SOUTH BAY SALT POND RESTORATION PROJECT

DRAFT ADAPTIVE MANAGEMENT PLAN

October 28, 2005
Science Team for the South Bay Salt Pond Restoration Project
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Executive Summary

This Adaptive Management Plan (AMP) is designed to assist the South Bay Salt Pond Restoration Project in achieving the Project Objectives. Adaptive management provides a guided approach to learning from restoration and management actions—actions for which many scientific and social uncertainties exist. The AMP lays out the background for adaptive management of the Project in Part I, including the importance of adaptive management in the Project and how adaptive management will guide this 50-year effort toward achieving the Project Objectives. Part II gives the scientific basis for adaptive management, focusing on conceptual models as guides to organizing adaptive management monitoring and applied studies. We provide specifics on the role of restoration targets, monitoring, applied studies and modeling for the Project overall, in the planning stage and in Phase 1. Part III discusses the institutional structure for undertaking adaptive management, beginning in the planning stage, and throughout the many phases of the Project. The purpose of this Plan is to help guide the planning and implementation of each Project phase.

In March 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. The South Bay Salt Pond Restoration Project (Project) is managed collaboratively by the California State Coastal Conservancy (CC), 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 developed by the Project Management Team and the Stakeholders, based on this goal, are central to Project planning.

While much is 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. This document describes adaptive management, the process of learning by doing and then using the results to improve management actions; 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*. As this AMP describes, information for adaptive management will be generated by **monitoring**, **applied studies** and **modeling**.

Project participants have developed a number of visions for what the restored ecosystem could look like in 2050. These visions are important for directing Project planning. However, due to the many Project uncertainties, we cannot currently accurately predict what mix of habitats will optimally meet the Project Objectives. Given this, the Project will use adaptive management as the process for determining how far the system can move toward full tidal action and naturally-functioning tidal marsh, while still meeting the Project Objectives.

The scientific support for this AMP has come from work by the Science Team, the Consultant Team and the National Science Panel with input from the PMT and Stakeholders. As part of the process for organizing this information, the basic conceptual models were combined with Project information to develop focused tidal marsh and managed pond conceptual models, which are used to identify key monitoring and applied studies needed to achieve the Project Objectives. These models show that the Science Team and other project participants have been thorough in identifying uncertainties and the applied studies that arise from them. However, cooperative work among the project participants is still needed to clearly reveal the system

responses we are most certain about. Because this work is not yet complete, restoration targets and associated monitoring parameters cannot be identified for the Project as a whole or Phase 1. Finalizing the AMP will require clearly delineating the best-understood system responses, relative to the Project Objectives, and developing restoration targets linked to those responses.

Adaptive Management relies on clear, measurable restoration targets that link directly with the Project Objectives. Restoration targets are set for those responses of the system for which we are most certain. The final AMP will include a list of restoration targets for the Project and Phase 1, developed cooperatively among the PMT, Science Team, Consultant Team, Stakeholders and appropriate regulatory agencies. Monitoring, using appropriate parameters, allows project managers to assess progress toward Project Objectives as defined by the restoration targets. The list of monitoring parameters for a large project such as this can easily become unmanageable, both financially and logistically. To prevent this, the Project must identify the most essential parameters and the most efficient methods to collect the needed data. Applied studies are undertaken to collect data on the system and its responses in order to reduce the uncertainty related to specific management actions. The Science Team, with input from other project participants, developed a list of key uncertainties and null hypotheses to test them. The AMP includes an Applied Studies Program for the Project that gives key uncertainties, hypotheses, the relationship to management actions and recommended studies. Work by Science Team and Consultant Team members during the planning stage has shown that the Project must develop modeling tools for predicting large-scale and long-term changes to the system. While some tools do exist in the public domain, a concerted research effort is needed to identify and adapt an appropriate model to the South Bay system.

During the planning stage, the Project has moved forward with monitoring, applied studies, and model development that will inform the EIR/EIS process and assist in the design of Phase 1. Monitoring during Project planning began in 2003 to characterize conditions in the ponds, sloughs, and, to some extent, the Bay before and after ISP implementation, i.e., the baseline conditions for the Project. USGS is collecting data on all 54 ponds and the current data set covers a 24-month period from 2003-2005. The USGS is also conducting compliance monitoring, specifically to track water quality conditions before and after culverts are opened for ISP operation. In addition to monitoring, applied studies are underway during the planning stage. Major study efforts include the research program developed by SFEI, USGS and the SCVWD to help establish baseline levels of mercury in indicator (sentinel) species. Another major research effort focuses on studying physical and vegetation changes at the Island Ponds, Ponds 19, 20, 21, during the first year after they are breached. In addition to these programs, several institutions are researching hypotheses on bird use of habitats and the effects of public access on wildlife. The Project has also tapped a team of modelers to begin developing the detailed predictive model the Project needs. This team has submitted a major proposal to NOAA, under the ecological forecasting program, to produce a 2-/3-D, landscape-scale predictive model

Project participants are currently developing the list of actions that will constitute the Phase 1 project, to be implemented beginning in 2008. Actions are being planned for each Project complex. In Phase 1, specific applied studies are coordinated with each restoration and management action and are designed to produce information directly related to Phase 2. The list of actions and associated applied studies are given in Section II. F. As part of the Program and Project (Phase 1) EIR/EIS and Record of Decision (ROD), Project managers will develop a monitoring plan for the Phase 1 actions, which will be used to assess conditions due to Phase 1 actions as well as condition in ponds managed according to the ISP.

Part III describes the proposed decision-making structure that completes the loop between information development and using that information to make decisions. The institutional structure for decision-making described here 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.

The Organizational Structure that will be used to carry out these functions includes three teams, the Project Management Team (PMT), which is responsible for decision-making and taking action on those decisions, the Adaptive Management Team (AMT), which is responsible for data generation, storage, and synthesis and the Information Management Team (IMT), which will organize, store and disseminate Project information. Together, the PMT and AMT will 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. In addition to decision making, the PMT also has important fund raising and public outreach functions. The AMT achieves its functions through three programs: applied studies, monitoring, and science coordination. The PMT and AMT will operate using processes that integrate their activities on three time scales, yearly, monthly and as needed. The AMP describes mechanisms to ensure close coordination between all parts of the organizational structure so that information is shared widely and decisions are made on a timely basis.

The AMP recommends the Project managers develop a *Detailed Plan for Adaptive Management Decision-making* that clearly describes coordination of the Project structure for effective decision-making and implementation. A companion document, *Science Plan for Adaptive Management*, is needed to delineate the roles, responsibilities, and operation of the elements of the science program.

Substantial public involvement is an essential component of successful adaptive management and project implementation 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.

Finally, it is clear that implementing the Adaptive Management Plan, as described here, will require significant and long-term sources of financial support. The Project will develop an explicit Funding Strategy that incorporates federal, state, local, and private funding.

PART I. INTRODUCTION: RATIONALE FOR ADAPTIVE MANAGEMENT

A. Purpose of the Adaptive Management Plan

This Adaptive Management Plan (AMP) is designed to assist the South Bay Salt Pond Restoration Project in achieving the Project Objectives. Adaptive management provides a guided approach to learning from restoration and management actions—actions for which many scientific and social uncertainties exist. The AMP lays out the background for adaptive management of the Project, then gives the scientific basis and institutional structure for undertaking adaptive management, beginning in the planning stage, and throughout the many implementation phases of the Project. This Plan will help guide the planning and implementation of each Project phase.

B. Project Description and Importance of Adaptive Management

In March 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 (CC), 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 developed by the Project Management Team and the Stakeholders, 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 entire Project area is surrounded by the extremely urbanized landscape of the South Bay, also known as Silicon Valley. In 2004, according to the US Census Bureau, over 3.8 million people lived in San Mateo, Santa Clara, and Alameda Counties (see http://quickfacts.census.gov/qfd/states/06000.html for these data), the counties that border the three Project complexes. This urban landscape means there is a significant human dimension to the Project. The Project Objectives that focus on flood management, public access, mosquito control and infrastructure protection attest to the importance of incorporating human needs and wishes into the Project.

The Project complexes consist primarily of former wetlands that were diked off from the Bay as early as the 1860s (Siegel and Bachand 2002). Creation of the levees, extensive urbanization and other actions in the Project region had large effects on the ecosystem of the South San Francisco Bay (south of the San Bruno Shoal) including:

- the loss of at least 85% of historic tidal wetlands;
- changes in sediment dynamics;
- changes in freshwater flows;
- introduction of pollutants, especially mercury;
- changes in species composition and distribution, and
- significant population changes for a number of key species.

The restoration of substantial tidal marsh habitat in the South Bay to reduce or reverse these impacts has long been a goal of the public and agencies (Habitat Goals 2000). However, complete restoration of tidal marsh to historic acreages 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 habitat uses.

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 between 2004 and 2005, at which time the agencies began to manage them under a strategy called the Initial Stewardship Plan (ISP). This plan is designed to manage water salinities and maintain the ponds as independent systems that no longer make salt, in other words, the ISP decouples the ponds from salt making. ISP management produces low to 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 ISP management, 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 much is 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. Monitoring and studies conducted during the Project's planning stage will address some of the uncertainties. However, we will not 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*; adaptive management 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**, **applied studies** and **modeling**. This information will permit effective changes to current phases and assist in the design of future phases of the Project. If data are not collected and applied to management decisions, aspects of the Project will fail or *appear* to fail. Without study, we will not understand the restored system nor will we be able to justify our management actions to the public. Such ignorance of the ecosystem will not generate public support or funding for future phases. Only by documenting progress toward goals and learning from surprises as well as targeted studies, 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 large spatial and long time scales. Before beginning restoration, the Project must collect data to reduce basic uncertainties to the greatest extent possible given the 5-year planning timeframe. The Project leaders will then move forward by implementing Phase 1 actions, monitoring and studying them, and then making improvements based on the information collected.

It is important to realize that large-scale restoration efforts may have effects that some people 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. The Project will also need to balance other goals including flood protection, public access and management of nuisance species. Monitoring, applied studies and modeling are required to understand the trade-offs and their social implications in order to make informed decisions.

Whether salt pond restoration is undertaken or not, the ponds and the South Bay ecosystem will change. 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 path of change and keeping the Project on track toward the Project Objectives.

This Project will occur in *phases* over the coming decades and it has a 50-year planning horizon. Adaptive management for the Project that allows project managers to learn from each phase must include:

- setting and meeting restoration targets for Project Objectives;
- collecting data on monitoring parameters that clearly assess progress toward restoration targets;
- collecting data that will reduce uncertainty related to management actions;
- tracking unexpected outcomes and ensuring timely responses to those outcomes;
- providing predictive modeling and data analysis in a timely manner for use by managers;
- supporting a transparent, publicly-accessible process.

Part II of this AMP gives the scientific basis for adaptive management of the Project, including possible restoration targets, potential monitoring parameters and applied studies. Part III describes 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.

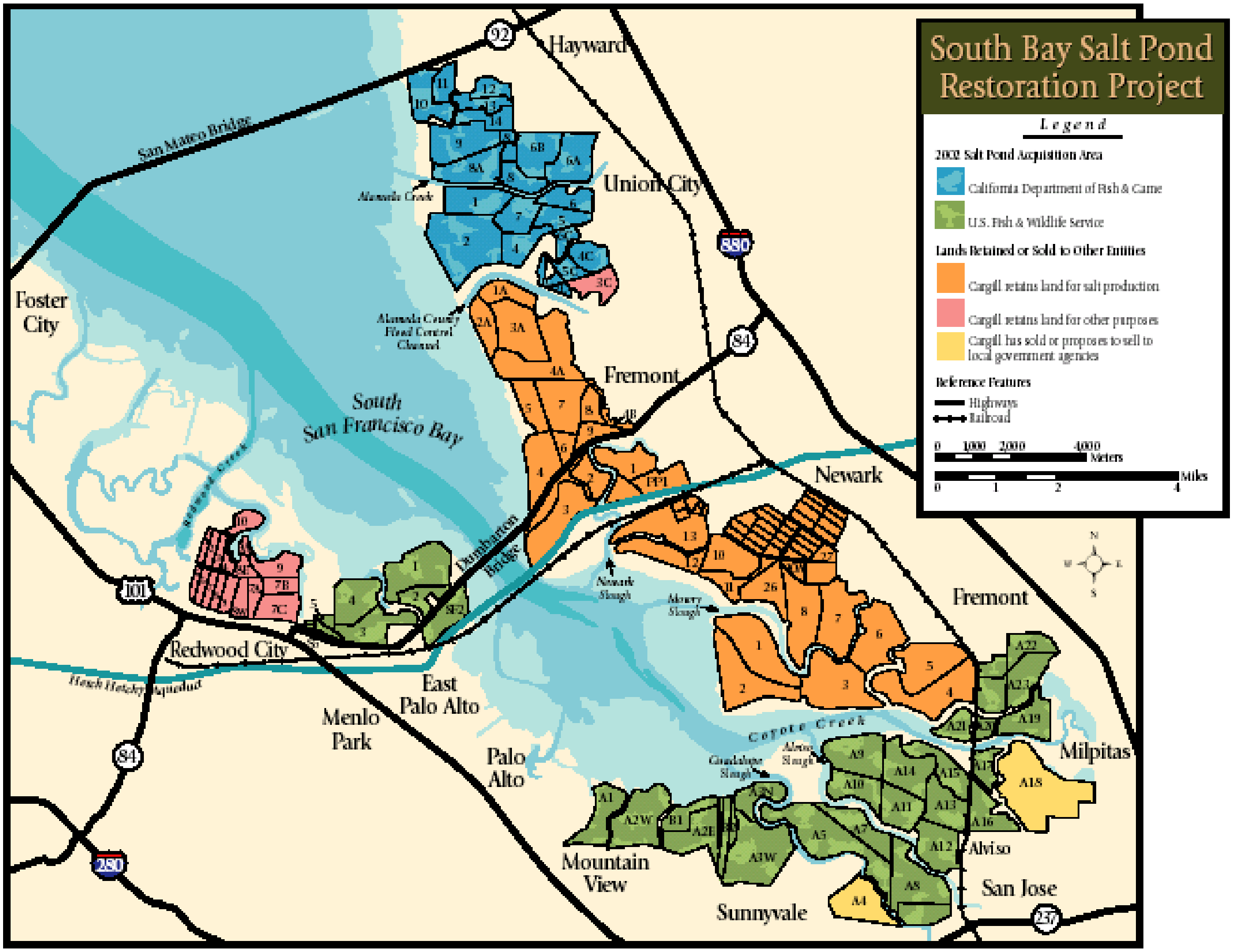
Objective 4. Protect or improve existing levels of water and sediment quality in the South Bay and take into account ecological risks caused by restoration.

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.



C. What is Adaptive Management?

Adaptive management for natural resources 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).

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, which typically reflects an incomplete understanding of critical components of the system. Also, it does not focus solely 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—to the extent we know them. "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 or 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 basic 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 for adaptive management in key management and science roles;
- a responsive and comprehensive Data Management and Storage Repository system;
- 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) has said, "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."

D. Scientific Basis of Project Objectives

Scientific information for the South Bay Salt Pond Restoration Project and the AMP has come from a number of sources including pre-Project reports, the Science Team's Science Syntheses (focused literature reviews) and technical workshops, the NSP Charette, data collected on baseline conditions by the USGS, as well as modeling, research and analysis done by the Consultant Team (Philip Williams and Associates, H.T. Harvey and Associates and PRBO Conservation Science [PRBO]). This information provides a foundation for understanding the ecosystem, setting initial restoration targets and identifying uncertainties.

A viable AMP must include clear, measurable restoration targets (and ranges of natural variability), which are used to judge 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 needed to determine the *minimum* physical, ecological and management conditions required to achieve each Project Objective. This evaluation will be useful for setting Project and Phase-level restoration targets, for determining if all the Objectives are achievable concurrently and for assessing 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 evaluation is still in draft form, but will be completed for the final AMP.

The information 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, although there is significant uncertainty associated with this assessment. Also, some of the ponded area, if managed correctly, may support 125 pairs of Western snowy plovers (*Charadrius alexandrinus nivosus*), an endangered species that uses seasonal wetlands. This is half the 250 pair target for the entire South Bay, as identified by the Western snowy plover recovery plan. Achieving the entire 250 pair South Bay snowy plover goal would, most likely, be difficult in the Project area, if the other Project Objectives are also to be met. For some assessments, it will ultimately be important to understand the extent to which other areas in the South Bay and beyond contribute to species protection and recovery goals. For example, if other parts of the South Bay ever support significant numbers of breeding Western snowy plovers, then demands in the Project area may be scaled accordingly. The extent to which ponds can be reduced and managed, while still meeting goals for migratory birds, nesting 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. The list of critical uncertainties identified by the Science Team (Trulio, et al. 2004) and participants at the NSP Charette (National Science Panel 2005) includes:

- **Mercury methylation**, especially the extent to which Project restoration and management actions might result in an increase in mercury in the food chain above pre-ISP levels.
- **Sediment dynamics**, especially the extent to which tidal marsh restoration might result in the loss of slough and Bay tidal flat habitat.
- **Bird response to habitat change**, especially the extent to which tidal marsh species can be recovered while maintaining the diversity and abundance of nesting and migratory waterbirds observed during pre-ISP conditions.
- **Impacts of invasive and nuisance species**, especially the invasive *Spartina* hybrids, red foxes, California gulls, and mosquitoes.
- **Non-avian species benefits**, especially the extent to which restoration and management can benefit fish and other critical species in the South Bay ecosystem.
- **Social dynamics**, especially the extent to which the local population in the South Bay actively supports the Restoration Project over time.
- **Impacts of large-scale factors**, especially impacts of sea level rise, unpredictable environmental changes (e.g., earthquakes), and changes along the Pacific Flyway.

Results from studies to address these uncertainties will be required in order to proceed from Phase 1 of the Project into later phases. For study, uncertainties must be translated into hypotheses (see Section II.D.). 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 as part of the adaptive management process. Thus, the list above should not be viewed as immutable.

E. 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 processes. Carbon uptake and loss, energy exchange, nutrient cycling and the water balance are typical processes used to distinguish one ecosystem from another (Woodward 1994). Ecosystems have 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, the Bay itself and factors beyond the Bay that are significant influences on South Bay conditions. Additionally, other restoration work and relevant projects around the Bay should be included in 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.

Ecosystem restoration is very complex and our understanding of these intricate systems is insufficient. The South Bay ecosystem is no exception. There are major information gaps and we have poor predictive capabilities on long-term and large spatial scales. Since the results of our management are not always clear, a basic goal of restoration is to allow natural processes to restore ecological structures and functions, to the greatest extent possible (NRC, 1992). Allowing nature to do the work is often the most successful approach to restoration, and in many cases requires less management and reduces project costs.

However, the South Bay is a highly altered system in an urban setting; some Objectives may be reachable only through constant management. Adaptive management will be used to determine the minimum amount of human intervention 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 II.C. for more on monitoring at different ecological levels.

Project participants have developed a number of visions for what the restored ecosystem could look like in 2050. The Consultant Team developed three draft Project alternatives for the NEPA/CEQA process, each with successively more tidal marsh, as shown by the triangles in Figure 2. In addition, the Charette participants developed two landscape visions, a tidal marsh/managed pond mix and a full tidal action vision (circle in Figure 2). These visions are important for directing Project planning. However, due to the many Project uncertainties, we cannot currently accurately predict what mix of habitats will optimally meet the Project Objectives. Given this, the Project will use adaptive management as the process for determining how far the system can move toward full tidal action and naturally-functioning tidal marsh, while still meeting the Project Objectives. The visions for the 50-year landscape are arranged in Figure 2 along a gradient from the configuration with the most managed pond and least tidal marsh (50% tidal action/50% managed pond) to the system with the most tidal marsh (100% of ponds open to full tidal action). As noted above, the scientific analysis of the Project Objectives (Appendix 1) indicates that 50% tidal action and 50% managed pond is a relatively low risk, rational initial vision for the Project, based on current information.

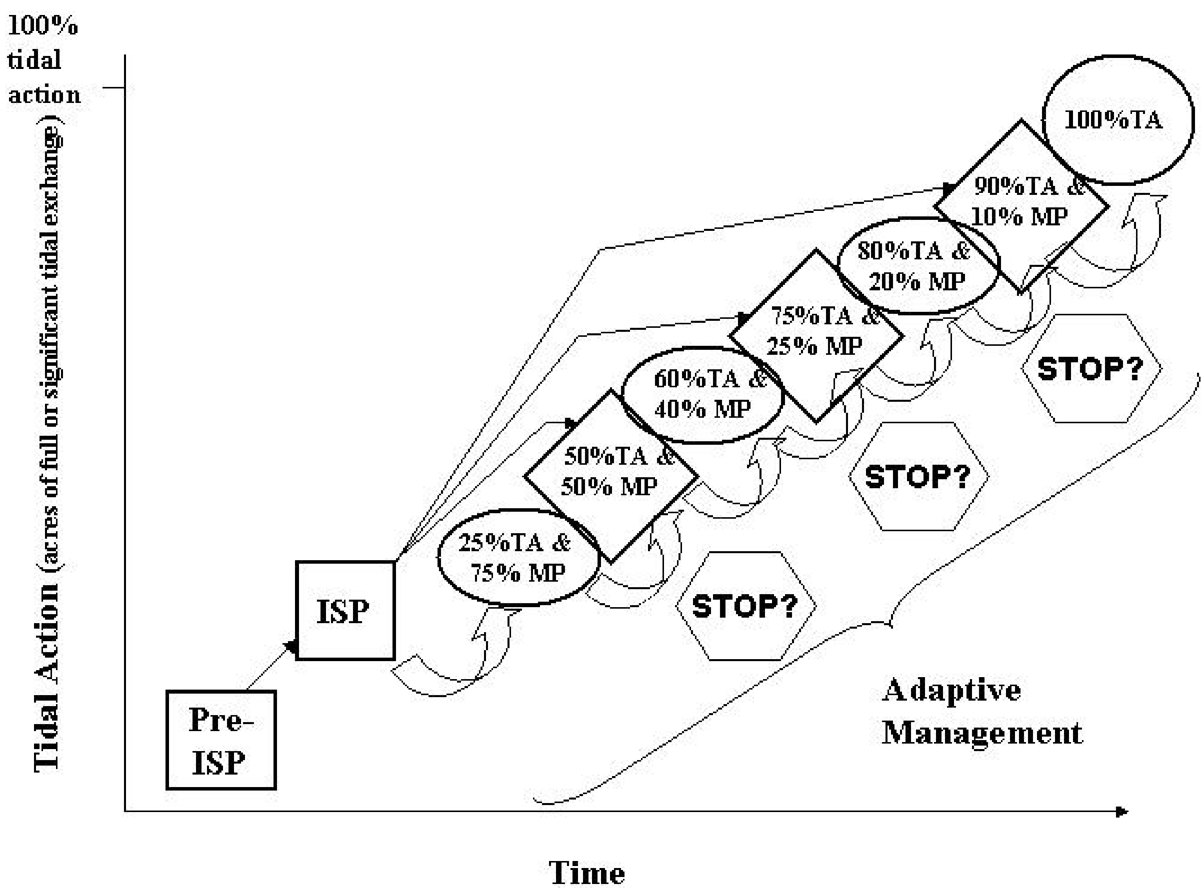
In moving the Project along the tidal action continuum, Project leaders must take care to avoid irreversible changes when there is moderate to high uncertainty with respect to the outcome (Walters 1997). Two situations to avoid are:

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.

For each Project phase, the actions implemented should include those for which we are most certain about the outcome as well as those that provide good opportunities to study uncertainties. As we learn more about the system during each phase, more types of actions will become predictable and can be implemented in later phases. Since many actions, such as levee breaches, are not easily reversible, the goal is to implement actions at each phase that are relatively certain that we will not want to reverse. Implicit in the Project mission is the principle that the Project will continue to add tidal marsh to the system, so long as the other Project Objectives are met.

The ultimate purpose of adaptive management using monitoring, applied studies and modeling 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. Alternative Visions of the Restored South Bay
(TA=percent of full or significant tidal action adequate to develop tidal marsh mosaic habitat; MP=percent of managed ponded habitat; ISP=Initial Stewardship Plan)



PART II. SCIENTIFIC BACKGROUND

A. Introduction

The scientific support for this AMP has come from work by the Science Team, the Consultant Team and the National Science Panel with input from the PMT and Stakeholders. Specifically, literature reviews, technical workshops, modeling, and baseline data have increased our understanding of current modeling capabilities, monitoring needs, Project uncertainties, and study needs. As part of the process for organizing this information, the Science Strategy Team (the initial 6-member Science Team) developed three conceptual models for the Project, which the Science Team has used to identify those aspects of the system about which we are most and least certain. Identifying strong and weak links in our understanding has helped us narrow the range adaptive management monitoring and applied studies needed. Section B discusses the conceptual models.

Focusing the monitoring and applied study efforts is critical 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 important information for Project management should be addressed by adaptive management data collection. The AMP is a guide to the most essential monitoring and applied studies, as identified at this point in the Project's development.

The remainder of the sections in Part II present information on restoration targets, monitoring parameters, applied studies and modeling for the Project and the Phase 1 actions. 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
- Evaluate effects of a specified management action.

Monitoring tells us what is happening, but typically not why. Closing the gaps in our knowledge about how to reach restoration targets requires applied studies to reduce scientific and management uncertainties. Applied 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. 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. Finally, modeling is a multi-purpose tool that allows integration and analysis of the data collected through monitoring and studies. Among other things, models can be used to predict the evolution of the system, evaluate the effects of management actions and provide real-time information to the public.

B. Conceptual Models to Guide Adaptive Management

The Science Strategy Team developed three conceptual models to illustrate processes and outcomes we are most and least confident about with respect to achieving the Project Objectives. A full description of the conceptual models is found in the *South Bay Salt Pond Restoration Project Science Strategy* (Trulio, et al. 2004), which summarizes our current understanding of the ecological functioning of the South Bay and develops landscape level, tidal marsh and managed pond conceptual models based on this information.

The conceptual models illustrate the key steps in moving the current system, dominated by former salt ponds, to a restored system of tidal marsh and managed ponds using restoration and management actions. The conceptual models are based on a stressor model approach to model development (Gross 2003) in which current conditions are altered by anthropogenic inputs/actions. Typically, stressor models evaluate how a naturally functioning ecosystem is impacted by human activities such as pollutant inputs or habitat loss. For our purposes, we reverse this progression. Thus, the initial condition is the impacted system and the human activities are the restoration and management actions we will take to move the system back toward a more naturally-functioning Bay. Primary model elements are initial conditions, restoration actions, the driving forces affected by restoration actions, desired outcomes and potential impacts. We developed models for landscape level changes, tidal marsh restoration and pond management (Appendix 2).

To guide adaptive management learning, we combined these models with literature reviews, monitoring data, consultant work and other information collected by the Project to identify what we know fairly well about how the system operates and where the key uncertainties lie. Monitoring will be implemented to assess outcomes for which we are most certain. Key uncertainties will be investigated with applied studies. Figure 3 shows a focused conceptual model to guide the monitoring and applied studies questions associated with tidal marsh restoration and figure 4 is the managed pond focused model. These models are templates for organizing information and they still require review and revision based on comments from the PMT, Science Team, Consultant Team and stakeholders. Ultimately, the system responses to be monitored and the key uncertainties needing applied studies given in these figures will be reflected in the restoration targets, monitoring and applied studies recommended in the AMP.

The Science Team and other project participants have been thorough in identifying uncertainties and the applied studies that arise from them. (Although, as noted earlier, the key uncertainties are evolving as the Project progresses and will continue to change throughout the live of the Project.) However, cooperative work among the project participants is still needed to clearly reveal the system responses we are most certain about. Because this work is not yet complete, restoration targets and associated monitoring parameters cannot be identified for the Project as a whole or Phase 1. Finalizing the AMP will require clearly delineating the best understood system responses, relative to the Project Objectives, and developing restoration targets linked to those responses. Monitoring plans to be developed for the Phase 1 environmental process will be designed to assess progress toward the restoration targets.

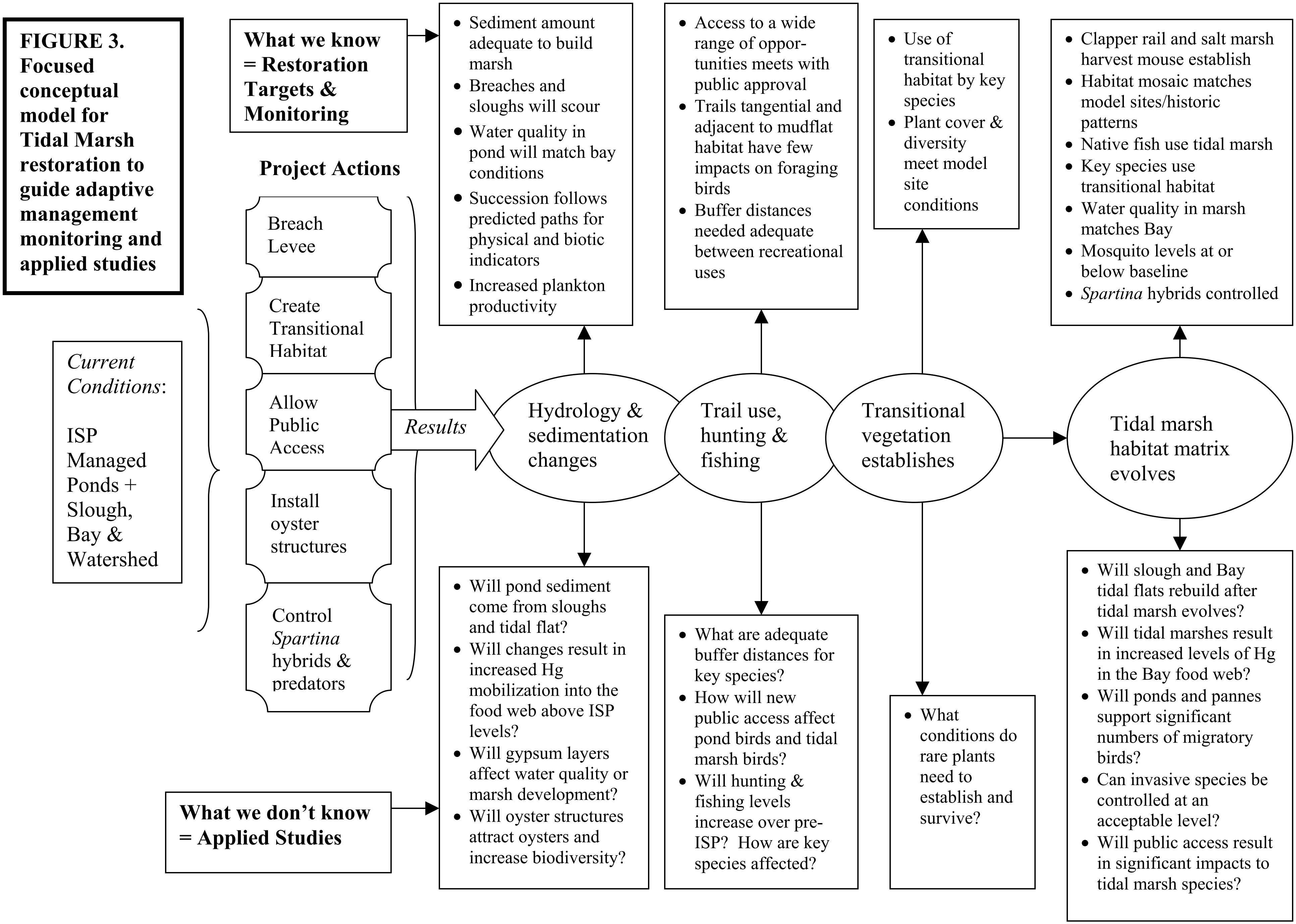


FIGURE 3. Focused conceptual model for Tidal Marsh restoration to guide adaptive management monitoring and applied studies
What we know = Restoration Targets & Monitoring
Project Actions
Breach Levee
Create Transitional Habitat
Allow Public Access
Install oyster structures
Control *Spartina* hybrids & predators
Current Conditions:
ISP Managed Ponds + Slough, Bay & Watershed
Results
Hydrology & sedimentation changes
Trail use, hunting & fishing
Transitional vegetation establishes
Tidal marsh habitat matrix evolves
• Sediment amount adequate to build marsh
• Breaches and sloughs will scour
• Water quality in pond will match bay conditions
• Succession follows predicted paths for physical and biotic indicators
• Increased plankton productivity
• Access to a wide range of opportunities meets with public approval
• Trails tangential and adjacent to mudflat habitat have few impacts on foraging birds
• Buffer distances needed adequate between recreational uses
• Use of transitional habitat by key species
• Plant cover & diversity meet model site conditions
• Clapper rail and salt marsh harvest mouse establish
• Habitat mosaic matches model sites/historic patterns
• Native fish use tidal marsh
• Key species use transitional habitat
• Water quality in marsh matches Bay
• Mosquito levels at or below baseline
• *Spartina* hybrids controlled
What we don't know = Applied Studies
• Will pond sediment come from sloughs and tidal flat?
• Will changes result in increased Hg mobilization into the food web above ISP levels?
• Will gypsum layers affect water quality or marsh development?
• Will oyster structures attract oysters and increase biodiversity?
• What are adequate buffer distances for key species?
• How will new public access affect pond birds and tidal marsh birds?
• Will hunting & fishing levels increase over pre-ISP? How are key species affected?
• What conditions do rare plants need to establish and survive?
• Will slough and Bay tidal flats rebuild after tidal marsh evolves?
• Will tidal marshes result in increased levels of Hg in the Bay food web?
• Will ponds and pannes support significant numbers of migratory birds?
• Can invasive species be controlled at an acceptable level?
• Will public access result in significant impacts to tidal marsh species?

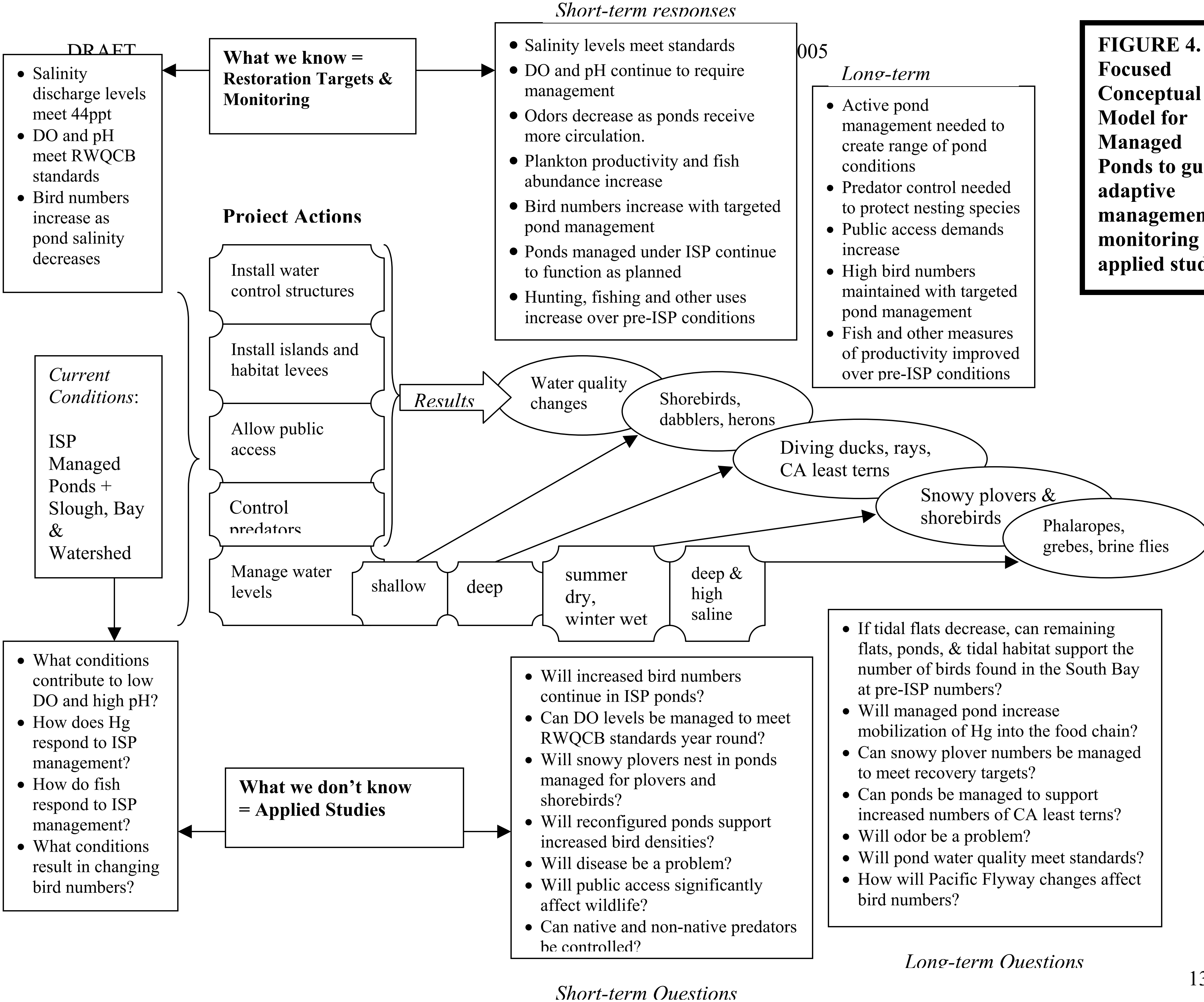


FIGURE 4. Focused Conceptual Model for Managed Ponds to guide adaptive management monitoring and applied studies

C. Restoration Targets and Monitoring for the Project

Restoration Targets. Adaptive Management relies on clear, measurable restoration targets that link directly with the Project Objectives. Restoration targets are set for those responses of the system for which we are most certain (for instance, those responses shown at the top of Figures 3 and 4 for "what we know"). Typically, they are quantitative benchmarks 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 expected at each phase of the implementation. While the targets are quantitative, they must also incorporate ranges of natural variability. When Project conditions diverge from the range of natural variability, managers will need to undertake corrective measures to bring the system back to the desired trajectory (see Section III.C.). 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).

The final AMP will include a list of restoration targets for the Project and Phase 1, linked to the Project Objectives. These targets will be developed cooperatively among the PMT, Science Team, Consultant Team, Stakeholders and appropriate regulatory agencies. Some restoration targets will be set by regulatory agencies. For example, water quality requirements will be primarily determined by the Regional Water Quality Control Board. The US Fish and Wildlife Service will set restoration targets for the South Bay populations of the clapper rail and salt marsh harvest mouse through the Tidal Marsh Species Recovery Plan.

Restoration targets that are not proscribed by agencies will be developed using the best information available. For example, the Scientific Basis for the Project Objectives provides a good starting point for a number of targets based on the literature. Producing targets for each Objectives may also require data from pre-disturbance conditions at the restoration site, measurements at reference sites (relatively undisturbed examples of the target habitat), historical data, or from modeling.

Table 2 gives examples of potential restoration targets; some are well-developed and some are not complete. In this table, only the targets for clapper rail recovery give quantitative goals with ranges of variability. These data, from work by the USFWS, indicate that a quantitative restoration target for the California clapper rail might be a population of between 1500-2000 birds in the Project area (Weiss, pers. comm.). Area of habitat needed to support the minimum number of birds is another target the USFWS may include. Targets for Project Objectives 2, 4 and 5 in Table 2 also have major regulatory components. The restoration target for migratory waterfowl will not be set by regulation and will need to be developed based on data collected by the USFWS before ISP implementation. The average numbers of key waterfowl species in winter and typical ranges of variation would be potential targets for this Objective. The targets for Objective 3, public access, are not well developed. One target might be levels of public satisfaction with access opportunities provided, which would be developed through social science research.

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. While the Project Objectives themselves are expected to remain unchanged throughout the life of the Project, it bears repeating that *restoration targets*, which are quantitative measures of progress toward the Project Objectives, are a set of expectations that may very well 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 in light of adaptive management monitoring and study results to determine if they are still efficient, accurate measures of progress toward the Project Objectives.

In addition, to targets for the 50-year Project and for each Project Phase, when predictive capabilities improve, the Project managers may develop targets that reflect expected conditions at various points in the evolution of the landscape, tidal marshes and managed ponds.

TABLE 2. Examples of Potential Restoration Targets and Monitoring Parameters

Project Objective: Sub-Objective	Potential 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 (from Weiss, pers. comm.)	• number of rails in winter • extent of vegetated tidal marsh • density, cover, height of cordgrass & pickleweed • acres of transitional upland • density of *Grindelia* and other transitional upland plants
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 • acres of intertidal and subtidal habitat in marshes, ponds, sloughs and Bay • fecal coliform levels in heavily used ponds
2. Maintain or improve existing flood protection level	* meet requirements of flood protection agencies (targets to be set by Alameda and Santa Clara County and Army Corps)	• 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
4. Protect or improve existing levels of water and sediment quality: water quality	* ISP and managed pond water quality meets RWQCB standards (many water quality targets will be set by the RWQCB)	• water salinity, DO, pH, temperature, turbidity • current velocity and distance from tidal inlet • nutrient levels (N, P) in tidal and pore water • reactive Hg and MeHg levels
5. Maintain or improve current levels of nuisance and invasive species: mosquitoes	* mosquito numbers do not increase above pre-ISP/ISP levels (allowable levels from the Santa Clara and Alameda mosquito abatement districts)	• methods and parameters as per the mosquito abatement districts

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 large number of parameters will need to be monitored, but monitoring will be constrained by time and cost.

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:

- Beyond the Ecosystem (Multiple Ecosystem) Scale: At this level, parameters should measure very large-scale processes that will affect the Project, such as 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 numbers in the Project area.
- Ecosystem Scale: Ecosystems are large-scale phenomena driven by water, carbon, energy, and nutrient dynamics. Physical metrics should measure sediment dynamics (sediment deposition or erosion and suspended sediment concentrations), 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.
- Community Scale: 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 hybrids) and nuisance species, especially mosquitoes. Typical metrics for populations are distribution, abundance, breeding success, predation rates, habitat quality and extent of habitat.

Monitoring parameters and the overall monitoring plan for Phase 1 and the Project will be developed as part of the EIR/EIS documentation. Table 2 gives examples of some monitoring parameters that may be used to measure progress toward the restoration targets. To be effective, the monitoring parameters chosen must assess ecological structure and function, different ecological levels, and long versus short-term processes. The suite of monitoring metrics should also be able to give early indications of problems in the system.

The list of monitoring parameters for a large project such as this can easily become unmanageable, both financially and logistically. To prevent this, the Project must identify the most essential parameters and the most efficient methods to collect the needed data. The PMT, Consultant Team and Science Team should develop a process for selecting monitoring parameters that will:

a) give data specific to the restoration targets,
b) measure structure and function,
c) include major trophic levels,
d) have existing protocols,
e) be affordable,
f) be measured using efficient monitoring methods.

Whenever possible, monitoring methods should be designed to collect data for multiple parameters. For example, aerial photo and satellite data collection methods can be very economical and can provide information on a range of parameters (Table 3). Other efficient automated data collection tools are LiDAR, data sondes, and photo trapping/monitoring. Field data collection once a month may be needed, but a wide range of sampling can be done in one visit. Collecting sediment cores and topographic elevations, perhaps done once a year, will provide valuable data for a number of parameters. Finally, some methods, such as call counts for clapper rails, which are time consuming and expensive, but may be the only way to assess some parameters.

TABLE 3. Efficient Monitoring Methods and Some Parameters they Measure

Monitoring Method	**Examples of Parameters Measured**	**Project Objective Evaluated**
Aerial Photos or satellite Images	• Aerial extent of tidal marsh • Connectivity of habitats • Form, location, density of channels • Primary productivity • Location, extent of *Spartina* hybrids & other invasive plants	• PO 1A: Increase habitat for tidal marsh species • PO 1A,C: Improve habitat quality for species • PO 1C: Improve ecosystem functioning • PO 5: Control non-native species
Photo trapping/monitoring	• Use of levees by predators, especially red fox, cats, etc. • Nest activities	• PO 1A,B: Improve habitat quality • PO 5: Control non-native species
Monthly site visits	• Waterbird abundance & diversity • Counts of trail users	• PO 1B: Protect current bird diversity • PO 3: Develop public access

	• Water samples for nutrients, productivity, pollutants	• PO 4: Protect water quality
Water quality data sondes	• DO, salinity, temperature, sediment concentrations, currents • Water level elevations	• POA,B,C: Improve ecological functioning • PO 4: Protect water quality
Sediment Cores	• Benthic species diversity • Accretion/erosion rates • Presence of contaminants	• PO 1A,B,C: Increase tidal marsh habitat, improve ecological functioning • PO 4: Protect water and sediment quality

After choosing parameters and methods, monitoring protocols for collecting data must be developed. 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 for Phase 1 should 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. See Section G. for more on Phase 1 monitoring requirements.

C. Applied Studies for the Project

Applied studies are undertaken to provide critical information for making management decisions, reducing uncertainty, and addressing *tractable* research problems (Walters, 1997). The primary uncertainties currently identified are listed in Section I.D. Applied studies use quantitative or qualitative research methods designed to test hypotheses or answer specific research questions. This is the only way to answer cause-and-effect questions and is more likely than monitoring to produce results for a specific question on a time frame needed by the Project. 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 and social 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 in Appendix 3. It is expected that more will develop during Project design and implementation.

Applied 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 a 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 the links between proposed studies and their value to management clear and direct.

For testing, uncertainties must be translated into hypotheses/research questions, which are then converted into study designs. Studies are then implemented and 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 3 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 4 for these study designs.

D. Long-Term Project Modeling

Work by Science Team and Consultant Team members during the planning stage has shown that the Project must develop modeling tools for predicting large-scale and long-term changes to the system. While some tools do exist in the public domain, a concerted research effort is needed to identify and adapt an appropriate model to the South Bay system. See section II.E., below, for work in this area initiated during planning.

For the long-term success of this Project, a well-developed, 2-/3-D model that predicts large-scale and long term changes in physical and biotic conditions will be essential. The uses of this model are varied:

1. To forecast the response of the system and parts of the system to different restoration and/or management actions, and thereby function as a design tool.
2. To predict certain types of conditions, such as low dissolved oxygen areas. For

example, models can be used to identify areas of the Project that are likely to have problems meeting water quality requirements.

3. To show problems in monitoring data, such as identifying where data sets were erroneously entered more than once.

4. To indicate where applied studies are needed by showing key gaps in our knowledge of the system.

5. To explain trends and act as a diagnostic tool to determine system response to hypothetical cases or alternative scenarios. For example, if *Spartina alterniflora* cannot be controlled and studies may indicate this invader will have a significant effect on the South Bay ecosystem, modeling alternative scenarios will be required to predict ecosystem response to this new state and predict how the system might respond to new management actions.

6. To provide the public with real-time information and analysis of system conditions.

E. Monitoring, Applied Studies and Modeling during Planning

During the planning stage, the Project has moved forward with monitoring, applied studies, and model development that will inform the EIR/EIS process and assist in the design of Phase 1.

Monitoring. Monitoring during Project planning began in 2003 to characterize conditions in the ponds, sloughs, and, to some extent, the Bay before and after ISP implementation, i.e., the baseline conditions for the Project. Table 4 lists the monitoring projects underway during planning.

USGS is collecting data on all 54 ponds and the current data set covers a 24-month period from 2003-2005. Data have been collected 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 soluble 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 measured 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 PRBO, as input to their Habitat Conversion Model (Stralberg et al. 2004).

Pond conditions were changing during the 2003 to 2005 monitoring period from what they had been under salt pond operation. During 2003 to 2004, Cargill reduced 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. Thus, the monitoring data include approximately a year of data before ISP operation began (during a period when Cargill was reducing salinities) and the first year of ISP management.

The USGS monitoring teams have written preliminary reports on mercury levels in the ponds as well as water quality, biotics and bathymetry, and when these reports are complete they will be on the Project website. Initial data are showing some unexpected findings. For example, in the first migratory season after the ISP was implemented, shorebird numbers increased at both the Eden Landing and Alviso Complexes by at least 100% from pre-ISP conditions (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 draw-downs reduced habitat and bird use by piscivores, diving ducks and grebes substantially from pre-ISP levels. Continued monitoring will determine whether these species responses will continue over time.

The USGS is also conducting compliance monitoring, specifically to track water quality conditions before and after culverts are opened for ISP operation. The data from this monitoring effort are posted on the Project website. One year of monitoring has shown that salinity, which Project managers worried would not meet requirements set by the Regional Water Quality Control Board, has not be a problem. Instead, low dissolved oxygen (DO) levels have, unexpectedly, plagued a number of ponds during the summers of 2004 and 2005 (CDFG 2005, USFWS 2005). Specific causes for the low DO levels are not clear and will be the subject of applied studies during the planning period. These early findings show that management actions in the Project area are already having some significant impacts on the system, some of which we must study to understand.

During the remainder of the planning phase (through 2008), compliance monitoring of ISP operation will continue. Also, data collection for the overall Project will continue for parameters that require long-term data sets. In 2005-2006, USGS will continue the current level of data collection at all 54 ponds with these exceptions:

1. No collection of benthic organisms;
2. No fish collection in ponds;
3. Monthly bird surveys on tidal flats in the Bay and sloughs will be added.

In addition to current data collection, future monitoring may include these parameters, identified by the Science Team, which are needed to improve modeling or develop baseline data for 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 open bay, tidal flats, ponds and marshes during low and high tides.

TABLE 4. Monitoring and Applied Studies during Project Planning

	Monitoring Project or Study*	Funded By*	Funding Amount
	Monitoring Project		
1	Pond and Project Area Monitoring—USGS, Takekawa, Schoellhamer, Jaffe (2003-05)	Project	~$600K/year
2	Pond and Project Area Monitoring—USGS, Takekawa, Schoellhamer, Jaffe (2005-06)	Project	~$350K
3	LIDAR Survey of South Bay--TerraPoint	Project	$178K
4	Bathymetry of the South Bay--Sea Surveyor, Inc.	Project	$380K
5	Urban Levee Flood Management Requirements--Moffat and Nichol	Project	$300K
6	ISP Water Quality Monitoring--USGS, Takekawa	FWS and DFG	
7	ISP Mercury Monitoring—USGS, Keith Miles (2005-06)	FWS and DFG	~$50K
	Applied Study or Modeling Project		
1	Bird and Habitat Change Modeling--PRBO	CC	$215K
2	Water Quality Data QC and Compilation—USGS, Cloern	USGS	In-kind
3	Pond A8/South Bay Mercury Study--SFEI, USGS, SCVWD	SCVWD, FWS, SFF, CC	~$440K (~$300K in-kind)
4	Bird Diversity and Abundance on Newark Ponds--SFBBO	SFF and FWS	$80K for 2 years
5	Bird Use of Mature and Restored Marshes--PRBO	SFF	$60K for 2 years
6	Snowy Plover use of Managed Ponds; Harbor Seal Response to Watercraft; CA Gull Impacts to Nesting Birds—SJSU, Trulio	SJSU	In-kind
7	Hg in SF Bay-Delta Birds: Trophic pathways, bioaccumulations, and ecotoxicological risk to avian reproduction—USGS, Josh Ackerman	CALFED	unknown
8	Invasive *Spartina* Project (mapping and control)	CC, FWS	unknown
9	Initiate development of 3-D, integrative and predictive model	Proposal to NOAA (10/27/05)	Funding being sought
10	Island Ponds/Eden Landing Adaptive Management Studies: Initial physical and vegetation change	Project	~$100,000
11	Island Ponds/Eden Landing Adaptive Management Studies: Long-term change and ecosystem response	??	Funding being sought

* Acronyms: FWS=US Fish and Wildlife Service; DFG=California Department of Fish and Game; SCVWD=Santa Clara Valley Water District; SFF=San Francisco Foundation; CC=Coastal Conservancy; COPC=California Ocean Protection Council; SJSU=San Jose State University

Applied Studies During Planning. In addition to monitoring, applied studies are underway during the planning stage, as listed in Table 4. Major study efforts include the research program developed by SFEI, USGS and the SCVWD to help establish baseline levels of mercury in indicator (sentinel) species and to assess whether a managed pond, A8, that is restored to tidal action results in increased mercury levels in the sentinel species (Applied Study #3 in Table 4). During planning, pond A8 and the surrounding system will be studied to develop baseline data. Then, during Phase 1, A8 will be opened to tidal action and the resulting mercury impact on local species studied.

Another major research effort focuses on studying physical and vegetation changes at the Island Ponds, Ponds 19, 20, 21, during the first year after they are breached. The ponds will be breached in March 2006 and the PMT will solicit proposals for targeted research using a "directed studies" process (see Appendix 6 for a description of this process). In addition to these programs, Point Reyes Bird Observatory, San Francisco Bay Bird Observatory, and San Jose State University are researching several hypotheses on bird use of habitats and the effects of public access on wildlife. In summary, these key uncertainties and null hypotheses are currently being studied:

- *Mercury*:
  Hypothesis: Levels of MeHg in sentinel species do not differ between tidal marsh and managed pond.

- *Sediment Dynamics*:
  Hypothesis 1: Sediment capture by breached ponds will not be adequate to support the development of tidal marsh on site.
  Hypothesis 2: Sediment loss as a result of breached ponds will not result in significant sediment loss to adjacent tidal flats.

- *Hydrology and Water Quality*:
  Hypothesis 1: Water quality in newly tidal ponds does not meet RWQCB standards during the first year after breaching.
  Hypothesis 2: Newly tidal ponds do not cause a significant change in the water quality of sloughs and the Bay adjacent to those ponds during the first year after breaching compared to pre-breach conditions.

- *Vegetation Changes*:
  Hypothesis 1: The extent and composition of vegetation in and adjacent to newly tidal ponds does not change significantly from pre-breach conditions during the first year after breaching.

- *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 numbers of breeding Western snowy plovers and foraging migratory shorebirds equal to ponds not managed in this way.
  Hypothesis 2: Increases in waterbird numbers on ISP-managed ponds are not due to losses in bird numbers from current salt ponds in Newark.

Hypothesis 3: Increases in waterbird numbers on ISP-managed ponds are not due to losses in bird numbers from local tidal flats.
Hypothesis 4: California gulls are not having a significant impact on the breeding success of waterbirds nesting in the Project area.

- *Public Access and Wildlife Interactions*:
  Hypothesis 1: Local watercraft do not cause significant differences in behavioral responses in loafing harbor seals compared to behavior without watercraft (conducted at Bair Island).

Specific studies central to understanding ponds as operated under ISP management will be identified in early 2006 through the focused work of the second Pond Ecology and Management Workshop and supplemented by a Science Synthesis on pond ecology and management that the Science Team will produce in 2006. The key ISP management uncertainties will appear in the final AMP as will applied studies to address those uncertainties. Certainly, one of those key uncertainties will focus on what pond conditions result in low DO and what management actions can be taken to prevent such conditions. We expect to undertake ISP pond studies in 2006.

Modeling During Planning. During planning, the Consultant Team has used several modeling approaches to predict changes to the system. Philip Williams and Associates is using the Landscape Scale Geomorphic Assessment (LSGA) to predict large-scale habitat changes under various restoration alternatives. The other major model set, PRBO's 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 and development will be the subject of applied studies.

The Consultant Team will also undertake hydrodynamic modeling, coastal flooding analyses and fluvial flooding analyses to support the development of alternatives and for the preparation of the Environmental Impact Statement/Report as required under NEPA and CEQA. In addition, more detailed modeling will be conducted during the design stage of Phase 1, which will provide specific information on the performance of Phase 1 design features.

To begin developing the detailed predictive model the Project needs, researchers associated with the Project have submitted a major proposal to NOAA, under the ecological forecasting program, to produce a 2-/3-D, landscape-scale predictive model (Appendix 6).

F. Applied Studies, Modeling and Monitoring during Phase 1

Phase 1 Actions, Applied Studies and Model Development. In 2008, planning for the Restoration Project will be complete and the Project Managers, Stakeholders and Science Team will have adopted a set of Phase 1 actions. These actions must, among other things, be visible to the public, provide early successes in meeting Project Objectives, and incorporate applied studies to reduce key uncertainties. The PMT and Stakeholders are refining the actions that will constitute Phase 1. Table 5 gives the draft list of Phase 1 actions, as of October 2005.

Table 5 also lists the applied studies that will be integrated into Phase 1 actions. In Phase 1, applied studies are coordinated with each restoration and management action and are designed to produce information directly related to Phase 2. The modest size of the restoration and management actions in Phase 1 is, in part, in recognition of the significant uncertainties currently facing the Project. Thus, applied studies in this Phase are part of the planning for implementing actions on a larger scale in Phase 2. Table 5 includes 13 hypotheses. While this may appear to be a daunting number of studies, many of the hypotheses, such as sediment and water quality, can be researched by one team. Also, a number of the hypotheses will include sites in two or three complexes. Some, such as studies of snowy plover use of managed ponds and the MeHg study, are continuations of current research.

Information developed through these applied studies will be used to determine the size, configuration and design of breached and managed ponds in Phase 2. As Project funding and other funding opportunities become available, additional studies will be undertaken in Phase 1. For example, the PMT fully expects to have longer-term adaptive management studies (developed through an RFP process) underway at the Island Ponds before 2008 and continuing into Phase 1 implementation. This research and that initiated in Phase 1 will augment each other in order to address key questions.

A significant issue for Phase 1 will be 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.). The effect of changes due to Phase 1 will require careful monitoring to understand how ISP ponds are functioning within the restoration project. Operation under the ISP has already revealed unexpected changes in water quality and bird use. Key uncertainties in pond ecology and management are being identified by the Project and we expect applied studies to begin before 2008 and to continue into Phase 1. Therefore, an important goal of ISP pond studies is to understand the effects of Phase 1 restoration and management activities on ponds remaining under ISP management.

Phase 1 is expected to include initial development of the detailed, landscape-scale, predictive model. This core model will be focused on predicting physical processes and changes in the far South Bay, below the Dumbarton Bridge, over 50 years. Applied studies and monitoring should be designed, whenever possible, to collect data to develop and validate the model. After the core model is in place, the Project will seek funding to expand the spatial capabilities of the model (e.g, to the San Bruno Shoal) and develop “extensions” of the model to include contaminant mobilization, vegetation change and ultimately habitat use by key species.

Phase 1 Monitoring Program. To determine progress toward Project Objectives, Project managers will develop a monitoring plan for the Phase 1 actions, which will ultimately supplement the Program and Project (Phase 1) EIR/EIS and Record of Decision (ROD). Monitoring will be used to assess conditions due to Phase 1 actions as well as condition in ponds managed according to the ISP. The goal will be 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 as provided by the AMP;
- Response triggers, which when met, will result in management response using remedial measures, contingency plans or alternative scenarios;

- Construction-related monitoring parameters and protocols;
- Parameters or metrics and protocols for monitoring performance in meeting restoration targets, including real-time monitoring methods and, if possible, 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);
- Roles and responsibilities for monitoring and reporting, 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 deadline.

TABLE 5. Proposed Phase 1 Actions and Associated Applied Studies

Complex	Proposed Phase 1 Action	Applied Studies Null Hypotheses Addressed
Eden Landing	1. Ponds E 10 through 13: manage for breeding and migratory birds—ponds not reconfigured; conduct applied studies on bird use	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
	2. Ponds E 8 and 9: open to full tidal action; conduct applied studies, especially on sediment dynamics	Hypothesis 2: Sediment captured by breached ponds will not be adequate to support tidal marsh ecosystems on site. Hypothesis 3: Sediment loss into breached ponds will not significantly affect tidal flat acreages in sloughs or Bay. Hypothesis 4: Sediment from tributary sources is not a significant input to breached ponds, sloughs or South Bay. Hypothesis 5: Newly tidal ponds do not cause a significant change in the water quality of sloughs and the Bay adjacent to those ponds during the first year after breaching compared to pre-breach conditions. Hypothesis 6: Access and use of restored tidal marsh by native fish species (steelhead, surfperch spp. and long-jaw mudsuckers, among others) for cover and is not significantly affected by breach configuration, restored marsh geometry or pond management for other purposes.
	3. Open trail out Mt. Eden Creek to the Bay edge, including historic Oliver saltworks site and loop around Pond E12; conduct applied studies on trail use effects on birds and user satisfaction	Hypothesis 7: A variety of high-quality passive recreation experiences focused in one part of the Complex will not result in high public satisfaction. Hypothesis 8: Ducks and other waterbirds are not significantly disturbed by trail users. Hypothesis 9: Increased hunting does not significantly reduce the satisfaction of passive recreational users.

Alviso	1. Pond A16: manage for breeding and migratory birds—pond reconfigured; conduct applied studies on bird use	Hypothesis 10: Creating isolated nesting islands, engineering levees with shallow (10:1 slopes) and engineering pond bottoms to provide water at a depth attractive to a variety of nesting and foraging waterbirds will not maintain shorebird and waterfowl densities and nesting bird densities at significantly higher levels than non-reconfigured ponds.
	2. Pond A6: open to full tidal action; conduct applied studies on gull response to habitat change	Same as Hypotheses 2-6 (see Action 2 in Eden Landing); include pond A6 and the Island Ponds in the study. Hypothesis 11: Displacing the gull colony at A6 will not significantly affect other species nesting in the South Bay.
	3. Pond A8: develop a reversible tidal action system; conduct applied studies on Hg mobilization	Hypothesis 12: Tidal marsh restoration and pond management does not increase MeHg levels in indicator (sentinel) species above baseline levels.
	4. Open trail behind NASA Ames Research Center; conduct applied studies on trail impacts on birds and user satisfaction	Same as Hypotheses 7-9 (see Action 3 in Eden Landing); Eden Landing and Alviso sites will both be part of the study.
	5. Open interpretive display at Pond A8	This location is an opportunity to assess user satisfaction with the Project (Hypothesis 7).
Ravenswood	1. Pond SF2: open outer portion to tidal action	Hypothesis 13: Tidal marsh created at SF2 does not create a connection between marshes to the north and south used by key species.
	2. Pond SF2: manage inner portion for breeding and migratory birds	Same as Hypothesis 1 for Eden Landing Action 1; include this pond in the study.
	3. Open interpretive display at Bayfront Park in Menlo Park overlooking the Ravenswood Complex	This location is an opportunity to assess user satisfaction with the Project (Hypothesis 7).

Part III. INSTITUTIONAL STRUCTURE

A. Adaptive Management Structures and Processes

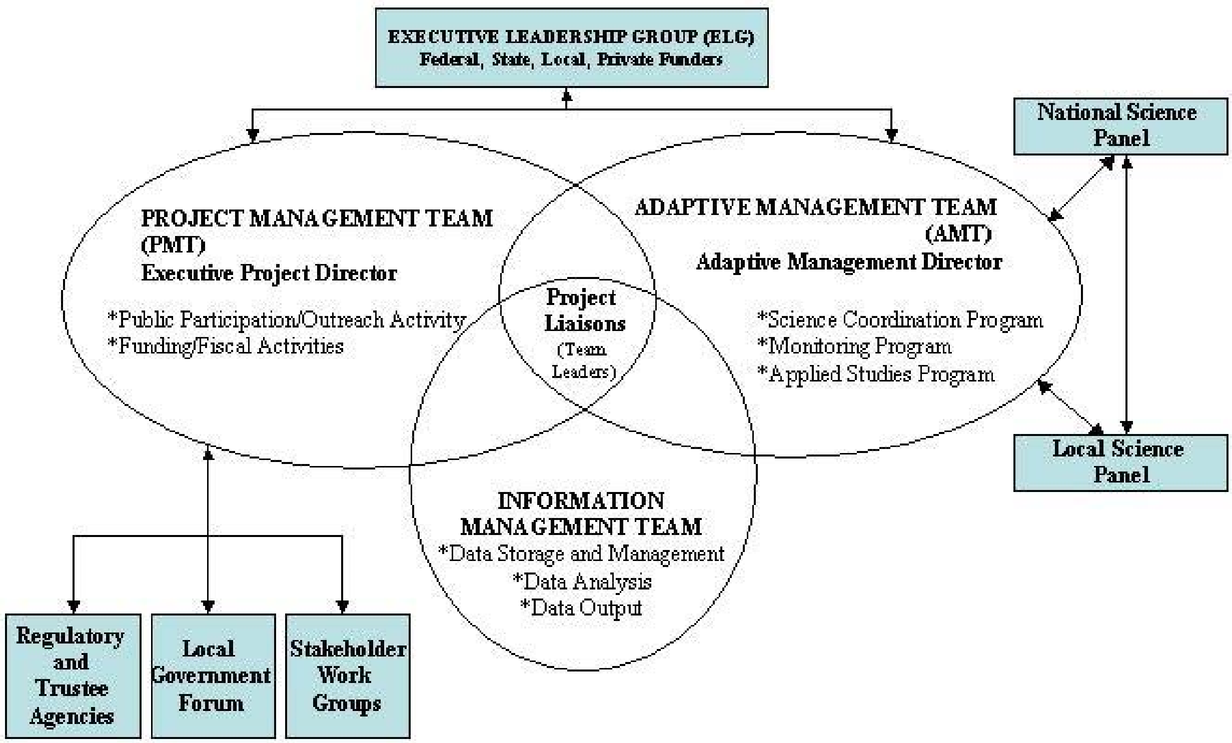
Introduction. Adaptive Management cannot be implemented without an effective decision-making structure that completes the loop between information development and the incorporation of that information into decisions. The benefits of adaptive management depend on appropriate institutional arrangements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

5. Generate and synthesize data (from monitoring and studies);
6. Convert the synthesized data into effective short and long-term management decisions;
7. Involve the public in decision-making; and
8. Store and organize data for use by the decision-makers and the public.

Figure 5 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 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 5 shows that the AMT has equal status with the PMT in providing direct input to the Executive Leadership Group on decision-making in the adaptive management process and ensuring that science is given equivalent consideration. However, the PMT is ultimately responsible for the decisions that are implemented. Figure 6 illustrates the interaction between the PMT and AMT as they implement the four functions listed above.

In developing this institutional structure, we reviewed adaptive management programs in other ecosystem restoration projects and found that 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 seven 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 5. Adaptive Management Organizational Structure for the South Bay Salt Pond Restoration Project



Another lesson from other projects is that adaptive management cannot succeed unless participants in the decision-making structure communicate well with each other to share information and take action in a timely manner. When different groups or functions remain in "boxes" separated from other parts of the structure, decision-making breaks down. Mechanisms for this Project to ensure communication include the presence of project liaisons on each team, regular meetings with all PMT and AMT members, regular reports from the PMT and AMT, and providing information to all project participants and the public on the Project website.

Other projects show that 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, applied studies, and modeling information?
- How and what scientific and public participation information will be fed back into the management process?
- What decision criteria will be used to trigger action and how will project managers decide what management actions to take?

Roles and Responsibilities of the PMT and AMT. Each group in the Organizational Structure in Figure 5 has one or more responsibilities 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. The ELG will meet regularly, perhaps 2-3 times per year, to discuss current and proposed management actions and activities in future Project phases.

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 restoration and management 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 land management agencies at the U.S. Fish and Wildlife Service (Don Edwards San Francisco Bay National Wildlife Refuge) and the Department of Fish and Game (Eden Landing Ecological Preserve), the PMT will include the Executive Project Director, the Adaptive Management Team Director, and a representative from the State Coastal Conservancy, the Santa Clara Valley Water District, the Alameda County Flood Control and Water Conservation District, the U.S. Army Corps of Engineers, and 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) among 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. Funding is critical to ensuring that adequate long-term financial support is provided to achieve the Project Objectives. The PMT will seek general project funding from agencies, foundations, organizations, corporations, and others. This work includes researching and developing close and long-term relationships with potential funders, incorporating a rigorous proposal and reporting process, and coordinating with the AMT Director on Science Program funding.

The PMT will also 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 Stakeholder Work Group meetings, community and other group presentations, holding workshops, participating in community events, installing displays, and coordinating 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 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 to help guide management direction. These Work Groups are essential to assisting the PMT and AMT in gaining a broader understanding of public and interest group perspectives. A representative from each of the Work Groups will attend the PMT meetings, provide input as appropriate, and report back to their groups. 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 and to assist the Work Groups 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 implementation.

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 Science Coordination, Monitoring, and Applied Studies Programs. These groups are described below. These groups will be comprised of scientists, agency staff, consultants, and others as appropriate. Some of the individuals may be members of the AMT may work on more than one program. AMT members will work with the Director and each other to accomplish their assigned tasks, and they will meet regularly to discuss progress/issues in their programs. 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 AMT Director determines the science direction for the Project. The AMT Director will also help 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 during Project planning.

Monitoring Program. The Monitoring Program is responsible for developing and overseeing the operation of a system-wide monitoring program, including identifying monitoring parameters, developing monitoring protocols and writing the Requests for Proposals (RFP) to hire a consultant or research team to collect the data. On a yearly basis, the program will determine whether the data collected are adequate to meet the Project's monitoring needs and will suggest revisions to the AMT and PMT Directors and Local Science Panel. Also yearly, this group will evaluate the monitoring data to determine progress toward restoration targets and levels of compliance, and will provide its findings and recommendations in a report to the AMT and PMT Directors and the Local Science Panel. After review, the report will go to the entire PMT. On a shorter-term basis, this group, especially the Monitoring Program leader, will coordinate directly with field crews collecting data to provide advice about data collection and system conditions. If the monitoring shows that the system is diverging from restoration targets, the Monitoring Program leader will engage the AMT Director and determine if immediate action is required.

Applied Studies Program. The Applied Studies Program will determine what research should be undertaken to reduce uncertainty and will conduct a competitive proposal process to ensure the research is performed. It is also responsible for implementing a peer review process for research completed, in conjunction with the Local Science Panel, and for compiling data into a report that summarizes the findings and their implications to the Project. The report will specifically evaluate findings with respect to implications for current management and future Project phases. After review by the AMT Director and Science Panel, the report will go to the PMT. On a yearly basis, this Program will reevaluate applied study priorities and begin the competitive proposal process again.

Science Coordination Program. This program 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. It will serve as scientific liaison to projects around the Bay and in other parts of the country. This group will set up conferences, technical workshops, and other meetings to bring the best science into the Project from other sources. It is also responsible for disseminating information generated by this and other projects in useful formats to the AMT, the public, and the scientific community. Its work will be peer reviewed by the Local Science Panel and external reviewers.

Local Science Panel (formerly the Science Team) (10-12 advisory members). The Local Science Panel (LSP) is composed of local scientific experts, especially researchers. This Panel functions in an independent, technical advisory and peer view role to provide high-quality, scientifically-based input to the AMT and 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 Local 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.
- Coordinates the independent peer review process evaluating proposals, scientific and technical papers, and the overall science program.
- Provides scientifically-based input to the PMT and AMT.

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

Technical Consultants and Researchers. Technical consultants will be hired to conduct such activities as design and implement restoration, 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.

Information Management Team (IMT)

This group is responsible for storing and managing all Project data and information. It will conduct basic analyses of data as directed by the AMT as well as disseminate information as directed by the PMT. The IMT will manage data from a real-time monitoring system and will manage the website that provides information to others. The IMT manager will coordinate with the AMT (especially the Science Coordination Program) and PMT to provide materials in appropriate formats such as general information, publications, status and trends, project maps, and processed and raw data.

Project Liaisons

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

Processes for Decision-making. The PMT and AMT will operate using processes that integrate their activities on three time scales: yearly, monthly and as needed. In Figure 4, the PMT roles and actions are in red and the AMT are in black. 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 6, operates primarily with yearly milestones. All reports are ultimately submitted to the PMT. Together, the AMT and PMT will:

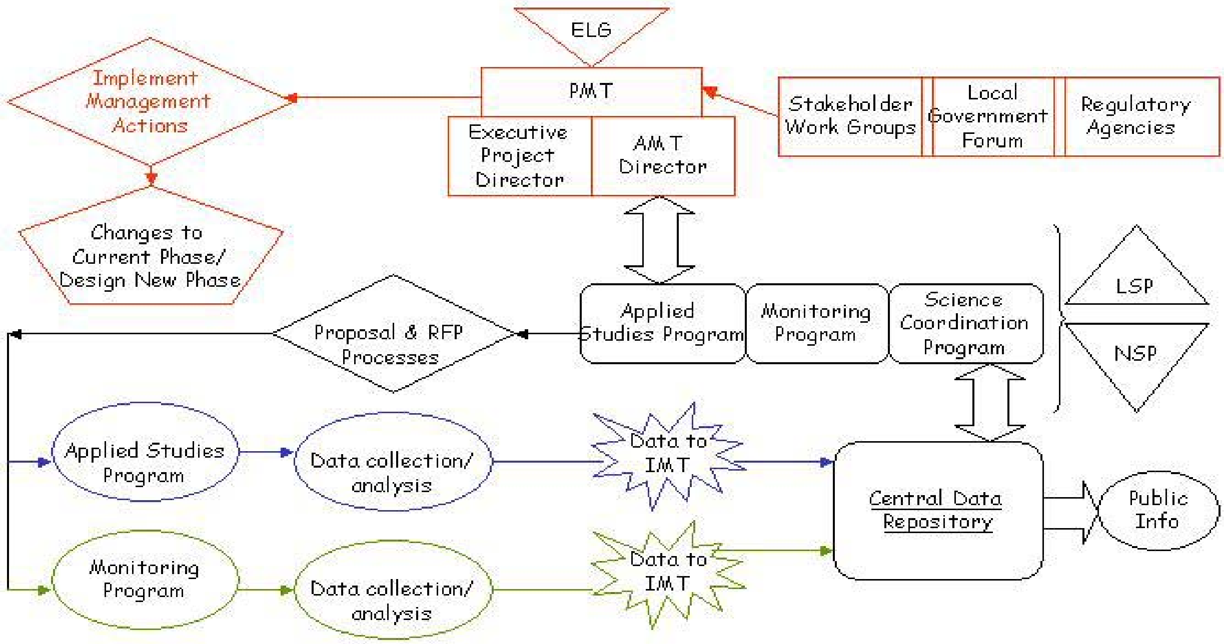
- Evaluate the progress of the project toward the restoration targets and Objectives;
- Evaluate the efficacy of the restoration targets as indicators of the Objectives;
- Evaluate the Project Objectives themselves for long-term viability;
- Determine any changes to be made to existing Project phases;
- Integrate information into planning for future phases;
- Determine the monitoring and applied studies that should be implemented in the coming year.

Two or three times a year, the AMT will provide an update on these activities during public meetings. It is expected that the ELG and PMT will also hold public meetings a few times annually, either in conjunction with the AMT or individually, to keep the public informed on current Project issues and activities.

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 staff and consultants to implement changes to phases and planning, and the AMT will conduct the yearly proposal solicitation for applied studies and monitoring.

The Monitoring Program (in green in Figure 6) provides data for shorter time scales of decision-making. The monitoring track generates data monthly or more often, which is reviewed by the Field Activity 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 staff 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 staff, 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.

FIGURE 6. Adaptive Management Data Collection and Decision-Making Processes



B. 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 include the AMT Director, the Monitoring Program, the Applied Studies Program, the Science Coordination Program, National Science Panel (NSP), and the Local Science Panel (LSP). These groups 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 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*, which will have these components:

- Definition of roles and responsibilities of the AMT Director and science program leaders; goals and operating procedures for each science program;
- Conceptual models showing ecological milestones when restoration targets, Project Objectives, and Phase Objectives should be achieved and showing specific hypotheses for testing;

- Defined role for modeling in data analysis, prediction and project design;
- Specific Project and Phase restoration targets, interim targets, monitoring parameters, monitoring protocols, and applied studies;
- Schedules for meeting each program and panel's goals;
- A schedule for regular, informational up-date meetings with the AMT Director and the science program 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. Because of the number and complexity of the key uncertainties, it will be necessary to be 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 important Project questions. The Applied Studies Program will design and disseminate RFPs for the research and will conduct the proposal review process (see Appendix 6 for the suggested proposal solicitation process). After conducting the proposal review process, the program leader will report the results to the AMT Director for approval. When appropriate, this process could also be used by the Monitoring Program to select consultants or researchers to conduct monitoring.

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 Programs will be peer reviewed by the LSP 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 NSP 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 leaders, and researchers will be expected to publish their work in peer-reviewed journals.

Table 5. Science Program Peer Review

Reviewers	**Tasks**
Local 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

C. Decision-making and Implementation

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 interpretation and the IMT will store and manage the Project's data. The Stakeholder 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 writing 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 when to take adaptive management actions (triggers for action) and which actions to implement;
- 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 IMP, 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.

Decision Criteria and Tools. A central element of the *Detailed Plan* is the set of decision criteria by which the PMT determines when to take corrective action and what actions to take. Decisions will be based on the Project's restoration targets, the PMT's evaluation of Project needs and resources available, and the scientific information available. Input from the public must also be part of setting the decision criteria, but public desires may be redefined by resource needs and/or scientific findings. The *Detailed Plan*, then, must clearly lay out the **triggers** for action and the **list of actions** that will be taken to address problems that arise during planning and Phase 1. Additional triggers and appropriate responses will be added as needed throughout the life of the Project.

At the heart of each trigger is a decision as to when the Project is diverging from the Project Objectives The PMT, AMT, Stakeholders and regulatory agencies will all be involved in developing triggers for action. These triggers are linked directly to the Project's restoration targets. As with restoration targets, some triggers will be relatively easy to determine, such as those defined by regulatory compliance requirements. These triggers are often simple thresholds that, when crossed, trigger corrective action. Non-regulatory triggers for ecological change will often be much more difficult to determine. They are likely to be relative to baseline conditions and will need to include ranges of natural variability. For example, the PMT will most likely need a trigger for action related to mercury levels. Specifically, if mercury levels begin to increase in South Bay biota, the PMT will need to know what level of increase, exceeding what range of variability, compared to baseline conditions will trigger action. For some Project Objectives, whether a trigger is acted upon will be based on determining if the Project is responsible for the change in conditions. For example, for the restoration target related to maintaining shorebird diversity and abundance, Project leaders may determine to take action if indicator species drop by a certain percentage for a certain period of time. However, Project Managers will need to have some assessment as to whether population declines are due to Project actions or to conditions along the Pacific Flyway, which are beyond the Project's control.

If a trigger is tripped, ideally, the PMT will want to have remedial measures or contingency plans already determined. This will require effort to predict what might go awry with the Project and what the best corrective actions will be. Project managers should develop a range of options for corrective actions. 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. 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 Programs can all assist in anticipating the unlikely and providing remedial measures and contingency plans to the PMT. Detailed plans, for example, must be in place for problems with dissolved oxygen, flood and vector control, and infrastructure problems.

While some effects may be anticipated and planned for, others may be entirely unexpected. An effective adaptive management monitoring and research plan will collect data to track the emergence of potential effects and will provide funding in the project budget to deal with unanticipated events. 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 will include a process for rapid response.

Project managers should also clearly identify, whenever possible, those circumstances, due to physical, fiscal, or other limitations, for which remedial action cannot be taken. For example, once a pond is opened to tidal action, it is very difficult to reverse that action by closing breaches. Similarly, once a trail is opened to public access, closing that trail is likely to engender considerable public ill-will. Work between the stakeholders and the PMT in October 2005 showed that the best solution to these situations is plan thoroughly and design each Phase so well that these situations *are avoided*. In addition to these difficult-to-remedy problems, good planning and design will also focus on preventing flood management problems, increased mosquito levels, and impacts to infrastructure.

Models will be important tools for predicting potential problems with particular management actions. In addition, modeling, especially on a large-scale and long-term basis, should be used to envision different scenarios. Scenario planning is a forecasting approach based on current data that typically uses models to predict system responses to: 1. a suite of management actions or 2. large-scale changes that could change the Project's ecological endpoints. In the first case, a large number of potential management scenarios should be developed for the PMT, AMT, and stakeholders to evaluate to assess how to proceed in future phases. In the second case, scenarios based on uncontrollable system events should be modeled. For example, if the invasive *Spartina* and its hybrids cannot be controlled (currently we assume they will be) and they ultimately dominate the system, how will the South Bay ecosystem respond? And, how might Project Objectives be forced to change under such a scenario? The detailed, 2-/3-D landscape scale predictive model the Project plans to develop should be a state-of-the-art tool for scenarios planning. 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 the context of specific cases in determining appropriate approaches.

Reporting and Program Evaluation. The *Detailed Plan* will 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 will 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 twice a year, 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.

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.

D. Public Involvement

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 and other material understandable to the public and available through the website;
- Public discussion of monitoring plans, applied studies, and contingency planning;
- Clear PMT reports on decisions made and the role of public input;
- A well-developed outreach program including educational and volunteer opportunities.

Education, volunteerism and outreach. Involving the public will engender support and long-term stewardship for the Project and, we hope, increase the public's overall awareness of society's role in protecting the environment. Public outreach must begin with the PMT providing scientific information and PMT reports to the public in a timely manner on the website. Outreach should include a quarterly or semi-annual newsletter summarizing the Project's work and opportunities for public involvement. TV and radio spots may also be useful in informing the public at-large about the Project.

Effectively getting people to be actively involved in the Project will require a number of techniques. For example, stakeholders during the planning process have encouraged the PMT to develop "virtual public access", available on the Project website. Virtual field trips will allow people to "visit" the site even if they can't get out of the house. Virtual access can also let people see things that are normally inaccessible; for example, "nest cams", video cameras set up at nest sites that broadcast to the website, are popular ways to see nature in action. Those craving knowledge about the science and management of the Project will appreciate being able to attend a series of technical workshops and/or public talks. Of course, these can be taped and put on the website. Finally, many restoration projects have active volunteer organizations that help publicize and manage aspects of the project. While managing volunteers takes staff and money, the good will they convey and actual work they do can be so beneficial for the Project.

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 about the human dimension. For example, what methods are most effective in conveying monitoring and research results to the public? What elements of the community are not being reached by the Project and how can they be involved? To address some of the institutional challenges attributed to adaptive management (Walters 1997, 1998), basic questions of social learning and the human aspects of the project 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, a major question that will drive social science research is: How do we involve the local community in the restoration and ensure long-term support? Specific applied studies questions that tier from this in the context of meeting the Project Objectives 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.

E. Data Management and Reporting

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 will be established as part of the Project's adaptive management implementation, overseen by the Information Management Team (IMT). The primary tasks 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.

Figures 5 and 6 show what an essential role the Information Management Team plays in the adaptive management process. This group is the link among the data collection groups, the AMT, the PMT, and the public.

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 is 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).

F. 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 identifies the Funding Activity as part of the PMT, to ensure ongoing financial support to meet the needs of the Project. As a part of this effort, it is essential to provide funding for adaptive management during the planning phase of the Project in order to collect baseline data and conduct applied studies and model development prior to Phase I implementation.

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:

- <u>PMT Operation</u>, including the full-time Executive Project Director, funding activities, public outreach activities, and any needed consultants.
- <u>AMT Operation</u>, including a full-time Adaptive Management Team Director and staff for the Monitoring Program, Applied Studies Program, and Science Coordination Program; the Local Science Panel, National Science Panel, and honoraria for external reviewers.
- <u>IMT Operation and Central Data Repository</u>, including staff, computers, software, etc.
- <u>Funds to Implement the Monitoring Program</u> to assess progress and compliance, and provide real-time monitoring.
- <u>Funds to Implement the Applied Studies Program</u> to conduct research designed to reduce project uncertainties.

It is clear that implementing the Adaptive Management Plan, as described here, will require a significant and long-term sources of financial support. The Project will develop an explicit Funding Strategy that incorporates federal, state, local, and private funding.

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APPENDIX 1.
DRAFT Scientific Basis of the Project Objectives

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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 locations, 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.
- some areas of the Project should provide refuge to wildlife from all public access. The extent of these public access-free sanctuaries will be determined by public access desires and the impacts of those activities on wildlife and their habitat.
- 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 that interferes with breeding, pupping and endangered species.
- 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.

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

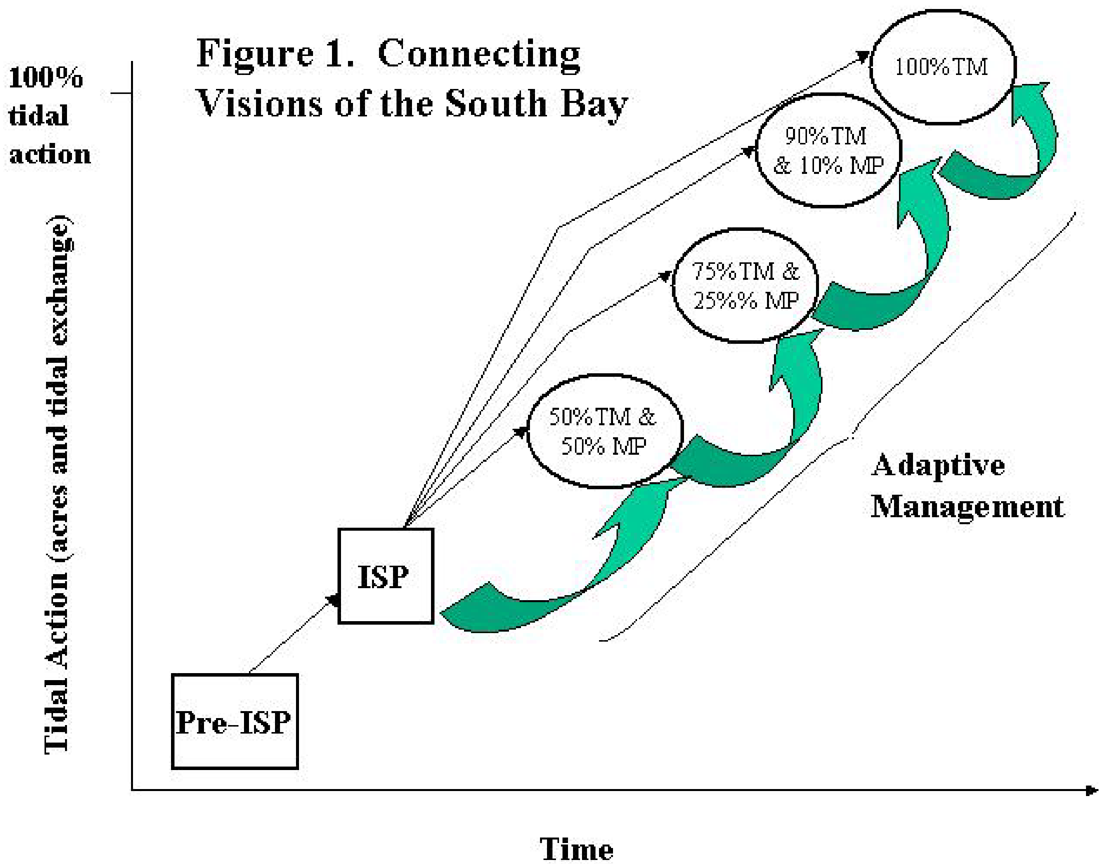


TABLE 1. Draft Requirements to meet Project Objectives (June 1, 2005)

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*)	Maintain baseline number of birds using South Bay post-breeding roosting sites; if possible develop South Bay nesting colonies	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

Project Objective	Sub-Objective	Population Target	Habitat Type	Habitat Size/Needs--Processes	Target Compatible with…; Conflicts with...	Sources
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.
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
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)

Project Objective	Sub-Objective	Objective Target	Conditions that prevent meeting Target	Processes/Actions to Meet Target	Target Compatible with…; Conflicts with...	Sources
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	
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.
Conceptual Models to Guide Restoration Planning and Adaptive Management Monitoring and Applied Studies (from Trulio, et al. 2004)

A. LANDSCAPE CONCEPTUAL MODEL

Model Goals and Elements

The Landscape Conceptual Model provides a guide for understanding how restoration actions initiated at the pond level will affect physical and ecological processes in the South Bay and associated sloughs, as well as potential effects of the surrounding landscape on the restored ponds. The elements included in this model are the same as those for the two pond-level models; however, the focus is on effects at the landscape level. The elements are linked in Figure B.1.1 to show relationships between driving processes, restoration actions, and South Bay ecology.

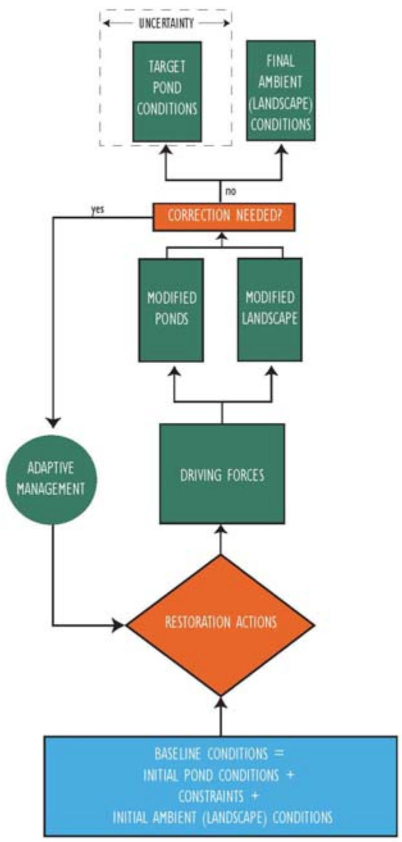


Figure B.1.1. Flowchart of Landscape Conceptual Model

B. TIDAL MARSH CONCEPTUAL MODEL

Model Goals and Elements

The purpose of this pond-level conceptual model is to provide a guide for understanding how restoration actions can alter current conditions in South Bay salt ponds to achieve vegetated tidal marsh habitat. This flowchart (Figure B.2.1) shows the connections between initial ecological conditions, restoration actions and target conditions (Gross, 2003). The model gives only general connections between the elements. Detailed submodels that illustrate relevant processes will need to be produced in the future to show the specific cause-and-effect relationships between the components that lead to tidal marsh and associated habitats.

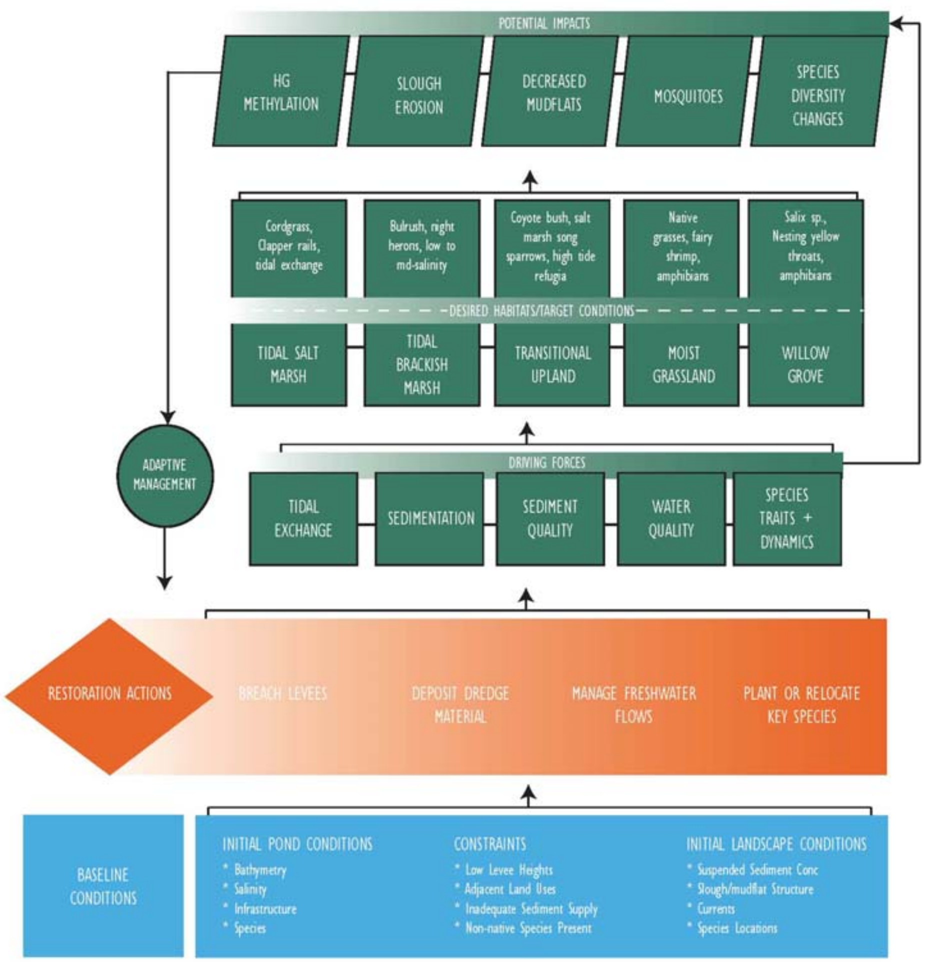


Figure B.2.1. Flowchart for the Tidal Marsh Conceptual Model

C. MANAGED POND CONCEPTUAL MODEL

Model Goals and Elements

The purpose of this pond-level conceptual model is to provide a guide for understanding how management actions can maintain and improve managed pond habitat and what effects may be associated with pond discharges. The Managed Pond Conceptual Model flowchart shows the relationship between the eight model components and provides specific conditions or actions for each component. Although this conceptual model describes actions and processes at the pond-level scale, we know ponds are part of a much larger system. Therefore, the flowchart shows the links between the pond and the landscape levels.

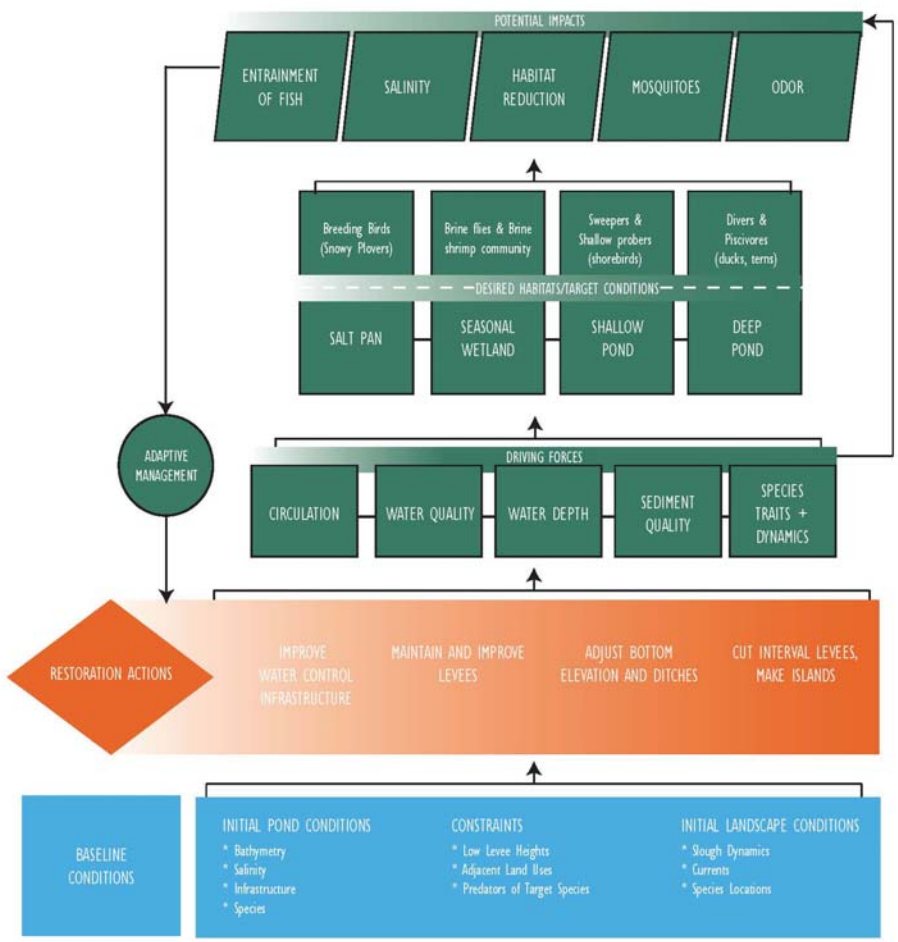


Figure B.3.1. Flowchart for the Managed Ponds Conceptual Model

APPENDIX 3.
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 impacts 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 4. 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 marsh plain 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

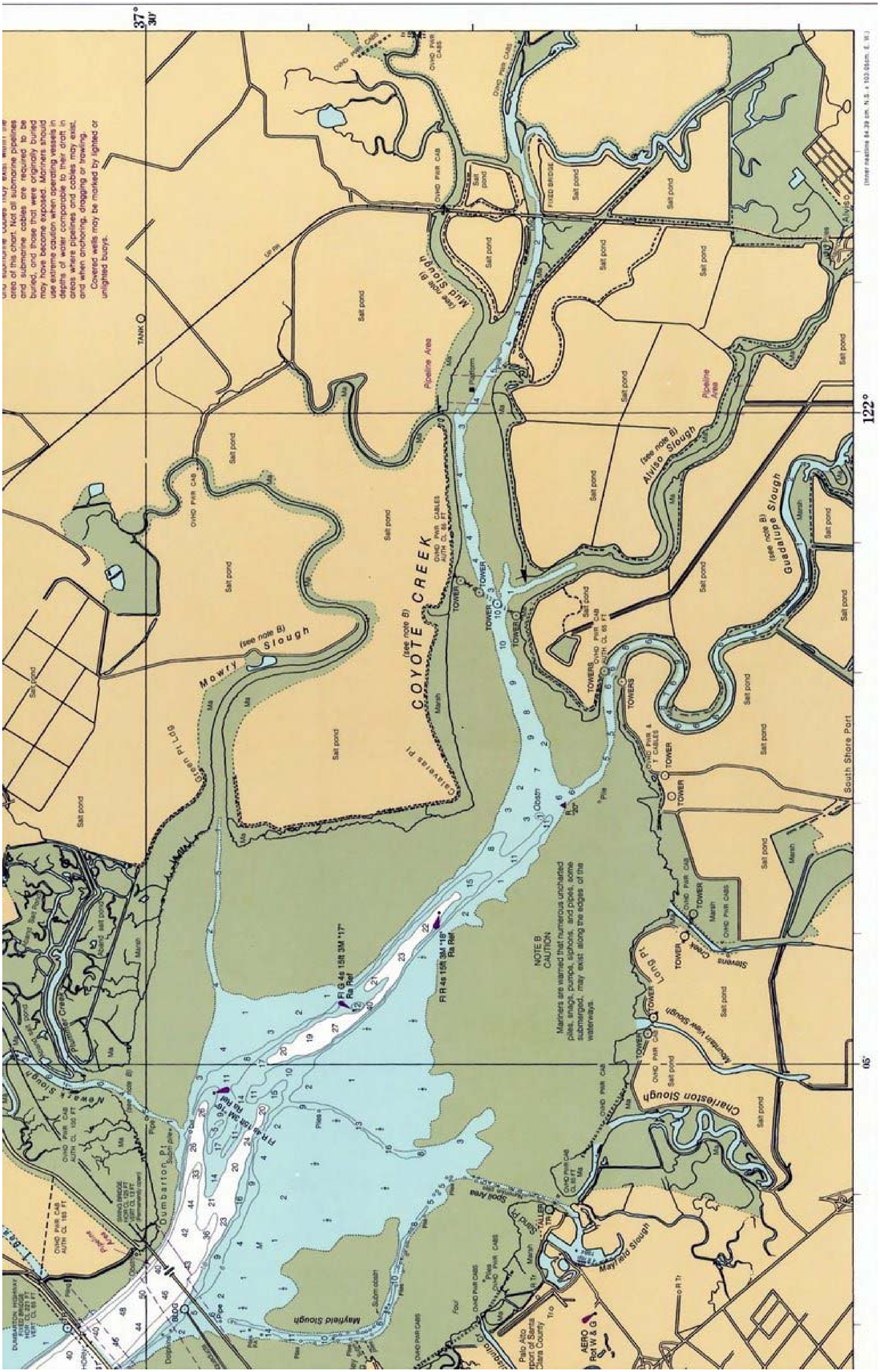
References

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


COYOTE CREEK
Mowry Slough
Mud Slough
Alviso Slough
Guadalupe Slough
Stevens Creek
Mountain View Slough
Charleston Slough
Mayfield Slough
Newark Slough
Plummer Creek
Dumbarton Pt
Calaveras Pt
Long Pt
South Shore Port
Alviso
Salt pond
Pipeline Area
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.
37° 30'
122°
05'

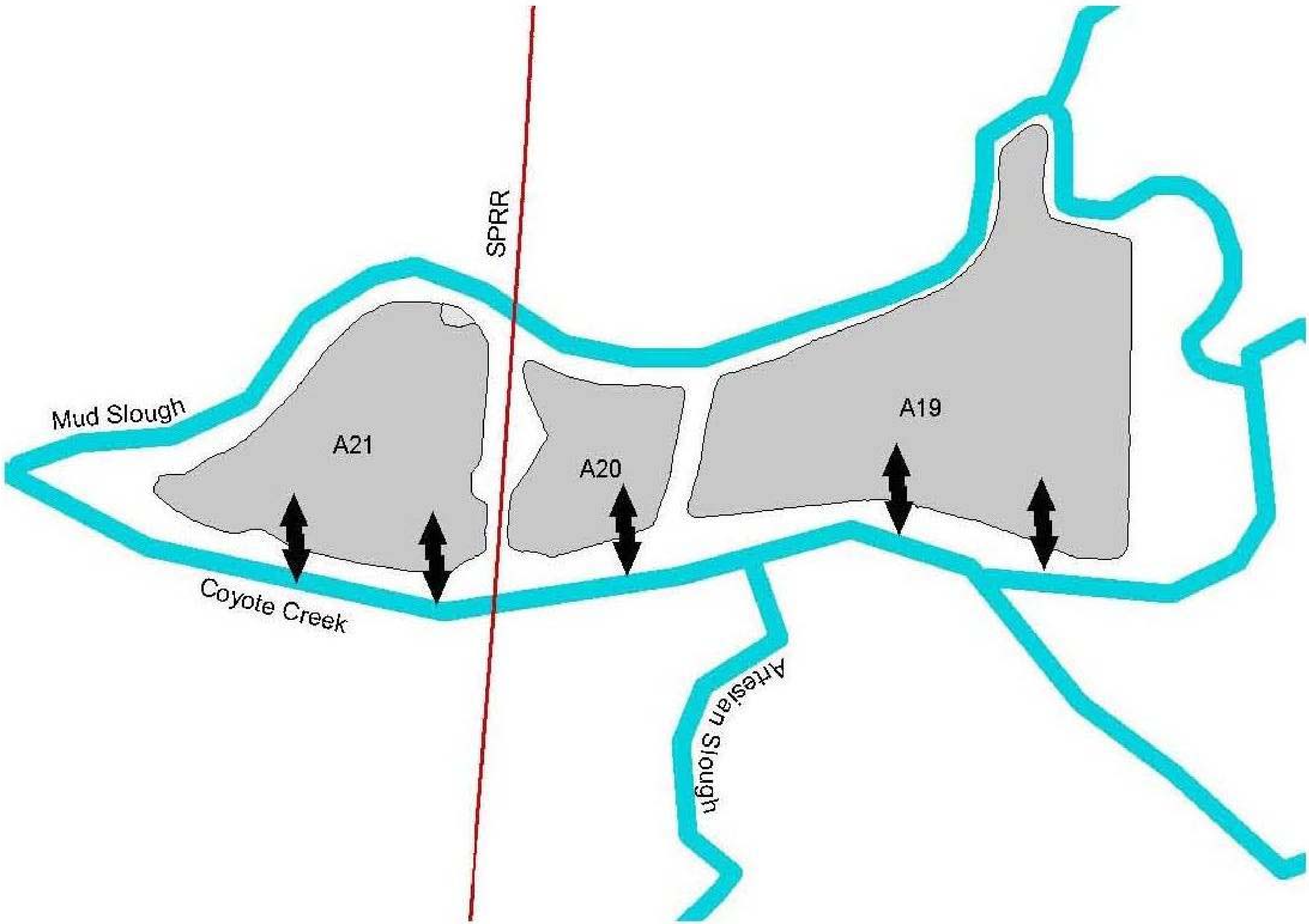


Figure 4-11
Map of Alviso Complex Island Breach Locations

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:
San Francisco Bay Bird Observatory
PO Box 247, Alviso, CA 95002
Contact: Cheryl Strong [cstrong@sfbbo.org]
and
H. T. Harvey & Associates Ecological Consulting
3150 Almaden Expressway, Suite 145
San Jose, CA 95118

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 5.
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.

APPENDIX 6. Abstract for Proposal Submitted to the NOAA Ecofore RFP

Ecofore 06: Sediment Transport and Habitat Disruption: Developing the Tools to Forecast the Effects of Large-Scale Ecosystem Restoration on Existing Habitats

Investigators:
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Jessica Lacy, U.S. Geological Survey
David Schoellhamer, U.S. Geological Survey

Total Budget: $2,320,701 for 5 years (starting May 1, 2006)

Summary:
The proposed work develops the necessary tools to forecast the effects of large-scale habitat restoration on estuarine ecosystems. This development will be done in conjunction with the second largest restoration project in U.S. history, the South Bay Salt Pond (SBSP) Restoration Project (www.southbayrestoration.org). The goal of the SBSP project is for the restored habitats to accrete sediment and become tidal marsh, restoring a habitat that was ubiquitous historically around the perimeter of South San Francisco Bay. The restored marshes are expected to provide habitat for endangered and threatened marsh species such as the Salt Marsh Harvest Mouse and California Clapper Rail. The success of the restoration project depends, in part, on the sediment dynamics for the southern reach of San Francisco Bay. As the new marshes develop, they place additional demands on the sediment supply in the region, potentially leading to erosion of existing habitats, including intertidal mudflats that provide habitat for wading birds.

The forecast system proposed for development here will rely on a highly resolved three-dimensional hydrodynamic model that includes sediment transport to predict how restoration actions will alter the estuarine system, including changes in local tidal dynamics, salinity and suspended sediment concentrations. Ecological analysis of the model results, at this stage, will focus on the response of existing vegetated habitats adjacent to the restoration sites. The model development will be closely linked to a series of observational studies that will provide calibration and verification data at the necessary range of spatial and temporal scales, including both basin-scale effects and the local effects anticipated in response to restoration activities.

Once the development, calibration and verification of the hydrodynamic and sediment transport model are complete, two applications of the forecast system of particular importance to the SBSP restoration project are proposed. First, the interannual variability in the sediment supply for the restoration project will be considered by resolving the annual cycle of sediment deposition and redistribution, with consideration of the potentially important influence of extreme events. Finally, the forecast system will be applied to inform future phases of the SBSP restoration effort by analyzing the implications of proposed alternatives for existing marsh and mudflat habitat. Further, the forecast tool will evaluate uncertainties in the response of the system and to help develop the most effective monitoring program for the adaptive management of the project.