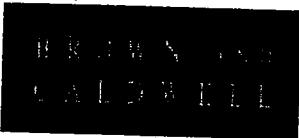


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May 31, 2002



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San Francisco District Office  
333 Market Street  
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11-22459-503/1

Subject: Final Cost Estimate of Napa Salt Marsh Salinity  
Reduction and Restoration Alternatives

Dear Mr. Mull and Ms. Galal:

We have finalized our analysis and cost estimate of salinity reduction and restoration alternatives for the Napa Salt Marsh. Our evaluation was performed in accordance with the Scope of Work for Engineering Services included as part of the Award Document authorized by the United States Army Corps of Engineers (ACOE) on March 6, 2002. The draft report below summarizes our results, and it includes three main subsections covering costs associated with salinity reduction alternatives, levee repair and maintenance, and restoration alternatives.

Note that this cost estimate is based on a conceptual design of water control structures and restoration components. Further definition of the concepts described herein will allow for the development of more accurate cost estimates for required facilities.

### SUMMARY

Estimated total costs for water control structures associated with salinity reduction alternatives are \$50.1 million for Alternative 1 (Napa River and Napa Slough Discharge), \$56.6 million for Alternative 2 (San Pablo Bay Discharge), and \$21.9 million for Alternative 3 (Napa River Discharge via Levee Breaches). These costs do not include those associated with the delivery of reclaimed water to the site.

Initial levee repair is estimated at \$1.6 million and peak annual levee maintenance is estimated at \$311,000 per year. Annual maintenance costs will decrease slightly during the first few years of the project as some ponds are converted to tidal marsh and their levees no longer require annual maintenance.

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Costs associated with restoration components are described in the final section of this report, and can be used to estimate the costs of various restoration alternatives that are currently under development. A generic restoration alternative with 10,000 feet of starter channels, 25 ditch blocks, 10,000 feet of levee lowering, 25 levee breaches, and 40 acres of sediment addition would cost an estimated \$8 million. These costs do not include water control structures associated with managed ponds.

## INTRODUCTION

In the early 1990s, the Cargill Salt Company ceased the production of salt and sold 9,850 acres of evaporation ponds and associated lands near the mouth of the Napa River to the State of California. The ACOE, the California Coastal Conservancy (CCC), and the California Department of Fish and Game (DFG) are proposing a salinity reduction and habitat restoration project for the site now known as the Napa Salt Marsh. The purpose of this project is to restore tidal salt marsh and ecologically related habitats to support populations of endangered species, migratory waterfowl, shorebirds, and anadromous and native fish. The long-term goal is to produce a natural, self-sustaining habitat that can adjust to naturally occurring changes in physical processes with minimum on-going intervention.

The study area contains 12 ponds formerly used in the salt production process. This process consisted of taking in Bay water at the southern edge of the pond system, allowing evaporation to occur, and then moving the brine to the next pond in the series for further concentration. Water transfers within the pond system occurred through a combination of pumps, tide gates, valves, siphons, and canals.

### Salinity Reduction

Removing salts from the ponds is the first step in the habitat restoration process. Once salinity reduction has been achieved, ponds can be opened up to tidal action or maintained as managed ponds, thus increasing their value as wildlife habitat. Salinity reduction is not currently required for Ponds 1, 1A, 2 and 2A. At the present, these ponds are functioning habitat and have salinity levels near ambient conditions. Salinity reduction is required for Ponds 3, 4, 5, 6, 6A, 7, 7A and 8. Currently, these ponds have salinity levels that either preclude use of the ponds by wildlife, or limit use of the ponds to a very small number of species. Based on Spring 2001 data from DFG, Ponds 3, 6, 6A and 7A range from 30 to 65 parts per thousand (ppt). Ponds 4 and 5 range from 150 to 200 ppt. Ponds 7A and 8 are the most saline ranging from 225 to 325 ppt. Salinity levels in most ponds fluctuate to some extent on a seasonal basis.

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Three alternatives have been previously developed by Philip Williams and Associates (PWA) to facilitate salinity reduction. These alternatives require construction of water control and conveyance structures, as well as the breaching of levees.

### **Restoration Alternatives**

Restoration alternatives are currently under development and will be implemented in parallel with salinity reduction. Restoration alternatives split the site into two components: ponds that will remain and be managed as ponds over the long-term (managed ponds), and ponds that will be opened to tidal action and be restored to tidal marsh. To date, four alternatives have been developed. Alternative 1 has roughly equal surface area of managed ponds and restored tidal marsh. Alternative 2 emphasizes tidal marsh while alternative 3 emphasizes managed ponds. Alternative 4 emphasizes tidal marsh and includes structural components within the ponds converted to marsh that will accelerate marsh development. Structural components associated with marsh restoration include starter channels, internal berms, ditch blocks, levee lowering, levee breaching, levee construction, sediment addition, and dredging of existing sloughs.

## **SALINITY REDUCTION ALTERNATIVES**

This section summarizes the facility requirements and costs of water control structures associated with the three salinity reduction alternatives. It includes a brief description of the three salinity alternatives, and describes how we sized various water control structures and how they would typically be constructed. Lastly, it discusses some assumptions behind our cost estimates.

### **Description of Salinity Reduction Alternatives**

Each salinity reduction alternative proposes different pond groupings, intake and discharge locations, and number and type of water control structures. Below we briefly describe each alternative, as well as the size and number of water control structures that will be required. In addition to these large-scale facilities, the following small-scale components are included in most alternatives:

- Check valves to ensure one-way flow through intakes or outlets.
- Manual knife valves to control the flow rate through structures.

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- Fish screens on intakes to protect fishery resources.
- Diffusers to enhance dilution of pond water into receiving waters.
- Levee breaches to promote water flow from pond to pond and between ponds and the Napa River.

**Salinity Reduction Alternative 1 – Napa River and Napa Slough Discharge.** For this alternative, the ponds are divided into three operational groups: Pond 3, Ponds 4/5/6/6A, and Ponds 7/7A/8. Pond 3 and Ponds 4/5/6/6A receive freshwater from the Napa River and/or surrounding sloughs and discharge pond water to the Napa River. Ponds 7/7A/8 all discharge to a common mixing chamber that dilutes bittern from Pond 7. Water from the mixing chamber is then discharged to the Napa Slough. Makeup water for Ponds 7A and 8 come from the Napa Slough. However, for Pond 7, our engineering analysis shows that this is not practical. We have assumed herein that reclaimed water will be used for make-up water to Pond 7. Facility structure requirements for each of the operational groups are outlined below.

**Pond 3:**

- Nine 52-inch-diameter intakes from the Napa River to the northeast corner of Pond 3.
- Three 48-inch-diameter intakes from Dutchman Slough to the southwestern side of Pond 3.
- Two 52-inch-diameter outfalls to allow flow from Pond 3 into the Napa River.

**Ponds 4/5/6/6A:**

- Seven 54-inch-diameter intakes from Napa Slough to the north-central section of Pond 5.
- Five 52-inch-diameter intakes from Napa Slough to the north-central section of Pond 6A.
- One 52-inch-diameter siphon to convey flow from Pond 6 to Pond 5.
- Two 48-inch-diameter outfalls from Napa Slough to the southeast section of Pond 4.

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Ponds 7/7A/8:

- 800 feet of dredged channel plus three 52-inch-diameter intakes from Napa Slough to the southwest corner of Pond 7A.
- One 42-inch-diameter outlet from Pond 8 to the Pond 8 canal.
- One 42-inch-diameter siphon in the Pond 8 canal to cross the slough.
- Mixing chamber at the site of the existing donut structure with inlets from Ponds 7, 7A, and 8 and an outlet to a canal.
- One 42-inch-diameter outfall from the mixing chamber canal to Napa Slough.

**Salinity Reduction Alternative 2 – San Pablo Bay Discharge.** Under this alternative, salinity reduction in the ponds is divided into two operational groups: Ponds 3/4/5 and Ponds 7/7A/8/1/2/6/6A. Ponds 3/4/5 are interconnected using levee breeches and siphons. These ponds receive freshwater from the Napa River and Napa Slough and discharge pond water to the Napa River. Ponds 7/7A/8 operate as in Alternative 1, but outflow from the mixing chamber is routed to Pond 6A rather than being discharged to the Napa Slough. Water from Pond 6A then flows through Ponds 6, 2, and 1 and out to San Pablo Bay. The salinity reduction process will occur simultaneously for all pond groups. The main difference from Alternative 1 is the greater reliance on siphons to move water from pond to pond and the fact that no water from the highly saline northern ponds is discharged to the Napa River system. Facility structure requirements for each of the operational groups are outlined below.

Ponds 3/4/5:

- Nine 54-inch-diameter intakes from the Napa River to the northeast corner of Pond 3.
- Three 48-inch-diameter intakes from Dutchman Slough to the southwestern side of Pond 3.
- Eleven 54-inch-diameter intakes from Napa Slough to the north-central section of Pond 5.
- One 48-inch-diameter siphon from Pond 3 to Pond 4.
- Two 52-inch-diameter outfalls to discharge flow from Pond 3 into the Napa River.

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Ponds 7/7A/8/1/2/6/6A:

- 800 feet of dredged channel plus seven 54-inch-diameter intakes from Napa Slough to the southwest corner of Pond 7A.
- One 42-inch-diameter outlet from Pond 8 to the Pond 8 canal.
- One 42-inch-diameter siphon in the Pond 8 canal to cross the slough.
- Mixing chamber at the site of the existing donut structure with inlets from Ponds 7, 7A, and 8 and an outlet to a canal.
- One 52-inch-diameter siphon from the Mixing Chamber Canal to Pond 6A.
- Two 54-inch-diameter siphons to connect Pond 6 to Pond 2.
- Two 54-inch-diameter siphons to connect Pond 2 to Pond 1/1A.
- One 72-inch-diameter pipe under Highway 37 (in addition to existing pipeline).

**Salinity Reduction Alternative 3 – Discharge to Napa River with Controlled Levee Breaches.** For this alternative, salinity reduction in the ponds is divided into three operational groups: Pond 3, Ponds 4/5/6/6A, and Ponds 7/7A/8. Salinity reduction in Pond 3 and in Ponds 4/5/6/6A is achieved by breaching levees on the Napa River. Inflow into Ponds 4/5/6/6A comes from an intake between the Napa Slough to Pond 6A. Facilities for Ponds 7/7A/8 are identical to Alternative 1. Facility structure requirements for each of the operational groups are outlined below.

Ponds 4/5/6/6A:

- Ten 54-inch-diameter intakes from Napa Slough to the north-central section of Pond 6A.
- One 52-inch-diameter siphon to convey flow from Pond 6 to Pond 5.

Ponds 7/7A/8 (same as Alternative 1):

- 800 feet of dredged channel plus three 52-inch-diameter intakes from Napa Slough to the southwest corner of Pond 7A.
- One 42-inch-diameter outlet from Pond 8 to the Pond 8 canal.

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- One 42-inch-diameter siphon in the Pond 8 canal to cross the slough.
- Mixing chamber at the site of the existing donut structure with inlets from Ponds 7, 7A, and 8 and an outlet to a canal.
- One 42-inch-diameter outfall from the mixing chamber canal to Napa Slough.

### Description of Structures

Salinity reduction alternatives use a combination of water conveyance and control structures including intakes, fish screens, outfalls, diffusers, siphons, mixing chambers, and levee breeches. This section briefly describes these facilities, how they were sized, and how they may be constructed. In addition, we briefly describe potential modifications to the structural assumptions used in the previous development of salinity reduction alternatives by PWA.

### Intake Structures

**Description.** Intake structures consist of a pipe or series of pipes penetrating a levee, and convey water from the river and sloughs into ponds during high tide. Pipes will be made of high-density polyethylene (HDPE). Intake pipes range in length from 300 to 600 feet and have diameters ranging from 48 to 54 inches. The number of pipes per intake ranges from 3 to 11, depending on alternatives and location within the site. Peak capacity of individual intake pipes range from 30 to 55 cubic feet per second (cfs) or 20 to 35 million gallons per day (mgd). Pipes will be fitted with check valve on the pond side of the structures that only open when the elevation of the river or slough is above that of the pond. Check valves will prevent backflow from the pond into the river or slough. Manual knife valves will also be included on all pipes within the levees. Fish screens will be installed on the river/slough side of intakes to protect fishery resources.

**Sizing.** We sized intake structures to meet peak flow requirements predicted from PWA's hydraulic modeling with the limited available head difference between the pond and the receiving waters. Lengths of pipes were determined from digitized topographical maps of the site. We estimated the effective head available to drive flows as the elevation difference between the pond and the river or slough, corrected for headlosses through fish screen and head required to overcome density differences between inlet and outlet waters. Based on discussions with manufactures, we assumed a headloss across fish screens of 0.5 feet at peak flow. Head to overcome salinity

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differences were estimated based on salinity modeling results provided by PWA. These values were, in some cases, quite substantial. For example, a 50-ppt difference is equivalent to a head differential of approximately 1 foot. After correcting for fish screens and density differences, effective head driving flows through intake structures ranged from 0.5 to 1.3 feet. We then determined the number and diameter of intakes using the hydraulic model H2ONET, which incorporated associated headlosses including entrance, exit, friction, valve, and bend losses.

Note that the design approach outlined above is conservative. Facilities sized herein may decrease in magnitude with more detailed study, which would aim to optimize the sizing of water control structures.

**Construction.** Construction of the intakes will be conducted using construction equipment brought to the needed location via levee tops and/or barges. A cofferdam will be constructed using sheetpiles on the pond and river/slough side of the levee. The inner areas of the cofferdam will be dewatered during construction as necessary. The levee will then be excavated and a pipe placed in the trench through the levee. A check valve will be fitted to the pond side of the intake pipe and a manual knife valve will be installed within the levee section of the pipe. The levee will then be back filled and compacted and the cofferdams removed. On the river or slough side of the levee, additional pipe will be installed so that the intake elevation is 3 to 4 feet below lower low tide. In areas where the terrain is above high tide, inlet pipes will be installed in a trench dug out by a clamshell digger. Where the pipe is underwater at high tide, it will be attached to support piles driven by a pile driver. On the river/slough side of the pipe, a fish screen will be attached to a flange on the end of the intake using a crane and divers. The intakes will be placed and sized so as to balance between the need to encroach as little as possible into the navigation channel while keeping structures submerged at low tide.

### **Fish Screens**

**Description.** Each intake pipe will include a cone-shaped fish screen that rests on top of the inlet at the end of the pipe. The fish screens used in this cost estimate are manufactured by Intake Screens Incorporated of Sacramento, California. The screens are self-cleaning using a brush system that intermittently rotates across the outer surface of the screen. The small submersible hydraulic motor that drives the brushes will be powered by a solar panel system. The frequency of cleaning will be set manually to meet field conditions. Screens are made of stainless steel and epoxy coated components that are cathodically protected. Protective piles are installed around the screen to protect them from large floating debris. Ducks Unlimited recently installed a similar screen system on an intake from the Napa River to Pond 8.



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Screens for the salinity reduction alternatives must be very large in order to achieve acceptable approach velocities at peak flow. They range in height from approximately 5 to 6 feet and diameter from 16 to 18 feet. Flow rates through fish screens range from 35 to 50 cfs (20 to 35 mgd). To our knowledge, fish screens of this size have not been installed in the local area. Thus, while we did obtain a price quote for these large fish screens from a local company, the cost estimate we developed is preliminary in nature.

Use of fish screens results in substantial headloss (around 0.5 feet) relative to the tidal head (around 2 feet). As a result, facilities with fish screens require more inlets than facilities without fish screens. For example, if fish screens were not used on the inlet from Napa Slough to Pond 3 in Salinity Reduction Alternative 1, the number of 54-inch-diameter inlets would decrease from nine to seven. This would result in a total cost savings of approximately \$6.6 million for the fish screens and \$1.8 million for the smaller number of inlets.

**Sizing.** Fish of concern for this project include the Delta Smelt, salmonid smolts, and the Sacramento Splittail. Based on the limiting species, the Delta Smelt, the National Marine Fisheries Service and the State of California Department of Fish and Game require that fish screens be designed with a maximum approach velocity of 0.2 feet per second (fps) and a screen gap of approximately 3/32 inch. We sized all screens to meet these constraints.

**Construction.** Fish screens will be lowered onto the inlet at the end of an intake structure using a crane and dive crew. The screens will be supported by a number of piles and additional piles will be installed around the screens to protect them from large, floating debris.

## Outfall Structures

**Description.** Outfalls are required for all alternatives to discharge water from ponds to the Napa River and sloughs during low tide. Each outfall runs from a pond or canal, through an external levee and straight out into the receiving water. A manual knife valve is included on the outfall within the levee so that flow through the outfall can be controlled. Outfalls will be constructed of HDPE. Depending on the alternative, outfalls range in length from 300 to 1,000 feet and 42 to 52 inches in diameter and include one or two outfall pipes. Peak capacity through each outfall ranges from 55 to 85 cfs (35 to 55 mgd). The end of each outfall includes a diffuser to enhance the dilution of saline pond water into receiving waters. Diffusers are the same diameter and material as the outfall and are roughly 50 to 100 feet in length. Each diffuser includes eight to ten 6- to 10-inch-diameter ports along its length and one

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10- to 14-inch-diameter port at its end. The ports are fitted with flexible neoprene check valves that open only when tidal elevation is lower than pond elevation. Diffusers are anticipated to border navigational channels within the Napa River and will be identified with appropriate signs and lighting.

**Sizing.** We sized outfalls using DIFF\$\$, Brown and Caldwell's proprietary diffuser hydraulics program that evaluates the flow distribution along an outfall. Outfalls were designed to meet peak flow requirements predicted from PWA hydraulic modeling based on head difference between the pond and the receiving waters. Maximum head at low tide was approximately 6 to 6.5 feet. Ports were sized to minimize headlosses while maximizing port discharge velocities. Higher velocities lead to greater dilution, but also higher headloss. We estimated peak port discharge velocities generally of about 12 fps.

We also performed dilution modeling of the diffusers using UM, an integral model that solves the equations of conservation of mass and energy as a plume moves away from a diffuser. UM is part of PLUMES, a computer interface that includes United States Environmental Protection Agency dilution models for effluent discharge. Dilution modeling confirms that diffusers achieve a dilution factor of around 1:10 when adequate jet velocity out of the ports was maintained. See Brown and Caldwell's Diffuser and Fish Screens Report dated May 15, 2002, for further details on dilution modeling results.

**Construction.** Outfalls are constructed in a similar fashion to intakes.

## Siphons

**Description.** Siphons are required in a number of salinity reduction alternatives to move water from one pond to another under sloughs. A number of old siphons that were used during salt production are currently in place. However, the condition of the current siphons and their remaining useful life is somewhat uncertain. As a result, we have assumed that new siphons will be required, and that all siphons (exclude that associated with Pond 8, which will have flow controlled at the pond outlet) will be installed with manually controlled knife valves. Siphons at the site will range in length from 250 to 350 feet and range in diameter from 42 to 54 inches. All siphons will be made of HDPE and flows through siphons range from 12 to 47 cfs (8 to 30 mgd).

**Sizing.** We sized siphons to meet peak flow requirements predicted from PWA hydraulic modeling with the limited head difference between the ponds (0.1 to 0.6 feet). Lengths of siphons were determined from digitized topographical maps of the site. We then determined the diameter of siphons using the hydraulic model H2ONET which

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incorporated associated head losses including entrance, exit, friction, valve and bend losses.

**Construction.** Construction of the siphons will be conducted using construction equipment brought to the needed location via levee tops and/or barges. Cofferdams will first be constructed using sheetpiles on the pond side of the levee on both ponds. The levees between the ponds and the slough will be excavated. A trench will then be excavated with a clamshell dredge across the slough from one levee breach to another. A gravel bed will be placed in the trench and the siphon will be placed on to the bed using divers and a crane. A manual knife valve will be installed on the siphon within one of the levees. Once the siphon and valve are in place, the trench along the bottom of the slough and the levee at each pond will be backfilled. After backfilling is complete, the cofferdams will be removed.

### Mixing Chamber

**Description.** Currently, a round, levee-enclosed structure called a "donut" connects flows from northern Ponds 7, 7A, and 8. For the salinity reduction alternatives, the existing donut structure will be used as a mixing chamber to dilute the highly saline water from Pond 7 with less saline water from Ponds 8 and 7A, and perhaps reclaimed water. To enhance turbulent mixing of the high-density brine with other inflows, new inlet structures from Ponds 7 and 7A will discharge into a 25-foot-diameter inner mixing chamber. Existing inlets that carry flow from Pond 8 will be extended to meet the inner mixing chamber. The mixed flow from the inner chamber will flow up and out into the outer mixing chamber area. It will then flow through outlet structures to a canal and either be discharged to the Napa Slough (Alternatives 1 and 3) or to Pond 6A (Alternative 2). All inlet and outlet structures will be made of HDPE, and all will have manual knife valves within the levee (excluding inlets from Pond 8, which will be controlled at the pond). Based on salinity alternatives developed to date, the mixing chamber is expected to meet a specific dilution ratio of Pond 7 inflow to total inflow from Ponds 7, 7A, 8 and reclaimed water to ensure adequate dilution of Pond 7 bittern prior to discharge to receiving waters.

**Sizing.** We sized inlet and outlet structures between the ponds and the mixing chamber to meet peak flow requirements predicted from PWA hydraulic modeling with the limited head difference between the ponds and the chamber, and the chamber and the outlet channel. Lengths of inlet structures were determined from a site visit. We then determined the diameter of inlets and outlets using the hydraulic model H2ONET, which incorporated associated headlosses including entrance, exit, friction, and valve losses.

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**Construction.** Installation of inlets and outlets through levees will be similar to the levee penetration scenario described for outlet structures. The inner mixing chamber will be constructed of concrete. Two sets of sheetpiles will be installed in a rough circle. Holes will then be cut in the sheet pile and inlet pipes will be extended into the inner-mixing chamber. Sheetpiles will then also be cut to the appropriate height so that they are just below the water elevation. Concrete will be poured between the sheetpiles after inlet pipes have been positioned through the sheetpiles.

### **Pipeline under Highway 37**

**Description.** Under salinity reduction Alternative 2, pond water is discharged from Pond 1 to San Pablo Bay via an existing 72-inch-diameter (63-inch-inner-diameter) pipeline and an additional new outlet. This new outlet pipeline is required to pass under Highway 37 to a discharge channel connected to the Bay. The outlet will be made of reinforced concrete and a knife valve will be installed on the pond side of the pipe.

**Sizing.** We sized the Pond 2 outlet to meet peak flow requirements predicted from PWA hydraulic modeling based on the head difference between Pond 2 and the Bay. Lengths of siphons were determined from digitized topographical maps of the site. We then determined the diameter of inlet, taking into account the capacity of the existing 63-inch outlet, using the hydraulic model H2ONET, which incorporated associated headlosses including entrance, exit, friction, and valve losses.

**Construction.** The pipeline will be installed using bore-and-jack trenchless construction methods. A geotechnical investigation will first be conducted to confirm that the site is suitable for construction. Cofferdams will be constructed on both the jacking side (Pond 1) and receiving side (the drainage channel to San Pablo Bay) of the site. The areas will be dewatered and jacking and receiving pits will be excavated. A concrete base will be constructed in the receiving pit and thrust piles will be driven to support jacking. Once pipe installation is completed, a knife valve will be installed on the pond side of the pipe, along with a pile-supported walkway to access the valve.

### **Internal and External Levee Breaches**

Interior and exterior levee breaches would be created using explosives. Typically, explosives are packed into PVC tubes that are drilled into the levee. The quantity of explosives is adjusted in proportion to the volume of levee material. The blast disperses the levee material over a wide area, so no soil movement is required. The flow of water through the levee and subsequent tidal action then opens the levee

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beyond the size of the initial breach. DFG staff have previously conducted a number of similar levee breaches at the site.

### **Structural Modifications**

During our cost estimate, we determined that there were a handful of structural assumptions that we could modify to allow for more economical construction. These are outlined below.

**Pond 5 Inlet from Napa Slough.** We moved the inlet roughly 2,500 feet to northwest. This decreased the length of inlet pipes from 2,200 to 500 feet. In addition, deeper channel morphology in the Napa Slough at this point was more conducive to fish screen operations.

**Pond 7 Intake from Napa Slough.** Perhaps the most significant result of our hydraulic modeling was the fact that there is not enough tidal head to overcome the extreme density gradient between Pond 7 (> 300 ppt salinity) and freshwater in the Napa Slough. Even at high tide, the dense brine from Pond 7 would tend to flow out an open pipe and into the slough. The same phenomena may occur at times in Ponds 4 and 5, which can reach salinity up to 150 to 200 ppt. An additional potential advantage of not installing intakes between Pond 7 and the Napa Slough is a decreased chance for an accidental release of bittern to the slough.

As a result of the above constraints, we have assumed that reclaimed water will be used as makeup water for Pond 7. We have not included any costs with respect to the importation of reclaimed water to the site. For Alternatives 1 and 3, the amount of makeup water required by Pond 7 is approximately 800 acre-feet per year (afy). This is based on evaporation losses of 550 afy and an average flow from the pond into the mixing chamber predicted by PWA hydraulic modeling (250 afy). Makeup water needed for Alternative 2 is 2,400 afy (550 afy plus 1,800 afy).

### **Cost Estimate for Salinity Reduction Alternatives**

Tables 1, 2 and 3 summarize costs associated with the three salinity reduction alternatives. Total estimated costs for Alternatives 1, 2 and 3 are \$52.8 million, \$56.6 million, and \$21.9 million, respectively. Note that we have split out costs associated with fish screens and control valves so that you can evaluate the impact of these structures on total project costs. Below we briefly discuss a number of assumptions that we developed to estimate costs associated with the salinity reduction alternatives.



**TABLE 2**  
**Napa Salt Marsh Restoration Project - Preliminary Facility Sizing and Cost Estimates**  
**Alternative 2: San Pablo Bay Discharge**

Location	BASE STRUCTURE					FISH SCREENS		KNIFE VALVES		Total cost, 1,000 dollars
	Structure Type	Structure length, ft	Number of units	Diameter of units, inches	Base cost, 1,000 dollars	Number of units	Cost, 1,000 dollars	Size and number of valves	Cost, 1,000 dollars	
<b>PONDS 3/4/5</b>										
Napa Slough to Pond 5	Inlets with fish screens	600	11	54	\$2,978	11	\$4,805	11 @ 54"	\$1,010	\$8,793
Pond 5 to Pond 4	Internal Levee Branch	100	4	NA	\$14	NA	\$0	NA	\$0	\$14
Pond 3 to Pond 4	Siphon	350	1	48	\$175	NA	\$0	1 @ 48"	\$70	\$245
Napa River to Pond 3	Inlets with fish screens	600	9	54	\$2,279	9	\$3,931	9 @ 54"	\$628	\$7,058
Dutchman Slough to Pond 3	Inlets with fish screens	300	3	48	\$345	3	\$1,310	3 @ 48"	\$210	\$2,065
Pond 3 to Napa River	Outfall with diffuser	1,100	2	52	\$952	NA	\$0	2 @ 52"	\$181	\$1,133
<b>PONDS 7/7A/8</b>										
Napa Slough to Pond 7A	Channel & Inlets with fish screens	500	7	54	\$2,135	7	\$3,056	7 @ 54"	\$643	\$5,838
Pond 8 to Pond 8 Canal	Outlet	200	1	42	\$47	NA	\$0	1 @ 42"	\$91	\$138
Pond 8 Canal to Mixing Chamber	Siphon	350	1	42	\$147	NA	\$0	NA	\$0	\$147
Mixing Chamber with inlets and Outlet	Mixing Chamber	NA	NA	NA	\$238	NA	\$0	1 @ 32", 4 @ 48"	\$304	\$542
Mix. Chamber Outlet Canal to Pond 6A	Siphon	350	1	52	\$220	NA	\$0	1 @ 52"	\$81	\$311
<b>PONDS 1/2/6/6A</b>										
Pond 6A to Pond 6	Internal Levee Branch	100	4	NA	\$14	NA	\$0	NA	\$0	\$14
Pond 6 to Pond 2	Siphon	300	2	54	\$333	NA	\$0	2 @ 54"	\$108	\$519
Pond 2 to Pond 1	Siphon	300	2	54	\$333	NA	\$0	2 @ 54"	\$108	\$519
Pond 1 to San Pablo Bay	Inlet/Outlet	200	1	72	\$628	NA	\$0	2 @ 72"	\$208	\$837
<b>SUB-TOTAL 1</b>					\$11,039		\$15,104		\$4,096	\$28,239
<b>INDIRECT COSTS (15% of Base Cost)</b>							\$0		\$0	\$1,656
<b>MOBILIZATION (11% of Base Cost)</b>							\$0		\$0	\$1,396
<b>OVERHEAD, PROFIT AND BOND (17%)</b>							\$0		\$0	\$1,396
<b>SUB-TOTAL 2</b>					\$2,396		\$2,228		\$696	\$5,320
<b>CONTINGENCY (40%, 25% for fish screens and knife valves)</b>					\$16,487		\$15,332		\$4,782	\$36,611
<b>TOTAL CONSTRUCTION COST</b>					\$6,665		\$3,833		\$1,198	\$11,696
<b>ENGINEERING, LEGAL AND ADMINISTRATION (20%, 15% for fish screens and knife valves)</b>					\$23,092		\$19,165		\$5,990	\$48,237
<b>TOTAL ALTERNATIVES COST (202 dollars)</b>					\$4,618		\$2,975		\$899	\$8,392
					\$27,700		\$22,000		\$6,900	\$56,600





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**Construction Methods.** Except for valves on the intakes from Pond 1 to San Pablo Bay and on the existing lines between the Pond 8 channel and the mixing chamber, all knife gates will be installed into connecting pipes within the levee on land. We assume that contractors will have a staging area available in the vicinity of Pond 8, and that all excavation spoils from the project can be spread on adjacent levee banks as part of maintenance operations or in the borrow ditches of ponds. Fish screens in rivers and sloughs will be installed in one continuous operation after the completion of most other construction activities.

**Unit Costs.** Check valve, knife valve and fish screen costs are based on quotes from manufacturers. Breaching costs were based on cost estimates developed by the DFG assuming that DFG staff and explosives experts would be available to perform required breaching. Where work is dependent on tides (e.g., work in sloughs or on the Napa River) costs include a 100 percent markup on standard labor as required by union rules. This accounts for workers having variable starting and finishing times that vary on a daily basis. In addition, a 50 percent markdown on standard equipment costs is included since equipment will not be used during low tide conditions.

**Replacement Costs.** For Alternatives 1 and 3, we assumed 50 percent valve replacement in the northern pond system (Ponds 7/7A and 8), which is expected to run for a number of decades. No valve replacement costs were included for Alternative 2 since valves are expected to last the life of the 20-year project.

**Added Project Costs.** A number of additional standard costs were added as a fraction of the base costs. These include:

- 11 percent for mobilization.
- 15 percent for indirect costs.
- 17 percent for overhead, profit and bond costs associated with project construction.
- 40 percent contingency to account for a number of uncertainties associated with the project.
- 20 percent for engineering, legal and administrative fees to cover the design and construction of the project.

**Costs not Included.** Our cost estimate does not include costs associated with water quality monitoring, restoration monitoring, additional land acquisition, project permitting, or reclaimed water delivery to the site.

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**Facility Decommissioning.** Some existing facilities (e.g., unused siphons) and new facilities associated with salinity reduction (inlets and outlets in ponds converted to tidal marsh) may need to be decommissioned early on in the project. Many of these facilities would be left in place and plugged, and some piping and most check valves and knife valves would be salvaged. We anticipate that fees collected through the sale of salvageable materials will roughly offset costs associated with decommissioning. Thus, we have not included a detailed evaluation of structure decommissioning in this cost estimate.

### LEVEE REPAIR AND MAINTENANCE

Levee repair includes an initial effort to upgrade existing levees while long-term maintenance entails ongoing efforts to maintain levees in good condition during both salinity reduction and restoration. Cost estimates associated with levee maintenance and repair are based on a number of assumptions including:

- Required footage of levee repair based on reports from the DFG.
- As noted by DFG, the dimensions of pond levees throughout the site are variable, as are the volumes associated with levee repair. Herein, we have assumed that the volumes required for levee repair and maintenance are equal to 2.5 feet of sediment spread over 30 feet of levee width. These values are based on discussions with DFG and knowledgeable contractors. This is equivalent to 2.8 cubic yards per foot of levee that requires repair or maintenance.
- Long-term maintenance requires repair of 10 percent of the length of levees per year. This value is between those cited by knowledgeable contractors (every 5 to 7 years) and that quoted in the recent report "South Bay Salt Pond Restoration" by Siegel and Bachand. They state that 10 miles of a total 220 miles of levee are maintained each year at the South Bay ponds (Section 14.1.2).
- Sediment from on site is used for levee repair and maintenance.
- Repair base unit costs assume the use of a barge mounted clamshell dredge for half of the repairs and a land-based hydraulic excavator for the other half of the repairs. It also includes the cost of spreading and dressing using a front-end loader.

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- Maintenance base unit costs assume the use of a land-based hydraulic excavator and spreading and dressing using a front-end loader.
- Costs include fees for mobilization (5.5 percent for land accessible or 11 percent for non-land accessible), indirect costs (15 percent), overhead and profit (17 percent), and contingency (40 percent).

Cost estimates of levee maintenance are presented in Table 4 on a per pond basis. Initial repair is estimated at \$1.6 million (\$26.64 per foot of levee) and annual maintenance is around \$200,000 to \$300,000 per year (\$12.66 per foot of levee). Note that these costs per foot of levee are in the range of levee maintenance costs cited in the "South Bay Salt Pond Restoration" report (\$10 to \$27 per foot). Maintenance costs are also similar to DFG and contractor estimates of \$7 to \$10 per foot.

Depending on the scope and timing of a given restoration alternative, both repair and maintenance costs can be estimated for applicable ponds and summed to evaluate a given salinity reduction and/or restoration alternative. This is shown in Table 4 for implementation of Salinity Reduction Alternative 1 and draft Restoration Alternative 1. In Year 1, all ponds would require repairs at a total estimated cost of \$1.6 million. In the second year, all ponds excluding Pond 3, which would presumably be breached in Year 2, and Pond 2A, which is already open to tidal action, would need maintenance at a cost of \$260,000 per year. After Year 3, Ponds 4/5 would be open to tidal action, and levee maintenance costs would drop to \$190,000 per year. Maintenance costs would remain at this level for the remainder of the project with ongoing levee maintenance being required for Ponds 1, 1A, 2, 6/6A, 7, 7A and 8. Costs reported herein are in 2002 dollars. These costs can be adjusted to develop the net present value of various combinations of salinity reduction and restoration alternatives.

Some cost savings may be achieved if levee repair is coupled with starter channel construction (see Restoration Alternative section). Rather than sediment from existing borrow ditches, sediment from the starter channels could be used to repair levees. Starter channels have only been proposed in Ponds 3, 4/5, and 6/6A, so cost savings could only be realized in these ponds. Sediment from 1 linear foot of starter channel is roughly equivalent to 4 linear feet of levee repair. Thus, assuming starter channels on the order of 3,000 feet per pond, starter channel sediment volumes would be adequate for repair of all levees in Pond 3 (12,380 feet of repair), Ponds 4/5 (1,210 feet of repair), and Ponds 6/6A (4,180 feet of repair). Note that for Pond 3, if sediment is used for levee repair, none would be available for berm construction.

**TABLE 4**  
**Napa Salt Marsh Restoration Project - Levee Repair and Maintenance Costs**

Pond	Levee perimeter, feet <sup>3</sup>	Initial Repair <sup>1</sup>		Total Footage, feet	Cost, dollars	Long-term Maintenance <sup>2</sup>		Annual cost of long-term maintenance assuming implementation of Salinity Reduction and Restoration Alternatives 1, dollars per year		
		Percent of levee footage				Footage per year	Annual cost, dollars per year	Year 1	Year 2	Year 3+
		Pass 1	Pass 2							
1	17,750	30%	30%	10,650	\$284,500	1,780	\$22,700	Repair	\$22,700	\$22,700
1A	25,250	15%	0%	3,790	\$101,300	2,530	\$32,300	Repair	\$32,300	\$32,300
2	30,250	40%	40%	24,200	\$646,600	3,030	\$38,700	Repair	\$38,700	\$38,700
3	41,250	15%	15%	12,380	\$330,800	4,130	\$52,800	Repair	\$0	\$0
4	33,750	0%	0%	0	\$0	3,380	\$43,200	-	\$43,200	\$0
5	24,250	5%	0%	1,210	\$32,300	2,430	\$31,000	Repair	\$31,000	\$0
6	18,500	5%	0%	930	\$24,800	1,850	\$23,600	Repair	\$23,600	\$23,600
6A	16,250	10%	10%	3,250	\$86,800	1,630	\$20,800	Repair	\$20,800	\$20,800
7	12,375	15%	0%	1,860	\$47,200	1,240	\$15,100	Repair	\$15,100	\$15,100
7A	15,625	5%	0%	780	\$19,800	1,560	\$18,900	Repair	\$18,900	\$18,900
8	10,000	10%	0%	1,000	\$25,400	1,000	\$12,100	Repair	\$12,100	\$12,100
Total for all Ponds				60,050	\$1,600,000	24,560	\$311,000		\$1,600,000	\$258,000
Unit cost, dollars per foot					\$26.64		\$12.66			

<sup>1</sup>Repair assumes the placement of soil 2.5 feet deep over 30 feet of levee width. Repair costs are based on base cost of \$4.60 per cubic yard. This is a composite unit costs assuming use of a barge mounted clamshell dredge for half of the repairs, a land-based hydraulic excavator for half the repairs, and spreading/dressing using a front-end loader on levee. Costs include mobilization (land accessible = 5.5%, non-land accessible = 11%), indirect costs (15%), overhead and profit (17%) and contingency (40%).

<sup>2</sup>Maintenance assumes the placement of soil 2.5 feet deep over 30 feet of levee width. Costs assume 10% per year levee maintenance. Maintenance costs are based on base cost of \$2.20 per cubic yard for a land-based hydraulic excavator and spreading/dressing using a front-end loader on levee. Costs include mobilization (land accessible = 5.5%, non-land accessible = 11%), indirect costs (15%), overhead and profit (17%) and contingency (40%).

<sup>3</sup>Repair footage is based on information from DFG (e-mail from Huffman to von Rosenberg, 4/18/02).