentalis	Western yellow-billed cuckoo		x	x	x
	Desmocerus californicus dimporphus	Valley elderberry longhorn beetle		x	x	x
	Eryngium racemosum	Delta button-celery	x			
	Sagittaria sanfordii	Sanford's arrowhead	x			
	Scutellaria lateriflora	Blue skullcap	x			
	Thamnophis gigas	Giant garter snake		x	x	x
Expands Available Habitat	*Accipiter cooperii*	Cooper's hawk				
	Archoplites interruptus	Sacramento perch		x		x
	Aster lentus	Suisan marsh aster	x			
	Buteo swainsoni	Swainson's hawk			x	x
	Carex vulpinoidea	Fox sedge	x			
	Clemmys marmorata marmorata	Northwestern pond turtle		x	x	x
	Eumops perotis californicus	Western mastiff bat		x	x	x
	Hibiscus lasiocarpus	Rose-mallow	x			
	Hypomesus transpacificus	Delta smelt		x	x	x
	Juglans hindsii	Northern California black walnut	x			
	Lathyrus jepsonii var. jepsonii	Delta tule pea	x			
	Lilaeopsis masonii	Mason's lilaeopsis	x			
	Limosella subulata	Delta mudwort	x			
	Phalacrocorax auritus	Double-crested cormorant			x	x
	Pogonichthys macrolepidotus	Sacramento splittail		x	x	x
	Riparia riparia	Bank swallow		x	x	x
	Scutellaria galericulata	Marsh skullcap	x			
	Sylvilagus bachmani riparius	Riparian brush rabbit		x	x	x
	Thamnophis gigas	Giant garter snake		x	x	x

Table 8A-2 Vegetated Levee Planting Schedule

SETBACK LEVEE PLANTING SCHEDULE

Zone	Elevation	Botanical Name	Common Name	Prop. Method	Size	Plant Spacing ft On Center / Seeding lb per acre			Total number of species rotated in plant spacing	Plant / LF	
										For Agencies	Simple
Zone 1	5-7 feet	*Salix* spp.	Willow species	pole cuttings	NA	6	6	Lower	1	0.278	0.278
	7-10 feet	*Cephalanthus occidentalis*	california buttonbush	container	T8	10	20	Lower	1	0.150	0.038
		Hoita macrostachya	large leather root	container	T4	10	30		2	0.075	0.008
		Leersia oryzoides	rice cutgrass	container	DP				2	0.075	0.008
		Euthamia occidentalis	western goldenrod	container	DP	3	6		6	0.278	0.069
		Eleocharis macrostachya	common spike rush	container	DP				6	0.278	0.069
		Juncus balticus	baltic rush	container	DP				6	0.278	0.069
		Juncus effusus	Soft Rush	container	DP				6	0.278	0.069
		Juncus xiphioides	iris-leaved rush	container	DP				6	0.278	0.069
		Salix spp.	willow species	pole cuttings	NA				6	0.278	0.069
		Carex barbarae	santa barbera sedge	container	D6	3	6	Upper	3	0.167	0.042
		Polygonum hydropiperoides	waterpepper	container	D6				3	0.167	0.042
		Equisetum laevigatum	smooth horsetail	container	D6				3	0.167	0.042
		Acer negundo	boxelder	container	T8	30	40		4	0.008	0.006
		Alnus rhombifolia	white elder	container	T8				4	0.008	0.006
		Fraxinus latifolia	oregon ash	container	T8				4	0.008	0.006
		Platanus racemosa	western sycamore	container	T8				4	0.008	0.006
		Salix spp.	willow species	pole cuttings	NA	3			1	0.167	0.167
			spike bentgrass	seed	NA	10	10	Upper & Lower	NA	0.007	0.007
			santa barbera sedge	seed	NA	5	5		NA	0.003	0.003
			slender hairgrass	seed	NA	10	10		NA	0.007	0.007
			saltgrass	seed	NA	10	10		NA	0.007	0.007
			western goldenrod	seed	NA	5	5		NA	0.003	0.003
			salt heliotrope	seed	NA	5	5		NA	0.003	0.003
			meadow barley	seed	NA	10	10		NA	0.007	0.007
			Soft Rush	seed	NA	10	10		NA	0.007	0.007
			american bugleweed	seed	NA	5	5		NA	0.003	0.003
			knotgrass	seed	NA	10	10		NA	0.007	0.007
Zone 1'	7-10 feet	*Euthamia occidentalis*	western goldenrod	container	DP	3	6	Lower	6	0.278	0.069
		Eleocharis macrostachya	common spike rush	container	DP				6	0.278	0.069
		Juncus balticus	baltic rush	container	DP				6	0.278	0.069
		Juncus effusus	Soft Rush	container	DP				6	0.278	0.069
		Juncus xiphioides	iris-leaved rush	container	DP				6	0.278	0.069
		Salix spp.	willow species	pole cuttings	NA				6	0.278	0.069
			spike bentgrass	seed	NA	10	10	Upper	NA	0.003	0.003
			santa barbera sedge	seed	NA	5	5		NA	0.002	0.002
			slender hairgrass	seed	NA	10	10		NA	0.003	0.003
			saltgrass	seed	NA	10	10		NA	0.003	0.003
			western goldenrod	seed	NA	5	5		NA	0.002	0.002
			salt heliotrope	seed	NA	5	5		NA	0.002	0.002
			meadow barley	seed	NA	10	10		NA	0.003	0.003
			Soft Rush	seed	NA	10	10		NA	0.003	0.003
			american bugleweed	seed	NA	5	5		NA	0.002	0.002
			knotgrass	seed	NA	10	10		NA	0.003	0.003
Zone 2 and 2'	9-13 feet	*Apocynum cannabinum*	clasping leaf dogbane	container	T4	10	30	Upper & Lower	3	0.033	0.011
		Baccharis salicifolia	mule fat	container	T4				3	0.033	0.011
		Cornus sericea	red twig dogwood	container	T4				3	0.033	0.011
		Populus Fremontii	fremont cottonwood	container	T8	40	60		1 (no treees in Zone 2')	0.025	0.017
		Artemisia douglasiana	mugwort	container	DP	3	6		5	0.333	0.083
		Carex barbarae	santa barbera sedge	container	DP				5	0.333	0.083
		Carex praegracilis	deer sedge	container	DP				5	0.333	0.083
		Leymus triticoides	creeping wildrye	container	DP				5	0.333	0.083
		Salix spp.	willow species	pole cuttings	NA				5	0.333	0.083
			spike bentgrass	seed	NA	5	5		NA	0.003	0.003
			western ragweed	seed	NA	5	5		NA	0.003	0.003
			mugwort	seed	NA	5	5		NA	0.003	0.003
			mule fat	seed	NA	5	5		NA	0.003	0.003
			tufted hairgrass	seed	NA	5	5		NA	0.003	0.003
			slender hairgrass	seed	NA	5	5		NA	0.003	0.003
			annual hairgrass	seed	NA	5	5		NA	0.003	0.003
			slender wheatgrass	seed	NA	5	5		NA	0.003	0.003
			meadow barley	seed	NA	10	10		NA	0.006	0.006
			dwarf barley	seed	NA	5	5		NA	0.003	0.003
			common rush	seed	NA	5	5		NA	0.003	0.003
			creeping wildrye	seed	NA	20	20		NA	0.012	0.012
			wild cucumber	seed	NA	5	5		NA	0.003	0.003
Zone 3'	Land side of setback levee		common yarrow	seed	NA	5	5	Upper & Lower	NA	0.017	0.017
			blue wildrye	seed	NA	5	5		NA	0.017	0.017
			slender wheatgrass	seed	NA	5	5		NA	0.017	0.017
			california poppy	seed	NA	5	5		NA	0.017	0.017
			telegraph weed	seed	NA	5	5		NA	0.017	0.017
			california barley	seed	NA	5	5		NA	0.017	0.017
			spanish lotus	seed	NA	5	5		NA	0.017	0.017
			miniature lupine	seed	NA	5	5		NA	0.017	0.017
			california oniongrass	seed	NA	5	5		NA	0.017	0.017
			purple needle grass	seed	NA	10	10		NA	0.034	0.034
			one sided bluegrass	seed	NA	10	10		NA	0.034	0.034

Table 8A-3 Summary Cost Estimate for Self-Mitigating Vegetating of Setback Levees

Item		Unit	unit/LF		per 1000 ft	unit per mile	Cost per Unit (Includes labor and material)	Cost per mile	Site Length (Miles)	Total Cost
Beaver Fence		FT	4.200	ft	4200	22176	$8.00	$177,408	115	$20,401,920
Container Plants	T4	EA	0.175		175	924	$120.00	$110,880		$12,751,200
	T8	EA	0.208		208	1100	$120.00	$132,000		$15,180,000
	DP	EA	4.186		4186	22102.7	$10.00	$221,027		$25,418,067
	D6	EA	0.500		500	2640	$10.00	$26,400		$3,036,000
Fascine Bundle		EA	0.083		83	440	$116.00	$51,040		$5,869,600
Pole Cutting		EA	1.167		1167	6160	$13.00	$80,080		$9,209,200
Instream Woody Material(IWM)		EA	0.042		42	220	$1,174.00	$258,280		$29,702,200
Irrigation		JOB	1.000		1000	5280	$63.76	$336,653		$38,715,072
Seeding		ACRE	0.005	ACRE	5.0	26.4242	$18,183.00	$480,472		$55,254,280
Plant Establishment		Month	1.000		1000	5280	$49.92	$263,578		$30,311,424
30% Contingency								$641,345		$73,754,689
Total								**$2,779,162**		**$319,603,651**

Note:
D6, DP, T4, and T8 refer to sizes of container plants. EA means each.

Table 8A-4 Summary Cost Estimate for Simple Design for Vegetating Setback Levees

Item		Unit	unit/LF		per 1000 ft	unit per mile	Cost per Unit (Includes labor and material)	Cost per mile	Site Length (Miles)	Total Cost
Beaver Fence		FT	2.100	ft	2100	11088	$8.00	$88,704	115	$10,200,960
Container Plants	T4	EA	0.042		42	220	$120.00	$26,400		$3,036,000
	T8	EA	0.079		79	418	$120.00	$50,160		$5,768,400
	DP	EA	1.036		1036	5471	$10.00	$54,707		$6,291,267
	D6	EA	0.125		125	660	$10.00	$6,600		$759,000
Fascine Bundle		EA	0.050		50	264	$116.00	$30,624		$3,521,760
Pole Cutting		EA	0.500		500	2640	$13.00	$34,320		$3,946,800
Instream Woody Material(IWM)		EA	0.010		10	53	$1,174.00	$61,987		$7,128,528
Irrigation		JOB	1.000		1000	5280	$63.76	$336,653		$38,715,072
Seeding		ACRE	0.005	ACRE	5	26	$18,183.00	$480,472		$55,254,280
Plant Establishment		Month	1.000		1000	5280	$49.92	$263,578		$30,311,424
30% Contingency								$430,261		$49,480,047
Total								**$1,864,466**		**$214,413,538**

Note:
D6, DP, T4, and T8 refer to sizes of container plants. EA means each.

Figures

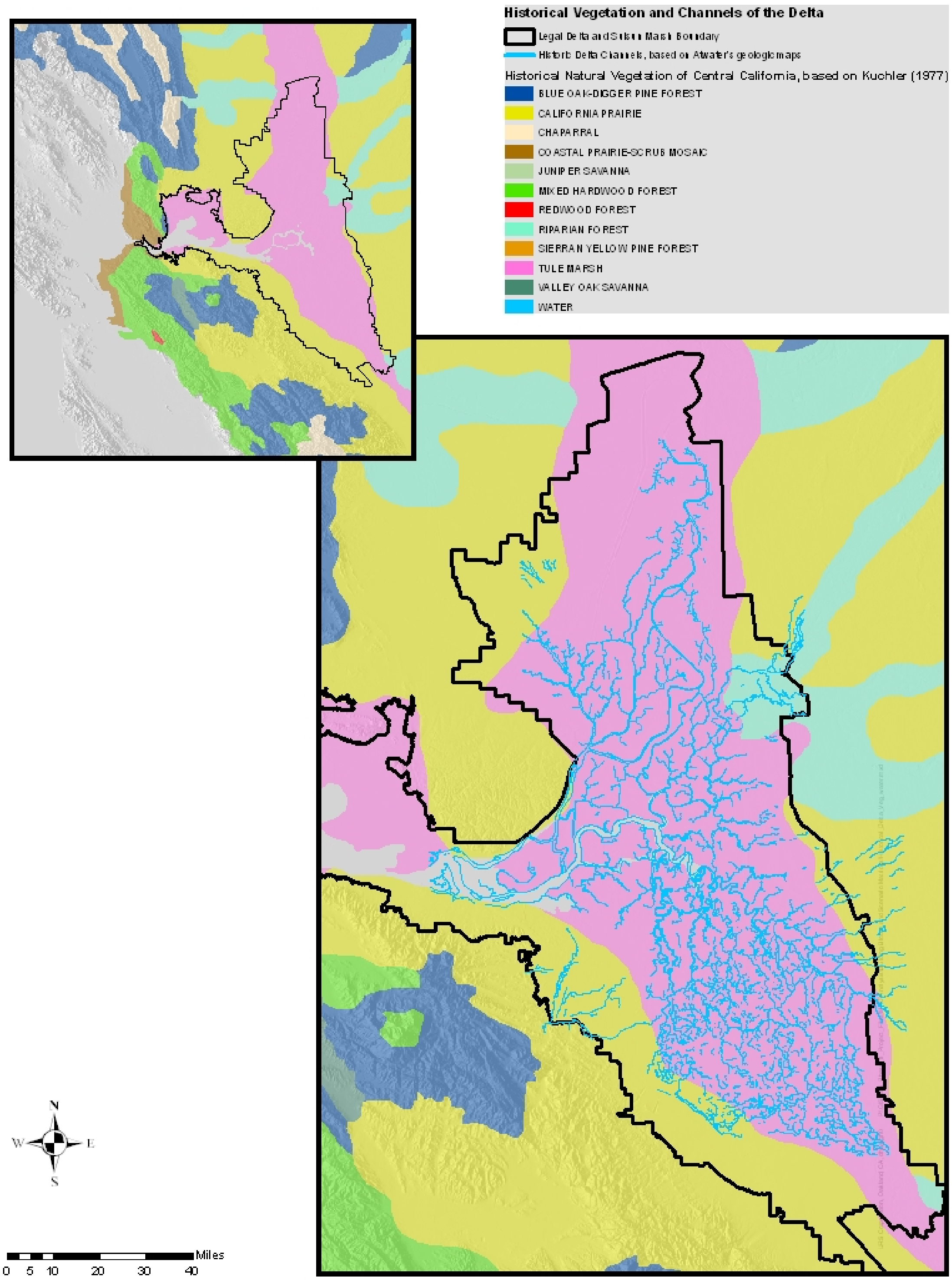


Figure 8A-1 Historical Distribution of Riparian Vegetation

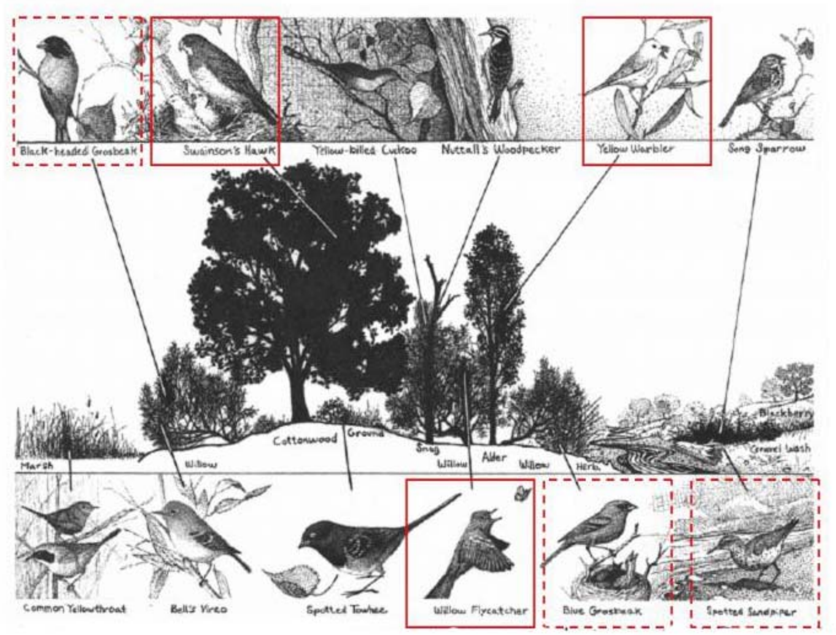


Figure 8A-2 Riparian Zone Habitats Utilized by Bird Species

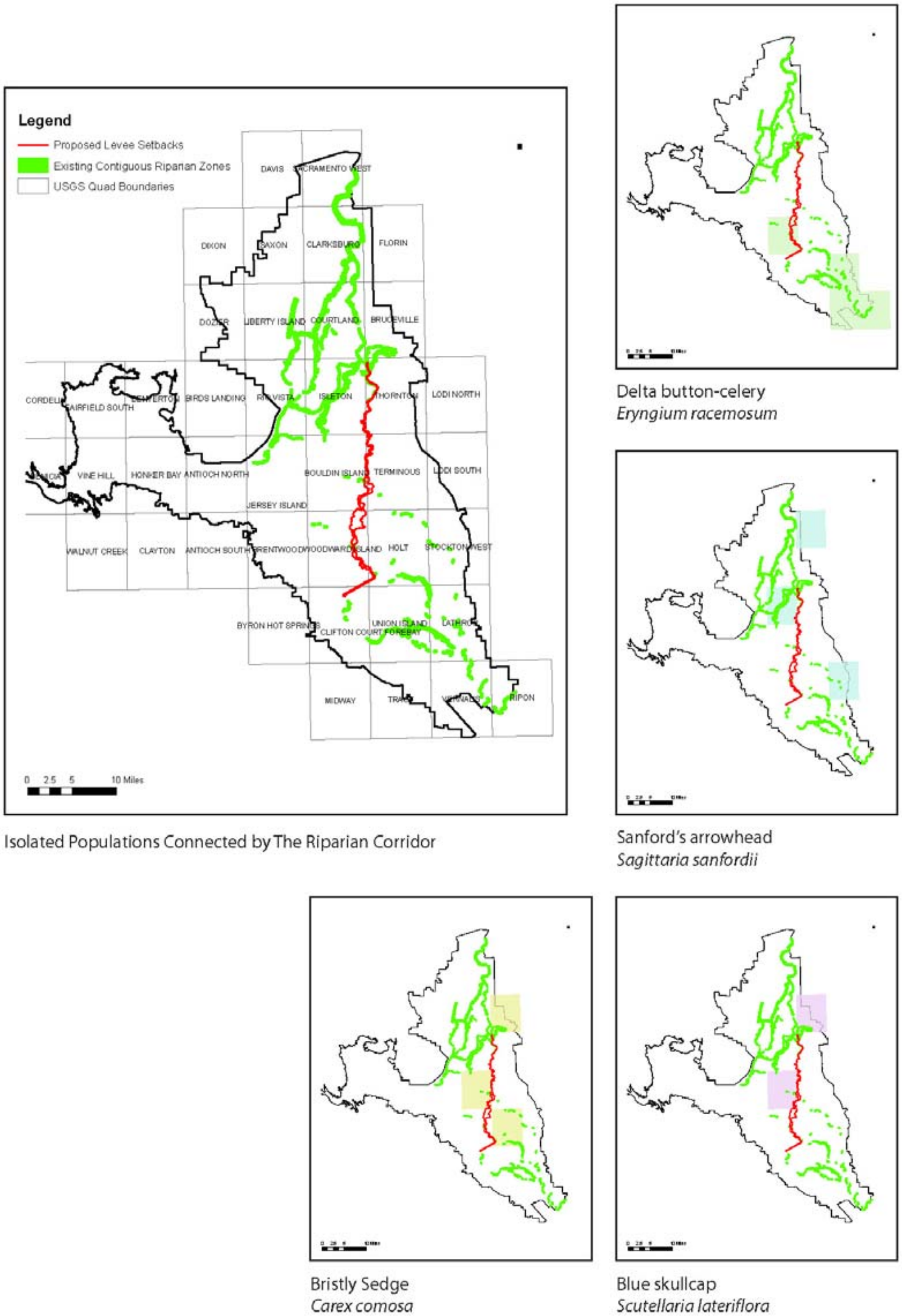


Figure 8A-3a Species Whose Populations Would Be Connected by Setback Levee Corridor: Plants

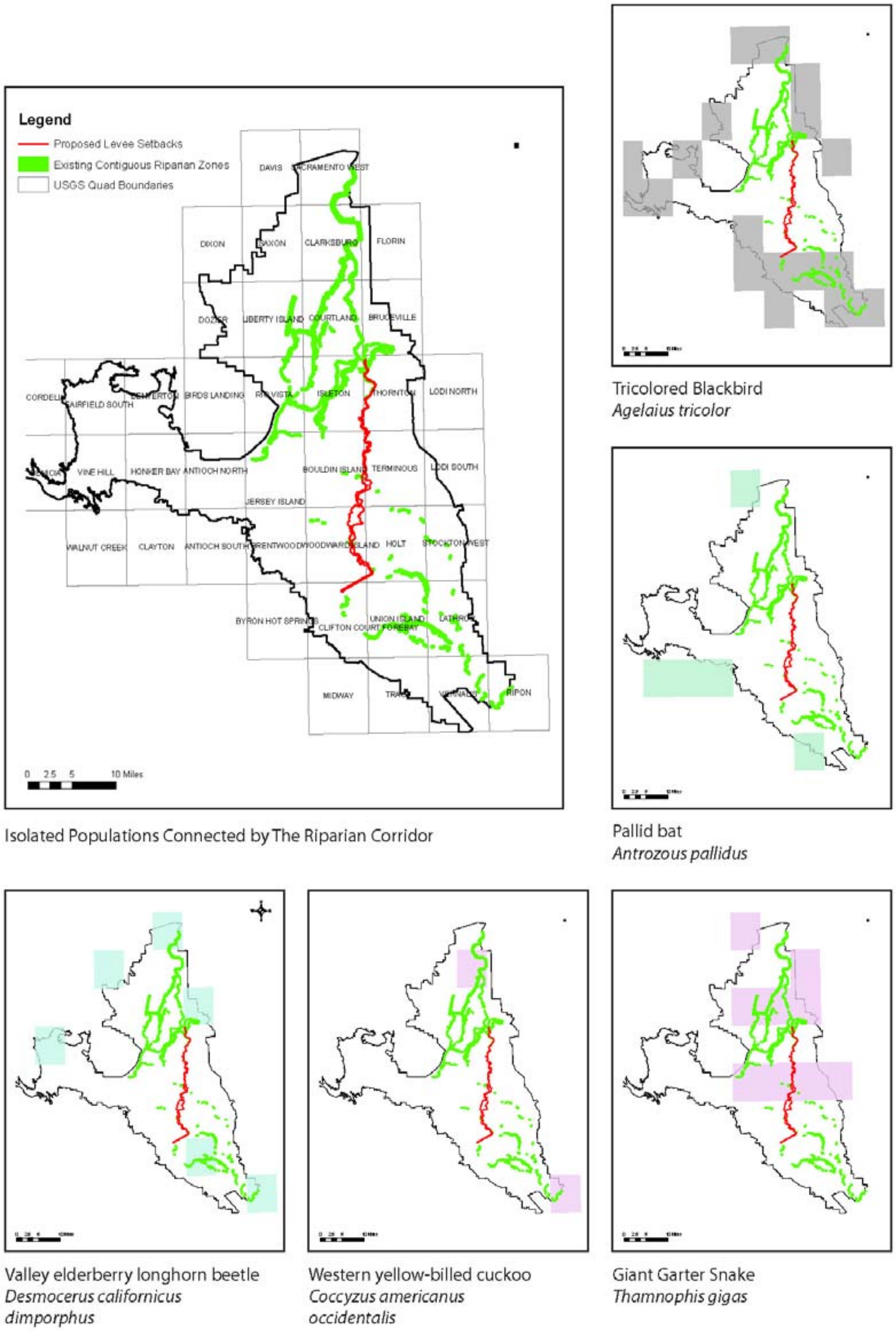
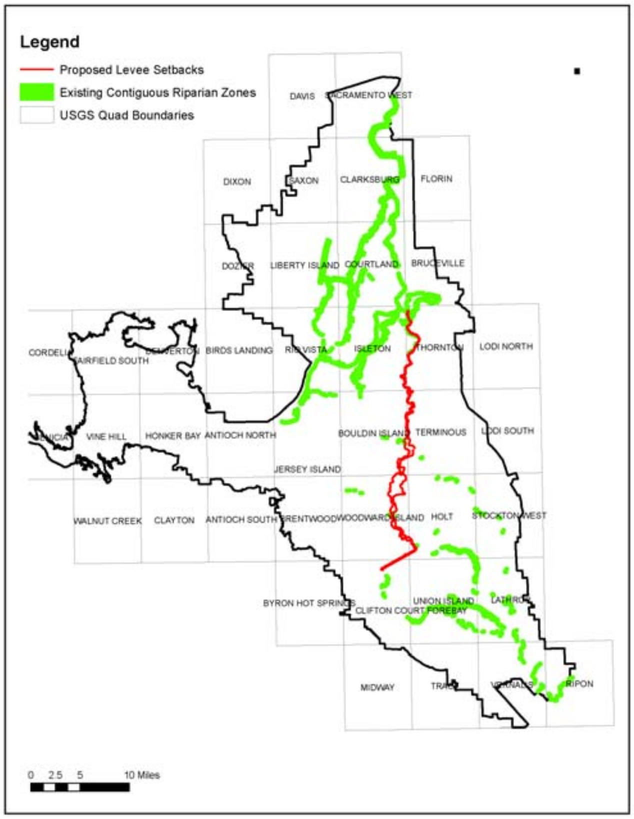
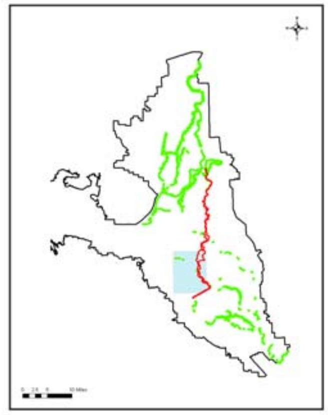


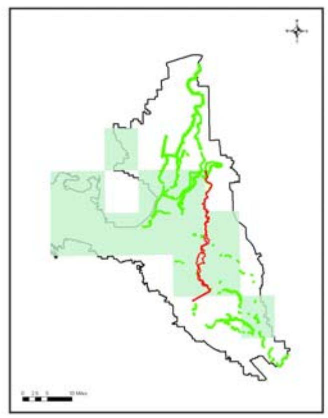
Figure 8A-3b Species Whose Populations Would Be Connected by Setback Levee Corridor: Wildlife



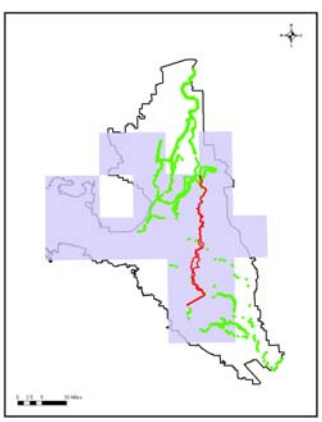
Species whose habitat improved by riparian setbacks



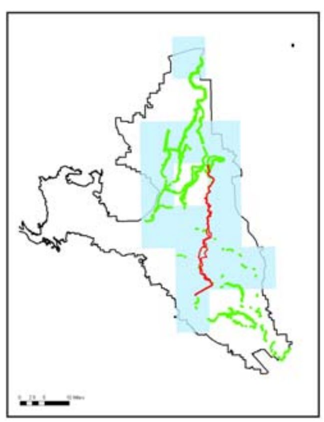
Fox sedge
Carex vulpinoidea



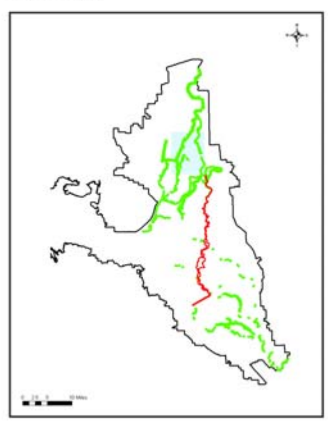
Suisun Marsh aster
Aster lentus



Mason's lilaeopsis
Lilaeopsis masonii

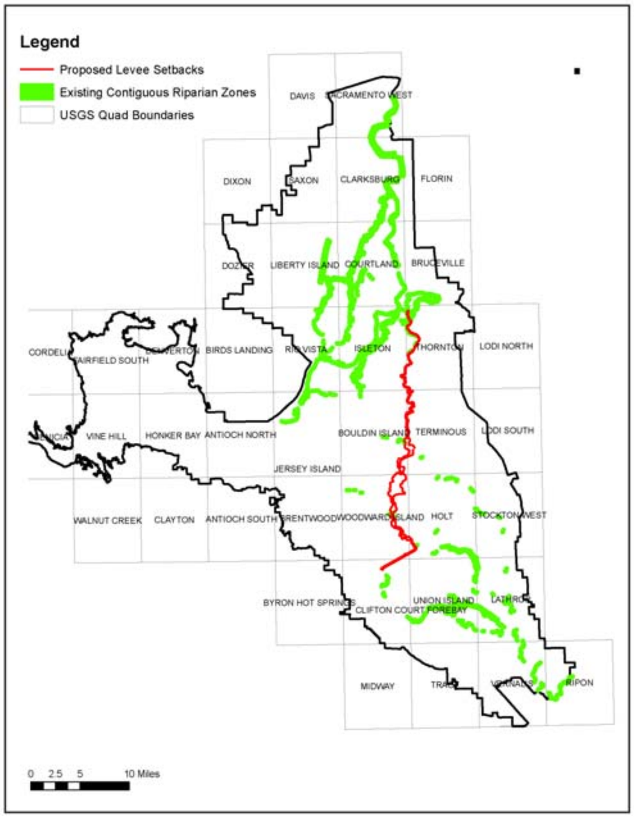


Rose-Mallow
Hibiscus lasiocarpus

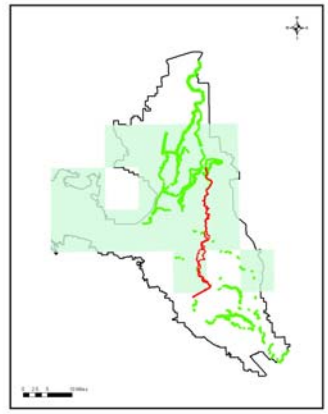


Northern california black walnut
Juglans hindsii

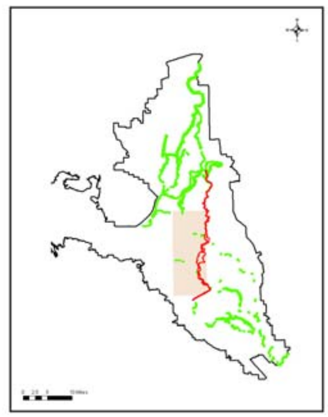
Figure 8A-4a Species Whose Habitat Area Would Be Increased by Setback Levee Corridor: Plants



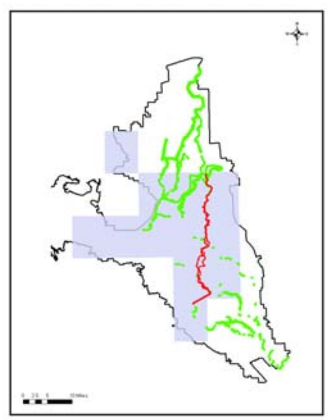
Species whose habitat improved by riparian setbacks



Delta tule pea
Lathyrus jepsonii var jepsonii

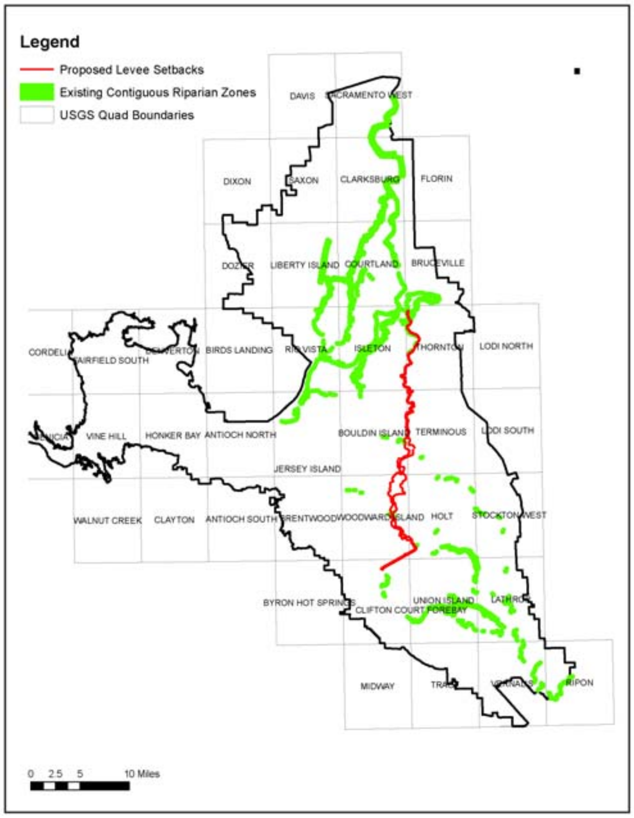


Marsh skullcap
Scutellaria galericulata

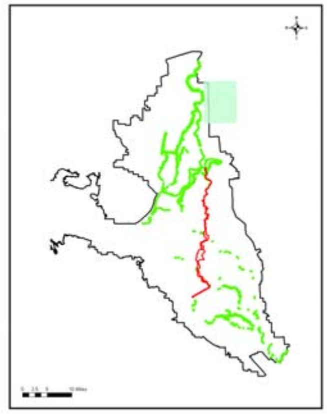


Delta mudwort
Limosella subulata

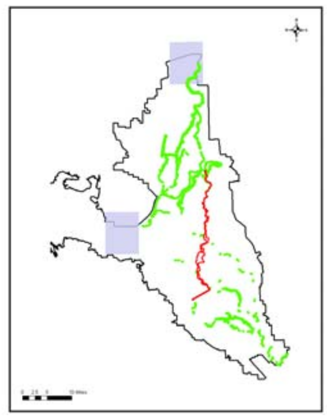
Figure 8A-4a Species Whose Habitat Area Would Be Increased by Setback Levee Corridor: Plants (continued)



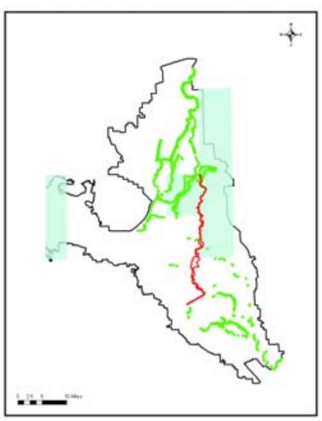
Species whose habitat improved by riparian setbacks



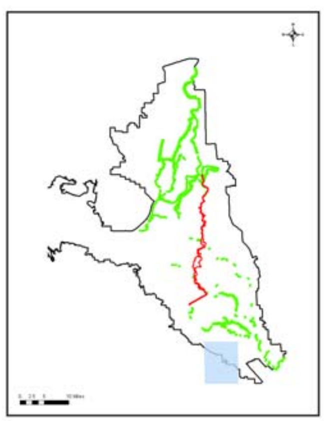
Cooper's hawk
Accipiter cooperii



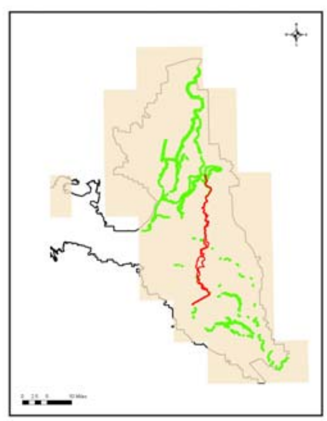
Sacramento perch
Archoplites interruptus



Northwestern pond turtle
Emys (=Clemmys)
marmorata marmorata



Western matiff bat
Eumops perotis californicus



Swainson's hawk
Thamnophis gigas

Figure 8A-4b Species Whose Habitat Area Would Be Increased by Setback Levee Corridor: Wildlife

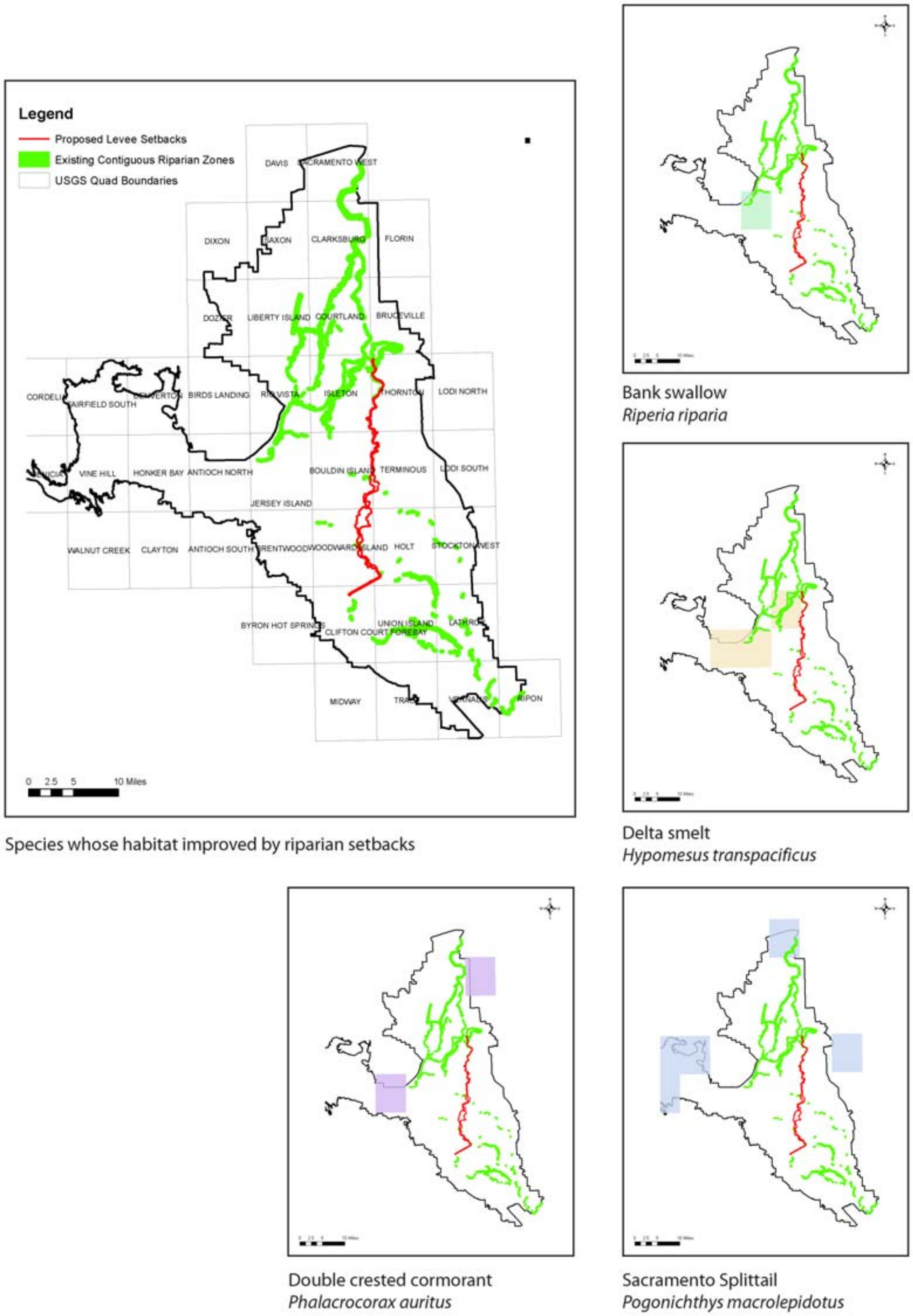


Figure 8A-4b Species Whose Habitat Area Would Be Increased by Setback Levee Corridor: Wildlife (continued)

Attachment 8A-1
Riparian Plants for Birds

The following riparian plants have been identified for bird habitat (PRBO et al. 2007):

- Aspen (*Populus tremuloides*)
- Bigleaf Maple (*Acer macrophyllum*)
- Box Elder (*Acer negundo*)
- California Bay (*Umbellularia californica*)
- Cottonwood (*Populus* sp.)
- Oregon Ash (*Fraxinus latifolia*)
- Valley Oak (*Quercus lobata*)
- White Alder (*Alnus rhombifolia*)
- Arroyo Willow (*Salix lasiolepis*)
- Dogwood (*Cornus* sp.)
- Sandbar (=narrowleaf) Willow (*Salix exigua*)
- Wild rose (*Rosa California*)
- CA Blackberry (*Rubus ursinus*)
- Mugwort (*Artemisia douglasiana*)
- Poison Oak (*Toxicodendron diversilobum*)
- Rushes (*Carex* sp.)
- Snowberry (*Symphoricarpos* sp.)
- Wild azalea (*Rhododendron* sp.)
- Blue Elderberry (*Sambucus Mexicana*)
- Wild grape (*Vitis californica*)