

**SONOMA BAYLANDS  
WETLAND DEMONSTRATION PROJECT**

**MONITORING PLAN**

**San Francisco District  
U.S. Army Corps of Engineers  
333 Market Street  
San Francisco, California 94105**

and

**California Coastal Conservancy  
1330 Broadway, Suite 1100  
Oakland, California 94612**

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**TABLE OF CONTENTS**

<b>PAGE</b>	<b>SECTION</b>
1	BASIS FOR MONITORING PLAN
5	SUCCESS CRITERIA
13	REMEDICATION
15	MONITORING PROGRAM
24	DATA ANALYSIS AND MANAGEMENT
26	ADDITIONAL MONITORING FOR SCIENTIFIC RESEARCH
27	MODIFICATION OF MONITORING PLAN
28	REFERENCES
APPENDIX A	SUMMARY OF MONITORING PROGRAM

**SONOMA BAYLANDS  
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**BASIS FOR MONITORING PLAN**

**OBJECTIVES OF THE PROJECT**

The primary objective of the Sonoma Baylands Wetland Demonstration Project is to restore a tidal salt marsh community on 289 acres of diked baylands within a period of 20 years from the restoration of tidal action.

A secondary objective of the Sonoma Baylands Wetland Demonstration Project is to increase the acreage of suitable habitat for two endangered species, the salt marsh harvest mouse and the California clapper rail, within a period of 20 years from the restoration of tidal action.

**RESTORATION DESIGN APPROACH**

The design approach used for the Sonoma Baylands project was based on a review of previous tidal salt marsh restoration projects in San Francisco Bay, including projects that used dredged material to restore diked, subsided former marshes. Design elements of that were successful in the previous projects were incorporated into the Sonoma Baylands project, while ineffective and detrimental design elements were avoided. The resulting design approach is based on the use of natural processes to allow a tidal salt marsh community to develop over a period of time. In essence, the Sonoma Baylands project consists of the construction of a tidal mudflat that will be converted to a tidal salt marsh within a relatively short period of time by natural physical and biological processes. This design approach is intended to duplicate the process of natural marsh development, but at an accelerated rate. This design approach is intentionally distinct from approaches that attempt to create an "instant" marsh by constructing the marsh topography in its final form and then planting appropriate vegetation. Review of previous marsh restoration projects strongly indicated that a greater reliance upon natural forces to determine the final form of the marsh ultimately results in a more natural system, particularly in regard to channel development.

Because the design approach used for the Sonoma Baylands project relies on natural forces to develop the final form of the marsh over many years, that final form has not been precisely defined in advance. While the primary objective of the project is to restore a tidal salt marsh system, the locations of specific features within that system, such as channels and vegetation types, will not be predetermined or controlled.

## Exhibit 5: Project Monitoring Plan

### PURPOSES OF MONITORING PLAN

The purposes of this plan are to establish success criteria for the Sonoma Baylands Wetland Demonstration Project and to establish a monitoring program for both the pilot and main units of the project. This monitoring plan has been prepared, and will be implemented, pursuant to the Project Cooperation Agreement for the Sonoma Baylands project, the Dredged Material Reuse Requirements for the project, and the conditions of the endangered species consultations for the project.

### PROVISIONS OF PROJECT COOPERATION AGREEMENT

The Corps of Engineers and the California Coastal Conservancy signed a Project Cooperation Agreement (PCA) regarding construction, maintenance, monitoring, and remediation of the Sonoma Baylands Wetland Demonstration Project in May 1994. Article VI of the PCA includes the following provisions regarding monitoring and remediation:

"The Corps and the Conservancy will prepare a detailed monitoring plan in coordination with other concerned agencies prior to the restoration of tidal action to the pilot unit. The monitoring plan will include, but not necessarily be limited, to the physical, biological, and chemical attributes to be monitored, methods for measuring those attributes, monitoring frequency and duration, preparation and distribution of monitoring reports, estimated monitoring costs, and success criteria with respect to both physical and biological functions. The monitoring plan may be subsequently revised by the Corps with the written concurrence of the Conservancy and in coordination with other concerned agencies.

In the event that the monitoring results indicate a potential need for remediation in order for the project to fulfill the success criteria for physical functions in the monitoring plan, an investigation will be conducted by the Corps pursuant to Section 106 of the Water Resources Development Act of 1992 to determine the feasibility of modifying the project to rectify any identified deficiency. The investigation and any remediation will be subject to receiving funds appropriated by the Congress of the United States and using funds provided by the Conservancy.

The Corps and the Conservancy will continue to monitor the project until the monitoring results indicate that all the success criteria in the monitoring plan have been met, or until it is mutually agreed that monitoring is no longer required."

The PCA also provides that the Coastal Conservancy will be responsible for operation, maintenance, repair, replacement, and rehabilitation of the Sonoma Baylands Wetland Demonstration Project following the completion of construction. Therefore, post-construction management of the site will be arranged by the Coastal Conservancy.

### **DREDGED MATERIAL REUSE REQUIREMENTS**

The California Regional Water Quality Control Board, San Francisco Bay Region adopted Dredged Material Reuse Requirements for the Sonoma Baylands project by Order No. 93-081 on July 21, 1993. The Self-Monitoring Program included in the Dredged Material Reuse Requirements requires monitoring of the restoration of marsh habitat and water quality at the site, and effects in the outboard marsh, during the post-construction phase following the restoration of tidal action. The Self-Monitoring Program requires preparation of a monitoring plan subject to the approval of the Executive Officer of the Regional Board.

### **REQUIREMENTS OF ENDANGERED SPECIES CONSULTATIONS**

During informal consultation between the Corps and the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act, NMFS identified concerns regarding potential impacts on the endangered Sacramento River winter-run chinook salmon. In response to those concerns, the Corps agreed to monitor tidal exchange characteristics and water quality, including temperature and dissolved oxygen, and the presence of fish and other aquatic species within the pilot unit beginning immediately after the restoration of tidal action (USACE 1994a and 1994c). The Corps also agreed to provide the monitoring plan to NMFS for approval. The monitoring results for the pilot unit will be considered jointly by NMFS, the Corps and the Conservancy to determine the need to remediate the pilot unit or modify the plan for restoration of tidal action to the main unit. If the pilot unit monitoring results or other new information indicate that the restoration of tidal action to the main unit is likely to adversely affect the winter-run salmon or its critical habitat, the Corps will initiate further consultation under the Endangered Species Act prior to the restoration of the main unit. NMFS's concurrence that the project was not likely to adversely affect the winter-run chinook salmon was based on these provisions (NMFS 1994).

The U.S. Fish and Wildlife Service has prepared a Biological Opinion regarding the impact of the project on existing California clapper rail and salt marsh harvest mouse habitat (USFWS 1996a). The Biological Opinion includes an incident take statement that requires the Corps and Conservancy to ensure that the restored tidal marsh within the Sonoma Baylands site will support a minimum of three pairs of California clapper rails. The incidental take statement also requires the Corps and Conservancy to prepare a monitoring plan for that specific component of the restoration project which defines the success criteria for that component and the attainment of suitable habitat for the salt marsh harvest mouse. The monitoring plan was submitted to the Service for review and received conditional approval (USFWS 1996b).

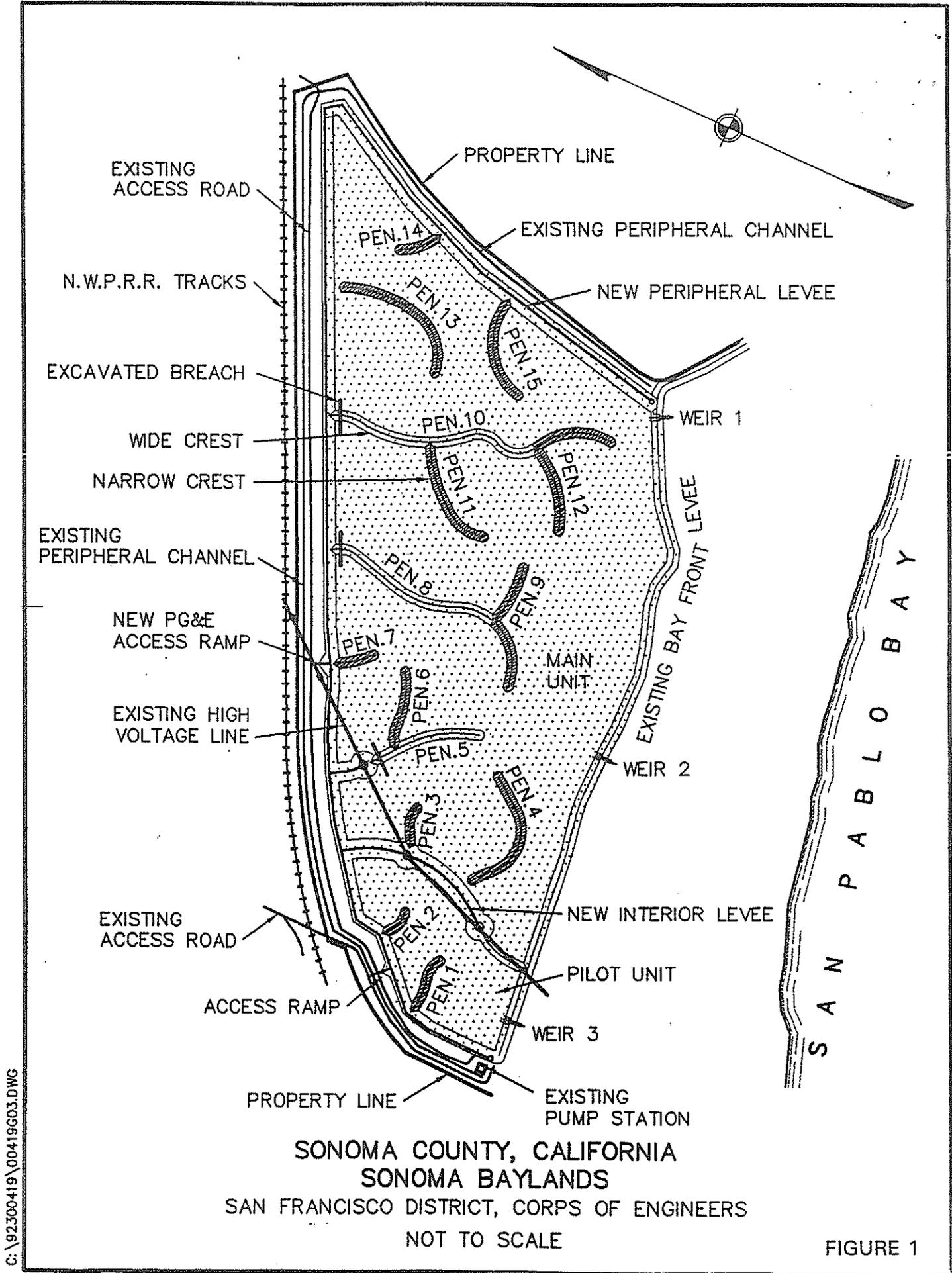
## Exhibit 5: Project Monitoring Plan

### PURPOSES OF MONITORING PROGRAM

The wetland at Sonoma Baylands will change and develop in response to many external factors as it trends toward equilibrium in the long term. This monitoring program will measure and analyze the course of the wetland's initial development.

Based on the requirements discussed above, the monitoring program must address the following purposes:

1. Determine whether the objectives of the project have been achieved by evaluating the restoration of wetland habitat within the project site in comparison to the biological success criteria established by this plan.
2. Determine whether physical remediation measures are required to achieve the primary objective of the project by comparing the physical development and characteristics of the project to the physical success criteria established by this plan.
3. Determine whether water quality conditions in the pilot unit are detrimental to winter-run chinook salmon and indicate that remediation of the pilot unit and modification of the restoration plans for the main unit are required to avoid impacts on the species.
4. Document the development of the physical and biological characteristics of the restored tidal wetland system to provide information for use in the design of future restoration projects.



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## SUCCESS CRITERIA

### SELECTION OF SUCCESS CRITERIA

The following physical and biological success criteria have been selected to address the first two purposes of this monitoring plan identified above. The physical success criteria are designed to evaluate whether remediation of the project is required in order for a productive wetland to develop through natural processes. The biological success criteria are designed to evaluate whether the objectives of the project have been achieved. The reasons for including each success criterion are briefly explained before each criterion is stated. The criteria are listed in the approximate chronological sequence in which they would be effective. Whenever the application of a success criterion requires a statistical determination of difference, a 90% significance level will be used.

### PHYSICAL SUCCESS CRITERIA

#### Dredged Material Fill Elevations

Previous wetland restoration projects have demonstrated that dredged material fill elevations should be below the equilibrium marsh elevation to allow development of an adequate tidal channel system. At Sonoma Baylands, the equilibrium marsh elevation is expected to be the same as for the existing bayward marsh, which is approximately +3.4 feet National Geodetic Vertical Datum of 1929 (NGVD), or Mean Higher High Water. Based on observations of previous restoration projects using dredged material, the design elevation for the dredged material fill was set at +2.0 feet NGVD. A conservative (i.e., low) design elevation was selected to reduce the possibility of fill being placed too high of an elevation due to engineering or construction errors. The available data suggest that the fill elevation should be a minimum of one-half foot below the equilibrium marsh elevation to allow an acceptable amount of channel formation. The Demonstration Project Report and Environmental Assessment (USACE 1994a) therefore identified +2.9 feet NGVD as the maximum allowable fill elevation. The elevation and density of the dredged material were monitored during construction using electrical resistivity staffs and elevation surveys. Dredged material was discharged into the site as a slurry and will consolidate prior to the restoration of tidal action (levee breach). The dredged material slurry was therefore placed to initial fill elevations above the design fill elevation to achieve the design elevation after initial consolidation. Any areas still filled above +2.9 feet NGVD after initial consolidation should be identified and remediated if they are expected to have a substantial effect on the development of the wetland.

The success criterion for the fill elevation should be effective near the time of restoration of tidal action so that any necessary remediation can be implemented prior to substantial development of the wetland. The sediment surface is not expected to be exposed above ponded water until very shortly before the restoration of tidal action. A substantial amount of consolidation may occur within one month after the restoration of tidal action due to the drainage of interstitial water during low tides.

## Exhibit 5: Project Monitoring Plan

Therefore, the success criterion should be effective approximately one month after the restoration of tidal action.

### *Physical Success Criterion No. 1:*

*The maximum dredged material surface elevation in each unit approximately one month after tidal action is restored will not exceed +2.9 feet NGVD (excluding material deposited on the toes of the constructed levee and peninsula slopes during initial consolidation).*

### **Chemical Constituents**

Exposure to excessive concentrations of detrimental chemical constituents must be prevented to allow development of a fully productive marsh community at the Sonoma Baylands site. Dredged sediments used in the Sonoma Baylands project were tested and selected in coordination with the U.S. Environmental Protection Agency and the California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB). The Petaluma River channel and Oakland Harbor sediments selected for Sonoma Baylands were found to be suitable for aquatic disposal based on chemical and biological testing. In addition, the RWQCB has established Interim Sediment Screening Criteria and Testing Requirements for Wetland Creation and Upland Beneficial Reuse (RWQCB 1992). Those Screening Criteria include sediment screening criteria for wetland creation cover and noncover material. Because the Sonoma Baylands project was not designed to permanently confine noncover material, all of the sediments used at the Sonoma Baylands site are considered to be wetland cover material. The Screening Criteria provide that any exceedence of the specified concentrations will be reviewed by the RWQCB on a case-by-case basis due to the inherent uncertainty in establishing sediment screening criteria.

Pre-dredge chemical and bioassay testing of the Petaluma River "across-the-flats" sediments used in the pilot unit indicated that the sediments contained only trace levels of contaminants, had no detected toxicity, and were suitable for either unconfined aquatic disposal or use in wetland restoration (USACE 1994a). The chemical test results also indicated that the sediments from all sections of the channel were very similar in their contaminant levels, as would be expected for recently deposited material in an open water channel. The contaminant concentrations in the channel sediments were also found to be very similar to the concentrations in reference sediments sampled from the tidal mudflat south of the Sonoma Baylands site. Because the sediments used in the pilot unit were found to be homogeneous and have been well-characterized, there is no need to retest those sediments.

Pre-dredge chemical testing of the Oakland Harbor sediments indicated that the sediments were heterogeneous in their concentrations of contaminants. Some Oakland Harbor sediments were determined to be unsuitable for wetland creation based on their contaminant levels. Because Oakland Harbor sediments were selected for use at Sonoma Baylands based on a limited number of sediment samples, it is possible that areas of sediment containing elevated levels of contaminants could have existed within the areas of sediment selected for use at Sonoma Baylands. Mixing of sediments during dredging and placement at Sonoma Baylands would tend to homogenize contaminant levels, thereby reducing the maximum concentrations. Nonetheless, testing of the Oakland Harbor material deposited

## Exhibit 5: Project Monitoring Plan

in the main unit of Sonoma Baylands is warranted to ensure that the future marsh community will not be exposed to deleterious levels of contaminants from dredged material.

Because the primary purpose of post-placement testing will be to verify that the pre-dredge testing adequately characterized the dredged material, chemical testing is considered to be sufficient. The expense of biological testing is not warranted unless chemical testing identifies a specific need for more intensive investigation.

### *Physical Success Criterion No. 2:*

*Prior to the restoration of tidal action to the main unit, concentrations of chemical constituents in the surface dredged material of the main unit will not exceed the Regional Water Quality Control Board (RWQCB) wetland cover screening guidelines in effect at the time the dredged material was deposited, or higher concentrations specifically approved by the RWQCB for the Sonoma Baylands project.*

In the case of the main unit, the RWQCB approved the use of Oakland Harbor sediments that exceeded the wetland cover screening criterion for chromium of less than 220 mg/kg dry weight. The chromium found in previously undisturbed Oakland Harbor sediments was apparently derived from native serpentine rock and had low levels of solubility, bioavailability, and toxicity due to the physical and chemical state of the chromium (USACE 1994b). It was therefore concluded that the interim sediment screening criterion for chromium was not appropriate for naturally occurring chromium in Bay sediments. Oakland Harbor sediments used at Sonoma Baylands had chromium concentrations ranging from 157 to 488 mg/kg. The RWQCB also approved the use of sediments from two specific areas (Oakland Harbor dredging polygons OC-13 and OC-6,7,8) in which the wetland cover screening criteria for mercury, zinc, PCB, and DDT were exceeded. Use of material from the two polygons allowed a substantial increase in the quantity of fine-grained material available for use at Sonoma Baylands. Mercury concentrations in the two polygons ranged from 0.417 to 0.490 mg/kg, compared to a screening criterion of less than 0.35 mg/kg. Zinc concentrations in the two polygons ranged from 165 to 175 mg/kg, compared to a screening criterion of less than 160 mg/kg. PCB concentrations in the two polygons ranged from 0.041 to 0.089 mg/kg, compared to a screening criterion of less than 0.050 mg/kg. One polygon had a total DDT concentration of 0.006 mg/kg, compared to a screening criterion of 0.003 mg/kg.

### **Exterior Tidal Channels**

Development of adequate tidal connections to San Pablo Bay is important to the physical development of the restored tidal marsh at Sonoma Baylands. During the initial planning of the project, it was decided that disturbance of the existing tidal salt marsh between Sonoma Baylands and San Pablo Bay should be minimized by allowing the connecting channels to erode naturally, rather than excavating the channels. Based on previous experience, the connecting channels are expected to erode to sufficient dimensions for the restored marsh within several years. However, if measurable erosion of the channels is not apparent within a year after the restoration of tidal action, remedial

## Exhibit 5: Project Monitoring Plan

action should be implemented to avoid further delay of the restoration process. Erosion will be considered to be measurable if the changes in channel widths or invert elevations exceed the range of measurement error.

### *Physical Success Criterion No. 3:*

*The primary tidal channel between each bayfront levee breach and San Pablo Bay will measurably erode toward the equilibrium channel geometry within one year of excavation of the levee breach.*

### **Tidal Regime**

As described above, the development of adequate tidal connections to San Pablo Bay is a critical aspect of the Sonoma Baylands project. The existing channels in the bayward marsh are expected to erode until they reach dimensions that are in equilibrium with the tidal prism of the restored marsh. To evaluate whether the tidal connections have eroded to an adequate size to serve the restored marsh, the dimensions of the connecting channels could be compared to those expected in a natural marsh of equal size. Because of site specific considerations (e.g., local tide range) and the relatively large range of variation among natural marshes, direct comparison of channel dimensions might not be definitive. In order to provide a more direct measurement of the functional adequacy of the connecting channels, the tidal regime within the restored area will be measured instead. In order for the topography of the marsh to develop through channel scouring and sediment deposition, and for vegetation to colonize the marsh plain, the restored area must be inundated and drained regularly.

### *Physical Success Criterion No. 4:*

*Within a period of five years, the mean tide range (i.e., difference between the elevations of the tides corresponding to mean high and mean low water tides in San Pablo Bay) in the primary channel within each unit near the levee breach will be at least 90% of the mean tide range in northern San Pablo Bay.*

The inverts of the primary channels within both units are expected to be below mean low water (MLW = -1.6 ft. NGVD) based on hydraulic geometry relationships developed by Philip Williams and Associates. However, the invert of the pilot unit channel could be above MLW and still be within the range of variation for marshes of equal area. If the pilot unit channel invert is above MLW, then only the portion of the mean tide range above the channel invert elevation will be considered in applying Physical Success Criterion No. 4. Nonetheless, if the channel invert is higher than -0.6 ft. NGVD (the limit of the known range of variation), the tidal hydrology of the pilot unit should be evaluated to determine whether it is functionally adequate.

## Exhibit 5: Project Monitoring Plan

### Peninsula Crest Elevations

Fifteen low "peninsulas" (earth berms) were constructed within the marsh restoration area to act as wind-wave barriers that will accelerate the natural deposition of sediment and reduce wave erosion of the perimeter levees during marsh development, and to prevent the formation of major channels along the toes of levees. The peninsulas were designed to be temporary features that will gradually subside and erode as the surrounding marsh develops. If the peninsulas fail to subside sufficiently during initial development of the marsh, they could provide permanent habitation sites for undesirable predators, such as the introduced red fox and rats. The peninsulas were therefore constructed with a crest elevation of only +5.0 feet NGVD, which is approximately the same as the highest normal (i.e., astronomical, not meteorological) tides. To accelerate erosion, most of the peninsulas were constructed with a crest width of only two feet. A few peninsulas were constructed with ten-foot crests to allow the extension of dredge pipeline to the center of main unit, if necessary. To reduce the use of the peninsulas by upland predators, the nine longer peninsulas will be separated from the peripheral levee by a constructed or excavated gap of about 75 feet.

The crest elevations of the peninsulas will be monitored to ensure that they subside and erode sufficiently to prevent their use as permanent habitation sites by upland predators. A crest elevation of +4.5 feet NGVD is only one foot above mean higher high water. Peninsulas with crest elevations at or below +4.5 feet NGVD will not provide sufficient dry soil for the excavation of burrows and will be occasionally overtopped by high tides. Sections of peninsulas that have a crest elevation at or below +4.0 feet NGVD will be regularly overtopped by summer and winter high tides.

#### *Physical Success Criterion No. 5:*

*At least 90% of the total length of the peninsulas will have a crest elevation below +4.0 feet NGVD, and all portions of the peninsulas more than 25 feet from the peripheral levees will have crest elevations below +4.5 feet NGVD, within 10 years after the restoration of tidal action.*

### Internal Channel Development

Development of adequate channels within the restoration area is desirable to provide important foraging habitat for California clapper rails, as well as tidal circulation and estuarine fish habitat. The internal channels will not be constructed, but are expected to develop over time through natural erosion and sediment deposition. The following success criterion is intended to ensure that the restored marsh will provide foraging habitat for clapper rails sufficient to offset the loss of foraging habitat in the existing bayward marsh resulting from channel erosion caused by the project. Channel development will be measured in terms of channel density, which is the ratio of total channel length to the marsh area. Because the existing bayward marsh has a poorly developed channel system, the specified criterion is a minimal degree of channel development. The existing bayward marsh contains a number of mosquito and borrow ditches. These artificial channels can be distinguished by their linear form and constant widths, and they will not be included in the comparison of the existing and restored marsh areas.

## Exhibit 5: Project Monitoring Plan

### *Physical Success Criterion No. 6:*

*Within twenty years following the restoration of tidal action, the density of channels within the restored marsh area will equal or exceed the pre-project density of natural channels (i.e., excluding artificial mosquito and borrow ditches) in the existing bayward marsh.*

## **BIOLOGICAL SUCCESS CRITERIA**

### **Marsh Vegetation Establishment**

The establishment of wetland vegetation is an obvious indicator of the development of wetland functions. Based on experience from previous tidal salt marsh restoration projects in the San Francisco Bay area, it was decided that active planting of wetland vegetation would not be necessary. That decision was based on the expectation that appropriate vegetation would begin to colonize the restored area within several years. If wetland vegetation does not start to grow within the restored tidal area within five years, it will be apparent that the planning assumptions regarding vegetation of the site need to be reconsidered. The initial establishment of vegetation also provides a short-term measurement of biological success to ensure that restoration of the wetland is progressing adequately.

### *Biological Success Criterion No. 1:*

*Tidal salt marsh vegetation will begin to establish in each unit within five years after the restoration of tidal action.*

### **Marsh Vegetation Cover**

The primary objective of the Sonoma Baylands Wetland Demonstration Project is to restore a tidal salt marsh community on 289 acres of diked baylands within a period of 20 years from the restoration of tidal action. Tidal salt marsh communities consist of unvegetated channels and mudflats and vegetated marsh plains. The development of these habitat zones at Sonoma Baylands will be primarily dependent upon the accretion of sediment over time, which is required to provide appropriate elevations, as well as the hydroperiod and colonization by vegetation. Under a normal tidal regime, cordgrass is expected to colonize areas ranging from about mean tide level to mean high water (MHW) and pickleweed is expected to colonize areas from about MHW to +5 feet NGVD. The proportion of area covered by tidal salt marsh vegetation is a direct measure of the extent to which a tidal salt marsh community has been created. Although the fully developed Sonoma Baylands wetland is expected to be predominantly vegetated marsh, the presence of some unvegetated habitats, including salt pannes, channels, and tidal flats, is also desirable. The project design is intended to encourage the persistence of mudflats in the southern portion of the main unit. Therefore, the minimum total marsh vegetation cover required for the Sonoma Baylands project to be considered fully successful is 65% within a period of 20 years.

## Exhibit 5: Project Monitoring Plan

### *Biological Success Criterion No. 2:*

*At least 65% of the entire tidal area will have marsh vegetation cover within 20 years of the restoration of tidal action.*

### **Birds**

One of the purposes for which the Sonoma Baylands Wetland Demonstration Project was specifically authorized was to "expand the feeding and nesting areas for waterfowl along the Pacific flyway (USACE 1994a)." Birds are a visible and widely understood indicator of habitat value and function. In addition to waterfowl, the Sonoma Baylands site is expected to support substantial populations of shorebirds, other waterbirds, raptors, and passerine birds. Because the Sonoma Baylands project is intended to provide habitat primarily for water-associated birds, only the shorebird, waterfowl, and other waterbird groups will be addressed by the success criterion for bird use. Densities for these three groups within marsh and mudflat portions of the restored area will be compared to corresponding natural marsh and mudflat reference areas. The mudflat reference area will be the existing bay mudflat southwest of the restored area. A marsh reference area that best duplicates the physical setting of restored area will be selected concurrently with the initiation of bird surveys in marsh portions of the restored area. The existing bayward marsh will be used as a reference area unless a superior marsh reference site, with greater similarity to the Sonoma Baylands site, is identified by the Corps, Conservancy and their consultants during the course of the monitoring period.

### *Biological Success Criterion No. 3:*

*The total population densities of shorebirds, waterfowl, and other waterbirds (measured as three separate groups) that use the restored tidal area will not be significantly less than the corresponding densities for marsh and mudflat reference sites within 20 years.*

### **Fishes**

The preservation of fishes was among the purposes for which the Sonoma Baylands project was authorized (USACE 1994a). Use of the site by estuarine fishes will indicate whether the restored marsh provides the aquatic food chain support and nursery habitat functions of a natural wetland. The number and type of species present can also indicate the general quality of the habitat.

### *Biological Success Criterion No. 4:*

*Estuarine fishes and their life stages will utilize tidal channels within the restored tidal area in total densities that are not significantly less than those of nearby reference marshes within 20 years.*

## Exhibit 5: Project Monitoring Plan

### Endangered Species

One of the purposes for which the Sonoma Baylands Wetland Demonstration Project was specifically authorized was to "provide habitat for endangered species (USACE 1994a)." A secondary objective of the Sonoma Baylands Wetland Demonstration Project is to increase the acreage of suitable habitat for two endangered species, the salt marsh harvest mouse (SMHM) and the California clapper rail, within a period of 20 years from the restoration of tidal action. Under the terms and conditions specified by the incidental take statement in the U.S. Fish and Wildlife Service's Biological Opinion (USFWS 1996), the Corps and Conservancy must ensure that the restored tidal marsh within the Sonoma Baylands site supports a minimum of three pairs of California clapper rails and provides suitable habitat for the SMHM. A required acreage of suitable habitat for the SMHM was not specified by the Service; however, the DPR (USACE 1994a) conservatively estimated that the project would provide at least 28 acres of suitable habitat. Relative to the estimated loss of 6.5 acres of existing potential SMHM habitat due to tidal scouring of the exterior channels, the restoration of a minimum of 28 acres of suitable SMHM habitat over a period of 20 years is considered sufficient to offset the potential impacts of the project on the SMHM.

#### *Biological Success Criterion No. 5:*

*The project site will support a minimum of three pairs of California clapper rails within 20 years.*

#### *Biological Success Criterion No. 6:*

*The project site will provide a minimum of 28 acres of suitable habitat for the salt marsh harvest mouse within 20 years. Suitable habitat will consist of either habitat found to be occupied by salt marsh harvest mice or habitat that meets the following criteria: Contiguous areas of at least five acres with a minimum of 80% coverage by pickleweed having an average height of at least 40 cm at the summer maximum of growth. These areas shall have an overall cover of 100% with a complexity of native halophytes in the form of fat hen (Atriplex triangularis or patula) and/or alkali heath (Frankenia salina), but not invasive nonnative plant species such as peppergrass (Lepidium latifolium).*

## REMEDATION

This monitoring plan identifies both physical and biological success criteria for the Sonoma Baylands project. As proposed in the Demonstration Project Report (DPR) (USACE 1994a) and prescribed by the Project Cooperation Agreement (PCA) between the Corps of Engineers and the Coastal Conservancy, the Corps will initiate a remediation investigation if the monitoring results indicate that one or more physical success criteria have not been met within the specified periods. The purpose of the investigation would be to determine the feasibility of modifying the project to rectify any identified physical deficiency. The investigation would be conducted under the authority of Section 106 of the Water Resources Development Act of 1992, which authorized construction, monitoring and remediation (i.e., corrective management) of the project.

The physical attributes of the restored marsh are subject to correction through structural modifications. The biological development of the restored marsh will be determined, in turn, by the physical attributes. Therefore, the DPR and PCA identify the physical success criteria, but not the biological success criteria, as the standards for initiating remediation. Biological success criteria are identified in this monitoring plan as standards of comparison to be used in determining whether the biotic attributes of the restored marsh have developed as initially expected, but not as mandatory performance requirements, with the exception of Biological Success Criteria No. 5 and 6 (Endangered Species). Nonetheless, the biological success criteria, and periodic analysis of progress toward those objectives, are important benchmarks against which the lessons of this demonstration project may be learned and applied to future projects.

Because fulfillment of Biological Success Criteria No. 5 and 6 is required to comply with the Endangered Species Act, it is a mandatory requirement. The Biological Opinion (USFWS 1996) notes that attainment of Biological Success Criterion No. 6 may be outside the control of the Corps and Conservancy, and that reinitiation of consultation may be warranted to modify this criterion should external factors, which result in a significant reduction or elimination of the California clapper rail population in north San Francisco Bay, be identified during the monitoring period.

Potential corrective measures that could be considered in the remediation investigation (and the associated success criteria) include:

Grading of dredged material and/or peninsulas to eliminate areas of excess elevation (Physical Success Criteria No. 1 and 5).

Removal, isolation, or treatment of chemical constituents exceeding allowable concentrations (PSC No. 2).

Enlargement of channels between restored area and the Bay (PSC No. 3 and 4).

Excavation of interior channels (PSC No. 6)

Vegetation management, predator management, and/or topographic modifications (Biological Success Criteria No. 5 and 6).

## Exhibit 5: Project Monitoring Plan

The PCA provides that the Corps and the Conservancy will continue to monitor the project until the monitoring results indicate that all of the success criteria in the monitoring plan have been met, or until it is mutually agreed that monitoring is no longer required. Monitoring pursuant to this plan would therefore be discontinued if all of the success criteria are met prior to the maximum periods specified in the individual success criteria. Monitoring may also be discontinued after 20 years if the Corps, Conservancy, and agencies approving this monitoring plan (RWQCB, USFWS, and NMFS) agree that monitoring is no longer required.

## MONITORING PROGRAM

The monitoring program for the Sonoma Baylands Wetland Demonstration Project is detailed below and summarized in Appendix A.

### PHYSICAL ATTRIBUTES

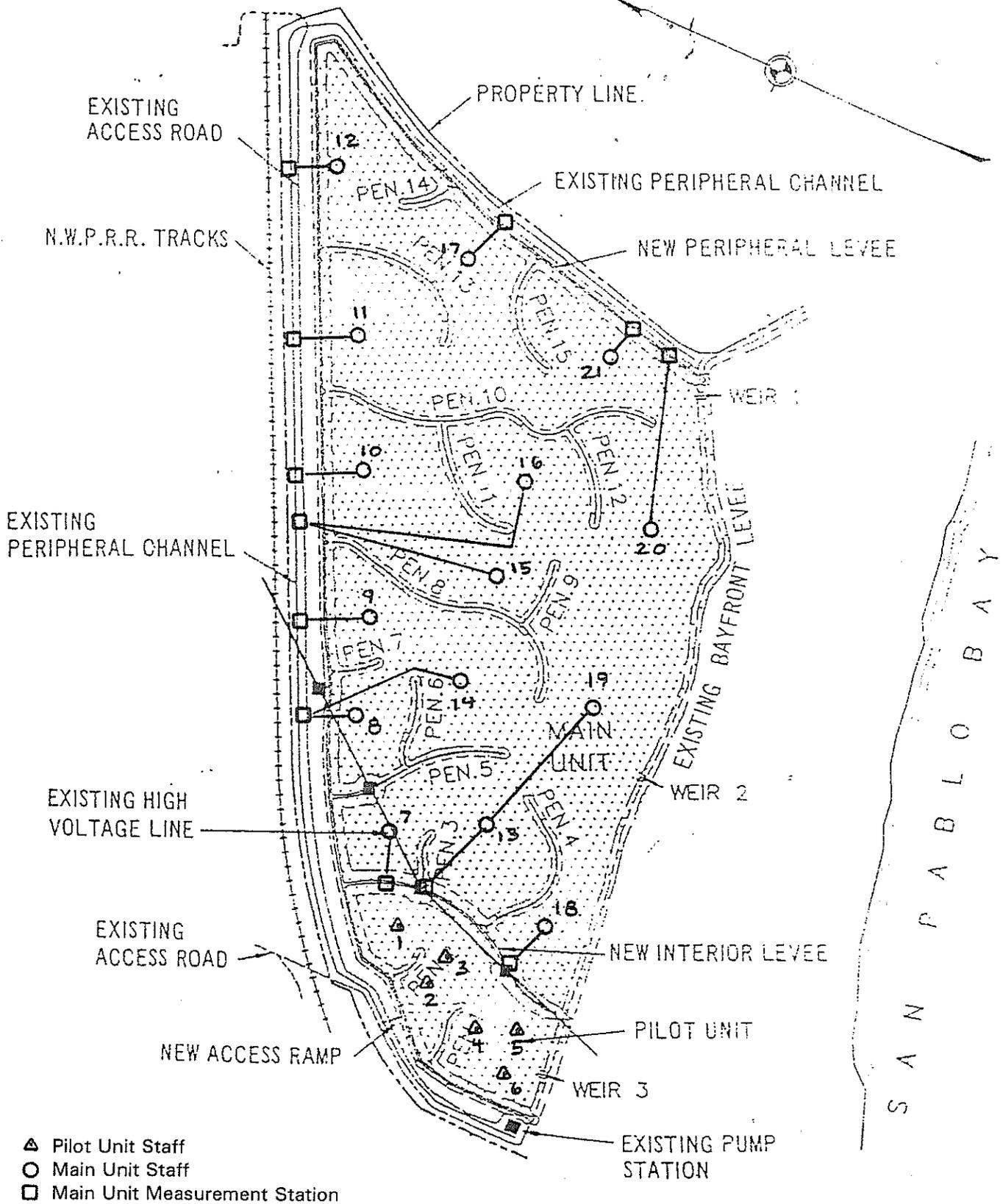
#### Dredged Material Fill Elevations

Measurement of the surface elevation of the dredged material fill after consolidation is required to determine whether Physical Success Criterion No. 1 has been met. These elevation data will also provide the baseline for measuring the physical development of the marsh plain and channels following the introduction of tidal action.

During the period between placement of dredged material and restoration of tidal action, and during the first year following the restoration of tidal action, the surface elevations and densities of the dredged material will be measured at monthly intervals using the same electrical resistivity staffs that were used to monitor the placement of the dredged material. There are six staffs in the pilot unit and fifteen staffs in the main unit (Figure 2). While the resistivity staffs provide elevation and density data for relatively few locations, those data will indicate whether consolidation of the dredged material is generally sufficient to meet the success criterion.

In the pilot unit, no dredged material was visible beyond the toes of the peripheral levees and peninsulas when the tide level in the unit was as low as +2.0 ft. NGVD following the restoration of tidal action. It was therefore apparent that none of the dredged material beyond the levee and peninsula toes exceeded an elevation of +2.9 ft. NGVD. Because the bottom elevation of the pilot unit was relatively low, the pilot unit did not drain sufficiently during low tides to allow a photogrammetric survey of the bottom following the restoration of tidal action. Instead, three transects across the pilot unit were surveyed to provide baseline elevation data.

A detailed photogrammetric topographic survey of the dredged material surface elevations in the main unit will be performed approximately one month after the restoration of tidal action to determine conformance with the success criterion. The surface contours will be mapped at an interval of one foot and any areas exceeding +2.9 feet NGVD will be specifically identified. Aerial photography for the survey will be taken at low tide to maximize the amount of dredged material surface area visible. If the water level in the main unit initially remains above +2.9 ft. NGVD at low tide, a ground-based survey will be performed instead.



- ▲ Pilot Unit Staff
- Main Unit Staff
- Main Unit Measurement Station

SONOMA BAYLANDS  
RESISTIVITY STAFF LOCATIONS  
NOT TO SCALE

PEN. - PENINSULA

FIGURE 2

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## Exhibit 5: Project Monitoring Plan

### **Chemical Constituents**

Measurement of the concentrations of chemical constituents in the dredged material placed in the main unit is required to determine whether Physical Success Criterion No. 2 has been met.

Sediment dredged from any particular location at Oakland Harbor has been dispersed over a relatively large area at Sonoma Baylands because of the hydraulic placement method. Therefore, relatively few sampling locations are needed to characterize the deposited sediments. Because the exposure of biological organisms to subsurface sediments will be very limited compared to exposure to surface sediments, sampling will be limited to the top one foot of sediments. Natural deposition of suspended sediment from the Bay is expected to begin as soon as the main unit is opened to tidal action. Therefore, sampling of the deposited dredged material should be done prior to the restoration of tidal action.

Grab samples of surface sediments will be collected at each of the fifteen sections of the Sonoma Baylands main unit defined by the locations of the fifteen electrical resistivity staffs. The samples will be tested for each of the constituents included in the RWQCB's sediment screening criteria (RWQCB 1992). The laboratory test results will then be compared to the wetland cover screening criteria and the maximum concentrations previously approved by the RWQCB for Sonoma Baylands to determine whether Physical Success Criterion No. 2 has been met. The monitoring test results will also be compared to the pre-dredge test results to provide information on how well the pre-dredge sampling predicted the post-dredge results.

If the test results for the sample from any section exceed the maximum concentration specified by Physical Success Criterion No. 2, the extent of the elevated concentration will be determined by testing samples from multiple locations within the affected section. The sampling design and interpretation of results would be coordinated with the RWQCB. If the results indicate that biological effects testing is warranted, wetland bioassays would be performed using at least two species of test organisms. Appropriate bioassay species would be selected in coordination with the RWQCB based on availability and the constituents of concern. Sediment from the natural wetlands south of Sonoma Baylands would be used as a reference. Toxicity and bioaccumulation by the bioassay organisms would be compared between the Sonoma Baylands and reference sediments. If the toxicity or bioaccumulation observed are excessive, a risk assessment would be conducted in coordination with the RWQCB to determine the need for remedial action.

### **Exterior Tidal Channels**

Measurement of changes in the geometries of the existing channels that will connect the levee breaches to San Pablo Bay is required during the first year following the restoration of tidal action to determine whether Physical Success Criterion No. 3 has been met. Continued monitoring of the channel geometries after the first year is needed to evaluate progress toward meeting Physical Success Criteria No. 4 and 5 (Tidal Regime) and to provide data on the rate of channel erosion for use in the design of future marsh restoration projects.

Prior to the excavation of the levee breaches for the pilot and main units, several cross-sections were monumented and surveyed along the existing marsh channels. For the pilot unit, seven cross-sections of the existing connecting channels, and, as a control, one cross-section of a nearby

## Exhibit 5: Project Monitoring Plan

channel not connected to the breach, have been surveyed and monumented. For the main unit, five additional cross-sections of connecting channels have been surveyed and monumented. The same cross-sections will be resurveyed, along with the levee breach, at six-month intervals during the first five years following the restoration of tidal action to the pilot and main units, respectively. The channel surveys will continue at annual intervals until there is no significant year-to-year increase in the channel dimensions.

As sediment accretes within the Sonoma Baylands site, the tidal prism of the restored marsh will gradually be reduced until the marsh is fully developed. Therefore, the connecting channels are expected to stop eroding and begin accreting sediment in concert with the restored marsh during the later stages of marsh development. Once that point has been reached, the monumented cross-sections will be resurveyed at five-year intervals until all of the success criteria have been met.

### **Tidal Regime**

Measurements of the tidal regimes of the two units are required to evaluate progress toward meeting Physical Success Criterion No. 4.

Synoptic measurements of tide elevations will be recorded over a complete two-week spring tide cycle, at minimum, using automated recorders with a sampling frequency of 5 to 15 minutes. Tide data will be collected concurrently with resurveys of the exterior channel cross-sections at six-month intervals during the first five years and annually thereafter. Tide recorders will be located at a Bay location (near the Bay end of an exterior channel or at the existing tide station on the railroad bridge at the mouth of the Petaluma River), on each side of the two levee breaches, and, if there is the potential for a significant water surface gradient within a unit, at the furthest points from the breach within each unit. Because significant water surface gradients within the units are not anticipated, intermediate measurements within each unit are not required. Therefore, a total of two or three measurement locations for the pilot unit and two to five locations for the main unit, plus one Bay location, are considered adequate.

### **Peninsula Crest Elevations**

Measurement of the crest elevations of the peninsulas is required to determine whether Physical Success Criterion No. 5 has been met.

A preliminary elevation survey of the peninsula crests will be performed five years after the restoration of tidal action to provide data on progress toward meeting the success criterion and on the rate of subsidence. For the preliminary survey, spot elevations will be taken at 100-foot intervals along the centerline of the crests of selected peninsulas. The peninsulas selected for the preliminary survey should include both two- and ten-foot crests. Peninsulas that were used as haul ramps during levee construction, resulting in additional compaction, should be included in the preliminary survey, as well as peninsulas that were not used as haul ramps. Peninsulas located throughout the project site should be included in the preliminary survey. Based on these criteria the following peninsulas will be included in the preliminary survey: both of the peninsulas in the pilot unit and Peninsulas No. 4, 5, 6,

## Exhibit 5: Project Monitoring Plan

10, 13 and 15 in the main unit. The combined length of the peninsulas included in the preliminary survey (6700 ft.) will represent approximately half of the total length of peninsulas on the site.

A complete elevation survey of the peninsula crests will be performed ten years after the restoration of tidal action to determine whether Physical Success Criterion No. 5 has been met. Spot elevations will be taken at 50-foot intervals along all peninsulas (excluding the interior levee and the portion of Peninsula No. 5 north of the PG&E tower). Any peninsula crests exceeding an elevation of +4.0 feet NGVD will be specifically delineated. All surveys should be tied into permanent elevation benchmarks referenced to NGVD of 1929.

### Tidal Sedimentation

Monitoring of sediment deposition rates and patterns will provide useful information regarding the accuracy of predictive sedimentation models and will help to quantify the acceleration of marsh restoration achieved by using dredged material. This information will be important in future decisions regarding the use of dredged material in marsh restoration projects. Information regarding sediment deposition patterns will also assist in understanding changes in vegetation patterns as the marsh develops and will provide a basis for evaluating the effectiveness of the interior peninsulas in accelerating sediment deposition.

The system of electrical resistivity staffs installed throughout the pilot and main units prior to the deposition of dredged material will be used to monitor changes in the elevation of the sediment surface and changes in the density of the dredged material and tidally deposited sediments. Resistivity staff data were collected monthly during the period between placement of dredged material and the restoration of tidal action in order to monitor the consolidation of the dredged material. During the first year following the restoration of tidal action to the pilot and main units, data will continue to be collected monthly to provide information on the changes in the dredged material surface elevation due to exposure during low tides, as well as initial sedimentation rates. After the first year, data from the resistivity staffs will be collected quarterly for four additional years to provide data on seasonal and annual variations in sedimentation rates. For the remainder of the monitoring program, data from the resistivity staffs will be collected once a year, concurrently with aerial photography, until there is no significant year-to-year change in the measured elevations, provided that the staffs continue to function properly.

Collection of data using the electrical resistivity staffs is relatively inexpensive. However, the electrical resistivity staffs will provide data for only six points in the pilot unit and fifteen points in the main unit. Because of the limited number of data points provided by the staffs, and because elevation measurements from the staffs have a range of error of at least 0.2 feet due to the spacing of the electrodes, additional data regarding sediment deposition and interior channel development will be collected by surveying elevation transects. The elevation transects will provide sufficient data regarding sediment deposition in the event that the resistivity staffs cease to function properly.

Three elevation transects will be located in the pilot unit and ten transects will be located in the main unit. One transect will traverse each of the three sections of the pilot unit, as defined by the peninsulas, perpendicular to the expected primary interior channel. In order to provide the most useful information, the locations of the transects within the main unit will be determined based on the

## Exhibit 5: Project Monitoring Plan

development of channels and the establishment of vegetation as the marsh develops. The approximate locations of transects will be identified during low tides when the marsh surface is visible.

Access within the units is expected to be difficult initially due to the soft ground surface and the need to minimize disturbance of the site. Transect elevations will be surveyed during high tides by boat using GPS or total station survey techniques until the marsh surface becomes accessible on foot at low tides. During the initial survey of each transect, both ends of the transect will be monumented with a plastic pipe or similar marker to assist in resurveys of the transect. The transects will be resurveyed annually during the first ten years and biennially thereafter until there is no significant change. The transects will be surveyed in the summer to allow correlation of elevation and vegetation data.

### **Internal Channel Development**

Tidal channels are the most important physical feature of a tidal salt marsh. The extent and pattern of the channel system determines many other attributes of the marsh, including hydrology, vegetation distribution, and habitat values. It is therefore important to document the pattern of channel development in Sonoma Baylands project for use in the design of future wetland restoration projects.

Measurement of internal channel development is also required to determine whether Physical Success Criterion No. 6 has been met.

Channel development will be mapped from stereoscopic aerial photographs. Channel mapping will be performed each year through the tenth year following the restoration of tidal action, then every second year until there is no significant change or all of the success criteria have been met.

Channels and vegetation will be mapped using the same aerial photographs. The aerial photographs will be stored on a Geographic Information System (GIS), along with the channel and vegetation maps. The use of a GIS will facilitate the mapping of incremental changes in topography and vegetation and the correlation of changes in topography, vegetation, and other physical features.

False color infrared photography will be used to aid in the differentiation of vegetation. Photographs will be taken in the late summer to show the maximum growth of vegetation and to allow year-to-year comparison. Photographs will be taken during a tide no greater than +2.0 ft. MLLW so that channels can be accurately mapped. A 60% overlap between photographs will be specified to allow stereoscopic viewing. Mapping will be performed at a minimum scale of 1:2400 (1" = 200'). Aerial photography will be obtained in a digital rectified format to allow the photography to be used in a geographic information system (GIS).

The elevation transects previously described will provide additional data on internal channel development, as well as tidal sedimentation.

## Exhibit 5: Project Monitoring Plan

### **Water Quality**

Measurement of water quality parameters is required by the conditions of NMFS's concurrence on the informal consultation for the winter-run chinook salmon, and by the RWQCB's Dredged Material Reuse Requirements for the project. Because adequate tidal circulation should preclude water quality problems (given that the dredged material used in the project was previously sampled and determined to be free of detrimental concentrations of contaminants), the water quality parameters monitored should be cost-effective indicators of the adequacy of tidal circulation. On that basis, the parameters selected to be monitored are salinity, temperature, and dissolved oxygen. Tidal circulation is expected to improve over time as the capacities of the tidal connections increase relative to the potential tidal prisms of the restored units. Measurements will therefore be taken during the first year following the restoration of tidal action to identify any water quality problems resulting from restricted circulation due the small size of the initial tidal connections between the restored marsh units and the Bay.

Salinity, temperature, and dissolved oxygen will be measured at biweekly (14-day) intervals during the first year following the restoration of tidal action in the pilot and main units. For the pilot unit, measurements will be taken at three permanent shoreline stations in the upper, center and lower sections of the pilot unit, as delineated by Peninsulas No. 1 and 2, as well as at one station along the connecting channel through the existing marsh. For the main unit, measurements will be taken at seven permanent stations. The seven stations will be selected by random stratified sampling of the fifteen main unit sections delineated by the peninsulas and identified by the locations of the fifteen electrical resistivity staffs. The main unit sections will be stratified for sampling according to their hydraulic distance from the levee breach.

Water quality measurements will be taken near high tide at approximately the same time of day to facilitate direct comparison of data sets. Measurements in the connecting channel will be taken during a flood tide to characterize the water that is input to the restored area from the Bay.

## **BIOLOGICAL ATTRIBUTES**

### **Marsh Vegetation Establishment**

Observation and documentation of the establishment of tidal salt marsh vegetation is required to determine whether Biological Success Criterion No. 1 has been met.

The pilot and main units will be visually inspected in the spring and fall to identify the initial occurrence of tidal salt marsh vegetation. The species and distribution patterns of the plants that initially colonize each unit will be documented. Visual inspections will be discontinued when mapping from aerial photography (with ground-truthing) is initiated, as described below.

## Exhibit 5: Project Monitoring Plan

### Marsh Vegetation Cover

Measurement of total marsh vegetation cover is required to determine whether Biological Success Criterion No. 2 has been met and to determine the rate of marsh development. Measurement of cover by species and vegetation height is required in selected areas to determine whether Biological Success Criterion No. 6 has been met.

The total area of marsh vegetation cover will be determined from aerial photography beginning the second summer after the initial establishment of marsh vegetation in each unit, which will be determined as described above. A map of the vegetation patches will be produced by viewing the photographs stereoscopically. Ground-truthing of species composition will be performed during field surveys of vegetation transects. Total vegetated area and percent cover by vegetation type will then be determined from the vegetation maps.

Transects for sampling vegetation will be located along elevation transects to allow correlation of the two data sets. Vegetation transects will be surveyed during the late summer. Data collected from the transects will include percent cover by species and height of vegetation.

Vegetation cover mapping will be performed each year through the tenth year following the restoration of tidal action, then every second year until all of the biological success criteria have been met.

### Birds

—Surveys of the presence and relative abundance of birds on the project site and nearby reference marshes and mudflats are required to determine whether Biological Success Criterion No. 3 has been met. Bird surveys will also provide a cost-effective and understandable measurement of changes in habitat value over time relative to natural marshes. A recurrent concern regarding marsh restoration projects is the length of time required before the restored area provides substantial habitat value. The Sonoma Baylands project provides an opportunity to assess the rate at which a newly constructed tidal mudflat and an evolving marsh develop into productive habitats for birds.

Because bird activity changes throughout the year due to seasonal migratory and breeding patterns, relatively frequent surveys are needed. A total of 18 surveys will be performed each year during the following periods:

March 1 to August 15	8 surveys
August 16 to October 31	4 surveys
November 1 to February 28	6 surveys

This schedule provides a fairly even distribution of surveys throughout the year, with a slight concentration during the fall migratory period and a slight decrease during the summer breeding season. Bird surveys will be conducted every other year following the restoration of tidal action until Biological Success Criterion No. 3 has been met during each of the three periods.

## Exhibit 5: Project Monitoring Plan

Because of the visibility of birds on a tidal mudflat, a complete census of birds within the Sonoma Baylands site will be performed from the perimeter levees during each of the initial surveys. Once vegetation begins to obscure visibility, the vegetated marsh areas will be sampled by walking transects of known dimensions along perimeter levees and peninsulas. Because there is relatively little bird activity on mudflats during the breeding season, only four surveys will be performed during the March-August period prior to the initiation of the transect surveys of vegetated marsh areas. During this initial period, two surveys will be performed during March to early May and two surveys will be performed during late July through August to provide data on migratory shorebird activity. Surveys will be performed during both low and high tide conditions during each survey period. Some surveys will be performed during rising or falling tides, when intertidal areas at Sonoma Baylands may be exposed while Bay mudflats are submerged, to provide data on peak shorebird use of the Sonoma Baylands site.

The existing mudflat south of the Sonoma Baylands site will be used as a reference area for the bird surveys. Areas of the mudflat of known size will be censused from the bayward edge of the marsh. Bird surveys in the reference marsh will be performed using permanent transects.

For each survey period, the mean total population densities of shorebirds, waterfowl and other waterbirds will be calculated for the Sonoma Baylands site and the reference areas to determine whether Biological Success Criterion No. 3 has been met.

### Fishes

Surveys of the presence and relative abundance of fishes in the project site and a nearby reference marsh are required to determine whether Biological Success-Criterion No. 4 has been met and to comply with the conditions of the informal consultation with NMFS regarding the Sacramento River winter-run chinook salmon. Fish surveys will also provide a widely understandable measurement of changes in habitat value over time relative to natural marshes.

During the first year following restoration of tidal action to the pilot and main units, the main purpose of the fish surveys will be to determine the presence of fishes including winter-run chinook salmon within the project site to assess potential impacts due to water quality conditions. Because channels will not yet have developed within the site, the presence of fishes will be determined by beach seining or trawling during a high tide. Replicate samples will be collected until no additional species are captured. Surveys will be performed during neap tides at monthly intervals from January through April when both adult winter-run chinook salmon migrants and juvenile outmigrants are expected to be present in the Bay. The collected fishes will be identified, counted, measured, and released. If necessary, single individuals of species other than salmon may be retained as voucher specimens for subsequent identification.

Use of the Sonoma Baylands site by fishes will be compared to a nearby reference marsh beginning in the fourth year following the restoration of tidal action. Surveys will be conducted every other year in March and September during neap tides. Juvenile and adult fishes will be sampled at replicate stations along tidal channels using 3 mm mesh block nets and a bag seine as described in PERL (1990). The collected fishes will be identified, counted, measured, and released. If necessary, single individuals of species other than salmon may be retained as voucher specimens for subsequent identification.

## Exhibit 5: Project Monitoring Plan

### **Endangered Species**

Suitable habitat for the California clapper rail and salt marsh harvest mouse will be delineated on marsh vegetation cover maps using vegetation transect data. In addition, surveys will be conducted for the presence of either species in areas of potential habitat. The presence of a species will provide an alternate and definitive method of identifying occupied habitat that may not meet all of the established suitability criteria.

Beginning five years after the restoration of tidal action, suitable habitat and potential habitat for the California clapper rail and salt marsh harvest mouse will be delineated on vegetation cover maps every fifth year until all of the success criteria have been met. Live trapping surveys for salt marsh harvest mice and call surveys for the California clapper rails will then be conducted as appropriate based on habitat conditions at the time of each survey. The Corps will coordinate the initiation and protocols for the surveys with the U.S. Fish and Wildlife Service.

### **Benthic Macroinvertebrate Colonization**

The rate of development of habitat value on a newly restored site is a concern of project planners and decision-makers. The rate of habitat development will determine the period of time required for the improved habitat to offset short-term impacts on existing habitat. The rate of habitat development is also an important consideration in weighing the benefits and costs of a habitat restoration project. The use of restored habitat by highly mobile and visible species, such as birds and fishes, may be incidental to their other movements. Vegetation structure is also often used as a measure of habitat value, but substantial habitat value is expected to be provided by the Sonoma Baylands project prior to the substantial development of vegetation. Benthic macroinvertebrate infauna will therefore be used as a qualitative indicator of the initial development of habitat value prior to the establishment of vegetation.

Benthic macroinvertebrates will be sampled at random stations in the vicinity of the stations used for water quality sampling in the pilot unit. Replicate sediment cores to a depth of 20 cm will be collected at each station. Organisms will be sieved from the cores and preserved in the field and then identified and counted in the laboratory. The number of individuals per unit of area sampled will be calculated for comparison with past and future results.

Benthic invertebrates will be sampled twice a year, in March and September, after the restoration of tidal action to the pilot unit. Sampling will be conducted during the first four years following the restoration of tidal action.

## DATA ANALYSIS AND MANAGEMENT

The Corps of Engineers will have general responsibility for implementing this monitoring plan, including conducting monitoring studies, preparing monitoring reports, and managing monitoring data, in coordination with the Coastal Conservancy. It is presently anticipated that most of the monitoring studies and report preparation during each year will be performed under a single contract by a general environmental consulting firm, with specialized studies subcontracted as necessary. Use of a single contract will minimize administrative costs, allow coordination of different aspects of the monitoring program, and facilitate report preparation.

Monitoring contractors will be responsible for data quality control, including the adequacy of sampling procedures and the accuracy of data. The Corps of Engineers will be responsible for data quality assurance through management of the monitoring contracts and review of draft reports.

Each year of the monitoring program, an annual report will be prepared to summarize and evaluate the results for the previous March through February period. The annual report will be prepared immediately after each reporting year for distribution by June. This scheduling will avoid funding and contract administration problems that often occur at the beginning or end of the Federal fiscal year. The first annual report will include results for January through April and be completed by July 1996 to allow review of the initial monitoring results for the pilot unit prior to the scheduled restoration of tidal action to the main unit in September 1996. Monitoring reports will be distributed by the Corps to concerned agencies and others who request copies.

Considerable interest in the Sonoma Baylands project has been expressed by academic and government researchers. To facilitate the distribution and analysis of quantitative data, the Corps will require monitoring data to be provided by contractors in the form of electronic files. Other researchers collecting data on the Sonoma Baylands site will also be requested to provide electronic data files. Compatibility with various application software will be achieved by using spreadsheet programs that are mutually translatable and standardized spreadsheet formats. This will allow data files to be distributed by either diskette or the Internet.

Spatial data will be displayed and compared using a Geographic Information System (GIS). These data will include aerial photographs, channel and vegetation maps, and the locations of other data points, such as sampling and transect sites. Use of a GIS will facilitate the correlation of different types of spatial data (e.g., cover maps and photography) and the display of temporal series (e.g., channel or vegetation development over time) through the use of overlays. Because the Corps District Office presently has no GIS, these analyses will initially be provided by contractors.

## Exhibit 5: Project Monitoring Plan

Monitoring data will be archived in an electronic database accessed through the Corps' local area network (LAN). The District Office's existing LAN system has sufficient storage capacity to accommodate the amount of data that will be produced by this monitoring program. The District Office currently intends to acquire a data server designed to store much larger volumes of data. Monitoring data would also be available to other academic or government repositories in the form of read-only files. More detailed data management procedures will be developed during the first year of monitoring following the restoration of tidal action to the main unit.

### ADDITIONAL MONITORING FOR SCIENTIFIC RESEARCH

The Sonoma Baylands Wetland Demonstration Project was authorized by Congress for the purpose of demonstrating the use of dredged material as a resource and facilitate the completion of San Francisco Bay Area dredging projects in an environmentally sound manner. The Sonoma Baylands project is an exceptional opportunity to investigate and document the restoration of a tidal marsh community using dredged material. Results of previous marsh restoration projects in San Francisco Bay, both with and without the use of dredged material, had a major influence on the design and implementation of the Sonoma Baylands project. Likewise, the Sonoma Baylands project is expected to yield information that will result in further improvements in the efficiency and effectiveness of future marsh restoration projects.

The range of research activities that could be conducted at Sonoma Baylands is virtually limitless. Because the financial resources available for monitoring are limited, priority must be given to collecting data on the parameters that will best characterize the physical and biological development of the wetland over time. The program outlined in this document is the basic monitoring that will be funded and implemented by the Corps of Engineers and the Coastal Conservancy. Other researchers will be encouraged to conduct additional research activities in or near Sonoma Baylands that may be more intensive or specific than those identified in this monitoring plan. It is anticipated that the availability of basic data on the Sonoma Baylands site provided through the basic monitoring program will encourage other research activities on the site. A summary of additional research activities being conducted at the Sonoma Baylands site will be included in each annual monitoring report. Research activities at Sonoma Baylands may also include extremely long-term monitoring beyond the period of marsh establishment addressed by this plan. The Coastal Conservancy will develop a protocol for the coordination and reporting of other research efforts on the property.

## Exhibit 5: Project Monitoring Plan

## Exhibit 5: Project Monitoring Plan

### REFERENCES

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- \_\_\_\_\_. 1996b. Letter from Sacramento Field Office dated September 10, 1996 to San Francisco District, Corps of Engineers, subject: Final Monitoring Plan for the Sonoma Baylands Wetland Demonstration Project, Petaluma River, Sonoma County, California (Service File Reference: 1-1-96-F-23).

Exhibit 5: Project Monitoring Plan

**APPENDIX A**

**SUMMARY OF MONITORING PROGRAM**

## SUMMARY OF MONITORING PROGRAM

PHYSICAL ATTRIBUTE	MEASUREMENT	SCHEDULE
Dredged Material Fill Elevations	Resistivity staff readings	Year 0: Monthly - Both units Year 1: Monthly - Main Unit
	Elevation transects	Year 0: Pilot Unit
	Photogrammetric surveys	Year 1: Main Unit (Approx. 1 month after levee breach.)
Chemical Constituents	Laboratory testing	Year 0: Main Unit
Exterior Tidal Channels	Channel cross-section surveys	Year 0: Establish cross-sections prior to levee breaches. Resurvey Pilot Unit 6 months after levee breach. Years 1 - 5: Resurvey both units semi-annually in March and September. Years 6+: Resurvey annually in Spring until no significant increase in dimensions, then every fifth year.
Tidal Regime	Tide elevations	Year 0: Pilot Unit 6 months after levee breach. Year 1 - 5: Both units semi-annually in March and September. Years 6+: Annually in Spring.
Peninsula Crest Elevations	Level line surveys	Year 5: Preliminary survey Year 10: Complete survey
Tidal Sedimentation	Resistivity staff readings	Year 1: Monthly Years 2 - 5: Quarterly Years 6+: Annually in Summer until no significant change.
	Elevation transects	Years 1 - 10: Annually in Summer Years 11+: Biennially in Summer until no significant change.

Exhibit 5: Project Monitoring Plan

PHYSICAL ATTRIBUTE	MEASUREMENT	SCHEDULE
Internal Channel Development	Mapping from aerial photography	Years 1 - 10: Annually in Summer Years 11+: Biennially in Summer until no significant change.
	Elevation transects	Years 1 - 10: Annually in Summer Years 11+: Biennially in Summer until no significant change.
Water Quality	Field testing of salinity, temperature, and dissolved oxygen	Year 0: Biweekly - Pilot Unit Year 1: Biweekly - Main Unit
BIOLOGICAL ATTRIBUTE	MEASUREMENT	SCHEDULE
Marsh Vegetation Establishment	Field survey	Years 0+: Semi-Ann. - Pilot Unit Years 1+: Semi-Annually until cover sufficient for aerial mapping.
Marsh Vegetation Cover	Mapping from aerial photography	Years 1 - 10: Annually in Summer Years 11+: Biennially in Summer
	Vegetation transects	
Birds	Census unvegetated areas from perimeter levees. Sample vegetated areas with transects along levees and peninsulas. Census/sample reference areas.	Year 0 - 1: 14 surveys/year in Pilot and Main Units. Years 3+: Biennially until success criterion is met. 14 surveys/year prior to vegetation. 18 surveys/year subsequently.
Fishes	Seine/trawl and enumerate species following restoration of tidal action.	Year 0: Monthly from Jan - Apr in Pilot Unit. Year 1: Monthly from Jan - Apr in Main Unit.
	Seine channels at site and reference marsh and enumerate species.	Years 3+: Biennially in March and September until success criterion is met.
Endangered Species	Map suitable/potential habitat.	Years 5+: Survey every fifth year.
	Call surveys for California clapper rail in suitable/potential habitat. Live trapping surveys for salt marsh harvest mouse in suitable/potential habitat.	
Benthic Macroinvertebrate Colonization	Sieve sediment cores and enumerate species in Pilot Unit.	Years 0 - 4: Semi-annually in March and September.

## Exhibit 5: Project Monitoring Plan

### NOTES:

Year 0 will end and Year 1 will begin upon the restoration of tidal action to the Main Unit, which is expected to occur in October 1996.

Restoration of tidal action to the Pilot Unit occurred during Year 0 on January 24, 1996.

Except as specifically noted, monitoring will continue until the monitoring results indicate that all of the success criteria have been met.