SOUTH BAY SALT POND RESTORATION PROJECT

DRAFT ADAPTIVE MANAGEMENT PLAN

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Science Team for the South Bay Salt Pond Restoration Project
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South Bay Salt Pond Restoration Project
Draft Adaptive Management Plan

I. INTRODUCTION: RATIONALE FOR ADAPTIVE MANAGEMENT

A. Project Description

In March of 2003, state and federal agencies acquired more than 15,000 acres (>6100 hectares) of solar evaporation salt ponds from Cargill Company in South San Francisco Bay. This acquisition provides the opportunity to restore wetlands on a scale unprecedented on the west coast of North America. The South Bay Salt Pond Restoration Project (Project) is managed collaboratively by the California State Coastal Conservancy, the U.S. Fish and Wildlife Service (FWS), and the California Department of Fish and Game (DFG). The overarching goal of the Project is the restoration and enhancement of wetlands in the South San Francisco Bay while providing for flood management and wildlife-oriented public access and recreation. The six Project Objectives, based on this goal, are central to Project planning (Table 1).

The Project Area consists of 54 ponds ranging from 30 to 680 acres in size in three distinct regions bordering South San Francisco Bay: the Alviso Complex (7,997 acres in 25 ponds), Eden Landing Complex (5,450 acres in 22 ponds) and the Ravenswood Complex (1,618 acres in 7 ponds) (Figure 1). The Project region consists primarily of former wetlands that were diked off from the Bay as early as the 1860s (Siegel and Bachand 2002). Creation of the levees and other actions in the Project region had large effects on the ecosystem of the South San Francisco Bay including:

- the loss of at least 85% of historic tidal wetlands;
- changes in sediment dynamics:
- changes in species composition and distribution, and
- the endangerment of a number of species.

The restoration of substantial tidal marsh habitat in the South Bay to reverse these impacts has long been a goal of the public and agencies (Habitat Goals 2000). However, complete restoration of tidal marsh would eliminate the salt ponds, which are now used for foraging and nesting by a wide variety of resident and migratory bird species. Restoration and management of the Project Area must balance tidal marsh restoration with preservation of current species use.

As a condition of the purchase, Cargill was responsible for reducing pond salinity to the "transfer level", a condition set by the Regional Water Quality Control Board (RWQCB). Cargill transferred the Eden Landing and Alviso ponds to the FWS and DFG from 2004 to 2005 at which time the agencies began to manage them under a strategy called the Initial Stewardship Plan (ISP). This plan is designed to reduce water salinities and maintain the ponds as independent systems that no longer make salt, in other words, decouple the ponds from salt making. ISP management will produce moderate salinity ponds prepared for restoration or other management action as determined by the Restoration Project. Pond management under the ISP is described in the *South Bay Salt Ponds Initial Stewardship Plan* (Life Science 2003a, b). As a result of these management actions, pond conditions, especially salinity, have changed since the purchase. These changes have been monitored by the USGS, whose monitoring program is summarized in Section II.C.

While there is much known about the South Bay ecosystem, the Science Team for the Project has identified a number of uncertainties and knowledge gaps that could inhibit our ability to achieve the Project Objectives. Baseline data collected during the Project's planning phase will address some of the uncertainties. However, we will never know everything we need to know about restoring this system before we start. In fact, many data gaps can *only* be addressed by implementing restoration actions and learning from the results.

This process of learning by doing and then using the results to improve management actions is called adaptive management, and this process is a critical component of implementation of the South Bay Salt Pond Restoration Project. For this Project to succeed, no phase can proceed without including adaptive management as a *design element*; it must be included in the project costs and implemented like any other part of the project. As this Adaptive Management Plan describes, information for adaptive management will be generated by **monitoring** and **applied studies**. This information will permit effective changes to current phases and assist in the design of the next phase of the Project. If data are not collected and applied to management decisions, aspects of the project will fail or *appear* to fail. Without studies, we will not understand what is happening to the system nor will we be able to justify our management actions to the public. Such ignorance of the system will not generate public support or funding for future phases. Only by documenting progress toward goals, learning from surprises, and responding to them can the Project show success.

Adaptive management allows projects to move forward in the face of uncertainty. Uncertainty is inherent in restoration, not only because of our lack of information, but also because nature is variable and unpredictable, especially at long time scales. Before beginning restoration, the Project must collect enough data to reduce basic uncertainties to the greatest degree possible given the 5-year planning timeframe. Then, the Project leaders must move forward by implementing Phase 1 projects, monitoring and studying them, and then making improvements based on the information collected.

It is important to realize that large-scale restoration, such is being planned in the South Bay, is likely to have effects that some people will perceive as negative. There are trade-offs or costs as well as benefits to nearly everything we do. For example, the planning for this project will incorporate recognition of the need for balancing the ecological benefits of tidal marsh restoration with the reduction of benefits that the salt ponds provide to some species. Monitoring and studies are needed to understand the ecological trade-offs and social implications in order to make informed decisions.

Whether salt pond restoration is undertaken or not, the ponds and the South Bay ecosystem are changing and will continue to do so. The challenge and promise of restoration is to direct change along a path that reverses damage caused by human activity and improves ecosystem integrity. Adaptive management is the process for assessing and understanding that trajectory and keeping the Project on track toward the Project Objectives.

This Project will occur in phases over the coming decades and has a 50-year planning horizon. Because there are many scientific and social uncertainties with respect to achieving Project Objectives, project managers must design an adaptive management process to learn from each restoration phase. Specifically, adaptive management for the Project must include:

- restoration targets for Project Objectives;
- monitoring parameters to clearly assess progress toward restoration targets;
- generating data that will reduce uncertainty related to management actions in current and future phases;
- revealing unexpected outcomes and allow timely responses to those outcomes;
- providing information in a timely manner for management decisions.

In Sections II-IV, this Adaptive Management Plan (AMP) gives the scientific basis for adaptive management of the Project, including restoration targets, monitoring parameters and applied studies. Sections V-IX describe the institutional structure by which data will be generated, analyzed, and incorporated into Project decision-making for effective adaptive management.

Table 1. South Bay Salt Pond Restoration Project Objectives

Objective 1. Create, restore, or enhance habitats of sufficient size, function, and appropriate structure to:

A. Promote restoration of native special-status plants and animals that depend on South San Francisco Bay habitat for all or part of their life cycles.
B. Maintain current migratory bird species that utilize existing salt ponds and associated structures such as levees.
C. Support increased abundance and diversity of native species in various South San Francisco Bay aquatic and terrestrial ecosystem components, including plants, invertebrates, fish, mammals, birds, reptiles and amphibians.

Objective 2. Maintain or improve existing levels of flood protection in the South Bay area.

Objective 3. Provide public access opportunities compatible with wildlife and habitat goals.

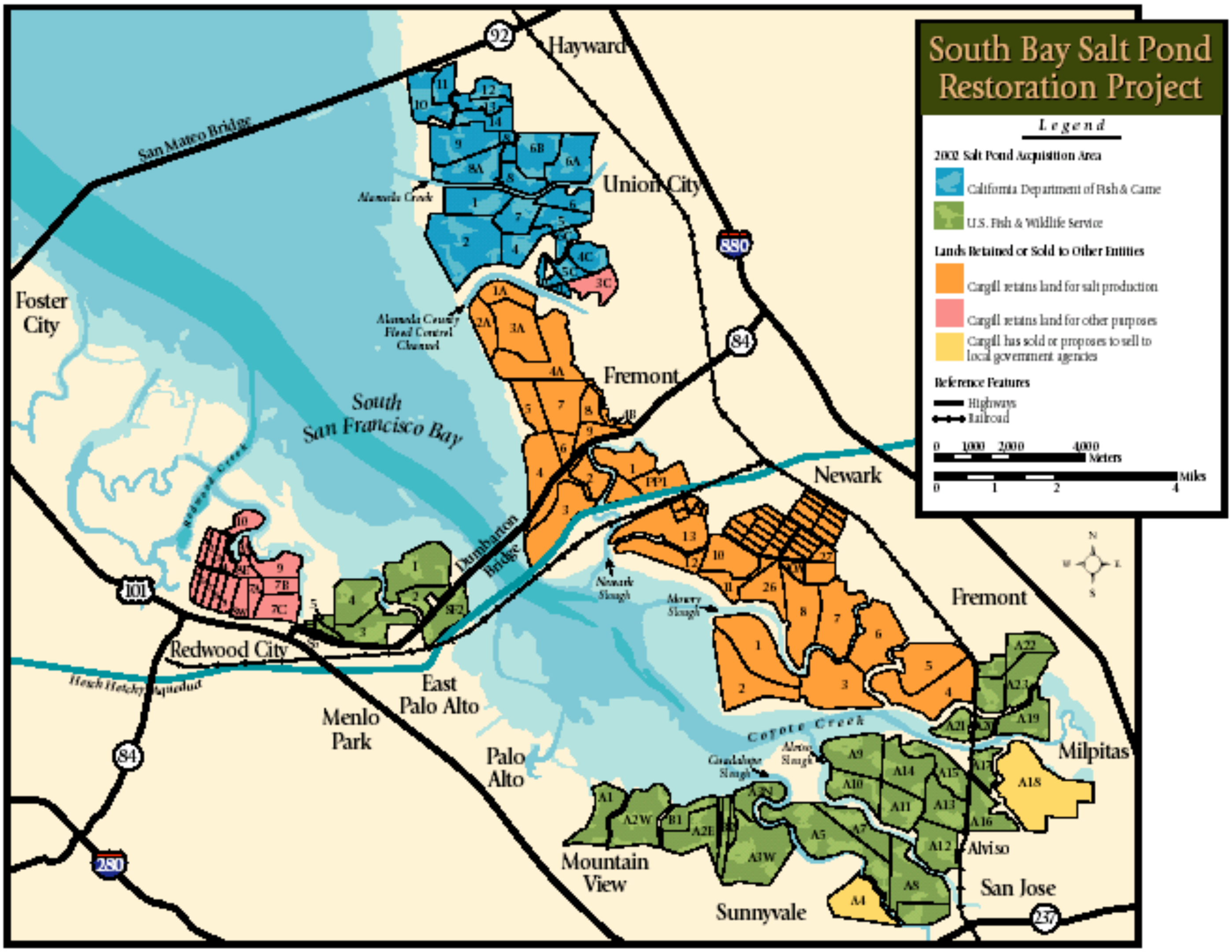
Objective 4. Protect or improve existing levels of water and sediment quality in the South Bay and take into account ecological risks caused by restoration.

Objective 5. Implement design and management measures to maintain or improve current levels of vector management, control predation on special status species and manage the spread of non-native invasive species.

Objective 6. Protect the services provided by existing infrastructure (e.g. power lines).

FIGURE 1. The South Bay Salt Restoration Project Area.

Blue Ponds are the Eden Landing Complex, green ponds from Mountain View to Milpitas are the Alviso Complex and green ponds in Menlo Park are the Ravenswood Complex. Orange and red ponds are retained by Cargill for salt production or other purposes, respectively.



B. What is Adaptive Management?

Adaptive management, as a resource management approach, was first described by Holling (1978). While there are many variations on the definition of adaptive management, one of the most applicable to this Project comes from Jacobson (2004) who states, "Adaptive management is a cyclic, learning-oriented approach to the management of complex environmental systems that are characterized by high levels of uncertainty about system processes and the potential ecological, social and economic impacts of different management options. As a generic approach, adaptive management is characterized by management that monitors the results of policies and/or management actions, and integrates this new learning, adapting policy and management actions as necessary."

Adaptive management promotes flexible, effective decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances our understanding of the system and helps adjust policies. Adaptive management incorporates natural variability in evaluating ecological resilience and productivity. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders (Water Science and Technology Board and Ocean Studies Board 2004).

As an interface among social, economic, physical-biological, and ecological models, the adaptive approach recognizes the need for integrative, and iterative approaches that incorporate multiple visions and values to negotiate multiple goals. At the same time, the process should be designed to organize an effective, science-based exploration of how a system is likely to respond to selected and alternative strategies.

In an adaptive management approach, resource management and restoration policies are viewed as scientific experiments. This is a critical concept. The environmental outcomes of management policies must be closely monitored because the results are uncertain. Adaptive management encourages an ecosystem–level approach to resource management and encourages close collaboration among scientists, managers, and other stakeholders on key policy decisions (Jacobson 2004). Adaptive management is a "formal process for continually improving management policies and practices by learning from their outcomes" (Taylor et al. 1997).

Effective adaptive management is NOT trial and error, an approach that typically reflects an incomplete understanding of the system. Also, it does not focus only on tracking and reacting to the fast, immediate variables; this leads to perpetual reactive, crisis management. For fundamental change, adaptive management monitoring focuses on the slow, driving variables. "Simply changing management direction in the face of failed policies does not constitute adaptive management. Rather, adaptive management is a planned approach to reliably learn why policies (or critical components of policies) succeed for fail" (Light and Blann 2003).

An effective AMP must have well-developed science generation and decision-making processes. According to the National Research Council (2003), the scientific elements of an effective AMP include:

- Clear restoration goals and targets,
- Sound conceptualization of the system,
- An effective process for learning from restoration and management actions, and
- An explicit process for refining and improving current and future management actions.

In addition, a successful decision-making process must include:

- a clearly-defined feedback loop of decision-making, monitoring and research, data synthesis and application, and decision-making;
- managers who assist in determining research and monitoring needs and scientists who participate in decision-making;
- champions for the Project and AMP in key management and science roles;
- a responsive and comprehensive Data Management and Storage Repository;
- effective communication between scientists, decision-makers and the public;
- a regular stream of adequate funding to implement the AMP.

To summarize the role of adaptive management in ecosystem restoration projects, the National Research Council (2003) says, "The learning process that will guide the 'adaptive implementation' of the Restoration Plan will depend on a research strategy that effectively combines monitoring, modeling, and experimental research with a high level of attention to information management, data synthesis and periodic re-synthesis of information throughout the implementation and operation of the Restoration Plan. As with any long-term environmental project, but especially one committed to an adaptive approach, learning depends on the continuity of adequate funding."

C. Scientific Basis of Project Objectives

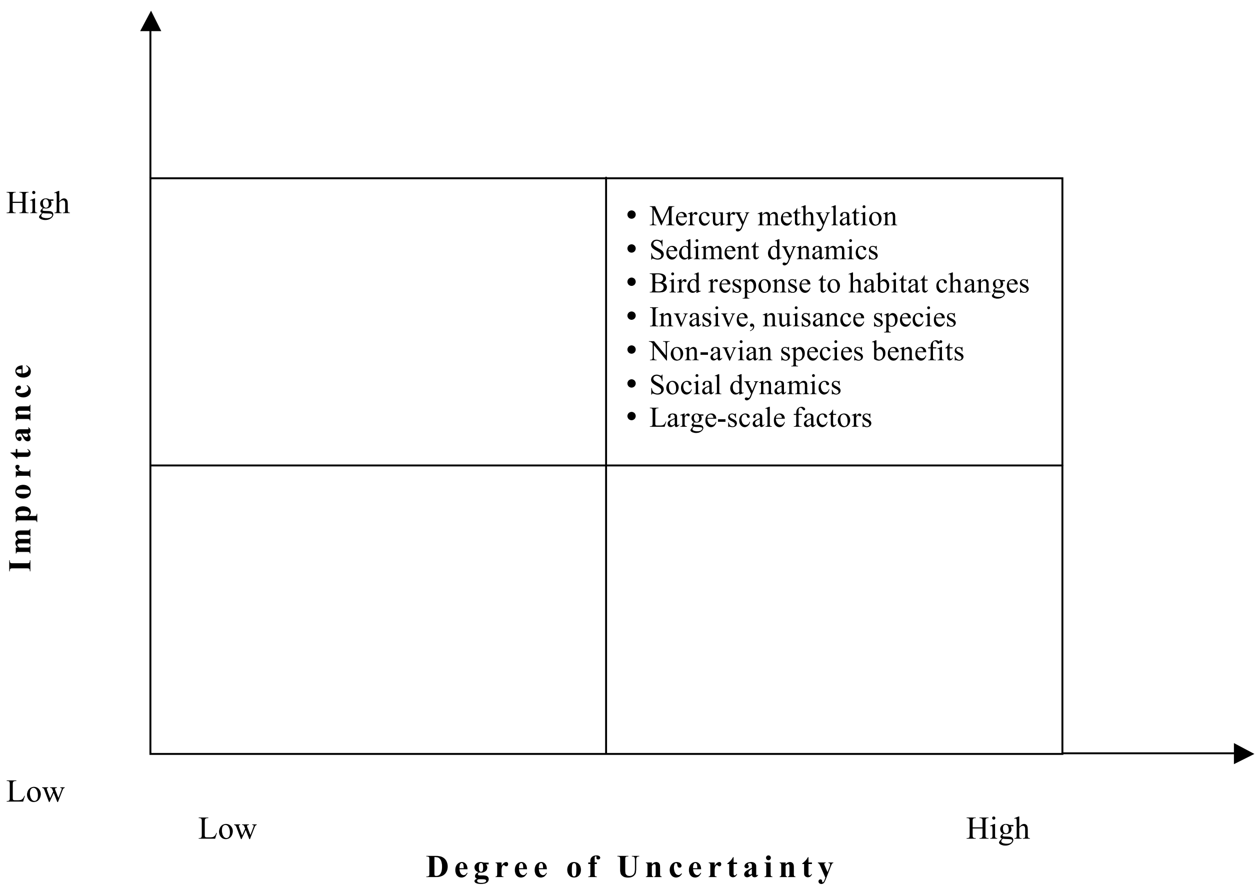
Scientific information for the South Bay Salt Pond Restoration Project and the AMP has come from the Science Team's Science Syntheses (focused literature reviews) and technical workshops, including the NSP Charette, data collected on baseline conditions by the USGS, modeling, research and analysis done by the Consultant Team (Philip Williams and Associates, H.T. Harvey and Associates and Point Reyes Bird Observatory), and other relevant, authoritative sources. This information provides a foundation for understanding the ecosystem and for setting restoration targets and identifying uncertainties.

A viable AMP must include clear, measurable restoration targets--the goals that indicate project success (Society of Wetland Scientists 2003). While the Project Objectives are good guides to restoration of the South Bay system, they are too general to measure and need to be converted into quantitative targets with obvious parameters that can be monitored. One way to develop targets is to evaluate the Project Objectives in light of the scientific knowledge to determine the *minimum* physical, ecological and management conditions required to achieve each Project Objective. This evaluation is useful not only for setting Project and Phase-level restoration targets, but for determining if all the Objectives are achievable and if any of the Objectives conflict. Based on the information sources listed above, the Science Team developed science-based evaluations of the Project Objectives (Appendix 1).

This analysis in Appendix 1 indicates that 50% of the Project Area opened to full tidal action, with the assumption that mature tidal marsh will eventually develop, is the likely minimum needed to meet the recovery requirements set by the FWS for the endangered California clapper rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*) in the South Bay. In addition, 50% ponded habitat managed for migratory and breeding bird species appears to be adequate for maintaining the pre-ISP diversity and abundance of these birds. Also, some of the ponded area, if managed correctly, may support the target goal of 125 nesting Western snowy plovers (*Charadrius alexandrinus nivosus*), an endangered species that uses seasonal wetlands. The extent to which ponds can be reduced and managed, while still meeting goals for migratory birds and snowy plovers, is uncertain and will be the subject of adaptive management monitoring and applied studies.

The balance between bird species using different habitats is one of the primary uncertainties identified by the Science Team. Other critical uncertainties identified by the Science Team (Trulio, et al. 2004) and participants at the NSP Charette (National Science Panel 2005) are listed in Table 2. Results from studies to address these uncertainties will be required in order to proceed from Phase 1 of the Project into later phases. To be studied, uncertainties must be translated into hypotheses (see Section III and Appendix 2). Project managers should note that the key uncertainties will evolve as the Project is implemented and information grows. Some uncertainties will be resolved, and others will arise. Because uncertainties are evolving, the list of key uncertainties should be revisited and revised each year. Thus, the list in Table 2 should not be viewed as immutable.

Table 2. Key Project Uncertainties



D. Visions of South Bay Ecosystem Restoration

The physical and temporal scales of the South Bay Salt Pond Restoration Project qualify it as an *ecosystem* restoration. An ecosystem is composed of interacting elements of the physical and biological world that produce large-scale systems. Carbon uptake and loss, energy exchange, nutrient cycling and the water balance distinguish one ecosystem from another (Woodward 1994). These functions operate to produce characteristic nutrient dynamics, disturbance regimes, microclimates, successional processes, and species diversity and interactions that occur over the majority of the system (Woodward 1994).

To promote a healthy ecosystem and to restore maximum ecological diversity, adaptive management for the Project must include the entire South Bay ecosystem. For example, while the projects for each phase will be the focus of adaptive management, the ponds that remain under ISP management must be included in adaptive management monitoring and studies. How the Project affects systems beyond the South Bay and vise versa should also be considered. Additionally, other restoration work and relevant projects around the Bay should be part of the on-going information synthesis for this Project. Examples of such projects include the Napa Salt Ponds Restoration Project, CALFed Restoration Program, and the Hamilton NAS Restoration. Table 3 provides a more complete list of San Francisco Bay and national projects whose information should be brought into the adaptive management process.

Ecosystem restoration is very complex and information on reconstructing these intricate systems is inadequate. Thus, a basic goal of restoration is to have as little human intervention as possible and allow natural processes to restore ecological structures and functions (NRC, 1992). Allowing nature to do the work is not only the most successful approach to restoration, it also requires the least management. The more management needed, the more difficult and expensive the Project.

However, the South Bay is a highly altered system in an urban setting; some Objectives may only be reachable through regular intervention. Adaptive management will be used to determine the minimum amount of management needed. In addition, restoring sustainable habitats for rare and indicator species may require intervention that focuses on particular species, habitats or habitat components. While species-specific management may be necessary, it should not replace the Project's ecosystem focus. It is important that restoration targets for the Project include criteria at both the ecosystem and species level. See Section III.B. for more on monitoring at different ecological levels.

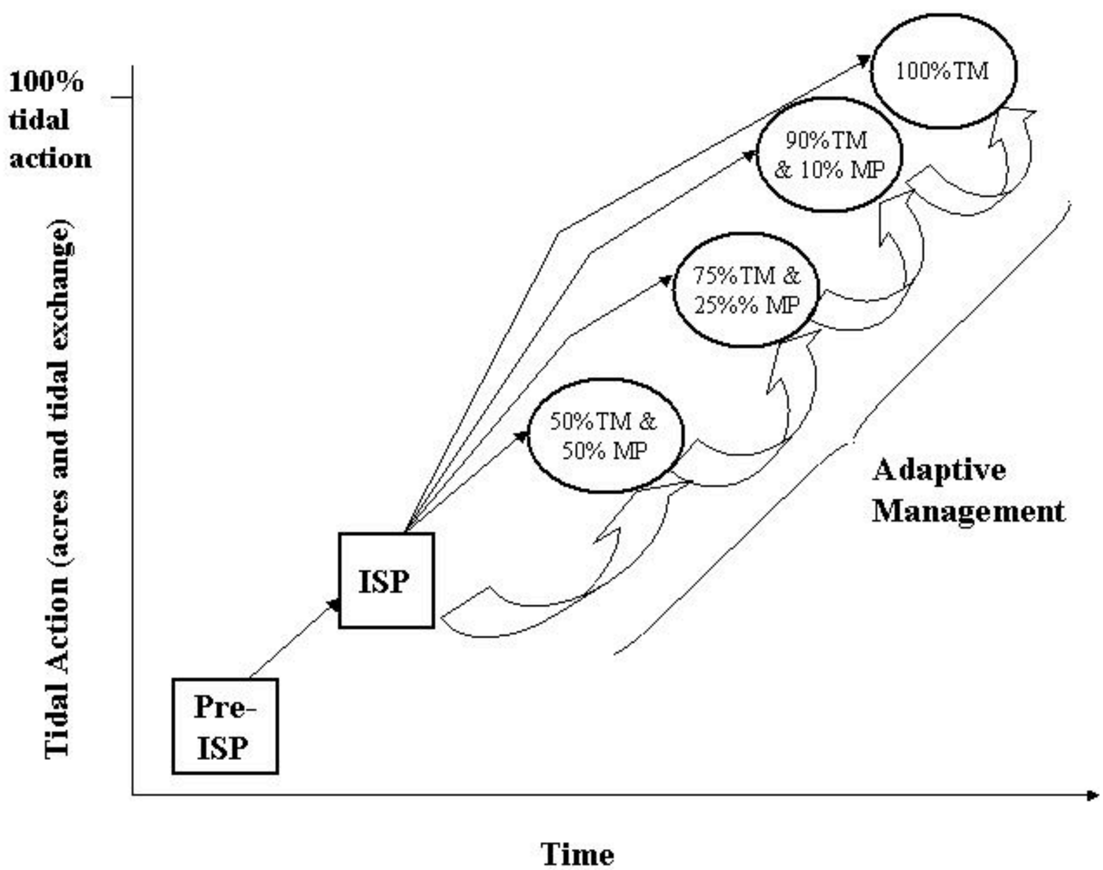
Project participants have developed four visions for what the restored ecosystem could look like in 2050 (not including the No Project scenario, which is continued management under the ISP). These visions are important for directing Project planning. However, this AMP is based on the principle that, currently, we cannot accurately predict the state of the ecosystem after 50-years of restoration. Given this, the Project will use AM to determine how far the system can be moved toward full tidal action and naturally-functioning tidal marsh while still meeting the Project Objectives. The four scenarios for the 50-year vision are arranged in Figure 2 along a gradient from the configuration with the most management and least natural process control (50% tidal marsh/50% managed pond) to the system with the most natural process control (100% of ponds open to full tidal action). As noted above, the scientific analysis of the Project Objectives indicates that 50% full tidal action and 50% managed pond is a relatively low risk, rational starting point for Project implementation, based on current information.

In moving the Project along the tidal action continuum, Project leaders must take care to avoid irreversible changes when there is moderate to high uncertainty with respect to the outcome (Walters 1997). Two such situations to avoid are:

1. Designing and implementing irreversible actions for which there is a moderate to high risk of failure. In other words, the design should not go beyond the limits of our scientific, technical and managerial grasp.
2. Designing and implementing actions that preclude reaching more complete levels of tidal action and natural ecological functioning. For example, implementing small tidal marsh areas may preclude developing a larger, more fully functioning one in the same place later.

The purpose of adaptive management using monitoring and applied studies is to learn how far the Project can move along the continuum of tidal action, from bottom to top, while still achieving the Project Objectives. To this end, this AMP describes the monitoring needed to assess progress toward the Objectives and the applied studies needed to reduce uncertainties.

FIGURE 2. Connecting Visions of the Restored South Bay in a Continuum (TM= aerial percent opened to full tidal action to develop tidal marsh mosaic habitat; MP=aerial percent of managed ponded habitat; ISP=Initial Stewardship Plan)



II. SCIENTIFIC BACKGROUND TO THE AMP

A. Introduction

The science support for this AMP has come from work by the Science Team, with input from the Consultant Team, PMT and Stakeholders. Specifically, literature reviews, technical workshops, modeling, and baseline data have increased our understanding of modeling capabilities, monitoring needs, Project uncertainties, and study needs. This work has resulted in the restoration targets, monitoring parameters, applied studies hypotheses, and research designs given in this and the next sections for the Project, as a whole, as well as during Project planning and Phase 1 implementation. As background to these recommendations, Section II gives a summary of ecological expectations for the South Bay system and a summary of monitoring conducted to date.

Focusing the monitoring and applied study efforts is essential because there are an infinite number of parameters that could be monitored and an equally infinite number of studies that could be undertaken. However, only the most essential information for Project management needs should be addressed by the adaptive management data collection.

B. Expectations for the Ecosystem

Introduction. The South San Francisco Bay is a wetland ecosystem historically dominated by tidal flats, tidal marsh, and moist grassland, whose natural functioning has been impaired by human activities. Urban development and diking to create salt ponds are two primary causes for tidal marsh losses of up to 85% and over 95% loss of moist grassland. While little can be done for habitat components, such as moist grasslands, covered by urban uses, diked areas can be restored to tidal marsh systems and some level of original ecological functioning. The level of function achieved will be determined by current and future land uses and their impacts to the system, our understanding of how the system originally functioned, the extent of public support, and our technical and financial ability to reinstate natural processes and structures.

Ecological restoration seeks to return an ecosystem to a condition approximating that prior to disturbance, by repairing and restoring the system's ecological structures and functions (NRC, 1992). Our understanding of the system prior to disturbance serves as a guide for developing restoration targets, or success criteria, for the restoration project. The following is a brief summary of the basic ecology of the South Bay system and tidal marsh and managed pond habitats taken from Trulio, et al. (2004).

South Bay Ecosystem Functioning. The South Bay includes a variety of habitat types that have been outlined and classified by a number of previous studies (SFEI EcoAtlas 1999; Goals Project 1999). The distribution of habitats is influenced primarily by the frequency of inundation and salinity regime. These processes are in turn driven by physical forces, especially tidal fluctuation and currents, fresh water inputs, sediment concentrations, deposition and erosion, water quality (including salinity, nutrients and pollutants), wind waves, and bathymetry and topography.

Frequency of inundation is determined by elevation relative to sea level, and salinity is affected by local freshwater inputs, as well as total freshwater inflows to the entire Bay. Historically, there was a complex spatial mix of habitat types across the South Bay, with a range of salinities and elevations relative to mean high water (MHW). Substantial shifts in habitat have occurred due to diking, filling of Bay habitats, and changes in freshwater inflows.

Bay and channel habitats (both deep and shallow) are subtidal, whereas tidal flats (mudflats) and tidal marshes are within the intertidal range. Tidal flats are uncovered by the low tides and remain unvegetated, and are at the lowest intertidal elevations. Tidal flats support an abundance of benthic invertebrates that are key food resources for the large shorebird and waterfowl populations that migrate though the Bay. In addition, a number of fish species use both subtidal and intertidal habitats, such as topsmelt (*Atherinops affinis*), longjaw mudsucker (*Gillichthys mirabilis*) and surfperch species (family Embiotocidae).

At slightly higher elevations, salt marsh habitats are found. *Spartina foliosa* (cordgrass) dominates the low marsh and *Salicornia virginica* (pickleweed) dominates the mid-marsh plain although older marshes are far more complex and species rich (Josselyn 1983; Goals Project 1999, 2000). Natural marshes are characterized by a complex network of tidal channels that connect these habitats to adjacent sloughs, tidal flats, and the Bay. The branching and sinuous channels provide a passage for tides to deliver sediment and nutrients to intertidal marshes, as well as passage for fish and the dispersal of other organisms. In South Bay, the low marsh supports an important native special status species, the endangered California clapper rail (*Rallus longirostris obsoletus*), and the higher marsh supports another native endangered species, the salt marsh harvest mouse (*Reithrodontomys raviventris*). In well-developed marshes, marsh pannes form at the mid- and high-marsh elevations. These pannes are shallow natural ponds that may become very saline and often support little vegetation. Moving toward shore, mid-elevation marsh grades into high marsh above mean higher high water. *Grindelia humilis* (marsh gum plant) is a showy indicator of this zone. Finally, the transitional wetland-upland ecotone occurs at the marsh's highest fringe. This is a very important component of the tidal marsh system, providing refuge for non-aquatic species at highest tides (Goals Project 1999). *Baccharis pilularis* (coyote bush) is a common plant here. The ecotone may grade directly into terrestrial habitats, especially non-native grasslands, or may consist of rare native communities such as moist grassland, vernal pool or willow grove habitats (Goals Project 1999).

In areas where freshwater inputs are significant, brackish marsh develops at similar elevations as tidal salt marsh, with the vegetation dominated by *Scirpus* species, as well as a wide mix of other species (Baye 2000). These areas are known to support a range of nesting bird species, such as ducks (gadwall, cinnamon teal) and colonial waterbirds (black-crowned night heron). Here again, the marsh-upland ecotone is an important habitat, supporting nesting species and amphibians. At even lower salinities, freshwater marsh forms, with *Typha* species (bulrush) dominating. Freshwater marshes may be found in both tidal and non-tidal areas, but are uncommon in the South Bay, except very close to wastewater treatment plant outfalls.

Managed marshes are also within the intertidal range, but the tidal hydrology is manipulated by water control structures. These marshes may be salt, brackish or freshwater depending on the salinity of the flooding waters. The objectives of managing hydrology for these marshes vary widely, from providing wildlife habitat to flood control. However, in all cases, the tidal range of the managed marsh is reduced, as is the opportunity for sediment input and biological connectivity to adjacent habitats.

Managed ponds are included because, although they were not a major component of the natural ecosystem, they have become so and have ecological values in their own right. Salt ponds support a great diversity and abundance of species, especially migratory shorebirds and waterfowl that have lost habitat elsewhere or find important foraging and roosting habitats in the salt ponds (Warnock et al. 2002). Habitat quality in salt ponds is determined by water salinity and depth. Low salinity (35-60 ppt) and mid-salinity (60-180 ppt) support a range of fish and invertebrates (especially brine shrimp and brine flies) that are important food sources to resident American avocets (*Recurvirostra americana*) and black-necked stilts (*Himantopus mexicanus*), as well as phalaropes (*Phalaropus spp*.) and many other avian migrants. Benthic invertebrates residing in the ponds are important food sources for shorebirds and many duck species. Very shallow ponds (2-4 inches deep) and ponds between 4 inches and 3 feet deep are especially attractive to birds seeking food in the mud (Goals Project 1999). Islands and insular levees within the ponds provide nesting and roosting habitat for a large number of waterbirds including Forster's terns, Caspian terns, endangered California least terns (*Sterna antillarum brownii*), double-crested cormorants, black skimmers, black-necked stilts, and American avocets. The Western snowy plover requires seasonal pond or island nesting sites with ponded water nearby that provides adequate forage (Neuman 2005). The needs of the California least tern, which currently breeds in the Central Bay and comes to the South Bay for post-breeding foraging, can be satisfied with isolated levees or islands near the Bay or ponded, foraging habitat.

The historic condition of the South Bay ecosystem in 1850 is a template and a guide for restored conditions. Work done by SFEI (SFEI EcoAtlas 1999) shows a pattern of tidal flats, tidal marsh, sloughs, moist grasslands, salinas (natural salt ponds), and sausals (willow groves) (Collins and Grossinger 2005). The tidal marshes themselves were a mosaic of habitat types including vegetated marsh plain, sloughs with tidal flats and channels, ponds and pannes. The extent of tidal marsh features varied with landscape factors especially tidal marsh size, wind-wave erosion, and amount of freshwater input.

In addition to landscape-level physical processes, there are also important landscape-scale habitat issues that have significant implications for population distribution, increasing species population numbers, and maintaining viable populations. Several key issues are:

- the size and shape of habitat patches, including the minimum habitat patches sizes needed to support species of special concern;
- habitat connectivity (including the influence of levee abandonment between restored areas);
- proximity between habitats and other features (e.g., the bay shoreline or developed areas)
- the effects of habitat edge (including the type and quality of adjacent transitional and upland habitats) on habitat value;
- food web support;
- species population dynamics at regional and larger (flyway) scales;
- large-scale patterns of sediment deposition and erosion affecting habitat distribution.

Landscape Scale Predictions. The Landscape Scale Geomorphic Assessment (LSGA), developed by the Consultant Team (Philip Williams and Associates in conjunction with David Schoellhamer, USGS), is designed to predict changes in bathymetry expected for the three Project Alternatives and the No Action Alternative developed for the EIR/EIS. Using findings from the model, the Consultant Team biologists (H.T. Harvey and Associates) will then estimate the acreages of various habitat types that would develop in 50 years. Finally, PRBO will take these analyses and use their Habitat Conversion Models to predict bird use. Table 3 shows preliminary expectations for the ecosystem, based on the LSGA modeling and biological analysis. This analysis is still in progress, but Table 3 illustrates that when complete, this analysis will provide one basis for developing final 50-year restoration targets. In addition, since the LSGM and Habitat models can also give results at various points during the 50-year horizon, they can be used to develop interim restoration targets for habitat acreages and bird use at different stages in marsh evolution.

Table 3. DRAFT Quantifiable Metrics at the Landscape Scale (from Philip Williams and Associates and H.T. Harvey and Associates). These numbers are NOT the final numbers from the Landscape Scale Geomorphic Assessment. Rather, they provide an indication of the metrics that will be produced by that modeling effort, which can be used to set restoration targets.

Metric	No Action Total	Alt 1 Total	Alt 2 Total	Alt 3 Total
Biological Habitat				
Area of subtidal mudflats (acres)		0	0	0
Area of intertidal mudflats (acres)		0	3	0
Area of salt marsh (acres)	490	4,900	7,500	8,100
Area of brackish marsh (acres)		5	200	200
Area above colonization elevation (acres)		5,900	10,000	12,000
Narrow / Area of upland transitional habitat (acres)		62	160	190
Wide / Area of upland transitional habitat (acres)		110	280	330
Length of marsh channels (miles)		340	460	550
Managed pond area (acres -- total)	13,000	6,100	3,300	1,600
System (enhanced)	7,700	2,000	750	0
System (winter) / High Salinity (summer)	360	0	0	0
System (winter) / Seasonal (summer)	1,500	750	310	0
Seasonal Ponds	1,600	860	170	0
Seasonal (summer) / High Salinity (winter)	790	410	0	0
High Salinity Ponds	830	520	520	0
Reconfigured Ponds	0	1,600	1,600	1,600

C. Baseline and Compliance Monitoring in the Project Area

Monitoring efforts in the Project Area are underway to determine provide baseline data on current conditions and document compliance with regulatory standards. A comprehensive monitoring program for the Restoration Project should include the relevant current monitoring parameters that help the Project assess the Project Objectives into the future.

In 2002, the State Coast Conservancy contracted with the USGS to collect two years of baseline data on conditions in the Project Area. USGS data collection includes all 54 ponds, covers a 24-month period from 2003-2005 and is designed to collect data on these parameters:

- Bathymetry (depth and topography) of the ponds, sloughs and South Bay;
- Monthly bird abundance and diversity in the ponds;
- Water salinity, pH, temperature, turbidity, DO, nitrogen (NH4-N and NO3-N), total and soluable phosphorus and sulfur concentrations;

- Chlorophyll 'a' (primary productivity);
- Sediment salt content, particle size, and bulk density;
- Invertebrate composition in sediment cores and from the water column (collected once);
- Monthly fish abundance and diversity, and habitat characteristics at capture locations;
- Hg and MeHg levels in sediment in the Alviso and Eden Landing ponds, MeHg levels in invertebrates; bacteria community analysis at high and low MeHg production sites in Eden Landing ponds.

In addition to pond bathymetry, bathymetry of the tidal flats and topography of levees was determined by LiDAR; subtidal bathymetry with some sediment surface classification was collected by Sea Surveyor, Inc. Bird diversity data on ponds and in tidal marshes was also collected by Point Reyes Bird Observatory, as input to their Habitat Conversion Model.

For the historic view, the San Francisco Estuary Institute EcoAtlas (1999) gives a detailed picture of the South Bay in the 1800s as a guide to conditions before serious habitat degradation and loss occurred. And, the USGS has used historic data to estimate sediment erosion and deposition patterns from the 1800s to the present.

Between 2003 and 2005, pond conditions were changing from their state as active salt ponds to ISP management. During 2003 to 2004, Cargill was reducing pond salinities to meet the transfer standard. And, in 2004, water control structures (culverts with gated culverts) were installed in pond A3W in the Alviso complex and ponds B2 and B10 at Eden Landing; in July, 2004, the culverts were opened, allowing Bay waters to flow into these ponds for the first time in many decades. USGS monitoring is tracking those changes and some biological responses. For example, initial data from the USGS shows shorebird numbers increased at both the Eden Landing and Alviso Complexes by at least 100% from pre-ISP conditions in the first migratory season after the ISP was implemented (Takekawa pers. comm.). FWS data for waterfowl showed similar increases in the Alviso complex (Morris pers. comm.). However, in the Eden Landing complex, water level drawdowns reduced habitat and bird use by piscivores, diving ducks and grebes substantially from pre-ISP levels. USGS is in the process of analyzing the baseline data to provide a picture of pond conditions, before and after ISP implementation, including how birds, fish, invertebrates and algae are responding to those changes.

As a condition of the ISP EIR/EIS, the DFG and USFWS are conducting compliance monitoring to track water quality conditions before and after culverts are opened for the ISP. Water quality requirements are prescribed in a permit with the RWQCB. USGS began data collection in 2004 inside managed ponds and in receiving waters near discharge locations. Monitoring parameters include salinity, temperature, DO, and pH. They also collected chlorophyll 'a' and turbidity data in September and October and water column Hg in September in ponds A2W, A3W and A7. Monitoring data for 2004 showed no violations of salinity, temperature or pH requirements set by the RWCQB (CDFG 2005, USFWS 2005). However, DO levels dropped below required levels at the monitoring locations for several ponds at times during the summer. Additional monitoring revealed low DO conditions occurred only near outflow structures and, as a result, managers took measures to move higher DO water through the culverts (Morris, pers. comm.).

III. RESTORATION TARGETS, MONITORING AND APPLIED STUDIES

A. Introduction

The Society of Wetland Scientists (2003) recommends that restoration planning documents clearly state science-based restoration targets (also known as success criteria or performance standards) that are indicators of habitat structure and function. These targets should be "measurable attributes of restored or created wetlands that, when measured over an appropriate period, can be used to judge whether project objectives have been met". Monitoring, repeatedly sampling biophysical parameters to measure change, is used to assess progress toward restoration targets. Functions of monitoring are to:

- Assess progress toward Project Objectives,
- Characterize baseline/reference conditions,
- Track regulatory compliance,
- Look for early signs of problems.

Monitoring tells us what is happening, but typically not why. Closing the gaps in our knowledge about how to reach restoration targets requires undertaking applied studies to reduce scientific and management uncertainties. Studies are designed to illuminate processes and help managers understand why the system is changing. Studies can also be used to quantitatively test the performance of different management actions whose results are uncertain and to improve predictive modeling. Finally, applied studies should be designed to anticipate the problems that monitoring might detect and provide information on the underlying mechanisms generating the problem. Only by understanding the causes of problems can managers choose the most effective responses.

B. Restoration Targets and Monitoring Parameters for the Project

Restoration Targets. Adaptive Management relies on clear, measurable restoration targets that represent success in achieving the Project Objectives. Typically, they are quantitative bench-marks that are used for measuring progress toward restoration objectives and for determining when the system is diverging from the desired restoration trajectory. Restoration targets should be set for *final* Project conditions, and *interim* conditions at successionary stages in habitat evolution. While the targets are quantitative, they must also incorporate ranges of natural variability. When Project conditions diverge from the range of natural variability, this triggers managers to undertake corrective measures to bring the system back to the desired trajectory. While restoration targets are useful guides to achieving Objectives, Project managers and the public must realize that restoration targets are a temporary set of expectations that will change as our knowledge of the system increases (NRC 2003).

Table 4 begins to develop a list of final, i.e. 50-year restoration targets for success in meeting the Project Objectives. The table gives restoration targets based on existing data, or gives the sources of the information to develop targets, or suggests methods for developing targets. These targets should be developed by the Science Team, Consultant Team and PMT for the final AMP. Interim targets have not yet been developed, but should also be as part of the final AMP.

At this point in its development, the table gives just a few quantitative targets. For example, the restoration target for the Western snowy plover is 125 breeding pairs in the Project Area. This target is not yet complete, as it does not include ranges of natural population variability. Another target for this species is the amount of habitat to support 125 breeding pairs, which experts estimate will vary from about 500 acres to 3,500 acres, depending on the amount of management applied.

To develop or complete the targets, data will need to be collected from pre-disturbance conditions at the restoration site, from measurements at reference sites (relatively undisturbed examples of the target habitat) from historical data, from the literature, or from modeling (such as the LSGA). Even with the best research, the targets may not be entirely accurate and ranges of certainty and natural variation may not be known. Only careful monitoring and applied studies will reveal if the target should be revised and, if so, how. It bears repeating that restoration targets are a temporary set of expectations that will change as our knowledge of the system increases (NRC 2003). Each year, in their evaluation of the Project's performance, Project managers will review the restoration targets and improve on them.

Monitoring Parameters.

"Assessment is the quantitative evaluation of selected ecosystem attributes, and monitoring is the systematic repetition of the assessment process, that is, measurement of the same attributes in the same way, on a regular schedule. The placement and timing of samples is tailored to the spatial and temporal variability… A one-time sample does not constitute monitoring, nor does the haphazard timing of repeated assessments or repeated measurement…using different sampling methods. The essence of monitoring is consistency. At the same time, monitoring programs must be able to evolve."

(Callaway et al. 2001)

Monitoring, using appropriate parameters, allows project managers to assess progress toward Project Objectives as defined by the restoration targets. Thus, monitoring parameters must be good indicators of the restoration targets. Other uses of monitoring are to collect data on baseline conditions, determine construction and post-construction compliance, and provide an early warning system to detect unanticipated changes.

A tremendous number of parameters can be monitored for any particular component of the system. Time and cost will constrain the number of parameters that can be measured. The most effective monitoring parameters will: a) give data specific to the restoration targets, b) measure structure and function, c) include major trophic levels, d) be easily measured, and e) be affordable. The Project's 50-year planning horizon necessitates measuring short and very long-term characteristics. In addition, monitoring parameters must measure structures and functions at different levels of ecological organization. Four levels of organization that monitoring parameters should assess are:

- <u>Beyond the Ecosystem (Multiple Ecosystem) Scale</u>: At this level, parameters should measure very large-scale processes that will affect the Project, such as global warming and resultant sea level rise. Metrics might include surface water temperatures and changes in mean sea level. Regional or hemispheric processes may also affect the Project or vice versa. For example, data on bird abundances along the Pacific flyway and at arctic breeding grounds could help us understand if our Project is affecting bird numbers or if exogenous factors are the driving bird number changes in the Project area.
- <u>Ecosystem Scale</u>: Ecosystems are large-scale phenomena driven by water, carbon, energy, and nutrient dynamics. Physical metrics should measure sediment budget (sediment deposition or erosion and suspended sediment concentrations), sediment dynamics, South Bay current patterns and hydrology changes, nutrient changes and organic carbon changes over time in different parts of the system. Ecological parameters should include extent and distribution of habitats in the South Bay ecosystem, tidal marsh systems and managed pond systems, community size, and habitat connectivity.
- <u>Community Scale</u>: Ecological communities are characterized by the diversity and interaction of species. Major communities in the Project Area are tidal marsh, managed

pond, tidal flat, and subtidal/deep water communities. Metrics should include measures of net primary productivity, nutrient levels, vegetation composition and cover, succession, bird/fish/benthic community composition, food chain development, water quality measures, pollutant levels in the food chain, predator-prey dynamics, and interaction of non-native and native species.

- Population Scale: Population measures are needed for listed species, indicator species, specific non-native species such as red fox and *Spartina alterniflora*, and nuisance species, especially mosquitoes. Typical metrics for populations are distribution, abundance, breeding success, predation rates, habitat quality and extent of habitat.

Table 4 lists suggested monitoring parameters that can be used to measure progress toward the restoration targets, including parameters that assess structure and function, different ecological levels, and long versus short-term processes. This suite of metrics should also be able to give early indications of problems in the system. Additional parameters for to meet all these goals and for compliance monitoring in different Project phases will be needed. This table requires revision, with input from the Science Team, Consultant Team and Project managers, to be sure the most efficient, economical metrics are used to achieve monitoring functions.

After choosing parameters, protocols for collecting monitoring data must be developed. While monitoring protocols are beyond the scope of this draft AMP, they should be included in the monitoring plan for Phase 1. In general, the monitoring protocols must be designed to collect enough data at a scale and frequency that allows managers to discern spatial differences and trends through time. In the South Bay, tides and seasons are important natural sources of variability that must be taken into account in designing the monitoring program. For example, for some parameters it may be necessary to sample at a consistent phase of the tide or part of the season, so that long-term trends can be separated from natural variability. Statistical methods to separate effects due to restoration actions from natural variation, such as the Before-After, Control-Impact (BACI) framework (Underwood 1992) should be used whenever possible. The BACI design compares pre- and post-impact conditions at a study site and uses multiple nearby control or reference sites to account for natural variability.

In addition to protocols, an adequate monitoring plan must also include: a) schedules for monitoring and reporting, b) assignment of responsibilities, c) a QA/QC plan, d) triggers for taking corrective action and e) clearly defined remedial measures/contingency actions that managers will take if monitoring reveals that targets are not being met. A monitoring plan for Phase 1 and the overall Project will need to be developed as part of the EIR/EIS. See Section IV for more on Phase 1 monitoring requirements.

Table 4. Project Objectives, Restoration Targets, and Potential Monitoring Parameters

Project Objective: Sub-Objective	**Restoration Target**	**Potential Monitoring Parameters****
1A. Assist in Rare Species Recovery: CA clapper rail	* 1500-2500 rails in winter at a density of 0.5-1.0 birds/2.5 acres * 3 subpopulations of 500+ birds in winter * targets now being developed by FWS	• number of rails in winter • chicks fledged/nest • acres of tidal marsh • channel density/extent • acres of transitional upland • density of vegetation, esp. cordgrass and *Grindelia* • soil texture, organic material & nutrient levels • levels of Hg in rail prey • predation rates
1A. Assist in Rare Species Recovery: Salt Marsh Harvest Mouse	* no population target * 7,500 acres of vegetated tidal marsh * targets now being developed by FWS	• extent of vegetated tidal marsh • density, cover and height of pickleweed • # of mice per acre • acres of transitional upland • density of *Grindelia* and other transitional plants
1A. Assist in Rare Species Recovery: Western snowy plover	* 125 breeding snowy plovers * 3 subpopulations * data on natural population variability may be available from SFBBO, PRBO and USFWS * additional data should be collected by the Project	• number of breeding adults • chicks fledged/nest • acres of nesting habitat • predation rates • brine fly density in nearest foraging areas
1A. Assist in Rare Species Recovery: CA least tern	* current levels of bird use * 20-year data from surveys available from DFG	• number of terns • amount of isolated roosting habitat adjacent to ponds • fish density in ponds
1A. Assist in Rare Species Recovery: Steelhead	* steelhead are found in tidal marshes * data may be available from DFG	• number of fish in tidal marshes • condition, including weight, parasite loads • food availability • predator numbers
Project Objective:	**Restoration Target**	**Potential Monitoring**

Sub-Objective		**Parameters**
1B. Maintain existing migratory birds: shorebirds.	* pre-ISP shorebird numbers and diversity available from USGS baseline data and PRBO Pacific flyway study * more data are needed to characterize natural variability	• number of species and abundance of each • acres of tidal flat foraging area in tidal marshes, ponds, sloughs and Bay • acres of low and medium salinity ponds • fecal coliform levels in heavily used ponds • for indicator species, percent of flyway popul. visiting South Bay • invertebrate density • Hg levels in invertebrates
1B. Maintain existing migratory birds: waterfowl	* pre-ISP waterfowl numbers, diversity and natural variability available from USGS monitoring and FWS annual winter surveys	• number of species and abundance of each • acres of intertidal and subtidal habitat in marshes, ponds, sloughs and Bay • fecal coliform levels in heavily used ponds • for indicator species, percent of flyway popul. visiting South Bay • invertebrate density • Hg levels in invertebrates
1C. Increase diversity and abundance of native species: breeding birds	* meet or exceed pre-ISP breeding bird numbers as determined by USGS, FWS and DFG monitoring	• # of pairs of breeding birds by species • chicks fledged/nest • predation rates
1C. Increase diversity and abundance of native species: native fish	* increase fish abundance above pre-ISP/ISP levels * data available from DFG, Marine Science Institute, literature, researchers * more data needed on natural population variability?	• abundance and diversity of fish in marshes, channels, Bay and on tidal flats • condition, including weight, parasite loads, Hg levels in tissues • primary productivity (chlorophyll ‘a’, algae cover by type)
1C. Increase diversity and abundance of native species: harbor seals	* seal numbers (data available from FWS) increase in Project Area * seals haul out in new Project Area locations * seals pup in the Project Area	• number of seals hauling out year round • number of pups in the Area • number of seals using South Bay habitats
Project Objective: Sub-Objective	**Restoration Target**	**Potential Monitoring Parameters**

1C. Increase diversity and abundance of native species: native oyster	* develop at least 3 self-sustaining oyster populations * South Bay oyster numbers from NOAA * no historic population numbers or measures of variability exist	• number of oysters on reefs • numbers in the Project Area • parasite loads • Hg concentration in tissues
1C. Increase diversity and abundance of native species: song sparrow	* 14,000 pairs (~20% of estimated historic population) * 7,000 additional acres of mature tidal marsh	• # of song sparrow • # of breeding pairs • area of mature marsh
1C. Increase diversity and abundance of native species: rare plants	* self-sustaining populations of 4 rare plant species * no data available on population variability or even basic ecology	• cover by native plants • successful reproduction
1C. Increase diversity and abundance of native species: ecosystem function	* meet conditions found in historic South Bay system as constrained by current irreversible anthropogenic impacts * collect data from other high quality West coast estuaries to help develop these targets	• primary productivity (chlorophyll 'a', algae cover by type) • carbon cycling between marshes and the Bay (TOC levels and sediment carbon) • sea level rise data • extent and connectivity of habitat and landscape features • fresh water budget, esp. from POTW inputs and extreme weather events • sediment budget, esp. SSC and tributary inputs • sediment accretion & erosion in marshes, sloughs and Bay
2. Maintain or improve existing flood protection level	* meet requirements of flood protection agencies	• elevations and topography of levees • freeboard amount during extreme events • sea level rise data • ground surface rebound
3. Provide public access opportunities compatible with wildlife	* public is satisfied with access opportunities provided * bird use and fish abundance not significantly affected by public access	• attitudes of public and recreationists toward the Project • bird abundance and diversity before and after public access • recreational and commercial fishing effort
Project Objective: Sub-Objective	**Restoration Target**	**Potential Monitoring Parameters**

4. Protect or improve existing levels of water and sediment quality: water quality	* ISP and managed pond water quality meets RWQCB standards	• water salinity, DO, pH, temperature, turbidity • current velocity and distance from tidal inlet • nutrient levels (N, P) in tidal and pore water • Hg and MeHg levels • Freshwater outflow amounts and local vegetation structure
4. Protect or improve existing levels of water and sediment quality: sediment quality	* Hg levels in organisms does not increase above pre-ISP/ISP levels * Other pollutants, especially legacy contaminants, do not increase above pre-ISP/ISP levels	• Hg and MeHg levels and legacy pollutants in sediment samples • Hg levels in indicator species • Organic matter, nutrient levels and bulk density • Redox potential
5. Maintain or improve current levels of nuisance and invasive species: mosquitoes	* mosquito numbers do not increase above pre-ISP/ISP levels * numbers available from the Santa Clara and Alameda county mosquito abatement districts	• Methods and parameters as per the mosquito abatement districts
5. Maintain or improve current levels of nuisance and invasive species: *Spartina alterniflora*	* cover by *Spartina alterniflora* and hybrids does not increase above pre-ISP/ISP levels * data available from the Invasive *Spartina* Project	• *Spartina* cover in Project area and the Bay
5. Maintain or improve current levels of nuisance and invasive species: non-native predators	* predation by red foxes does not increase above pre-ISP/ISP levels * data from FWS	• Methods and parameters to estimate fox numbers and predation as per FWS
5. Maintain or improve current levels of nuisance and invasive species: corvids and CA gulls	* predation by CA gulls and corvids does not increase above pre-ISP/ISP levels * data from FWS	• Methods and parameters to estimate gulls and corvid numbers and predation as per FWS and SFBBO
5. Maintain or improve current levels of nuisance and invasive species: future invasive and nuisance species	* no new invasive or nuisance species significantly affects the ecological functioning of the South Bay ecosystem	• Use fish, bird, vegetation and invertebrate monitoring to assess changes in community composition
6. Protect services provided by existing infrastructure.	* Project has no significant, unmitigated impact on infrastructure * locations and sensitivities of structures available from local and regional utilities	• Document as-built conditions designed to protect infrastructure • Inspect sensitive structures on a regular basis

** Parameter selection was guided by current monitoring efforts, Science Team advice, PERL (1990) and Zedler (2001).

C. Restoration Targets and Monitoring during Project Planning

Monitoring during Project planning through mid-2005 (see Section III.C.) was designed to characterize conditions in the ponds, sloughs, and, to some extent, the Bay before and after ISP implementation. Compliance goals are the primary restoration targets for this period (DFG

2005, FWS 2005). During the remainder of the planning phase (through 2008), data collection should continue for all current parameters. However, to ensure that time and money are used most efficiently the Project should:

1) coordinate with other Bay monitoring programs such as the Regional Monitoring Program, DFG South Bay fish studies, San Francisco Bay Bird Observatory research and ongoing USGS monitoring efforts in the Bay, and
2) use existing data to redesign sampling approaches to reduce either the number of ponds sampled or number of sampling times while still collecting adequate amounts of data. Other approaches to monitoring that could save money, including the use of permanent data sondes, should be explored.

In addition to existing parameters, future monitoring should include these parameters, identified by the Science Team, which are needed to improved modeling or develop baseline data for monitoring Adaptive Management monitoring after Project implementation:

- Suspended sediment concentrations in the Bay;
- Tributary inputs to the South Bay sediment budget;
- Hg levels in sentinel species;
- DO, pH, salinity, temperature and chlorophyll 'a' in the Bay (to understand system conditions versus pond conditions);
- Population numbers or trends and distributions of corvids and CA gulls;
- Fecal coliform levels in breeding bird and foraging bird ponds;
- Bird use of tidal flats, ponds and marshes during low and high tides.

D. Applied Studies to Advance Project Design and Management

Applied studies are undertaken to provide critical information for making management decisions, reducing uncertainty, and addressing *tractable* research problems (Walters, 1997). The primary scientific uncertainties currently identified are listed in Table 2.

How do applied studies differ from monitoring? Applied studies use quantitative research methods designed to test hypotheses or qualitative research methods to answer specific research questions. Quantitative research typically uses experimental manipulations and/or comparisons of different conditions. This type of research compares treatments to controls and uses inferential statistical methods (as opposed to descriptive statistics) to analyze the data with respect to the hypothesis being tested. This is the only way to answer cause-and-effect questions and is more likely than monitoring to produce specific results on a time frame needed by the Project. Qualitative methods are not amenable to inferential statistics but gather data using rigorous procedures designed to answer a research question. Qualitative and quantitative studies must undergo peer review and must employ well-designed, unbiased data collection and analysis methods, as accepted in their fields.

In addition to scientific unknowns, applied studies can address questions about how management actions will perform. Such questions might be: Do ponds managed as dry in spring/summer and wet in fall/winter attract both nesting snowy plovers and migratory shorebirds? Or, what is the best design, location, material, etc. for wind breaks? Several management-related hypotheses are currently listed in the set of specific hypotheses. It is expected that more will develop during Project design, implementation and management phases.

Applied studies will need to include work to improve predictive models for the Project. Two modeling efforts have been used by the Consultant Team in the planning phase. Philip

Williams and Associates used the Landscape Scale Geomorphic Assessment, mentioned earlier, to predict large-scale habitat changes under various restoration alternatives. This Assessment uses a set of nested models. The other major model set, Point Reyes Bird Observatory's (PRBO) Habitat Conversion Model, is designed to predict bird population response to the restoration alternatives. Formal and informal reviews of these models by other scientists reveal sources of inaccuracy and limitations in the predictive power of the models. The time line for Project planning does not allow further refinement of these models during the planning phase. Thus, model refinement should be the subject of applied studies. For some model inputs, monitoring appropriate parameters may be adequate to supply the needed data.

For testing, uncertainties must be translated into hypotheses/research questions, which are then converted into study designs. Studies are then implemented, data are collected, analyzed, interpreted and provided to the Project managers. Study development should follow this process:

1. Identify conceptual basis for the ecological/physical processes using graphical or written conceptual models.
2. Identify the most important uncertainties as indicated by weak linkages in graphical models or data gaps identified in written descriptions.
3. Articulate hypotheses, including null hypothesis or research questions.
4. Describe essential elements of the study design, including study site, study design, factors to be measured, comparisons to be made and statistical or other analytical methods.
5. Clearly identify management actions that will be affected by the results of the study, including implications for changing current conditions and for designing future Project phases.

The Science Team used this process to develop an Applied Studies Program for the Project that gives key uncertainties, hypotheses, the relationship to management actions and recommended studies. See Appendix 2 for this Program. For several hypotheses from sediment, and bird use uncertainties, Science Team members also designed studies that could be implemented during Project planning and Phase 1. See Appendix 3 for these study designs.

E. Beyond Studies: New Predictive Tools

Data from monitoring and/or applied studies results will allow the development of new predictive tools to better anticipate the ecosystem's response to change. For example, statistical methods to determine flight distances in birds might be needed if some species do not occur, as expected, in new areas opened to public access. New models may be required to characterize processes not currently modeled or to address alternative scenarios, if important project assumptions are not being met. For example, monitoring may reveal that *Spartina alterniflora* cannot be controlled and studies may indicate this invader will have a significant effect on the South Bay ecosystem. In such a case, modeling alternative scenarios will most likely be required to predict ecosystem response to this new state and predict how the system might respond to new management actions. Additional modeling should be a part of the applied studies program when needed.

IV. PHASE 1 MONITORING AND APPLIED STUDIES

A. Introduction.

In 2008, planning for the Restoration Project will be complete and the Project Managers, Stakeholders and Science Team will have determined a Phase 1 project or set of actions. The Phase 1 action is expected to be a project that, among other things, is visible to the public, provides early success in meeting Project Objectives, and allows for reducing key uncertainties.

Information developed through Project planning suggests that projects at the Eden Landing Complex are most likely to achieve Project Objectives for marsh restoration quickly and thereby provide early successes. The Eden Landing ponds are the highest elevation ponds ready for restoration and mercury issues are not as pressing as in the Alviso Complex. The Eden Landing Complex does have the significant issue of *Spartina* infestation; Phase 1 projects will require intensive *Spartina* management and monitoring. Applied studies on *Spartina* and sediment dynamics are appropriate as part of a project at Eden Landing.

The Alviso Complex is not as suited as Eden Landing to achieving early visible success in meeting Project Objectives, but this area is ideal for applied studies research to reduce uncertainty on mercury and bird use of changing habitats. Applied studies should be implemented at Alviso in Phase 1 to develop the information needed to move into future phases. The Ravenswood Complex has not yet been transferred to FWS from Cargill and so is not available for Phase 1 projects.

A very significant issue for Phase 1, where ever it occurs, is the effect of restoration activities on ponds that will continue to be managed under the ISP. Under the ISP, groups of ponds are linked together for circulation in a coordinated design of water intake and outflow that prevents salt making. If some ponds in a circulation group are restored or managed under the restoration Project differently from the ISP, then the remaining ponds will not function as designed under the ISP (Gross per. comm.). For example (per Gross pers. comm.), pond A1 currently takes in water from the Bay and circulates it to pond A2W. If A2W were restored, but A1 was not, then A1 might not be able to discharge into A2W. Even if it still can discharge into the restored area, the timing and magnitude of flows would be different from what was planned under the ISP. This situation will require careful monitoring to understand how ISP ponds are functioning within the restoration project; it is quite possible that ISP pond functioning will become an area of significant uncertainty that requires applied study. Indeed, ISP functioning is already headed that direction. As the 2004 compliance monitoring for the ISP revealed, a number of ponds had water quality problems that were not anticipated or well-understood.

B. Restoration Targets and Monitoring Parameters

This section will be developed when the Phase 1 project is determined.

C. Monitoring Implementation

Monitoring parameters will be used to assess changing conditions in ponds managed according to the ISP, to assess progress (performance) toward restoration targets including compliance standards, and to detect problems in meeting restoration targets.

The monitoring plan developed for the Phase 1 actions should include these elements:

- Restoration Targets, including ranges of variability when appropriate, tied to Project Objectives;
- Response triggers, which when met, will result in management response with remedial measures, contingency plans or alternative scenarios;
- Pre-construction and construction monitoring parameters and protocols;
- Parameters and protocols for monitoring performance in meeting restoration targets, including real-time monitoring methods and the use of volunteers;
- Plans for responding to potential problems, including remedial measures (single actions in response to problems), contingency plans (a coordinated suite of actions) and/or alternative scenarios (actions that change the direction of the restoration action and result in different restoration targets);
- Responsibility for monitoring, including who will do what and when;
- Monitoring schedule describing the timing and location of all monitoring actions;
- Protocols for ensuring QA/QC;
- Reporting requirements and deadlines.

D. Applied Studies

As mentioned above, the design of Phase 1 should include applied studies. These studies may require construction of features for isolating treatments or otherwise implementing the manipulation. In some cases, the study may conflict with restoration goals (Walters 1997). For example, dividing a pond into cells to test the effectiveness of different cover treatments to control Hg mobilization may fragment the site and preclude development of well-developed tidal marsh. Whenever possible, irreversible changes for study manipulations should be avoided (Walters 1997). But, if they cannot, Project managers will need to evaluate the trade offs between the benefits the study provides in reducing uncertainty and the costs to achieving specific Project Objectives.

Another caveat about applied studies is that, although they are chosen to try to reduce known certainties and develop meaningful information to assist Project managers in decision-making, some studies may not produce useful data. While this situation is almost inevitable, it can be kept to a minimum by regular reevaluation of key uncertainties and by always making clear, direct links between proposed studies and their value to management.

In Phase 1, key uncertainties and hypotheses that could be addressed include these:

- *Mercury*:
  Hypothesis 1: Tidal marsh restoration and pond management does not increase MeHg levels in indicator species above baseline levels.
  Hypothesis 2: MeHg levels in indicator organisms are not reduced by chemical and physical pretreatment in high-risk ponds and marshes.

- *Sediment Dynamics*:
  Hypothesis 1: Sediment capture by breached ponds will not be adequate to support tidal marsh ecosystems on site.
  Hypothesis 2: Sediment loss into breached ponds will not support shallow water ecosystems in sloughs and the open Bay.

- *Bird Use of Changing Habitats*:

Hypothesis 1: Managing water levels in ponds so that they are dry in the summer and flooded to a depth of <15 cm in the winter will not attract breeding Western snowy plovers and foraging migratory shorebirds at the same levels as ponds not managed in this way.
Hypothesis 2: Creating isolated nesting islands, engineering levees with shallow slopes and reconfiguring pond bottoms to provide water at a depth accessible to birds will not significantly increase breeding bird densities or significantly increase the foraging bird densities compared to pre-ISP conditions.

- *Invasive and Nuisance Species*:
  Hypothesis 1: California clapper rail numbers and reproductive success, fish use and invertebrate density in *Spartina alterniflora* marshes are not significantly different than in *Spartina foliosa* marshes.
  Hypothesis 2: Colonies of terns and shorebirds that include aggressive species, especially avocets, have significantly higher nest success than colonies without the aggressive species.

- *Non-Avian Species Benefits*:
  Hypothesis 1: Access and use of restored tidal marsh by native fish species (steelhead, surfperch spp. and long-jaw mudsuckers, among others) or cover and reproduction (as appropriate to the species) is not significantly affected by breach configuration, restored marsh geometry or pond management for other purposes.

- *Social Dynamics*:
  Hypothesis 1: What Bay user groups are not represented on the Stakeholder Forum and what are their concerns and desires for the Project?
  Hypothesis 2: How can local and indigenous knowledge, as well as anecdotal information be used to inform decision-making?

- *Large-scale Issues:*
  Hypothesis 2: The Project has no effect on Pacific flyway numbers and, conversely, conditions in the Pacific flyway have no effect on numbers of migratory birds visiting the South Bay.

V. ADAPTIVE MANAGEMENT DECISION-MAKING

A. Adaptive Management Structures and Processes

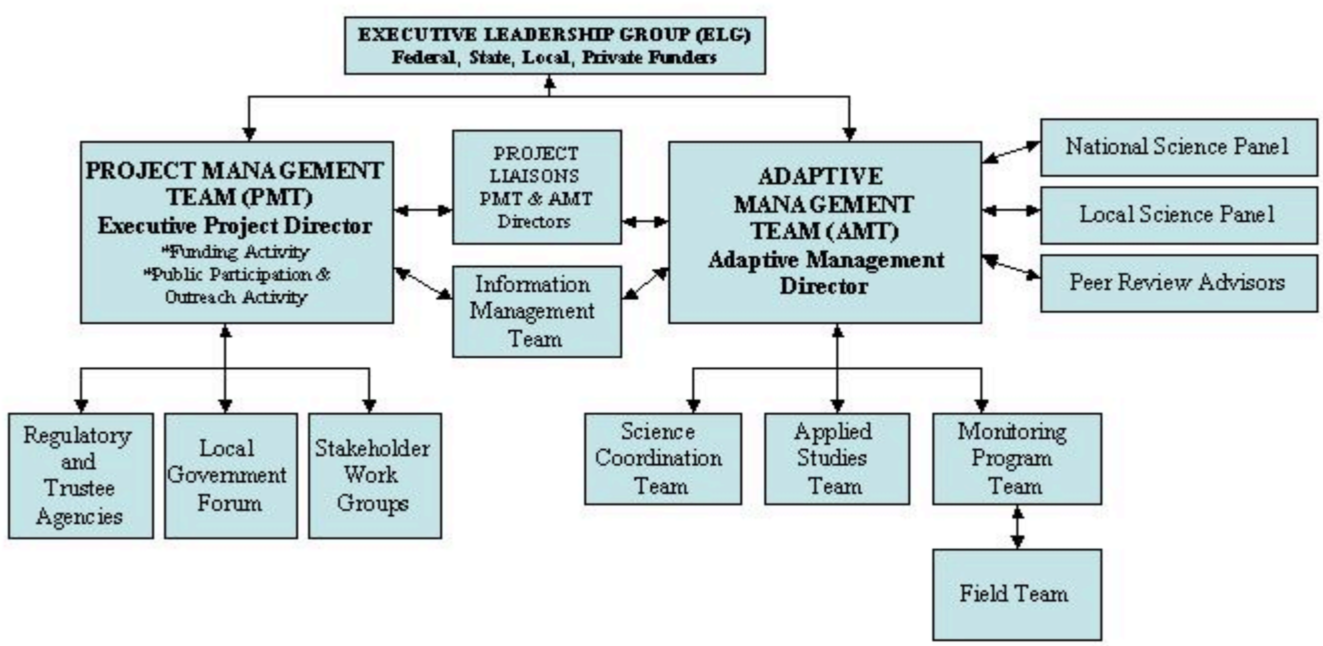
Adaptive Management cannot be implemented without an effective decision-making structure that completes the loop between information development and the incorporation of that information into decisions. The benefits of Adaptive Management depend on appropriate institutional arrangements for applying information to decisions and to ensuring transparency in the process. The institutional structure for decision-making is designed to achieve these four functions:

1. Generate and synthesize data (from monitoring and studies),

2. Convert the synthesized data into effective short and long-term management decisions,
3. Involve the public in decision-making, and
4. Store and organize data for use by the decision-makers and the public.

Figure 3 shows the Organizational Structure that will be used to carry out these functions. This structure includes two teams, the Project Management Team (PMT), which is responsible for decision-making and taking action on those decisions, and the Adaptive Management Team (AMT), which is responsible for data generation, storage, and synthesis. Collectively, the PMT and AMT will periodically evaluate: a) progress toward Project Objectives and restoration targets, b) monitoring and applied study priorities, and c) the effectiveness of the two Teams in decision support. Project Liaisons will ensure science and project management are represented in each Team. Figure 3 shows that the AMT has equal status with the PMT in the Adaptive Management process, providing direct input to the PMT on decision-making.

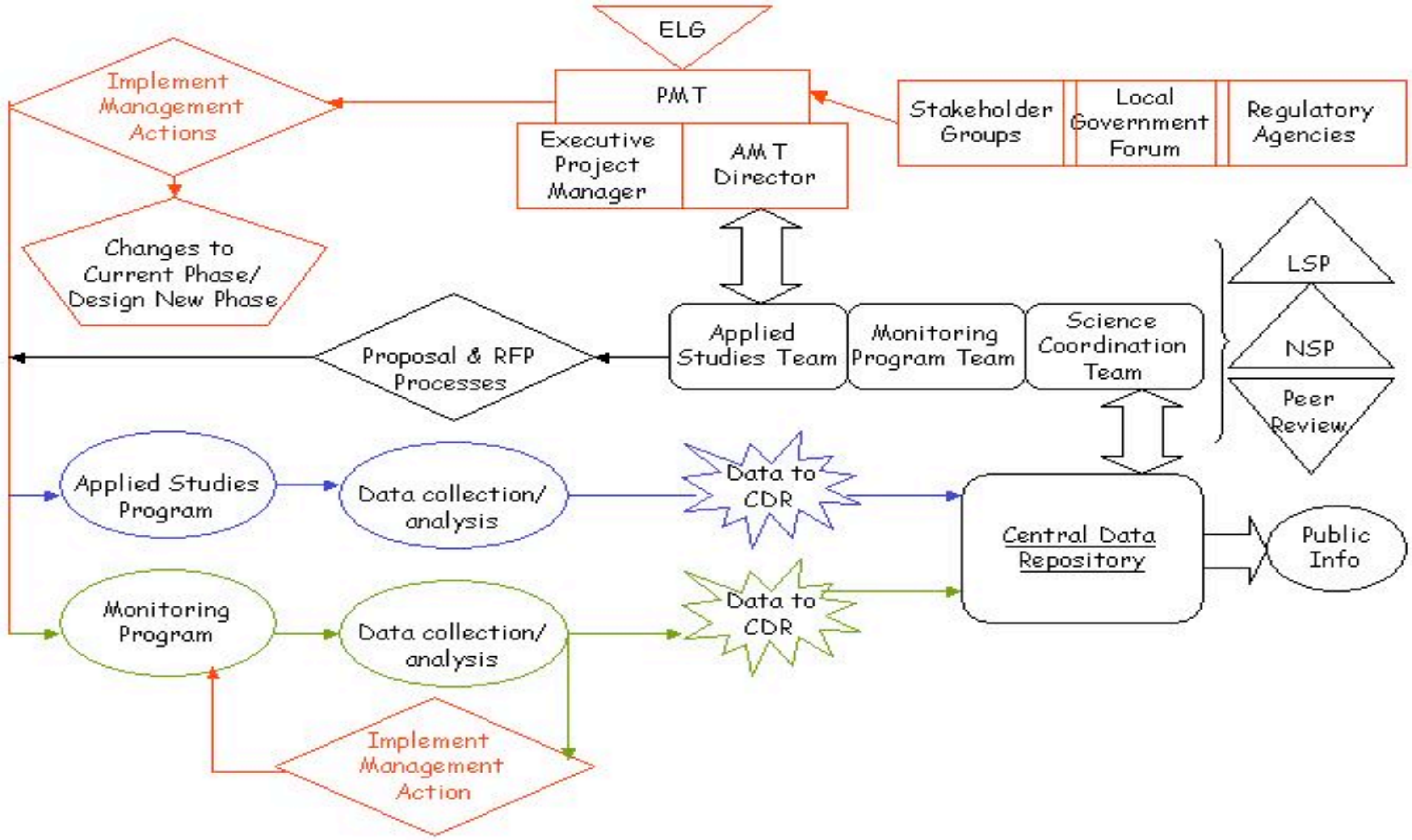
FIGURE 3. ADAPTIVE MANAGEMENT ORGANIZATIONAL STRUCTURE
For the South Bay Salt Pond Restoration Project



However, the PMT is ultimately responsible for the decisions that are implemented. Figure 4 illustrates the relationship between the PMT and AMT as they implement the four functions listed above.

The practice of Adaptive Management is unique to each ecosystem. Every Adaptive Management program is structured differently to address the unique ecological and social features of the system. Society has not yet perfected the social, economic, and institutional components of Adaptive Management needed in specific contexts (Gunderson et al 1995; Holling 1978; Lee 1993; Walters 1986, 1997). One lesson from other ecosystem restoration projects is that institutional arrangements themselves need to be flexible and adaptive, as most attempts to institutionalize adaptive management into a standard template have failed (Light 1999). In fact, Walters (1997) notes that of 25 ecosystem restoration projects he evaluated, only 7 took Adaptive Management past the modeling stage. He found that failure to implement Adaptive Management was almost always due to institutional obstacles. Project managers will need to be open to institutional interaction that involves cooperation to put ecosystem health first and individual institutional processes second (Walters 1997).

Figure 4. Adaptive Management Data Collection & Decision-making Process



Decision-making is most effective when managing institutions:

1) Accept that management actions are experiments and uncertainty is inherent; admitting there is uncertainty is not a weakness, but a reality (Walters 1997),
2) Commit to ongoing management adjustments based on long-term monitoring and scientific research;
3) Shift from fragmented management decisions, monitoring programs and scientific investigations to integrated ecosystem science;
4) Pay explicit attention to scientific uncertainties in ecosystem processes and in the effects of management alternatives;
5) Commit to careful monitoring of ecological and social effects and of responses to management operations;
6) Use monitoring and research analyses to guide future management decisions,
7) Implement effective systems for close collaboration among stakeholders; managers, and scientists in all phases of these processes.

To further evolve the decision-making structure for the South Bay Salt Pond Restoration Project into one that can successfully implement Adaptive Management, these questions will require further consideration:

- What organizational structures need to be established to ensure that managers are informed of scientific results and public needs?
- How can the relevant institutions ensure rapid processing and management of monitoring and applied studies data?
- How and what scientific and public participation information will be fed back into the management process?
  By what decision criteria will information be used to modify management actions?

B. Roles and Responsibilities of the PMT and AMT

Each group in the Organizational Structure in Figure 3 has one or more responsibility in developing the information for decision-making, providing it to project managers and the public, and making and implementing decisions based on that information.

<u>Project Management Team (PMT)</u>

Executive Leadership Group. The Executive Leadership Group (ELG) is comprised of funding entities at all levels, federal, state, local and private. This group has overall authority for how funds are spent in project implementation. The ELG coordinates directly with the PMT and AMT on high-level decisions.

Project Management Team. The Project Management Team (PMT) manages the day-to-day project development, administers project elements, and provides overall guidance and oversight. The PMT is the primary decision-making body, in consultation with the Adaptive Management Team. An Executive Project Director, who works directly for the PMT, is essential for managing all the parts of the Project. This is expected to be a full-time position.

The PMT provides leadership for the planning process and is responsible for many components of the planning effort including, but not limited to, evaluation of scientific information in conjunction with the Adaptive Management Team; overall plan design; public participation and outreach; public policy impacts and analysis; budgeting and funding; dispute resolution; integration of the planning process with flood management, public health, public access, and regulatory entities; and state and federal legislative and local government relations.

In addition to leaders from the US Fish and Wildlife Service (Don Edwards San Francisco Bay National Wildlife Refuge) and the Department of Fish and Game (Eden Landing Ecological Preserve)—the land management agencies--the PMT will include the Executive Project Director, the Adaptive Management Team Director, the State Coastal Conservancy, the Santa Clara Valley Water District, the Alameda County Flood Control and Water Conservation District , the US Army Corps of Engineers, and representatives of other entities directly related to managing and funding part or all of the Project area. The land management agencies will use this forum to coordinate and cooperate for the benefit of the overall project, but will retain their independent land management authority. A Memorandum of Understanding (MOU) between the PMT agency members will define the roles and responsibilities of the members with respect to achieving the Project Objectives and implementing Adaptive Management.

Key elements of the Project Management Team's functions are obtaining funding for implementation and Adaptive Management and providing for public participation and outreach. The two activities identified below will be undertaken by Project Management Team members, as well as other appropriate agency staff and consultants.

1. *Funding Activity*. Funding is critical to ensuring that adequate financial support is provided to carry out the restoration project and to enhance its longevity and success. The PMT will seek general project funding from agencies, foundations, organizations, corporations, and others. This work includes researching and developing critical relationships with potential funders, incorporating a rigorous proposal and reporting process, and coordinating with the AMT on Science Program funding.

2. *Public Participation and Outreach Activity.* The PMT will develop informational materials and conduct educational outreach to the general public and others stakeholder groups about the project. Some activities should include:
   - Developing community restoration and monitoring participatory activities.
   - Developing and coordinating collaborative learning opportunities among project teams, communities, business and government representatives, agencies, NGOs and others.
   - Conducting an Annual Symposium on Project activities, progress and Adaptive Management efforts
   - Publishing an Annual Report tied to the Annual Symposium
   - Conducting Work Group meetings, community and other group presentations, holding workshops, participating in community events, installing displays and other activities related to the project.
   - Coordinating with the Information Management Team to provide information to the public via the Project website.
   - Coordinating media coverage for significant project milestones.

Regulatory and Trustee Agencies. This group is composed of the Regulatory and Trustee Agency staff representing regulatory and public trust agencies with permitting authority for the restoration plan. Staff involved with issuing and overseeing regulatory approval should be included. This group provides "early warnings" to the PMT on regulatory issues.

Stakeholder Work Groups. The purpose of the Stakeholder Work Groups is to provide ongoing, publicly- derived input to the PMT and AMT on major components of the restoration plan. This input will be used by the PMT and AMT as a basis to provide feasible and substantive direction. These Work Groups are essential to assisting the PMT and AMT in gaining a broader understanding of public and interest group perspectives. The PMT will periodically assign specific tasks to be undertaken by specific Work Groups on an ad hoc basis. In addition, the AMT will consult with and advise the Work Groups. The AMT's function will be to provide direction technical support and knowledge building to the public members of the Work Groups and to assist them by providing high quality, scientifically-based advice.

Local Government Forum. This group includes elected members from cities, counties, special districts and other municipal entities adjacent to the Project area. Members may also be public works, environmental services, and/or planning directors from the municipalities. Periodic dialogue and updates will be conducted -among local governments, the PMT, and AMT on the progress and milestones of plan development.

Consultants (as needed). Individual experts or consulting firms may be hired by the PMT to conduct project management-related activities, environmental policy, fundraising, outreach, and other actions as required.

Adaptive Management Team (AMT)

The Adaptive Management Team (AMT) consists of the AMT Director, as well as leaders of the Field Team, Science Coordination Team, Monitoring Program Team, Applied Studies Team, and Information Management Team. These sub-teams are described below. The AMT is responsible for building Adaptive Management into the very essence of the organizational process and for overseeing the science and technical components of the project. The Adaptive Management Team Director determines the science direction for the Project.

Local Science Panel (formerly the Science Team) (10-12 advisory members). Under the direction of the AMT Director, the Local Science Panel (LSP) is composed of local scientific experts, especially researchers. This Panel functions in a technical advisory and peer view role to provide high-quality, scientifically-based input to the PMT. Panel members are prohibited from participating on any consultant team hired to design elements of the plan and/or undertake environmental compliance work. Specifically, the Science Panel:

- Reviews analyses from monitoring and applied studies programs.
- Recommends adaptive management actions, monitoring and studies.
- Works with the National Science Panel to assess the overall science development and implementation in the Project.
- Oversees the independent peer review process evaluating proposals, scientific and technical papers, and the overall science program.
- Provides scientifically-based input to the PMT.

National Science Panel. The National Science Panel (NSP) is made up of national and locally-recognized experts familiar with large-scale wetlands restoration efforts and knowledgeable about application of adaptive management protocols and long-term monitoring. The NSP's role is to provide the AMT Director and Science Panel with high-level science oversight on the scientific structure and direction used in making management decisions.

Adaptive Management Team. The AMT is headed by the AMT Director, a senior scientist who will set the direction for the Science Program and oversee all activities of the AMT. The AMT Director will also help to negotiate compromises among scientists, regulators, and stakeholders, and serves as a liaison between the PMT and AMT. This is a full-time position and replaces the Lead Scientist in the administrative structure that exists during Project planning.

In addition to the Director, the AMT is composed of the Leaders of each team identified below. These teams will be comprised of scientists, agency staff, consultants, and others as appropriate. Some of individuals may be members of more than one team. They will be convened at appropriate frequencies throughout each year to accomplish their assigned tasks.

Monitoring Program Team. The Monitoring Program Team is responsible for developing and overseeing the operation of a system-wide monitoring program, including developing monitoring protocols and the RFP to hire a consultant or research teams to collect the data. On a yearly basis, the team will determine whether the data collected are adequate to meet the Project's monitoring goals and will suggest revisions to the AMT Director and Science Panel. Also yearly, this Team will evaluate the monitoring data to determine progress toward restoration targets and levels of compliance, and will provide their findings and recommendations in a report to the AMT Director and the Local Science Panel. After review, the report will go to the PMT. On a shorter-term basis, this Team, especially the Team leader, will coordinate directly with the Field Team, as needed, providing advice about system conditions and engaging the AMT Director if field data indicate immediate action is required. The Monitoring Program Team Leader is expected to be a full-time position.

- *Field Team*. This team is charged with early response to unwanted or unexpected changes in the Project area. On a weekly or monthly basis, as required, the Field Team will review the monitoring results from the monitoring consultants and will conduct independent site visits to assess conditions. If either of these activities indicates deviations from Project restoration targets, the Field Team leader will compile and analyze the available data, meet with the AMT for consultation, and assist the PMT and AMT with management decisions. It is possible that the monitoring consultants and researchers could perform this function. Independent review of the data and recommendations would then fall to the Monitoring Program Team.

Applied Studies Team. The Applied Studies Team will determine what studies should be undertaken to reduce uncertainty and will conduct a competitive proposal process to ensure the research is performed. They are also responsible for implementing a peer review process for research completed and for compiling data into a report that summarizes the findings and their implications to the Project. After review by the AMT Director and Science Panel, the report will go to the PMT. On a yearly basis, this Team will reevaluate applied study priorities and needs and begin the competitive proposal process again. The Leader for this team is expected to be a half-time position.

Science Coordination Team. This team is responsible for analyzing and synthesizing data from numerous sources, especially other restoration and management projects, to ensure that the Project has the most up-to-date and comprehensive information available. They will serve as scientific liaisons to projects around the Bay and in other parts of the country. This Team will set up conferences, technical workshops and other meetings to bring the best science into the project from other sources. They are also responsible for disseminating information generated by this and other Projects in useful formats to the AMT, the public and the scientific community. Their work will be peer reviewed by the Science Panel and external reviewers. The Leader for this team is expected to be a half-time position.

Information Management Team (IMT). This group is responsible for storing and managing all Project data and information. They will conduct basic analyses of data as directed by the AMT and provide data dissemination and reporting as directed by the PMT. They will manage data from a real-time monitoring system and the web site that provides the data. The IMT manager will coordinate with the PMT to provide information such as general information, publications, status and trends, project maps, and processed and raw data for the public.

Technical Consultants and Researchers. Technical consultants will be hired to design and implement restoration, management, monitoring, and environmental compliance activities. Typically, research for applied studies (including model development) will be obtained through the competitive proposal process to solicit research proposals from academics, agencies, or consultants.

Project Liaisons

The PMT Executive Project Director and the AMT Director will be members of both the PMT and AMT to ensure that science and management are always represented in the two major teams. One or two other members from each team may also be project liaisons.

C. Timelines for Decision-making

In Figure 4, the PMT roles and actions are in red and the AMT are in black. These teams will generate information and implement it on three time scales: yearly, monthly and as needed. Each year, the AMT reviews and synthesizes information generated that year and will produce reports on applied studies, monitoring and science coordination. Data synthesis for the reports begins with the Information Management Team, which provides a yearly report describing data available (old and new), provides basic analysis of monitoring and research data, and reports on public outreach systems and outcomes. The Applied Studies track, in blue in Figure 4, operates primarily with yearly milestones. All reports are ultimately submitted to the PMT. Together, the AMT and PMT will:

- Evaluate the progress of the project toward the restoration targets and Objectives;
- Evaluate the efficacy of the restoration targets as indicators of the Objectives;
- Evaluate the Project Objectives themselves for long-term viability;
- Determine any changes to be made to existing Project phases;
- Integrate information into planning for future phases;

- Determine the monitoring (parameters and methods) that should be implemented in the coming year, and
- Determine what applied studies should be conducted in the coming year.

The PMT makes all final decisions and, at the end of the yearly cycle, will provide its findings and decisions in a report to the NSP, key decision-makers and the public. Ultimately, the PMT will work with consultants to implement changes to phases and planning, and the AMT will begin the yearly proposal solicitation process for applied studies and monitoring work.

The Monitoring Program (in green in Figure 4) provides data for shorter time scales of decision-making. The monitoring track generates data monthly or more often, which is reviewed by the Field Team for any problems in data collection and/or in the ecosystem. If there are no problems, the information is sent to the IMT for basic analysis. If the data reveal problems in parts of the restoration area, the Field Team will visit the site to evaluate the situation and then confer with the Monitoring Program Team Leader and the AMT Director. If warranted, the Field Team, the Monitoring Program Leader and AMT Director will meet with the PMT for any decisions on changes to the project necessary to rectify the problem. This decision-making process will occur on an ad-hoc basis, as dictated by on-the-ground data. The IMT will make monitoring data available to the public in monthly updates. Some monitoring data will be provided continuously through real-time monitoring accessible through the Project website.

D. Science Support for Adaptive Management

The Science Program is housed in the AMT and is responsible for developing the data and science direction for the restoration Project. The Science Program elements include the National Science Panel (NSP), peer reviewers, the AMT Director and these science teams: the Local Science Panel, the Monitoring Program Team, the Field Team, the Applied Studies Team, and the Science Coordination Team. These teams will develop the monitoring program, determine applied studies, interface with the Information Management Team (IMT), evaluate current site conditions, and synthesize information for use by the PMT and public. The AMT science teams will not only provide data, but will interpret those data with respect to achieving the Project Objectives and will make recommendations for remedial action, contingency plans, and alternative scenarios. The information generated by the science teams will be used by the PMT and AMT to determine progress of current restoration phases and to design future phases.

The roles, responsibilities, and operation of the elements of the science program will be described in a guiding document, the *Science Plan for Adaptive Management*. This Plan, to be included as part of the final AMP, will have these components:

- Definition of roles and responsibilities of the AMT Director and science team leaders; roles, goals, responsibilities, and operating procedures for each science team, especially the Competitive Proposal Process and the Peer Review Process;
- Conceptual models showing ecological milestones when restoration targets, Project Objectives and Phase Objectives should be achieved and showing specific hypotheses for testing;
- Specific Project and Phase restoration targets, interim targets, monitoring parameters, monitoring protocols, and applied studies;
- Schedules for meeting each team and panel's goals;
- A schedule for regular, informational up-date meetings with the AMT Director and the science team leaders;

- A schedule and goals for yearly science up-date meetings with the entire AMT to review findings and outcomes from data collection and management, and review the implications for management decisions and future monitoring, studies, and outreach;
- A schedule of PMT meetings, public meetings, and scientific conferences;
- A schedule and procedures for internal and external review of science program products and for external review of the science program itself.

The goal of the Science Program is to bring the best and most relevant science to decision-makers and the public. Two important mechanisms, central to achieving the science program's goals, are the competitive proposal process and peer review.

Competitive Proposal Process. Because of the number and complexity of the key uncertainties, it will be necessary to be very selective in choosing the questions to be addressed as well as the teams that will be asked to carry out the required studies. A competitive proposal process provides the mechanism through which awards can be granted to those study teams that demonstrate the best ability to address the questions most important to the PMT.

The Applied Studies Team will develop the list of applied studies questions, will design and disseminate RFPs for the research, and will conduct the proposal review process (see Appendix 4 for the suggested proposal solicitation process). After conducting the proposal review process, the team will report its results to the AMT Director for approval, and facilitate the distribution of funding to the proponents of successful new and renewal proposals. When appropriate, this process could also be used by the Monitoring Program Team to select consultants or researchers to conduct monitoring.

Peer Review. Peer review, a defining part of the scientific process, will occur at all levels in the Science Program (Table 5). First, yearly reports, solicitations for proposals and monitoring, and other products generated by the Science Coordination, Applied Studies and Monitoring Teams will be peer reviewed by the Local Science Panel and AMT Director. Second, reviewers external to the project will review proposals for research as well as any other science products, as appropriate. In addition, they will evaluate the overall organization and functioning of the Science Program. Third, the National Science Panel will review reports from the AMT Director, providing peer review and guidance on the overall direction and activities of the Science Program. Finally, the AMT Director, science managers, and researchers will be expected to publish their work from the Project in peer-reviewed journals.

Table 5. Science Program Peer Review

Reviewers	Tasks
Science Panel and AMT Director	• Reviews all AMT science documents • Sets up panels of external reviewers
External Reviewer Panels	Review: • Proposals from Competitive Proposal Process • Science Coordination reports • Other science program reports • Science Program
National Science Panel	• Reviews reports from the AMT Director

VI. DECISION MAKING AND IMPLEMENTATION

A. Detailed Plan for Adaptive Management Decision-making

Adaptive management programs in the U.S. are being implemented under a variety of organizational structures, funding arrangements, and resource management settings. Each Adaptive Management program is unique, dictated by the project goals, institutions involved, level and sources of funding, and the ecosystems being restored. In the South Bay Salt Pond Restoration Project, the PMT is responsible for making and implementing decisions that move the Project toward meeting its Objectives. The AMT will provide science and data management support, and the Work Groups, Regulatory and Trustee Agencies, and Local Government Forum will provide public involvement and input. Coordinating all of these elements for effective decision-making and implementation will require an expansion of this guiding document, to become a *Detailed Plan for Adaptive Management Decision-making*, containing these components:

- Structure of the PMT and AMT, definition of roles and responsibilities, and operating guidelines for the PMT and AMT.
- A set of decision criteria that the PMT will use to determine which Adaptive Management actions to implement on a yearly and shorter-term basis..
- Institutional procedures for implementing decisions.
- A schedule and requirements for reporting to decision-makers and the public, including an annual report.
- A schedule for regular informational up-date meetings with the AMT Director, IMT leader, and stakeholders.
- A schedule and goals for yearly science up-date meetings with the entire AMT to review findings and outcomes from data collection and management, and review the implications for management decisions and future monitoring, studies, and outreach.
- Clear operating guidelines for the Central Data Repository, Stakeholder Work Groups, Regulatory and Trustee Agencies, and Local Government Forum.
- Methods for resolving disputes about technical and social issues.
- A schedule and procedures for external review and assessment of the Project's decision-making system to improve the effectiveness of institutional arrangements and interaction.

B. Decision Criteria and Tools

A critical element of the *Detailed Plan* is the set of decision criteria by which the PMT will determine which Adaptive Management actions to implement, both in current phases and in future ones. Decisions must be based on the PMT's evaluation of Project needs and resources available (funding, staff, etc.), as well as the scientific information available. Input from the public must also be part of the decision criteria, but public desires may be redefined by resource needs and/or scientific findings. A process for involving the public is given in Section VII.

Project leaders can use a number of tools to help them identify options for action and help them decide among options. To identify options for current phases, the PMT and AMT should begin with lists of likely remedial measures (single actions) and contingency plans (a suite of actions) for potential "surprises" revealed through monitoring. For example, deviations from water quality standards, the appearance of an endangered species, or the spread of a new non-native species are all "surprises" potentially envisioned. By thinking ahead to potential problems and developing responses, the PMT can move more quickly on decisions. They may also vet the response options with the public before action is needed, so that the public has been prepared. The Science Teams can all assist in anticipating the unlikely and providing remedial measures and contingency plans to the PMT.

While some effects may be anticipated and planned for, others may be entirely unexpected. A monitoring and research plan for Adaptive Management should include the latter, as well as the former, and be accommodated for in the project budget. Remedial/contingency actions for these unforeseen effects will need to be developed and evaluated after the problem has occurred, sometimes on a relatively swift time-scale. PMT decision-making procedures should include a process for rapid response.

Contingency planning, as described here, is applied to decisions on previously implemented phases. Such planning may also be useful for determining what restoration and management actions to implement in future phases, but a better tool is scenario planning. Scenario planning is a visioning approach based on current data that typically uses models to predict the outcome of a range of management actions/programs. To plan for the future, a large number of potential management scenarios should be developed as a tool for the PMT, AMT, and stakeholders to evaluate. The models and the input data for the models must be continually updated to develop the most reliable scenarios. It is critical that model assumptions and the degrees of confidence associated with scenarios be communicated in understandable formats to the decision-makers. The Landscape Geomorphic Assessment and Habitat Conversion Model are two such modeling efforts used in the Project's planning phase to develop alternative scenarios. Models are just one approach to scenario development. Empirical (field) data on reference and restored sites should also be collected and used to create alternative views of the future under different management regimes.

As part of the decision-making process, for both current and future phases, the PMT and AMT must evaluate the risk of failure associated with different courses of action, plans, or scenarios. Risk analysis will include such factors as the level of scientific certainty, probability of human error or accidents (such as failure of flap-gates during storm events), and the potential for engendering public disapproval with a particular action.

The PMT and AMT will want to reduce risk whenever possible. One approach is to establish venues through which key areas of uncertainty and public concern can be readily identified and tied to management actions. In addition, the Commission on Ocean Policy (2004) lists these methods to reduce risk in decision-making:

- Use standards of acceptable risk in NEPA, CEQA and ESA, which differ (e.g., negligible impact, small numbers, jeopardy, etc.).
- Improve modeling to supplement limited empirical information. Conduct real-world validation/corroboration studies, and use adaptive management strategies to allow feedback.
- Conduct benefit-cost and uncertainty analyses.
- Improve transparency about assumptions underlying models used to make decisions.
- Move toward quantitative risk assessments that describe and quantify uncertainties, as a standard procedure in decision-making.
- Employ alternative decision-making tools (e.g., expert panels, expert opinion, management review processes, etc.). Retain a variety of options, but consider context of specific cases in determining appropriate approaches.

C. Reporting and Program Evaluation

Reporting. The *Detailed Plan* should describe methods by which the PMT reports to the public and decision-makers on short and longer time scales. PMT reporting should include decisions and scientific information, summarized in a way that is understandable to the general public and disseminated to stakeholders in a timely manner. As a minimum, the PMT and AMT should conduct an Annual Symposium regarding Project activities, progress and Adaptive Management activities. An Annual Report should be published in conjunction with the Annual Symposium. Such outreach and education efforts are critical for gaining long-term support for restoration efforts (Van Cleve et al. 2004). With respect to short time lines, recent advances in computer technology and water resource modeling allow reporting of real-time physical data, especially hydrology and climate, with user-friendly graphical model interfaces. This reporting function of the project should be handled by the Information Management Team (see Section VI), under the direction of the PMT and AMT.

Perhaps as often as quarterly, the PMT should provide a report summarizing monitoring data, ongoing studies, and management decisions. The *Detailed Plan* will provide a timeline and report requirements. Each year, starting at the end of the first year of implementation, the PMT and AMT will produce a comprehensive report that summarizes monitoring data, applied studies data, science coordination, management decisions, and stakeholder activities. The report will state current progress toward Project Objectives and compliance, the scientific and management uncertainties reduced, corrective management actions taken, and decisions for designing future phases.

Program Evaluation. The *Detailed Plan* should also outline periodic review of its programs and activities. Some large restoration programs incorporate independent review panels, comprised of qualified individuals who are not participants in the long-term monitoring and research studies. These panels include peer reviewers and science advisors, as previously discussed, and also protocol evaluation panels to assess the quality of research, monitoring, and science being conducted through the Adaptive Management program, and provide recommendations for further improvement. These can be conducted annually during the first few years of implementation and also over longer timeframes, such as every five years for monitoring and research protocols.

It is also imperative that the Project Management operations and activities be routinely reviewed as well to determine how effectively implementation is being conducted. Outside review panels can, for example, characterize how management is providing information to its stakeholders, if the public is involved in meaningful ways, if processes are innovative and flexible, how useful Project publications are, how transparent decision-making is, and many other questions that provide important feedback to the Project Management Team.

VII. PUBLIC INVOLVEMENT AND TRANSPARENCY

A. Stakeholder Participation

Substantial public involvement is essential for support and stewardship of long-term restoration projects and is one of the four functions of the AMP institutional structure. Successful public participation includes collaborative learning among scientists, managers, and the public (see Section below), allows for public comment and input on the decision-making process, and ensures transparency through Project reporting.

The elements of public involvement and outreach that are needed in adaptive management are:

- Well-defined roles for stakeholders within the Adaptive Management Program;
- Adequate discussion of competing goals and visions;
- Avenues by which the PMT receives recommendations from stakeholders;
- Regular educational meetings with stakeholders on science, management, and policy issues;
- Clear science reports understandable to the public;
- Public discussion of monitoring plans, applied studies, and contingency planning;
- Clear PMT reports on decisions made and the role of public input.

B. Collaborative or Social Learning

A significant, but often overlooked component of adaptive management is collaborative or social learning, in which all players interact with and learn from each other. One obvious avenue for social learning is educating the public about the science and policy of the restoration project. Van Cleve et al. (2004) did a study of effective adaptive management practices in large-scale restoration efforts. They found that, while rigorous adaptive management is a necessary tool in a project's success, it can only "be effectively used if all program participants understand it. Therefore, education about what adaptive management is and is not, is an important aspect of management efforts". Providing the public with clear summaries of monitoring and research information will help them advance their understanding of the ecosystem. Without this effort, the learning necessary to refine and revise management objectives may not occur (Parson and Clark 1995). As noted above, this Adaptive Management process has a number of features to ensure public education.

Similarly, experts or technical information providers need to understand the collaborative process in order to appreciate the legitimacy of non-expert values before a plan can be implemented. Social learning occurs as stakeholders and scientists gain a clearer understanding of how the ecosystem works, how it responds to management alternatives, how society interprets and values those responses and, on the basis on that new knowledge, makes conscious trade-offs and adjustments (Parson and Clark 1995). Scientific and stakeholder communication can help both groups identify and understand scientific and social factors critical to achieving restoration goals. Thus, science team members must interact with the stakeholders. The PMT and AMT will conduct Adaptive Management workshops to assist in the development of a shared understanding of the Project's Adaptive Management Plan and how information will be used to move the Project forward.

While public education and involvement is essential, there are also many unknowns. For example, what methods are most effective in conveying monitoring and research results to the public? What do lay people learn from the different methods? What difference does this information make for their information needs, ecosystem visions, resource valuation and, ultimately, their recommendations to the project management? To address some of the institutional challenges attributed to Adaptive Management (Walters 1997, 1998), these basic questions of social learning should be formally incorporated as hypotheses for Adaptive Management applied studies.

Social and policy-based research can assist in many areas of successful implementation of adaptive management, especially with respect to social learning. For the South Bay Salt Pond Restoration Project, an overarching question that will drive social science research is: How do we integrate understanding of physical and biological systems with social dynamics and long-term changes in social expectations, which drive demands and goals for the system? Specific applied studies questions that tier from this will need to address changing Bay Area demographics, public attitudes about open space and restoration, public health and safety concerns, policy approaches that people support, and the public's willingness to financially support restoration.

VIII. DATA MANAGEMENT AND REPORTING

A. Central Data Repository

The final function of the institutional structure is data and information storage, management, and basic analysis. To do this, a Central Data Repository (CDR, a function currently performed by the San Francisco Estuary Institute) will be established as part of the Project's Adaptive Management implementation, overseen by the Information Management Team (IMT). The primary purposes of the IMT will be to store and manage all data for the Project, scientific, policy, or stakeholder related, perform basic analysis of the data for the PMT and AMT, and provide on-line data for public education. Other data management activities, done by data management groups for similar projects include scheduling, document management, performance reporting, shared information networks, financial management, cost estimates and forecasts, budgeting, and human resource data. Given the complexity and duration of the restoration project, the data management system should include:

- Clear data and metadata transfer and input policies and standards;
- Policies and procedures for data validation;
- Mechanisms to ensure data integrity and security;
- Policies and procedures for public information access and outreach;
- Database software and database models to facilitate storage and retrieval;
- Tools to facilitate basic data analysis as determined by the PMT and AMT;
- Human and technological capacity to maintain a growing and increasingly complex store of data and information.

Figure 7 shows what an essential role the CDR plays in the Adaptive Management process. This group is the link among the data collection groups, the science teams, the PMT, and the public.

B. Data Organization and Public Availability

Data in large-scale restoration projects can be organized in a hierarchy, as follows, depending on the level to which the data have been synthesized and processed:

- General information—press releases, fact sheets, information summaries, abstracts
- Publications—reports, agreements, printed materials; peer reviewed articles
- Status and trends—high-level interpretations, graphs, charts
- Maps—watershed profiles, bay atlas
- Raw Data—real-time monitoring, preliminary studies, raw monitoring data

At the bottom of the hierarchy are raw data, which are high-quality data but have not been interpreted. Thus, they are not generally understandable by the public or PMT. The exception is real-time monitoring data, which come from systems that provide easily understood data for immediate dissemination on a website which should be built into the Project. At the next two levels, data are converted to graphical form for easier interpretation. Some of this graphical work should be conducted by the IMT. Complete analysis occurs at the publication level where the AMT analyzes the data, makes recommendations, and provides all of this in reports to the PMT and in peer-reviewed articles. At the top level, information from the previous levels is reported to the public in forms that are clear and understandable.

One example of a well-developed data management system is the Chesapeake Bay Program's Information Management System, which provides an organized library of information and software tools designed to increase the public's access to Chesapeake Bay data analysis. The system allows instant desktop access through the Internet, organizes information handling, improves data quality by keeping responsibility with the data provider, provides technical tools and support to users, and can evolve quickly to be responsive to users' needs (CIMS website 2005).

IX. FUNDING CONSIDERATIONS

This AMP cannot occur without adequate funding. To be successful, Adaptive Management must be included in the costs and funding of every Project phase and must be considered as essential as any physical component of implementation. Lack of funding is one of the primary reasons that Adaptive Management plans fail. Case studies of large-scale adaptive management programs analyzed by the Puget Sound Nearshore Partnership found that these "programs tend to plan poorly for numerous expensive and time-consuming unknowns that are characteristic of ecosystem management" (Van Cleve et al. 2004). A proactive assessment of the political climate, public receptiveness, and technical challenges, for example, should help avoid these problems. The AMP previously recommended there be a Funding Team as part of the institutional structure to ensure ongoing financial support to meet the needs of the Project.

The Project's National Science Panel recommended that the science budget equal 10% of the total annual Project budget. It is anticipated that initial cost estimates for the Project will be available in late 2005. The 10% estimate is a good general guide but is not based on direct cost estimates for all of the Adaptive Management components.

Any estimate for carrying out the AMP during Phase 1 and beyond should consider these cost categories:

- PMT Operation, including the Executive Project Manager, Funding activities, Public Outreach activities, and any needed consultants.
- AMT Operation, including a full-time Adaptive Management Team Director and Monitoring Team Leader and part-time leaders for the Field Team, Applied Studies Team, and Science Coordination Team, five full and part-time professional staff, administrative staff, Local Science Panel, National Science Panel, and honoraria for external reviewers.
- Central Data Repository, including staff, computers, software, etc.
- Monitoring Program, including progress, compliance, and real-time monitoring.
- Applied Studies Program, including funding for applied studies.

It is clear that implementing the Adaptive Management Plan, as described here, will require a significant and long-term source of funding. The Project will be developing an explicit Funding Strategy that incorporates Federal, state, local, and private funding. A separate work group of the Project is developing that and will incorporate the needs of the Adaptive Management Plan.

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APPENDIX 1.
Scientific Basis of the Project Objectives

Lynne Trulio, Lead Scientist and the Science Team
South Bay Salt Pond Restoration Project
May 26, 2005

Introduction

This report will answer the question: According to the scientific literature, Project data and modeling, what restoration targets will achieve each Project Objective and what general approaches (natural and anthropogenic) must be used to achieve those targets? The answer to this question will show compatibilities and conflicts between Project Objectives. This is a Science Team analysis and is not the official position of the Project Management Team.

For the Project to succeed, we must understand the minimum conditions required for reaching the Project Objectives, based on the best available information. Those requirements also reveal potential conflicts among the Objectives. These basic requirements can also be viewed as restoration targets, that is, measures of the Project's success. The purpose of this analysis is to help guide Project Management Team (PMT), the Consultant Team and Stakeholder decisions on alternatives evaluation and the development of Project success targets.

The information in this report was taken from the Science Syntheses, Technical Workshops including the National Science Panel (NSP) Charette, Consultant Team analysis and modeling, USGS data collection and other relevant, authoritative sources. This analysis is based on a number of assumptions:

- A major assumption is that the Project will take full responsibility for achieving the *South Bay* recovery goals of the Clapper Rail and Salt Marsh Harvest Mouse. The PMT or Stakeholders may not want to hold the Project to this goal, but we used it here as the highest good the Project could achieve for these endangered species.
- Similarly, in this document the Science Team assumed that, *within the Project Area*, the Project would try to accommodate the migratory bird diversity and abundance that existed under *pre-ISP (Initial Stewardship Plan) conditions*. Pre-ISP numbers are well known for waterfowl and less so for shorebirds. Once again, the PMT or Stakeholders may not want to hold the Project to this goal, but the Science Team believes it represents the highest goal for the Project for these species.
- As the two points above show, this analysis considers only within the Project Area as the geographic extent for achieving the Project Objectives.
- The analysis provides only general information on achieving the Project Objectives. Detailed restoration and management actions, such as breach locations, etc., are or will be included in Consultant Team and Science Team products.
- The visions shown in Figure 1 can be viewed as potential endpoints for the Project as well as intermediate phases in restoration progress. How far up the diagram toward 100% tidal the Project will go will be determined by Adaptive Management, an iterative data collection, evaluation and decision-making process.
- The analysis assumes ponds will be managed to enhance migratory bird use, fish use, and biodiversity, either through the ISP or as reconfigured under the Project.

This report specifically addresses several key Project issues, including:

- Can Project Objectives be met for both for recovery of tidal marsh species, especially the California clapper rail and salt marsh harvest mouse, and managed pond species, especially migratory and breeding birds, the Western snowy plover and California least tern?
- Can Project Objectives for species and public access be met?
- Will increased methylmercury (MeHg) in the food chain due to Project actions prevent achieving ecological Project Objectives?
- Can ecological Project Objectives be met given the presence of invasive species, especially *Spartina alterniflora*, and pest species, especially mosquitoes?
- Will tidal marsh restoration result in significant tidal flat loss outside the ponds and significant changes in subtidal and deep channel bathymetry?

Results

The habitat requirements or approaches to meet targets for each Project Objective are found in Table 1, including compatibilities and conflicts. With respect to Objectives 1A and 1B, summaries of the scientific literature and current monitoring data from the Project show that:

- According to the 1984 Recovery Plan for the California clapper rail and salt marsh harvest mouse, these species together require restoration of approximately 7,400 additional acres of high tidal marsh with abundant channels in patches at least 300 acres in size, with abundant high marsh/transition zones as refuge from high tide. This is approximately half the Project area. The 1984 analysis is outdated and the US Fish and Wildlife Service is now revising the recovery requirements for these species. Recent preliminary analysis suggests that approximately 1500 rails should be supported in the South Bay for clapper rail recovery (Weiss, pers. comm.). At a winter density of 0.5 to 1 rail per 2.5 acres, this population goal would require approximately 3,750 to 7,500 more acres of tidal marsh in the South Bay (Weiss, pers. comm.)--once again, about half the Project Area.
- Neuman (2005) states that, to meet the Western Snowy Plover Recovery Plan goal of 125 breeding pairs in the South Bay, this species will need between 500 and 3,500 acres of unvegetated, managed pond--depending on the intensity of habitat management. Ponds will need to include associated levees surrounded by ponds or tidal areas for foraging. Some or all plover habitat could function to support other breeding shorebirds such as avocets and black-necked stilts. In addition, snowy plover nesting pond could be managed to support foraging shorebirds and waterfowl, if ponds are dried out for plovers during the spring/summer breeding season and reponded in the fall and winter for migratory birds. Another approach to accommodate both bird groups is to reconfigure ponds to have permanent islands and ponded water year-round.
- These results assume *Spartina alterniflora* can be controlled or that the infestation will not negatively affect the species recovery. Study must be conducted to assess the impacts of this infestation on rare species and South Bay ecology and alternative scenarios must be developed in the event that this species and its hybrids cannot be controlled.
- Data collected by the USGS on reduced salinity conditions in the Project's ponds during the first year of the ISP and studies by H.T. Harvey on managing pond habitat for shorebirds and waterfowl in the Central Valley indicate that bird densities on ponds in

the Project Area can be doubled over the pre-ISP conditions. Thus, it appears that the pre-ISP diversity and abundance of birds could be sustained on about half the current acres of ponds. Habitat in the Project Area available to these species will also include ponds, pannes, large tidal channels and associated tidal flats in restored tidal marshes. Collins (pers. comm.) estimates that, in 7,500 acres of restored marsh, approximately 12% or 900 acres will be shorebird and waterfowl habitat. This means that if 7,500 acres is managed as ponded, unvegetated habitat and 7,500 becomes tidal marsh, then overall the Project Area will have about 8,400 acres of shorebird and waterfowl foraging habitat. Even less area may be needed, depending on habitat quality and the intensity of management. How much managed pond and tidal marsh pond/panne/slough habitat will ultimately be needed to achieve this Objective will be answered through Adaptive Management monitoring and studies.

- In summary, Project Objectives for tidal marsh species recovery and maintenance of current migratory bird populations seem to be achievable in the Project area. However, requirements for snowy plover habitat conflict, to some extent, with tidal marsh species and migratory birds. The extent to which snowy plovers can be accommodated in managed pond areas must be studied.

With respect to Objective 1C, the Science Syntheses and other information show that other species, especially fish, can benefit from increased ecological functioning achieved with tidal marsh restoration and wildlife-oriented pond management, providing MeHg does not increase in the food chain and public access is well-designed. However, other species will need specific design features. For example:

- Harbor seals (*Phoca vitulina richardsi*) will need lower levees for new haul out sites, an improved prey base, pollutant control, and low levels of human disturbance. These changes may help harbor seal populations, but much is not known about the seals' requirements.
- Native oysters (*Ostrea lurida* (=*conchaphila*))will need artificial reefs in locations with optimal conditions, especially low suspended sediment in the water column. Oyster restoration in the Bay is very experimental.
- Fish species will benefit from the habitat heterogeneity of restored tidal marshes. Populations may also need oyster reefs, pollutant control and lower fishing pressure. Surfperch species (family Embiotocidae) are good transient species to monitor, because they are good indicators of habitat heterogeneity. In addition, this important group of native species has declined significantly over the decades in the South Bay and increasing their populations would be a great benefit of the Project. The longjaw mudsucker (*Gillichthys mirabilis*), a native, resident species, is a good species to monitor for pollutant effects and population change.
- Rare plants will need high marsh/transition elevations and planting and research on the limiting factors to growth and reproduction (Callaway 2005).

Successful restoration assumes that levees for flood protection (Objective 2) will be maintained and improved to meet expected impacts of the Project. Primary levees are expected to be at the inboard edge of the Project, which will not be a significant impediment to achieving the ecological Project Objectives. This alignment will segregate tidal marshes from upland habitats, but is far preferable to Bayside or internal flood control levees. Landside perimeter levees for tidal flood protection can be designed with a shallow slope to also provide high marsh/upland transition habitat. Some features of the restoration, such as tidal marsh restoration at the mouths of creeks and rivers, will improve tributary water movement and storage capacities, thereby improving flood management.

Published literature and current research show that a wide range of public access and recreation (Objective 3) can be accommodated without significantly harming species, if access opportunities are well designed. The best recreational opportunities are for increased trail mileage on inboard levees, overlooks, and access to historic sites. Specifically:

- the landward levees and flood management levees provide great opportunities to complete the Bay Trail and provide a Bayside experience with minimal species impact.
- public access must be restricted in breeding, pupping and spawning habitat.
- trails should be placed next to very large expanses of habitat, so that organisms do not need to be near the trail to be in their required habitat.
- in most locatins, overlooks should be used instead of boardwalks into marshes or ponds.
- high marsh and upland transitional habitat, which will function as high tide refugia and sites for rare plant species, should be designed to be inaccessible to public assess and terrestrial predators.
- dogs should be prohibited on trails, except perhaps, on the Bay Trail spine.
- the majority of the Project area should not permit public access and recreation, especially hunting, fishing and boating.
- fishing pressure on native species should be assessed and managed, if needed.
- the Project should include significant interpretive/educational features that discuss the effects of public access on species.

Objective 4 deals with water and sediment quality. Mercury methylation is a key issue. The Mercury Technical Memorandum (Beutel, Abu-Saba, and Paulson 2004) and current USGS research (Marvin-DiPasquale pers. comm.) show that some South Bay sediments have high inorganic and organic mercury levels. The primary source is the New Almaden mine that releases mercury into the Guadalupe River. Research also indicates that mercury methylation may be increased by some tidal marsh conditions and in some seasons, but other data conflict with this finding. The extent methylation this may occur in restored in South Bay marshes and increase Hg concentrations in the food chain requires targeted study as soon as possible. Throughout the initial phases of the Project, and even beyond, mercury availability to the food chain will require careful study to determine if this problem could constrain the amount of tidal marsh restored and/or the location of restored marshes. Studies should assist managers in identifying effective solutions to minimize Hg methylation.

Davis (2005) states in his Science Synthesis that other pollutants may also threaten the food chain. Concentrations of legacy contaminants such as DDT, PCBs, and PAHs, could rise if they are remobilized from buried sediment. In addition, emerging contaminants such as PBDEs and pyrethroid insecticides, and contaminants such as PAHs that are still in use could pose threats to species. These pollutants and others that emerge as potential threats must be evaluated with respect to the risk posed to the South Bay ecosystem.

Salinity gradients, a water quality issue, caused by fluvial discharges and effluent from Publicly-Owned Treatment Plants (POTW) are not mentioned specifically in the Project Objectives. However, salinity is a major driving factor for many aspects of the intertidal zone, including sedimentation rates, tidal marsh channel density, panne size, mercury methylation, and community structure. Other water quality parameters, especially dissolved oxygen, will need monitoring and, potentially, study if monitoring shows unanticipated problems or poorly understood ecological processes.

Literature reviews and other studies show that achieving the Project Objectives will require control of a number of invasive and nuisance species (Objective 5). In particular, successful restoration of native species and ecosystem functions assumes aggressive *Spartina alterniflora* control to prevent hybrids from invading the Project area and eliminating the native cordgrass (*S. foliosa*). The Invasive *Spartina* Project, now being implemented to control *S. alterniflora* in the South Bay, will show the level of effort and funding needed to control this invader. How well this Objective can be achieved is currently not known and, therefore, will need to be the subject of Adaptive Management monitoring and study. In particular, studies of the invasive *Spartina*'s ecological impacts on the South Bay ecosystem are needed.

Continued red fox control is also mandatory to achieve species recovery, especially the clapper rail and snowy plover. Current management efforts have been very successful and will need to continue. Explosive growth of native California gull and covid populations is an emerging issue for the Project. The extreme numbers of these species poses a threat to rare species and breeding birds. This issue requires monitoring and testing of control strategies.

Mosquitoes (*Culex* spp., *Ochlerotalus* spp., and *Aedes* spp.) are nuisance species that must not be exacerbated by Project actions. According to the Science Synthesis by Josselyn, et al. (2005), "Restoration projects in San Francisco Bay have the potential to either create or eliminate mosquito breeding habitat. For example, by restoring tidal action to previously isolated marshes mosquito breeding habitat can be eliminated, while on the other hand, creation of isolated pools of water in the upper reaches of a restored marsh could create mosquito habitat." Josselyn, et al. (2005) include a list of recommendations developed by the Alameda County Mosquito Abatement District for avoiding mosquito problems in salt marsh restoration projects.

Infrastructure functions and their protection (Objective 6) are not expected to be significant impediments to achieving Project Objectives. This issue will be addressed through careful planning to avoid sensitive structures or reinforce others that will experience increased pressure due to restoration activities. The presence of major structures, such as power towers, represent a threat to native species as they attract avian predators. Once again, careful planning will be needed to keep sensitive species away from dangerous structures.

Sediment supply and dynamics are not mentioned specifically in the Project Objectives. But, three issues are important here:

- Preliminary sediment transport analyses performed by the USGS and PWA, especially the Landscape Scale Geomorphic Assessment model, suggest that, even if all ponds in the Project Area are restored to tidal marsh, most ponds are likely to accrete to marsh elevations within the 50-year planning period. Much of this sediment would erode from existing tidal flats in sloughs and the Bay. Substantial sources of uncertainty in the analysis include sea level rise, future subsidence or rebound in the Alviso region and sediment loading in local tributaries.
- Preserving the current extent of tidal flats in sloughs and the Bay may be important to a variety of species, but the degree of importance is not well understood. Thus, the amount of tidal flat needed for species must be studied. The degree to which tidal marsh development causes the loss of tidal flats in the sloughs and Bay is being modeled, but actual effects must be monitored. Sediment contributions from local tributaries to the

South Bay are not well understood. Currently, USGS is measuring sediment inputs to the Bay from Coyote Creek. Similar data collection for other large tributaries may be needed to understand this key factor in tidal flat change and tidal marsh restoration.

- The Landscape Scale Geomorphic Assessment (PWA 2005) will give a general indication of how changes in South Bay sediment dynamics due to tidal marsh restoration are expected to affect subtidal and deep channel bathymetry. Whatever the model results, physical changes will need to be monitored.

In our analysis, we considered the following management activities essential to achieving the ecological Objectives:

- Large areas of tidal marsh, 300 acres or larger, will be restored at any one time.
- Create a tidal marsh corridor with broad upland transitional areas.
- Tidal marsh restorations will occur next to existing salt marsh harvest mouse habitat and within dispersal distance of existing clapper rail populations.
- Distribute nesting habitat and ponds among the three complexes.
- Restore tidal marshes adjacent to anadromous fish migration corridors.
- *Spartina alterniflora* will be aggressively controlled.
- Non-native and native predators having significant impacts on rare and breeding species will be controlled.
- There will be no public access into breeding, pupping and endangered species areas.
- ISP management will continue for ponds that are not undergoing restoration or are being reconfigured under the Project.
- Parameters that measure progress toward Project Objectives will be monitored.
- Targeted studies of methylmercury, pond management for migratory birds, model results, tidal flats change and usage by species, etc. will be undertaken to reduce key uncertainties.

Visions of the South Bay: A Continuum Informed by Adaptive Management

The PMT, Stakeholders, Consultant Team and scientific experts have developed four visions, or alternative scenarios, of the restored South Bay. These visions (Figure 1) exist along a continuum from least to most tidal action, based on the area open to the tides and the amount of tidal exchange (muted to full) in those areas. The greater the tidal action, the more natural processes control restoration and, typically, the less human intervention is needed.

The ISP is the starting point for the Restoration Project and is a condition in which the three Island Ponds are restored to full tidal action and all other ponds experience muted tidal exchange or limited communication with the Bay. The 50% tidal marsh/50% managed pond vision is Alternative 1, developed by PWA, the PMT and the Stakeholders, and significantly increases the amount of Project area opened to full tidal fluctuation. Each vision includes more fully tidal area until the entire area is fully tidal. There is no value judgment implied in this progression; that is, 100% fully tidal is not necessarily the most beneficial condition for the South Bay.

Since this is a phased project, the extent to which Project Objectives are achieved with each phase will be monitored and evaluated before adding more fully tidal areas. It is essential that the design of each phase avoid these two irreversible situations:

3. Designing and implementing irreversible actions for which there is a high risk of failure. In other words, the design should not go beyond the limits of our scientific, technical and managerial grasp.
4. Designing and implementing actions that preclude reaching more complete levels of tidal action and natural ecological functioning. For example, implementing small tidal marsh areas may preclude developing a larger, more fully functioning one in the same place later.

Each vision might ultimately be an endpoint for the Project or it might just be a snapshot of conditions on the trajectory to the final conditions. The final conditions for the Project cannot be known at this time, and the ultimate configuration of the Project may be somewhere in between the specific alternatives that will be evaluated in the Record of Decision.

The ideal Project to meet all the biological objectives consists of an array of habitat mosaics distributed across the landscape in accordance with natural estuarine and fluvial processes. Overall, the ideal Project will result in a self-sustaining ecosystem, which needs as little human intervention as possible.

In Alternative 1, developed by PWA, the PMT and the Stakeholders, 50% of the Project area is restored to tidal marsh and 50% is managed pond. Based on the scientific literature and supporting information, this appears to be a good place to start. This is vision has the greatest likelihood, based on what we know today, of meeting the Project Objectives, but this scenario also requires the most human intervention. Thus, it may incur higher risk and operations and management costs than scenarios more dependent on natural processes.

Using Adaptive Management, we will learn about issues essential to moving in the direction of greater dependence on natural processes and less management. Critical issues include managing ponds for higher migratory bird use, managing for snowy plovers and migratory birds in the same ponds, understanding migratory bird use of tidal marsh features, minimizing MeHg exposure to the food chain, controlling *Spartina alterniflora* and its hybrids, and controlling invasive predators. Information on these key issues, and others that will undoubtedly emerge, will allow us to move toward more tidal marsh and less managed pond, visions depicted by Alternatives 2, 3 and the Charette, fully-tidal scenario.

The fully-tidal scenario requires the least human intervention of all. Adaptive Management is the key to determining if this vision meets all the Project Objectives. Likely constraints to reaching this vision are: a) Migratory bird support by tidal marsh features; b) Snowy plover recovery and California least tern protection; c) Mercury methylation and bioaccumulation in the food chain; and d) Mosquito production.

The basic goal of Adaptive Management is to collect the information needed to move the Project toward more tidal marsh and to assess at what point on the continuum we cannot meet all the Project Objectives. When that point is reached, decision-makers will determine whether the Project is complete or whether Project Objectives should be revised.

Table 1. Project Objectives

Objective 1. Create, restore, or enhance habitats of sufficient size, function, and appropriate structure to:

A Promote restoration of native special-status plants and animals that depend on South San Francisco Bay habitat for all or part of their life cycles.

B. Maintain current migratory bird species that utilize existing salt ponds and associated structures such as levees.

C. Support increased abundance and diversity of native species in various South San Francisco Bay aquatic and terrestrial ecosystem components, including plants, invertebrates, fish, mammals, birds, reptiles and amphibians.

Objective 2. Maintain or improve existing levels of flood protection in the South Bay area.

Objective 3. Provide public access opportunities compatible with wildlife and habitat goals.

Objective 4. Protect or improve existing levels of water and sediment quality in the South Bay and take into account ecological risks caused by restoration.

Objective 5. Implement design and management measures to maintain or improve current levels of vector management, control predation on special status species and manage the spread of non-native invasive species.

Objective 6. Protect the services provided by existing infrastructure (e.g. power lines).

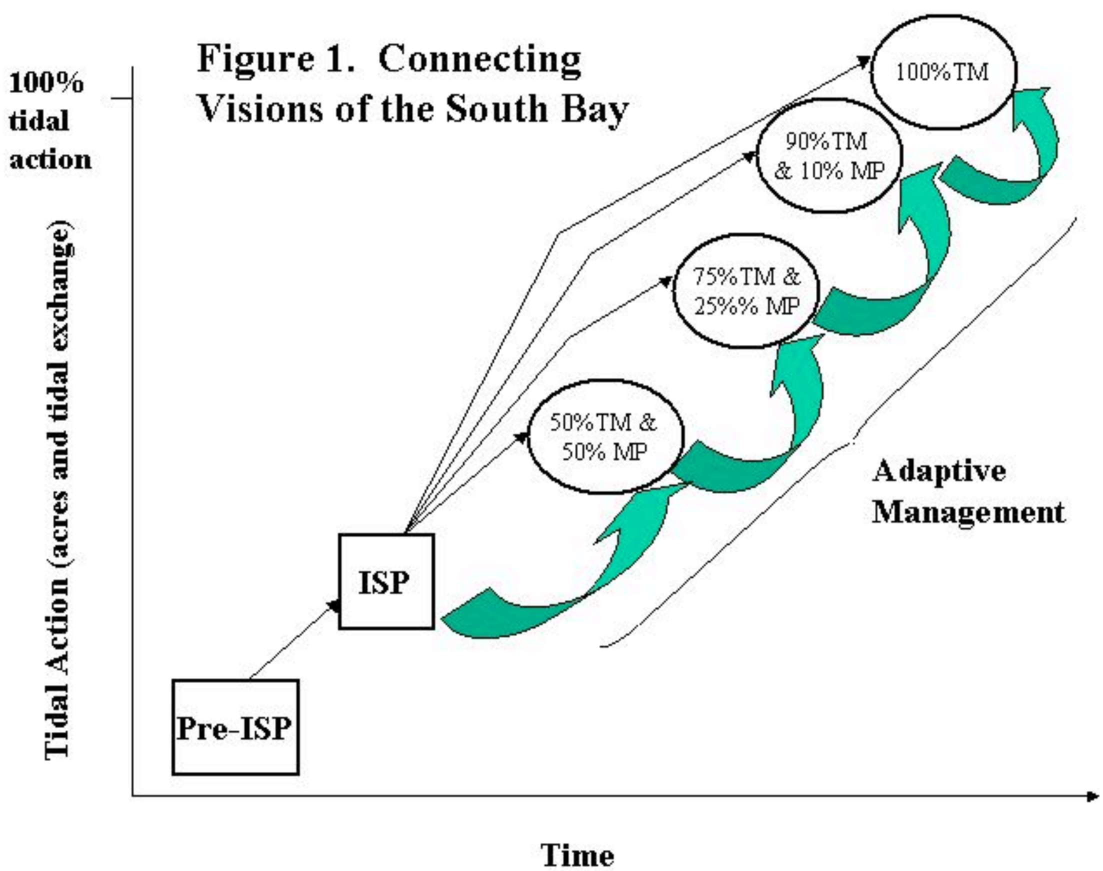

TABLE 1. Requirements to meet Project Objectives (June 1, 2005)

Project Objective	Sub-Objective	Population Target	Habitat Type	Habitat Size/Needs--Processes	Target Compatible with…; Conflicts with...	Sources
1A	California Clapper Rail *(Rallus longirostris obsoletus)*	1500 birds in winter; 0.5 to 1 bird per 2.5 acres	Fully tidal marsh with *Spartina foliosa*, high channel density, at least 250 acres in size; will use brackish marshes	~3,750 to 7,500 acres tidal marsh with predator and *Spartina* hybrid control; install high marsh and transitional habitat along 2 sides of ponds; limit public access	Compatible:SMHM Conflicts:WSP, CLT and Migratory birds; Public access	Weiss, pers. comm.
1A	Salt Marsh Harvest Mouse (SMHM) (*Reithrodontomys raviventris raviventris*)	?? (At least 500 breeding pairs?)	Dense pickleweed (50-100% cover); high marsh/ transitional to upland; adjacent to existing populs; connected to other populs; at least 250 acres in size	~7,400 acres tidal marsh with predator and *Spartina* hybrid control; install high marsh and transitional habitat along 2 sides of ponds; lower levees separating habitat patches; limit public access	Compatible:Rail Conflicts:WSP, CLT, Migratory Birds	1984 Recovery Plan
1A	Western Snowy Plover (WSP) (*Chardrius alexandrinus*)	250 birds; 125 nests	seasonal wetland; dry in summer; habitat patches divided up between 3 complexes	3,520 acres--w/natural processes; 2,350 acres--with predator control and natural processes; 500 acres--with predator and water management; limit public access	Compatible:CLT, Migratory birds; Conflicts:Rail and SMHM; Public access	Neuman (2005) Synthesis
1A	California Least Tern (CLT) (*Sterna antillarum brownii*)	No target	levees for post-breeding roosting sites	Levees with no public access adjacent to ponds and the Bay for fishing	Compatible:WSP, Migratory birds; Conflicts:Rail, SMHM; Public access	
1B	Migratory Birds: Waterfowl	Diversity and abundance of pre-ISP ponds; use FWS winter survey numbers and USGS 2002-2004 Project Area data	Managed ponds and tidal flats with some use of tidal marsh	Unknown but we hypothesize ~7,000 acres, managed as in ISP; even less area may be needed with targeted management, but this requires study; the number of waterfowl that tidal marsh ponds/pannes can support is unknown and requires study.	Compatible:WSP, CLT; Conflicts:Rail and SMHM	Data from USGS and FWS
1B	Migratory Birds: Shorebirds	Diversity and abundance of pre-ISP ponds; use PRBO baywide survey and USGS 2002-2004 Project Area data	Managed ponds and tidal flats with some use of tidal marsh	Unknown but we hypothesize ~7,000 acres, managed as in ISP; even less area may be needed with targeted management, but this requires study; the number of shorebirds that tidal marsh ponds/pannes can support is unknown and requires study.	Compatible:WSP, CLT; Conflicts:Rail and SMHM	n PRBO, ıd H.T.

Project Objective	Sub-Objective	Population Target	Habitat Type	Habitat Size/Needs--Processes	Target Compatible with…; Conflicts with...	Sources
1C	Harbor Seal (*Phoca vitulina richardsi*)	Current population; increases desirable	Haul outs on tidal marsh next to deep water; adequate prey base; low disturbance; low pollutants	Physically lower levees along bay and sloughs; improve fish populs; decrease pollutants	Compatible:Fish Conflicts: Public access	Trulio, et al. (2003)
1C	Fish Species, esp surfperch (family Embiotocidae), longjaw mucsucker (*Gillichthys mirabilis*)	Significant increase over current populations; regular use of new tidal habitat; no increase in pollutant loads; no outbreak of invasive fish species	Subtidal, tidal, veg tidal marsh, brackish marsh, riparian zones; low pollution	Natural processes of marsh creation; install oyster reefs; reduce fishing pressure	Compatible:Oysters, tidal marsh Conflicts:Public access?	Herbold and Schafer, pers. comm.; Fish Workshop (May 20, 2005)
1C	Oyster (*Ostrea lurida*)	Self-sustaining reefs/beds in each pond complex	Solid substrate in subtidal; moderate currents; low SSC; managable predator pressure	Install oyster reefs at sites that meet oyster habitat needs	Compatible:Fish Conflicts:None	Obernolte (2005 Synthesis
1C	Song Sparrow (*Melospiza melodia pusillula*)	~14,000 pairs (20% of est. historic levels)	Vegetated tidal marsh with many small channels and complex veg structure with *Grindelia*; some high marsh and transitional	Currently has ~6,700 acres; and additional 7,000 acres recommended processes as decribed for Rail and Mouse	Compatible:Rail, SMHM; Conflicts:WSP, CLT, Migratory birds	Shellhammer (2000) *Goals Report*
1C	*Castilleja ambigua* subsp. *ambigua*, *Cordylanthus maritimus* subsp. *palustris*, *Lasthenia glabrata* subsp. *glabrata*, and *Suaeda californica*	??	Found in high marsh/transitional areas	C*ordylanthus maritimus* subsp. palustris is a hemi-parasite with a wide number of potential hosts; *Castilleja ambigua* subsp. ambigua is hemi-parasite--will establish without a host if given supplemental water; *Lasthenia glabrata* subsp. glabrata is an annual species, prefers low soil salinity and regular moisture; *Suaeda californica* is a rare perennial.	Compatible:SMHM, Song Sparrow; Conflicts:WSP, CLT, Migratory birds	Callaway (2005) Synthesis

Project Objective	Sub-Objective	Objective Target	Conditions that prevent meeting Target	Processes/Actions to Meet Target	Target Compatible with…; Conflicts with...	Sources
1C	Tidal Flat Retention	Changes in South Bay tidal flat area and contour do not significantly harm birds and aquatic spp.	Marsh restoration erodes tidal flats; restoration causes Bay bathymetry changes that negatively affect aquatic spp.	Model changes and study to assess impact of restoration; phase project to determine tidal flat impacts; implement design features to preserve tidal flats in important areas; retain managed ponds and/or locate ponds to control tidal flat loss	Compatible:Migratory birds, fish, benthics; Conflicts:Tidal marsh restoration, perhaps	Schoellhamer (2005) Synthesis; Sediment Workshop 1 and 2 (see Workshop *Synopses*)
2	Flood management	No increase above current levels		Implement ACOE South Bay Shoreline Plan	Compatible:Tidal marsh, pond management; Conflicts:Connecting w/upland habitats	
3	Public Access & Recreation	Complete Bay Trail; increase historic site access; increase near-Bay access and waterside access	Presence of sensitive and nesting species will, in part, determine trail and other public access features.	Design trails around pond edges; avoid edges with transitional upland; avoid breeding sites, CLT roosting sites and high-use roosting sites; keep trails/public access at appropriate buffer distances; provide large areas of wildlife refuge (public access prohibited)	Compatible:Species protection, if designed well; Conflicts:Species protection, if not designed well	Trulio (2005) Synthesis
4	MeHg Levels in Food Chain	No increase above current levels (as measured in key trophic levels)	Hg inputs to the Bay from Guadalupe River; resuspension of buried Hg due to tidal scour from restoration; increased methylation due to Project changes (esp marsh restoration)	Focus on natural processes and habitats that limit methylation and implement design features (if any exist) to control methylation in important areas; study MeHg in food chain to determine impacts	Compatible:Target is compatible with ecological and recreation goals; Conflicts:Tidal marsh restoration and certain types of managed, perhaps	Mercury Technical Memo (2004)
4	Water Quality	Parameters meet regulatory standards	Pond management; long water residence time; urban inputs	Tidal marsh processes; filtration from native oyster and other bivalves	Compatible:Ecological and recreation goals; Conflicts:Managed pond, perhaps	

Project Objective	Sub-Objective	Objective Target	Conditions that prevent meeting Target	Processes/Actions to Meet Target	Target Compatible with…; Conflicts with...	Sources
5	Non-native plant species	0% cover by *Spartina alterniflora*; control other invasives as required	Opening ponds to tidal restoration could increase spread of hybrids; cost of control could prevent meeting target; other invasives could threaten ecological functioning	Aggressively control *Spartina* hybrids in Project area; track other non-native and nusiance spp. and control when they threaten Project Objectives	Compatible:Ecological goals; Conflicts:None	Josselyn, et al. (2005) Synthesis
5	Non-native and nuisance predators	Control red fox and gull predation	Cost of control, inability to remove predator perches and forage	Continue fox control and expand where needed; study gull problem to determine impacts and solutions	Compatible:Ecological goals; Conflicts:None	Josselyn, et al. (2005)
5	Mosquitoes	No increase above current levels	This target must be met.	Design to limit ponded water near vegetation	Compatible:Unveg, managed ponds; Conflicts:High, poorly drained tidal marsh, seasonal wetlands; veg managed ponds	Josselyn, et al. (2005)
6	Infrastructure	Protect existing services, esp. PGE, bridges, POTWs	This target must be met.	Study impacts and design to avoid impacts or to reinforce structures	Compatible:Managed ponds; Conflicts:Tidal marsh, esp. slough scouring	Trivedi (2005) Synthesis

APPENDIX 2.
Applied Studies Program for Adaptive Management of the South Bay Salt Pond Restoration Project

Uncertainties and Hypotheses
The Science Team and Charette participants identified seven main regions of uncertainty. Results from studies to address these uncertainties will be required in order to proceed from Phase 1 of the project into later phases. The direct result of these studies will be information that managers can use to identify the placement, management and extent of managed ponds versus restored tidal marsh in later Project phases.

Below we identify the key uncertainty in each area, the hypotheses to be addressed, the measurements likely to be necessary to test the hypothesis and the management actions that will rest upon the results of these studies. For several mercury, sediment and bird hypotheses we have designed studies. For the other hypotheses and research questions, we have not yet attempted to describe tests.

This Program emphasizes the importance of gathering baseline data and conducting pilot studies during the ISP and the need for effective experimental approaches to be incorporated into the Phase 1 projects.

MERCURY
Key uncertainty: Will mercury be mobilized into the South Bay food web and off site at a greater rate than prior to restoration?

Hypothesis 1: Tidal marsh restoration and pond management does not increase MeHg levels in indicator species above baseline levels.

- Measurements: A complete study design for implementation at pond A8 during the planning phase is in development by Collins and colleagues (Collins, pers. comm.).

1. Mercury loads and methylation rates will be measured in both the water column and sediments and in indicator species before (baseline) and after management actions to determine methylation potential and rates. Baseline data should also be collected before and during the study at similar sites not undergoing the management action.
2. Ponds selected for the management treatment, such as pond A8, and baseline study will be ponds with high methylation potential based on current Hg measurements and future mercury inputs, especially tidal marsh restoration.
3. Indicator species will include resident organisms at different trophic levels. Likely species are the Alameda song sparrow (*Melospiza melodia pusillula*), brine flies (*Ephydra* spp.), longjaw mudsucker (*Gillichthys mirabilis*) and topsmelt (*Atherinopsis affinis*) to measure biologic uptake on site (Collins, pers. comm.).
4. Indicator species may also include migratory animals and sentinel organisms such as oysters in areas adjacent to breaches to measure biologic dispersal offsite.

- Management actions based on results:
  1. If hypothesis is not disproved by data within 5 years, then additional pond breaches may be appropriate based on results of wildlife needs.
  2. If mercury effects are consistent only within ponds and/or within resident species, then pond management should be changed to reduce methylation

3. If migratory and/or sentinel species exhibit significant increases in Hg loads, then further pond breaches may not be appropriate.

Hypothesis 2: MeHg levels in indicator organisms are not reduced by chemical and physical pretreatment in high-risk ponds and marshes.

- Measurements:
  1. Mercury loads and methylation rates will be measured in both the water column and sediments and in indicator species before and after sites are treated by covering with "clean" dredge material or by chemical treatment intended to reduce mercury methylation (Mark Stacey, pers. comm.).
  2. Ponds selected for this study will be sites with high methylation potential based on current Hg measurements mercury inputs. Ponds must be amenable to creating cells or other features needed to contain the treatment while not constraining future management actions.
  3. Indicator species will include resident organisms at different trophic levels. Likely species are the Alameda song sparrow (*Melospiza melodia pusillula*), brine flies (*Ephydra* spp.), longjaw mudsucker (*Gillichthys mirabilis*) and topsmelt (*Atherinopsis affinis*) to measure biologic uptake on site (Collins pers. comm.).
  4. Indicator species may also include migratory animals and sentinel organisms such as oysters in areas adjacent to breaches to measure biologic dispersal offsite.
- Management actions based on results:
  1. If treatments are successful, then they may be used when physically and economically practical to prevent or reduce Hg mobilization at sites identified as problematic under Hypothesis 1.
  2. If treatments are not successful, managers will need to use other methods to limit Hg mobilization into the food web due to their management actions.

SEDIMENT DYNAMICS

Key Uncertainty: Is there sufficient sediment available in the South Bay to support the transformation of ponds to marshes without causing unacceptable impacts on other shallow habitats in sloughs and the Bay?

Primary Hypotheses:

1. Sediment capture by breached ponds will not be adequate to support tidal marsh ecosystems on site.
2. Sediment loss into breached ponds will not support shallow water ecosystems in sloughs and the open Bay.

- Measurements: See attached study designs for the Island Ponds and Eden Landing, both to be implemented during the planning phase.
- Management Actions based on results:
  1. If ponds are found to accrete only at the expense of existing intertidal habitats then future pond breaches will need to be restricted to areas with surplus sediment supplies, near stream mouths or other areas where intertidal habitats are not shown to suffer deterioration from pond breaches.

2. If accretion rates are found to be insufficient to support tidal marsh development, then future pond breaches will need to be restricted to shallower ponds where sediment balances are adequate to support restoration.

BIRD USE OF CHANGING HABITATS

Key Uncertainty: Can the pre-ISP number and diversity of migratory and breeding shorebirds and waterfowl be supported in a reduced habitat area?

Hypothesis 1: Managing water levels in ponds so that they are dry in the summer and flooded to a depth of <15 cm in the winter will not attract breeding Western snowy plovers and foraging migratory shorebirds.

- Measurements: See attached study design for Eden Landing to be implemented during the planning phase.
- Management Actions based on results:
  1. If plovers nesting and productivity is not within acceptable ranges, then other nesting sites and/or methods to encourage nesting will need to be sought. If plovers will not nest and shorebirds forage in the ponds, then the ponds should remain flooded year round.
  2. If shorebirds do not forage in shallow water ponds, concurrent observations on predation, disturbance, and toxins are expected to guide management priorities

Hypothesis 2: Creating isolated nesting islands, engineering levees with shallow (10:1 slopes) and engineering pond bottoms to provide water at a depth attractive to birds will not maintain shorebird and waterfowl diversity and will not double the foraging bird number compared to pre-ISP conditions.

- Measurements: See attached study design for the Alviso complex to be implemented during Phase 1.
- Management Actions based on results:
  1. If at least double the migratory bird numbers over the ISP are sustained over 5 years, more ponds should be engineered in this manner. If not, research will need to be conducted on other methods to increase migratory bird use of ponds.
  2. If some species are not increasing, then the particular needs of those species will need to be assessed and provided for in pond management, if possible.

Hypotheses 3: Restored young and mature tidal marshes do not support the diversity and abundance of migratory birds as ponds in the pre-ISP condition.

- Measurements:

1. Collect data on the diversity and abundance of migratory birds using tidal marsh features, ponds, pannes, sloughs, in a) restoring marshes dominated by tidal flat, b) young marshes dominated by newly colonized vegetation and c) mature marshes.
2. Map the location and aerial extent of tidal marsh features in each marsh type and the location of birds relative to these features.
3. Compare the overall abundance and diversity of migratory birds in each marsh type with that of ponds in the pre-ISP condition.

- Management Actions based on results:

1. If tidal marshes at various points in their evolution can support the same overall diversity and abundance of migratory shorebirds as existing in the pre-ISP condition, then nearly all ponds can be restored to tidal marsh.
2. If tidal marshes cannot support the equivalent diversity and abundance of migratory shorebirds, then other habitats that do support large bird numbers will need to be included in the Project area. The number of birds that mature tidal marshes do support should be considered in determining the amount of other habitat to provide.

INVASIVE AND PROBLEM SPECIES
Key Uncertainty: Can invasive species such as *Spartina alterniflora*, corvids and the California gull be controlled, and if not, how can the mpacts of these species be reduced in future phases of the project?

Hypothesis 1: California clapper rail numbers and reproductive success, fish use and invertebrate density in *Spartina alterniflora* marshes are not significantly different than in *Spartina foliosa* marshes.

Hypothesis 2: Colonies of terns and shorebirds that include aggressive species, especially avocets, have significantly higher nest success than colonies without the aggressive species.

Hypothesis 3: California gull numbers can be controlled through colony disturbance.

BENEFITS TO NON-AVIAN SPECIES
Key Uncertainty: How can restoration actions be configured to maximize benefits to non-avian species both onsite and in adjacent waterways?

Hypothesis 1: Access and use of restored tidal marsh by native fish species (steelhead, surfperch spp. and long-jaw mudsuckers, among others) for cover and reproduction (as appropriate to the species) is not significantly affected by breach configuration, restored marsh geometry or pond management for other purposes.

- Measurements:
  1. Abundance of desirable fish species and diversity of all fish species in tidal marsh restoration in pond sites will be compared with numbers and diversity in mature marshes. Particular attention will be paid to differences among sites in patterns of connectivity into and within the restored sites vs open marsh sites Structural elements within ponds that can be expected to favor desirable fish species (pilings and other structures and diverse depths of channels to promote low tide refugia) should be incorporated as possible in Phase 1 and their value assessed..
  2. Movement of desirable fish species into and off the sites and the impacts, both positive and negative, on nearby fish habitats (including proposed oyster beds below) will be assessed.
  3. Comparison of abundance, growth, and survival of fish in areas with varying levels of public access will be compared to assess the impacts of human use on aquatic resources.
  4. Measurements will include bathymetry, vegetation cover, primary productivity and water quality in marshes, adjacent sloughs and the Bay.

5. The fish community will be analyzed for evidence of potentially important new non-native species.

- Management Actions based on results: If different breach or levee structures are shown to affect the value of restored tidal marshes for desirable fish species, then future levee breaches and marsh channel designs should incorporate favorable conditions.
  1. If structures or diverse bathymetries are demonstrated in Phase 1 to provide significant benefits to fish, then their expanded use should be considered in Phase 2.
  2. If human exploitation of the resource is found to exceed to the capacity of the system to support, further management, consistent with the expectations of public access will need to be incorporated in Phase 2.

Hypothesis 2: Self-sustaining oyster reefs cannot be established.

- Measurements:
  1. Study the conditions that are resulting in the survival of oyster beds in Westport Slough, Redwood City, and the Shoreline Sailing Lake, Mountain View. Review other research on native oyster establishment in the San Francisco and Tomales Bays.
  2. Use the findings to design experimental oyster reefs that would establish self-sustaining populations at sites that would also benefit fish.
  3. Measure the effects of established oyster reefs on water quality, primary productivity and fish diversity. Measure parasite load and Hg levels in oysters.
- Management Actions based on results:
  1. If experimental reefs are successful, include more reefs as parts of future Project phases to increase abundance to historic levels.
  2. If oysters cannot be established, document the reasons why and what conditions would be necessary to establish oyster populations. Then, either attempt oyster establishment in the future or acknowledge that the Project cannot include this species as part of ecosystem restoration.

Hypothesis 3: Self-sustaining populations of rare, high marsh plant species cannot be established. [Given the very limited amounts of upland habitats available on site, should some of this section discuss the value that various limited configurations of upland habitats such as levees and/or island configurations on site?]

- Measurements:
  1. Study limiting factors to growth and reproduction for these rare species, *Castilleja ambigua* subsp. *ambigua*, *Cordylanthus maritimus* subsp. *palustris*, *Lasthenia glabrata* subsp. *glabrata*, and *Suaeda californica*.
  2. Use the findings to design experimental planting treatments to test the conditions that result in long-term, self-sustaining populations within the Project Area.
- Management Actions based on results:
  1. If experimental plant treatments are successful, include plantings as parts of future Project phases to increase abundance to historic levels (if this is known).
  2. If any or all of these species cannot be established, document the reasons why and what conditions would be necessary to establish them. Then, either attempt new experiments in the future or acknowledge that the Project cannot include the species as part of ecosystem restoration.

SOCIAL DYNAMICS

Key Uncertainty: What concerns and desires does the Bay Area public have with respect to the restoration and how can the Restoration Project effectively engage the public to ensure long-term support for the Project?

Research Questions:

1. What Bay user groups are not represented on the Stakeholder Forum and what are their concerns and desires for the Project?
2. How can local and indigenous knowledge, as well as anecdotal information be used to inform decision-making?

- Measurements:
  1. Identify other Bay user groups, such as commercial users, users in ethnic groups not represented on the Forum, education and research groups and indigenous peoples. Determine how they use the Bay and their perceptions (positive and negative) of the Project.
  2. Determine what kind of information they and the Stakeholder Forum members have collected about the Bay, the South Bay in particular.
  3. Determine how that information could be included in the Project, in particular in the analysis of restoration activities and management decision-making.
- Management Actions based on results:
  1. If under-represented groups have concerns about the Project, develop management methods and/or educational methods to address those concerns.
  2. Include members of these groups on the Stakeholder Forum.
  3. Use information collected in analysis and decision-making to the extent feasible. Communicate to the Stakeholders how the information was used.

Research Question 3: How are the changing demographics of the South Bay and California likely to affect the ability of the Project to achieve the Project Objectives and secure funding?

- Measurements:
  1. Determine how population size, demographic groups and land use in the South Bay are expected to change over the next 50 years.
  2. Evaluate how these changes may affect public access desires, flood control demands, freshwater inputs, land use impacts and financial resources for the Project.
  3. Anticipate long-term changes in California demographics and land use that could affect the Project.
- Management Actions based on results:
  1. Develop long-term plans for addressing the most important factors that could negatively affect the Project.

Research Question/Hypothesis 4: What approaches to engaging public interest work best to ensure long-term financial support?

- Measurements:
  1. Poll the population in the appropriate area to determine support for local measures to provide long-term funding for the project. Determine the level of knowledge about

the Project and reasons why citizens would or would not vote for local funding measures.
2. Evaluate the range of approaches to increasing knowledge and positive support for the Project.

- Management Actions based on results:
  1. Implement methods to build public knowledge of the Project and build support for long-term funding measures.

LARGE-SCALE FACTORS
Key uncertainty: How are regional and global changes likely to affect the Project's ability to meet and sustain its Objectives?

Hypothesis 1: Different predictions for sea level rise will not affect achieving Project Objectives over the long term?

Hypothesis 2: The Project has no effect on Pacific flyway numbers and, conversely, conditions in the Pacific flyway have no effect on numbers of migratory birds visiting the South Bay.

- Measurements:
  1. Coordinate with researchers and flyway site managers to develop an integrated approach for assessing what areas along the flyway may be affecting migratory bird diversity and abundance.
  2. Conduct a comprehensive study of shorebird diversity and abundance in the San Francisco Bay approximately once every 10 years.
  3. Continue monitoring bird numbers and diversity within the Project Area to track changes. Collect data as required for coordination with other flyway sites.
- Management Actions based on results:
  1. Use the information to inform the public on the relationship between the Project and the Pacific flyway.
  2. If data show that the Project is having significant negative effects on flyway numbers, then evaluate what actions should be taken improve conditions for migratory birds.
  3. Alter current Phases and design future Phases to try to reverse effects based on this evaluation.

Hypothesis 3: Projected changed in California water distribution will not affect achieving and sustaining the Project Objectives.

APPENDIX 3.
Suggested Study Designs

Key Uncertainty: SEDIMENT DYNAMICS

STUDY DESIGN 1. PROPOSED ISLAND POND RESTORATION

Potential Sediment Dynamics Study for the Planning Phase (proposed by South Bay Science Team)

The Fish & Wildlife Service proposes to restore the Island Ponds in the Alviso Complex (ponds A19, A20, A21) to tidal action by Spring 2006, as part of the Initial Stewardship Plan (ISP) (Life Science, 2003). Aerial photographs, local bathymetry, characteristics of the ponds, and the proposed ISP action (preliminary) are included in Table 1 for reference. The bottom elevations of the ponds are relatively high for the Alviso System, providing opportunities for restoration to tidal marsh. Borrow ditches are present in each pond, with elevations ranging from 4 to 8 feet lower than pond elevation. The location, size, and characteristics of the ponds lend themselves to incorporating different design elements and conducting sediment dynamics studies, which could be used to reduce uncertainties in design and ultimate performance for other phases of the South Bay Salt Pond Restoration Project.

This region of San Francisco Bay is shallow, with mudflats/marshes along the levees on both sides of Coyote Creek, and exhibits characteristics of a smaller scale estuary, including strong longitudinal salinity gradients and periodic stratification (Simons, 2000) due to flows from the San Jose/Santa Clara Water Pollution Control Plant and the Coyote Watershed. Tides are particularly strong in this region of San Francisco Bay, with an average tidal range of 2.19 meters at nearby NOAA station 9414575. It is also an area that is high in suspended sediment load, and exhibits significant stratification during winter/spring runoff. Conditions along the edges of all 3 ponds are expected to be different (pond A19 experiences lesser tidal influence than downstream ponds).

In addition to constraints that apply to many ponds, outlined in the Initial Opportunities and Constraints Summary Report (PWA 2005), the design of tidal restoration may be constrained by several factors unique to these ponds

- Presence of Southern Pacific Railroad between pond A21 and A20
- Presence of railroad bridges across Coyote Creek and Mud Slough
- Limited accessibility of ponds

The railroad crossing may limit design flexibility because it prohibits hydrologic connections between A21 and A20 and due to concerns of scour of sediment at the bridges. The limited accessibility of the ponds increases the expense of grading or other construction activities.

The design strategy stated in the ISP is to establish full tidal circulation into the 3 ponds by locating levee breaches in a manner that would minimize disturbance to tidal marsh habitat (Life Science, 2003). The actions will potentially involve removal of any brine, constructing new levee breaches between the ponds and Coyote Creek, and abandoning or removing existing hydraulic control structures (siphons, pumps, gates).

The project presents the opportunity to incorporate different design elements into the 3 ponds. The primary objectives of this study are:

- To evaluate the effect of design features on sediment accretion rates and patterns within the restored pond(s).
- To evaluate offsite changes in the vicinity (suspended sediment, mudflat scour) resulting from the restoration.
- To test whether accretion rates in the ponds can be accurately predicted from observed suspended sediment concentration in the channel.

The influence of the following design elements on sediment retention and deposition rates will be monitored :

- type of breach (trapezoidal channel versus lowering of levee section, etc.)
- breach geometry (shape and dimensions of breach)
- location of breach (orientation of breach relative to direction of velocity vector)

Additional design elements may be incorporated in the design

- filling of borrow ditches near breach locations
- construction of pilot channels
- construction of wind fetch breaks

It is recommended that borrow ditches are plugged near breach locations and that breach locations are placed near remnant channels to the extent possible. If remnant channels are not present near breach locations, it may be appropriate to construct pilot channels. Wind fetch breaks may be appropriate in pond A19 due to the large size of this pond.

The exact design proposed in the Island Pond restoration will be largely a function of budget availability and will require significant planning. The Science Team suggests the following

- Different breach geometries should be used in different ponds to allow differences in inundation properties among the ponds.
- If possible, breaches should be placed on both Mud Slough and Coyote Creek.
- Due to the relatively high bottom elevation in pond A21 (2.3 ft NGVD), it may be appropriate to grade sections of levee to marshplain elevation to allow some tidal flows in and out of A21. Initially this geometry would limit tidal flows and tidal range in A21 which may increase as channels develop to connect A21 to Coyote Creek.
- A20 and A19 have similar bottom elevations but the area of A19 is approximately four times greater than the area of A20. Due to the large size of pond A19 it could be divided into multiple regions separated by high marsh or relatively low levees in a North South alignment. Both A20 and the regions of A19 could be initially connected to Coyote Creek at different elevations to test the effect of tidal exchange on sediment accretion. A low elevation (deep) breach, particularly if connected to a borrow ditch, remnant channel or pilot channel, would allow maximum tidal exchange and the entry of relatively large sediment mass during each flood tide. However, this geometry may not be effective at trapping sediment inside A19. A relatively high breach invert (shallow breach) would allow less sediment mass to enter a pond but would improve sediment trapping efficiency. One or more region may be connected to Mud Slough by an additional breach that would increase circulation.

The parameters to be monitored and potential monitoring locations will include the following:

1. Elevation and settlement monitoring using graduated markers or stakes at various locations within the restored ponds. The markers would be installed and tied in to appropriate survey monuments prior to breaching. Pond bottom elevation and settlement would be monitored at the markers on a weekly basis for a period immediately after breaching (few months, depending on timing of breach) and less frequently after that (monthly, tailing off to quarterly). Depending on sedimentation rates, the frequency of monitoring would be adjusted after the first year or two.
2. Cross section surveys in the vicinity of the breach (landward and seaward of each breach) to assess morphologic changes in the channel, mudflats, and fringing marshes.
3. Suspended sediment concentration within Coyote Creek prior to breaching, inside and outside the restored pond. The data would be collected as stationary, continuous measurements in Coyote Creek landward of the Island Ponds, adjacent to the Island Ponds and seaward of the Island Ponds. Data collection at these continuous measurement stations should commence as soon as possible to provide baseline (pre-breach) data. Additional continuous monitoring stations should be placed in or near individual breaches and inside the restored ponds.
4. High frequency pressure measurements in conjunction with SSC measurements inside one or more Island Pond to evaluate the effect of wind-wave resuspension on SSC.
5. It is assumed that other hydrologic data including water levels, wind speed and direction, rainfall, atmospheric pressure, and salinity would be an ongoing monitoring effort as part of the SBSP planning and environmental studies. Therefore, it is not included as part of this effort.

Results would be used to develop a sediment budget for the immediate area, and estimate accretion rates for different areas within the restored ponds. The rate of accretion will probably vary spatially (based on pond elevation, tidal hydrodynamics) and temporally (spring-neap cycle, seasonality), which will be evaluated in the results.

The Island Ponds also present opportunities to increase knowledge regarding several other key physical and ecological processes/issues in the South Bay Salt Pond Restoration Project, including:

- Methylation of mercury
- Primary productivity in restored areas
- Dissolved oxygen dynamics

Each of these issues is important both near the Island Ponds and in other regions of the Project. Furthermore, different design among ponds would change the duration, frequency and depth of inundation which will affect these physical and ecological processes. Other important differences among restored Island Ponds are also likely, including salinity, residence time and turbidity differences.

In addition to advancing scientific knowledge relevant to the Project, monitoring of the Island Pond restoration will also provide valuable data that can be used by the Consultant Team in model calibration and/or validation.

Table 1. Characteristics of Island Ponds

Pond	Size (acres)	Existing Elevation (approximate)		
		(ft, MLLW)	(ft, NGVD)	(ft, MHW)
A19	276	6.2	1.8	-1.8
A20	67	6.2	1.8	-1.8
A21	142	6.7	2.3	-1.2

References

Life Science Inc. 2003a. South Bay Salt Ponds Initial Stewardship Plan, June 2003. Woodland, CA. 251 pp. http://www.southbayrestoration.org/Documents.html

Simons, R. 2000. Stratification and suspended solids patterns in an artificially forced salt-marsh channel, Coyote Creek, South San Francisco Bay, California. Unpublished report, Stanford University, Stanford, CA.


A21
A20
A19


A19
A20
A21


37° 30'
122°
05'
COYOTE CREEK
(see note B)
Mowry Slough
Mud Slough
Alviso Slough
Guadalupe Slough
Newark Slough
Plummer Creek
Charleston Slough
Mountain View Slough
Mayfield Slough
Stevens Creek
Dumbarton Pt
Calaveras Pt
Long Pt
Sand Pt
South Shore Port
Alviso
Pipeline Area
Salt pond
Marsh
TOWER
TANK
UP RR
FIXED BRIDGE
Spoil Area
Palo Alto Airport of Santa Clara County
NOTE B
CAUTION
Mariners are warned that numerous uncharted piles, snags, pumps, siphons, and pipes, some submerged, may exist along the edges of the waterways.
Fl G 4s 15ft 3M "17" Ra Ref
Fl R 4s 15ft 3M "18" Ra Ref
Fl R 4s 15ft 3M "16" Ra Ref
Covered wells may be marked by lighted or unlighted buoys.

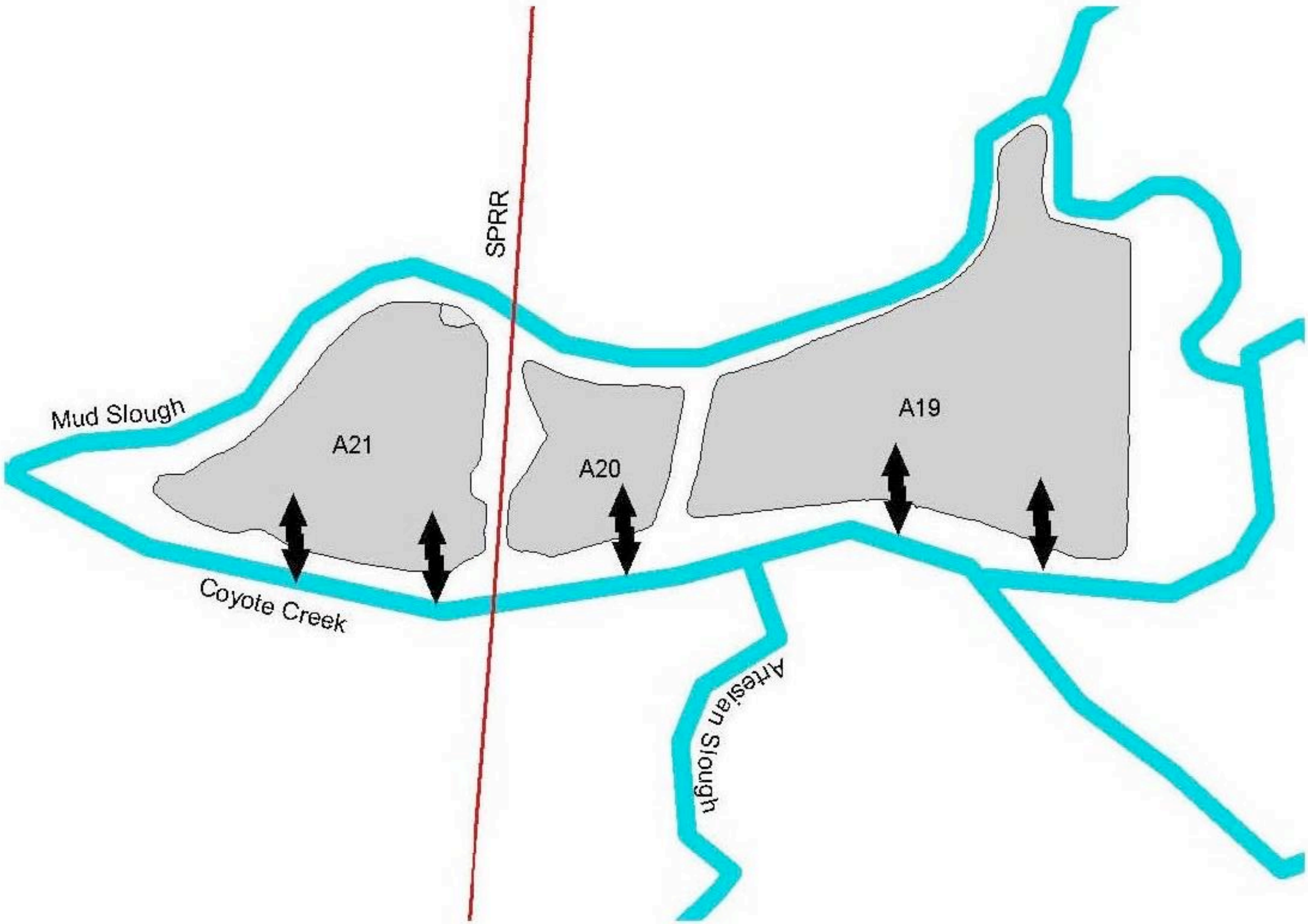

Figure 4-11
Map of Alviso Complex Island Breach Locations

STUDY DESIGN 2.
PROPOSED EDEN LANDING PRE- AND POST-BREACH EVOLUTION STUDIES FOR THE PLANNING PHASE

David Schoellhamer and Greg Shellenbarger, USGS, May 2005

In September 2005, some of the 835 acres of the Eden Landing Ecological Reserve owned by the California Department of Fish and Game and adjacent to the Baumberg salt pond complex will be opened to tidal action. Initially, a connection to Old Alameda Creek will be made, followed by an opening to Mt. Eden Creek in the following year (C. Wilcox, CDFG, personal communication). The opening of the previously diked areas will lead to an increase in tidal prism in Old Alameda Creek as it delivers water from the bay to the restoration site. It is assumed that this channel will undergo an erosive period because of the increase in the volume and velocity of the water passing through it. There is also potential that the mudflats immediately in front of Old Alameda Creek will also erode because of the increased flows. The Eden Landing restoration can serve as a model for potential restoration effects in other channels and mudflats of South Bay. We will address the question of whether breaching will significantly increase erosive forces in the channels and mudflats and quantify any erosion.

1) Pre-breach monitoring: A pre-breach bathymetric survey will be conducted in the channel of Old Alameda Creek. The mudflats that are immediately in front of the mouth of the channel were surveyed in January 2005 as part of the entire South Bay bathymetry study, so these regions will not have to be re-surveyed before breaching. Some additional survey data from the channels may be available from Alameda. One, half-circle acoustic Doppler current profiler (ADCP) transect series on the Bay side of the mouth of Old Alameda Creek over a flood-ebb tidal cycle will be used to quantify flow strength and patterns on the mudflats in front of the channel mouth.

2) Breach monitoring: Water discharge and suspended sediment flux will be monitored in Old Alameda Creek channel with an ADCP/CTDO (conductivity, temperature, depth and optical turbidity sonde) for one month prior to breaching at Eden Landing and two months afterward. This will allow us to calculate the change in tidal prism and sediment transport caused by the breaching.

3) Post-breach monitoring: The channel and mudflats will be resurveyed during summer 2006 to calculate changes that have occurred since the proposed September 2005 breaching events. The mudflat transect will be remeasured with the ADCP to quantify the change in flow strength and patterns for an equivalent tidal cycle. A journal article or report describing results of all three study components will be written.

Key Uncertainty: BIRD USE OF CHANGING HABITATS

STUDY DESIGN 1. DRAFT AMP Study Design to Reduce Uncertainties for Birds: Multi-use managed ponds for shorebird foraging and snowy plover nesting
May 24, 2005

Drafted by Cheryl Strong, SFBBO, and Lynne Trulio, SJSU
Comments from Carl Wilcox, DFG, Ron Duke, HT Harvey, and John Bourgeois, HT Harvey

General Uncertainty Addressed: Can the pre-ISP number and diversity of migratory and breeding shorebirds and waterfowl be supported in a reduced habitat area?

Specifically, this study tests whether ponds flooded for shorebirds in the winter/migrating period can be used by western snowy plovers if dried out in the spring/summer to create panne nesting habitat. If ponds are managed as multi-use wildlife habitat for birds whose habitat needs seem to conflict, then less acreage of managed ponds may need to be maintained.

Because this study requires only water level management, it should be conducted during the planning phase of the Project.

Specific Hypothesis:
Ho: Managing water levels in ponds so that they are dry in the summer and flooded to a depth of <15 cm in the winter will not attract breeding Western snowy plovers and foraging migratory shorebirds at the same levels as ponds not managed in this way.

Treatment Sites:
Carl Wilcox, California Department of Fish and Game, suggests that these ponds in the Eden Landing complex are candidates for experimental manipulation for this study: 6A/B, 12/13/14 and 15/16.

Control Sites:
We need to identify at least three ponds of comparable depth and salinity currently used by foraging birds. Ideally, they will be adjacent ponds at the Eden Landing/greater Baumberg complex, but they may be in other parts of the Project or Bay.

We need to identify at least three ponds that are current snowy plover nesting areas. Ideally, they will be within the Eden Landing/greater Baumberg complex, but they may be in other parts of the Project or Bay.

Parameters Measured:

1. **Shorebird** diversity, abundance and percent time feeding in treatment and control ponds.

2. **Number of snowy plover** nests and nest productivity in treatment and control ponds.

3. **Distance** to forage for snowy plovers in treatment and control ponds or percent time spent feeding in ponds if high salinity areas of brine flies are available within ponds.

4. **Invertebrate** density, diversity, and abundance in treatment and control ponds including benthic invertebrates during shorebird migratory seasons and brine fly availability/abundance in ponds during nesting season; may also determine biomass and caloric value of invertebrate prey.

5. Pond characteristics including salinity, depth, temperature, DO, pH, chlorophyll ‘a’, and nutrients during periods when treatment ponds are flooded; measure shorebird control ponds during this period.

Methods:

1. August-April, each month (minimally, may increase to each week for a more concentrated survey) birds on each of the six ponds will be counted within three hours of high tide. All birds will be located on pond, counted and identified to species. Behavior of birds will be identified as feeding and not feeding. This is a modified version of current USGS protocols that will make these data comparable to USGS data.

2. April-August, all snowy plover activity on the pond will be identified to determine foraging and nesting use of the six ponds. Foraging birds will be counted as shorebirds above; nesting birds will be followed as per SFBBO/FWS protocols: nests identified, egg date determined, and return visits at approximate 1-2 times/week to determine nest fate. In addition, banding of chicks and adults could occur to determine reproductive success.

3. Weekly to monthly invertebrate surveys will be conducted using sweep and benthic samples in three locations in each pond with water. Samples will be preserved and identified as per USGS protocol. In addition, brine fly availability and abundance will be determined by sweep samples in ponds. Biomass and caloric value of invertebrates can be determined from samples.

4. Water salinity, pH, temperature, dissolved oxygen will be determined with Hydrolab-type water quality meters. Water depth can be measured using existing staff gauges within ponds. Water quality sampling to occur in conjunction with shorebird and invertebrate sampling above. Other possible nutrients that can be measured include: chlorophyll, nitrogen, phosphorous, and sulfur.

Timeline:

This study should be conducted during the Project planning period. Pond drying and inundation would follow this schedule.

Month:	J	F	M	A	M	J	J	A	S	O	N	D
Management:												
Water levels	<0.15m	<0.15m	<0.15m	Allow pond to dry	Dry	Dry	Dry	Water back into pond	Water level at ~ <0.15m	<0.15m	<0.15m	<0.15m
Sampling:												
Water quality	X	X	X	X				X	X	X	X	X
Snowy Plovers				X	X	X	X	X				
Shorebirds	X	X	X	X				X	X	X	X	X
Brine flies				X	X	X	X	X				
Benthic invertebrates	X	X	X	X				X	X	X	X	X

Possible issues:

Weather. If ponds do not dry fast enough, there will be no plover nesting habitat. If the entire pond does not dry, the creation of islands or isolated peninsulas will be necessary to create plover nesting habitat.

Vegetation. Will vegetation cover be an issue if ponds are not flooded with salt water long enough?

Plover use. Some attraction (i.e. decoys) may be required to draw plovers to breed in experimental ponds. An adjacent area capable of producing large numbers of brine flies is required if no borrow ditch or other high salinity areas are available within the experimental ponds themselves.

Alternative Experimental Approach: **Water on the Treatment Sites Year-round**

If snowy plover breeding habitat could be combined with year-round water, shorebird foraging could be supported even during the plover nesting season. For such a study, plover nesting islands would need to be created (such as through furrowing). In addition, the treatment ponds would need to have a gradient for flow and pond infrastructure that allowed water to move continually through the site. Several problems may occur with this study design:

- Water levels would have to be carefully managed so that nests are not flooded.
- Water would need to move fast enough to boost DO and prevent mosquito breeding.
- Water flow may leach salts allowing vegetation to invade, which would reduce the sites' value to shorebirds and plovers.
- Overall, this is a difficult management regime (Wilcox, pers. comm.).

Piggy-backing other Uncertainties Studies

Other primary areas of uncertainty for the Project are social dynamics, sediment dynamics, predator and problem species control, and methylmercury mobilization.

A study designed to determine MeHg mobilized by this water management regime could logically accompany this bird uncertainty study. In addition, a study of methods to protect plovers and chicks from predators could also be co-designed with this experiment.

STUDY DESIGN 2. Draft AMP Study Design to Reduce Uncertainties for Birds: Reconfiguring Ponds for Migratory and Nesting Birds
June 1, 2005

Adapted from a December 15, 2004 proposal by:
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General Uncertainty Addressed: Can the pre-ISP number and diversity of migratory and breeding shorebirds and waterfowl be supported in a reduced habitat area?

Specifically, this study tests whether ponds, reconfigured to provide nesting islands for breeding birds and accessible foraging habitat for migratory birds can increase bird use above pre-ISP levels of diversity and abundance. If ponds are managed for higher densities of birds, while still proving high quality habitat, then less acreage of managed ponds will need to be maintained.

Because significant engineering and earth-moving is required, this study should be conducting during the Phase 1 project.

Specific Hypothesis:
Ho: Creating isolated nesting islands, engineering levees with shallow slopes and reconfiguring pond bottoms to provide water at a depth accessible to birds will not significantly increase breeding bird densities or significantly increase the foraging bird densities compared to pre-ISP conditions.

Treatment Sites:
We will reconfigure ponds by changing the bottom topography and adding material to levee sides to provide shallow water (<15 cm) and deep water (>50 cm) foraging habitat. We will also create number of islands of different sizes and configurations. These treatments will occur in at least two ponds. Ponds will be chosen that hold water during the breeding season under current management and that are expected to be retained as managed waterbird habitat under the long-term restoration project. Potential ponds include pond A16 and pond A3W in the Alviso area.

Control Sites:
We will identify at least three ponds of comparable depth and salinity currently used by foraging birds and nesting birds. Ideally, they will be adjacent ponds in the same complex as the treatment ponds, but they may be in other parts of the Project or Bay.

Parameters Measured in Treatment and Control Ponds:
1. Shorebird and waterfowl diversity, abundance and percent time feeding in treatment and control ponds.

2. Number of breeding bird nests by species and nest productivity (as measured by chicks fledged) in treatment and control ponds.

3. Invertebrate density, diversity, and abundance including benthic invertebrates during shorebird migratory seasons and brine fly availability/abundance in ponds during nesting season; may also determine biomass and caloric value of invertebrate prey.

4. Habitat quality characteristics including fecal coliform levels, fish abundance and diversity, predation rates (especially by fox, corvids, gulls).

5. Pond characteristics including salinity, depth, temperature, DO, pH, chlorophyll 'a', and nutrients.

Methods:

1. Islands will be created from adjacent pond mud, using a dredge, and smoothed on top to provide suitable nesting habitat. In each pond, we will create 12 islands. Three sizes will be used: small (about 3m by 3m), medium (about 5m by 50m), and large (about 10m by 100m).
2. Islands will be oriented parallel to the prevailing northwesterly winds to prevent wind waves from spilling over the top. Two shapes will be used on the medium and large islands: straight, and zig-zag. The zig-zag shape will provide greater edge length, and may provide more sheltered habitat on the leeward sides of the islands and potentially greater nesting densities of some bird species that prefer not to nest within direct sight of another nest.
3. On the small islands only two substrate treatments will be used: none (dredge spoils), and decomposed granite or a sand/shell mix. Four islands of each size will be constructed in each pond, to allow for two replicates in each pond of the size and substrate treatments.
4. From March to September, nesting islands will be monitored weekly using spotting scopes from adjacent levees, or by kayak, if islands are too far from levees to estimate number of nests. We will record the number and species of birds roosting and nesting, stage of nests, and fledging success. Predation and harassment events will be counted.
5. During winter, islands will be monitored weekly at high tide, to assess their utilization by roosting shorebirds and other waterbirds. Surveys will be conducted starting the first March after construction, and continuing for five years.
6. Each month (minimally, may increase to each week for a more concentrated survey) foraging birds in the ponds will be counted within three hours of high tide. All birds will be located on pond, counted and identified to species. Behavior of birds will be identified as feeding and not feeding. This is a modified version of current USGS protocols that will make these data comparable to USGS data.
7. Weekly to monthly invertebrate surveys will be conducted using sweep and benthic samples in three locations in each pond with water. Samples will be preserved and identified as per USGS protocol. In addition, brine fly availability and abundance will be determined by sweep samples in ponds. Biomass and caloric value of invertebrates can be determined from samples. Fish will be sampled every other month.

9. Water salinity, pH, temperature, dissolved oxygen will be determined with Hydrolab-type water quality meters. Water depth can be measured using existing staff gauges within ponds. Water quality sampling to occur in conjunction with shorebird and invertebrate sampling above.
10. Samples for fecal coliform, chlorophyll 'a' and nutrients will be collected in conjunction with shorebird and invertebrate sampling above.

Piggy-backing other Uncertainties Studies

Other primary areas of uncertainty for the Project are social dynamics, sediment dynamics, predator and problem species control, and methylmercury mobilization.

A study designed to determine MeHg mobilized by this water management regime could logically accompany this bird uncertainty study, especially since MeHg is of particular concern in the Alviso Complex. In addition, a study of methods to protect breeding birds and chicks from predators could also be co-designed with this experiment.

APPENDIX 4.
Suggested Proposal Solicitation and Directed Studies Processes

PART 1. PROPOSAL SOLICITATION

Calls for Proposals

The process for developing questions for study will be directed by the Applied Studies Team. When the list of approved applied study questions has been developed, one or more RFPs, designed to solicit proposals for addressing these study questions, would be prepared by the Project's sponsoring agencies and reviewed by the appropriate management and technical oversight bodies. The sponsoring agencies will also publicize the criteria to be used in proposal evaluation (see draft list below).

Pre-Proposals. It is expected that the South Bay Salt Pond Applied Studies Program will result in the submittal of many proposals. In order to reduce the necessity for a large number of proponents to expend much effort in developing proposals that are eventually not funded, the Applied Studies Team (AST) will require that all proposals be preceded by a brief pre-proposal. Pre-proposals will be reviewed by the sponsoring agency staff, assisted by the AST and Local Science Panel to ensure that the proposed work is responsive to the RFP, that the proposed work has apparent scientific merit, and that the funding request seems reasonable.

Proposals. Each proposal study plan must contain sufficient information to allow for technical and statistical evaluation by peer reviewers, including details about experimental design, field and laboratory procedures, data collection, and quantitative methods.

The following format is recommended for all Focused Research Program proposals:

1. *Cover sheet* - A transmittal document that includes the RFP number and date; the title of the proposal; a brief statement of the purpose and objectives of the proposed study; the total funding requested by year; the name and home institution(s) of the PIs and Co-PIs; the name of the institution's Grant Administrator; the applicant's tax status; and dated signature lines for the Principal Investigator(s) and the institutional representative.
2. *Abstract* – A brief, topical abstract (200 words or less).
3. *Background and justification* - Statement of the problem(s) being addressed, hypotheses being tested, information needed, and relationship/relevance of the problem(s) being addressed to other South Bay Salt Pond Restoration Project projects or sponsoring agency projects and programs, with reference to appropriate literature citations regarding the problem(s).
4. *Study Objectives* – Description of the planned outcome of the study
5. *Study area(s)* – Description of the study location, i.e., whether it is a field and/or laboratory study. A field study proposal should include clear identification and description of the study sites, with a map.
6. *Approach* – Description of the study approach, with sampling and analytical procedures clearly described for each objective. Include details on methods/techniques, equipment and facilities, data collection, statistical analysis and quality assurance procedures, and describe the criteria to be used in hypothesis testing.

7. *Data archiving procedures* – Description of how the data will be handled, stored, and made accessible. All data collected under the auspices and funding of the South Bay Salt Pond Restoration Project will be made accessible through an SFEI database.
8. *Work Schedule* - An annual time line with expected start and stop dates, and accomplishment of major milestones.
9. *Hazard assessment/safety certification* – Identification of anticipated hazard or safety concerns affecting project personnel (e.g. aircraft, off-road vehicles, chemicals, and extreme environmental conditions).
10. *Permission to access CA Department of Fish & Game and US Fish & Wildlife Service lands* – Documentation of permission to access government property for purposes of conducting research and monitoring, or documentation that permission will be granted if funding is provided.
11. *Animal care and use certification* – Discussion of anticipated uses of animals in the research, including copies of approved forms for animal care and use. If animals are not to be used, collected, manipulated, or experimented upon, include a specific statement to the fact that no animals will be used in the research.
12. *Expected product(s)* - List of planned publications, reports, presentations, advances in technology, information transfer at workshops, seminars, or other meetings.
13. *Qualifications of Investigators, partnerships, and cooperators* - Brief resumes (two pages) of the principle investigators that include descriptions of the qualifications of principal personnel, identification of affiliations, expected contributions to the effort, including logistical support, and relevant bibliographic citations.
14. *Budget and staff allocations* - Detailed budget including salaries and benefits for each participant and costs for travel, equipment, supplies, contracted services, vehicles, and necessary overhead.
15. *Literature cited* - List of all of the publications cited in the text of the proposal.
16. *List of potential reviewers* - Names (minimum of three) and addresses of research scientists with subject area expertise who could serve as peer reviewers for the proposal.

Proposal Review Process

The South Bay Salt Pond Project will award research grants that are selected competitively on the basis of technical merit and relevance of the proposed work to South Bay Salt Pond Restoration Project goals and objectives. To do this will require instituting an objective process for the anonymous peer evaluation of proposals that is efficient and achieves broadest acceptance of the process within the scientific and resource management communities.

To provide overall direction of the review process, an individual having high scientific stature, a broad mandate, and no potential conflicts of interest, will be appointed Chair of the Peer Review Coordination Panel ("Review Panel"). The Science Team could function as this review panel. The Chair would work with the AST Manager to develop and carry out the review process. The Chair would be provided with sufficient funds to cover his/her costs (salary and expenses).

The review process comprises a three-tiered system:

- The Peer Review Panel, which could be the Science Team;
- Technical experts who are solicited by the Peer Review Panel members, perhaps with honoraria for non-agency participants, to provide the first level of anonymous review.

- The AMT and PMT will select the projects to be funded based on the results of the peer review and the priorities of the sponsoring agencies.

Peer Review. The Peer Review Panel would comprise a group of 10-15 technical experts. If so desired, the role of the Review Panel could be assumed by the Local Science Panel. The members of the Peer Review Panel should be active estuarine, freshwater or watershed research scientists/engineers who have a high degree of stature, are well connected with other scientists in their respective fields, represent different specialties within these fields, and have some familiarity with the San Francisco Bay-Delta-watershed system. The Focused Research Program Coordinator would ensure that panel members have no conflicts of interest (e.g., current or pending support from the Program).

The members of the Peer Review Panel will be tasked with soliciting and overseeing the anonymous external (mail) review of proposals. This will be accomplished by having each individual member solicit reviews by at least three experts for each proposal within his/her specialty areas, then summarize and prioritize the member's findings for presentation to the other members of the panel.

Reviewers will score the proposals, based on their scientific merit and the relevance to the RFP, with numerical ratings from 1 (Poor) to 5 (Excellent) using the following criteria:

- Technical merit including (a) research scope, justification, and importance of expected results; (b) reasonableness of the hypotheses and experimental design; (c) soundness of proposed steps for data collection, analysis and synthesis
- The appropriateness of the proposed study to the South Bay Salt Pond Restoration Project goals and objectives and responsiveness to the RFP.
- Qualifications of the investigators and adequacy of the facilities for carrying out the proposed research
- Reasonableness of costs
- Likelihood of success

In the case of continuing projects, consideration will also be given to the level of progress achieved to date.

When all reviews have been received, the proposals will be ranked within each topical category by the Peer Review Panel based on the external mail reviews and the Panel's own evaluation. The panel will develop an overall prioritization of the proposals and will transmit its funding recommendations to the South Bay Salt Pond Focused Research Office for forwarding to the Sponsoring Agency Panel.

PMT Review. The PMT, in conjunction with the AMT, will provide its review and approval of the new proposals to be funded based on the funding available for support of the proposals under each RFP. In its deliberations, the PMT will give most serious consideration to those proposals having been rated 4 or 5 by the Peer Review Panel, and will not select proposals rated 1 or 2. The PMT will also evaluate renewal proposals for continuation beyond the first year. The Applied Studies manager will oversee the administration of funds to support the research efforts.

PART 2. DIRECTED STUDIES PROGRAM

In the course of developing the focused research questions, it will probably become apparent that a specific, sustained research effort may be necessary to resolve one or more of the areas of uncertainty regarding the important resources of the bay-delta-watershed critical to the Restoration Project's goals and objectives. Examples of such needs might include the following:

- Developing an understanding of a specific ecological phenomenon over long temporal and/or large spatial scales
- Conducting major synthetic and theoretical efforts
- Providing information for the identification and solution of specific salt pond management or restoration problems
- Quantifying the linkages between potential stressors and the abundance of species populations

Addressing such needs may require interdisciplinary research coordinated among investigators, experimental studies across a range of appropriate spatial and temporal scales, and development of analytical and numerical models of critical ecosystem functions and responses to management actions.

Given the scope and complexity of some of the issues facing the Restoration Project, it may be necessary to support such sustained commitments of effort irrespective of the responses of scientists/engineers to the annual requests for proposals. In such cases, the PMT may wish to contract with specific individuals or entities, because of recognized expertise, accomplishment, and past responsiveness, to carry out a program of directed research that is not well accommodated in the year-to-year RFP process.

Such questions, identified by the AMT and PMT, will become the subject of contractual arrangements with specific individuals or entities. In each case, the individual/entity will develop a research proposal, using the RFP format described above, that will be subject to review and concurrence (or rejection) by the Science Team and other additional subject-matter referees as necessary, with revisions being made accordingly.

In recognition of the need in these instances for sustained study effort, funding will be provided to successful proponents for specified periods up to six years. It is expected, therefore that the Directed Research Program proposals will incorporate a detailed multi-year strategy and budget. It will also be understood that the Principal Investigator(s) will be expected to make a long-term commitment to meeting the critical South Bay Salt Pond Restoration Project research need(s) described in the contract.

The sustained research efforts under the Directed Research Program will be subject to frequent, vigorous peer review, i.e., at the proposal stage, during the conduct of the research, and upon the conclusion of the study. Written progress reports will be required at the end of each year, or sooner if needed, with a full review of project progress and accomplishment by the Science Review Board at least every three years. Contract renewals will be contingent upon the successful demonstration of progress toward meeting project goals and Restoration Project needs and the submittal of meritorious renewal proposals.