

Site Description, Options, and Alternatives

2.1 Introduction

This chapter provides information on the project area, habitat restoration goals and objectives, and development of alternatives for the Napa River Salt Marsh Restoration Project. It also discusses project alternatives and alternatives not considered in this document.

2.2 Site Description

2.2.1 Project Location

The project area was historically the marshland between the Napa River and Sonoma Creek in the north San Pablo Bay region and is now called the Napa River Unit of the California Department of Fish and Game's (DFG's) Napa-Sonoma Marshes Wildlife Area (NSMWA). Figure 2-1 shows the project area and some of the surrounding DFG-managed wildlife areas. The Napa-Sonoma Marsh historically encompassed more than 38,000 acres extending from San Pablo Bay north to the historic limits of the tidal baylands and east to west between the Napa River and Tolay Creek. Of the 38,000 acres, 25,000 acres of the marshlands were in the Napa River watershed. Today, approximately 36% of this acreage remains classified as wetland habitat, while 25% consists of inactive solar salt production ponds, 12% residential areas, and 20% cropland and pasture; the remaining 7% has miscellaneous uses. The salt ponds, cropland, and pasture are diked to prevent tidal and fluvial inundation under normal conditions. A majority of the remaining wetland areas are public lands and are under the management of DFG as part of the NSMWA.

2.2.2 Historical Operation

Cargill Salt Company operated the salt ponds in sequence to concentrate salt by solar and wind evaporation. Tidal flows initiated the salt production process by pushing water into Pond 1 that could then be pumped consecutively to the other ponds (Pond 1A, Pond 2, Pond 2A, Pond 3, etc.), successively increasing the salt

concentration (salinity) in each pond. After reaching Pond 8, the saline concentrate would be pumped to the east side of the Napa River to be further processed in one of the “pickle ponds” and then in one of the “crystallizer ponds” (the pickle and crystallizer ponds are not part of the current project area). Pond 7 was used as the bittern pond, a repository of concentrated soluble salts other than sodium chloride. In general, Cargill had target salinity ranges for each pond and maintained these salinities unless there were management problems in the system. Cargill added cross levees between Ponds 1 and 1A, 6 and 6A, and 7 and 7A to improve its management of salinities in these ponds. Cargill used materials excavated from borrow ditches to construct interior and exterior levees and as a part of its postconstruction maintenance of all levees. Cargill had a full-time operator and owned dredging equipment, in particular a specially modified shallow draft dredge called the *Mallard*, for the maintenance of the ponds.

2.2.3 Current Operation

Current operations are designed to manage the site for wildlife. However, deteriorating infrastructure, existing high salinity conditions, and limited funding often make this task difficult. The on-site DFG manager strives to use both San Pablo Bay water and Napa River water to reduce/manage salinities to the extent possible and ensure appropriate water levels for wildlife. Generally, Napa River water is moved south and San Pablo Bay water is moved north. Salinity in and elevation of each pond are recorded monthly.

Current operating conditions provide a mix of wildlife habitats including tidal mudflats, deep water, salt ponds, levees, and marsh sloughs. These habitats are described in detail in Chapter 6, “Biological Resources—Wildlife.”

Activities currently underway by DFG as ongoing operation and maintenance include installation of the new water control structure at Pond 8, ongoing maintenance and repair of water control structures, limited levee maintenance, and water level/salinity management for wildlife habitat.

2.2.4 Existing Facilities and Conditions

Existing facilities and conditions are depicted in Figure 2-2 and described below.

2.2.4.1 Pond Acreage and Conditions

The 9,460-acre site consists of 7,190 acres of salt ponds and levees and 2,270 acres of fringing marsh and sloughs (Table 2-1).

Table 2-1. Approximate Pond Acreage and Percentage of Total Site Acreage

Project Area	Acreage			Pond Percent	Site Percent
	Pond Area	Levee Area	Total		
Pond 1	371	12	383	5%	
Pond 1A	573	17	590	8%	
Pond 2	738	22	760	11%	
Pond 2A	525	19	543	8%	
Pond 3	1,255	29	1,284	18%	
Pond 4	907	27	934	13%	
Pond 5	742	18	760	11%	
Pond 6	721	16	737	10%	
Pond 6A	425	18	443	6%	
Pond 7	306	11	317	4%	
Pond 7A	306	13	319	4%	
Pond 8	112	7	119	2%	
Subtotal:	6,981	210	7,190	100%	76%
Fringing marsh and slough:			2,270		24%
TOTAL (DFG property):			9,460		100%

For the purpose of this document, Ponds 1, 1A, 2, 3, 4, 5, 6, and 6A will be referred to as the *lower ponds*. Ponds 7, 7A, and 8 will be referred to as the *upper ponds*. The lower ponds are located south of Napa Slough; the upper ponds are located north of Napa Slough. Pond salinity ranges and pond bottom elevations are depicted in Figure 2-3. Detailed site topography information was collected and used for the project as described in Chapter 3, “Hydrology.” Additional pond salinity and water quality information is provided in Chapter 4, “Water Quality.”

In 1995, Pond 2A was breached by DFG and allowed to restore to tidal marsh. A baseline monitoring of the recovery of this pond performed between 1996 and 2000 revealed that overall vegetation cover increased dramatically from 10% coverage to 90% coverage within 5 years (MEC Analytical Systems 2000).

In addition, in August 2002, an unknown party dug a small 2-foot-wide ditch between Pond 3 and South Slough. While this ditch provided some water exchange in Pond 3, it also is located very close to the siphon leading from Pond 3 to Pond 4 and, if it widens, could undermine the siphon, leading to a possible release from Pond 4. DFG subsequently obtained an emergency exemption to create a small 2-foot-wide ditch on the southeast side of Pond 3 to take the pressure off of the ditch on South Slough, by facilitating some circulation of water in and out of Pond 3. USGS is currently monitoring salinity within and outside the small ditches. Initial findings indicate that the small amount of tidal exchange that occurs through these ditches has a negligible effect on water quality in the adjacent sloughs (Schoellhamer, pers. comm.).

2.2.4.2 Levees

The levees in the project area are deteriorating in multiple locations (Figure 2-2). In some areas, levee deterioration is a result of erosion of the inboard slope because of wind/wave action in the pond, and in other instances levee deterioration is a result of tidal fluctuation and scour of the outboard portion of the levee.

Because the levees were constructed with native bay muds, they are more vulnerable to erosion from wind/wave action and tidal inundation than they would have been had they been constructed with engineered fill. The results of a preliminary geotechnical survey of the levees and a report from the on-site manager are depicted in Figure 2-2. These indicate the following conclusions:

- Ponds 1 and 1A have effectively become one large pond because of a breach between the two ponds. The eastern levee of Pond 1 needs to be reinforced in the next 5 years as it serves as an important staging area for individuals who need to access the pumphouse and caretaker facilities. The levee is also used as a parking lot by members of the Can Duck Club. The northern levee of Pond 1A bordering South Slough needs reinforcement or it may be lost.
- The north and northeast levees from Pond 2 are likely to breach in the next 5 years unless they are repaired. Because of the high wind/wave action and past inability to regulate water levels in this pond, the crest of the levee is only 4–5 feet wide and has been undercut 2–3 feet in some areas.
- Approximately one-third of the eastern portion of the levee along the southern edge of Pond 3 is likely to breach within the next 5–10 years.
- Levees along the outside bends of Ponds 3, 4, and 5 have obvious scour/steep banks and are vulnerable to levee breaching in the next 5–10 years.
- There is substantial erosion of the outboard levee toe along Napa Slough on the west side of Pond 6A, just north of the dividing levee between Ponds 6 and 6A. There is also erosion on the north levee of Pond 6A, including the outboard toe into Napa Slough on the outer levee of the canal that runs along the north and east levees of Pond 6A. This section of levee (± 100 feet) is high and narrow with a steep drop-off into the slough. The majority of the west and north levees of Pond 6A have strips of accreted marsh protecting the existing levees.
- Significant erosion from wind/wave action is apparent at the levee between Ponds 7 and 7A.

2.2.4.3 Water Control Structures

A variety of water control structures are used throughout the site including pumps, canals, siphons, “donuts,” tide gates, breaches, and borrow ditches. These structures are described below.

Pumps

Two large pumps move water throughout the pond system. There are two 15,000-gallon-per-minute (gpm) pumps in the northern portion of Pond 1 and a 6,000-gpm pump adjacent to the Napa River next to Pond 8. Generally, these pumps are operated in the evenings and on weekends (when electricity prices are lower to minimize pumping costs), during the appropriate tides, to bring water onto the site. The operating time for the pumps is dependent on availability of DFG funds. In addition, DFG has just completed the installation of a new water control intake structure on the south side of Pond 8. The rate of intake at this structure is driven by the tide; the average (root-mean-square [RMS]) flow rate for this water control structure is estimated to be 9,000 gpm.

The pump/intake system is capable of moving water throughout the pond system by building head (water height) elevations in successive ponds (i.e., the water pressure from one pond would force the water into the next pond via a siphon). Recently, moving water through the system has become difficult because the salinity differential between the ponds created a reverse density gradient, requiring more head pressure than is possible within a pond. The problem is exacerbated by the development of a “saline wedge” in the bottom of the siphon. A *saline wedge* is viscous, dense brine that forms in the siphon when the denser, heavier saline water falls to the bottom of the siphon and blocks the passage of water. Preliminary assessments undertaken in the feasibility study indicate that the pump system is largely incapable of controlling salinity levels in the summer. In winter periods precipitation levels greatly enhance the ability of the pumps to maintain water levels and manage salinity.

Canals and Culverts

Four primary canals allow the distribution to and bypass of some of the salt ponds (Figure 2-2). Beginning from the southern portion of the site, the intake canal extends from San Pablo Bay into Pond 1 through a culvert under State Route (SR) 37. Water in this canal is tidally driven. The “All American Canal” conveys water from Pond 2 into Pond 3, bypassing Pond 2A. There is, however, some limited flow from Pond 2A to Pond 3 via the All-American Canal. There is a 42-inch water control structure (the old drain of Pond 2A) at the southwest corner of Pond 2A at the canal. At high tides in Pond 2A a redwood flap gate opens that delivers water into the canal and from there to Pond 3.

The remaining two canals are in the northern portion of the site, with a canal on the northeast side of Pond 6 and 6A and a canal along the southern and eastern sides of Pond 7 that connects to a large canal that leads to Pond 8.

Siphons

Siphons are large pipes, ranging from 36 to 72 inches in diameter, that convey pond water under sloughs between adjacent ponds. There are six siphons on-site:

from Pond 1 to Pond 2; All American Canal to Pond 3; Pond 3 to Pond 4; Pond 5 to Pond 6; Pond 6A to canal (under Napa Slough); and canal to canal under Mud Slough (Figure 2-2). There is also a pipeline under the Napa River that allows DFG to receive water from Cargill on the east side of the river.

Because of the effects of a reverse salinity gradient and the formation of a saline wedge, the siphons between Ponds 3 and 4 and Ponds 5 and 6 often become clogged. The siphon between Ponds 3 and 4 is currently clogged, and the siphon between Ponds 5 and 6 only recently became unclogged when winter rains began. Prior to the rains, the siphon did not operate for 1 year.

Donuts

Donuts are circular water control structures that have multiple intakes. They are used to distribute water through the canal and siphon system. Donuts are located where canals and multiple ponds intersect. They are found at Pond 1, Pond 2, Pond 6A, and Pond 7/7A in the northeast and southwest.

Tide Gates and Other Gates

Pond 2 has two tide gates. The tide gate on the west side allows both intake and discharge of water from the adjacent slough; the tide gate on the east side allows discharge only. Pond 1 has electronic tide gates that can be manipulated to obtain desired water elevations depending upon the tides. Other manually operated gates allow the DFG site manager to direct water to specific ponds. These gates are located at all donuts and siphons. The gate between Ponds 5 and 6 is no longer functional; water flow between Ponds 5 and 6 currently cannot be controlled.

Breaches

A series of intentional and unintentional breaches occurs throughout the pond system, increasing circulation between the ponds (Figure 2-2). Intentional breaches were created to avoid levee failure and allow the restoration of Pond 2A. An intentional breach also was created on the levee between Ponds 4 and 5 because of impending levee failure. Unintentional breaches have occurred in the levees between Ponds 1 and 1A and Ponds 6 and 6A.

Borrow Ditches

Internal to each pond, adjacent to the levees, are borrow ditches. These ditches were formed when native bay muds were excavated to create and later maintain the levees. These ditches continue to convey water when pond water levels are very low.

2.2.4.4 Recreation Facilities

There are few recreation facilities on-site because of the area's rural conditions, wildlife habitat, and lack of roads. DFG manages two parking lots for recreational access; one is on the northern side of Pond 1 and the other is north of Pond 7A. DFG also leases Pond 2 to the Can Duck Club for waterfowl hunting and fishing. The Can Duck Club is a private duck club with 50 member families. The duck club facilities include a small clubhouse on the southwestern shore of Pond 2 and several hunting blinds around the pond. There is also a privately held duck club on the northeastern portion of the island on which Pond 6A is located. This parcel is privately owned. There are two public boat ramps just outside the project area that allow reasonably good boat access to the sloughs. One is at Cuttings Wharf and the other is on Hudeman Slough. There is also a parking lot at the south end of Pond 8 (at the end of the road between the pond and the houses).

2.2.4.5 Easements and Other Agreements

The Can Duck Club maintains a lease on Pond 2 that is being updated. DFG has requested a rental fee evaluation from the Wildlife Conservation Board (WCB) and asked the WCB to extend the Can Duck Club's lease for an additional 5 years. As in the previous lease, DFG will require the duck club to do facility maintenance and special projects for rental credit. When the time comes that the lease is no longer renewed, the pond will be opened to the public for duck hunting and fishing opportunities.

Pacific Gas & Electric Company (PG&E) maintains 12-kilovolt utility lines in a utility easement across the southern portion of the site through Ponds 1A, 1, 2A, and 4.

DFG has a contract with Cargill to pump water from the east side of the river to the canal north of Pond 8. DFG typically pumps as much water as possible during the summer months until the contract amount has been fulfilled.

2.3 Habitat Restoration Project Goals and Objectives

The project sponsors have developed goals and objectives for the Napa River Salt Marsh Restoration Project. These include both habitat restoration goals and other related goals. The other opportunities provided by the project include the opportunity to beneficially reuse recycled water and the opportunity to enhance recreational options.

Habitat restoration goals are described first, followed by goals for recycled water use and recreation.

2.3.1 Habitat Restoration Goals

Habitat restoration goals were developed by the project team after careful consideration of and integration with the *Baylands Ecosystem Habitat Goals* report (Goals Project 1999). Overarching and project-site goals are described below.

2.3.1.1 Overarching Goals

The project sponsors developed the following overarching goals:

- Restore a mosaic of diverse habitats that will benefit a broad range of fish, wildlife, and plant species, including endangered and threatened species, fish and other aquatic species, and migratory shorebirds and waterfowl.
- Restore natural, self-sustaining systems that can adjust to naturally occurring changes in physical processes with minimum ongoing intervention.
- Implement habitat restoration using adaptive management techniques.
- Recognize constraints, which are a driver in determining restoration objectives.
- Evaluate the restoration from a regional perspective, as not all regional objectives can be addressed within the project boundaries.
- Protect special-status species, to the extent possible, during the restoration process.
- Restore habitats in the NSMWA that will change over time as a result of inherent dynamic characteristics of the estuarine system (in terms of seasonal as well as longer-term changes).
- Phase the restoration in the project site and time the restoration in relationship with restoration projects throughout the NSMWA, particularly Cullinan Ranch and Skaggs Island, to reduce negative impacts (such as erosion of existing marshes and unintended breaching of levees) resulting from excessive changes in the tidal prism.
- Accelerate the speed of habitat restoration by conducting salinity reduction of the former salt ponds as quickly as is safely and financially possible.
- Meet as many of the goals and objectives of the *Baylands Ecosystem Habitat Goals* report as feasible, focusing on how this project's goals and objectives fit within the entire north bay region.

These goals were based on the *Baylands Ecosystem Habitat Goals* report (Goals Project 1999) (p. 97), which states:

The overall goal for the North Bay is to restore large areas of tidal marsh and to enhance seasonal wetlands. Some of the inactive salt ponds should be managed to maximize their habitat functions for shorebirds and waterfowl, and others should be restored to tidal marsh. Tributary streams and riparian vegetation

should be protected and enhanced, and shallow subtidal habitats (including eelgrass beds in the southern extent of this subregion) should be preserved or restored.

Tidal marsh restoration should occur in a band along the bayshore, extending well into the watersheds of the subregion's three major tributaries—Napa River, Sonoma Creek, and Petaluma River. Seasonal wetlands should be improved in the areas that are currently managed as agricultural baylands. All remaining seasonal wetlands in the uplands adjacent to the Baylands should be protected and enhanced.

...In total, the Goals for the North Bay subregion call for increasing the area of tidal marsh from the existing 16,000 acres to approximately 38,000 acres, and creating about 17,000 acres of diked wetlands managed to optimize their seasonal wetland function.

2.3.2 Project-Specific Habitat Restoration Goals

Specific project-site habitat restoration goals developed by the project sponsors using recommendations for the Napa River and Sonoma Creek areas from the *Baylands Ecosystem Habitat Goals* report include:

- In a phased approach, restore large patches of tidal marsh that support a wide variety of fish, wildlife, and plants, including
 - special-status mammals and water birds, specifically the salt marsh harvest mouse, California clapper rail, and black rail;
 - endangered fish, specifically Delta smelt, splittail, steelhead trout, and chinook salmon, and other fish species; and
 - aquatic animals, including the dungeness crab, and other benthic and planktonic invertebrates.
- Ensure connections between the patches of tidal marsh (in the project site and with adjacent sites) to enable the movement of small mammals, marsh-dependent birds, and fish and aquatic species.
- Restore tidal marsh in a band along the Napa River to maximize benefits for fish and other aquatic animals.
- Manage water depths of ponds to maximize wildlife habitat diversity, with shallow-water areas for migratory and resident shorebirds and dabbling ducks and deepwater areas for diving benthivores.
- Manage salinity levels in ponds to support a rich diversity of biota.
- Break up unneeded levees to create refuges for roosting and nesting shorebirds.
- Manage invasive plant species, as feasible.

2.3.3 Beneficial Reuse of Recycled Water

The recycled-water-reuse goal for the project is to maximize use of available recycled water for desalination. SCWA has formed a coalition of north bay water agencies with the intent of achieving 100% reuse (zero discharge) of recycled water. Minimizing discharge of recycled water is a requirement imposed by the State of California. It is the coalition's goal to divert 15,000 acre-feet (af)/year of recycled water from discharge to surface water bodies to beneficial upland reuse.

The overall concept is to construct a pipeline from all of the major treatment facilities in the north bay region to the agricultural users in Napa and Sonoma Counties. In the long term, the ability to transport water from west to east through the proposed pipeline would mean that agricultural users would have access to recycled water rather than using surface water from small streams and creeks in the north bay. The use of recycled water is appealing to agricultural users because the supply is consistent from year to year. If the pipeline is not built, each wastewater treatment plant (WWTP) would look for local reuse opportunities, but these reuse opportunities may not be sufficient to achieve zero discharge.

In the short term, a portion of the recycled water could be made available to the Napa River Salt Marsh Restoration Project to enhance desalination. The pipeline would be constructed in stages, and the amount of water initially available would be between 6,000 and 7,000 af/year. While reuse of recycled water for the project would not meet the long-term goal of zero discharge (i.e., the recycled water would eventually still be discharged to the Napa River or San Pablo Bay), use of the recycled water for desalination would be a beneficial reuse. This water would be especially valuable as a means of further diluting bittern (i.e., increasing the allowable bittern discharge rate). Reusing the recycled water for desalination would ensure that sufficient discharge capacity is available to accommodate the available volume of water. The availability of discharge capacity would be crucial in the early phases of the recycled water project, and would enable coalition members to participate. After the salinity reduction process is completed, the pipeline constructed to the ponds would be modified by SCWA to provide irrigation water to nearby agricultural lands.

If recycled water is not used for desalination, it is likely that the pipeline would not be built. The timing for deciding to use recycled water is crucial, as the WWTPs are currently in need of immediate reuse opportunities for a portion of their water.

2.3.4 Recreation

The NSMWA currently provides limited recreational facilities, as described above. The project goals include enhancing recreational access to and use of the project area by providing improved recreational facilities. Proposed improvements to recreational facilities may include interpretive signs, an

information kiosk, paved and lighted parking areas, a toilet, improved footpaths to the ponds, and a wildlife viewing blind.

2.4 Development of Options

2.4.1 Introduction

The Napa River Salt Marsh Restoration Project includes three primary components—salinity reduction, habitat restoration, and water delivery. Each of these components had numerous approaches to being implemented. The following sections describe the screening process that was used to focus the EIR/EIS and define a reasonable range of alternatives.

2.4.2 Options as Components of Alternatives

Because of the complexity of the salinity reduction and habitat restoration processes and the project sponsors' desire to select the best salinity reduction and habitat restoration approaches, this EIR/EIS separates the components of alternatives into salinity reduction, water delivery, and habitat restoration options. These options are screened and analyzed separately, then combined in Chapter 17, "Alternatives," to arrive at a reasonable range of alternatives.

2.4.3 Screening Process

Several approaches were used to develop and screen options, including using a restoration decision flowchart developed by the project team (Figure 2-4) and the Corps' *Economic and Environmental Principles and Guidelines for Water Related Land Resources Implementation Studies* identified in the Corps' *Planning Guidance Notebook (ER 1105-2-100)* (U.S. Army Corps of Engineers 2000a), which includes screening based on effectiveness, efficiency, completeness, and acceptability. Environmental, economic, and social screening criteria were also used to evaluate and screen restoration components.

A wide range of options was identified and evaluated at a screening level. Options that were identified as viable in the first round of screening were retained for more detailed evaluation. Salinity reduction options were further subdivided into two components—the salinity reduction process, and supplemental (fresh or recycled) water delivery.

Preliminary screening of the salinity reduction options was achieved by conducting initial hydrologic modeling runs to determine the feasibility of various salinity reduction approaches. The water delivery options were evaluated by assessing the economic and institutional feasibility. The habitat restoration options were screened by characterizing the evolution of the site over time with

varying assumptions. The most viable options were carried forward for consideration as potential project options. Potential habitat restoration options were then presented to the Napa-Sonoma Marsh Restoration Group for review and critique.

2.4.4 Options Considered but Eliminated

Twenty-four salinity reduction, seven habitat restoration, and three supplemental water delivery options were considered at the screening stage. Of these, 21 salinity reduction options, three habitat restoration options, and two water delivery options were eliminated from further analysis because of criteria described above. These options are briefly described below.

2.4.4.1 Salinity Reduction Options

Reverse Operation of the Ponds

As described earlier, during the salt production process, bay water was moved from the southernmost ponds in sequence to the northern ponds. The initial salinity reduction options considered consisted of reversing the flow so that the higher salinity (northernmost) ponds would discharge into the lower salinity ponds (closest to the bay). Numerous permutations of this option were considered including reverse operation of all the ponds and reverse operation of selected ponds, as well as different discharge locations. Hydrologic modeling indicated that reverse operation would delay the salinity and habitat restoration process because desalination of the lower salinity ponds would be delayed until desalination of the higher salinity ponds had been completed. In addition, the salinity in the lower salinity ponds would increase initially as the water from the upper ponds is discharged to the lower ponds.

Concentration of Brine in One or More Central Ponds

Another option for conducting salinity reduction is to move brine from the lower and upper ponds to one or more centrally located ponds. The centrally located pond(s) would serve as a holding chamber(s) for the brine and would be used to discharge the brine over time. If all the brine were discharged to a small number of ponds, the remaining ponds could be restored sooner than under the reverse flow scenario. Several preliminary salinity reduction options used a version of this approach. Preliminary analysis of these options indicated that one or more ponds would have a very large increase in salinity, and (in several scenarios) one or more ponds could dry out completely. In addition, very high water volumes would be required for most of these options. The loss of habitat value and potential long-term damage to one or more ponds associated with desiccation made these options unacceptable.

Physical Removal of the Bittern

These options were developed to evaluate the potential for expediting the restoration of the upper ponds by speeding up the removal of bittern from Pond 7. Physical bittern removal would consist of pumping out and/or scraping up the contents of Pond 7 and then disposing of or reusing these materials off-site. Many variations of this option were considered, including ocean dumping, reuse, and land-based disposal. Cost and environmental effects made these options infeasible. If a purchaser can be found for bittern, this option may become economically feasible.

Use of Only Recycled Water to Desalinate All Ponds

This option was designed to eliminate potential impacts on aquatic life from use of Napa River, Napa Slough, or San Pablo Bay water for desalination. Water-balance calculations indicated that there would not be sufficient recycled water to compensate for net evaporation, much less to desalinate all ponds.

Flood Event Salinity Reduction

During high flow periods (i.e., flood events), a higher volume of water is available to dilute the brines from the ponds, and to carry the diluted discharge out of the river into San Pablo Bay. Under this option, brine could be discharged only during flood events, or, alternatively, could be discharged at a higher rate during flood events. This option is not a complete desalination option by itself, because this approach cannot be used for the bittern and may not be appropriate for the highest salinity ponds. The use of high-flow waters to help reduce salinity was integrated into Salinity Reduction Options 1B and 1C, as described below.

2.4.4.2 Water Delivery Options

Using fresh (nonsaline) water in the salinity reduction process would expedite the salinity reduction process, thus requiring less time to accomplish salinity reduction.

Maximum Recycled Water Delivery

As discussed earlier, recycled water is potentially available to the Napa River Salt Marsh Restoration Project from WWTPs in the north bay region. The Maximum Recycled Water Delivery Option assumes that the water/sanitary agencies in the region would provide a combined 15,000 af/year of recycled water for salinity reduction. This volume would require most of the recycled water that is not currently slated for other uses, and would also require the installation of a pipeline to allow for the delivery of water from as far away as

eastern Marin County. The feasibility and timing of constructing a pipeline system to convey recycled water to the project site from all WWTPs in the north bay region have not been determined. As such, the Maximum Recycled Water Delivery Option is not considered feasible at this time; however, a portion of this option is currently feasible, as described below under Section 2.5.3, “Water Delivery Option.”

Use of Site Groundwater

Another potential source of fresh water for salinity reduction is the groundwater beneath the site. Reportedly, when hay production was occurring in the project area, groundwater was used for irrigation. This option was eliminated from further consideration because of the relatively small volume of water available, the cost of installing the required wells and water distribution system, the risk of causing saltwater intrusion into the shallow aquifer, and the opposition of the San Francisco Bay RWQCB to use of limited potable water for desalination when other options are feasible. However, use of groundwater may be appropriate for select aspects of the long-term maintenance program for the project area.

2.4.4.3 Habitat Restoration Options

Species-Focused Options

Species-focused options consist of restoring the site for primary use by specific species such as waterfowl and shorebirds or by endangered species. If the site were managed primarily for diving benthivores and other waterbirds, it would remain entirely as ponds. If the restoration were focused primarily on endangered species such as the California clapper rail, the site would be converted to tidal marsh in its entirety.

Maximizing habitat for shorebirds and waterfowl would completely eliminate the largest likely potential for recovery of endangered species and the largest likely potential for increasing tidal marsh and associated ecosystem services (including benefits to the bay) anywhere in the north bay region. The Bay-Delta estuary has lost 79% of its tidal marshes, to the serious detriment of not only many tidal marsh species, but also the bay as an ecosystem. This loss of potential benefits would be grossly in conflict with the Habitat Goals and with federal and state plans for endangered species recovery, and would be widely considered unacceptable.

Maximizing habitat for endangered species would cause disproportionate negative impacts on shorebirds and waterfowl by eliminating excellent high tide refugia and feeding habitat for the former and substantial feeding and resting habitat for the latter. These impacts are particularly important because of the project’s location on the Pacific Flyway. These impacts are considered unacceptable to the project sponsors and many others.

Thus, these two options do not provide suitable habitat for the large diversity of species currently residing in the NSMWA, and therefore do not meet project goals. In addition, species-focused options are particularly difficult to design and do not allow the flexibility needed to manage the multispecies project area. For example, managing ponds for shorebird use (i.e., maintaining shallow water levels) is very difficult given the large area of the ponds and the high evaporation rates that occur in the summer months. The habitat restoration options that were retained provide suitable habitat for a wide range of existing species.

Land Exchange

One possibility for optimizing habitat development in the region is to integrate activities at adjacent or nearby restoration sites. Specifically, Cullinan Ranch, which is owned by USFWS, is deeply subsided, yet is slated for redevelopment into tidal marsh. One possible option is to exchange the Cullinan parcel for a DFG parcel in the project area so that land more suitable for tidal marsh restoration is used to create tidal marsh and a deeply subsided area such as Cullinan Ranch is used to create pond habitat. This habitat restoration option, although technically and economically sound, is logistically infeasible because the terms underlying congressional funding and USFWS's purchase agreement mandated that Cullinan Ranch be restored to tidal marsh.

Sediment-Import Options

Habitat restoration could be accelerated and/or seasonal wetland and upland habitat could be created with the import of large quantities of sediment. The sediment would be placed into the ponds before breaching to avoid or minimize the need for sediment accretion prior to the establishment of marsh vegetation. In addition, imported sediment could be used to raise grades at the northern ponds to create upland or seasonal wetland habitat. Large-scale sediment import was eliminated from consideration because sediment import may not enhance the environmental values substantially over existing conditions and because DFG supports only limited use of sediment. Additionally, initial calculations have shown that existing sediment supply is greater than the predicted postrestoration demand, indicating that there may be sufficient sediments to restore the ponds naturally (Philip Williams and Associates 2002a). Creation of seasonal wetland or upland habitat is not part of the goals for this project.

2.4.5 Options Evaluated in This EIR/EIS

As described earlier, three sets of options are evaluated in this EIR/EIS. Because both salinity reduction and habitat restoration are required to complete the project, the habitat restoration options are combined with appropriate salinity reduction options and water delivery options (Chapter 17, "Integration of Options and Alternative Selection") to document the full extent of potential impacts associated with complete alternatives. In addition, both CEQA and NEPA

require evaluation of a no-project alternative. This section describes first the No-Project Alternative, then the salinity reduction options, the water delivery options, and the habitat restoration options. The options are described briefly below and in detail in Section 2.5, “Project Options.”

- **No-Project Alternative.** Under the No-Project Alternative, site conditions would continue to deteriorate and salinity in the ponds closed to tidal influence would continue to increase. Additional No-Project Alternative assumptions are described in Section 2.5, “Project Options.”
- **Salinity Reduction Option 1A: Napa River and Napa Slough Discharge.** This option proposes to conduct the salinity reduction process in a phased approach, decoupling desalination of the upper ponds from desalination of the lower ponds. Primary discharges from the upper ponds would be to Napa Slough, and primary discharges from the lower ponds would be to the Napa River. The use of recycled water for dilution of the upper ponds may be included in this option.
- **Salinity Reduction Option 1B: Napa River and Napa Slough Discharge and Breach of Pond 3.** This option also proposes to conduct the salinity reduction by separating the upper and lower ponds. Primary discharges from the upper ponds would be to Napa Slough. Salinity reduction of the lower ponds would occur by creating a 50-foot breach on the Pond 3 levee during a high flow event and constructing an intake on Pond 5 and a discharge on Pond 4. The use of recycled water for dilution of the upper ponds is included in this option.
- **Salinity Reduction Option 1C: Napa River and Napa Slough Discharge with Breaches of Ponds 3 and 4/5.** This option is similar to Salinity Reduction Option 1B except that the Pond 4 levee would also be breached and the intake and discharge would not be constructed. Salinity reduction of the lower ponds would occur by strategically timing the levee breaches during a large storm event when the Napa River flow is high. The use of recycled water for dilution of the upper ponds is included in this option.
- **Salinity Reduction Option 2: Napa River and San Pablo Bay Discharge.** This option also proposes to conduct the salinity reduction process in a phased approach; however, desalination of the upper ponds is coupled with desalination of some of the lower ponds. Primary discharges from the upper ponds would be conveyed through Ponds 6A, 6, 2, and 1/1A, then under SR 37 to San Pablo Bay. Primary discharges from Ponds 3, 4, and 5 would be to the Napa River. The use of recycled water for dilution of the upper ponds could be included in this option.
- **Water Delivery Option.** This option focuses on project-specific and programmatic delivery of recycled water to the project area. Project-specific delivery would occur from the Sonoma Valley County Sanitation District (SCVSD) WWTP, the Napa Sanitation District (NSD) WWTP, and the City of American Canyon (CAC) WWTP. Programmatic delivery could come from other WWTPs in the north bay region.
- **Habitat Restoration Option 1: Mixture of Tidal Marsh and Managed Ponds.** This option provides a balanced mix of tidal marsh habitat and

managed pond habitat, with an emphasis on restoring Ponds 3, 4, and 5 to tidal marsh and maintaining the remaining ponds as managed ponds. Ponds 6 and 6A would be managed as ponds in the short term (the initial 10–20 years). Adaptive management criteria would be used at that point to determine whether these ponds should also be opened to tidal action, or whether they should remain as managed ponds.

- **Habitat Restoration Option 2: Tidal Marsh Emphasis.** This option provides a larger amount of tidal marsh habitat and proposes to reconfigure the levee in Pond 2 because of deteriorating site conditions. Ponds 3, 4, 5, 6 and 6A, and the eastern half of Pond 2 would be restored to tidal marsh.
- **Habitat Restoration Option 3: Pond Emphasis.** This option provides a larger amount of pond habitat; only Ponds 3 and 4 would be restored to tidal marsh.
- **Habitat Restoration Option 4: Accelerated Restoration.** This option adds design features such as more extensive starter channels and berms, the use of imported sediment to fill an area to near tidal marsh elevation, and to accelerate marsh restoration.

2.5 Project Options

2.5.1 No-Project Alternative

CEQA and NEPA require the analysis of a no-project alternative. The No-Project Alternative for this project is depicted in Figure 2-5. Under this alternative, site conditions would continue to deteriorate and salinity in the ponds would continue to increase. DFG would manage the site to reduce day-to-day pond salinity, if possible, by taking San Pablo Bay water into Ponds 1 and 1A and Napa River water into Pond 8 and moving water through the pond system via water control structures. Annually there would be a net increase in the total salt load.

Water would be delivered to the system from two locations: the new intake at Pond 8 and the pump station that transfers water from Pond 1 into Pond 2. The Pond 8 intakes are estimated to provide an average (RMS) flow of 20 cubic feet per second (cfs); the pump station has two 15,000-gpm-capacity pumps. The flow from the intakes to the remaining ponds is driven by elevation (“head”) differential. Initially, the ponds would be expected to dry out more frequently as siphons continue to be or become inoperable as a result of increased salinity gradients. Other water control structures would continue to deteriorate, reducing DFG’s ability to manage water levels and pond salinity for wildlife habitat. Thus, the quality of wildlife habitat in the area would continue to deteriorate quickly.

However, even more significant than the deterioration in wildlife habitat is the increased ecological threat that would be posed to the ponds in the next 10–15 years. If DFG attempts to maintain the ponds’ water levels by compensating for

annual net evaporation, the salt mass in the ponds would increase dramatically from year to year. In the short term, depending on the amount of make-up water available for each pond, some ponds could dry out each year. In the long term, the increasing salinity in the ponds would reduce evaporation rates sufficiently that the estimated available amount of water would be sufficient to keep the ponds wet all year. If the amount of water delivered to the ponds was kept the same, water levels would then slowly start to rise, and eventually water intakes would have to be cut back to avoid overfilling the ponds. However, salinities in the ponds at this point would exceed 350 ppt (the approximate solubility of sodium chloride), and sodium chloride would start to precipitate. As the salinity would increase, the liquid in the ponds would gradually turn into bittern; the sodium chloride would precipitate, and the remaining brine would have the same composition as the bittern waste left over after the salting process.

Thus, if DFG attempts to manage the water levels in the ponds without discharging to the Napa River or Napa Slough, sufficient salt would accumulate in the ponds that Ponds 4–8 would turn first into highly saline brine and then into bittern ponds with a large precipitated salt mass. Coupled with the deterioration of the levees, the ponds would present an ecological threat in the next 5–30 years.

Ongoing erosion of inboard levees by wind and waves and scour of outboard levees, in conjunction with high tides and high rainfall events, would likely result in one or more levee breaches. Figure 2-5 indicates potential breach locations. DFG would potentially fix the levees on an emergency basis as needed, requiring the mobilization of construction equipment to the site. Because of the remote locations and emergency contracting issues (i.e., permits, funding, contractor availability), these repairs often cannot be started in a timely manner, and much of the potential damage (i.e., possible fish kills) resulting from uncontrolled releases of highly saline water or bittern would be instantaneous. By the time the levees were fixed (approximately 3–4 weeks), most of the negative effects already would have occurred, as large quantities of highly saline pond water/bittern would have been released. The Pond 3 vandalism will not be repaired because adverse effects are not anticipated, and it is consistent with the general salinity reduction approach that the project sponsors are pursuing.

Allowing the ponds to dry out is considered to be even less environmentally acceptable than continuing to increase the mass of salt in the ponds over time. If the ponds are allowed to dry out, the sulfides in the sediment would convert to sulfuric acid and reduce the pH in the ponds. This occurred at Pond 8, and the pH at Pond 8 now ranges from a low of 2.2 to a high of 4.2, depending on the quantity of water in the pond. Low pH also poses a substantial environmental risk, and could require even greater dilution prior to discharge than the bittern.

2.5.2 Salinity Reduction Options

Salinity reduction is the first step in the habitat restoration process. Currently, many of the ponds have salinities that either preclude use of the ponds by

wildlife, or limit use of the ponds to a very small number of species seasonally. Reducing the salinities in the ponds to a level that makes the ponds usable for a wide range of wildlife would be the first step in enhancing the habitat value of the ponds. Generally, once the ponds are desalinated, they could be opened up to tidal action or maintained as managed ponds.

Salinity reduction is not currently required for Ponds 1, 1A, 2, and 2A. Ponds 1, 1A, and 2 all have salinities that are at or near ambient conditions (i.e., salinity levels near San Pablo Bay/Napa River levels), and Pond 2A has been restored to tidal marsh. Ponds 1, 1A, and 2 have water exchange (i.e., they can continue to function as ponds in the long term without salinity build-up in the ponds). Pond 3 is partially open to tidal exchange; however, because the ditches are so small, salinity reduction of Pond 3 still needs to be conducted. For the purposes of desalination, Ponds 4 and 5 are treated as one pond (the interior levee is breached), as are Ponds 6 and 6A for the same reason. Thus, salinity reduction is required for six ponds: Pond 3, Pond 4/5, Pond 6/6A, Pond 7, Pond 7A, and Pond 8.

All salinity reduction options would use the existing water conveyance infrastructure to the degree possible. However, the existing water conveyance structures are deteriorated, and the engineering evaluation suggests that all siphons would require refurbishing or replacement. In addition, all options require construction and/or repair of intakes, outfalls, and other water conveyance structures (such as pumps, siphons, weirs, and fish screens).

The intakes would be equipped with fish screens, if required by USFWS and NMFS. Use of unscreened intakes and/or bypass of fish screens may be permissible for part of the year or specific ponds, or once certain salinity thresholds have been met. The physical location of each intake or set of intakes may affect the type of screens or whether a fish screen is required. Any fish screens would have trash racks and scrapers to remove debris. If fish screens are required, they would reduce the flowrate through a given intake by approximately 50%, thus doubling the required number of intake structures. This document uses the higher number of intake structures in assessing potential project-related impacts. If fish screens are not required, the resulting construction impacts would be less than described herein.

Any water control structures and other equipment installed for this project would be subject to highly corrosive environments, high turbidity, and impacts from debris. Water conveyance structures that will be used in the long-term (i.e., for ponds that have long desalination periods or will become managed ponds) will be constructed of HDPE and/or stainless steel to extend the life of the equipment as much as possible. It is estimated that HDPE pipe will last for the life of the project; any structures requiring use of stainless steel, however (e.g., knife valves for intakes and outfalls) would likely last a maximum of 30 years. Because the project life is 50 years, any such equipment would have to be replaced at least once. The construction materials would reflect the need for a high level of corrosion resistance, and any electronic equipment required would be extremely rugged. Water conveyance structures required only for short periods of time (e.g., intakes on ponds that would be opened to tidal action in the near term)

could be made of less resistant materials to reduce the construction impacts and costs (these structures would be lighter and easier to install).

A difficulty likely to be encountered with monitoring equipment and any other high value equipment is theft and vandalism. Experience with past monitoring efforts has shown that most monitoring equipment was stolen or vandalized within a matter of weeks. Thus, this type of equipment would have to be enclosed by high fences topped with razor wire. Fencing off monitoring and other electrical equipment would also eliminate any potential risks to the public associated with tampering with the equipment.

Levee repairs would be conducted at the start of the desalination period for those ponds requiring desalination. The amount of repairs required depends on the desalination option selected, because different ponds would be desalinated at different rates under the different options (i.e., the duration for which the levees would have to retain their integrity, and which levees are required to retain their integrity, vary by option). For ponds that require a long time for desalination (e.g., Pond 7), levee maintenance would be required before and during the desalination period. It is estimated that 5% of all levees would require repairs every year.

2.5.2.1 Salinity Reduction Option 1: Napa River and Napa Slough Discharge

Introduction

Salinity Reduction Option 1 is designed to create improved site conditions in the various ponds as quickly as possible. Under this option, salinity reduction in the lower ponds (3, 4/5, and 6/6A) would be achieved through a phased approach: restoration to near ambient Napa River salinity levels would begin at Pond 3, then continue to Ponds 4/5, and then proceed to Ponds 6/6A. As mentioned previously, Ponds 1, 1A, and 2 already have salinities at or near ambient conditions, and Pond 2A has been restored to tidal marsh. Salinity reduction in the upper ponds (7, 7A, and 8) would be carried out in a parallel phase.

With a phased salinity reduction process, each pond would achieve increased habitat value as soon as possible. Ponds that are slated to remain managed ponds would be fully functioning habitat as soon as salinity reduction is completed. Each of the ponds that is slated to be opened up to tidal action could be opened up to tidal action as soon as its salinity and water quality parameters are in the appropriate range as determined by the San Francisco Bay RWQCB and other regulatory agencies.

One of the concerns associated with existing conditions at the Napa River Unit of the NSMWA is that one or more of the pond levees could breach and that that breach would result in an uncontrolled release of saline brine. Such breaches could occur at any time of year, as a result either of levee erosion caused by wind and waves or of high flow or flood events, but they are more likely to occur

during high wind/rainfall events. These potential uncontrolled breaches are of most concern for the more saline ponds (i.e., Ponds 4/5 and 8) and the bittern pond (Pond 7), and for releases to the sloughs (which have a relatively low daily tidal exchange compared to the Napa River). However, controlled, managed breaches into the Napa River, especially for the less saline ponds, represent a potentially effective means of desalinating some of the ponds. The goal of the breaches proposed under this scenario would be to desalinate the ponds. Additional breaches would be added to allow for full tidal exchange and return the ponds to tidal habitats.

The portion of the Napa River adjacent to Ponds 3 and 4/5 experiences a significant daily tidal flow, which would result in a high dilution rate for brines discharged in this area. Modeling has shown that controlled breaches for the lower ponds can be an effective means of desalinating these ponds. Consequently, Salinity Reduction Option 1 has three suboptions: Option 1A, Option 1B, and Option 1C. These options use differing processes for desalinating Ponds 3 and 4/5 but the same process for desalinating Ponds 6/6A, 7, 7A, and 8:

- Option 1A, “Napa River and Napa Slough Discharge,” uses constructed intakes and outfalls for all ponds, including Ponds 3 and 4/5. This option provides the most control over the rate of pond discharge and resulting salinity increases in the Napa River. The existing ditches would need to be repaired under this option.
- Option 1B, “Napa River and Napa Slough Discharge and Breach of Pond 3,” uses a controlled levee breach to desalinate Pond 3 during a high flow event. The remaining intakes and outfall locations are the same as for Option 1A.
- Option 1C, “Napa River and Napa Slough Discharge with Breaches of Ponds 3 and 4/5,” would desalinate both Ponds 3 and 4/5 via controlled levee breaches during high flow events.

The required construction activities, facilities, and operation and maintenance for Ponds 3 and 4/5 are described first, followed by the same information for Ponds 6/6A, 7, 7A, and 8.

The breaches proposed under Options 1B and 1C would eventually have to be created to return the ponds to tidal marsh. The advantages of using controlled breaches to desalinate one or more of the ponds would be as follows:

- much of the construction associated with desalination would be avoided,
- fish entrapment and other impacts on fish from intakes would be minimized,
- the ponds would be desalinated more quickly, and
- salinity increases in the Napa River would be of more limited duration.

Ponds 3 and 4/5

Construction

Facilities. New water intakes and water control discharge locations (outfalls) would be required so that an effective water circulation pattern could be established. For Salinity Reduction Options 1B and 1C, the breaches allow for tidal circulation. The anticipated intake and discharge (outfall) locations for each of the ponds are shown in Figures 2-6 through 2-8 for Options 1A through 1C, respectively. Intakes and outfalls would be constructed at locations that would minimize effects on existing marsh habitat and minimize the length of pipes needed (because they would take advantage of deepwater river or slough channels close to the levee). Interior levees would be breached using explosives where applicable. Exterior levee breaches would be constructed either using explosives or by excavating the levee. The ditches connecting Pond 3 to the adjacent sloughs would be repaired under Salinity Reduction Option 1A.

Intakes and Outfalls for Option 1A. New intake and outfall culverts would be built to connect

- the Napa River to the northeast corner of Pond 3 (four 52-inch intake culverts that bisect the levee and extend approximately 600 feet into the river);
- Dutchman Slough to the southwestern side of Pond 3 (three 48-inch-diameter intake culverts that bisect the levee and extend approximately 300 feet into the slough);
- the southeast side of Pond 3 to the Napa River (four 52-inch-diameter outfall culverts bisecting the levees and extending 1,100 feet into the river);
- Napa Slough to the north-central section of Pond 5 (seven 54-inch diameter intake culverts that bisect the levee and extend approximately 500 feet into the slough); and
- the south-central section of Pond 4 to the Napa River (two 48-inch-diameter outfall culverts bisecting the levees and extending 1,100 feet into the river).

Intakes and Outfalls for Option 1B. New intake and outfall structures would be constructed to connect

- the southeast side of Pond 3 to the Napa River (one 50-foot breach serving as both intake and outfall);
- Napa Slough to the north-central section of Pond 5 (seven 54-inch diameter intake culverts that bisect the levee and extend approximately 500 feet into the slough); and
- the south-central section of Pond 4 to the Napa River (two 48-inch-diameter outfall culverts bisecting the levees and extending 1,100 feet into the river).

Intakes and Outfalls for Option 1C. Breaches would be built to connect

- the southeast side of Pond 3 to the Napa River (one 50-foot breach serving as both intake and outfall) and

- the south-central section of Pond 4 to the Napa River (one 50-foot breach serving as both intake and outfall for Ponds 4/5).

To ensure effective mixing in Ponds 4/5, the existing Pond 4/5 interior levee breaches would be expanded to four 100-foot-long breaches. In addition, the existing siphon between Ponds 5 and 6 would be refurbished or replaced with a new 250-foot-long, 52-inch-diameter siphon. All culverts for Ponds 3, 4, and 5 would be constructed of a lighter-weight material, most likely a coated corrugated iron. These intakes are only required to last until the ponds are opened to tidal action as part of the habitat restoration effort, most likely no more than 5 years.

All culvert intakes would be equipped with gate valves to prevent water from passing into the sloughs or the Napa River from the gates. These intakes would also be equipped with manual knife valves to allow manual control of the intakes, as needed. If fish screens are required, they would be installed on the river or slough side of the intakes. The size and number of intakes described above is sufficient to compensate for the reduced intake flow effects of any fish screens that may be required.

All culvert outfalls would be equipped with diffusers to enhance mixing/dilution of the discharge. Diffusers would be the same diameter as the outfall, and would vary from 50 to 100 feet in length. Each diffuser would include ten 8- to-10-inch-diameter discharge ports along its length, and one 12- to 16-inch-diameter discharge port at its end. The ports would be fitted with neoprene check valves that open only when the tidal elevation is lower than the pond water elevation. The diffusers would be located close to the Napa River channel and would be marked by appropriate navigation aids.

To reduce impacts on existing habitat and minimize construction costs, the Pond 4/5 culvert outfalls would be located in an area with minimal accreted marsh (Figure 2-6). If necessary to ensure adequate circulation, water could be brought into the southernmost portion of Pond 4 via the siphon between Ponds 3 and 4.

Levee Repairs and Long-Term Levee Maintenance. Levee repairs would not be required for Pond 3 or 4/5, as the ponds would be desalinated prior to any projected potential levee failure.

Equipment. Installation of water control structures around Ponds 3 and 4/5 would require the use of heavy equipment delivered to the site by barge at extreme high tide. Heavy equipment, generally low-pressure, long-reach excavators, would be used to construct the intakes and outfalls. The equipment would have wide tracks and/or use mats to ensure that its weight is evenly supported and that compaction rates on existing habitats would be low.

Approximate types and maximum quantities of equipment that would be used for Option 1A include one or two long-reach excavators, two or three diesel-powered barges, one or two small to medium bulldozers, trucks, a diesel generator, a sheet pile driver, and small boats for daily transportation to and from the site. Breaches would be constructed using explosives.

Construction of Option 1B would require the same equipment as Option 1A, but for only about half the time. The only equipment required for Option 1C is a small bulldozer to dig trenches for explosives and excavate the exterior levee, and the small boats required to transport the explosives crew and their supplies.

Timing and Duration. The required water control structures would be constructed in the late spring and summer to meet construction/species habitat windows, and salinity reduction would begin in the winter or early spring to take advantage of the rainy season (December–March). Construction would require most of the season for Option 1A, and correspondingly less time for Options 1B and 1C. To assess maximum potential impacts, this document assumes that the breaching of Ponds 3 and 4/5 for Option 1C would be conducted simultaneously. It is likely that breaching of these ponds would be phased to allow for monitoring and adaptive management.

Operations and Maintenance

Operations and maintenance (O&M) for Option 1C would consist simply of monitoring the salinity reduction in newly breached ponds and the salinity of the receiving waters. O&M for Options 1A and 1B is described below.

Facilities. The ponds would be filled with water at the start of the wet season to reduce salinity as much as possible. However, the maximum water height in the ponds would be controlled to remain at least two feet below the levee crest, to avoid further erosion concerns with the levees.

Intakes and outfalls would largely be tidally driven but could also be manually closed to reduce flows, if required. Locations of intake and outfall culverts are described above under “Construction.”

Under Salinity Reduction Option 1A, to allow maximum dilution of the brine at the point of Pond 3 discharge, the discharge would occur at the deepest portion of the Napa River feasible, as determined by the engineers. Because the Napa River is wide and shallow in the project area (there are large tidal flats at low tide), the discharge location should be immediately adjacent to the Napa River deepwater channel (if that location meets navigation constraints), approximately 1,100 feet from the Pond 3 levee.

For Options 1B and 1C, appropriate breach locations on the levees would be identified before the wet season and set up for breaching during the high flow event. Explosives would be set and the breaches created as soon as it has been determined that a major storm event is in progress.

Levees would be breached at the southeast corner of Pond 3 for Option 1B (Figure 2-7), and, for Option 1C, on the east side of Pond 4 as well (Figure 2-8). Any additional breaches required to facilitate habitat restoration would be created after pond desalination has been completed. Each breach would be approximately 50 feet wide. The proposed breach locations correspond to the mouths of major historical sloughs as feasible.

Timing and Duration. Based on current modeling results and assumed initial conditions, operations associated with Ponds 3 and 4/5 could proceed on the following schedule beginning in approximately September 2004.

■ **Pond 3 (Option 1A only):**

Salinity reduction would require approximately 6 months. Following construction of habitat restoration features, Pond 3 would be opened to tidal action with the breaching of one or more levees at the location of the water control structures. Breaching of the levees is considered part of the habitat restoration options (see Section 2.5.4, “Habitat Restoration Options”).

■ **Pond 3 Only (Option 1B only):** The typical 2-year high flow event is sufficient to allow breaching of Pond 3 following construction of habitat restoration features. Option 1B would result in a maximum average salinity increase of 7 ppt in the Napa River. Within 48 hours, that maximum increase would have dropped to 4 ppt, and within 4–5 days, the difference would be approximately 2 ppt (i.e., the same as for discharge via outfalls), well below the target threshold of 5 ppt. After approximately 1 month, there is no further discernable influence on the ambient salinity in the Napa River. It should be noted that the salinity increase is relative to the Napa River baseline, which drops to near 0 ppt during a high flow event. It is very likely that the salinity “spike” would at most bring the ambient salinity back to the same level that it was before the high flow event.

■ **Pond 4/5 (Options 1A and 1B):**

Salinity reduction would require approximately 12–18 months. This process would begin simultaneously with desalination at Pond 3. Once Pond 4/5 is desalinated, it would serve as a mixing chamber during desalination of Pond 6/6A. During this time, Pond 4/5 may be opened to muted tidal action by simply keeping all water control structures open.

■ **Ponds 3 and 4/5 (Option 1C only):** Because Pond 4/5 has a higher salinity than Pond 3, breaching both Ponds 3 and 4 following construction of habitat restoration features would result in a higher salinity spike during the same 2-year high flow event. The maximum estimated increase in ambient salinity would occur within 24 hours, and is estimated to be 17 ppt over ambient levels. As with Option 1B, it should be noted that this spike is relative to the drop in salinity resulting from the high flow event. Salinities less than a week prior to the high flow event could easily be higher than the salinity after Ponds 3 and 4 are breached. The salinity spike begins to dissipate rapidly, dropping to a daily maximum differential of approximately 10 ppt within 48 hours, a daily maximum differential of approximately 6 ppt within 1 week, and to less than 4 ppt within 2 weeks. After approximately 2 months, there is no measurable increase in ambient salinity. In other words, the ambient salinity differential would be at or below the target threshold within approximately 1 week. One week is considered to be the minimum amount of time that would be required to repair an accidental levee breach.

Thus, depending on the desalination option selected, Pond 3 would be available for habitat restoration 1–6 months after the start of desalination, and Pond 4/5 would be available for habitat restoration 2 months–3 years after the start of desalination.

Ponds 6/6A, 7, 7A, and 8

Construction

Facilities. New water intakes and water control discharge locations (outfalls) would be required so that an effective water circulation pattern could be established. The anticipated intake and outfall locations for each of the ponds are shown in Figures 2-6 through 2-8. As noted earlier, facilities at and operation of Ponds 6/6A, 7, 7A, and 8 are the same for Salinity Reduction Options 1A–1C.

Intakes and outfalls would be constructed at locations that would minimize effects on existing marsh habitat and minimize the length of pipes needed (because they would take advantage of deeper slough channels close to the levee). Interior levees would be breached using explosives where applicable. Levee repairs would also be required.

Intakes. New intake culverts would be built to connect

- Napa Slough to the north-central section of Pond 6A (five 52-inch-diameter culverts that bisect the levee and extend approximately 250 feet into the slough);
- the Pond 7/7A canal to Pond 6A and the Pond 6/6A canal (one 52-inch-diameter, 350-foot-long siphon under Napa Slough);
- Napa Slough to the south side of Pond 7A (an 800-foot intake canal linked to culverts that bisect the levee); and
- the recycled-water pipeline to Pond 7.

A new intake consisting of two 30-inch-diameter culverts with gates and fish screens has already been constructed for Pond 8. The culverts are made of HDPE. The existing donut on the northeast side of Ponds 7 and 7A would be replaced with a mixing chamber, with the appropriate inlets and outlets to control flows into and out of the mixing chamber. Intakes, outfalls, and siphons for Ponds 6/6A, 7, 7A, and 8 would be constructed of HDPE; valves would be made of stainless steel.

All intakes would be equipped with gate valves to prevent water from passing into the sloughs or the Napa River from the ponds. The intakes would also be equipped with manual knife valves to allow manual control of the intakes, as needed. If fish screens are required, they would be installed on the river or slough side of the intakes. It should be noted that the size and number of intakes describes above is sufficient to compensate for the effects of any fish screens that may be required.

To ensure effective mixing in Ponds 6/6A, the existing 6/6A interior levee breaches would be expanded to four 100-foot-long breaches.

Outfalls. New outfall culverts would be built to allow water to flow from the southern portion of the canal adjacent to Pond 7 to Napa Slough (one 42-inch diameter culvert extending 300 feet into the slough).

The outfalls for the upper ponds and the replacement siphons would be constructed of HDPE to ensure a long operating life. The outfalls would be equipped with diffusers to enhance mixing/dilution of the discharge. Diffusers would be the same diameter as the outfall, and would vary from 50 to 100 feet in length. Each diffuser would include ten 8- to 10-inch-diameter discharge ports along its length, and one 12- to 16-inch-diameter discharge port at its end. The ports would be fitted with neoprene check valves that open only when the tidal elevation is lower than the pond water elevation. The diffusers would be located near the deepest portion of the Napa Slough, and would be marked by appropriate navigation aids.

Other Water Control Structures. Two new discharge gates would be built connecting Ponds 7 and 7A to a mixing chamber. The gate at Pond 7 would be built so that a dilution ratio of 5:100, or other approved dilution ratio (1:100), could be achieved at the mixing chamber. New or refurbished water control structures would connect Pond 5 to Pond 6, and Pond 8 to Pond 8 canal, and the Pond 8 canal to the mixing chamber.

Levee Repairs and Long-Term Levee Maintenance. Initial levee repairs would be required for Ponds 1, 1A, 2, 6/6A, 7, 7A, and 8 to reinforce areas that could fail in the near future (within 5–15 years). Desalination of Ponds 7, 7A, and 8 may not be completed before these levees would fail. Initial levee repairs are also required at Ponds 1, 1A, and 2, if these ponds are to be maintained as ponds in the long term. If Ponds 6/6A are to be adaptively managed, levee repairs are required to ensure that the levees retain their integrity during the adaptive management period (10–20 years). An estimated total of 2 miles of levee would require initial repairs; the levee on Pond 2 would require two rounds of material placement because it is so deteriorated (Huffman pers. comm.). The material deposited in the first round would have to settle and achieve sufficient stability from drying. The second round of material would then be used to fill, compact, and dress the levee for future access.

Long-term levee maintenance for Salinity Reduction Option 1 would consist solely of levee maintenance at Ponds 7, 7A, and 8. Salinity reduction for the upper ponds is expected to require 30 years if recycled water is used to aid in desalination (see Section 2.5.3.1). Desalination for Ponds 7A and 8 is expected to be completed in 1–3 years. Without the use of recycled water, desalination of Pond 7 could require an additional 10–20 years. Approximately 5% of the length of these levees is expected to require repairs each year.

Levee repair and long-term maintenance would require the same types of activities. Soil would be added to the existing levees either through importing material or excavating soil from the internal borrow ditch in each of the ponds.

In general, most of this work could be done from the levee itself. Ponds 1, 1A, 7, 7A, and 8 are all accessible by land and imported material could be used. However, the cost would be high, and it is likely that the material used to repair the levees at these ponds would also be excavated from the borrow ditch. Ponds 2 and 6/6A would use borrow ditch material because barges would be unable to carry material to Pond 2 or Pond 6/6A.

Material to reinforce the levees would be excavated from the existing borrow ditches using a long-reach excavator. The excavated material would be placed at the sides and tops of the levees, with specific locations, soil heights, and slopes to be determined by a geotechnical engineer. As it completes repairs, the excavator would move forward along the top of the levee. The excavator could also work from a barge if needed; however, obtaining access to the levees by barge would be difficult in many locations because of the accreted outboard marsh. Limited dredging may be required to allow access for the barges associated with the levee repair work, as well as for the barges delivering materials and equipment to install the water conveyance structures.

Equipment. Repair of levees and installation of water control structures at Ponds 1, 1A, 2, 6/6A, 7, 7A, and 8 would require the use of heavy equipment delivered to the site by road or barge (SR 37 for Ponds 1, 1A, and 2; Buchli Station Road for Ponds 7 and 7A; SR 12/121 via Duhig Road, Las Amigas Road, Cuttings Wharf Road, and Milton Road for Pond 8; and via barge at high tide for Ponds 2 and 6/6A).

Heavy equipment, generally low-pressure, long-reach excavators, would be used to construct the intakes and outfalls. The excavators would need to have a reach of at least 40 feet to complete work at Pond 2. They would have wide tracks and/or use mats to ensure that their weight is evenly supported and that compaction rates on existing habitats would be low. The excavators would be brought to the needed location for Ponds 7, 7A, and 8 on trucks, and to Ponds 2 and 6/6A on barges that can travel at extreme high tides. Approximate types and maximum quantities of equipment that would be used for the project sites include one or two long-reach excavators, two or three diesel-powered barges, one or two small to medium bulldozers, five or six land-based dump trucks, a small clamshell dredge, a diesel generator, a sheet pile driver, and small boats for daily transportation to and from the site.

Timing and Duration. The required water control structures would be constructed in the late spring and summer to meet construction/species habitat windows, and salinity reduction would begin in the winter or early spring to take advantage of the rainy season (December–March).

Operations and Maintenance

Facilities. Intakes and outfalls would largely be tidally driven but could also be manually closed to reduce flows, if required. Locations of intake and outfall culverts are described above under “Construction.”

For Options 1A and 1B, the discharge for Pond 6/6A would be to Pond 4/5 via the siphon between Ponds 5 and 6. Pond 4/5 would act as a mixing pond for

discharge from Pond 6/6A, and the ultimate discharge would continue to be the outfall at the southeastern side of Pond 4. Currently the salinities in Pond 6/6A are low, and the project sponsors may allow water to flow from Pond 6/6A into Pond 5, providing additional dilution water into Pond 4/5. Flow through the siphon between Ponds 5 and 6 would be controlled to ensure that the salinity in Pond 4/5 remains at an acceptable level.

For Option 1C, discharge from Pond 6/6A would also be to Pond 4/5; however, Pond 4/5 would be open to tidal action as a result of the breach. Modeling for Salinity Reduction Option 1A has shown releasing water from Pond 6/6A to the Napa River via Pond 4 results in only a minor increase in ambient salinity (typically less than 2 ppt). Thus, releasing Pond 6/6A water into Pond 4/5 under Option 1C does not pose a concern for receiving waters in the ponds. Releasing Pond 6/6A water to Pond 4/5 under Option 1C is also unlikely to cause a substantial salinity increase in the Napa River, because Pond 6/6A salinities are much lower than Pond 4/5 salinities (Pond 6/6A salinities are closer to Pond 3 salinities). Once Pond 6/6A is largely desalinated, breaches may be made from Pond 5 to Napa Slough. This would improve circulation of the water in this area.

While each of the lower ponds would be desalinated in series, the upper ponds are linked for desalination. The upper ponds present special challenges in desalination because Pond 7 is the bittern pond, and Pond 8 contains high salinity brine and also has a low pH. Toxicity studies completed by Cargill (S.R. Hansen and Associates 1993) indicate that bittern is toxic to aquatic organisms at concentrations exceeding 1%. Thus, as a conservative assumption, bittern in its current state must be diluted 100:1 before discharge or diluted using other high salinity brine to provide an improved anion/cation balance. Chronic aquatic toxicity tests (7-day) were conducted in 2002 to determine possible discharge levels (Pacific EcoRisk 2002). In addition, it may be necessary to raise the pH in Pond 8 prior to discharging from this pond at high rates.

Discharges from Ponds 7, 7A, and 8 would be combined in a mixing chamber before discharge into Napa Slough. Discharge from Pond 7 would be controlled so that its flow is 1%–5%, depending on the discharge permit, of the total flow entering the mixing chamber. (The design of the mixing chamber would also allow the addition of recycled water, if recycled water use is incorporated into the complete alternative.) If recycled water is added, the discharge from all of the upper ponds could increase. The discharge from Pond 7 would increase by a rate equivalent to 1%–5% of the recycled water, depending on the discharge permit. The increase in discharge from Ponds 7A and 8 would depend on the salinity of the ponds. Given the relatively small volumes of brine in Ponds 7A and 8, however, the increased dilution provided by the recycled water would not have a substantial effect on the time required to desalinate these ponds. The use of recycled water is described in Section 2.5.3, “Water Delivery Option.”

Pond 8 would convey water into the canal passing to the northeast of Mud Slough (Figure 2-8). Pond 8 would operate based on water level (hydraulic head) only. Flow rates from Pond 7A into the mixing chamber would be determined by the hydraulic head present in the ponds and the mixing chamber. The control gates from Ponds 7A and 8 into the mixing chamber would regulate inflows and

would depend on the relative pond salinities. Water from the mixing chamber would be sent through the canal to discharge into the Napa Slough. After initial salinities have decreased (after 1–2 years), the discharge from the mixing chamber could be increased with the same rate of discharge to Napa Slough, and additional discharge either into Pond 6A or into the canal adjacent to Ponds 6/6A and from there into Pond 5. This approach could potentially double the rate of bittern discharge, and reduce the time required to desalinate Pond 7 by 15–25 years.

The estimated discharge from Ponds 7, 7A, and 8, via the mixing chamber and the reconstructed canal is 7 cfs (RMS); this could potentially double to 14 cfs (RMS) once discharge through the siphon under Napa Slough is added.

Timing and Duration. Based on current modeling results and assumed initial conditions, operations could proceed on the following schedule beginning in approximately September 2004.

- Pond 6/6A:
 - Salinity reduction would require approximately 12–18 months. This process would begin once Pond 4/5 has reached ambient salinities, i.e., either 1–2 months after the start of desalination under Option 1C or 12–18 months after the start of desalination under Options 1A and 1B.
 - Breaching of Pond 6/6A may occur many years after it has reached ambient or near-ambient salinity as described in Section 2.5.4, “Habitat Restoration Options,” if at all. The future management of Pond 6/6A depends on the habitat restoration option selected.
- Ponds 7, 7A, and 8:
 - Pond 7A has relatively low salinity and of the three ponds is expected to reach ambient salinity levels first; the estimated time for Pond 7A to reach ambient salinity levels is 1–2 years.
 - Pond 8 salinities have also decreased; however, Pond 8 has a low pH and may require adjustment of the pH prior to desalination.
 - Pond 7 contains high-salinity bittern. Salinity reduction in Pond 7 is estimated to require 30–50 years. The duration required to desalinate Pond 7 is much greater than that for the rest of the ponds because the bittern requires such high dilution prior to discharge. Decreasing the required pre-dilution ratio for bittern would reduce the time required for salinity reduction in this pond.

2.5.2.2 Salinity Reduction Option 2: Napa River and San Pablo Bay Discharge

Introduction

As noted earlier, numerous reverse flow options were considered but eliminated because they would increase desalination time (delay the time at which one or more ponds could be opened to tidal action) and/or could lead to unacceptably high increases in salinity in the lower ponds, which are already viable habitat. However, reverse flow would allow discharge to San Pablo Bay, which could increase the San Francisco Bay RWQCB's allowable discharge rate for salt (because San Pablo Bay is more saline than the Napa River, has a larger tidal flow, and has much better mixing and dispersion).

This modified reverse-flow option addresses the issue of delay in opening the ponds, as well as controlling the salinity increases in the lower ponds, while still allowing discharge to San Pablo Bay. Under this option, there would be two components: salinity reduction in Ponds 3, 4, and 5, with discharge to the Napa River; and salinity reduction in Ponds 7, 7A, and 8 via Ponds 1, 1A, 2, and 6/6A, with discharge to San Pablo Bay. Although salinity reduction is not required for Ponds 1, 1A, and 2, water would be discharged to San Pablo Bay in part through the existing culvert at Pond 1; therefore, this component includes transfer of higher salinity water through Ponds 1, 1A, and 2, which are already managed tidal ponds.

The salinity reduction process for these two components would occur simultaneously as described below and illustrated in Figure 2-9.

Ponds 3 and 4/5

Construction

Facilities. Construction would be very similar to that described for Ponds 3 and 4/5 under Salinity Reduction Option 1A. As for Salinity Reduction Option 1A, the two ditches in the Pond 3 levees would have to be filled in. Under Salinity Reduction Option 2, Pond 3 would not be opened to tidal action immediately after it reaches ambient salinity, but instead would act as a mixing chamber for the desalination of Pond 4/5. This means that no outfall would have to be built from Pond 4 to the Napa River.

The locations of the intakes and outfalls are shown in Figure 2-9. Pond 3 intake and outfall locations are identical to those described for Salinity Reduction Option 1A. The intake at Pond 5 for desalination of Pond 4/5 is also the same as for Salinity Reduction Option 1A; however, the discharge would be via the outfall at the southeast corner of Pond 3. In addition, as noted above, the existing levee breaches between Ponds 4 and 5 would be widened so that there would be four 100-foot-long breaches. A manual control structure would be installed at the siphon between Ponds 3 and 4 (the structure would be closed if the Pond 3 discharge exceeds the permit requirements). The number and sizes of intakes

and outfalls would be different than for Salinity Reduction Option 1A, because there would be no discharge from Ponds 6/6A. This option would include the water conveyance structures for Ponds 3 and 4/5 listed below.

Intakes. Intakes would be constructed to connect

- the Napa River to the northeast corner of Pond 3 (nine 54-inch culverts that bisect the levee and extend approximately 600 feet into the river);
- Dutchman Slough to the southwestern side of Pond 3 (three 48-inch-diameter culverts that bisect the levee and extend approximately 300 feet into the slough);
- Napa Slough to the north-central section of Pond 5 (eleven 54-inch-diameter culverts that bisect the levee and extend approximately 500 feet into the slough); and
- Pond 4 to Pond 3 (one 48-inch-diameter, 350-foot-long siphon under Napa Slough).

Outfalls. Outfalls would be constructed to connect the southeast side of Pond 3 to the Napa River (two 52-inch diameter culverts bisecting the levees and extending 1,100 feet into the river).

Equipment. Equipment used for construction would be the same as under Salinity Reduction Option 1A.

Timing and Duration. Timing of construction would be the same as under Salinity Reduction Option 1A.

Operations and Maintenance

Facilities. Salinity reduction operations for Ponds 3 and 4/5 would be very similar to the operations for these ponds under Salinity Reduction Option 1A. However, as described above, after it reaches ambient salinity Pond 3 would act as a mixing chamber for the desalination of Pond 4/5. Widening the breaches of the levee between Ponds 4 and 5 would promote mixing between the ponds. The water from Pond 4/5 would be transferred southward under South Slough to Pond 3 through the siphon between Ponds 3 and 4, before being discharged into the Napa River. Flow through the Pond 3/Pond 4 siphon would be controlled to ensure that the salinity in Pond 3 remains at an acceptable level.

- Operation and monitoring of the intakes and outfalls would be identical to that described for Pond 3 intakes and outfalls in Salinity Reduction Option 1A.

Timing and Duration. As under Salinity Reduction Option 1A, operations would begin in approximately September 2004. Because Pond 3 would act as a mixing chamber for Pond 4/5 desalination, habitat restoration could not begin there until the desalination of Pond 4/5 is complete. Ponds 3 and 4/5 could be opened to tidal action approximately 2–3 years after the start of the desalination process. However, to avoid adverse impacts associated with the increased tidal

prism, it is likely that ponds would have to be opened to tidal action sequentially; therefore, Pond 4/5 probably could not be opened to tidal action until several years after it is desalinated.

Ponds 1, 1A, 2, 6/6A, 7, 7A, and 8

Construction

Facilities. The intakes at Ponds 7, 7A, and 8 would be similar to those under Salinity Reduction Option 1, although the outfall into Napa Slough would not be constructed, and no intakes would be required for Ponds 6/6A. Additional infrastructure for this option includes

- installation of two 54-inch siphons from Pond 6 to Pond 2;
- replacement of an existing 72-inch siphon that connects Pond 2 to Ponds 1 and 1A with two 54-inch siphons, or refurbishing the existing siphon; and
- construction of one new 63-inch–inner diameter (72-inch–outer diameter) outfall culvert underneath SR 37, allowing water to flow from Pond 1 to San Pablo Bay. The second culvert would be installed to increase the dilution capacity in Ponds 1 and 1A, and thereby increase the rate at which water can be discharged from the upper ponds.

As with Salinity Option 1, the interior levee for Pond 6/6A would have four 100-foot breaches to ensure proper mixing.

Equipment. Equipment used for construction would be the same as under Salinity Reduction Option 1.

Timing and Duration. The increased construction required by this salinity reduction option would either require additional staff and equipment, or would require an additional 2 months to complete compared to the construction effort under Salinity Reduction Option 1.

Operations and Maintenance

Facilities. Salinity in the upper ponds (Ponds 7, 7A, and 8) and Pond 6/6A would be reduced through mixing and discharge via Ponds 1, 1A, and 2. As shown in Figure 2-9, additional water from Napa Slough would be introduced into the upper ponds and conveyed southward through Ponds 6A, 6, 2, and 1/1A, in that order, before being discharged into San Pablo Bay.

Discharge from the upper ponds would follow the same general approach as under Salinity Reduction Option 1. Ponds 7, 7A, and 8 would discharge to a mixing chamber. As with Salinity Reduction Option 1, recycled water could be introduced into the mixing chamber to provide added dilution. The use of recycled water is described in Section 2.5.3, “Water Delivery Option.” From the mixing chamber, the water would be conveyed through the siphon under Napa Slough into Pond 6/6A.

In general, flow from the upper ponds would be controlled by measuring the salinity of the water leaving Pond 6/6A. The siphon under Napa Slough would be equipped with a water control structure that would close if the salinity at the Pond 6/6A discharge location exceeds a preset value. The closing of the siphon under Napa Slough would in turn trigger closure of the mixing chamber discharge. The increased water height (head) in the mixing chamber would then prevent more water from the ponds from entering the mixing chamber. The flow from Pond 7 into the mixing chamber would be controlled at a ratio that considers the flow from Ponds 7A and 8, as well as the added dilution water provided in Ponds 1 and 1A.

From Pond 6/6A, the water would pass through a new siphon to Pond 2, and from there through the refurbished siphon or replacement siphons into Ponds 1A and 1. Ponds 1 and 1A would be used as a mixing chamber for the water conveyed from Pond 2. From Ponds 1 and 1A the water would be discharged into San Pablo Bay through the two outfall culverts under SR 37.

The capacity of the intakes for Ponds 7 and 7A would be double that of Salinity Reduction Option 1. The outfalls (discharges to the mixing chamber) would allow 2.5 times the flow of Salinity Reduction Option 1. As with Salinity Reduction Option 1, the bittern would have to be diluted by a factor between 1:100 and 5:100 before discharge. The higher overall water flow through the system (including the dilution water brought into Ponds 1 and 1A) means that the total discharge from Pond 7 would be approximately 2.5 times higher than for Salinity Reduction Option 1.

Timing and Duration. As under Salinity Reduction Option 1, operations would begin in approximately September 2004. Salinity reduction would proceed as follows:

- **Ponds 1, 1A, 2, and 6/6A:** Because higher salinity water would be mixed with the water in these ponds, salinity would increase temporarily during the desalination period. The increase in salinity would peak at approximately 20–30 ppt over existing salinities for Ponds 1, 1A, and 2; the Pond 6/6A salinity would not increase above the starting salinity. Salinity in Ponds 1, 1A, and 2 would begin to decrease as the salinities in the upper ponds begin to decrease.
- **Ponds 7, 7A, and 8:** Flushing the bittern pond (Pond 7) is estimated to be reduced to ambient conditions in less than 10 years; it may require up to 15 years if recycled water is not employed. Ponds 7A and 8 have lower salinities than Pond 7; coupled with the much greater discharge rate from the ponds, the estimated time required to desalinate both of these ponds under Salinity Reduction Option 2 is 6 months–1 year. If recycled water is used, monitoring would be conducted to ensure that there are no adverse consequences for the existing habitat values in the ponds. Because the recycled water would be introduced into the lower ponds (rather than being discharged directly to the Napa Slough), there is a possibility that eutrophication could occur seasonally.

Due to the higher concentration of bittern released from the mixing chamber, the water from the upper ponds could not be discharged through the Pond 6/6A canal into Pond 5, so the discharge is limited to the amount that would be discharged to San Pablo Bay.

2.5.3 Water Delivery Option

In addition to water delivery to the project site by the tidal influence of San Pablo Bay, this option includes the delivery of tertiary-treated recycled water from WWTPs in the north bay region. This option includes a *Water Delivery Project Component* and a *Water Delivery Program Component*:

- *Water Delivery Project Component*: A combined 6,000–7,000 af/year of tertiary-treated recycled water would be provided from three local WWTPs—the Sonoma Valley County Sanitation District (SVCS D) WWTP, the Napa Sanitation District (NSD) WWTP, and the CAC WWTP—for salinity reduction, and subsequently for agricultural irrigation. This component is considered feasible and therefore is currently a part of the Water Delivery Option.
- *Water Delivery Program Component*: Tertiary-treated recycled water from other reclamation plants in the north bay region could be added to the system at some point in the future assuming the Water Delivery Project Component is implemented.

The alignment, construction program, and operational characteristics of each of the two pipelines currently proposed for the Water Delivery Option are described below. In addition, pipeline alignments, construction programs, and operational characteristics are described more generally for the potential future addition of recycled water from other reclamation plants.

The impact analyses in Chapters 3–16 of this document are at a project level for the currently proposed concept (Water Delivery Project Component) and at a program level for the potential future phase(s) (Water Delivery Program Component). If specific proposals are made for such future phases, Sonoma County Water Agency (SCWA) would prepare more detailed information. The potential environmental impacts of those future detailed proposals would then be addressed by SCWA at a project level of analysis through a separate supplemental environmental document. The Corps and Coastal Conservancy would not serve as the lead agencies for future analysis, and the current analysis of the water delivery options must also be certified by SCWA.

2.5.3.1 Water Delivery Project Component

Figure 2-10 shows the alignments proposed for the recycled water conveyance pipelines from the SVCS D, CAC, and NSD WWTPs to the proposed new mixing chamber within the Napa River Unit site. The pipeline proposed to carry tertiary-

treated recycled water from the SVCSD WWTP is referred to as the *Sonoma Pipeline*, the tertiary-treated recycled-water pipeline from the NSD WWTP is referred to as the *Napa Pipeline*, and the tertiary-treated recycled-water pipeline from CAC WWTP is referred to as the *CAC Pipeline*. The specific characteristics of each pipeline are described below.

Water Delivery Project Component (Sonoma Pipeline)

Alignment

The proposed Sonoma Pipeline would carry water from the SVCSD WWTP to the Napa River Unit Project site, as illustrated in Figure 2-10. The pipeline would have the two segments described below.

Segment 1: The first segment of the Sonoma Pipeline would be 3.3 miles long and consist of two 18-inch pipes constructed of polyvinyl chloride (PVC). One pipe is existing; the other pipe would be added as part of project component construction. Segment 1 of the pipeline would carry water only from the SVCSD WWTP to the water storage reservoirs near the intersection of the railroad line owned by the Northwestern Pacific Railroad Authority (NWPRA) and Ramal Road.

This segment would begin just south of the SVCSD WWTP, near an existing flow-splitting structure. This structure directs flow either to a wet-season discharge into Schell Slough or to a pipeline to convey water to storage reservoirs used during the dry season. The existing pipeline, an 18-inch transmission line (T-1), carries water during the dry season but does not have enough capacity to handle higher wet-season flows (approximately 12 million gallons per day [mgd]).

To increase the capacity of the existing pipeline, a pump station would be constructed near the splitting structure, and a second 18-inch PVC pipeline would be built to parallel the existing T-1 transmission line. This pipeline would travel east from the splitting structure for approximately 3,900 feet, then would turn southeast and continue approximately 13,300 feet along the NWPRA alignment.

Two portions of this pipeline segment, each less than 100 feet long, would be constructed to cross under a portion of Schell Slough and another unnamed creek.

Segment 2: The second segment of the Sonoma Pipeline would be 3.8 miles long, 36 inches in diameter, and constructed of either PVC or high-density polyethylene (HDPE). This segment of pipeline would carry water from both the SVCSD WWTP and potential future pipelines from the west (Water Delivery Program Component).

The new pipeline would begin near the terminus of both the T-1 transmission line and the new 18-inch transmission pipeline. A new pump station would be required at this location to provide additional capacity for accommodating the existing SVCSD WWTP peak flows and any future increases in peak flow that

may result from the addition of recycled water from other treatment plants in the north bay region. The new pump station would be designed and constructed in a modular fashion so that additional capacity could be provided incrementally. The new pump station would seek to maximize use of the existing reclamation storage basins, conveyance pipelines, and pumping capacity to provide a seamless interaction with the existing system.

From the new pump station, Segment 2 would extend east along the south side of the NWPRA railroad tracks for approximately 3,100 feet to Skaggs Island Road. Depending on localized soil conditions and surface topography, it is anticipated that the pipeline would have a minimum burial depth of 4–6 feet along the entire alignment.

At Skaggs Island Road, the pipeline would cross to the north side of the railroad tracks. The pipeline would continue east along the north side of the railroad for another 2.3 miles until it reaches the access road for Ponds 7 and 7A. At least two additional sections, each less than 100 feet long, would be required through this section to cross streams.

At the access road, the pipeline would cross to the south side of the railroad tracks and continue south along the access road for approximately 4,200 feet to its terminus at the mixing chamber.

Construction Characteristics

As described above, the pipeline would be placed mainly within the railroad right-of-way (ROW); the southernmost segment would be located along the Pond 7 and 7A access road on DFG property, and the northwestern portion would be located in an existing easement through grazed and farmed baylands. It is anticipated that the pipeline would be constructed using primarily open-trench methods; the trench would be approximately 6 feet wide and 8–10 feet deep.

The construction corridor activity zone for trenching and pipeline installation would typically be about 30 feet wide, but could be narrowed to 20 feet for short distances if necessary (i.e., if there are physical or natural resource constraints). Figure 2-11 provides a cross section of the typical pipeline trench construction area. Traffic control plans would be implemented to maintain traffic flows, including possible use of temporary detours or reconfiguration of travel lanes and turning movements, while the pipeline is installed.

Trenchless construction methods would be used at specific locations along the pipeline route, such as when transitioning the pipeline alignment from one side of the railroad tracks to the other (two such crossings are proposed) and to cross beneath, rather than trench through, streams (at least four such crossings are anticipated).

Construction staging would occur near the proposed pipeline route and include either a single 2-acre staging area centrally located near the route, or two 1-acre staging areas, one near the beginning of the route and the other near the terminus of the route. Staging area location(s) would be selected in conjunction with final design/construction specifications and in coordination with the construction

contractor. The staging area(s) would be situated within existing clearings or other disturbed areas.

The typical construction equipment mix for the pipeline construction is likely to include

- a loader/backhoe;
- a small crane;
- six dump trucks, each with a capacity of about 15–18 cubic yards;
- an excavator and/or excavator/compactor;
- a paver and a pavement distributor;
- a roller;
- a water truck;
- a 50-horsepower generator; and
- four pickup trucks for the construction crew.

The contractor's selection of equipment may vary, to some degree, from the above list depending on site conditions, construction needs, and availability of specific pieces of equipment. Only a subset of the above equipment would be in operation or present on-site at any given time, changing at each specific stage of pipeline construction.

It is anticipated that the open-trench pipeline construction method would use 200- to 300-foot-long trench sections and that construction would proceed at an average rate of approximately 50 linear feet of pipeline completed per day. Three work crews would work simultaneously on different sections of the pipeline so that the pipeline could be completed in approximately 1 year, with work days likely to be approximately 10 hours long. Work would typically occur Monday through Friday, beginning between 5 a.m. and 7 a.m. and ending between 3 p.m. and 5 p.m. The total duration of construction and days/hours of activity could vary from those described above based on weather, field conditions, contractor performance, and special circumstances.

Operational Characteristics

Flows within the pipeline would vary depending on the amount of tertiary-treated wastewater being processed at any given time at the source plant(s). Segment 1 of the pipeline would operate under pressurized flow conditions, and would be designed to convey a maximum wet-weather flow of 12 mgd. Segment 2 would also operate under pressurized flow conditions but would be designed for a maximum peak wet-weather flow of 50 mgd, which would only be experienced under potential future phases (see Section 2.5.5.2, "Water Delivery Program Component"). Any peak flows in excess of 50 mgd (e.g., resulting from storm influence) would be attenuated using the existing SVCS D reservoirs.

The pipeline would include a monitoring system to detect any sudden change in pressure (e.g., pipeline break, leak, blockage, or other problem). The system

could include a series of pressure gages, spaced along the pipeline or at critical locations, connected to an alarm/autodialer unit or telemetry system that would immediately notify operations personnel of a potential problem.

Water Delivery Project Component (Napa Pipeline)

Alignment

In general, the proposed alignment (see Figure 2-10) can be described in terms of the two segments described below.

Segment 1: The first segment of the Napa pipeline would be 3.3 miles long, 24” in diameter, and constructed of either PVC or HDPE. The pipeline would connect to an existing NSD reclaimed water pipeline that conveys water north to users in the City of Napa. The pipeline would head northwest toward the Los Carneros region and cross under the Napa River using a directional bore process. Once on the western side of the Napa River, the pipeline would proceed northwesterly and connect with Stanly Lane (3,100 feet). The pipeline would continue on Stanly Lane for approximately 1,500 feet until the pipeline turns southwest for approximately 5,000 feet to connect with Cuttings Wharf Road. The pipeline would travel in Cuttings Wharf Road for 3,000 feet and onto Milton Road for 1,700 feet. The pipeline would then turn west on Las Amigas Road for approximately 3,000 feet until it met with Buchli Station Road.

Segment 2: The pipeline would turn south on Buchli Station Road for approximately 5,000 feet and would connect with the Sonoma Pipeline just south of the Northwestern Pacific Railroad Authority rail line. This segment of the pipeline would also be 24” in diameter and constructed of either PVC or HDPE.

Segment 1 has been analyzed previously in the “Los Carneros Recycled Water Irrigation Pipeline Initial Study/Negative Declaration.” For the purposes of this EIR/EIS, Segment 2 will be evaluated in all resource categories; Segment 1 will be evaluated for resource categories where a change in the existing conditions could change the conclusions of the earlier analysis.

Construction Characteristics

The overall characteristics of the construction program for the Napa Pipeline would be comparable to those of the Sonoma Pipeline described above. The pipeline would be placed mainly within the existing road ROW. A portion of the pipeline (5,000 feet) would also traverse the Stanly Ranch property including crossing an unnamed drainage. Trenching would be used for pipeline construction across the drainage ditch. Approximately 2 acres would likely be required for construction staging at one or two locations along the pipeline route. Staging area locations would be selected in coordination with the construction contractor and are anticipated to be local paved, cleared, or otherwise disturbed lots.

Based on construction methods and a rate similar to those described above for the Sonoma Pipeline, completion of the Napa Pipeline is estimated to take approximately 1 year. Actual construction activity characteristics may vary from

those described above based on weather, field conditions, contractor performance, and special circumstances.

Operational Characteristics

The basic operational characteristics of the Napa Pipeline are comparable to those described above for the Sonoma Pipeline, with the most notable exception that the peak wet-weather design capacity of the Napa Pipeline would be only 8.5 mgd rather than 50 mgd.

Water Delivery Project Component (CAC Pipeline)

Alignment

The proposed alignment (see Figure 2-10) is described below in two segments.

Segment 1: The CAC Pipeline would originate at the CAC WWTP. The pipeline would be 18" in diameter and constructed of PVC. The pipeline would run approximately 2,000 feet north beneath Mezzetta Court through a developed industrial area. The pipeline would intersect with Green Island Road and follow the roadway onto Cargill Salt's property. The length of this segment is approximately 14,000 feet.

Segment 2: This segment of the pipeline would make use of Cargill Salt's existing conveyance pipeline crossing the Napa River. The segment would begin at an existing pumping station on the east side of the river and run directly west through an existing 24-inch transite pipeline to a 16-inch rubber pipeline. The total length of this segment is approximately 2,500 feet. Once the treated water reaches the west side of the Napa River, it could easily be conveyed to the surrounding salt ponds using existing surface waterways within the salt pond complex.

Construction Characteristics

The overall characteristics of the construction program for the CAC Pipeline would be comparable to those of the Sonoma Pipeline described above. The pipeline would be placed mainly within existing roadway and railroad alignments. Approximately 2 acres would likely be required for construction staging at one or two locations along the pipeline route. Staging area locations would be selected in coordination with the construction contractor and are anticipated to be local paved, cleared, or otherwise disturbed lots.

Based on construction methods and a rate similar to those described above for the Sonoma Pipeline, completion of the CAC Pipeline is estimated to take approximately 1 year.

Operational Characteristics

The basic operational characteristics of the CAC Pipeline are comparable to those described above for the Sonoma Pipeline. Similar to the Napa and Sonoma Pipelines described above, the CAC pipeline would convey increased flows during the wet season, when more reclaimed wastewater would be available. The

only difference is that the peak winter flows would be 2.5 mgd instead of 8.5 mgd for the Napa Pipeline and 50 mgd for the Sonoma Pipeline.

2.5.3.2 Water Delivery Program Component

If the proposed concept described above is implemented, adding tertiary recycled water from other WWTPs in the north bay region is a reasonable possibility. As the use of tertiary-treated recycled water for salinity reduction and/or agricultural irrigation proves to be a feasible and desirable means of treatment plant water management, and as conveyance pipelines are extended within the north bay region, thereby reducing the incremental amount of new pipeline that each water/sanitation district would need to construct, there would be greater impetus for the other districts to participate. There is considerable uncertainty about the exact nature, extent, and timing of such participation by other water/sanitation districts in the north bay region; however, basic assumptions can be made regarding potential pipeline alignments. As noted above, more detailed project data and attendant project-level environmental analysis would be completed if and when such future proposals were to proceed.

There are three WWTPs in the north bay region that could provide additional tertiary-treated recycled water in a potential future phase of the Water Delivery Option. The following describes and Figure 2-12 illustrates the location of, and potential pipeline route for, each WWTP.

- *Novato Pipeline:* The Novato Sanitary District (Novato SD) WWTP is approximately 14 miles southwest of the project site. A potential pipeline route for conveying tertiary-treated recycled water would start at the plant, proceed northeast along SR 37 for approximately 7 miles to SR 121, then follow an existing railroad ROW for approximately 4 miles, then extend eastward along a small unpaved road for approximately 2 miles, and finally connect with the Sonoma Pipeline.
- *Petaluma Pipeline:* The City of Petaluma WWTP is approximately 14 miles west of the project site. A potential pipeline route for conveying tertiary recycled water would start at the plant, proceed southeast along Lakeville Road for approximately 10 miles, and then connect with the Novato SD WWTP pipeline.
- *Las Gallinas Pipeline:* The Las Gallinas Valley Sanitary District (LGVSD) WWTP is approximately 17 miles southwest of the project site. A potential pipeline route for conveying tertiary-treated recycled water would start at the plant and proceed north along U.S. Highway 101 (U.S. 101) for approximately 4 miles, and then connect with the Novato SD WWTP pipeline.

It is anticipated that the construction methods, equipment mix, and average work crew size for each pipeline would be generally comparable to those described above for the Water Delivery Project Component. The specifics of the

construction activity and the exact alignment of the pipeline route would be determined during the more detailed engineering and design phases. Although this document covers these activities on a programmatic level, future environmental documentation would be required.

2.5.4 Habitat Restoration Options

2.5.4.1 Introduction

This introduction provides an overview of the two types of habitats, tidal marsh and managed ponds, that would be created at the project site, and how these habitats would be created. Tidal marsh is discussed first, followed by managed ponds.

Overview of Tidal Marsh and Tidal Wetland Restoration

Overview of Tidal Marsh

Tidal marsh is vegetated wetland that is subject to tidal action. It occurs in the baylands from the lowest areas with vascular vegetation to the top of the intertidal zone. Tidal marsh plant communities vary tremendously based on salinity, substrate, and water depth, and other factors like wave energy, marsh age, sedimentation, and erosion. There are three general zones of vegetation in tidal marshes: lower tidal marsh, middle tidal marsh, and upper (high) tidal marsh. The locations of these zones vary based on elevation and distance from shore, and are illustrated in Figure 2-13. At elevations below tidal marsh are the intertidal mudflats, shallow bay, and deep bay. Uplands are at elevations above the upper marsh.

Tidal marshes have a variety of important components including tidal channels. Both large tidal channels and smaller tributaries form a drainage network that distributes tidal waters throughout the marsh. For level marshes, channels tend to be sinuous or braided; for steep marshes, channels tend to be straighter. Channel density, the amount of channel habitat per acre of marshplain, is directly related to *tidal prism*, the volume of water that flows into and out of the marsh. An upper marsh with a small tidal prism typically will have fewer channels than a lower marsh with a larger tidal prism. (Goals Project 2000.)

A *microtidal marsh* is a tidal marsh that receives less than full tidal flow because of a physical impediment. Areas that do not receive full tidal flow are frequently referred to as being “muted.” This muting can result from the presence of natural formations such as a sand bar or of human-made structures such as tide gates, culverts, or other water control structures. Muted tidal marshes exhibit many of the same features of fully tidal marshes, although they frequently lack the same range of plant diversity. Muted tidal marshes may be important to some wildlife groups such as shorebirds during the fall migration, but may also exclude other species. (Goals Project 2000.)

Tidal Wetland Restoration

Tidal wetland restoration involves hydrology, civil engineering, biology, and other scientific and engineering disciplines. This section provides a brief overview of the processes and factors involved in tidal wetland restoration. These factors were considered in developing the habitat restoration options described later in this section.

Tidal wetland restoration is a long-term process. As stated in the *Baylands Ecosystem Habitat Goals* report, produced by the San Francisco Bay Area Wetlands Ecosystem Goals Project (Goals Project 1999) (pp. 149–150):

Tidal wetlands take time to develop; when a site is restored, the initial set of habitat components will evolve for many years. After establishment, a tidal marsh with adequate sediment typically evolves in the following ways: (1) the drainage network becomes less complex, (2) remaining channels become deeper and narrower, (3) salinity gradients across the marsh plain become more variable and steeper, (4) the amount of marsh plain that is not directly serviced by any channel increases, (5) surface drainage decreases, and (6) the amount of pans increases. Even at restoration sites where there is rapid sedimentation (e.g., Pond 2A in North Bay and the Petaluma River Marsh), it may take many years, even decades, before the marshes exhibit a full array of habitat features.

Also according to the Goals Report, a high-quality marsh has

- a natural transition to adjacent uplands,
- wide upland buffers to minimize human disturbance,
- connections with other large patches of tidal marsh that enable marsh-dependent birds and small mammals to move safely between them,
- pans in the marshplain and along the marsh/upland transition,
- other wetland types and mudflats nearby,
- a dominance of appropriate species of native plants and animals, and
- a minimum of uplands or structures intruding into or fragmenting the marsh to discourage predator access.

Tidal Habitat Evolution

During the evolution of subtidal areas (the elevations of most pond bottoms are at or below mean tide level [MTL]) to fully functioning marsh, there are typically a series of successive habitats. Initially, sediment is deposited in the subtidal areas and intertidal mudflats develop. As sediment continues to deposit, portions of the area reach elevations where colonization by lower marsh vegetation is feasible. Once lower marsh vegetation is established, it continues to trap sediment and organic detritus, and the elevation of the site increases further to middle marsh plain. Upper marsh may also form along the upland edge (preexisting high ground) such as the levees.

The habitat restoration options were analyzed by PWA to better characterize the evolution of the site over the next 50 years. Evolution of the project area was evaluated in terms of creation and loss of subtidal, intertidal mudflat, lower

marsh, middle marsh (marshplain), and upland/transition habitats, both within the breached ponds and in the remnant slough channels between ponds. The analysis assumed that the rate at which marshes evolve after being opened to the tide is a function of

- initial site elevation;
- vegetation colonization elevations; and
- sedimentation rates, which vary depending upon suspended sediment supply, tidal inundation, and wind/wave resuspension.

The analysis also assumed good low-tide drainage within the ponds. Poor drainage can limit delivery to the ponds and impede establishment of vegetation.

The initial site elevation of a restoration site greatly influences how quickly the site can be restored. Sites that are at or near the height required for initial vegetation colonization typically are restored much more quickly. Figure 2-14 compares initial elevation of restoration sites in the San Francisco Bay to the time it took for the site to reach 50% vegetative cover. The initial site elevations of the ponds in the Napa River Unit are shown in Figure 2-3. A digital elevation model of the pond interiors was used to calculate colonization as a function of elevation (Figure 2-15). As can be seen from Figure 2-15, all ponds are subsided below the level where vegetation colonization is expected to occur and Pond 3 is the closest to reaching an elevation suitable for vegetation colonization.

Vegetation colonization observed at other restored marshes in San Francisco Bay has been used to predict vegetation rates, patterns, and colonization relative to tidal elevations. It has been assumed for the ponds that initial colonization by lower marsh species (predominantly cord grass, bulrush, and cattail) would occur only on high-elevation mudflats, 0.3 meter above MTL and higher. Vegetation would extend to lower elevations through lateral colonization, down to MTL. Lower marsh vegetation is assumed to gradually increase in percent coverage. Once fully established (100% coverage), lower marsh is assumed to transition to middle marsh after 10 years. Middle marsh vegetation up to mean higher high water (MHHW) has been assumed to increase more quickly, from 0% to 100% over 3 years from initial colonization.

Since the ponds are subsided below vegetation colonization elevations in many areas, sedimentation rates will control the evolution of tidal habitats once the ponds are breached. According to the *Baylands Ecosystem Habitat Goals* report (p. 19),

Although deposition rates vary around the Bay, tidal marshes eventually reach intertidal heights suitable for plants, and later, with the addition of organic sediment that the plants provide, the marshes reach equilibrium with sea level rise. Initial accretion rates of more than two feet per year are common in deeply subsided areas, but these rates decrease as the marsh plain rises... Tidal marsh restoration projects underway at several sites in the Estuary indicate that substantial accretion and re-colonization by marsh vegetation can occur quickly. For example, the Petaluma River Marsh has accreted sediment at a rate of about 1.5 feet per year since the site was opened to tidal action in 1996, and marsh

vegetation is becoming well established (Siegel 1998). Marsh vegetation began to colonize Pond 2A in the Napa Marsh within six months after it was opened to tidal action in 1995 (Swanson, pers. comm.).

An initial assessment of existing sediment fluxes to the system compared to projected sediment demand by year with the restoration indicates that the current influx of sediment is more than the maximum demand. However, existing sediment supply may not be sustainable once the restoration occurs, because of the increased sediment sink and changes in the regional sediment budget. Conversely, sediment supply may actually increase as a result of the erosion of the existing tidal sloughs that run through the site. The uncertainty in the long-term sediment supply is considered in the phasing of the habitat restoration options.

Sedimentation is also affected by wind/wave action and by neighboring projects. Waves generated in the ponds by wind could reduce the sedimentation rates by either resuspending recently deposited muds or keeping suspended sediments from depositing. Cullinan Ranch, located between SR 37 and the project area, is owned by USFWS as part of the San Pablo Bay National Wildlife Refuge and is slated for restoration to tidal marsh in 2004 at the earliest. Once levees are breached, the demand for sediment in the Napa River Unit will increase, reducing the amount available to the breached ponds.

Design features can be used to speed marsh evolution and to nurture the evolution of marsh components. Faster marsh evolution would reduce potential impacts associated with marsh habitat loss that would occur as a result of scouring of the existing slough channels (once ponds are breached and the tidal prism is increased). The following design features are being considered for the Napa River Unit:

- blocking the borrow ditches between the levee breaches with sediment to keep them from capturing tidal circulation;
- regrading a portion of the levees to an elevation of MHHW by sloping them into the ponds;
- excavating starter channels, and using the excavated sediment to create berms; and
- placing limited amounts of fill to speed initial vegetative colonization and offset short-term decreases in marsh habitat.

These design features are described below. The specific design features applicable to each habitat restoration feature are described under each of the habitat restoration options.

Ditch Blocks. A *ditch block* is simply an area of earth fill that crosses an existing borrow ditch or other channel to inhibit flow. *Borrow ditches* are humanmade drainage channels located adjacent to levees. The purpose of the ditch block is to inhibit existing borrow ditches from capturing the tidal supply

and impeding reestablishment of the natural historic channels. Ditch blocks would be constructed based on a consideration of natural marsh morphology.

The levees adjacent to the proposed ditch block locations would be lowered to provide fill. Levees would be lowered close to MHHW to maximize generation of relative dry earth, while maintaining a weight-bearing surface for construction equipment. The ditch blocks would be approximately 100 feet long and 40 feet wide at the top. They would have a finished grade of about MHHW with an average height of 4 feet, and 5:1 side slopes.

Levee Lowering. Levee lowering would consist of excavating the upper portion of an existing levee, and partially filling an adjacent borrow ditch or pond with the excavated material. Borrow ditches would not be filled completely; they would allow continued movement of aquatic species. Levee lowering as referred to here would be in addition to that accompanying the construction of ditch blocks.

Levees would be lowered for several reasons. Levees are human-made features, and can provide access and habitat for predators that compromise the ecological objectives of restoration. Levees can also act as barriers to species migration by creating discontinuous habitat. The lowering of levees near large patches of fringing marsh to elevations consistent with upper marsh vegetation, particularly gumplum (*Grindelia stricta*), can provide high-tide refugia for marsh species, reducing the risk of predation during high winter tides. The lowering of levees to elevations consistent with marsh vegetation where smaller sections of fringing marsh along slough channels are expected to erode can maintain connectivity between larger patches of fringing marshes, so that marsh species traveling between marshes are less subject to predation. Each habitat restoration option includes a total number of feet of levee that would be lowered, but the exact locations for levee lowering would be determined in consultation with resource agencies, in order to best serve marsh species. The figures for each habitat restoration option only show the initial work to identify sections of levees to lower; these figures are subject to change.

The crest elevation of certain sections of levees would be lowered to an elevation consistent with marsh vegetation and habitat. Levee lowering would consist of moving earth from the upper part of the levee sideways onto the back slope and into the adjacent borrow ditch, if appropriate.

Starter Channels and Berms. A *starter channel* is an excavated channel extending from a breach into a pond. Starter channels would benefit habitat restoration by facilitating more rapid channel and marsh development, and may increase the eventual density of channel drainage. Starter channels would help establish a desired channel pattern, typically similar to the historic pattern, which is likely to result in maximum habitat benefits. Starter channels would provide habitat for fish soon after construction, and would promote the more rapid formation of smaller channels that may ultimately become habitat for rails and other wildlife. The starter channels would also improve site drainage, which may enhance the rates of sedimentation and vegetation establishment.

A starter channel would typically follow a semisinuuous path consistent with the historic channel path. The constructed cross section would be roughly trapezoidal. The optimal channel size is the estimated equilibrium channel size. However, actual channel dimensions may be smaller, depending on construction practicality and costs. For example, a much smaller channel can still provide benefit and a much larger channel can be constructed without adversely affecting the restoration. Starter channels could be excavated at some or all of the levee breaches.

Sediment excavated from the starter channels would be placed into berms on one or both sides of the starter channel. The berms would be discontinuous so that side-channels are not obstructed. A *berm* is an embankment of earth fill located within a pond. Berms would directly facilitate rapid development of a diversity of marsh habitat by providing ground elevations conducive to vegetation establishment. Berms would also facilitate marsh establishment by serving as dissipaters of wave energy, creating more sheltered conditions conducive to sedimentation and vegetation colonization.

The proposed berms would be located parallel to the starter channels. The berm crest elevation would vary around MHHW. The intent would be to create an irregular, wide, low-height mound with flat slopes and a sinuous shape roughly paralleling the starter channels. A berm would likely be constructed on only one side of the channel, but berms could be constructed on both sides.

Fill Placement. This design feature would consist of placing up to 100 acres of earthen fill (sediment) into the southern portion of Pond 4, or a similar location with low historic channel density. The purpose of this fill would be to accelerate evolution to a vegetated marsh. The sediment would be placed no higher than 1 foot below MHHW elevation, to facilitate channel development on the new marsh. The fill could be placed by bucket or hydraulic means. Fill would be placed carefully to avoid creating undrained sections of the borrow ditch that could trap fish at low tide. Sediment would either be imported from a north bay source, or would be generated by dredging existing slough channels to deepen them. Any sediment used in this fill would be wetland cover quality.

Project Goals for Tidal Wetland Restoration

The goal of the project is to provide a mosaic of wetland habitats within the Napa River Unit, including tidal habitats and managed ponds. This mix of habitats would benefit a diversity of wildlife, including special-status species, migratory waterfowl and shorebirds, anadromous and resident fish, and other aquatic animals. All of the habitat restoration alternatives provide for a mix of tidal marsh and managed ponds, but vary in the extent of managed ponds restored to full tidal exchange.

Goals for tidal habitat restoration, which would include middle marsh, lower marsh, intertidal mudflat, and subtidal areas, are as follows:

- In a phased approach, restore large patches of tidal marsh that support a wide variety of fish, wildlife, and plants, including special status species.
- Create connections between the patches of tidal marsh (in the project site and with adjacent sites) to enable the movement of small mammals, marsh-dependent birds, and fish and aquatic species.
- Restore tidal marsh in a band along the Napa River to maximize benefits for fish and other aquatic animals.

The approach to tidal restoration for ponds opened to tidal action is to enhance tidal circulation and sediment deposition to enable natural processes to gradually regenerate a self-sustaining marsh ecosystem. As noted earlier, a high-quality marsh is well drained, has an extensive channel network, and has other wetland types nearby. Thus, the creation of a high-quality marsh ensures that other tidal habitats are also created.

Subtidal and mudflat habitat are the preliminary stages of tidal marsh restoration and also provide significant habitat values for invertebrates, birds, and fish.

Overview of Managed Pond Habitat and Pond Management

More than 7,000 acres of the Napa River Unit consist of inactive salt ponds that were used for salt production through the solar evaporation of bay water. These ponds, both historically and currently, serve as habitat for phytoplankton, invertebrates, fish, waterfowl, and shorebirds.

The habitat restoration options each provide for the continued management of at least five of the 12 ponds as ponds. Project goals for pond habitat are to enable DFG to better and more efficiently control water depth and salinity for the benefit of shorebirds and waterfowl. Waterfowl and shorebird use of the ponds is influenced by the water depth, salinity, and size of each pond. DFG will write a management plan for the Napa River Unit that will provide for pond management in the long term.

Levees and water control structures for all the ponds that would be preserved as ponds would need to be repaired or replaced so that salinity could be reduced in the short term and the water supply could be managed in the long term. The goal would be to maintain both the depth and salinity for a given pond within a specified range. The range would reflect the needs of different bird species likely to be present in the project area throughout the year, as well as seasonal variations. For example, it is likely that the managed ponds would have higher water levels and lower salinities in the winter (wet season) than in the summer (dry season). Water from the Napa River or Napa Slough would be added to ensure that the ponds do not drop below a certain critical depth, but the salinity of the water would increase during the dry season. Modeling suggests that the high evaporation rates during the dry season coupled with the increase in salinity in the intake water result in increases in salinity even when the water intake and

discharge structures are left open to maximize tidal exchange. Recycled water could also be used to help maintain the levels in the ponds but would only be used until salinity is reduced in the upper ponds. Potential eutrophication concerns would have to be addressed if this approach is chosen.

Habitat Evolution

The various habitat restoration options would evolve over different periods of time (Figure 2-16) and achieve different mixes of habitats (Table 2-2). These habitat estimates are based on detailed modeling by Philip Williams and Associates (PWA) (Philip Williams and Associates 2002a) and provide a reasonable estimation of future site conditions given the habitat restoration approaches pursued under each habitat restoration option. The approximate dimensions of the design elements are provided in Table 2-3 and the number and length of the design elements, including middle marsh habitat created by option, are provided in Table 2-4. All habitat restoration options are assumed to begin after salinity reduction occurs.

The habitat restoration options and methods for implementing these options are described in greater detail in the following pages. The habitat restoration approaches include four options:

- Habitat Restoration Option 1: Mixture of Tidal Marsh and Managed Ponds;
- Habitat Restoration Option 2: Tidal Marsh Emphasis;
- Habitat Restoration Option 3: Pond Emphasis; and
- Habitat Restoration Option 4: Accelerated Restoration.

Figure 2-16 and Table 2-2 indicate that Habitat Restoration Option 2 would result in the greatest increase in subtidal and intertidal mudflat habitats, and that Habitat Restoration Option 4 would result in the greatest increase in lower and middle marsh habitats. Habitat Restoration Option 3 would contain the largest area of managed ponds. For areas restored within Habitat Restoration Options 1, 2, and 3 these restoration efforts follow similar trends in the evolution of lower and middle marsh habitats, and are within 100 acres of one another until 40 years after restoration begins and more lower marsh evolves under Habitat Restoration Option 2.

Table 2-2. Habitat Mix Associated with Each Habitat Restoration Option (Acres)

	Year 10					Year 50			
	Present	Option 1	Option 2	Option 3	Option 4	Option 1	Option 2	Option 3	Option 4
Pond Interiors									
Subtidal	0	140	220	110	140	150	220	110	150
Intertidal mudflat	0	2,410	3,760	1,720	2,130	1,550	2,730	860	820
Lower marsh	0	260	280	260	400	50	190	50	610
Middle marsh	0	100	140	90	240	1,170	1,250	1,160	1,340
Managed ponds	6,460	3,550	2,080	4,290	3,550	3,550 ^a	2,080	4,290	3,550
Upland/transition	200	190	190	200	190	190	190	200	190
SUBTOTAL	6,660	6,660	6,660	6,660	6,660	6,660	6,660	6,660	6,660
Sloughs									
Subtidal	430	620	700	570	620	630	710	580	630
Intertidal mudflat	80	80	80	80	80	80	80	80	80
Lower marsh	30	30	30	30	30	30	30	30	30
Middle marsh	1,210	1,020	940	1,070	1,020	1,010	920	1,060	1,010
SUBTOTAL	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
Ponds & Sloughs									
Subtidal	430	760	920	680	760	770	930	680	770
Intertidal mudflat	80	2,490	3,840	1,790	2,210	1,620	2,800	930	900
Lower marsh	30	300	310	290	440	90	230	80	640
Middle marsh	1,210	1,120	1,080	1,160	1,260	2,190	2,180	2,220	2,360
Managed ponds	6,460	3,550	2,080	4,290	3,550	3,550	2,080	4,290	3,550
Upland/transition	200	190	190	200	190	190	190	200	190
SUBTOTAL	8,410	8,410	8,410	8,410	8,410	8,410	8,410	8,410	8,410
OTHER^b	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050
PROJECT TOTAL	9,460	9,460	9,460	9,460	9,460	9,460	9,460	9,460	9,460

^a If Ponds 6 and 6A are also restored to tidal marsh after 10–20 years, the total area of managed ponds at year 50 would be 2,404 acres.

^b “Other” category includes nonevolving marsh (fringing marsh and Pond 2A) and sloughs and upland habitat areas.

Note: Assumes SSC is 125 mg/l for Pond 3 and 75 mg/l for Ponds 4, 5, 6, 6A, and 2 East; also assumes a fill area of 100 acres for Option 4. Slough erosion occurs over 20 years with 50% by Year 5 and 80% by Year 10. Calculations do not include opening Ponds 6/6A to tidal action. Totals may not add up because of rounding.

Table 2-3. Approximate Dimensions of Design Elements

Design Element	Top Width (feet)	Key Elevations	Typical Side Slope ^a (H:V)	Length (feet)	Potential Middle Marsh Area Created
Breach	Approx. 100 ^b	Invert 3–5 feet below MLLW	5:1	NA	NA
Pilot channel	~50	Minimum invert at least several feet below the marshplain	5:1	Varies	NA
Starter channel ^c	50–100	Longitudinal slope deepest near the breach (3–5 feet below MLLW) and shallower in the pond interior (1 foot above to 1 foot below MLLW)	5:1	Varies by option	NA
Berm ^d	Approx. 10	~MLHW to MHW at crest; no higher than +0.5 foot above MHHW	7:1	Varies by option	0.2 acre/1,000 feet
Ditch block ^e	40	~MHHW at crest	5:1	100	0.12 acre/block
Levee lowered to construct ditch block	30	~MHHW at crest	NA	330	0.23 acre/block
Additional levee lowering for high marsh restoration ^f	46	~MHHW at crest	NA	Varies by option	1.1 acre/1,000 feet
Fill placement	NA	~1 foot below MHHW	NA	NA	100 acres assumed, may be less

^a Side slopes would vary, depending on constructability.

^b Width at mean higher high water.

^c Starter channels could be narrower and shallower, depending on cost and constructability constraints.

^d The width of the lowered levee would be 30 feet. Material from levee lowering would be used to fill a 16-foot width of borrow ditch, giving an effective width of 46 feet for potential marsh habitat

^e The width of the berm for Habitat Restoration Option 4 would be sized to allow the berm to serve as an effective wave break and may be larger than the width shown here.

^f Three hundred thirty feet of levee would be lowered to provide material to construct a ditch block.

Source: Philip Williams and Associates 2002c.

Table 2-4. Number and Length of Design Elements and Middle Marsh Habitat Created, by Option

	Option 1	Option 2	Option 3	Option 4
Number and Length of Design Elements				
Breaches (number)	23	31	19	23
Ditch blocks (number)	22	26	16	22 ^a
Lowered levees ^b (ft)	22,200	34,600	14,600	22,200
Berms (ft)	27,500	40,600	19,600	55,300
Starter channels (ft)	27,500	40,600	19,600	55,300
Middle Marsh Area Created by Design Feature (ac)				
Ditch blocks	3	3	2	3
Lowered levees ^c	21	34	13	21
Berms	6	9	4	13
Area fill	-	-	-	100
Total	30	46	20	136

^a Fewer ditch blocks may be needed, depending on the location of the fill placement.

^b Includes 330 ft. for each ditch block.

^c Includes area of partial borrow ditch fill, except when that fill is a ditch block.

Source: Philip Williams and Associates 2002c.

2.5.4.2 Habitat Restoration Option 1: Mixture of Tidal Marsh and Managed Ponds

Introduction

Habitat Restoration Option 1 provides for a mosaic of tidal habitats and managed ponds. Under this option, the existing ponds would be restored as follows:

- Ponds 1, 1A, 2, and 2A would be maintained as they are, with levee repair and water control improvements as needed.
- Ponds 3 and 4/5 would be opened to the tidal prism in an orderly manner. Levee breaches would depend on accretion rates and sediment budget (Figure 2-17).
- Pond 6/6A would be maintained as a managed pond during the initial restoration of Ponds 3 and 4/5, an estimated 10–20 years. Adaptive management of the project would determine whether Pond 6/6A is converted to tidal marsh or retained as a pond in the long term. The decision is dependent upon success of tidal marsh development in Ponds 3 and 4/5, availability of other waterfowl and shorebird habitat, and funds available for O&M.
- Ponds 7, 7A, and 8 would be managed as ponds after their salinity has been reduced to ambient or near-ambient levels. Levees would be repaired and water control improvements would be made as needed.

Habitat Restoration Option 1 would lead to the following habitat distribution when the project has matured (Figure 2-18):

- Ponds 1, 1A, 2, 7, 7A, and 8: managed pond;
- Pond 2A and other existing tidal marsh and slough habitat;
- Ponds 3, 4, and 5: new tidal marsh, mudflat, slough, and open water;
- Ponds 6 and 6A:
 - short term—managed ponds;
 - long term—adaptive management approach (Option 1A, new tidal marsh, mudflat, slough, open water; or Option 1B, managed pond).

The evolution of habitat types is illustrated in Figure 2-19.

Ponds 1, 1A, 2, 7, 7A, and 8 (Managed Ponds)

Construction

Facilities. Water control structures would be repaired or replaced as needed. In particular, the siphon between Pond 1 and 2 would be refurbished or replaced with two 54-inch-diameter siphons, and the existing intakes and outlets at Pond 2 would be replaced with new culverts and pipes. (The siphon would have been refurbished and at least 1 siphon would have been installed as part of salinity reduction efforts, if Salinity Reduction Option 2 is implemented.) Some of the valves and related equipment on Ponds 7, 7A, and 8 may require replacement when these ponds are converted to managed ponds. Initial levee repairs for all of these ponds would have been completed as part of the salinity reduction effort.

Equipment. The estimated annual equipment required to complete maintenance, repair, and replacement activities for Ponds 1, 1A, 2, 7, 7A, and 8, including replacement of water control structures, is one or two barges, two long-reach excavators, a small bulldozer, refueling tanks, a diesel generator, and a small boat for transportation to and from the project site.

Timing and Duration. Construction activities are expected to be completed within 1 year.

Operations and Maintenance

Facilities. Ponds 1 and 1A would continue to be managed as ponds, and Pond 2 would continue to be managed as a deepwater pond. Ponds 7, 7A, and 8 would be variable-depth, managed ponds after the desalination process. Salinity and depth would be managed by DFG in Ponds 7, 7A, and 8 to provide habitat for migratory waterfowl.

Water control structures for all six ponds would require ongoing maintenance and possibly replacement in the long term (as long as these ponds are managed as ponds).

Equipment. See “Equipment” under the discussion of construction for Habitat Restoration Option 1 above.

Timing and Duration. Long-term maintenance and replacement of the water control structures would require several months of construction each year. Levee maintenance would consist of repairing approximately 5% of the levees each year.

Ponds 3, 4, 5, 6, and 6A (Tidal Habitat)

Construction

Facilities. Tidal habitat restoration activities for Ponds 3 and 4/5, and possibly Ponds 6 and 6A would be designed to facilitate evolution of the site to mature marsh. Activities for Ponds 3, 4, and 5 would include

- removing intake and outfall structures,
- constructing breaches that provide for optimal tidal exchange (23 breaches),
- breaching levees in areas with minimal existing marsh and near historical channels to minimize loss of fringing marsh and encourage the scouring of remnant slough channels,
- creating ditch blocks with associated levee lowering (22 blocks),
- regrading additional levees in areas where habitat continuity could be disrupted during the restoration period (22,200 linear feet), and
- installing starter channels in the ponds (27,500 linear feet).

Habitat Restoration Option 1 relies on natural sediment processes for the majority of the restoration area, and on natural colonization by marsh vegetation.

Under this option, levees would first be breached to open Pond 3 to full tidal influence. The exterior levees on Ponds 4 and 5 would subsequently be breached. Ponds 4 and 5 are already connected to each other via breaches along the interior levee; these levee breaches would be increased as part of the salinity reduction effort (see “Salinity Reduction Options” above).

Equipment. Equipment used to create the habitat restoration features would be of the same types and quantities as those used during the salinity reduction process and would be delivered to the site in the same manner (via barge at high tide). Construction activities to restore Ponds 3, 4, and 5 to tidal action would consist of excavating or placing explosives to breach levees where needed, and using heavy equipment to remove intake and outfall structures, block the borrow ditches, reslope the levees near the breaches, lower levees, and excavate starter channels.

Timing and Duration. Habitat restoration would begin upon the reduction of salinity in the ponds and would start with the breaching of the Pond 3 levees, likely proceeding as follows:

- The evolution of Pond 3 to vegetated lower marsh habitat is expected to happen within 10 years because its elevation is higher than those of Ponds 4 and 5.
- Within no more than 5 years after Pond 3 is opened to the tide (depending on the evolution of Pond 3 and the continued availability of sediment), the exterior levees on Ponds 4 and 5 would be breached.
- A decision regarding the long-term habitat at Ponds 6 and 6A would be made no later than 20 years after the start of the project. If these two ponds are opened to tidal action, it is likely that they would require a longer time to accrete to tidal marsh than the ponds located along the Napa River.

Operations and Maintenance

Facilities. Ponds 6 and 6A would be managed as ponds for approximately 10–20 years, and would then either be restored to tidal marsh or continue to be managed as ponds, based on

- the availability of sufficient, high-quality waterfowl and shorebird habitat, including open-water habitat (Ponds 1, 1A, 2, 7, 7A, and 8), in the Napa River Unit and at nearby existing or restored sites;
- the success of tidal marsh restoration in Ponds 3 and 4/5 (success would be determined by percentage of marsh vegetation cover);
- the availability of funding for the operation and maintenance of Ponds 6 and 6A as managed ponds. Funds would be needed to maintain levees and water control structures and to operate the water control structures; and,
- the physical feasibility of operating these large, shallow ponds within the desired water level and salinity ranges.

Maintenance of Ponds 4 and 5 in the short term (until Pond 3 is sufficiently restored that they can be breached) would require ongoing operation and maintenance of the water control structures. Maintenance of Ponds 6 and 6A as ponds in the short term, and possibly in the long term, would require the repair of levees and ongoing maintenance and operation of water control structures. Additional water control structures for Pond 6/6A, which would be required if Salinity Reduction Option 2 is implemented, would be constructed in the same manner as described for Salinity Reduction Option 1.

Equipment. Significant maintenance on or replacement of the water control structures and levee maintenance at Ponds 6 and 6A would be accomplished using heavy equipment delivered to the construction area by barge at high tide. The estimated equipment required to complete ongoing maintenance, repair, and replacement activities for Ponds 6 and 6A is one or two barges, two long-reach excavators, a small bulldozer, refueling tanks, a diesel generator, and a small boat for transportation to and from the project site.

Timing and Duration. Long-term maintenance would require several months of construction each year.

2.5.4.3 Habitat Restoration Option 2: Tidal Marsh Emphasis

Introduction

Habitat Restoration Option 2 provides for a mosaic of tidal habitats and managed ponds with an emphasis on tidal habitats. Under this option, the existing ponds would be managed as follows:

- Ponds 1 and 1A, the western half of Pond 2 (Pond 2W), and Pond 2A would be maintained as they are, with levee repair and water control improvements as needed. A new levee would be built down the middle of Pond 2 (Figure 2-20).
- Ponds 3, 4, 5, 6, and 6A, and the eastern half of Pond 2 (Pond 2E) would be opened to the tidal prism with levee breaches, in an orderly manner depending on accretion rates and sediment budget. Design features would be used as needed for improved accretion rates and habitat evolution. Pond 3 would be opened to tidal action first, followed by Ponds 4 and 5, then Ponds 6 and 6A and Pond 2E. Ponds 2 and 6/6A would be maintained as ponds, with levee repair and water control improvements as needed, until significant habitat development occurs in Ponds 3, 4, and 5.
- Ponds 7, 7A, and 8 would be managed as ponds after their salinity has been reduced to ambient or near-ambient levels, with levee repair and water control improvements as needed.

Habitat Restoration Option 2 would lead to the following habitat distribution when the project has matured (Figure 2-21):

- Ponds 1, 1A, 2W, 7, 7A, and 8: managed shallow-water and deepwater pond habitat;
- Ponds 2E, 3, 4, 5, 6, and 6A: new tidal marsh, mudflat, slough, and open water; and
- Pond 2A and other existing tidal marsh and slough habitat.

The evolution of habitat types is illustrated in Figure 2-22.

Ponds 1, 1A, 2W, 7, 7A, and 8 (Managed Ponds)

Construction

Facilities. Levees would be repaired and water control structures would be repaired or replaced as needed. As under Habitat Restoration Option 1, initial levee repairs would be conducted as part of the salinity reduction effort. The water control structures installed as part of the salinity reduction effort would continue to be used for Ponds 7, 7A, and 8. Replacement of the Pond 1 pump station and refurbishing or replacement of the Pond 1 to 2 siphon may be required (if Salinity Reduction Option 1 is implemented).

Equipment. The estimated equipment required to complete the initial repair and replacement efforts for the water control structures is the same as for managed pond construction under Habitat Restoration Option 1.

Timing and Duration. As under Habitat Restoration Option 1, the length of time required for levee repairs or water control structure repair or replacement would depend on the amount of work needed.

Operations and Maintenance

Facilities. Ponds 1 and 1A would continue to be managed as shallow-water ponds and Pond 2W would continue to be managed as a deepwater pond. Ponds 7, 7A, and 8 would be managed as ponds after completion of the desalination process. DFG would manage salinity and depth in Ponds 7, 7A, and 8 to provide habitat for migratory waterfowl.

Levees and water control structures for these ponds would require ongoing maintenance and possibly replacement in the long term. Because of the demanding environment in which the water control structures operate, it is expected that knife valves and other features made of stainless steel would last for approximately 30 years. The pipes themselves would be made of HDPE, and are expected to last for the life of the project (50 years).

Equipment. The estimated annual equipment required to complete maintenance, repair, and replacement activities for these ponds is the same as under Habitat Restoration Option 1.

Timing and Duration. Long-term maintenance and replacement of the water control structures and long-term maintenance of the levees would require slightly less effort and would occur over the same period of time as under Habitat Restoration Option 1.

Environmental Commitments. The environmental commitments are the same as under Habitat Restoration Option 1.

Ponds 2E, 3, 4, 5, 6, and 6A (Tidal Habitat)

Construction

Facilities. Habitat restoration activities for Ponds 2E, 3, 4, 5, 6, and 6A would be designed to facilitate evolution of the site to mature marsh and would include the same features as under Habitat Restoration Option 1. The number of breaches and ditch blocks would increase relative to Habitat Restoration Option 1; the total length of starter channels and levee lowering would also be greater. An estimated 31 breaches, 26 ditch blocks, and 40,600 linear feet of starter channels would be constructed and 34,600 linear feet of levees would be lowered under this option. In addition, a new levee (1,800 feet long) would be constructed from north to south along the narrowest portion of Pond 2. A levee formerly existed in this area, but was allowed to disintegrate (Huffman pers. comm.). Finally, water control structures would be repaired as needed.

Equipment. Equipment used to construct the habitat restoration features would be of the same types and quantities as those used during the salinity reduction process and delivered to the site in the same manner (via barge at high tide). Construction activities to restore Ponds 2E, 3, 4, 5, 6, and 6A to tidal action would consist of excavating or placing explosives to breach levees where needed, and using heavy equipment to remove intake and outfall structures, block the borrow ditches, reslope the levees near the breaches, lower levees, and excavate starter channels.

Timing and Duration. The amount of time required to construct this portion of Habitat Restoration Option 2 is somewhat longer than that required for the tidal habitat for Habitat Restoration Option 1 because more breaches, starter channels, and ditch blocks would be constructed under this option. In addition, the construction of a levee would also be required. It is estimated that the work required could be completed within 18 months.

Operations and Maintenance

Facilities. Habitat Restoration Option 2 relies on natural sedimentation processes and on natural colonization by marsh vegetation to achieve marshplain elevations in the restoration area. Ponds 3–5 would be opened to tidal action and would generally be expected to accrete to marshplain elevations in the same sequence as under Habitat Restoration Option 1.

Ponds 2E, 6, and 6A would be managed as ponds, and would then be restored to tidal marsh, based upon the evolution of Ponds 3, 4, and 5 and the continued availability of sediment. Pond 2E is significantly subsided, which would slow marsh evolution.

Maintenance of Ponds 4 and 5 in the short term (until Pond 3 is sufficiently restored that they can be breached) would require ongoing operation and maintenance of any water control structures installed on the ponds. Maintenance of Ponds 2, 6, and 6A as ponds in the short term would require ongoing maintenance and operation of water control structures. Unlike Habitat Restoration Option 1, the levees on Ponds 2E and 6/6A would not require repairs (i.e., the ponds would be opened to tidal action before levee failure is likely to occur). Even if levee failure does occur, it is unlikely that the levees for these ponds would be repaired, because the ponds would be opened to tidal action at some point, salinities in the ponds would be low, and the size of the breach would also be relatively small.

Equipment. Repair of the water control structures for Ponds 2E and 6/6A, if needed, would be accomplished using heavy equipment delivered to the construction area by barge at high tide. Approximate types and quantities of equipment that would be used for the repair efforts include an excavator, a diesel-powered barge, and a small bulldozer.

Timing and Duration. Long-term maintenance would require several months of construction each year.

2.5.4.4 Habitat Restoration Option 3: Pond Emphasis

Introduction

Habitat Restoration Option 3 provides for a mosaic of tidal habitats and managed ponds, with an emphasis on managed ponds. Under this option, the existing ponds would be managed as follows:

- Ponds 1, 1A, 2, and 2A would be maintained as they are, with levee repair and water control improvements as needed.
- Ponds 3 and 4 would be opened to the tidal prism with levee breaches in an orderly manner depending on accretion rates and sediment budget. Pond 3 would be opened to tidal action first, followed by Pond 4 (Figure 2-23).
- Ponds 5, 6, 6A, 7, 7A, and 8 would be managed as ponds after their salinity has been reduced to ambient or near-ambient levels, with levee repair and water control improvements as needed.

Habitat Restoration Option 3 would lead to the following habitat distribution when the project has matured (Figure 2-24):

- Ponds 1, 1A, 2, 5, 6, 6A, 7, 7A, and 8: managed ponds;
- Ponds 3 and 4: new tidal marsh, mudflat, slough, and open water; and
- Pond 2A and other existing tidal marsh and slough habitat.

The evolution of habitat types is illustrated in Figure 2-25.

Ponds 1, 1A, 2, 5, 6, 6A, 7, 7A, and 8 (Managed Ponds)

Construction

Facilities. Levees would be repaired and water control structures would be repaired or replaced as needed. The same new structures and repair/replacement would be required as under Habitat Restoration Option 1 for Ponds 1, 1A, 2, 7, 7A, and 8. The overall construction effort would be somewhat greater than required under Habitat Restoration Option 1, because the levee breaches in the Pond 4/5 interior levee would have to be repaired, and levee repairs would also be required for the exterior levees at Pond 5. In addition, a new outfall would have to be constructed for Pond 5; this outfall structure would discharge to the Napa River.

Equipment. Equipment required would be the same as for construction at Ponds 1, 1A, 2, 7, 7A, and 8 under Habitat Restoration Option 1.

Timing and Duration. The timing and duration of construction would be somewhat greater than that under Habitat Restoration Option 1 because construction required at Pond 5 would take longer.

Operations and Maintenance

Facilities. Ponds 1 and 1A would continue to be managed as ponds, and Pond 2 would continue to be managed as a deepwater pond. Salinity and depth in Ponds 5, 6, 6A, 7, 7A, and 8 would be managed after the desalination process.

For all ponds, levees and water control structures would require ongoing maintenance and possibly replacement in the long term. Because of the demanding environment in which the water control structures operate, it is expected that any metal components would have to be replaced approximately every 30 years.

Equipment. The estimated annual equipment required to complete maintenance, repair, and replacement activities is the same as for Habitat Restoration Option 1.

Timing and Duration. Long-term maintenance would require several months of construction each year.

Ponds 3 and 4 (Tidal Habitat)

Construction

Facilities. Construction would include the same components as under Habitat Restoration Option 1. However, because only two ponds would be restored to tidal habitat, the number of breaches and ditch blocks would decrease to 19 and 16, respectively. There would be correspondingly less levee lowering (14,600 feet) and fewer starter channels (19,600 feet) as well. No levee maintenance or repair or replacement of water control structures is required for this portion of Habitat Restoration Option 3.

Only minimal construction activities would be required at Pond 3; construction would be completed on the levee between Ponds 4 and 5 (see discussion above).

Equipment. Equipment used to construct the habitat restoration features would be of the same types and quantities as those used during the salinity reduction process and delivered to the site in the same manner (via barge at high tide). Construction activities to restore Ponds 3 and 4 to tidal action would consist of excavating or placing explosives to breach levees where needed, and using heavy equipment to remove intake and outfall structures, block the borrow ditches, reslope the levees near the breaches, lower levees, and excavate starter channels.

Timing and Duration. The estimated time required to complete construction activities is 12 months.

Operations and Maintenance

Facilities. Habitat Restoration Option 3 relies on natural sedimentation processes for the majority of the restoration area, and on natural colonization by marsh vegetation. Under this option, Pond 3 would be restored to tidal marsh. Levee breaches would open Pond 3 to full tidal influence. The evolution of Pond 3 to marsh habitat is expected to happen fairly quickly because of the higher elevations of this pond. Within no more than 5 years after Pond 3 is

opened to the tide (depending upon the evolution of Pond 3 and the continued availability of sediment), the exterior levees on Ponds 4 would be breached. The elevation of Pond 4 is slightly lower than Pond 3, so evolution to tidal marsh is expected to be slower.

Maintenance of Pond 4 in the short term (until Pond 3 is sufficiently restored that it can be breached) would require ongoing operation and maintenance of the water control structures.

Equipment. See “Equipment” under the discussion of construction of this option.

Timing and Duration. Only very short periods of time (several days per year) would be required to maintain the water control structures at Pond 4.

2.5.4.5 Habitat Restoration Option 4: Accelerated Restoration

Habitat Restoration Option 4 is identical to Habitat Restoration Option 1 in terms of the habitat mix; however, more extensive construction activities would occur at the ponds opened to tidal action. The additional construction activities, described below, are intended to accelerate marsh evolution (Figure 2-26). Figure 2-27 illustrates the habitat endpoints associated with this option, and Figure 2-28 illustrates the evolution of the habitat types associated with this option. The managed ponds (Ponds 1, 1A, 2, 7, 7A, and 8) would be constructed and operated in the same way as for Habitat Restoration Option 1, and are not discussed again here.

The added components included for Habitat Restoration Option 4 are as follows:

- **Filling of 100 Acres of Pond 4 (or a Similar Location).** Clean and local sediment would be placed in the southern portion of Pond 4, or a similar location with low historic slough channel density, to raise the pond elevation to within 1 foot of MHHW. This limited fill placement would speed initial vegetative colonization by raising the initial elevation of the site. This fill would help compensate for the anticipated temporary reduction in fringing marsh.
- **Increase in the Number and Length of Starter Channels.** The total length of starter channels and associated berms would increase from 27,500 feet to 55,300 feet. The increased number and length of starter channels would increase the channelization within the marsh, and sediment transport into the interiors of the ponds. The increased amount of berms would provide more wave breaks, more sacrificial sediment sources, and more opportunities for early colonization by marsh vegetation.

The addition of these more extensive design features could accelerate the habitat evolution compared to the other habitat restoration options (Figure 2-16). The

number of breaches and ditch blocks and the amount of levee lowering would be the same as under Habitat Restoration Option 1.

The additional design features would require additional construction work. Sediment for the 100-acre fill area would potentially be available from three sources: a former dredge spoil disposal area at Edgerley Island; deepening of existing slough channels; or maintenance dredging of the Napa River. In either case, the most likely dredge is a low-profile hopper dredge that would suction sediment from the bottom of the slough or the Napa River deepwater channel and pump it into the fill area. Any maintenance dredging sediment used to raise elevations in the interior of the ponds would first be tested to ensure that it meets wetland cover criteria.

If Napa River sediment is used, project-related impacts would be limited to discharge and placement of the sediment, as impacts associated with mobilizing the equipment and dredging the channel are addressed by the Corps' maintenance dredging program. Impacts associated with deepening existing slough channels would be considered entirely project-related.

2.6 Project Alternatives

Based on a detailed option screening process (Section 2.4, Development of Options) and alternative screening process (Chapter 17, "Alternatives"), the following nine alternatives were included for detailed analysis:

- No-Project Alternative;
- Alternative 1: Napa River and Napa Slough Discharge (Salinity Reduction Option 1A), Recycled Water Delivery, and Mixture of Ponds and Tidal Marsh (Habitat Restoration Option 1);
- Alternative 2: Napa River and Napa Slough Discharge and Breach of Pond 3 (Salinity Reduction Option 1B), Recycled Water Delivery, and Mixture of Ponds and Tidal Marsh (Habitat Restoration Option 1);
- Alternative 3: Napa River and Napa Slough Discharge and Breach of Pond 3 (Salinity Reduction Option 1B), Recycled Water Delivery, and Tidal Marsh Emphasis (Habitat Restoration Option 2);
- Alternative 4: Napa River and Napa Slough Discharge and Breach of Pond 3 (Salinity Reduction Option 1B), Recycled Water Delivery, and Pond Emphasis (Habitat Restoration Option 3);
- Alternative 5: Napa River and Napa Slough Discharge and Breach of Pond 3 (Salinity Reduction Option 1B), Recycled Water Delivery, and Accelerated Restoration (Habitat Restoration Option 4);
- Alternative 6: Napa River and Napa Slough Discharge with Breaches of Ponds 3 and 4/5 (Salinity Reduction Option 1C), Recycled Water Delivery, and Mixture of Ponds and Tidal Marsh (Habitat Restoration Option 1);

- Alternative 7: Napa River and San Pablo Bay Discharge and Breach of Pond 3 (slight modification of Salinity Reduction Option 2), Recycled Water Delivery, and Accelerated Restoration (Habitat Restoration Option 4); and
- Alternative 8: Napa River and Napa Slough Discharge and Breach of Pond 3 (Salinity Reduction Option 1B), No Recycled Water, and Mixture of Ponds and Tidal Marsh (Habitat Restoration Option 1).

The specific components of these alternatives are described under Section 2.5, “Project Options.”

2.7 Project Monitoring

The project sponsors are committed to ensuring that the options selected are implemented safely and minimize adverse environmental impacts. To this end they have developed a draft monitoring plan to monitor, track, and evaluate changes in biological parameters. The construction monitoring and the salinity reduction and habitat restoration monitoring proposed for the project are described below.

2.7.1 Construction Monitoring

The available construction time is limited by protection periods established for endangered species. To minimize impacts on wildlife resulting from construction-related disruption and to minimize impacts on habitat, construction activities would be grouped by area. For example, all water control structures in a given area, fish screens, and monitoring equipment would be installed at one time. Construction of the required water control structures for all ponds would be completed as quickly as possible to allow improved management of pond water levels and ensure that salinity reduction can begin expeditiously.

The project sponsors will conduct preconstruction surveys for federally listed and state-listed plants and animals.

The Bay Area Air Quality Management District’s (BAAQMD’s) soil management best management practices (BMPs) would be implemented by the project sponsors and SCWA in areas with the potential to create airborne dust. These BMPs may include the following list.

- All construction areas, unpaved access roads, and staging areas will be watered as needed during dry soil conditions, or soil stabilizers will be applied.
- All trucks hauling soil or other loose material will be covered or have at least 2 feet of freeboard. Wherever possible, construction vehicles will use paved roads to access the construction site.

- Vehicle speeds will be limited to 15 mph on unpaved roads and construction areas, or as required to control dust.
- Streets will be cleaned daily to remove soil material carried onto adjacent public streets.
- Soil stabilizers will be applied daily to inactive construction areas as needed.
- Exposed stockpiles of soil and other excavated materials will be enclosed, covered, watered twice daily, or applied with soil binders as needed.

2.7.2 Salinity Reduction Monitoring: Water and Sediment Quality

Water and sediment samples from 40 sites within the pond complex, along with sites in the Napa River, Napa Slough, and San Pablo Bay were collected in October 2001 by HydroScience Engineers after development of the *Sampling and Analysis Plan and Quality Assurance Project Plan*, which was approved by the San Francisco Bay RWQCB (HydroScience Engineers 2001). Samples were analyzed by MEC Analytical Systems, Inc., for volatile and semivolatile organics, pesticides, polychlorinated biphenyls (PCBs), heavy metals, dioxins, and general water quality parameters, including nutrients, total dissolved solids (TDS), total suspended solids (TSS), pH, temperature, salinity, and dissolved oxygen (DO).

A comprehensive water quality monitoring program would be prepared and implemented for the duration of the salinity reduction process. The monitoring would have well-defined data quality objectives, monitoring procedures, and data analysis and reporting protocols to ensure that project operations are controlled according to waste discharge requirements (WDRs) or the requirements of any National Pollutant Discharge Elimination System (NPDES) permit issued by the San Francisco Bay RWQCB. Monitoring at specific locations would be completed and phased out as each successive pond is restored and salinity has been reduced to ambient levels.

The discharge monitoring would include continuous recording devices for key parameters and periodic grab samples for specific constituents of concern. Measurement of key continuous monitoring variables (flow, water level stage, salinity, temperature, and TSS/turbidity) would be implemented at several pond and receiving water locations to provide for real-time management of the intakes and discharges and ensure that changes in water quality would be within the acceptable range specified in the WDRs or NPDES permit requirements. Grab samples would be used to characterize long-term changes in other constituents of concern that might be identified by the resource agencies; these constituents could include dissolved oxygen, pH, or selected inorganic ions and trace metals. Aquatic toxicity tests would also be conducted on a periodic basis.

2.7.3 Habitat Restoration Monitoring

USGS and DFG biologists and hydrologists, along with contractors as needed, would monitor the restoration project. The primary objectives of the monitoring are to evaluate changes in wildlife use of restored tidal habitats, ponds, and fringing marsh and physical evolution of restored tidal habitats and the external slough channels. Monitoring would occur during salinity reduction of each pond and continue for a minimum of 10 years after each pond is breached.

USGS has been monitoring six ponds of varying salinities (Ponds 1, 2, 2A, 3, 4, and 7) since 1999. This interdisciplinary study, involving biologists and hydrologists, has included avian, macroinvertebrate, and fish surveys, along with collection of salinity and other water quality data in the ponds and collection of hydrodynamic, salinity, and suspended sediment concentration data in the sloughs. (Takekawa et al. 2001.) The ongoing nature of this monitoring effort would allow for before-and-after comparisons of wildlife use, water quality, and physical processes.

Marsh evolution and wildlife use in the restored Pond 2A site was monitored first by PWA and then by MEC Analytical Systems, Inc., from 1996 to 2000 (Philip Williams and Associates 1997, MEC Analytical Systems 2000). The physical and biological evolution of the 550-acre Pond 2A marsh was monitored through surveys of levee breaching and equilibrium of the width of the natural slough channel, sediment chemistry and grain size, sedimentation rates, tidal range and response, fish usage, avian usage, and plant colonization. Although Pond 2A has different characteristics than the remaining ponds (Pond 2A was slightly less subsided and was never farmed before being converted to a salt pond), it can be used as one point of comparison. Comparisons would also be made to other restoration projects in the north bay region that are currently being monitored (such as Guadalcanal and Tolay Creek), and to the fringing marsh that exists along the slough channels within the salt pond complex.

2.7.3.1 Marsh Evolution: Sedimentation, Hydrology, and Vegetation Monitoring

A topographic and bathymetric survey of the salt ponds, slough channels, and associated marsh plain was conducted by Towill, Inc., as part of the feasibility study with the Corps (Towill 2001). The aerial survey included a very accurate primary-control-level loop through the site that was connected to high-confidence benchmarks outside the site. This survey was used in the development of the hydrodynamic model by PWA and will be useful for before-and-after comparisons of elevations.

Sediment, hydrology, and vegetation monitoring would be conducted immediately before levee breaching to establish baseline conditions, and annually for approximately 10 years after breaching. Prebreach monitoring would involve performing additional surveys for consistency with postproject monitoring locations, as well as installation of sedimentation monitoring stations.

Postconstruction (postbreach) and some additional prebreach surveys of tidal geomorphic evolution would document rates and patterns of habitat evolution and key underlying physical processes in each pond restored to tidal habitats.

Monitoring results would be used to identify the need for any adaptive management required to improve tidal circulation within restored ponds. They would also be used to inform and adaptively manage the tidal wetland restoration designs for future tidal restoration in other ponds.

Sedimentation Rates

Sedimentation would be monitored to understand rates and patterns of marsh evolution within breached ponds. Sedimentation would be measured using methods such as marker horizons, sedimentation plates and pins, and topographic resurveys.

Levee Breach and Slough Channel Cross Sections

Cross-sectional surveys of levee breaches, external sloughs, and pond-internal sloughs and adjacent berms (if used) would be conducted to understand patterns of tidal scour and drainage and to determine when the widths and depths of the breaches and external and internal sloughs reach equilibrium in response to the tidal prism. Water surface elevations in the sloughs and restored ponds would be monitored to identify any drainage constraints caused by increases in the tidal prism.

Vegetation Colonization

Vegetation-elevation transects would be conducted within breached ponds to document rates and patterns of vegetation colonization in the new tidal marsh. For comparison, similar data would be collected for a natural reference marsh. Aerial photographs would aid in the documentation of vegetation colonization throughout an entire breached pond.

Introduced Vegetation

Vegetation surveys would also include monitoring for introduced species of cordgrass (*Spartina* spp.). The project team would work with the San Francisco Estuary Invasive *Spartina* Project to monitor and control introduced species of cordgrass, to ensure regional coordination and use of effective eradication techniques.

2.7.3.2 Wildlife Monitoring in Managed Ponds and Restored Tidal Habitats

Integrated Wildlife-Usage Surveys

Baseline, construction, and postconstruction macroinvertebrate, fisheries, and avian usage data would be collected at locations within restored and managed ponds to assess the impacts of the restoration upon the wildlife. The baseline condition would incorporate data collected by USGS during 1999 and 2000 (Takekawa et al. 2001). All surveys would be conducted within Universal Transverse Mercator (UTM) grids overlaid on the ponds. Results from initial waterbird surveys would be used to select a subsample of grids, based on bird presence (random grids would be selected if bird use is not evident), for further survey each quarter. Analyses would examine both temporal and seasonal variation in pond usage.

Primary and Secondary Productivity

Water samples would be collected quarterly from each sample site within each pond for chlorophyll-a and nutrient (nitrogen and phosphorous) analyses. Chlorophyll-a concentration, a measure of algal community primary productivity, would be determined using spectrophotometry (Wetzel and Likens 1991). Nutrient concentration (soluble reactive phosphorous, total phosphorous, and nitrogen) would be determined using standard analytical methods (Clesceri et al. 1989). Zooplankton would be collected, preserved, and identified under a stereomicroscope (Pennak 1989).

Invertebrates

Invertebrates would be sampled in the water column using net sweeps and in the benthos with Eckmann grab samples. Sweep and grab samples would be taken monthly in each pond. Biomass (dry weight) and diversity of invertebrates would be measured on a seasonal basis.

Fish

Fish populations would be surveyed seasonally. Surveys would assess distribution and relative abundance of juvenile and adult fishes, with special emphasis on small species likely to occur in the study area (e.g., rainwater killifish [*Lucania parva*], topsmelt [*Altherinops affinis*], yellowfin goby [*Acanthogobius flavimanus*]) (Lewis Environmental Services and Wetland Research Associates 1992). Captured fish would be counted, identified to the species level, and subsequently released. A subset of the captured individuals of each species would be measured for standard length and weight. Relative weight (measured weight of an individual divided by a standard weight for the species),

a measure of body condition, would be also calculated for these individuals (Wege and Anderson 1978; Anderson 1980). Stomach contents would also be collected and analyzed for a sample of individuals from selected species.

Waterbirds

Surveys would be conducted bimonthly following current USGS protocols (Takekawa et al. 2001). Locations of flocks would be mapped in a grid overlay and displayed in geographic information systems (GIS) maps. Usage trends would be examined by comparing data from before and after installation of water control structures and/or restoration to tidal habitats. Water depth and foraging preferences would also be examined (Collazo et al., in review).

Contaminants

Invertebrate samples would be analyzed yearly for chemical residues to determine the level to which elemental contaminants such as mercury are being transferred to animals feeding on pond-dwelling macroinvertebrates. Net sweeps samples and grab samples of benthic invertebrates would be collected during the month of maximum bird use. Contaminant presence would be analyzed using standard laboratory techniques.

Introduced Predators

Nighttime spotlight surveys and track surveys would be conducted to monitor for the presence of introduced mammalian predators, particularly red fox, on the project site. Surveys would be focused on marshes containing populations of California clapper rails. When possible, nighttime predator surveys would include searches for fox dens and surveys of wildlife remains near fox dens. Track stations would be set up for the track surveys. Wildlife services staff from the U.S. Department of Agriculture would be hired to monitor for introduced mammalian predators, if staff are available.

2.7.4 Adaptive Management

Adaptive management is an approach to resource management in which management goals remain the same, but management objectives and techniques may be modified in response to feedback (such as monitoring results) from the system being managed. Adaptive management recognizes that human knowledge regarding biological and physical systems is limited and that these systems may not always behave as expected. When a management or restoration project is to be implemented but there is some uncertainty regarding the response of the system to particular actions, adaptive management provides a way for management actions to respond to feedback from the system being managed.

Adaptive management would be implemented if specific restoration standards are not met or if it appears that actual conditions would diverge far enough from intended conditions to threaten the achievement of overall project goals. Funding for adaptive management would be included in the project cost estimates so that this option would be available in the future if needed.

Should the development of the site fail to meet quantitative standards to be stated in the detailed monitoring plan, action would be undertaken to correct these shortfalls if such action could reasonably be expected to assist in the achievement of these standards. Corrective action could include vegetation management, predator management, changes in the phasing of breaches, or modifications to restoration design features.