

## **Appendix G – Monitoring and Adaptive Management Plan**

### **INTRODUCTION**

The Napa Salt Marsh Restoration (NSMR) project proposes to restore approximately 9,460 acres of historic salt ponds to tidal salt marsh and managed open water ponds. The project is unique in that restoration will be achieved mainly through reliance on natural processes such as tidal action to restore habitat rather than constructed features. After initial construction activities are complete, adaptive management and monitoring are necessary to address uncertainties and ensure project success.

#### **Project Uncertainty and Adaptive Management/Post Construction Monitoring:**

The NSMR project is unique in that this is the first large-scale restoration of salt ponds to tidal marsh in the United States and will serve as a model for future COE salt marsh restoration projects. Because of this uniqueness, there are a number of project uncertainties that could affect outcome including:

- Project scale - the Napa Salt Marsh project is approximately 9,460 acres and would be the largest restoration project undertaken west of the Mississippi River,
- Sediment accretion rates for tidal marsh evolution are dependent on river flow rates and sediment supply which are driven by unpredictable weather patterns,
- Wildlife use of evolving tidal habitats is subject to unpredictable fluctuations based on site-specific conditions.

During the project feasibility stage, a predictive hydrodynamic model of the pond system was developed. A habitat evolution assessment, based on model predictions, sediment budget, and analysis of other natural processes, gave the estimated time periods for tidal marsh development. The evolution of Pond 3 from intertidal habitat to tidal marsh is expected to take 20 to 30 years post construction. Pond 4, which is more subsided than Pond 3, is expected to evolve from predominantly intertidal habitat to tidal marsh within approximately 40 years post construction. Pond 5, which is also more subsided than Pond 3 and is relatively isolated from sediment sources, would take longer to evolve to tidal marsh.

Due to the long time frame for tidal marsh evolution and the difference in wildlife values of various types of tidal habitats, it is difficult to determine the end-point for project success. The project incorporates post-construction monitoring and adaptive management to assess whether natural processes can sustain the long-term evolution of tidal marsh.

#### **Adaptive Management and Project Success Criteria**

Due to the size of the area to be restored and the timeline for restoration, acreages for tidal marsh restoration have not been established as quantified project success criteria. The project does not target individual species for mitigation and habitat restoration. For

this reason, changes to wildlife populations and densities are not quantified as project success criteria. The project success criteria to be used as the basis for adaptive management decisions consist of the following:

- 1) Desalination of Ponds 3, 4, 5, 6, 6A, 7, 7A and 8 to ambient salinity levels,
- 2) Achievement of applicable surface water quality standards both within the pond system and in the receiving waters,
- 3) Establishment of a stable sediment deposition process in the ponds opened to tidal action and quantifiable evolution to tidal marsh habitat in Ponds 3, 4 and 5,
- 4) Establish benchmarks for tidal marsh evolution in Ponds 3, 4 and 5 adequate to inform future decisions on management of Ponds 6 and 6A,
- 5) Establish beneficial wildlife habitat for an array of species resulting in a net increase in biological diversity and productivity,
- 6) Insure the control and management of exotic and invasive plant species and introduced predators.

### **ADAPTIVE MANAGEMENT**

This section describes the adaptive management process and costs associated with the proposed adaptive management program. The project phasing of monitoring and adaptive management activities is summarized in Table 1. Costs associated with specific adaptive management tasks and personnel are summarized in Table 2 – Adaptive Management.

The adaptive management process consists of the following steps:

- 1) Evaluate in-field monitoring data and assess progress of restoration,
- 2) Identify potential adverse conditions impacting progress of restoration,
- 3) Determine if adverse conditions can or should be remedied, and
- 4) Implement the appropriate adaptive management action, as required.

As part of the adaptive management process, the project team and a panel of senior scientists/engineers will confer to assess the results of the monitoring effort and determine whether adaptive management actions are necessary. Once the adaptive management team completes the assessment, recommendations for action will be made. If these actions require on-site construction activities, a scope of work will be prepared and plans and specifications developed. Personnel will be mobilized from construction services to oversee and monitor on-site construction activities. Costs for construction services personnel are based on an estimated time for construction of four months.

**Adaptive Management Scenarios:**

Adaptive management would be used to address one of the following six conditions:

- 1) Habitat evolution is faster than predicted;
- 2) Habitat evolution is slower than predicted;
- 3) Salinity control in the managed ponds is more difficult than anticipated;
- 4) Adverse impacts to receiving water or pond water quality;
- 5) Wildlife populations are adversely affected; and/or
- 6) There are unanticipated consequences of the restoration effort.

These conditions would be identified from the monitoring program described in the NSMR project monitoring plan. Possible adaptive management scenarios to respond to the conditions outlined above are summarized below. The decision making process for adaptive management decisions is illustrated in Figure 1. Only the most likely actions were included in the cost estimate (see Table 2) and actions were scoped at the most appropriate scale. Adaptive management actions are divided into actions for tidal areas and managed pond areas.

Potential cost savings associated with faster habitat evolution were not included in the adaptive management estimate. For example: significant cost savings would be realized if habitat evolution is faster than anticipated in Ponds 4 and 5, reducing the need for constructed restoration features. Adaptive management actions for Condition 6, unanticipated consequences of the restoration, cannot be determined. However, the phasing of the project and monitoring program will help to avoid or minimize unintended consequences in tidal areas. In addition, the monitoring program for the managed ponds will allow modification of pond operations (water depth, salinity) if bird use and/or productivity of the ponds declines unexpectedly.

**Adaptive Management Costs:**

The actual in-field adaptive management costs cannot be determined at this point. However, certain adaptive management costs, such as adjusting water levels and salinities in managed ponds are likely to be required, and are listed in Table 2. Current USACE guidance limits spending on adaptive management to 5% of construction costs, including contingencies. For the NSMR project, the combined monitoring and adaptive management costs approach 16.9% of total construction costs. Monitoring costs in comparison to the adaptive management construction costs are low. Total monitoring costs are approximately 2.9% of total construction costs. It should be noted that the NSMR project has lower up-front construction costs per acre than comparable restoration projects. Adaptive management costs therefore appear higher based on the lower

construction cost per acre. In addition, construction costs for adaptive management are proposed costs and are likely to be substantially lower than proposed.

#### Tidal Area Adaptive Management Actions and Costs (Ponds 3, 4, and 5)

The most likely concern for tidal areas is that habitat evolution occurs more slowly than expected. The causes could be an overall lack of sediment in the system, excess sediment re-suspension, or inadequate vegetation colonization. The only adaptive management feature included in Table 2 for tidal areas is designed to enhance sediment deposition and prevent sediment re-suspension. If sediment deposition is inadequate and/or sediment re-suspension is occurring, then the existing starter channels and berms will be modified. Widening and/or deepening the starter channels at the levees would act to increase tidal exchange and sediment supply. Lengthening the starter channels and berms would decrease wave action and erosion and address the problem of inadequate sediment deposition. For Ponds 4 and 5, they will be extended to correspond to the length of starter channels and berms included in Habitat Restoration Option 4 (Accelerated Restoration). Starter channels and berms in Pond 3 will be increased by approximately 7,150 linear feet (an increase of 32%). This is less than the recommended amount associated with Habitat Restoration Option 4. In addition, to partially compensate for the delay in tidal marsh formation caused by the slower habitat evolution, additional levee lowering will be conducted to improve connectivity between existing and developing tidal marsh areas. The total estimated adaptive management cost for the tidal areas is \$5.7 million.

Inadequate vegetation colonization is not considered likely (Pond 2A vegetated rapidly, and there are other seed sources in the area), and no adaptive management features are included to address vegetation colonization. Similarly, while the sediment supply may be lower during dry years, leading to a somewhat slower rate of habitat evolution during those years, the overall sediment supply is believed to be adequate. Thus, adaptive management actions such as importing fill were not included in the adaptive management cost estimate.

#### Managed Pond Adaptive Management /Costs (Ponds 1, 1A, 2, 6, 6A, 7, 7A, and 8)

The most likely concern for ponds is that control of salinity and water levels is more difficult than anticipated. The cause would be an inability to move water into and out of the ponds as quickly as needed. This could occur if the water control structures installed for salinity reduction are not adequate to successfully manage the ponds over the long term. This concern would be addressed by increasing the number of water control structures at managed ponds. Based on current operations, Ponds 1, 1A, and 2 function effectively as managed ponds. The proposed project replaces the unreliable existing water control structures with new structures of the same size/capacity. Thus, there is little likelihood that additional water control structures will be required. The costs associated with fine-tuning operations at Ponds 1, 1A, and 2 have been included in the OMRR&R costs.

Similarly, Pond 8 is operating successfully with the new intake structures installed by the California Department of Fish and Game. Because the operation of Pond 8 also affects

the ability to operate Pond 7 long term management and oversight of the water control structures is required.

Managed Ponds 6, 6A, 7, and 7A present the greatest potential need for adaptive management. Ponds 6 and 6A are relatively shallow and large, which means that moving water through these ponds by gravity flow can be difficult. Based on the current information, there will be a significant seasonal fluctuation in salinity in these ponds, even if the water control structures are operated at full capacity. If the seasonal fluctuations exceed the desired range, additional water control structures may be required. The adaptive management cost for Ponds 6 and 6A is based on doubling the water transfer capacity for the two ponds (intakes on Pond 6A, and discharge from Pond 6). Ponds 7 and 7A are smaller and deeper than Ponds 6 and 6A, and are therefore more likely to be manageable within a desired range. However, past experience with managed pond operations suggests that discharges from the ponds may at times not be as effective as intakes. This may be because tidal water levels do not drop as much during certain portions of the seasonal tidal cycle. Consequently, the adaptive management estimate includes an additional outfall to the mixing chamber from both Ponds 7 and 7A. This adaptive management option would also allow the project team to increase the discharge of bittern from Pond 7, should a greater discharge rate be permissible following the on-going testing. The estimate cost for adaptive management for the managed ponds is \$4.5 million.

### **Monitoring and Adaptive Management Decision-Making:**

Monitoring information will be used to determine the type, extent and duration of adaptive management activities. Monitoring activities for adaptive management can be grouped into 4 categories: water quality monitoring in the ponds, water quality monitoring in the receiving waters, monitoring of wildlife use/presence, and monitoring of habitat evolution in tidal ponds. Each of these types of monitoring will be used in the adaptive management decision-making process. Figure 1 (Decision Tree) shows the decision/analysis process for each type of monitoring information. A brief description of the process applicable to each type of monitoring is provided below.

Water quality and biological monitoring may be required in order to achieve compliance with applicable state and federal environmental requirements. It is likely that the desalination discharge from the ponds to receiving waters will be regulated under an National Pollutant Discharge Elimination System (NPDES) permit. The possible impacts of construction activities on federally listed threatened and endangered species may require biological monitoring. Biological monitoring may be required to satisfy mitigation requirements under the National Environmental Policy Act (NEPA) and the requirements established under the biological opinion (BO) issued to the project by the U.S. Fish and Wildlife Service (USFWS). Table 3 breaks out the four types of monitoring and lists how each monitoring type applies to compliance with state and federal environmental law.

### Water Quality Monitoring in the Ponds

Water quality in the ponds may be regulated either under an NPDES permit or Waste Discharge Requirement (WDR) to ensure that the ponds meet applicable federal and state surface water quality standards. The applicable surface water quality standards (dissolved oxygen, temperature) and indicator parameters (salinity) in the ponds will be monitored throughout the project life. This monitoring will determine whether modifications to pond operations to meet surface water quality standards or desalination objectives are required. If water quality parameters such as dissolved oxygen or temperature do not meet applicable surface water quality standards, the most likely cause is lack of water circulation. The project team will determine whether inadequate circulation/flow is the cause of the poor water quality before beginning adaptive management efforts. The first step in the adaptive management process is to modify the water flows as much as possible in the desired direction using existing water control structures. If running the water control structures at maximum flow does not fully resolve the impaired water quality, then additional water control structures may be required to meet water quality objectives. Changes in the total discharge flow, whether through existing water control structures or through additional water control structures, will be monitored under the NPDES permit or WDR to ensure that there are no adverse consequences on the receiving waters.

### Water Quality Monitoring in the Receiving Waters

The discharge from the ponds to receiving waters may be monitored under either an NPDES permit or WDR to establish whether applicable surface water quality standards are being met. During the desalination process, the Regional Water Quality Control Board (RWQCB) may establish a mixing zone for salinity and/or metals in the receiving waters. A mixing zone would establish an area within the receiving water where ambient concentrations of salinity or metals would be met at the boundaries of the mixing zone. Compliance with surface water quality standards or mixing zone requirements may determine whether modifications to pond operations are required. If permit requirements in the receiving water are not being met, the most likely cause is excess discharge flow. In this case, the adaptive management measure is to reduce discharge flows to meet permit conditions. In cases where permit conditions are not met, accelerated water quality monitoring may be required and further modifications to the discharge rate may be made. If discharge rates must be altered, pond water quality will be monitoring to ensure that the alternations do not result in adverse consequences to water quality in the ponds (i.e., that discharges do not drop below a critical threshold level). If discharge criteria cannot be met without reducing flows at the discharge point, and reducing the flows results in adverse water quality in the ponds, then additional discharge locations (water control structures) will have to be added. A cost estimate has been included in the adaptive management plan for the construction and installation of additional water control structures in the event that this occurs.

### HABITAT EVOLUTION MONITORING IN TIDAL PONDS

Habitat evolution monitoring (changes in bathymetry, tidal range, landscape features, and vegetation) will be used to assess whether tidal habitat is developing at the projected rate. If habitat evolution is slower than anticipated, the data collected will be used to determine whether there is an overall sediment deficit, or whether re-suspension of sediment is

causing the slow rate of accretion. In addition, the project team will assess whether the reduced rate of habitat formation could lead to unacceptably high interim losses of tidal marsh habitat. If the projected interim loss of tidal marsh habitat is unacceptably high, one of two adaptive management approaches will be implemented. If a sediment deficit is causing the slow rate of accretion, then additional levee lowering and ditch blocks will be constructed to increase areas for vegetation colonization. Vegetation colonization in these areas will increase the total tidal marsh acreage quickly, and will also increase sediment trapping rates. Additional starter channels and berms may also be constructed to increase water flow and thus sediment loads to the interior of the pond(s), and to provide sacrificial sources of sediment. If sediment re-suspension is the cause of slow habitat formation, then additional starter channels and berms will be constructed to reduce wind-wave action in the ponds.

If monitoring indicates that sediment accretion in Pond 3 is happening faster than anticipated, then the extent of habitat design features in Ponds 4 and 5 can be reduced. The Pond 3 habitat evolution monitoring data will be used to reassess the need for these features in Ponds 4 and 5 as part of the detailed design effort.

#### Fish and Wildlife Use and Presence in the Monitoring Area

The project is designed to provide improved habitat to a wide range of species. Fish and Wildlife monitoring will be conducted to ensure that there are no unacceptable losses of certain fish and wildlife types/species as a result of the project, and to document the benefits of the project. If monitoring shows that fish and wildlife use is stable and/or increasing, then no adaptive management actions are required. If monitoring indicates that fish and wildlife use/presence is decreasing, then the cause for the decrease will be identified. If the cause is associated with changes in pond management (e.g., water level or salinity) pond management will be modified so that the pond(s) will become more attractive to fish and wildlife. If the cause is associated with landscape-level changes (e.g., the creation of tidal habitat), then regional patterns of fish and wildlife use/abundance will be evaluated to assess whether the affected species have migrated to another area. In the unlikely event that insufficient appropriate habitat is available regionally for the affected species, the project team will work with other projects in the area to ensure that sufficient regional habitat is provided. (This latter adaptive management action is not likely to be required, and a cost estimate cannot be developed for this contingency.)

#### MONITORING

Monitoring of the Napa-Sonoma Marsh Restoration Project will be coordinated with the Regional Monitoring Program, the Regional Water Quality Control Board and other State and federal agencies. The data will be available to the public. The primary objectives of the project monitoring are to:

- Monitor and evaluate the physical evolution of restored tidal habitats and the external slough channels;

- Evaluate the changes in wildlife use of restored tidal habitats, ponds, and fringing marsh;
- Assess water and sediment quality in the ponds, sloughs, and Napa River; and
- Determine compliance with applicable water quality standards.

In general, monitoring of managed Ponds (1,1A, 2, 6, 6A, 7A and 8) will focus on salinity and general water quality parameters, water elevation in the pond, productivity (primary productivity, invertebrates, and fish), and bird use.

Monitoring of ponds opened to tidal action (Ponds 3, 4, 5) will focus on habitat evolution. Bathymetric surveys and suspended sediment measurements will be used to evaluate sediment deposition rates and channel development. Vegetation surveys will be used to assess development of marsh vegetation. Water quality parameters will be assessed in order to determine the success of desalination and changes to water circulation patterns.

### **Project Phases, Timing and Monitoring:**

#### ***Pre-Construction***

A comprehensive biological, bathymetric and water quality survey of all the ponds will be conducted prior to commencement of construction. This intensive survey will be used as the project baseline. This monitoring effort will be cost-shared.

#### ***Construction***

The construction period for each of the ponds varies, and ranges from 1 year (for ponds that only require levee repairs and water control structures) to up to 5 years (for ponds that will be opened to tidal action). Monitoring during construction will consist of monthly monitoring of water indicator parameters and the monitoring required by the project National Pollutant Discharge Elimination System (NPDES) permit.

#### ***Post Construction***

Cost shared post construction monitoring is necessary to ensure project success and to support the adaptive management process. Post construction monitoring data will be used to determine if adaptive management actions should be taken and when. Post construction monitoring will be concurrent with the adaptive management phase.

Therefore, post construction monitoring is planned for 5 years post construction for managed ponds (Ponds 1, 1A, 2, 6, 6A, 7A and 8), 10 years for ponds opened to tidal action (Ponds 3, 4, 5) and 10 years for the bittern pond (Pond 7).

#### ***Typical post-construction monitoring***

Typical post-construction monitoring consists of a monthly survey of water indicator parameters (dissolved oxygen, pH, temperature, water depth and pH) and an annual aerial survey documented with digital photography.

### ***Intensive post-construction monitoring***

In order to assess the overall success of the project and to inform adaptive management decision making, comprehensive biological, bathymetric, tidal elevation and water quality surveys of the ponds are necessary. The most cost-effective means of achieving this is to conduct intensive surveys on a periodic basis post construction. This intensive survey information will be collected at all nine ponds post construction in Years 6, 10 and 13. The data collected in Year 13 will constitute a project-wide survey which be used to determine what final adaptive management activities should take place in the tidal ponds in Year 15. Intensive surveys will be performed in Year 8 for Ponds 3, 4 and 5.

Intensive surveys will include a full biological and physical assessment. The biological assessment will include integrated wildlife surveys including invertebrates, fish and birds. The physical assessment will include a full bathymetric survey, a levee breach and slough channel cross-section survey, sediment recruitment survey and vegetation colonization survey.

### ***NPDES Discharge Monitoring***

A National Pollutant Discharge Elimination System (NPDES) permit may be required during desalination for discharges to the Napa River from Pond 4 and the combined discharge to the Napa River/ Napa Slough from Ponds 7, 7A and 8. This monitoring will be required under the Clean Water Act and represents approximately one half of total monitoring costs (see Table 2). The NPDES permit is issued for a five-year period and would require water quality monitoring within the ponds and within the receiving water at points located up-stream and down-stream of the discharge. NPDES monitoring is likely to require monthly monitoring of metals, conventional pollutants and water quality indicators and quarterly monitoring of priority pollutants such as pesticides.

NPDES monitoring at Pond 4 may only be required for one five-year permit cycle, however, project costs reflect the possibility of the permit being reissued for another five-year period. The NPDES permit coincides with the period of post-construction monitoring and adaptive management. Because the NPDES permit will have an impact on adaptive management decisions for Pond 4, the project proposes to cost share the NPDES monitoring costs for this pond. The combined discharge for Ponds 7, 7A and 8 may require an NPDES permit for longer than the 10-year post construction monitoring/adaptive management period. NPDES permit monitoring required past the post-construction monitoring phase of 10 years will be considered to be OMRR&R and will not be cost shared.

### ***Operations and Maintenance***

Activities and monitoring associated with operations and maintenance (OMRR&R) will not be cost-shared and will commence at the conclusion of the construction phase for each pond. OMRR&R will occur primarily at managed ponds and will consist of operating water control structures and maintaining levees and water control structures. OMRR&R is generally not required for the areas opened to tidal action, although limited removal of non-native invasive smooth cordgrass may be conducted.

Post-construction monitoring is not considered to be part of OMRR&R except for routine monitoring of levee repairs, operation and maintenance of new water control structures and NPDES monitoring that exceeds the adaptive management time period. Long term NPDES monitoring may be needed for the combined discharge from Ponds 7, 7A and 8. NPDES permit monitoring required in excess of the 10-year adaptive management period for the combined discharge from Ponds 7, 7A and 8 will be considered to be OMRR&R and will not be cost-shared.

## **Monitoring Activities:**

### ***Wildlife Monitoring in Managed Ponds and Restored Tidal Habitats***

Macroinvertebrate, fisheries, and avian species data will be collected at locations within Ponds 1, 1A, 2, 3, 4, 5, 6 and 7A during the pre-construction and post-construction phases of the project. Avian data alone will be collected at Pond 7, the bittern pond. This data will be collected as part of the intensive monitoring surveys conducted to assess the impacts of the restoration upon wildlife through time. This intensive survey information will be collected during pre-construction Year 0 and post construction Years 6, 10 and 13 for Ponds 1, 1A, 2, 3, 4, 5, 6, 6A and 7A. Intensive survey information will be collected for Ponds 3, 4 and 5 in Year 8.

### ***Invertebrates***

Invertebrates will be sampled in the water column by AD-Ring@ net sweeps and in the benthos with Eckmann grab samples. Ten sweep and ten grab samples will be taken in each pond (90 of each sample each month); sweep sampling will consist of 3 AS@ sweeps per sample, and each benthic sample will be a composite of 5 cores. Biomass (dry weight) and diversity of invertebrates will be measured on a seasonal basis.

### ***Fish***

Fish species assemblages will be surveyed seasonally. Multiple sampling gear will be used to assess distribution and relative abundance of juvenile and adult fishes, with special emphasis on small species likely to occur in the study area (e.g. rainwater killifish, *Lucania parva*; topsmelt, *Altherinops affinis*; yellowfin goby, *Acanthogobius flavimanus*) (LES 1992). Captured fish will be identified to species with taxonomic keys and counted. The first 25 of each species will be measured for standard length (to the nearest mm) and weight (damp-dry biomass to the nearest 0.1 g). Relative weight ( $W_r$ ), a measure of body condition, will be computed from the formula,  $W_r = W / W_s \times 100$ , where  $W$  is the actual weight of the fish and  $W_s$  is a standard weight (Wege and Anderson 1978; Anderson 1980). Twenty-five individuals from selected species will be analyzed for stomach contents.

### ***Waterbirds***

Ponds will be overlaid with 250 m Universal Transverse Mercator (UTM) grids (6.25 ha cells), and all integrated samples will be located within this grid. Locations of flocks,

species identification and densities will be mapped in the grid overlay and displayed in GIS maps. Ground surveys in intensive monitoring years will be supplemented with analysis of annual digital aerial photography. Trends will be examined by comparing data from before and after installation of water control structures and/or restoration to tidal habitats.

#### ***Marsh Evolution: Sedimentation, Hydrology, and Vegetation Monitoring***

Sediment, hydrology, and vegetation monitoring will be conducted immediately pre-breach to establish baseline conditions. Pre-breach monitoring will include some additional surveys for consistency with post-project monitoring locations, plus installation of sedimentation stations. Post-construction (post-breach) monitoring of tidal geomorphic evolution will document rates and patterns of habitat evolution and key underlying physical processes in each pond restored to tidal habitats.

Monitoring results will be used to identify the need for any adaptive management needed to improve tidal circulation within restored ponds. They will also be used to inform and adaptively manage the tidal wetland restoration designs for future tidal restoration in other ponds. For example, the extent of starter channels in Ponds 4 and 5 will take into account their performance in enhancing habitat evolution in Pond 3.

#### ***Sedimentation Rates***

Sedimentation will be monitored to understand rates and patterns of marsh evolution within breached ponds. Digital aerial photography of Ponds 3, 4 and 5 will be taken during annual fly-overs. The digital photography will be rectified and habitat delineated for Ponds 3, 4 and 5 on an annual basis. Trends in sedimentation processes will be ground-truthed during intensive survey years by the use of marker horizons, sedimentation plates and pins, and topographic re-surveys.

#### ***Levee Breach and Slough Channel Cross Sections***

During intensive survey years, cross-section surveys of levee breaches, external sloughs, and pond-internal sloughs and adjacent berms (if used) will be conducted to understand patterns of tidal scour and drainage and to determine when the widths and depths of the breaches and external and internal sloughs reach equilibrium in response to the tidal prism. Water surface elevations in the sloughs and restored ponds will be monitored monthly to identify any drainage constraints due to increases in the tidal prism.

#### ***Tidal Surveys***

For ponds opened to tidal action, the progress of the tidal regime towards reference conditions will be monitored using appropriate recording equipment. Measurements of tide elevations will be recorded periodically or continuously at locations within the site and at a nearby reference location. The tidal regime and tidal prism will be determined from these measurements.

#### ***Vegetation Colonization***

Vegetation-elevation transects will be conducted during intensive survey years within breached ponds to document rates and patterns of vegetation colonization in tidal marsh

restoration projects in the Napa-Sonoma Marsh. This data will be used to ground-truth the results of annual aerial photography surveys.

### ***Introduced Vegetation***

Vegetation surveys will also include monitoring for introduced species of cordgrass (*Spartina spp.*) and other invasive species of concern such as *Lepidium*. The project team will work with the San Francisco Estuary Invasive Spartina Project to monitor and control introduced and invasive, in order to ensure regional coordination.

### **Water and Sediment Quality**

A comprehensive water-quality monitoring program will be prepared and implemented for the duration of the salinity reduction process. The monitoring will have well-defined data quality objectives, monitoring procedures, and data analysis and reporting protocols to ensure that project operations are controlled according to the NPDES or WDR permit discharge requirements. Monitoring at specific locations will be completed and phased out as each successive pond is restored and salinity has been reduced to ambient levels.

Under the NPDES permit, measurement of key continuous monitoring variables (flow, water level stage, salinity, temperature, and TSS/turbidity) may be implemented at several pond and receiving water locations to provide for real time management of the intakes and discharges. Grab samples will be used to characterize long-term changes in other constituents of concern that might be identified by the resource agencies and could include dissolved oxygen, pH, or selected inorganic ions and trace metals. Aquatic toxicity tests may also be conducted on a periodic basis.

### **Past and Current Monitoring:**

#### ***Wildlife Use of Ponds***

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

#### ***Hydrodynamics***

U.C. Davis, in collaboration with USGS, conducted an intensive hydrologic and water quality data collection project in the Napa-Sonoma Marsh tidal slough network and in the Napa River and Sonoma Creek to determine the physical processes controlling circulation patterns of water and suspended sediment (Warner, *et al.* 1999). Velocity, water level, conductivity, temperature and suspended sediment concentration were measured at 17 sites from September 1997 to March 1998. Future monitoring of physical processes can be compared to this baseline data.

#### ***Wildlife Use and Habitat Evolution of Pond 2A***

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

### ***Topographic and Bathymetric Survey***

A topographic and bathymetric survey of the salt ponds, slough channels, and associated marsh plain was conducted by Towill, Inc. as part of the Feasibility Study with the U.S. Army Corps of Engineers (Towill, 2001). The survey included a very accurate primary control level loop through the site, which was connected to high confidence benchmarks outside the site. This survey was used in the development of the hydrodynamic model by Philip Williams and Associates and will be useful for before and after comparisons of elevations.

### ***Water Quality***

Water and sediment samples from 40 sites within the pond complex, along with sites in the Napa River, Napa Slough, and San Pablo Bay were collected in October, 2001, by Hydroscience, after development of a Sampling and Analysis Plan and Quality Assurance Project Plan approved by the RWQCB (Hydroscience, 2001). Samples were analyzed by MEC Analytical Laboratories for volatile and semi-volatile organics, pesticides, PCBs, heavy metals, dioxins, and general water quality parameters, including nutrients, TDS, TSS, pH, temperature, salinity, and DO.

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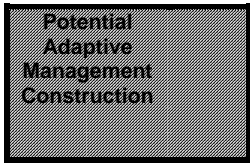
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**TABLE 1 – MONITORING ACTIVITIES**

Pond	Year					Year				Year			Year				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1, 1a, 2	Red	Blue	Pink	Pink	Pink	Pink	Red		Grey		Red		Grey	Red		Grey	
3	Red	Blue		Pink				Pink		Pink		Pink	Grey	Red		Pink	
4	Red	Blue	Blue	Blue	Blue	Blue	Red		Pink		Red		Pink	Red	Pink	Grey	
5	Red	Blue	Blue	Blue	Blue	Blue	Red		Pink		Red		Pink	Red	Pink	Grey	
6, 6a	Red	Blue	Blue	Blue	Blue	Pink	Red		Pink		Red		Grey	Red		Grey	
7	Red	Blue	Blue	Pink	Pink	Pink	Red		Pink		Red		Pink	Red		Grey	
7a	Red	Blue	Pink	Pink	Pink	Pink	Red		Grey		Red		Grey	Red		Grey	
8	Red	Blue	Pink	Pink	Pink	Pink	Red		Grey		Red		Grey	Red		Grey	

KEY:

	Type of Survey and Number of Surveys per Year				
	Fish, Avian, Invertebrates	Habitat Evolution	Water Indicator	NPDES/Water Quality (Pond 4 and Upper Pond Discharge), up to Year 10	
Construction monitoring	0	0	12	12	
Post-construction, cost-shared monitoring	0	1	12	12	
Intensive monitoring (pre-construction and post-construction, cost-shared)	4	1	12	12	



LR = Levee Repair and installation of water control structures

**SR** = Salinity Reduction

**HR** = Construction of Habitat Restoration Features

**P** = Construction of reclaimed water pipeline and mixing chamber for ponds 7, 7a and 8

**TABLE 2– MONITORING AND ADAPTIVE MANAGEMENT COSTS**

<b>MONITORING</b>								
<b>Activity</b>	<b># Times/Year</b>	<b>Which Years?</b>	<b># Years</b>	<b>Cost/Unit</b>	<b>Unit</b>	<b># Units</b>	<b>Total Cost for Activity</b>	<b>Notes</b>
<b>Water Quality/NPDES</b>	12	0-10	11	\$7,530	month	264	\$1,988,000	Assuming two discharge monitoring points required at Pond 4 and combined discharge of 7, 7A and 8
<b>Habitat Evolution/Sediment/ Bathymetric Surveys</b>								
Pond 3	2	2	1	\$18,687	bi-annual	2	\$37,374	2 surveys in Pond 3 in year 2
Pond 3	1	0,6,8,10	5	\$17,150	year	4	\$68,600	
Pond 4	1	0, 6, 8, 10, 13	5	\$15,400	year	5	\$77,000	
Pond 5	1	0, 6, 8, 10, 13	5	\$15,400	year	5	\$77,000	
Shallow Water Sounding System						1	\$40,000	
<b>Aerial Surveys for Sediment/ Vegetation</b>								
Pond 3, 4, 5	1	0-15	15	\$6,250	year	15	\$93,750	includes rectification and assessment of habitat types
<b>Vegetation Surveys</b>								
Ponds 3, 4 and 5	2	0,6,8,10,13	5	\$17,000	bi-annual	10	\$170,000	on-ground transect, verification of aerial photography
Pond 3	2	2	1	\$17,000	bi-annual	2	\$40,000	
<b>Water Quality Indicators</b>								
Pond 1	4	0-6, 10, 13	9	\$425	month	108	\$45,920	
Pond 1A	4	0-6, 10, 13	9	\$425	month	108	\$45,920	
Pond 2	4	0-6, 10, 13	9	\$425	month	108	\$45,920	
Pond 3	4	1 - 13	13	\$368	month	156	\$57,440	
Pond 4	4	0-15	16	\$344	month	192	\$66,080	
Pond 5	4	0-15	16	\$344	month	192	\$66,080	
Pond 6/6A	4	0-10, 13	12	\$379	month	144	\$54,560	
Pond 7	4	0-13	14	\$359	month	168	\$60,320	
Pond 7A	4	0-6, 10, 13	9	\$425	month	108	\$45,920	
Pond 8	4	0-6, 10, 13	9	\$425	month	108	\$45,920	
<b>Wildlife and Productivity</b>								
<b>Avian</b>								
Ponds 1, 1A and 2	6	0, 3, 6, 10, 13	5	\$767	quarterly	30	\$23,000	
Pond 3	6	0, 6, 8, 10, 13	5	\$767	quarterly	30	\$23,000	
Pond 4	6	0, 6, 8, 10, 13	5	\$767	quarterly	30	\$23,000	
Pond 5	6	0, 6, 8, 10, 13	5	\$767	quarterly	30	\$23,000	
Ponds 6, 6A	6	0, 6, 10, 13	4	\$808	quarterly	24	\$19,400	
Pond 7	6	0, 6, 10, 13	4	\$808	quarterly	24	\$19,400	
Pond 7A	6	0, 6, 10, 13	4	\$808	quarterly	24	\$19,400	

Pond 8	6	0, 6, 10, 13	4	\$808	quarterly	24	\$19,400	
<b>Invertebrates</b>								
Ponds 1, 1A and 2	2	0, 3, 6, 10, 13	5	\$2,200	quarterly	10	\$22,000	
Pond 3	2	0, 6, 8, 10, 13	5	\$2,200	quarterly	10	\$22,000	
Pond 4	2	0, 6, 8, 10, 13	5	\$2,200	quarterly	10	\$22,000	
Pond 5	2	0, 6, 8, 10, 13	5	\$2,200	quarterly	10	\$22,000	
Ponds 6, 6A	2	0, 6, 10, 13	4	\$2,325	quarterly	8	\$18,600	
Pond 7a	2	0, 6, 10, 13	4	\$2,325	quarterly	8	\$18,600	
Pond 8	2	0, 6, 10, 13	4	\$2,325	quarterly	8	\$18,600	
<b>Fish</b>								
Ponds 1, 1A and 2	2	0, 3, 6, 10, 13	5	\$2,300	quarterly	10	\$23,000	
Pond 3	2	0, 6, 8, 10, 13	5	\$2,300	quarterly	10	\$23,000	
Pond 4	2	0, 6, 8, 10, 13	5	\$2,300	quarterly	10	\$23,000	
Pond 5	2	0, 6, 8, 10, 13	5	\$2,300	quarterly	10	\$23,000	
Ponds 6, 6A	2	0, 6, 10, 13	4	\$2,425	quarterly	8	\$19,400	
Pond 7A	2	0, 6, 10, 13	4	\$2,425	quarterly	8	\$19,400	
Pond 8	2	0, 6, 10, 13	4	\$2,425	quarterly	8	\$19,400	
<b>TOTAL for surveys</b>							\$3,589,404	
<b>Administrative Costs</b>	1	0 to 15	8	\$78,029	year	8	\$624,236	Includes supervision, monitoring report, based on 20% of total cost of monitoring surveys
<b>TOTAL for monitoring</b>							<b>\$4,213,640</b>	

**TABLE 2 - ADAPTIVE MANAGEMENT COSTS**

Evaluation Activities	Item	Which Years?	# Years	Cost/Unit	Unit	# Units	Total Cost for Activity	Rationale
Evaluation of Monitoring Data		3, 7, 11, 14	4	\$100	hour	160	\$16,000	To assess effects of restoration and progress with tidal habitat evolution, to validate modeling efforts and to test model projections. Year 3 assessment is required to verify habitat restoration features required for Ponds 4 and 5.
Identification of Response Options and Recommendations								
	Experts' and Senior Management Staff time	3, 7, 11, 14	4	\$100	hour	160	\$16,000	To fund participation of a panel of experts in a yearly meeting to review monitoring data and project progress. Panel will identify appropriate plan of action, if any.
	Project Team Labor	3, 7, 11, 14	4	\$100	hour	160	\$16,000	To prepare for each panel meeting
	Report	3, 7, 11, 14	4	\$100	hour	40	\$4,000	Documents response options and recommendations
Construction Services	oversight	5,9,13,15	4	\$100	hour	7680	\$768,000	On-site construction supervision for adaptive management activities
Budget Assessment		3, 7, 11, 14	4	\$100	hour	40	\$4,000	To determine ability to act on preferred plan of action
<b>TOTAL for Evaluation</b>							<b>\$824,000</b>	

Activities								
Implementation Activities (Potential Physical Construction)								Includes only actions that would incur additional costs
	Location	Item	Which Year(s)?	Cost/Unit	Unit	# Units	Total Cost for Activity	Rationale
<b>TIDAL PONDS</b>								
	Pond 3	Starter Channels and Berms	8, 12, and/or 15	\$200	linear foot	7,150	\$1,430,000	To increase rate of habitat evolution (starter channels and berms) and provide additional habitat connectivity (levee lowering) if tidal marsh evolution is slower than projected. Quantities listed would increase the extent of these measures to the level the represented by Habitat Restoration Option 4 (accelerated restoration), except for starter channels and berms in Pond 3 (this increase was halved).
		Levee Lowering		\$54	linear foot	4,900	\$264,600	
	Pond 4	Starter Channels and Berms		\$200	linear foot	10,300	\$2,060,000	
		Levee Lowering		\$54	linear foot	3,500	\$189,000	
	Pond 5	Starter Channels and Berms		\$200	linear foot	8,400	\$1,680,000	
		Levee Lowering		\$54	linear foot	2,900	\$156,600	
<b>MANAGED PONDS</b>								
	Pond 6	Additional siphon	8, 12, and/or 15	\$878,000	lump sum	1	\$878,000	Pond management is not meeting project goals of salinity reduction or water depth, due to water circulation issues. Proposed budget is based on doubling the design-level water flows.
	Pond 6A	New intakes		\$3,445,000	lump sum	1	\$3,445,000	
	Pond 7	Additional discharge into mixing chamber		\$100,000	lump sum	1	\$100,000	
	Pond 7A	Additional discharge into mixing chamber		\$100,000	lump sum	1	\$100,000	
<b>TOTAL for adaptive management implementation</b>							<b>\$10,303,200</b>	
<b>TOTAL FOR ALL ADAPTIVE MANAGEMENT</b>							<b>\$11,127,200</b>	

**TABLE 3 – COMPLIANCE MONITORING BREAKDOWN**

	<b>Regulatory Requirement</b>			
	<b>CWA – NPDES permit</b>	<b>Biological Opinion</b>	<b>NEPA Mitigation</b>	<b>Adaptive Management Only</b>
<b>Type of Monitoring</b>				
Water Quality Monitoring Ponds	<b>Y</b>		<b>Y</b>	
Water Quality Monitoring Receiving Water	<b>Y</b>		<b>Y</b>	
Avian Surveys		<b>Y</b>	<b>Y</b>	
Fish Surveys		<b>Y</b>	<b>Y</b>	
Invertebrate Surveys		<b>Y</b>	<b>Y</b>	
Vegetation Surveys		<b>Y</b>	<b>Y</b>	
Habitat Evolution/Sediment/Bathymetric Survey				<b>Y</b>
Tidal elevation measurements				<b>Y</b>

FIGURE 1 – ADAPTIVE MANAGEMENT DECISION MATRIX

