

**Feasibility Analysis**

# **South Bay Salt Pond Restoration**

**San Francisco Estuary, California**



**Stuart W. Siegel, PWS  
Philip A.M. Bachand, PhD**

Copyright © 2001, 2002 by Stuart W. Siegel and Philip A.M. Bachand

All rights reserved. This work is protected under U.S. copyright laws. The authors will conditionally permit reproduction and re-publication of the entire work for commentary and informational purposes so long as full acknowledgement with citation to the authors is prominently displayed.

Please cite this report as:

Siegel, S.W. and P.A.M. Bachand. 2002. Feasibility Analysis of South Bay Salt Pond Restoration, San Francisco Estuary, California. Wetlands and Water Resources, San Rafael, California. 228 pp.

This project has been funded in part by:

- Save San Francisco Bay Association
- California State Coastal Conservancy
- Citizens Committee to Complete the Refuge
- Wetlands and Water Resources

The contents and views of this document do not necessarily reflect the view and policies of Save San Francisco Bay Association, California State Coastal Conservancy, or the Citizens Committee to Complete the Refuge.

To order additional copies of this report (suggested \$30 donation), please contact:

Wetlands and Water Resources  
P.O. Box 10293  
San Rafael, CA 94912 USA  
(415) 457-6746; (415) 457-6769 fax  
<http://www.swampthing.org>

Cover photo of Newark crystallizer ponds, February 28, 2001

## **Credits**

### **Authors**

Stuart W. Siegel, P.W.S. – President and Principal Environmental Scientist, Wetlands and Water Resources  
Philip A.M. Bachand, Ph.D. – Principal Wetland Engineer, Wetlands and Water Resources

### **Contributors**

Laird Henkel – biological resources

### **Geographic Information System Map Atlas**

Jake Schweitzer – GIS Analyst and Cartographer, Wetlands and Water Resources

### **Report Production**

Darren Campeau – design and layout – [www.dcampeau.com](http://www.dcampeau.com)

### **Cover photo**

Darryl Bush – San Francisco Chronicle





To: Interested Parties  
From: Stuart Siegel and Philip Bachand  
Date: March 2002  
Re: Feasibility Analysis of South Bay Salt Pond Restoration, San Francisco Estuary, California

This Feasibility Analysis culminates two years of research and analysis into restoration feasibility of the South Bay Cargill salt ponds to tidal marsh. This work contributes to two major efforts: (1) current negotiations for public acquisition of a large portion of the salt ponds, and (2) restoration planning, design, and long-term implementation. The purpose of this report is to provide a scientifically based analysis independent of any particular interest group. In preparing this report, we followed standards for a peer reviewed publication: we drew information from relevant publications, interviewed nearly 40 experts, underwent peer review, and provided full references.

This report highlights issues that we believe require further consideration for acquisition and restoration. Though some or all of these issues may be part of the acquisition negotiations, those negotiations are closed to the public so we do not know their status. The report is not intended to provide a final determination on these issues. Rather, it is intended as a starting point to identify issues we consider very important to achieve a successful restoration effort. Our report contains all the data we used so that others can develop their own conclusions.

Our seven major conclusions are:

1. A comprehensive program must mix tidal marsh restoration with costly permanent management of shallow open water ponds in order to meet multiple ecological goals, as recommended by the Goals Report and the upcoming U.S. Fish and Wildlife Service Tidal Marsh Ecosystem and Snowy Plover recovery plans.
2. Phasing and/or dredged sediment reuse will be essential to resolve a massive sediment deficit without disrupting ecologically important South Bay mudflats.
3. Dredged sediment reuse may prove economically feasible and, because it could cut the overall restoration time in half, ecologically beneficial.
4. Acquisition negotiations must ensure that Cargill (a) removes all bittern and hypersaline brines from the sale area and (b) takes full long-term responsibility for bittern stored on public lands in Newark. We estimate total annual bittern production to be 4 times greater than Cargill estimates, highlighting the importance of addressing all forms of bittern.
5. Long-term operations, maintenance and monitoring will be costly and must be fully funded to avoid South Bay flooding risks and to maximize wildlife benefits.
6. Remaining salt production, invasive species, and constantly changing wildlife use of salt ponds all must be carefully considered for a successful restoration effort.
7. Relatively few ponds can be restored easily. The Cargill proposal transfers most of the "problem" ponds to public control and retains most of the "easy" ponds in Cargill control.

We have estimated that costs should range between \$314 million to \$1.1 billion (in 2001 dollars), plus \$300 million for acquisition, to restore and manage the 16,000-acre package Cargill offered the public in 2000. Recent negotiations have scaled the acquisition down to \$100 million for 13,000-15,000 acres. Too few details are public for us to evaluate this package equally but we estimate that the modest reduction in acreage translates into a modest reduction in restoration and management costs. These cost estimates consider restoration with and without dredged sediment reuse and the ranges are intended to reflect uncertainties in the estimate. We anticipate annual costs of \$6.5-\$14 million initially, with costs gradually dropping over many decades to \$1.4-\$3.4 million annually.



# Executive Summary

---

The Cargill Salt Corporation produces about 1 million tons of common salt annually from its 26,190-acre South San Francisco Bay salt pond complex. Cargill owns 14,760 acres (56%) of these salt ponds. The Don Edwards San Francisco Bay National Wildlife Refuge owns the remaining 11,430 acres (44%), which it acquired in the 1970s. As part of that sale, Cargill (then Leslie Salt) retained the mineral rights for salt production on all these lands. Nearly the entire South Bay salt pond complex (97% total area) consists of former tidal marshlands diked for decades. Only about 670 acres (3%), representing about three-quarters of the Newark crystallizer ponds, were built outside the tidal marshlands on the adjacent grassland/vernal pool complexes. The historical condition affects ecological restoration goals and the extent of current federal regulatory jurisdiction under the Clean Water Act and Rivers and Harbors Act. Jurisdiction, in turn, can affect the property value of the salt ponds through its restrictions on development and therefore has bearing on the current acquisition negotiations.

A long-established and worthy goal of the regional resource management community has been to acquire the entire South Bay salt pond complex and restore it to its pre-existing tidal marsh condition. Two actions have taken place in the past few years that may bring this goal to fruition and which serve as the impetus for this Feasibility Analysis. First, the San Francisco International Airport has been evaluating salt pond restoration (in part or in whole) as mitigation for its proposed runway extension project. Second, in 2000 Cargill formally offered to sell about 16,000 acres plus 600 acres of South Bay tidelands and another 1,400 acres along the Napa River to the state and federal governments for \$300 million. Those 16,000 acres include 12,000 acres Cargill owns and mineral rights on 4,000 acres the Refuge owns. Negotiations have been ongoing since 2000, and a smaller deal for \$100 million representing 13,000 to 15,000 acres may soon be reached that may or may not involve SFO mitigation funds.

ES-1

In negotiating with Cargill and other entities, resource managers will need to understand not only the short-term goals of acquiring property but also the long-term goal of sustainable restoration and management. Restoration, especially along the scale of the South Bay salt ponds, is a process and not an event. The complexity of this process crosses many scales. Most basically, each restoration site must undergo a number of changes to transform from the current salt pond condition to the ultimate goal for that site whether it be tidal marsh, ponds, pannes or some combination. Some of the important issues and challenges facing resource managers and planners that will affect the rate at which salt ponds can be restored to tidal marsh include: proximity to colonizing plants and animals, initial site elevations creating sediment deficits, sediment supply and dredged sediment availability, bittern and hypersaline brine removal and pond desalination, restoration and ongoing operations and maintenance costs, containing invasive species, protecting existing biological resources, and decreasing survival pressures on the many special status species that utilize tidal marsh and salt ponds. These issues have implications on a broad spatial scale and a long temporal scale, one of the most significant of which is resolving the sediment deficit with scouring ecologically important South Bay mudflats. Restoration does not mean that today it is a salt pond and the day after breaching a levee we have a vegetated, natural marsh.

The purpose of this Feasibility Analysis is to provide a starting point for evaluating all topics relevant to the purchase and restoration of some or all of the South Bay salt ponds. To achieve this purpose, we examined the suite of biological, physical, chemical, and economic issues relevant to restoring tidal marsh on the entire 26,000-acre South Bay salt pond complex as well as the smaller 16,000-acre Cargill proposed sale area. We then integrated these data into a pond-by-pond restoration feasibility determination and developed a set of key conclusions pertinent to undertaking acquisition and restoration. In this Executive Summary we summarize these seven key conclusions, provide summary South Bay salt pond statistics for use by planners and resource managers, and present a rough cost estimate for restoring the 16,000 acres Cargill has recently offered for public acquisition.

## Seven Key Conclusions Summarized

From all the material we evaluated and people we talked with in preparing this Feasibility Analysis, we have identified seven key conclusions that we believe are the most salient to negotiating a purchase and planning the restoration of all or a portion of the South Bay salt pond complex. Although we support acquisition and restoration fully, addressing the challenges summarized in these seven key conclusions will require careful planning and thoughtful action to achieve the desired environmental and ecological benefits in a cost effective manner. The important message from these analyses is that a long-term commitment will be required to realize the benefits of salt pond purchase and restoration.

### Conclusion 1: Mix Tidal Marsh Restoration and Shallow Open Water Management

**Promoting recovery of federally listed species and species of concern should be a primary consideration in restoration planning and implementation. To accommodate conflicting ecological requirement between many of these species, an overall restoration plan should include about one-third of the salt ponds retained as managed shallow open water areas and two-thirds restored to tidal marsh.**

Tidal marsh represents the historical condition for nearly all the salt ponds and their loss is directly responsible for declines in numerous plant, fish and wildlife species around which a broad consensus exists for their recovery. Shallow open water, historically less common in the South Bay and currently provided almost entirely by the salt ponds, supports a thriving bird community around which a broad consensus also exists for its protection. Several threatened and endangered species depend on and/or utilize both ecosystem types. Reconciling these competing goals translates into retaining about one-third of the South Bay salt ponds as managed shallow open water habitats and restoring the remainder to tidal marsh. This approach is consistent with recommendations originally put forth by the Goals Project as well as goals to promote recovery of special status species as stated in the two draft U.S. Fish and Wildlife recovery plans applicable to the South Bay (Western Snowy Plover and Tidal Marsh Ecosystems). How these goals are accomplished in the context of ongoing Cargill operations presents a complex challenge for restoration planners. Though based clearly in conservation needs, permanently maintaining one-third of the salt ponds as shallow open water habitats will require a long-term operations and maintenance (O&M) funding commitment that would not be necessary were all ponds restored to tidal marsh. Thus, the resource management community must understand and accept the permanent costs associated with meeting its conservation goals as well as the consequences of failing to meet those funding needs (see Conclusion #4).

### Conclusion 2: Resolve Sediment Deficit with Phased Restoration and/or Dredged Sediment Reuse

**A very large sediment deficit exists for restoring tidal marsh elevations on subsided salt ponds that will require restoration phasing over many decades and/or dredged sediment reuse in order to protect South Bay mudflats.** Subsidence is a common feature of San Francisco Estuary diked baylands. Most of the salt ponds from Mountain View to San Jose (the "Alviso Plant") have subsided from 6 to 8 feet below marsh height due to groundwater pumping ongoing through the 1960s. Surrounding uplands in the South Bay have subsided even more, up to 13 feet in some places. Most of the remaining salt ponds have subsided from 1 to 4 feet below marsh height.

**We estimate this subsidence to represent a sediment deficit of about 108 million cubic yards (MCY) to restore tidal marsh elevations for the entire 26,000-acre South Bay salt pond complex and about 89 MCY for the 16,000-acre Cargill proposed sale area.** The actual deficit will be less according to how many and which ponds are retained as managed shallow open water (or retained for salt production). Meeting this sediment deficit *without scouring the ecologically important South Bay mudflats* will require one of two approaches: (1) phase restoration over many decades to match sediment demand with the rate at which sediment naturally enters the South Bay (estimated by others at about 0.9 MCY per year), or (2) partially fill ponds with clean dredged sediment. We estimate the first option would require about 120 years to restore two-thirds of the entire South Bay salt pond complex and 99 years for two-thirds of the smaller Cargill proposed sale area. Dredged sediment reuse can reduce these time frames to as short as 56 years and 39 years for the full complex and Cargill proposed sale area, respectively, depending on the rate of dredged sediment availability. These time periods could be reduced further if greater quantities of dredged sediment could be made available more rapidly. Dredged sediment, however, has economic consequences that must be considered; these are discussed next.

### Conclusion 3: Dredged Sediment Reuse May Be Desirable and Economically Feasible

**Our cost estimate ranges for “natural sedimentation” and “dredged sediment reuse” restoration approaches overlap considerably, suggesting that dredged sediment may be economically feasible.**

Further, dredged sediment reuse can speed the overall period of restoration, thereby achieving ecological goals decades sooner. A fundamental aspect of salt pond restoration is that the sediment supply to offset the sediment deficit cannot, as a matter of natural resource protection, come at the expense of South Bay mudflats. Our estimates indicate that the “mudflat-sustainable” natural sedimentation restoration approach will require on the order of 120 years to restore two-thirds of the total salt pond complex to tidal marsh and 100 years for two-thirds of the smaller Cargill proposed sale area ponds. The dredged sediment reuse options reduced that time frame to 56-72 years and 39-52 years for the total salt pond complex and the Cargill proposed sale area, respectively. The range in years reflects different amounts of dredged sediment reuse that could be considered. These time periods could be shortened further if suitable dredged sediment were available more rapidly than we assumed for our analyses. Because total restoration costs include interim and ongoing O&M costs, more rapid restoration shortens the duration of the more costly interim O&M and thus reduces costs further. Additionally, accelerated restoration efforts, if well planned, will also achieve the environmental and ecological benefits sooner. These benefits have not been estimated though their consideration is critical in developing any accurate cost-benefit analyses that considers using dredged sediment.

Our rough cost estimate for the “mudflat-sustainable” natural sedimentation approach consists entirely of interim and permanent O&M and comes in at \$621 million to \$1.49 billion for restoring two-thirds of the total South Bay salt pond complex (or about 18,000 acres). For the 16,000-acre Cargill proposed sale area, those costs span a range of \$315 to \$764 million. For dredged sediment reuse, we considered three scenarios reflecting variable quantities of dredged sediment. Though dredged sediment reuse has considerable up-front costs, it gains a vital economic benefit — it reduces the time period over which costly interim O&M is necessary. To calculate these costs, we used a suite of assumptions including that restoration sponsors would be responsible only for the incremental costs of dredged sediment reuse not normally paid for by dredging projects. Dredged sediment reuse cost estimates range from \$457 to \$1.48 billion for the full salt pond complex and \$222 to \$899 million for the Cargill proposed sale area. In other words, dredged sediment has the potential to be a very effective and economically competitive approach to restoring the South Bay salt ponds. In practice, the single greatest issue is dredged sediment availability, as competition now exists for reusing dredged sediment for wetland restoration (e.g., Montezuma and Hamilton-Bel Marin Keys).

ES-3

### Conclusion 4: Account for All Bittern and Hypersaline Brine in the Short and Long Term

**The current acquisition negotiations need to include requirement for full bittern and hypersaline brine removal from the Redwood City ponds included in the Cargill proposed sale area and a formulation of a binding plan for Cargill’s long-term disposition of bittern and hypersaline brines stored in Newark.**

Bittern is the hypersaline byproduct of solar salt production. Bittern occurs in both a liquid and solid state and consists of naturally occurring minerals in bay water *minus* the commercially harvested common salt and some other salts that solidify within the pond system as part of evaporation (mainly gypsum). Bittern is thus distinguished from bay water by a salinity level over ten times higher and by its *ionic imbalance*, both of which make it toxic to aquatic organisms. Hypersaline brines are the concentrated bay waters that arise from salt production prior to salt harvesting and from any efforts to “clean” bittern and other high-salinity ponds during pond decommissioning. Three specific issues require incorporation into current acquisition negotiations.

#### ***Bittern Definition Must Include All Components of Bittern in Acquisition Negotiations***

Considerably different estimates of the ongoing bittern production rates exist that we believe stem in part from varying definitions of bittern. Cargill currently estimates it produces 0.15 million tons of bittern annually. Leslie Salt, Cargill’s predecessor, estimated 1 million tons annually. Resolving this disparity is critical to ensure that bittern in all its forms are properly removed from Redwood City as part of acquisition so that the public does not take on this costly liability as it did with the North Bay salt ponds in the 1990s. **Bittern is defined as the total liquid bittern, including dissolved ions and salts and the water in which they are dissolved, plus the precipitated bittern salts that have deposited on bittern pond bottoms.** Using this definition and assuming that Cargill stores bittern at the highest

salinity possible in the region (dictated by rainfall and solar evaporation), our new mass balance analysis estimates an annual bittern production rate of about 0.6 million tons. We believe that Cargill's estimate of 0.15 million tons is too low to account for all forms of bittern regardless of storage salinity and liquid or solid phase and that Leslie's estimate of 1 million tons is too high because it failed to account for evaporative concentration in the bittern storage ponds.

### ***Acquisition Should Provide Plan for Hypersaline Brines***

Hypersaline brines are the concentrated bay waters that arise from salt production prior to salt harvesting and from post-acquisition efforts to "clean" (i.e., desalinate) bittern and other high-salinity ponds. Hypersaline brines pose similar toxicity issues to that of bittern, though at reduced levels of significance since their ionic imbalance is less than bittern. Negotiations should clearly define responsibilities, terms and conditions for the disposition of these brines. The volume produced will depend upon the desalination method and the initial salinity level of ponds being desalinated and could be an additional one to two volumes in addition to what is currently within a pond. Because of its very large volume, transferring brine into Cargill's salt production stream at a rate that is economically and logistically feasible while meeting state and federal restoration goals will require close coordination between Cargill and the resource management agencies.

### ***Provide a Long-Term Plan for Existing Stockpiled Bittern Disposition***

In the early 1970s, the federal Clean Water Act and the state Porter-Cologne Water Quality Act ended unregulated bittern discharge to the Bay. Since that time, the available market for bittern has been relatively minor. Consequently, Cargill has stockpiled roughly 30 years of bittern at Redwood City and Newark. We have estimated that stockpile to be about 19-20 million tons of bittern. It is our understanding that all the bittern stockpiled in Redwood City will be transferred to Newark. Most of Cargill's Newark-stored bittern is located in Ponds 12 and 13 in Newark Plant #2; these ponds are owned by the Refuge. Transfer of the Redwood City bittern to Newark may require converting additional ponds to bittern storage, and whether these additional ponds would be on Cargill or Refuge property is to be determined as part of the acquisition.

The 1979 operating agreement under which Cargill exercises its mineral rights on Refuge-owned salt ponds places Cargill under no obligation to clean up bittern or any other problems it has created on these publicly-owned lands. Solar salt production in the highly urbanized San Francisco Estuary may not be an economical operation in the long-term as suggested by Cargill's current efforts to reduce local salt production and increase production efficiencies. Over the anticipated period for sustainable restoration, it seems likely that Cargill will cease salt production altogether. **Thus, current acquisition negotiations are the forum to establish clear Cargill responsibility for long-term disposition of all bittern, including the existing stockpiles and all future bittern production.** The State of California has learned the hard way from the Napa River salt ponds just how difficult and costly bittern remediation can be. Cargill has currently undertaken efforts to reduce bittern volumes through reprocessing bittern in the salt production process and creating and enlarging commercial markets for bittern.

## **Conclusion 5:**

### **Commit to Immediate and Long-Term Operations, Maintenance and Monitoring**

**Immediate and long-term ongoing operations, maintenance, and monitoring funds are essential to achieve ecological goals and protect against levee failures that could flood locally large segments of the South Bay. These funds represent a need for long-term political and fiscal commitment by local, state, and federal agencies. Securing these funds may be more important and difficult than the initial purchasing of the property.** Beyond the first step in restoration (acquisition), it will be essential to maintain hundreds of water control structures and some significant portion of the 234 miles of levees enclosing the salt ponds. Adaptive management will provide the best approach for ensuring a successful restoration program that will take decades to complete. Monitoring data are the essential information resource for adaptive management and therefore monitoring should be adequately funded throughout the restoration effort.

### ***Water Control Structures Provide the Means for Wildlife Management in Retained Ponds***

Pond water levels, salinity and water quality are all essential elements for wildlife management in the salt ponds. These parameters are governed largely by the amount and rate of water exchange between ponds and the South Bay. Numerous pumps, pipes, gates, and related infrastructure are necessary to

carry out any water management. Therefore, inadequately maintaining water control structures could compromise ecological goals and provide the potential for water quality problems (i.e., unintended “salt production” leading to hypersaline brines and gypsum deposition).

### ***Flood Protection Levees Protect Subsided South Bay Uplands***

Cargill currently maintains a total of 21 miles of levees that separate salt ponds from adjacent inland land uses and another 180 miles of levees bayward of these levees, some of which provide flood control protection remotely. Public agencies maintain another 17 miles of levees enclosing the salt ponds. Inadequate levee maintenance could lead to failures potentially flooding extensive areas of the South Bay that lie below sea level.

### ***Estimated Operations and Maintenance Activities and Costs***

O&M activities will vary according to the phase of overall restoration and the target ecosystem types being managed. We have divided the restoration effort into three phases: initial planning and design, interim management of ponds targeted for tidal marsh restoration, and permanent management of ponds retained as shallow open water habitats. The full range of O&M activities that will be required for most of these phases includes water management, levee maintenance, water control structure maintenance, and meeting regulatory act requirements. We estimate annual O&M costs (in 2001 dollars) for all these activities to range between \$284 and \$686 per acre. These costs translate to \$4.5 to \$11 million total annually for the 16,000-acre Cargill proposed sale area (a slightly reduced version of which is currently being negotiated) and \$7.4 to \$17.8 million total annually for the entire salt pond complex. Annual costs will decline over time as described next. All O&M funds would need to go to the Don Edwards San Francisco Bay National Wildlife Refuge, the entity expected to own and be responsible for all the acquired salt ponds. Actual O&M costs will depend also on which ponds are restored to tidal marsh and which are retained as open water, as levee maintenance costs will vary depending on the nature of individual levees.

**Initial planning and design period.** During the initial planning and design period, which we assume would last five years, we expect that full O&M activities and funds will be required for all purchased properties. For the 16,000-acre Cargill proposed sale area, initial O&M will cost somewhere between \$23 and \$55 million total. For the entire 26,000-acre South Bay salt pond complex, these costs would be \$37 to \$89 million.

**Interim management of ponds restored to tidal marsh.** During the extended period over which two-thirds of the pond acreage would be restored to tidal marsh, O&M activities and costs will gradually decline. At the outset, the full range of O&M activities would be required. Once a pond is restored to tidal marsh, only levee maintenance would be required and we assume that ends once marsh vegetation becomes well established for levee erosion protection. For two-thirds of the Cargill proposed sale area, these O&M costs will be somewhere between \$156 and \$357 million for the longer implementation time required by the natural sedimentation approach and \$62 to \$151 million for a shorter period associated with dredged sediment reuse.

**Permanent management of ponds retained as shallow open water habitats.** The one-third of pond acreage retained as shallow open water habitat will require the full range of O&M activities and costs in perpetuity. For the Cargill proposed sale area, these costs will be between \$1.4 and \$3.4 million annually. These costs would be \$2.3 to \$5.5 million annually for the entire salt pond complex.

### ***Monitoring***

Monitoring funds will also be required and are likely necessary shortly after acquisition. We estimate that monitoring will cost \$1.5 to \$3.0 million dollars annually for the 16,000-acre Cargill proposed sale area and will extend over a 40-year period and perhaps longer. We would anticipate that actual monitoring costs will rise and fall from one year to the next, so this 40-year estimate should approximate those total costs. Total costs over those 40 years would range between \$60 and \$120 million, in 2001 dollars.

## **Conclusion 6: Restoration Needs to Consider the Many Pressures on Biological Resources**

**During the restoration process, many environmental and economic pressures will threaten existing biological resources and thus are important considerations in acquisition and restoration planning.** We have identified three topics of particular concern: increased importance to wildlife of remaining salt production ponds, dynamics of wildlife use of South Bay salt ponds, and the invasive eastern cordgrass, *Spartina alterniflora*.

### **Increased Importance of Remaining Salt Production Ponds**

Converting two-thirds of salt ponds to tidal marsh (regardless whether of the entire salt pond complex or the smaller Cargill proposed sale area) will increase the importance of the remaining salt ponds for species that rely on shallow open water environments. The situation becomes more complex in the context of Cargill retaining salt production on a reduced area consisting of Newark #1 and #2 plants, which comprise about 10,000 acres. Cargill recently began a series of modifications to those plants intended to increase production efficiency by about 25% in anticipation of public acquisition. Historically, conflicts exist between salt production and wildlife management on existing Refuge-owned ponds in Newark #1 and #2 plants. Although these conflicts have diminished in recent years, Cargill's higher salt production expectations and the inherent need to optimize the salt production process could lead to less flexibility for pond operations in an ecologically friendly manner. Some of these modifications have, however, improved wildlife conditions by providing more ponding in certain areas that were previously difficult to keep flooded adequately.

### **Dynamic Ecological Resources**

Wildlife resource use of the South Bay salt ponds is best characterized by its dynamics. Variability in pond environmental conditions occur from interannual climate differences as well as Cargill operations. Wildlife continually adjust their use of any particular salt pond in response to these varying conditions. Therefore, throughout the restoration planning and implementation effort, it will be important for restoration planners to have current information. These information needs emphasize the role of ongoing monitoring, within an Adaptive Management framework, to provide data on species recovery and decline that can be used to adjust restoration planning and goals as the process moves forward.

### **Spartina alterniflora**

The invasive *Spartina alterniflora*, an aggressive eastern cordgrass, diminishes marsh habitat functions relative to the native cordgrass, *S. foliosa*. No current controls effectively prevent *S. alterniflora* spread once it has become established. It is particularly problematic in the East Bay between the San Mateo and Dumbarton bridges. Restoring ponds close to existing stands of *S. alterniflora* should be undertaken cautiously until more research into and demonstration of its control has been completed.

## **Conclusion 7: Buyer Beware of Differential Restoration Feasibility**

**Not all ponds can be restored with equal ease. The current Cargill proposed sale area contains many of the most difficult and costly to restore ponds while retaining most of the easiest and least costly to restore ponds under Cargill control.** Restoration costs for a given pond depend upon many factors but are most impacted by the degree of subsidence. The feasibility of restoring any given salt pond to tidal marsh varies according to a variety of site-specific factors as well as how surrounding ponds are treated. Thus, which ponds the public buys and which ponds Cargill retains in salt production have tremendous economic and ecological ramifications for all parties. Using a suite of biological, physical, and chemical criteria, we reached the following conclusions about restoration feasibility: 2,690 acres (10 percent total area) are high feasibility, 13,240 acres (51 percent total area) are medium feasibility, 8,430 acres (32 percent total area) are low feasibility, and 1,830 acres (7 percent total area) we had insufficient data to make a determination. Without dredged sediment reuse, we estimate per-acre restoration costs to be approximately \$1,500 versus \$5,000 for high and low feasibility ponds, respectively.

**Most of the "high feasibility" ponds are not part of the Cargill proposed sale area.** Cargill has offered to sell the most costly ponds to manage and restore, especially the deeply subsided Alviso ponds, while retaining the most easily restored ponds. Of the 108 MCY estimated sediment deficit for the total salt pond complex, those ponds Cargill has offered for public acquisition represent 89 MCY or 82 percent of that total deficit. Further, under the range of possible dredged sediment reuse options we evaluated, virtually all that sediment is needed only in the ponds Cargill is currently offering the public. Only under the maximum reuse scenario would ponds currently not part of the proposed acquisition be considered for dredged sediment reuse, and those ponds account for only 4 MCY of 58 MCY under that scenario.

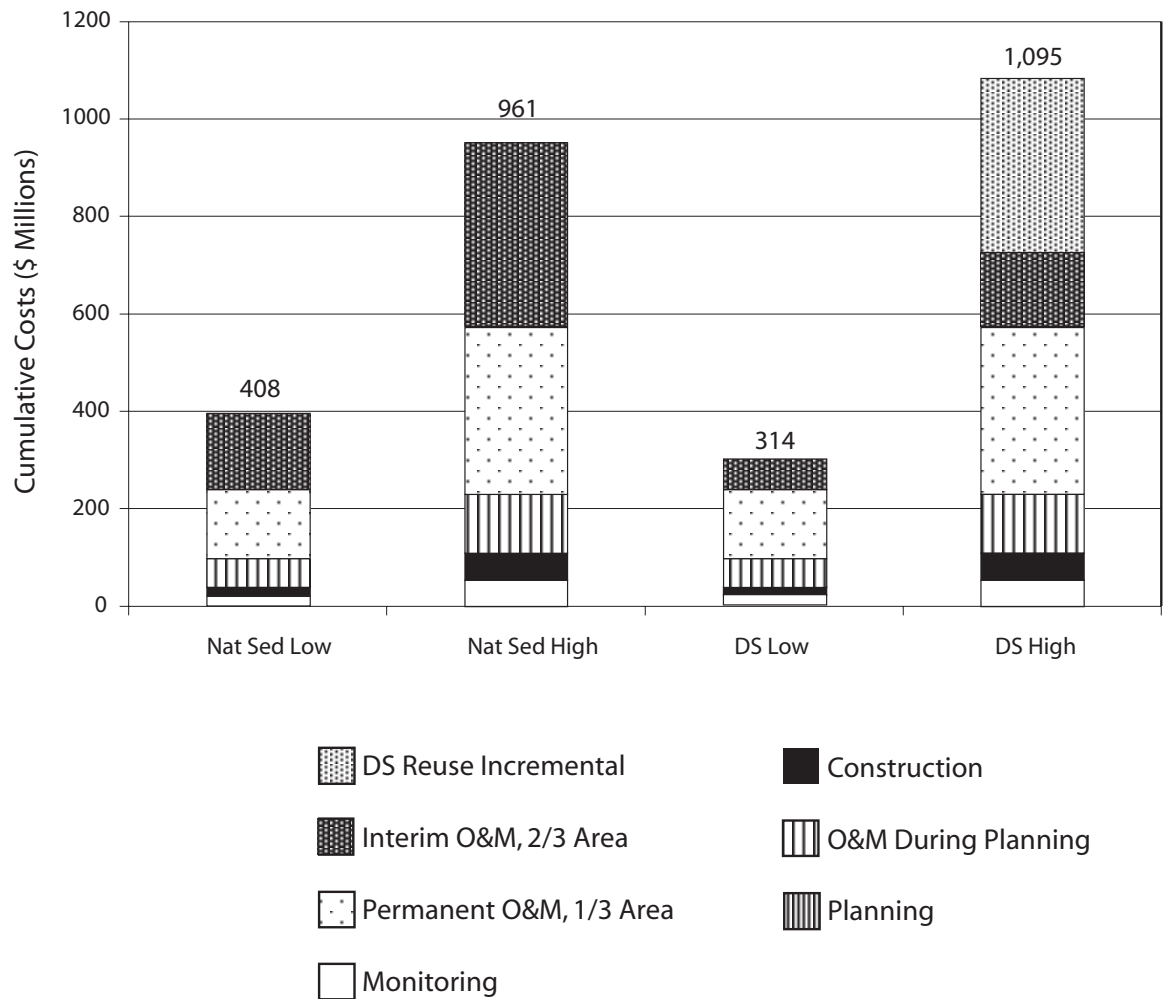
In addition to these economic ramifications, this arrangement has ecological consequences. Most of the "high feasibility" ponds are represented by just three salt ponds — Mowry 1, 2 and 3 in Alameda

County. These three ponds have long been targeted for restoration because of their particular suitability to yield tremendous ecological recovery benefits. Because they are easily restored and have undergone minimal subsidence, those benefits could be reached with a minimum of cost and in comparatively short time periods. Their exclusion from the acquisition poses an important constraint on achieving ecological recovery goals for the San Francisco Estuary.

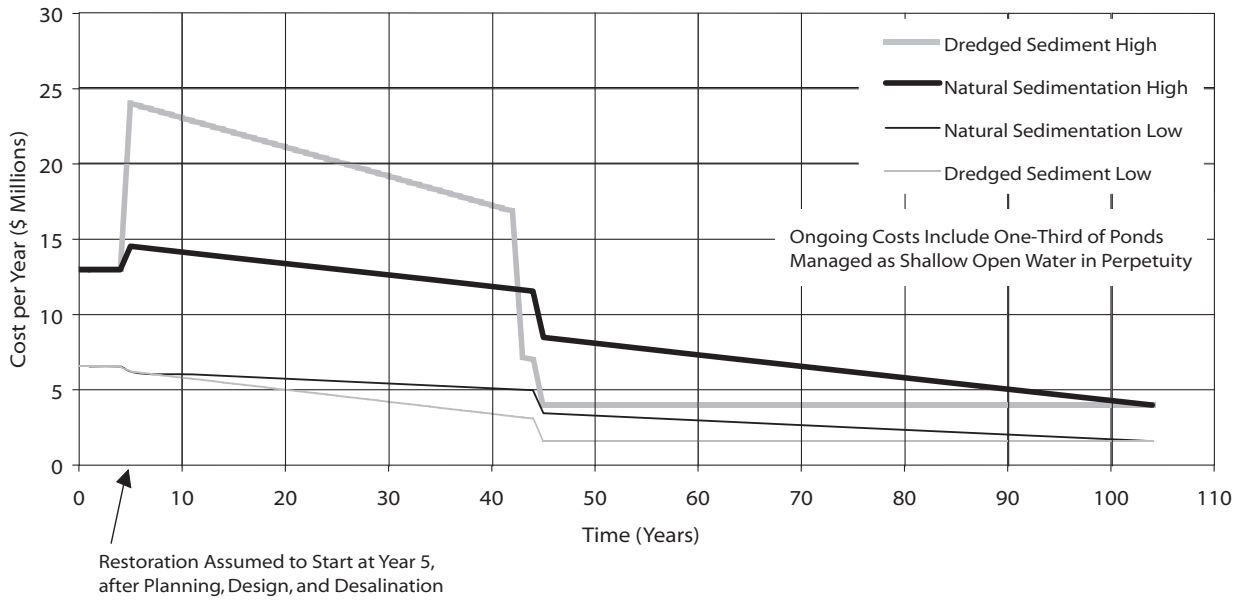
### Rough Cost Estimate to Restore the 16,000 Acres Offered by Cargill

This feasibility analysis has identified seven general cost categories for managing and restoring the 16,000 acres of South Bay salt ponds that Cargill offered in 2000 for public acquisition. This cost estimate includes tidal marsh restoration on 11,000 acres and managed shallow open water on 5,000 acres. For each of the two restoration strategies — “mudflat-sustainable” natural sedimentation and dredged sediment reuse — we present a “low” and “high” cost estimate to bracket the uncertainties contained in estimating costs for each of the seven categories. The total costs are shown in Figure ES-1 and we break out these costs annually in Figure ES-2 and cumulatively in Figure ES-3. In Table ES-1 we have summarized seven myriad data from which we derived these cost estimates.

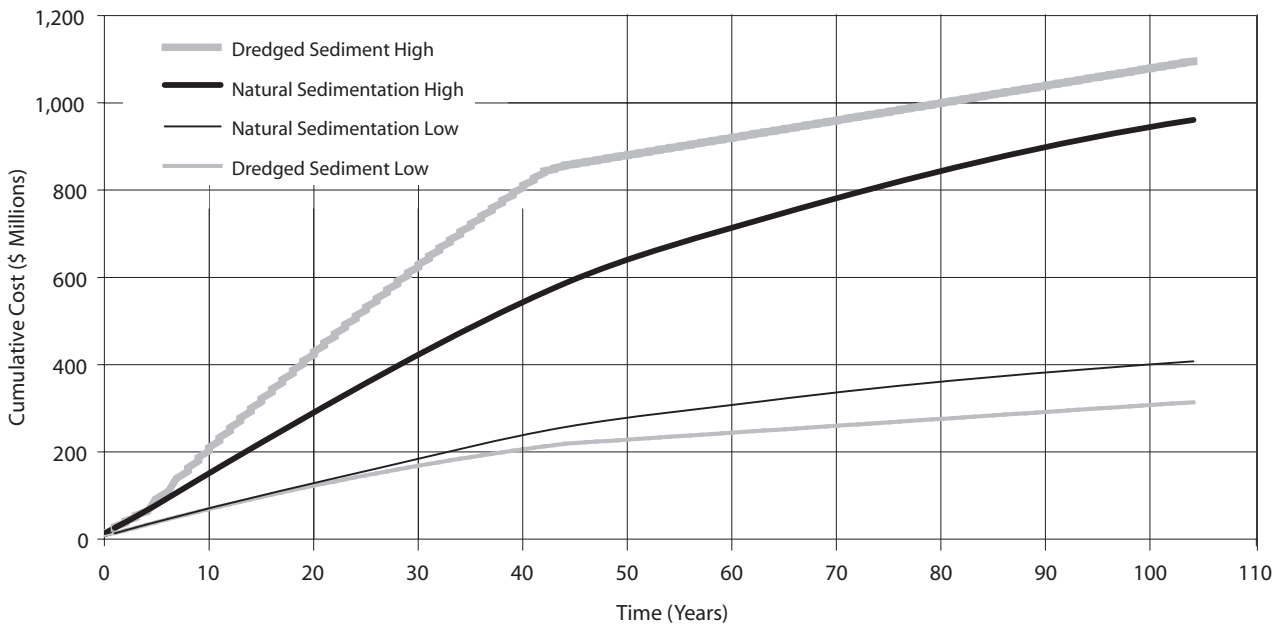
**Figure ES-1. Estimated total restoration and management costs for 16,000-acre Cargill proposed sale area, excluding acquisition, 2001 dollars**



**Figure ES-2. Annual restoration and management costs for 16,000 acre Cargill proposed sale area, excluding acquisition costs, 2001 dollars**



**Figure ES-3. Cumulative restoration and management costs for 16,000 acre Cargill proposed sale area, excluding acquisition costs, 2001 dollars**



**Table ES-1. Summary data for South Bay salt ponds**

<b>Description</b>	<b>Units</b>	<b>Value</b>
<b>Salinity Levels</b>		
Median South Bay near intakes	part per thousand	15 - 30
Sea water	part per thousand	35
Gypsum formation, beginning of ionic toxicity	part per thousand	147
Crystallizers	part per thousand	356 - 395
Bittern storage and desalting ponds	part per thousand	395 - 447
<b>Current Production</b>		
Annual salt production	million tons	1
Annual bittern production	million tons	0.6
Bittern stockpiled on site	million tons	19-20
<b>Current Salt Pond Ownership</b>		
Total pond area	acres	26,190
Cargill owned	acres	14,760
Refuge owned	acres	11,430
<b>Current Salt Pond Use</b>		
Total pond area	acres	26,190
Brine concentrators	acres	23,240
Crystallizers	acres	1,340
Bittern desalting and storage	acres	1,610
<b>Current Levees</b>		
Total	miles	220
Upland unprotected	miles	21
Flood protection, publicly-owned	miles	17
Bayfront	miles	80
Internal to salt ponds	miles	76
No data	miles	26
<b>Cargill's 2000 Proposed Sale</b>		
Total cost	\$ million	300
Total acreage of South Bay ponds	acres	15,860
Acreage owned by Cargill	acres	11,940
Acreage owned by Refuge — sell mineral rights	acres	3,920
<b>Current Acquisition Negotiations (full details are not public)</b>		
Total cost	\$ million	100
Total acreage of South Bay ponds	acres	13,000 - 15,000
<b>Restoration Feasibility</b>		
High feasibility ponds	acres	2,690
Medium feasibility ponds	acres	13,240
Low feasibility ponds	acres	8,430
Insufficient data for feasibility determination	acres	1,830
<b>Sediment Deficit and Supply</b>		
Subsidence range of all ponds	feet	0 - 8
Total sediment deficit, entire complex	million cubic yards	108
Total sediment deficit, Cargill proposed sale area	million cubic yards	89
Sediment supply rate to the South Bay	million cubic yards per year	0.89
<b>Estimated Mudflat-Sustainable Natural Sedimentation Restoration Time Periods</b>		
On two-thirds total salt pond complex	years	120
On two-thirds Cargill proposed sale area	years	99
<b>Estimated Dredged Sediment Reuse Restoration Time Periods</b>		
On two-thirds total salt pond complex	years	56 - 72
On two-thirds Cargill proposed sale area	years	39 - 51

continued

**Table ES-1. Continued**

<b>Description</b>	<b>Units</b>	<b>Value</b>
<b>Cost Estimate Components, 2001 Dollars</b>		
Operations and maintenance (initial, interim, permanent)	\$ per acre	284 - 686
Restoration construction — no dredged sediment	\$ per acre	1,500 - 5,000
Restoration construction — with dredged sediment	\$ per acre	up to 100,000
Incremental dredged sediment reuse costs	\$ per cubic yard	0 - 10
Planning and design	\$ million, lump sum	10
Monitoring	\$ million, lump sum	60 - 120
<b>Total Estimated Costs, Cargill Proposed Sale Area, excluding acquisition, 2001 Dollars, 99-Year Restoration Period*</b>		
Natural sedimentation, low per unit costs	\$ million	408
Natural sedimentation, high per unit costs	\$ million	961
Dredged sediment reuse, low per unit costs	\$ million	314
Dredged sediment reuse, high per unit costs	\$ million	1,095

\* includes planning, design, O&M, construction, monitoring, incremental dredged sediment reuse (if applicable)

# Table of Contents

---

<b>List of Tables</b> .....	iv
<b>List of Figures</b> .....	vi
<b>List of Maps</b> .....	vii
<b>List of Appendices</b> .....	vii
<b>Agency and Organization Abbreviations</b> .....	viii
<b>Units of Measurements</b> .....	ix
<b>Definition of Terms</b> .....	x
<b>PART I. INTRODUCTION</b> .....	1
<b>Chapter 1. Introduction</b> .....	1
<b>Chapter 2. Ecological Goals — a Regional Perspective</b> .....	3
2.1 Comprehensive Conservation Management Plan .....	5
2.2 Baylands Ecosystem Habitat Goals Report .....	6
2.3 U.S. Fish and Wildlife Service Endangered Species Recovery Plans .....	7
2.4 San Francisco Bay Regional Water Quality Control Board Basin Plan .....	7
2.5 San Francisco Bay Conservation and Development Commission Bay Plan .....	8
2.6 San Francisco Bay Joint Venture Implementation Strategy .....	8
<b>PART II. EXISTING CONDITIONS AFFECTING SALT POND RESTORATION</b> .....	9
<b>Chapter 3. Salt Production and its South Bay History</b> .....	9
3.1 An Introduction to Solar Salt Production .....	11
3.2 Cargill South Bay Salt Production System .....	12
3.3 System Maintenance .....	17
3.4 Regulatory Authorizations for Salt Pond Operations .....	18
3.5 Salt Production Operations within the Don Edwards National Wildlife Refuge ..	19
<b>Chapter 4. Biological Conditions Affecting Salt Pond Restoration</b> .....	21
4.1 Salt Pond Ecology and Wildlife Values .....	23
4.2 Protecting Existing Biological Resources .....	30
4.3 Non-Native Introductions .....	31
4.4 Accounting for Dynamic Salt Pond Biology .....	32

<b>Chapter 5. Physical Conditions Affecting Salt Pond Restoration</b>	33
5.1 Pond Sediment Characteristics	35
5.2 Pond Bottom Elevations and Subsidence	36
5.3 Antecedent Channel Networks	39
5.4 Borrow Ditches	39
5.5 Hydrologic Connection to Tidal Waters	40
5.6 Flood Control and Surrounding Land Uses	41
5.7 Infrastructure	42
<b>Chapter 6. Environmental Chemistry Issues Affecting Salt Pond Restoration</b>	43
6.1 Existing Water Quality	45
6.2 Pond Sediment Chemistry	45
6.3 Hypersaline Brine	47
6.4 Gypsum	47
6.5 Nuisance Algae and Hydrogen Sulfide Production	49
6.6 Sediment pH After Cessation of Salt Production	49
<b>PART III. RESTORATION CHALLENGES AND OPPORTUNITIES</b>	51
<b>Chapter 7. Lessons Learned from the Napa River Salt Ponds</b>	51
7.1 Bittern Management and Removal	54
7.2 Interim Management	54
7.3 Restoration Planning	55
7.4 Summarizing Lessons Learned from the Napa River Salt Ponds	58
<b>Chapter 8. Restoring Salt Ponds to Tidal Marsh Elevations</b>	59
8.1 Sediment Dynamics in the South Bay	61
8.2 Estimating the Sediment Deficit for Salt Pond Restoration	64
8.3 Using Natural Sedimentation to Restore Elevations	64
8.4 Using Dredged Sediment to Restore Elevations	66
8.5 Retaining Subsided Alviso Ponds as Open Water Habitats	74
<b>Chapter 9. Evaporator Pond Desalination</b>	75
9.1 Introduction to Desalination and Water and Salt Management	77
9.2 Evaporator Pond Desalination and Disposal Overview	79
9.3 Three Desalination Strategies for Evaporator Ponds	84
9.4 Ecological Goals for Interim and Long-Term Management	87

**Chapter 10. Bittern** .....89

10.1 Defining Bittern .....91

10.2 Estimates of Bittern Production Rates .....92

10.3 Estimates of On-Site Bittern Storage .....93

10.4 Bittern Pond Desalination Water Volumes .....94

10.5 Conclusions Regarding Bittern Disposal Negotiations .....101

**Chapter 11. Restoration Opportunities** .....103

11.1 Biological Opportunities .....105

11.2 Geomorphic and Engineering Opportunities .....106

**PART IV. PLANNING FOR THE ACQUISITION AND BEYOND** .....109

**Chapter 12. Review of the Cargill Proposals** .....109

12.1 Cargill Sale Proposals .....111

12.2 Restoration Cost Estimates for 2000 Cargill Proposal .....114

12.3 System Modifications to Re-Engineer for a Smaller Cargill System .....117

**Chapter 13. Restoration Feasibility and Two Case Studies** .....121

13.1 Restoration Feasibility .....123

13.2 Case Study 1: Restoring High Feasibility Salt Ponds to Tidal Marsh .....125

13.3 Case Study 2: Restoring Low Feasibility Salt Ponds to Tidal Marsh .....129

**Chapter 14. Estimated Operations and Maintenance Costs** .....135

14.1 Identifying Costs for Operation and Maintenance Items .....137

14.2 Comparable Projects .....140

14.3 A Preliminary South Bay Operations and Maintenance Budget .....141

**PART V. CONCLUSIONS** .....145

**Chapter 15. Conclusions and Recommendations** .....145

15.1 Seven Key Conclusions Summarized .....147

15.2 Other Considerations and Recommendations .....151

**References** .....153

**Communications** .....157

**MAP ATLAS** .....159

**APPENDICES** .....177

## List of Tables

Table 2-1	Ecological types identified in the USFWS Tidal Marsh Ecosystem Recovery Plan . . .	7
Table 3-1	The chemical composition of seawater . . . . .	11
Table 3-2	Solubility of salts found in seawater . . . . .	12
Table 3-3	The Ver Planck ten-pond salt precipitation model . . . . .	13
Table 3-4	Bittern ionic composition at 32 °Be (395 ppt) . . . . .	14
Table 3-5	Summary of pond area by type, each production plant . . . . .	15
Table 3-6	Summary of Cargill salt pond operations . . . . .	15
Table 4-1	Special status species occurring in the vicinity of South Bay salt ponds . . . . .	24
Table 4-2	Common and special status bird species found in the vicinity of South Bay salt ponds . . . . .	26
Table 5-1	Summary of Reyes and Novato soil series descriptions . . . . .	35
Table 5-2	Range of sedimentation needs to reach local mean higher high water . . . . .	38
Table 5-3	Lengths of South Bay salt pond complex levees and berms . . . . .	41
iv Table 6-1	Predicted water quality and odor characteristics of Cargill salt ponds . . . . .	46
Table 6-2	Characteristics of evaporator pond sediments relative to nearby tidal marsh sediments . . . . .	47
Table 6-3	Estimates of calcium sulfate (gypsum) accumulation rates . . . . .	48
Table 6-4	Gypsum dissolution times for permanently flooded conditions . . . . .	49
Table 6-5	Gypsum dissolution times for intermittent flooding . . . . .	49
Table 7-1	Summary of bittern and pickle acute and chronic toxicity results . . . . .	53
Table 8-1	Timeframe for restoration with mudflat-sustainable natural sedimentation . . . . .	65
Table 8-2	Sediment volumes used to calculate restoration costs in Tables 8-3 and 8-4 . . . . .	70
Table 8-3	Predicting restoration implementation costs with and without dredged sediment, full salt pond complex . . . . .	72
Table 8-4	Predicting restoration implementation costs with and without dredged sediment, Cargill 2000 proposed sale area . . . . .	73
Table 9-1	Three phases of restoration . . . . .	77
Table 9-2	Water and sediment characteristics in relation to salinity . . . . .	78
Table 9-3	Required conversion steps and ecosystem type compatibility as a function of existing pond salinity . . . . .	78
Table 9-4	Estimated existing HRTs based on salt pond water budgets . . . . .	79
Table 9-5	Operating characteristics for a typical evaporator pond . . . . .	80

Table 9-6	Reduction in pond salinity as a function of HRT .....	.81
Table 9-7	Pond outflow salinity for different HRTs and initial pond salinity levels .....	.82
Table 9-8	Estimated desalination times for ponds with different water depths and HLRs ...	.82
Table 9-9	Estimated time to dilute and discharge evaporator pond brines .....	.83
Table 9-10	Three strategies for interim management .....	.84
Table 10-1	The fate of bittern ions during solar salt production .....	.92
Table 10-2	Typical bittern ionic composition at 32 °Be (395 ppt) for Mediterranean Sea water .....	.92
Table 10-3	Definitions of bittern and its components .....	.93
Table 10-4	Assumptions used to develop mass balance calculations for bittern production in the South Bay salt ponds .....	.94
Table 10-5	Estimated total bittern by-product per ton of salt harvested .....	.95
Table 10-6	Estimated amount of bittern generated during salt production .....	.95
Table 10-7	Estimated bittern accumulation over 30-year production period .....	.96
Table 10-8	Estimated thickness of bittern stored in the 1,050 acres of bittern ponds .....	.97
Table 10-9	Methods to desalinate the bittern ponds .....	.97
Table 10-10	Operating characteristics for typical bittern pond .....	.98
Table 10-11	Estimated water volumes to desalinate bittern ponds without dilution for bay discharge .....	.99
Table 10-12	Estimated water volumes to dilute bittern for bay discharge .....	100
Table 10-13	Estimated total time required to dilute and discharge bittern ponds .....	101
Table 12-1	Estimated total restoration and management costs for Cargill proposed sale area, 2001 dollars .....	115
Table 13-1	High feasibility case study site summary information .....	125
Table 13-2	Rough estimated construction costs for high feasibility restoration case study ...	128
Table 13-3	Low feasibility case study site summary information .....	130
Table 13-4	Rough estimated construction costs for low feasibility restoration case study ..	133
Table 14-1	South Bay levee lengths and funding responsibilities .....	138
Table 14-2	Cargill South Bay pumping stations .....	139
Table 14-3	Operations and maintenance budget for 7,000 acres of North Bay salt ponds ..	140
Table 14-4	Annual operations and maintenance budgets for selected state and federal refuges in California .....	141
Table 14-5	Estimated operations and maintenance costs for South Bay salt ponds .....	142

## List of Figures

Figure 3-1	Ver Planck ten-pond salt production model .....	12
Figure 3-2	Decreasing net evaporation rates with increasing salinity .....	14
Figure 3-3	Typical salt pond levee maintenance technique .....	18
Figure 5-1	Tidal marsh vegetation versus elevation .....	36
Figure 5-2	Sediment deposition thickness and volumes as a function of pond area .....	37
Figure 5-3	Typical antecedent channel network .....	39
Figure 8-1	Sediment cycling in South San Francisco Bay .....	62
Figure 9-1	Flushing characteristics of evaporator ponds .....	81
Figure 9-2	Conceptual model for desalinating ponds with low to medium salinity levels ...	83
Figure 9-3	Conceptual models describing three alternative salt pond desalination strategies .....	85
Figure 10-1	Bittern pond vertical structure schematic .....	93
Figure 10-2	Typical bittern pond desalination time as a function of hydraulic loading rates ..	98
Figure 10-3	Conceptual design for bittern pond desalination and dilution prior to Bay discharge .....	100
Figure 12-1	Estimated total restoration and management costs for 16,000-acre Cargill proposed sale area, excluding acquisition, 2001 dollars .....	116
Figure 12-2	Annual restoration and management costs for Cargill proposed sale area, excluding acquisition, 2001 dollars .....	116
Figure 12-3	Cumulative restoration and management costs for Cargill proposed sale area, excluding acquisition, 2001 dollars. ....	117
Figure 13-1	United States Coast and Geodetic Survey 1857 T-Sheet historic conditions map for Redwood City Ponds 1 and 2 .....	126
Figure 13-2	Existing conditions and conceptual restoration plan at high-feasibility Redwood City Ponds 1 and 2 .....	127
Figure 13-3	United States Coast and Geodetic Survey 1857 T-Sheet historic conditions map for Alviso Ponds A2E, A3N, A3W, B1, and B2 .....	131
Figure 13-4	Existing conditions and restoration elements at Alviso Ponds A2E, A3N, A3W, B1, and B2 .....	132

## List of Maps

Map 1	Study Area: South Bay Salt Ponds and Crystallizers Owned or Operated by Cargill .....	161
Map 2	Land Ownership of Operating South Bay Salt Ponds .....	162
Map 3	Areas Cargill Proposed for Sale, 1999 and 2000 .....	163
Map 4	BCDC Bay Plan Map 7 .....	164
Map 5	South Bay Salt Pond Operations .....	166
Map 6	Relative Shorebird Use of the South Bay Salt Ponds .....	167
Map 7	South Bay Salt Pond Salinity 1999 .....	168
Map 8	Salt Pond Elevations Relative to NGVD .....	169
Map 9	Salt Pond Elevations Relative to Tides .....	170
Map 10	Potential Hydrologic Connections to the Tides .....	171
Map 11	Existing Levees and Berms in the South Bay Salt Ponds .....	172
Map 12	Infrastructure Potentially Affecting the South Bay Salt Ponds .....	173
Map 13	Gypsum Constraints with Salt Pond Elevation .....	174
Map 14	Relative Feasibility of Restoring the South Bay Salt Ponds to Tidal Marsh .....	175

## List of Appendices

Appendix A	Dependence of Evaporation Rates of Salinity and Water Temperature .....	179
Appendix B	1979 USFWS - Leslie Salt Company Agreement on Salt Production on Refuge Lands .....	183
Appendix C	Geographic Information System (GIS) Data .....	195
Appendix D	Salt Mass Balance .....	207
Appendix E	Natural Sedimentation Assumptions .....	213
Appendix F	Hydrologic and Mass Balance Analyses of Ponds during Dilution .....	217
Appendix G	Annual Salt Pond Restoration and Management Estimated Costs .....	229

## Agency and Organization Abbreviations

BCDC	San Francisco Bay Conservation and Development Commission
CCMP	Conservation and Management Plan
CDFG	California Department of Fish and Game
Corps	U.S. Army Corps of Engineers. Also referred to as USACE.
CSCC	California State Coastal Conservancy
NGS	National Geodetic Survey, part of the National Oceanic and Atmospheric Administration
NOS	National Ocean Service, part of the National Oceanic and Atmospheric Administration
RWQCB	San Francisco Bay Regional Water Quality Control Board
SCWPCP	San Jose/Santa Clara Water Pollution Control Plant
SFBJV	San Francisco Bay Joint Venture
SFEP	San Francisco Estuary Project
SSFBA	Save San Francisco Bay Association
USACE	U.S. Army Corps of Engineers. Also referred to as Corps.
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WRMP	Wetland Regional Monitoring Plan
WWR	Wetlands and Water Resources

viii

## Units of Measurements

<b>ac</b>	acres
<b>°Be</b>	degrees Baume. Salinity measurement convertible to specific gravity
<b>cy</b>	cubic yards
<b>ft</b>	feet
<b>lf</b>	linear feet
<b>ls</b>	lump sum
<b>in</b>	inches
<b>m</b>	meters
<b>mcy</b>	million cubic yards
<b>mgd</b>	million gallons per day
<b>mm</b>	millimeters
<b>ppm</b>	parts per million (one part of parameter for each million parts of solution or mass)
<b>ppt</b>	parts per thousand (one part of parameter for each thousand parts of solution or mass); one tenth of one percent
<b>y</b>	years

## Definition of Terms

### Anhydrite

Crystals formed from the chemical precipitation of calcium and sulfate to form calcium sulfate ( $\text{CaSO}_4$ )

### Anion

Negatively charged ion. For instance, with NaCl chloride is the anion

### Bittern

Residual brine or salt solution discharged from crystallizer ponds after harvesting of sodium chloride. Initially a liquid at discharge and composed of dissolved salts, primarily magnesium ( $\text{Mg}^{2+}$ ), potassium ( $\text{K}^+$ ), bromide ( $\text{Br}^-$ ), chloride ( $\text{Cl}^-$ ) and sodium ( $\text{Na}^+$ ). Bittern continues to concentrate after discharge because of evaporation and separates into a solid and liquid phase

### Bittern desalting ponds

Pond in which liquid bittern is concentrated further before being transferred to bittern storage ponds

### Bittern storage ponds

Ponds in which bittern is stored

### Bittern salts

Salts that exist in the bittern. These salts include magnesium sulfate, magnesium chloride, potassium chloride and magnesium bromide. Salts can be either dissolved or particulate. The ratio of dissolved to precipitate salts depends upon the bittern salinity

### Brine

Hypersaline water

### CFSTR

Continuous-Flow Stirred Tank Reactor. Reactor model used in mass balance analyses describing system in which water is well mixed and water quality parameters throughout pond are constant and equal to outflow concentrations

### Choker

Small berm constructed on levee top on the side where slip-outs are deemed unacceptable. Constructed to contain dredge muds from slipping into marshes or ponds

### Concentrator ponds

Ponds where evaporation concentrates salt in solution. Brine is reduced by about 90% to where it is saturated with respect to sodium chloride

### Crystallizer ponds

Ponds in which approximately 95% of the sodium chloride precipitates from the brine and forms crystal deposits on the pond beds. Sodium chloride is commercially harvested from crystallizer ponds

### DO

Dissolved oxygen

### $\text{CaCO}_3$

Calcium carbonate. Sedimentary rock formed from the chemical precipitation of calcium and carbonate

### $\text{CaSO}_4$

Calcium sulfate. See gypsum and anhydrite

### Carbonates

Class of minerals in which carbonate ( $\text{CO}_3^{2-}$ ) is the anion

### Cation

Positively charge ion. For instance, with NaCl, sodium is the cation

### Evaporites

Solids formed from the chemical precipitation of salts from saturated solutions

### Evaporator ponds

See Concentrator ponds

### Gypsum

Crystal formed from the chemical precipitation of calcium and sulfate to form calcium sulfate ( $\text{CaSO}_4(2\text{H}_2\text{O})$ ) crystals. Gypsum is the hydrated form of anhydrite and forms when water is added to anhydrite. Gypsum is therefore the form of calcium sulfate most likely to form on pond bottoms

### Halite

Technical name for sodium chloride ( $\text{NaCl}$ ). Also known as common salt or table salt. Halite occurs as crystals or granular masses

### High marsh

Marsh area defined by tidal range between MHW and MHHW (Goals Report 1999)

### HLR

Hydraulic loading rate ( $\text{cm day}^{-1}$ )

### HRT

Hydraulic retention time. The amount of time the water stays within a given pond system

### Iron oxides

Solids formed from the chemical precipitation of iron. Does not readily dissolve

### Intertidal marsh

Marsh defined by tidal datum between MTL and MHW

### KCl

Potassium chloride

**K<sub>2</sub>SO<sub>4</sub>**

Potassium sulfate

**Low marsh**

Marsh area defined by tidal range between MTL and MHW

**MgBr<sub>2</sub>**

Magnesium bromide

**MgCl<sub>2</sub>**

Magnesium chloride

**MgSO<sub>4</sub>**

Magnesium sulfate

**MHHW**

Mean higher high water, average of the higher of two daily high tides

**MHW**

Mean high water, average of all high tides

**MLLW**

Mean lower low water, average of the lower of two daily low tides

**MLW**

Mean low water, average of all low tides

**MTL**

Mean tide level, average of all tidal water levels

**NaCl**

Sodium chloride (see salt, halite)

**NAVD 88**

North American Vertical Datum of 1988. Fixed vertical geodesic datum established by NGS in 1988 to replace NGVD 29

**NGVD 29**

National Geodetic Vertical Datum of 1929. Fixed vertical geodesic datum established by NGS predecessor in 1929. No longer supported by NGS

**pH**

Logarithmic measure of hydrogen ion concentrations

**Pickle**

Brine at saturation with respect to halite

**Pickle ponds**

Final evaporative pond used for storing pickle. Salinity is approximately 317 ppt

**Precipitation**

Formation of solids through combination of dissolved ions. Occurs when the liquid is supersaturated with respect to the ions

**Salt**Commonly used to describe sodium chloride. However, salts are technically any substances resulting from the reaction between an acid and a base. In the formed salts, the hydrogen ion on the acid is displaced by a metal ion. For instance, NaCl forms by displacing the hydrogen ion from the acid HCl (hydrogen chloride). Other salts include magnesium chloride, magnesium sulfate, calcium carbonate, and calcium sulfate. Salts can be in dissolved or solid forms. Solids form when solutions become supersaturated with respect to the ions which form the salts. For instance, NaCl forms when the solution becomes supersaturated with respect to sodium (Na<sup>+</sup>) and chloride (Cl<sup>-</sup>)**Slip-outs**

When amounts of dredged material slips from exterior levee tops and falls onto the vegetated shoulder or onto the marsh plain

**Stage 1 Ponds**

Series of evaporative ponds before gypsum begins to form. Approximately 60% of the production pond area. Ranges in salinity from about 12 to 120 ppt. Brine volume is reduced by about 80%

**Stage 2 Ponds**

Series of evaporative ponds in which gypsum precipitation occurs. Approximately 30% of the production pond area. Ranges in salinity from about 120 to 250 ppt

**Sulfates**Class of minerals in which sulfate (SO<sub>4</sub><sup>2-</sup>) is the anion**Supersaturated**

When the solubility product of a mineral is exceeded resulting in precipitation of the mineral

**Specific gravity (SG)**

The ratio of the mass of the liquid to the mass of water. For brine solutions can be considered a measure of salinity

**TDS**

Total dissolved salts

**Tidal datum**

Average local heights of the tides

**Tidal flat**

Defined by tidal range between MLLW and MTL

**Tidal range**

Local range of the tides, measured either from lowest to highest observed tides or from MLLW to MHHW

**Upland ecotone**

Defined by tidal range between MHHW and extreme high tide

**Upland**

Land areas currently outside the range of the tides and not supporting wetlands. Technically, refers to lands topographically above the range of tides. Commonly applied (and used in this report) to lands diked from San Francisco Bay that reside behind levees (diked baylands) that are now in urban land uses.

# Part I.

## Introduction

# Chapter 1.

## Report Purpose and Background

The San Francisco Estuary and the Sacramento-San Joaquin Delta form the West Coast's largest estuary, draining approximately 40 percent of California's land. With its blend of fresh and ocean waters, thousands of miles of rivers and streams, and numerous microclimates and landscapes, the Estuary is an ecological treasure that supports an enormous diversity of fish, animals, and plants. Approximately 120 fish species, 255 bird species, 81 mammal species, 30 reptile species, and 14 amphibian species live in the Estuary, relying on the riparian and wetland habitats for breeding, nursing, and feeding. Nearly half the birds of the Pacific Flyway and two-thirds of California's salmon pass through the Estuary.

Wetlands play a vital and often overlooked role in maintaining a healthy ecosystem, particularly in the Bay-Delta Estuary. Wetlands improve water quality, provide essential wildlife habitat, act as natural flood control, prevent shoreline erosion, recharge groundwater, and provide recreational and educational opportunities. More productive than all but tropical ecosystems, wetlands feed and shelter countless species, support a diverse plant community, and form a major foundation of the Bay's food web.

Unfortunately, more than 90 percent of California's original wetland acreage has been diked, drained, filled, and destroyed. Many of the remaining wetlands are threatened by pollutant runoff and diverted freshwater flows. Riparian areas have been lost as creeks are routed underground or channelized for flood control and urban development. The San Francisco Bay Area—the nation's fourth largest metropolitan region—has suffered severe wetland losses due to urban development, agricultural conversion and salt production. As a result, we have lost nearly 95 percent of our historic wetland and riparian habitats, particularly in San Francisco and San Pablo Bays. Scientists estimate that a minimum of 100,000 acres must be restored to tidal marsh to keep the Estuary a well-functioning ecosystem.

For these reasons, many governmental and non-governmental organizations have long sought acquisition and restoration of the 26,000-acre complex of salt production ponds located in the southern portion of the San Francisco Bay (Map 1). Although the Cargill Salt Company (Cargill) currently operates on all of these ponds, the ponds have mixed ownership. Cargill owns 56 percent of the land area (14,760 acres), and the Don Edwards National Wildlife Refuge owns the remaining 44 percent on which Cargill owns mineral rights for salt production (11,430 acres; Map 2). The Don Edwards National Wildlife Refuge (Refuge) is one of four refuges contained in the San Francisco Bay National Wildlife Refuge system.

After decades of salt production in the San Francisco Bay Area, in 2000 Cargill announced its intention to consolidate its salt production operations and offer decommissioned ponds for public acquisition and restoration. Improved efficiency means that Cargill can continue making salt at half its current production levels on

roughly one-third the amount of land it currently uses. Therefore, Cargill began negotiations with the State of California and the federal government for sale of mineral rights on lands already owned by the Refuge and outright sale of other lands in South San Francisco Bay for a total of \$300 million. The area involved in the negotiation totals nearly 16,000 acres of South Bay salt production ponds plus another 1,400 acres of former salt production ponds in the North Bay along the Napa River and 600 acres of open bay in the South Bay. The restoration potential of these ponds is enormous. Map 3 shows the areas subject to these negotiations. Chapter 12 provides more details on Cargill's proposal and this historic opportunity. Recent economic conditions have adjusted the negotiated lands and price downward to a package totaling \$100 million and encompassing a slightly smaller area that presumably excludes lands in the Redwood City Plant that have higher appraised value.

The San Francisco International Airport has also examined the South Bay salt pond complex as possible mitigation areas for its proposed runway expansion project. Though there has been substantial publicity about the potential link between these two projects, currently there is no connection between these two projects. Current acquisition negotiations reportedly do not include San Francisco Airport funding.

The proposed salt pond purchase is a unique, once-in-a-lifetime opportunity that we cannot afford to let slip away. This historic opportunity prompted preparation of this report to evaluate the feasibility of restoring some or all of these ponds to tidal marsh and related habitats. Wetland restoration has not been attempted on this scale in the Bay Area, but the significance of this acquisition makes it imperative that we try. Though Cargill has offered only a portion of the total South Bay salt pond complex, we chose to evaluate the entire complex in this Feasibility Analysis. Salt pond restoration would provide approximately 15 percent of the Estuary's overall restoration needs and roughly two-thirds of the South Bay's restoration goals.

Ecological restoration of the South Bay salt ponds will be an enormous and complicated undertaking. It will take many years and require considerable financial resources and ongoing commitment from the region's natural resource managers. The salt ponds have important ecological, environmental, and hydrologic impacts on the San Francisco Bay Area and beyond. Although the constraints presented by existing conditions will shape the final outcome to some extent, a variety of approaches exist to achieve successful ecological restoration. Therefore, solid planning and decision making must proceed from a clear understanding of the opportunities and challenges present.

This feasibility analysis is designed to help with the complex planning and decision making process for the South Bay salt pond acquisition and restoration. We have organized the information into five parts:

- **Introduction** – Chapters 1 and 2
- **Existing conditions affecting restoration** – Chapter 3 thru 6
- **Challenges and opportunities** – Chapters 7 through 11
- **Planning for the acquisition and beyond** – Chapters 12 through 14
- **Conclusions** – Chapter 15

Following these chapters are a **map atlas** depicting a variety of restoration constraint "overlays" (Maps 5 through 13) that are then compiled into a single map (Map 14) rating each salt pond's restoration feasibility, and **appendices** containing more detailed technical materials.

For easy access, a list of acronyms and definitions for chemical, engineering, and operational terms are provided in the front of the report.

## Acknowledgements

We would like to acknowledge a number of organizations that made this report possible. First and foremost, Save San Francisco Bay Association provided the impetus and initial funding, through Packard Foundation grants and other sources, that paid for the research and analysis contained in this report. Save the Bay also provided invaluable editorial guidance. The California State Coastal Conservancy funded production of the Geographic Information System (GIS)-based map atlas presented in this report. The U.S. Fish and Wildlife Service, through the Don Edwards San Francisco Bay National Wildlife Refuge and the Endangered Species Mare Island Field Office, provided invaluable input, advice, and review. The California Department of Fish and Game, California State Coastal Conservancy and U.S. Army Corps of Engineers provided essential background on the Napa River salt pond case study that helped inform a variety of issues for South Bay salt pond restoration. Cargill Salt Company provided us with some additional information. Especially helpful were members of the Citizens Committee to Complete the Refuge, who provided a wealth of information along with funding for report production. Many others answered our countless questions and requests for documents (see Communications references) and we offer our gratitude to all those who helped make this work possible.

## Report Preparers

Stuart Siegel and Dr. Philip Bachand of Wetlands and Water Resources, a wetland science and restoration consulting firm based in San Rafael, California, prepared this report. Mr. Siegel is President of Wetlands and Water Resources. He is a certified Professional Wetland Scientist with over 16 years of experience in wetland science, restoration, and policy with a geographic emphasis on the San Francisco Estuary. Mr. Siegel will be receiving his Ph.D. in Geography from the University of California at Berkeley in May 2002. Dr. Philip Bachand is a Principal Engineer at Wetlands and Water Resources. He is an Environmental Engineer with over 8 years experience in wetland biogeochemical processes. Dr. Bachand received his Ph.D. in Environmental Engineering from the University of California at Berkeley in 1996.

We subcontracted to Laird Henkel, an independent biologist based in Santa Cruz, California, to prepare the biological resources component of this report. Mr. Henkel has 10 years experience in wetland biology in the San Francisco Estuary and coastal California. He is a Master's candidate in Marine Science at the Moss Landing Marine Laboratory.

Jake Schweitzer, GIS Specialist at Wetlands and Water Resources, prepared the GIS map atlas. Mr. Schweitzer has six years experience with all facets of GIS software and cartographic map production.

Adam Klein, a California Registered Geologist, provided invaluable peer review on several complex quantitative analyses.

Chicory Bechtel of Wetlands and Water Resources provided editorial assistance.

## Disclaimers

The views and opinions expressed herein are solely those of its authors, Stuart Siegel and Philip Bachand, and not of any other persons or entities. Within the confines of budgetary constraints, we have attempted to be as thorough as possible in data gathering, quality checking, and analysis. These data necessarily span a wide range of subject matter, sources, intent for original preparation, quality, and completeness. We understand that others may evaluate the same data in different ways and reach different conclusions. We recognize that errors in our analyses could exist, though we have tried diligently to omit them. Further, we recognize the public interest value of this work and the appropriateness of scrutiny by others. Consequently, we have tried to make available within this report the data and logic processes we used so that others can go back to that original data, examine it independently, and, if interested, apply different analytical approaches. This report is not intended for use in preparing a salt pond restoration design but instead is intended to provide a starting point for evaluating all topics relevant to the purchase and restoration of some or all of the South Bay salt ponds. The sole risk of using this report is assumed by the user, and any warranty or merchantability, or any other warranty of fitness for any purpose, is expressly disclaimed.

# Chapter 2.

## Ecological Goals – a Regional Perspective

---

2.1	Comprehensive Conservation Management Plan	5
2.2	Baylands Ecosystem Habitat Goals Report	6
2.2.1	General Recommendations for the South Bay	6
2.2.2	Specific Recommendations for the South Bay Shoreline	6
2.3	U.S. Fish and Wildlife Service Endangered Species Recovery Plans	7
2.4	San Francisco Bay Regional Water Quality Control Board Basin Plan	7
2.5	San Francisco Bay Conservation and Development Commission Bay Plan	8
2.6	San Francisco Bay Joint Venture Implementation Strategy	8
Table 2-1	Ecological types identified in the USFWS Tidal Marsh Ecosystem Recovery Plan	7



# Chapter 2.

## Ecological Goals – a Regional Perspective

The San Francisco Estuary and the Sacramento-San Joaquin Delta form the West Coast's largest estuary, draining approximately 40 percent of California's land. With its blend of fresh and ocean waters, thousands of miles of rivers and streams, and numerous microclimates and landscapes, the Estuary is an ecological treasure that supports an enormous diversity of fish, animals, and plants. This resource is surrounded by the nation's fourth largest metropolitan region, bustling with shipping, commerce, and an expanding population. The Bay Area provides a home to a population of six million people that is expected to soar in the next two decades.

There have been—and will continue to be—significant alterations to the San Francisco Estuary's watershed. Wetlands have been drained, filled, and converted to farmlands, salt ponds, highways, sewage lagoons, landfills, industrial complexes, shopping malls, parking lots, housing developments, and airports. These impacts have prompted broad community interest in protecting existing wetlands from destruction and in restoring degraded wetlands and diked, former wetlands (known as baylands) to productive ecosystems.

Several regional efforts have been initiated to address bayland restoration. The first such effort resulted in the Comprehensive Conservation and Management Plan (CCMP). The CCMP identifies 145 actions necessary to restore the San Francisco Estuary and specifies the design of an estuary-wide plan to protect, enhance, restore, and create wetlands. By 1994, several resource agencies discussed the development of a "shared vision" for Bay wildlife. These included the San Francisco Estuary Institute (SFEI), the California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS). This led to the Baylands Ecosystem Habitat Goals Project (Goals Project).

The Goals Project involved more than 100 participants from local, state and federal agencies, academia, and the private sector. It developed a collaborative blueprint for future estuary restoration based upon an ecological foundation. More recently, the USFWS has begun developing regional plans for the recovery of several threatened and endangered species dependent in part or in whole on the region's wetlands.

In this chapter we discuss the six major plans that establish goals for tidal salt marsh restoration in the San Francisco Estuary:

1. The Comprehensive Conservation Management Plan.
2. The Baylands Ecosystem Habitat Goals Report.
3. The USFWS Endangered Species Recovery Plans.
4. The San Francisco Bay Regional Water Quality Control Board Basin Plan.
5. The Bay Conservation and Development Commission Bay Plan.
6. The San Francisco Bay Joint Venture Implementation Strategy.

### 2.1 Comprehensive Conservation Management Plan

The Comprehensive Conservation and Management Plan (CCMP) resulted from a five-year cooperative effort called the San Francisco Estuary Project (USEPA 1993). The U.S. Environmental Protection Agency funded this effort, which involved local, state and federal government agencies; environmental, agricultural and recreational organizations; and private sector interests. The CCMP was developed under the National Estuary Projects as defined by the Clean Water Act. The Act states as one of its purposes the "develop(ment) of a comprehensive conservation and management plan that recommends priority corrective actions ... to restore and maintain the chemical, physical, and biological integrity of the estuary."

The CCMP found that wetland loss had led to declines in San Francisco Estuary wildlife and reduced the Estuary's capacity to support sustainable fish and wildlife populations as well as provide other benefits associated with wetlands. These benefits included water purification and filtration, flood control, and scenic and recreational enjoyment.

The CCMP established several goals for wetland management in the San Francisco Estuary:

- Protect and manage existing wetlands,
- Restore and enhance the ecological productivity and habitat values of wetlands,
- Expedite a significant increase in the quantity and quality of wetlands, and
- Educate the public about the value of wetland resources.

Two actions were recommended to meet these goals:

1. The acquisition of South Bay salt ponds should salt production cease.
2. Large-scale restoration of these and other former wetlands in the South Bay.

The CCMP also made recommendations for Estuary management—e.g., pollution prevention and reduction, dredging and waterway modification, and land use:

- Protect against toxic effects such as bioaccumulation and toxic sediment accumulation;
- Eliminate unnecessary dredging activities;
- Maximize the use of dredged material as a resource; and
- Manage modification of waterways to avoid or offset the adverse impacts of dredging, flood control, channelization, and shoreline development and protection projects.

To maximize the benefit of South Bay salt pond and/or other bayland restoration, these recommendations must be integrated into the restoration strategy wherever possible.

## 2.2 Baylands Ecosystem Habitat Goals Report

The Baylands Ecosystem Habitat Goals Project was a four-year effort in the San Francisco Bay Area involving more than 100 participants from the public, nonprofit, academic, and private sectors. The Goals Project focused on ecological restoration of the San Francisco Estuary. The end result was the Baylands Ecosystem Habitat Goals Report (Goals Project 1999). The report identified key species and habitats, assembled and evaluated information, and developed recommendations to improve key bayland habitats and the plant and animal species dependent upon those habitats. The Goals Report did not specifically address other environmental and hydrologic services provided by wetlands such as nutrient cycling, flood control, or water quality improvements.

The Goals Report provided general ecological restoration goals for the South Bay salt ponds, identified the differing perspectives on such restoration goals, and considered connectivity to the surrounding habitats (e.g., intertidal mudflats, wetlands, streams, uplands). The following sections describe in more detail the recommendations presented in the Goals Report for the South Bay salt ponds.

It is important to recognize that dissenting opinions emerged during preparation of the Goals Report. On the one hand, the full restoration of salt ponds to tidal marsh is a fundamental goal that has been articulated in numerous contexts for several years. In contrast to full tidal marsh restoration, some Goals Project participants desired restoration of only a portion of the ponds. This would preserve the ecological functions currently provided by the salt ponds in their highly managed state, namely shorebird and waterfowl habitat (see Chapter 4 of this report). The significance of these differing perspectives is that restoring all South Bay salt ponds to tidal marsh would adversely affect at least some shorebird and waterfowl species. Consequently, the Goals Report identified a number of ecological restoration goals for the South Bay salt ponds as described below, and it presented geographic distributions of these multiple goals in a broad context. The Goals Report did not provide a specific pond-by-pond blueprint.

### 2.2.1 General Recommendations for the South Bay

The Goals Report's overall goal is to restore between 16,000 and 21,000 acres of the existing South Bay salt ponds to intertidal marsh and to manage between 10,000 and 15,000 acres for shorebird and waterfowl habitat. These areas should be connected by wide corridors of similar habitat, and both the restored tidal marsh and managed salt ponds should be interspersed throughout the South Bay. There should be natural transitions from mudflat through tidal marsh to adjacent uplands wherever possible. Adjacent moist grasslands, particularly those with vernal pools, should be protected and improved for wildlife. Riparian vegetation and willow groves should be protected and restored wherever possible.

The planning efforts also concluded that different ecosystems should be intermingled as much as possible and need not follow existing salt pond boundaries. Restored areas should be linked to each other and to existing or restored riparian corridors. Uplands, transitional habitats, and existing wildlife should be protected. In addition, the ecosystems must be buffered from urban development.

We opted not to include a map depicting this information because the Goals Project membership generated several alternative scenarios. Copies of this report can be obtained from the U.S. Environmental Protection Agency, Region IX, San Francisco, CA, and the San Francisco Regional Water Quality Control Board, Oakland, CA.

### 2.2.2 Specific Recommendations for the South Bay Shoreline

The Goals Report divided the South Bay into six subregions in San Mateo, Santa Clara, and Alameda counties. Recommendations for each segment follow and can be found on pages 126 to 137 of the Goals Report (Goals Project 1999).

- **Segment N:** Steinberger Slough to Dumbarton Bridge, San Mateo County
  - Manage crystallizer ponds on Redwood Creek for shorebirds and waterfowl.
  - Create tidal marsh along Westpoint Slough and Redwood Creek and in a wide band along the bayfront down to the Dumbarton Bridge.
  - Retain inland salt ponds for shorebird and waterfowl habitat.
- **Segment O:** Dumbarton Bridge to Alviso Slough, San Mateo and Santa Clara Counties
  - Restore large areas of tidal marsh with continuous bayfront corridor.
  - Create more and wider buffers from human activities because existing Palo Alto marshes contain the highest density of California clapper rails in the Bay Area.
  - Manage two or three salt pond complexes for shorebird and waterfowl habitat, including the pond located just south of the Dumbarton Bridge.
  - Enhance seasonal wetlands in Sunnyvale.
  - Connect wetlands to riparian corridors at San Francisquito Creek, Guadalupe Slough, and other streams where possible.
- **Segment P:** Alviso Slough to Albrae Slough, Santa Clara and Alameda Counties
  - Restore large areas of tidal marsh.
  - Link restored wetlands to the vernal pool complex in Warm Springs and the Coyote Creek riparian corridor.
  - Manage a large complex of salt ponds for shorebird and waterfowl habitat.
  - Mitigate the effects of the City of San Jose's freshwater effluent.
- **Segment Q:** Albrae Slough to Dumbarton Bridge, Alameda County
  - Create tidal marsh along the bayfront and transition to uplands at the upper end of slough channels.
  - Manage some salt ponds for shorebird and waterfowl habitat, including the crystallizer pond complex located between Mowry and Newark Sloughs.
  - Protect the harbor seal haul out in Mowry Slough.
  - Contend with Hetch Hetchy aqueduct.

**Table 2-1. Ecological types identified in the USFWS Tidal Marsh Ecosystem Recovery Plan**

Ecosystem Type	Description	Species Benefits
Tidal Marsh	Pickleweed- and cordgrass-dominated marsh with tidal action.	Habitat for California clapper rail, salt marsh harvest mouse, fisheries.
Tidal Marsh – Salt Panne Complex	Vegetated tidal marsh interspersed with unvegetated salt pannes.	Same as tidal marsh, plus snowy plover nesting. If panne is tidal, habitat for other shorebirds and waterfowl.
Salt Panne	Unvegetated flat substrate.	Nesting habitat for snowy plover, shorebird roosting, possible least tern foraging.
Microtidal Lagoon	Shallow open-water lagoon with dampened tidal action, seasonal variation in water level, variable salinities. Most reflects existing salt ponds.	Feeding and roosting habitat for waterfowl, shorebirds, and other birds. Habitat for invertebrates and fish.

Source: USFWS (in preparation)

- **Segment R:** Dumbarton Bridge to Alameda County Flood Control Channel, Alameda County
  - Retain salt ponds in southern section for shorebird and waterfowl habitat.
  - Restore tidal marsh in northern section.
  - Consider removing lower reaches of flood control levees along Alameda County Flood Control Channel.
  - Address the invasion of smooth cordgrass (*Spartina alterniflora*).
- **Segment S:** Alameda County Flood Control Channel to San Mateo Bridge, Alameda County
  - Manage salt ponds around Turk Island and parts of Baumberg Tract for shorebird and waterfowl habitat.
  - Restore remaining area to tidal marsh.

tidal wetland-dependent wildlife species (Baye, personal communication). The plan emphasizes re-establishment of diverse wetland habitats within the South Bay, including the range of habitats that would have persisted under natural conditions. In addition, the plan recommends restoration designs that minimize engineering or ongoing maintenance.

The new recovery plan is not yet available for public review. Recent drafts of the plan identified four ecosystem types applicable to the salt ponds considered in this Feasibility Analysis: tidal marsh, tidal marsh—salt pan complex, salt pans, and microtidal lagoons (i.e., managed salt ponds). The functions and species benefits of each are detailed in Table 2-1.

### 2.3 U.S. Fish and Wildlife Service Endangered Species Recovery Plans

The USFWS is mandated under the Endangered Species Act to address the recovery of species listed as endangered under the Act. In 1984, the Service developed a recovery plan to address two of the Estuary’s tidal marsh-dependent endangered species, the California clapper rail and the salt marsh harvest mouse (USFWS 1984). That recovery plan focused on habitat requirements for the two endangered species and provided the basis for USFWS habitat enhancement and restoration approaches and recommendations.

The concept of recovery plans has evolved since that time from a species-specific approach to a broader approach that addresses the restoration of overall ecosystem functions. The objective is to conserve the ecosystems on which endangered or threatened species depend. This includes restoration of habitats that will reliably promote recovery of federally listed species and species of concern (federal, state, or regional). The USFWS is currently preparing two new recovery plans. These plans are the Tidal Marsh Ecosystem Recovery Plan and the Snowy Plover Recovery Plan.

The Tidal Marsh Ecosystem Recovery Plan will supersede previous recovery plans and will address a broader suite of species as well as tidal marsh ecosystems as a whole. Once completed, this plan will help define ecological goals for South Bay salt pond restoration and present guidelines for achieving those goals. The plan incorporates the recommendations developed in the Snowy Plover Recovery Plan and should reflect a synthesized perspective for all

### 2.4 San Francisco Bay Regional Water Quality Control Board Basin Plan

The overall mission of the San Francisco Bay Regional Water Quality Control Board (RWQCB or Regional Board) is to protect the beneficial uses supported by the Bay Area’s surface and ground waters. By law, the Regional Board is required to develop, adopt and implement a water quality control plan (known as the Basin Plan) for the San Francisco Bay. The Basin Plan is the master policy document that contains descriptions of the legal, technical and programmatic basis for water quality regulation in the region. The plan must include three items. First, a statement of beneficial water uses that the Regional Board will protect. Second, a list of water quality objectives necessary to protect the designated beneficial water uses. Third, a discussion of the strategies and time frame needed to achieve these water quality objectives.

The San Francisco Bay Basin Plan recognizes many beneficial uses of wetlands (RWQCB 1995). These uses include wildlife habitat, preservation of rare and endangered species, water-based recreation (both contact and non-contact), marine and estuarine habitat, fish migration and spawning, shellfish harvesting, and ocean, commercial and sport fishing (RWQCB 1995). In other words, the Regional Board recognizes that wetlands and related habitats comprise some of the most valuable natural resources in the San Francisco Estuary.

To protect the beneficial uses of wetlands and other aquatic systems, the Regional Board uses narrative and numerical water quality objectives. When factors degrade water quality beyond the designated levels or limits, the Regional Board conducts a case-by-case, cost-benefit analysis. When the analysis indicates that benefi-

cial uses will be adversely impacted by further degradation, the Regional Board will not allow controllable factors to degrade water quality further.

The Estuary's beneficial uses are often affected by diking and draining wetlands, or by discharging fill material into them. The Regional Board regulates these activities. Discharge of fill material into waters of the United States must comply with a permit obtained from the U.S. Army Corp of Engineers (USACE). Under the Clean Water Act, Section 401, the State—through the Regional Board—must certify that any Section 404 permit issued by the Corps complies with water quality standards set by the State. However, the State can waive such certification. Generally, the Regional Board has independent authority to regulate waste discharges into wetlands that would adversely affect their beneficial uses.

## 2.5 San Francisco Bay Conservation and Development Commission Bay Plan

The overall mission of the San Francisco Bay Conservation and Development Commission (BCDC), a state regulatory agency, is to protect and enhance San Francisco Bay. To do this, the BCDC ensures that minimum bay fill occurs as part of any development project and promotes public access to the Bay shoreline. The regulatory activities of the BCDC are based on the McAteer-Petris Act and the San Francisco Bay Plan (BCDC 1998).

The Bay Plan contains several general findings and policies regarding the South Bay salt ponds, and it contains a number of site-specific planning recommendations. The Bay Plan findings recognize economic importance, climatic and air pollution benefits, and ecological functions of the salt ponds. The Bay Plan policies regarding the salt ponds are summarized below:

- If public funds are available, purchase and tidally restore salt ponds no longer needed for salt production.
- If public funds are not available, pursue other alternatives for protecting salt ponds:
  - If areas are proposed for development, obtain an open space dedication.
  - When development occurs, retain substantial amounts of open water, provide substantial public access, and develop the site in accordance with BCDC policies regarding non-priority shoreline uses.
  - Promote saltwater aquaculture activities to retain area as open water.
- Build recreational developments, such as marinas and parks, in appropriate areas outboard of salt ponds or in sloughs, so long as the ability to produce salt and restore tidal action to salt ponds is not compromised.
- Pursue purchase of development rights on salt ponds.

The specific geographic policies and suggestions for the South Bay salt ponds are contained in Plan Map 7 of the Bay Plan, reproduced here as Map 4. The policies and suggestions fall into five main categories:

- Acquisition for wildlife protection (many areas).
- Improvements for public access (interspersed).
- Reservation for possible future airport (ponds B1 and A2E immediately north of Moffett Field in Mountain View).
- Reservation for possible shallow-draft port (bayward edge of ponds B1, A2E, and B2 immediately north of Moffett Field). Note that this designation is proposed for deletion under

Bay Plan Amendment 3-00.

- Flood flow storage (ponds near Ravenswood Slough in Menlo Park).

## 2.6 San Francisco Bay Joint Venture Implementation Strategy

The San Francisco Bay Joint Venture (SFBJV) is a partnership that brings together public and private agencies, conservation groups, development interests, and others to collaborate in restoring wetlands and wildlife habitat in the San Francisco Estuary. The SFBJV is one of 11 habitat joint ventures in the United States created to help implement the North American Waterfowl Management Plan, an international agreement among the United States, Canada, and Mexico. The goal of the SFBJV is "to protect, restore, increase, and enhance all types of wetlands, riparian habitat, and associated uplands throughout the San Francisco Bay region to benefit waterfowl and other fish and wildlife populations". To carry out its mission, the SFBJV recently prepared an Implementation Strategy (SFBJV 2001) that outlines specific measures to achieve its goals over a 20-year time frame.

The primary waterfowl goal of the SFBJV is to support diving ducks at recent peak population levels, and the secondary goal is to support dabbling ducks at recent peak population levels. The main impediments currently faced by these species are limitations in habitat quantity and quality, limited submerged aquatic vegetation as a food resource, and exotic aquatic species displacing native aquatic flora and fauna. The Implementation Strategy identifies a number of measures to achieve its goals and to overcome these impediments. These measures center largely on habitat protection, enhancement, and restoration, as well as improved management of existing habitats.

The Implementation Strategy identifies the South Bay salt ponds as important habitat for a variety of waterfowl species, with different ponds providing different levels of ecological support functions (see Chapter 4 of this report). To meet its goals, the SFBJV recommends several strategies for restoring the South Bay salt ponds:

- Where appropriate, restore higher salinity salt ponds (> 70 parts per thousand [ppt]) rather than low salinity ponds to tidal marsh or seasonal ponds because low salinity ponds have higher waterfowl habitat value.
- Where consistent with other goals, retain large (200 to 550 hectare) salt ponds of moderate salinity (20-30 ppt) for large diving ducks, and manage those ponds for production of widgeon grass (*Ruppia maritima*).
- Where consistent with other goals, retain medium (50 to 175 hectare) salt ponds of variable salinity (low to medium; <70 ppt) for small diving ducks and dabbling ducks (especially the northern shoveler).
- If salt production ceases in the South Bay, explore the possibility of maintaining several high salinity ponds (<140 ppt) for production of brine shrimp and brine flies, an important food source for some waterfowl species.
- Related points identified in the Implementation Strategy pertinent to the South Bay salt ponds include incorporating large ponds within tidal marsh restoration designs.
- For ponds slated for restoration, manage in their current condition during the interim period before restoration.
- For ponds slated for retention as salt ponds, manage over the long term.