Monitoring Report
Fall 2000 to Fall 2001, Project Year 3
MLK Jr. Regional Shoreline Wetlands Project
Oakland, California

February 2002

Prepared for

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Project No. 1044

WETLANDS AND
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1.0 Introduction

The Port of Oakland constructed the Martin Luther King, Jr. Regional Shoreline Wetlands Project (the Project) in 1998, with tidal action being restored on 10 June 1998. The site is located in San Leandro Bay, Oakland, California (Figure 1). The approximately 72-acre (29-hectare) Project site consists of three distinct restoration elements: tidal marsh, seasonal ponds, and uplands. These elements are shown in Figure 2. A complete site description is presented in the Six-Month Monitoring Report (LFR 1999a).

Previous Reports. Five previous reports pertaining to project monitoring have been prepared for this project:

- The Monitoring and Maintenance Plan (LFR 1999b, “MMP”) presents the Project objectives, performance criteria, and monitoring protocols developed to assess the progress of the Project.
- The Six-Month Monitoring Report presents the results of the first six months of monitoring, encompassing the period from project initiation through February 1999 (LFR 1999a). That report presented data collected on sediment accretion; tidal hydrology; channel morphology; seasonal pond depth and acreage; seasonal pond morphology; and bird use of the site.
- The Year 1 Monitoring Report presents the first year’s monitoring period of the Project Site (LES 1999). This report included data collected on the vegetation colonization of both the tidal, seasonal, and upland portions of the site and soil quality characteristics; and continued monitoring of sediment accretion, seasonal pond depth and acreage, and bird use of the site.
- 1998-1999 Bird Use Report (HNEC 2000) presented results of bird monitoring conducted by the Golden Gate Audubon Society from October 1998 to April 1999.

The Year 2 Monitoring Report presented the second year’s monitoring period of the Project Site (WWR 2001). This report included results from the continued monitoring of sediment accretion; tidal hydrology; channel morphology; seasonal pond depth and acreage; vegetation dynamics; and bird use.

Current Report for Fall 2000 to Fall 2001 Monitoring. This report presents the results of monitoring conducted from Fall 2000 to Fall 2001, representing Project Year 3. Table 1 shows planned and actual field schedules for the 2000-2001 monitoring year. This report divides WWR monitoring activities into two broad categories: hydrogeomorphic monitoring (Section 2) and biological monitoring (Section 3). Within each of these two categories, this report presents monitoring results for the tidal wetlands, seasonal ponds, and upland areas. Section 4 includes a list of monthly EBRPD maintenance activities.

Section 5 provides an evaluation of project performance in the aforementioned areas (i.e. hydrogeomorphic, biologic, and maintenance). Performance evaluation is based on performance criteria and stressor indicators established in the Monitoring and Maintenance Plan (LFR 1999b). We have included recommendations for modifications to management and monitoring methods for areas of the restoration project that fail to meet minimum performance criteria, or for techniques that have been ineffective at determining information necessary to monitoring (Sections 5 and 6).

2.0 Hydrogeomorphic Monitoring

The monitoring plan (LFR 1999b) included seven hydrogeomorphic monitoring activities (Table 1). This section discusses all seven monitoring activities and is organized in the following manner:

- Section 2.1, Channel cross sectional morphology
- Section 2.2, Sediment accretion
- Section 2.3, Seasonal pond size
- Section 2.4, Tidal inundation
- Section 2.5, Channel velocity, turbidity, and water quality
- Section 2.6, Air photo
- Section 2.7, Channel planform meander

2.1 Channel Cross Sectional Morphology

The constructed network of channels at the site serve a critical function by transporting the tides into and out of the site. The channels therefore serve both ecological and hydrogeomorphic functions. Evaluating the evolution of these features is an important component of the monitoring program. Monitoring of channel morphology is presented in Section 2.6 of the Monitoring and Maintenance Plan (LFR 1999b).

2.1.1 Methods

We conducted field topographic surveys on 12 July 2001 and 24 August 2001 using a laser total station survey instrument. Cross section endpoints are PVC markers previously placed so that precise cross section locations could be reoccupied. Distance along cross section and relative elevation were recorded. Each cross section was then surveyed from a local reference point to established permanent benchmarks located on and near the pedestrian bridge across the breach at the north end of the site; elevations of the permanent benchmarks were provided by the Port of Oakland (see Appendix A). PVC markers at the end of cross sections were painted red to identify them more clearly from the numerous other PVC markers found throughout the marsh.

2.1.2 Results and Discussion

The cross section locations are shown in Figure 2. Figure 3 shows the two first-order channel cross sections, Figure 4 shows the two second-order channel cross sections, and Figure 5 shows the third-order cross section. Previous cross section survey data are plotted along with the current data in these figures. Field surveying data are provided in Appendix B; previous data were contained in LFR (1999a) and WWR (2001). Data from the LFR report have not been verified; horizontal and vertical controls were not clearly evident for all previous cross sections and are so noted in the figures where problems were encountered.

All cross sections are plotted from "left bank" to "right bank" with ebb tide representing the flow direction. Thus, each cross section is looking "downstream" toward the open bay, consistent with plotting terrestrial stream cross sections. In this view, the channel left bank on an ebb tide is shown to the left and the channel right bank is shown to the right. These plots reverse that presented in LFR 1999a.

All cross sections are plotted with matching horizontal and vertical scales so that relative channel sizes are visually evident between cross sections. These plots adjust that presented in LFR 1999a.

Cross section XS-1W (western first order channel; Figure 3) indicates channel size reduction from sedimentation, especially along the right bank. Since 1999, channel width decreased by 0.5 and 2.5 ft on the left bank and right bank, respectively. Channel depth has decreased by 0.3-0.4 ft. Sedimentation of 0.25 and 0.35 ft has occurred on the marsh plains adjacent to the left and right banks, respectively.

Cross section XS-1E (eastern first order channel; Figure 3) changes within the past six months are imperceptible. From 1998 to 2001, however, sedimentation occurred within and around the channel. Channel depth decreased by 0.2-0.3 ft. During the same period of time, channel width decreased by about 2 ft overall. Sediment accretion on the marsh plain adjacent to the left and right banks was 0.15 and 0.30 ft, respectively.

Cross section XS-2W (western second order channel; Figure 4) also indicates some sedimentation within and adjacent to the channel. The horizontal and vertical data from the previous surveys appeared more reliable and thus the observed differences may be reflective of actual field conditions. If so, then this channel has reduced in size by up to 3.5 ft in total width and up to 0.40 ft in depth. Sedimentation of 0.35 and 0.30 ft has occurred on the marsh plains adjacent to the left and right banks, respectively.

Cross section XS-2E (eastern second order channel; Figure 4) indicates some lateral shift of the channel on the order of 2-3 ft, with slight sedimentation in the channel bed and on the adjacent marsh surface of 0.2 and 0.1 ft along the left and right sides, respectively.

Cross section XS-3 (third order channel, Figure 5) indicates that the enlargement observed in 2000 has persisted into 2001 and is relatively unchanged. In 2000, the channel bottom deepened by about 0.2 ft and eroded laterally on the right bank by about 2-3 ft. Sediment accretion on the marsh plain adjacent to the left and right banks was approximately 0.1 to 0.2 ft, respectively.

Discussion of Morphologic Changes. These data all indicate that changes in the channel morphology are small and are indicative of natural processes that will promote establishment of a viable tidal marsh ecosystem.

The more headward channels seem to be rising vertically in space, with the XS area remaining relatively constant. These small rates of upward growth are expected outcomes at this site and they indicate channels are maintaining a dynamic equilibrium as the site moves through its early years after restoration. The daily ebb and flood of the tides within the site matches that found outside the site (see Section 2.4), which further indicates that the channel adjustments are within the expected range of conditions. The apparent lateral shift of the main third-order channel near the levee breach is small and is not threatening any of the shoreline protection nor the pedestrian bridge.

2.2 Sediment Accretion

The project design (LFR 1996) estimated the sedimentation rate for the project site using nomographs developed by the San Francisco Estuary Institute (Collins 1994). That estimate was accomplished during design by collecting a water sample from near the project site at slack high tide and measuring suspended solids concentration (SSC) of that sample. Two sedimentation periods (not rates) were predicted in the design. The first sedimentation period corresponded to higher-elevation areas ("high marsh") and predicted 100 years to reach local mean higher high water (MHHW) elevations assuming a starting elevation of 0.57 ft (0.17 m) below local MHHW. That predicted sedimentation period corresponds to an average annual sedimentation rate of 0.006 ft/yr or 0.002 m/yr. The second sedimentation period corresponded to lower-elevation areas ("low marsh") and predicted 10 years to reach 1 ft below local MHHW elevations assuming a starting elevation of 1.5 ft (0.46 m) below local MHHW. That predicted sedimentation period corresponds to an average annual sedimentation rate of 0.05 ft/yr or 0.015 m/yr. The estimated sedimentation periods were considered conservative estimates and were expected to be slightly higher once the site is vegetated.

The elevations of the marsh surface were designed below the elevations of reference sites to facilitate the accretion of natural sediments in order to provide a better substrate for salt marsh vegetation establishment. Therefore, the accretion of sediments is a very important process for Project success. The monitoring of sediment accretion is required in Section 2.3 of the MMP (LFR 1999b).

2.2.1 Methods

Twelve sedimentation pins were installed at the site, six on 18 July 1998 and six on 7 Jan 1999. Six of these pins are located on the perimeter of the seasonal ponds (SP-1 through SP-6) and six are located within the tidal portions of the site (SP-7 through SP-12). The locations of the sediment pins are shown in Figure 2. At each sediment pin, the distance from the top of the pin to the ground surface is measured with a measuring tape. Sedimentation is measured as the difference in these distances between successive measurements. This method carries an inherent measurement uncertainty due to the unevenness of the ground surface and the potential for the measuring tape to sink slightly into the deposited sediments. This uncertainty is estimated to be ±0.005 m.

Sedimentation rate is calculated as the amount of sediment that has deposited divided by time since the sediment pin was placed in the ground. This uncertainty is estimated to be ±0.007 m. Sedimentation calculations are reported as interval and cumulative values; the former indicates changes between successive measurement dates, and the latter yields changes since the beginning of the monitoring period. Values yielded from sediment pin measurements and estimated from cross section surveys are reported in metric and English units; however, the unit that was used in the original measurement is shown first, and the conversion follows in parentheses. For example, sediment pins were measured using the metric system, so sedimentation values are reported in meters first, with the converted English value in parentheses. Cross section surveys, on the other hand, were measured in feet, and thus are reported primarily in English units and secondarily in metric units.

2.2.2 Results and Discussion

Current monitoring period field measurements were made on August 24, 2001. Results of sediment accretion and rates of deposition are presented in Table 2. For purposes of comparing longer-term sedimentation trends, results from the cumulative measurements are discussed here, unless otherwise indicated.

In the low intertidal marsh area (SP-7, SP-9; Table 2), depth of deposited sediment since restoration was 0.43 and 0.10 m (1.41 and 0.30 ft), respectively, which translates to sedimentation rates of 0.14 and 0.03 m/yr (0.45 and 0.10 ft/yr), respectively. The predicted sedimentation rate for low marsh was 0.015 m/yr, so the low marsh area is meeting and exceeding this prediction at the two measurement locations.

In the high intertidal marsh area (SP-8, SP-10, SP-11, and SP-12; Table 2), depth of deposited sediment since restoration was more varied and ranged from 0.02 to 0.27 m (0.07 to 0.87 ft), which yields an annual average sedimentation rate range of 0.01 to 0.09 m/yr (0.02 to 0.28 ft/yr). The predicted sedimentation rate for high marsh was 0.002 m/yr, so the high marsh area is meeting and exceeding this prediction at the four measurement locations.

Sediment pins are proving to not be a reliable tool for measuring sedimentation at this site. There are inconsistencies in some, but not all, locations. Other entities use the MLK site for education purposes and to conduct additional monitoring, which may inadvertently alter the sample locations. The actual sediment pins are 1" PVC pipes in a sea of markers at the site. The potential for physical disturbance of the pins is relatively high. See "Recommended Modifications of Monitoring Program," (Section 6.0) for further discussion and suggested alternative methods for measuring sediment accretion.

Sedimentation is visible from the channel topographic cross sections described in Section 2.1 (Figures 3, 4, and 5). These data help to establish sedimentation rates in areas where sediment pin measurements are questionable (low marsh SP-7 and SP-9, and high marsh SP-10). Between 1998 and 2001, sediment thickness along the marsh plain adjacent to the left bank of XS-3 increased by 0.13 ft (0.04 m), which translates into 0.04 ft/yr (0.01 m/yr). This area is low marsh, near the location of SP-7 (Figure 2). Average measurements from marsh plain adjacent to and between the left bank of XS-2E and the right bank (RB) of XS-2W were 0.2 and 0.3 ft (0.06 and 0.09 m), respectively. The corresponding sedimentation rates were 0.07 and 0.10 ft/yr(0.02 and 0.03 m/yr). This area is also low marsh, and is in close proximity to SP-9 (Figure 2). In the high marsh area near SP-10, the marsh plain adjacent to the right bank of XS-2E showed sediment accretion of 0.1 ft (0.03m) from 1998 to 2001, with a sedimentation rate of 0.03 ft/yr (0.01 m/yr). Based on cross section survey data, the low marsh and high marsh areas are exceeding the performance criteria for sediment accretion.

2.3 Seasonal Pond Depth and Acreage

The seasonal ponds constructed in the southern portion of the Site were designed primarily as habitat for shorebirds. There are three ponds filled by rainfall captured by drainage basins (Figure 2). To minimize water percolating into the soil and thereby draining the ponds, the pond basins were covered with Bay muds excavated from the Project Site. To monitor the progress of these ponds, pond depth and acreage are measured as required by Section 2.4 of the MMP (LFR 1999b).

2.3.1 Methods

Monitoring frequency. The original monitoring plan called for monthly monitoring four times during the wet season. During the first monitoring year (1998 to 1999), pond depth and acreage were measured eight times from November 1998 to July 1999 (Table 3). During the second monitoring year (1999 to 2000), the ponds were monitored twice only because of transitions in contractual arrangements for monitoring. The approach for the third monitoring year (2000 to 2001) spreads five measurements across 5 to 6 months (from December to July) in order to characterize ponding trends during and following the rainy season.

Pond depth is determined by reading water levels on staff gauges in each pond. Two sets of staff gauges have been installed in the seasonal ponds. The first set was installed shortly after construction; the second set was installed between fall and winter of 2000 to upgrade the original staff gauges. Both sets are currently in the ponds. All staff gauges were installed at the lowest point within each pond. The original staff gauges consisted of ¾-inch schedule 40 PVC driven to resistance into the pond bottoms. Each gauge had graduated adhesive staff gauge tape placed on it to show water levels. The replacement staff gauges consisted of 1½-inch galvanized steel slotted angle iron pounded into the pond bottom to resistance. Porcelain-coated steel graduated staff gauges were bolted onto a second piece of slotted angle iron and the combination then bolted onto the angle iron pounded into the pond bottom. If needed for stability, ½-inch steel rebar was also pounded into the pond bottom and attached to the staff gauge.

Pond acreages are determined by walking the pond perimeters with a handheld GPS unit that recorded position once every three seconds. The position file is then downloaded and corrected with a differential correction service. The resulting file is then imported into ArcView GIS to calculate the area of the polygon. EBRPD staff handles the data download and acreage calculations. As we accumulate more paired stage-area data from ongoing monitoring activities, we are better able to estimate pond area from stage readings alone. We used this approach for the April 2001 event. Figure 6 shows this stage-area curve.

Rainfall totals for each water year are obtained on the Internet from the California Department of Water Resources Division of Flood Management (http://cdec.water.ca.gov). The nearest rainfall monitoring station that records daily totals is the Oakland South station (code OSO, rainfall sensor 45), operated by the Oakland Fire Services Agency. The station is located in the Oakland hills at 1,000 ft elevation, at latitude 37.7830°N and longitude 122.1500°W.

2.3.2 Results and Discussion

Table 3 presents the pond acreage and depth data from late 1998 through mid- 2001 and Table 4 presents the rainfall data for the 1998-1999, 1999-2000, and 2000-2001 water years.

All three seasonal ponds hold water very well. At the peak stage monitoring event of 22 March 2001, total pond acreage was 9.94 acres, exceeding the performance criterion of 4.5 acres. That monitoring event followed the end of a series of large storm events (see Table 4), in accordance with performance criteria. The 26 April 2001 monitoring data showed a ponding area of 7 acres, which also exceeded the performance criteria. Pond depths met or exceeded the required range of 10 to 59 cm (0.3 to 1.9 ft) from January to April 2001 (Table 3). Water levels exceeding the target range are believed acceptable because they translate into far larger surface area and, combined with the gradual pond slopes, provide a large area of desired water levels. All three ponds had dried by early July, following two months of virtually no rainfall (Table 4).

2.4 Tidal Inundation

Tidal inundation is a fundamental aspect of any tidal marsh and in this restoration project it is vital to the successful formation of intertidal marsh. The tides carry sediment, nutrients, fish, plant seeds and seedlings, plankton, and detritus into and out of the marsh, helping to establish the role of the tidal wetland as a component of the bay ecosystem. Tidal inundation evaluates two portions of the site – the low and high tidal marsh area and the intertidal pond.

2.4.1 Methods

Tidal inundation is measured at two locations within the marsh and compared to tides outside the restoration site. Within the site, we deploy atmospherically vented automatic water level recorders (In-Situ Troll 4000) within simple stilling wells for a one-month period that encompasses a large spring tide series. One recorder is placed within the intertidal pond (the Intertidal Pond station) to evaluate its function and the second within the smaller constructed channels at XS-1E (the Channel station; see Figure 2). Sensor elevations are surveyed to the permanent reference benchmark so that water levels can be converted to a fixed vertical datum (the Port Datum; see Appendix A). Sensors are calibrated at the beginning and end of the deployment period.

Tidal water level data for outside the site are downloaded from the National Ocean Service for the nearby continuous recording station in Alameda (NOS Station 941-4750). Data are downloaded relative to the mean lower low water datum and converted to Port Datum via current and old benchmark sheets that relate NGVD, NAVD and MLLW to one another (see Appendix A).

2.4.2 Results and Discussion

Figure 7 shows the tidal water level data for July to August 2001, which encompassed a spring tide series that incorporated a tidal range of up to 9.5 ft (2.9 m). The height of the tides within the site closely tracked that of the Alameda reference station. The Channel station water levels were consistently higher than the Alameda water levels, with a difference of about 0.2 ft (0.07 m). The Intertidal Pond station water levels were also consistently higher than the Alameda reference station and slightly below the Channel station by about 0.1 ft (0.03 m). These data indicate that the site is receiving full tidal inundation and is functioning appropriately in this regard.

Both site stations retained some water at low tide. Figure 8 shows absolute water depths above the ground surface at each station. Water depths at low tide during the 2001 monitoring period varied between 0.8 and 1.3 ft at the Intertidal Pond station and between 0.7 and 1.0 ft at the Channel station. Water depths at low tide during the previous monitoring event were between 0.9 and 1.1 ft for the Intertidal Pond station, and between 0.3 and 0.5 ft for the Channel station (WWR 2001). A small channel has developed during 2001 between the breach in the Intertidal Pond and the eastern first-order channel where the Channel station instrument is located (see further details below). Water held in the Intertidal Pond at low tide reflects the slow rate at which water can drain either over the berm (at higher water levels) or through the small breach. Water held in the Channel at low tide reflects ongoing drainage feeding into the eastern first-order channel where the instrument was located; this ongoing drainage likely comes from the Intertidal Pond which feeds into the Channel station.

Breach in Intertidal Pond Berm and Inundation Regime. A small breach occurred in the berm enclosing the Intertidal Pond (see location in Figure 2) sometime in 1999 or 2000. The breach had not been repaired prior to the collection of this year's data. During the time this breach has been open, a small channel developed between the breach in the Intertidal Pond and the Channel. The data in Figures 7 and 8 and discussed above show three important aspects of the Intertidal Pond hydrology: (1) it continues to receive full tidal inundation during high tides, (2) it retains water during low tides, even during neap tide events, and (3) the small channel connecting the breach to the nearby constructed channel has enlarged during 2001, thereby allowing increased drainage at low tide. The breach and newly formed channel still do not allow the Intertidal Pond to drain fully, as the water depth data show (Figure 8). However, they appear to have lowered the "sill" over which ebb tides drain, such that the minimum water level is lower than it would be otherwise.

2.5 Channel Velocity, Turbidity, and Water Quality

The velocity and turbidity of the tidal waters that flood and drain the site are indicative of the physical processes within a tidal marsh that are responsible for sediment accumulation on the marsh plain and channel network development. Water quality measurements are useful indicators of current or potential problems that may develop in a tidal marsh.

2.5.1 Methods

Sample locations and tide stage. During the 2000-2001 monitoring period, sampling locations corresponded to the five topographic cross section locations (shown in Fig. 2). Samples were taken during a flood tide for velocity, turbidity, and water quality. During the 1999-2000 monitoring period, three of these five cross section locations were sampled for velocity and turbidity on an outgoing (ebb) tide: the western first order (XS-1W), the eastern second order (XS-2E), and the third order (XS-3) (see Figure 2). During the 1998-1999 monitoring period, nine locations were sampled, four in first order channels, four in second order channels, and one in the third order channel (LFR 1999a), with precise locations not known.

Velocity during the 1999-2000 and 2000-2001 monitoring period was measured with a Montedoro-Whitney model PVM-2A electronic water velocity meter on a rod lowered at 25-cm intervals from 5 cm below the surface to near the channel bed, thereby obtaining velocity profiles. The current meter averaged readings at 1-second intervals for a 20-second duration. During the 1998-1999 monitoring period, velocity was measured with a propeller-type water velocity meter placed 6 inches below the water surface for one minute (LFR 1999a).

Turbidity during the 2000-2001 monitoring period was measured at each location from two water samples (one from the surface and one from mid-depth). The samples were collected into vials for immediate measurement in an H.F. Science model DRT-15CE turbidity meter. During 1999-2000, three water samples were collected at each location with a DH-48 depth-integrated suspended sediment sampler. Samples integrated from the surface to third, half, and bottom depths and were collected to provide a suspended sediment profile according to USGS sampling standards (Guy and Norman 1970). Subsamples of the three water samples were also placed into vials for immediate measurement in an H.F. Science model DRT-15CE turbidity meter. During the 1998-1999 monitoring period, turbidity samples were collected from the top 4 to 6 inches of the water column (LFR 1999a).

Water quality measurements include temperature, pH, dissolved oxygen, conductivity, and redox potential. Water quality was measured using a YSI multi-probe instrument. At each sample location, the probe was placed below the surface of the water, and kept in a constant back and forth motion against the current to facilitate sensor-water contact until the readings stabilized.

2.5.2 Results and Discussion

Samples for the current monitoring period were collected on 24 August 2001.

Tidal water level conditions. Sampling occurred during incoming (flood) tides shortly before slack high water for the August 2001 sampling event and during outgoing (ebb) tides for the previous years' events (Figure 9).

Velocity ranged between 0.73 and 1.37 meters per second (m/s) in 2001 and between 0.31 and 0.49 m/s in 2000 (Table 5). The higher velocities during 2001 compared to previous years may be attributed to sampling during a flood tide rather than an ebb tide. The velocity profiles collected in 2001 show higher velocities near the surface (5 cm depth) and slightly lower velocities with depth. These data contrast with data collected in 2000, in which the reverse trend occurred with depth. The differences in velocity profiles between years may reflect different characteristics of water movement during ebb and flood tides.

Turbidity ranged between 2.8 and 7.4 Nephelometric Turbidity Units (NTU) in 2001, similar to measurements of between 4 and 8 NTU in 2000 (Table 5). Both years yielded ranges much lower than the range of 26 to 42 NTU observed in 1999. The 1999 data were collected in the winter less than a week after a winter storm whereas the 2000 and 2001 data were collected in the fall about 4½ months after the last storm event (Table 4). These data show a greater amount of sediment is available in the water column for marsh plain accretion during the winter than in the fall, suggesting that sedimentation on the marsh plain follows seasonal patterns.

Water quality measurements indicated no abnormal conditions this year (Table 6). Comparison of this year's data with future monitoring events will be used to detect changes in water quality.

2.6 Air Photo

A series of two aerial photographs have been taken since site restoration. The first aerial photograph of the series was flown on 25 September 2000 and is shown in Figure 10. The regional Spartina Control Group contracted for this photography as part of its larger regional effort to map the distribution and spread of the invasive Spartina alterniflora in the San Francisco Estuary, and this site has been colonized by S. alterniflora. The photography was flown at a scale of 1:6,000 and the San Francisco Estuary Institute (SFEI) orthorectified the photographs. The second aerial photo (Figure 11) was flown 24 July 2001, at a scale of 1:12,000, and was orthorectified by Wetlands and Water Resources.

2.7 Channel Planform Meander

Meander is the lateral migration of a channel brought about by bank erosion. Monitoring channel planform meander requires orthorectified time series aerial photography to obtain spatially accurate data over time. The 25 September 2000 orthorectified aerial photograph currently serves as the baseline data point. One can see from comparing the 2000 and 2001 photographs (Figures 10 and 11) to the design drawing (Figure 2) that, from a qualitative perspective, the channels were constructed as designed and have remained stable with relatively no lateral movement. Channel position is now included in site GIS data along with the vegetation map shown in Figure 12.

Field observations indicate that small channels are beginning to form in a few places within the marsh plain. These channels are small, generally less than 0.3 m (1 ft) wide. They appear to be draining the areas that pond at low tide, which are generally evident in the aerial photograph as the darkest areas on the marsh plain. These small channels are not yet distinct enough for capture via remote sensing techniques.

3.0 Biological Monitoring

The monitoring plan (LFR 1999a) included six biological monitoring activities (Table 1). The 2000-2001 monitoring period included all six monitoring activities, though only five of these six activities were monitored by WWR. Bird use monitoring is conducted separately by GGAS; the final 1999-2000 data are included here. The 2000-2001 data are not yet compiled for inclusion. This section is organized in the following manner:

- Section 3.1, Vegetation
- Section 3.2, *Spartina foliosa* transplants
- Section 3.3, Weed invasion
- Section 3.4, Loafing island vegetation
- Section 3.5, Bird use

3.1 Vegetation

The restored tidal marsh portion of the site is expected to support three habitat zones typical of San Francisco Bay marshes, including an upper zone of peripheral halophytes, a middle zone of pickleweed (*Salicornia virginica*), and a lower zone of cordgrass (*Spartina foliosa*.). In the long term, the intertidal plant community at the site should be comparable with those found at reference tidal marshes in the vicinity. Monitoring of the tidal marsh vegetation is required in Section 2.3 of the MMP (LFR 1999b). Two reference sites for marsh vegetation have been identified; Arrowhead Marsh, corresponding to low marsh vegetation dominated by cordgrass; and Damon Marsh, corresponding to high marsh vegetation dominated by pickleweed. Sampling of these reference sites is not part of this monitoring program.

Monitoring of the vegetation within and around the seasonal wetlands is an important component of the monitoring program for the site because of the possible loss of ecological function for shorebirds and waterfowl caused by excessive vegetation growth in these areas. Performance criteria for the seasonal wetland areas distinguishes between the pond bottoms and the surrounding seasonal wetlands. The Performance criterion states that the pond bottoms should develop vegetation cover of less than 20 percent. Additionally, long-term goals for the vegetation cover of the surrounding seasonal wetlands should develop to at least 80 percent across two-thirds of the area and between 20 and 80 percent on the remaining one-third. An additional performance criterion states that no large patches of invasive species should be present. Monitoring of the seasonal wetlands vegetation is required in Section 2.4 of the MMP (LFR 1999b).

3.1.1 Methods

During the 1998-1999 monitoring period colonization of the site by intertidal vegetation was at very low densities. Therefore, permanent transects as specified in the Monitoring and Maintenance Plan were not appropriate at that time to assess the vegetation colonization of the tidal portions of the site. Instead, the vegetation colonization of the site was assessed qualitatively by walking the entire site. A general description of the vegetation distribution was recorded during this survey and a list of all species present was also generated. Those results are reported in LES (1999) and are not repeated here.

Transect Locations in Tidal Marsh Portion of Site. Beginning with the 1999-2000 monitoring period, sufficient vegetation colonization had occurred to justify establishment of permanent vegetation transects. We established a total of five transects (Figure 2). Three transects run off a center point located approximately 35 meters north of the intertidal pond in the center of the restored tidal marsh. At that location we placed an orange stake and white PVC pipe to mark the central point. Transect V1 has a bearing of 250 degrees from the center point and runs westerly to the fence at the western edge of the tidal marsh. Transect V2 has a bearing of 70 degrees from the center point and runs easterly to the fence at the eastern edge of the tidal marsh. Transect V3 has a bearing of 150 degrees from the center point and runs southerly across the Intertidal Pond and continues across Seasonal Pond 2 and the seasonal wetlands to the southern edge of the site ending at the fence. Transect V4 traverses the northern part of the site starting at the chain link gate at the southern end of the main parking lot and bearing 70 degrees east across the site to the eastern edge at the fence. Transect V5 runs at a 100-degree easterly angle from SP-8 near the western edge of the tidal marsh east to the fence and running through SP 10.

Transect Locations in Seasonal Wetland Portion of Site. Transect V3 from the tidal marsh portion was carried south to the southern edge of the site, through Pond 2 (see Figure 2). In addition, previous monitoring activities had established six permanent transects. At each of the three ponds, two transects began on the drainage divide and extended toward the center of the pond to the staff gauge. The upper end of each transect was permanently marked with a piece of ¾-inch rebar pounded into the ground with a pin-flag attached to permit the easy relocation of the marker. Transect identifications, bearings, and lengths are:

Pond and Transect ID	Compass Bearing to Staff Gauge	Distance (m) to Staff Gauge
1-1	94	77.2
1-2	244	73
2-1	238	85
2-2	340	88
3-1	310	50.9
3-2	94	63.6

Vegetation Sampling along each Transect. Vegetation along each transect was delineated into patches of similar vegetation composition based on visual observations. Within each patch, we collected data on species dominance, total species composition, percent cover and stature.

Vegetation Map from Aerial Photograph. Beginning with the 24 July 2001 aerial photograph, we have used remote sensing image analysis tools available as part of the ArcView® and ArcInfo® geographic information system software packages to generate vegetation maps from the aerial photography for the tidal marsh portion of the site. We used this photograph to prepare a preliminary vegetation map that we then ground truthed during the September 2001 vegetation sampling effort. Ground truthing comprised evaluating species composition and percent cover.

3.1.2 Results and Discussion – Tidal Marsh

Field surveys were conducted on 6 September 2001. Table 7 presents the vegetation transect data, Figure 13 shows percent vegetation cover over time, and Appendix C presents a complete list of vegetation species observed at the site, indicating new species detected in the 2001 surveys.

Thirteen species typical to San Francisco Estuary tidal salt marshes were observed along the five tidal marsh transects. Annual pickleweed (*Salicornia europaea*) continues to dominate the tidal marsh vegetation. Perennial pickleweed (*S. virginica*), salt grass (*Distichlis spicata*), Pacific cordgrass (*Spartina foliosa*), invasive smooth cordgrass (*S. alterniflora*), brass buttons (*Cotula coronopifolia*), salt-marsh arrow-grass (*Triglochin cocinna*), alkali bulrush (*Scirpus maritimus*), sand-spurry (*Spergularia marina*), marsh gum-plant (*Grindelia stricta* var. *angustifolia*), fleshy jaumea (*Jaumea carnosa*), spear scale (*Atriplex patula*), alkali heath (*Frankenia salina*), and the invasive *Salsola soda* were also observed on the site.

There are some basic patterns of vegetation colonization at the site as evidenced by the field data, the vegetation map (Figure 12), and the data summarized from the vegetation map:

- There are three general spatial characteristics:
    - The constructed low marsh portions of the site generally have a greater amount of vegetation colonization than the constructed high marsh portions. The low marsh is essentially the middle of the site between the two main branches of the constructed tidal channels (see Figure 2).
    - There is greater vegetation colonization near to the tidal source (the north end of the site) than there is farthest from the tidal source.
    - There is a relatively narrow "ring" of vegetation along the marsh/upland edge comprising a more mixed species composition and nearer to the tidal source dominated by the invasive smooth cordgrass.
- Bare ground still dominates the site, though at reduced levels relative to the 2000 monitoring period. During 2001, bare ground ranged between 43 and 96 percent of the transects, down from 66 to 97 percent from 2000.

- The bare ground areas are often covered with algae mats.
- The dominant plant species at the site is annual pickleweed.
- The invasive smooth cordgrass has colonized the site and is found mostly but not entirely closer to the tidal source.

Transect V1. The southwest portion of the restored tidal marsh, represented by the 159-m Transect V1 (Table 7), has shown considerable colonization by annual pickleweed during 2001. Total percent cover of bare ground dropped from 94% in 2000 to 60% in 2001, showing considerable increases in vegetation cover (Figure 13).

Transect V2. The southeast portion of the restored tidal marsh, represented by the 179-m Transect V2 (Table 7), shows a much greater extent of vegetation colonization (Figure 13). Bare ground dropped from 78% of total transect in 2000 to 56% in 2001, with much of this colonization occurring in the high marsh east of the channel. The low marsh portion of the transect is roughly half bare ground with some algae and the other half is predominantly annual pickleweed with small amounts of perennial pickleweed and salt grass. The high marsh vegetation is more evenly mixed between annual and perennial pickleweed with a small patch of native Pacific cordgrass. The invasive smooth cordgrass has colonized along the marsh edge.

Transect V3. The southern portion of the restored tidal marsh, represented by the 169-m Transect V3 through the Intertidal Pond (Table 7), is very similar to Transect V2 but with a higher plant diversity at the marsh edge and a large amount of bare ground (97% of total transect). The marsh edge includes salt marsh arrow grass, alkali bulrush, salt grass, and brass buttons. Little additional vegetation colonization occurred along this transect during 2001 (Figure 13).

Transect V4. The northern portion of the restored tidal marsh near the tidal source, represented by the 80-m Transect V4 (Table 7), shows a considerable amount of vegetation (Figure 13), with bare ground comprising 58% of the total transect, down from 66% in 2000. Species diversity is the highest of all transects within the tidal portion of the site. The invasive smooth cordgrass was not found along this transect in 2001, suggesting that control efforts have positively affected this portion of the site.

Transect V5. The central portion of the restored tidal marsh, represented by the 239-m Transect V5 (Table 7), has the greatest amount of vegetation colonization (Figure 13), with bare ground comprising 43% of the total transect, down from 72% in 2000. Annual pickleweed continues to dominate this area, though perennial pickleweed and the native cordgrass are also found here

Overall Progress of Vegetation Colonization. Based on these data, it appears clear that the site is progressing toward meeting its five-year performance criteria (see Section 5). The primary concern in meeting these performance criteria is colonization by smooth cordgrass, *Spartina alterniflora*. The project design anticipated this problem and the site is now included as one of the target sites for the regional Spartina Control Group. From the very limited occurrence of *S. alterniflora* in 2001, it appears that these control efforts are positively affecting the site.

3.1.3 Results and Discussion – Seasonal Ponds

Field surveys were conducted on 22 March and 26 April 2001.Table 9 presents the vegetation transect data and Appendix C presents a complete list of vegetation species observed at the site, indicating species newly observed in 2001. Surveys were conducted at 6 transects, two at each pond. During the March 2001 survey we determined that many species had not fully emerged, therefore we conducted another survey in April 2001.

The vegetation in the drainage basins feeding the seasonal ponds is typical of disturbed upland habitat with weedy exotic herbaceous species and grasses. Much of this area is bare ground at 50 to 60 percent. Species coverage appears to be steadily increasing in comparison to bare ground percentages of 70 to 80 percent in 2000. The most common species observed in 2001 were cutleaf plantain (*Plantago coronopus*), prickle grass (*Crypsis vaginiflora*), sour clover (*Melilotus indica*), and loosestrife (*Lythrum hyssopifolium*).

3.1.4 Results and Discussion – Vegetation Map for Tidal Marsh

The 2001 vegetation map for the tidal marsh portion of the site is shown in Figure 12. We have shown the map adjacent to the original air photo to allow examination of the classification used.

3.2 Spartina foliosa *Transplants*

Tracking success of *Spartina foliosa* transplants has proved infeasible due to the significant efforts at controlling the invasive *S. alterniflora*. These efforts, along with many volunteer efforts to eradicate *S. alterniflora*, have resulted in accidental removal of *S. foliosa*. These efforts have consequently altered the transplant experiment, such that tracking its results is no longer possible. However, one case seen from the tidal marsh vegetation data (Table 7) shows that the native cordgrass, *S. foliosa*, is found on the site.

3.3 Weed Invasion

Spartina alterniflora

Individuals of *S. alterniflora* were observed along the eastern margins of the tidal marsh, and were seen growing within the eastern portion of the marsh plain. Some plants appeared growing next to *S. foliosa* plantings and may be hybridizing. Although we did not estimate patch sizes of *S. alterniflora* (and hybrids), Table 7 shows the percent cover each species occupied along transect surveys. Percent cover decreased along Transects 2 and 4 between 2000 and 2001 surveys. However, percent cover along Transect 3 increased between 2000 and 2001 surveys. *S. alterniflora* was not found in Transects 1 or 5 during either years. Attempts to define a trend in invasive cordgrass populations may prove to be meaningless due to frequent removal by EBRPD and volunteers in efforts to restrict *S. alterniflora* growth.

Other Weeds

Weed invasion within the tidal marsh area is largely restricted to marsh upland edges and appears minimal. As mentioned above, *S. alterniflora* is colonizing in the marsh area. In the seasonal wetland area (Pond 2) several invasive species were observed. These include French broom (*Genista monspessulana*), sweet fennel (*Foeniculum vulgare*), peppergrass (*Lepidium latifolium*), pampas grass (*Cortaderia jubata*), yellow star thistle (*Centaurea solstitialis*), bristly oxtongue (*Picris echioides*), and *Salsola soda*. None of these species were present in dense patches and were largely restricted to the southern end of the site near the fence line. Staff managed invasive vegetation, with some assistance from volunteers. Most of the work was done by hand.

3.4 Loafing Island Vegetation

Vegetation on the loafing islands is minimal and mostly restricted to the edge and base of each island. No tall vegetation is present on the islands. Perennial pickleweed (*Salicornia virginica*) appears at about 20% coverage on the edges with plant height averaging about 0.3 m. An occasional salt-marsh arrow-grass (*Triglochin cocinna*) can also be found. Island B shows slightly greater vegetation growth than Island A.

3.5 Bird Use

In August 2001, the second summary of bird use at the site was completed (Henkel 2001), and in December 2001 the third summary was completed (Henkel and Neuman 2001). Both summaries are included in Appendix D. During these two study periods (August to April 1999-2000 and 2000-2001) trained volunteers from the Golden Gate Audubon Society monitored bird use of the site, and bird use of adjacent reference sites. Volunteers conducted four surveys per month, corresponding to four tidal cycles: high, outgoing, low, and incoming.

The restoration site, consisting of tidal wetlands and seasonal ponds, provided significant habitat for shorebirds, waterfowl, and other birds. At least 49 bird species were recorded at the tidal wetlands, and 32 species at the seasonal ponds. Tidal wetlands supported mostly small shorebirds (occasionally in very high abundance). The seasonal ponds supported fairly low numbers of waterfowl, gulls, and shorebirds. Abundance of birds using the Seasonal Ponds decreased dramatically in 1999-2000, but rebounded somewhat in 2000-2001. It is not known why bird use of the Seasonal Ponds decreased in the second monitoring season. Overall, the restoration site provided a mosaic of habits, including areas with varying degrees of tidal action. This range of habitats supported birds at all tidal cycles, although the site may be especially important as a high-tide refuge for shorebirds.

Up to two Burrowing Owls (Athene cunicularia *hypugea*), were seen on surveys during the 1999-2000 and 2000-2001 studies. Owls were seen near nest boxes, and breeding by Burrowing Owls was documented in 2000-2001. This was the first documented nesting by Burrowing Owls at the Site. Up to nine California Clapper Rails (*Rallus longirostris obsoletus*) were seen in Arrowhead Marsh in 1999-2000, within the reference sites. The maximum number of rails seen in 2000-2001 was four. No rails were seen in the restoration area, due to the lack of suitable habitat at this early stage of the restoration. As native salt march vegetation develops within the tidal wetlands site, rail habitat should become available.

Key objectives of the restoration included providing breeding habitat for California Clapper Rails, and providing foraging and resting habitat for migratory waterfowl and shorebirds. Although a full analysis of these goals will be possible only after the full five-year study, it appears that significant progress toward these goals is being made. The second goal has probably already been met, and the first goal will likely be met after several more years of vegetation development.

4.0 Maintenance

EBRPD carried out a variety of maintenance activities during the 2000-2001 monitoring period. Activities performed during 2001 are listed here and are also referred to in appropriate sections elsewhere in this report.

January
- Picked up litter and debris from inside the New Marsh area.
- Planted replacement shrubs at landscaped areas.
- Spread mulch around shrubs of landscaped areas.

February
- Irrigation repair of the landscaped areas.
- Planted replacement shrubs at landscaped areas.
- Picked up litter and debris from inside the New Marsh area.
- Sprayed herbicide (Round-up) at landscaped areas.
- Soil (100 yards) was removed from one of the landscaped areas with drainage problems.
- Pulled out the invasive shrubs Russian olive (*Elaeagnus angustifolia*) from inside the New Marsh area.

March
- Picked up litter and debris from inside the New Marsh area.
- Line-trimmed along the fence-line of the New Marsh.
- Hand-pulled yellow starthistle (*Centaurea solstitialis*) from inside the New Marsh area.
- Hand-weeded around shrubs at the landscaped area.

April
- Picked up litter and debris from inside the New Marsh area.
- Planted replacement shrubs in landscaped areas.
- Sprayed the herbicide Round-up along the outside fence-line of the New Marsh and along the edges of the cross-trail.
- Soil was replaced (100 yards) at the landscaped area with poor drainage.
- Replacement soil was spread and graded.
- Spread mulch around shrubs of landscaped areas.
- Hand-pulled yellow starthistle (*Centaurea solstitialis*) from inside the New Marsh area.

May
- Picked up litter and debris from inside the New Marsh area.
- Irrigation repair for the landscaped areas.
- Grubbed invasive weeds (broom, fennel, yellow starthistle, bristly oxtongue, etc.) growing inside the New Marsh area.

June/July
- Off season for regular ranger
- Other staff built bollards to install at cross trail on south end of restoration area
- Seeds collected from Grindelia and Arrowgrass inside marsh area

August
- Seeds propagated and maintained in service yard "nursery" for later planting
- Picked up litter and debris from inside the New Marsh area.
- Hand weeded around shrubs in the landscaped areas.
- Irrigation repair of the landscaped areas.
- Hand pulled yellow star thistle from inside the New Marsh area.

September
- Picked up litter and debris from inside the New Marsh area.
- Hand pulled yellow starthistle from inside the New Marsh area.
- Grubbed invasive weeds (broom and fennel) growing inside New Marsh area.

October
- Picked up litter and debris from inside the New Marsh area.
- Mowed inside the New Marsh and Cross-trail areas in order to maintain the stand of California native grasses.
- Repaired (150 feet) damaged fence of New Marsh along the road to Arrowhead Marsh.

November
- Planted Grindelia along high tide line inside eastern edge of new marsh.
- Removed litter and debris from inside new marsh.
- Planted native grasses in some viewing areas around perimeter of marsh.

December
- Patched fence.
- Checked water system.

Throughout the year students from Audubon classes assisted with maintenance and monitoring of the health of the marsh. They removed *Lepidium*, yellow star thistle, fennel and other invasive weeds and picked up trash that came in on the tides. Students also participated in the bird surveys. Audubon maintains the data from these field observations.

5.0 Project Performance and Suggested Modifications

The project performance evaluation has been organized according to the three groups of objectives for this restoration project: ecological, engineering, and maintenance. The following sections present the performance criteria that the project is required to meet within a five-year period and the stressor indicators that are intended to identify problems early on that may hinder the ability of the project to meets its performance criteria.

The Port of Oakland restored tidal action to the site on 10 June 1998. Therefore, this report represents the third year following restoration. Consequently, the monitoring data presented in the previous sections are expected to show positive progress toward meeting the five-year performance criteria; there is no expectation that the five-year criteria are met after three years.

5.1 Ecological Objective 1: Provide Suitable Breeding Habitat for California Clapper Rail

The MMP (LFR 1999b) included one performance criterion and one stressor indicator for this objective.

5.1.1 Performance Criterion

Performance criterion 1-1. Positive trend in vegetation measurements, with CCR habitat defined as salt marsh plain dominated by a dense tall cover of pickleweed (*Salicornia virginica*) and/or cordgrass (*Spartina foliosa*) (LFR 1999b, pp.3-4).

Progress toward performance criterion 1-1. At the end of the third year following project construction, colonization by desired tidal marsh vegetation is progressing appropriately. Vegetative cover continued to increase in 2001, relative to 2000. The primary constraint on meeting this progress is establishment of the invasive smooth cordgrass, *Spartina alterniflora.*

5.1.2 Stressor Indicator

Stressor indicator 1-1. Alkali bulrush (*Scirpus maritimus*) should not be present in large continuous patches (LFR 1999b, p.4).

Field evidence of stressor indicator 1-1. There is one small patch of alkali bulrush located at the southern central portion of the tidal portion of the site, between the intertidal pond and the seasonal wetlands. At this point, this patch is not deemed problematic.

5.2 Ecological Objective 2: Support Waterfowl and Shorebirds

The MMP (LFR 1999b) included two performance criteria and no stressor indicators for this objective.

Performance criterion 2-1: Comparable numbers and species of shorebirds between the existing "loafing peninsula" near the Site, and the resting areas on the Site.

Comparable numbers and species of shorebirds were found on the "loafing peninsula" in the Eastern Reference site and the restoration sites. Performance criterion 2-1 was met in the 1999-2000 season.

Performance criterion 2-2: Comparable numbers and species of shorebirds and waterfowl between the Site and nearby waterfowl and shorebird habitats.

Progress toward these performance criteria. Both abundance and diversity of shorebirds were higher at the Tidal Wetlands portion of the Site than at adjacent reference areas. Abundance and diversity of shorebirds were lower at the Seasonal Ponds portion of the Site than at reference areas. Waterfowl abundance and diversity were higher at reference sites than at either portion of the Site, due to lack of open water habitat at the site. Overall, numbers and species of waterfowl and shorebirds were comparable between the Site and adjacent reference sites. Performance criterion 2-2 was met in the 1999-2000 season.

5.3 Ecological Objective 3: Support Intertidal Plant Communities

The MMP (LFR 1999b) included three performance criteria and one stressor indicator for this objective.

5.3.1 Performance Criteria

Performance criterion 3-1: The high marsh plain should develop a 50 percent cover of salt-marsh plant (generally dominated by pickleweed, saltgrass, jaumea, or alkali heath) within five years of Project construction (LFR 1999b, p.9).

Progress toward performance criterion 3-1. At the end of the third year following project construction, colonization by desired tidal marsh vegetation is progressing appropriately. The vegetation map (Figure 12) indicates total high marsh cover at 29% overall.

Performance criterion 3-2: The low marsh plain should demonstrate a positive trend increasing toward a 50 percent cover of salt marsh plants dominated by cordgrass (*Spartina* spp.) (LFR 1999b, p.9).

Progress toward performance criterion 3-2. At the end of the third year following project construction, colonization by desired tidal marsh vegetation is progressing appropriately. The primary constraint on meeting this progress is establishment of the invasive smooth cordgrass, *Spartina alterniflora.* The vegetation map (Figure 12) indicates total low marsh cover at 39% overall.

Performance criterion 3-3: Over a period of five years, sedimentation should raise the average elevation of the low marsh plain from 5.5 to 5.75 ft Port Datum (LFR 1999b, p.9).

Progress toward performance criterion 3-3. Sedimentation is occurring within the range of predicted values, suggesting positive progress toward meeting this performance criterion. Progress on low marsh accretion is best evaluated from the channel topographic cross sections (Figures 3, 4, and 5). In nearly all instances, it appears that low marsh has already accreted to 5.75 ft Port Datum or above.

5.3.2 Stressor Indicator

Stressor indicator 3-1: Within the tidal marsh areas, there should be no large (greater than 10 square meters), continuous patches of exotic, invasive species, or bare patches of ground present (LFR 1999b, p.9).

Field evidence of stressor indicator 3-1. Aside from smooth cordgrass (*Spartina alterniflora)*, no large patches of exotic, invasive species have become established. Much of the tidal marsh remains bare ground, which is indicative of the early stage of the project evolution only three years after restoring tidal action. Percent vegetation cover is increasing across this site (see Table 7 and Figure 13).

5.4 Ecological Objective 4: Support Seasonal Ponds and Seasonal Vegetated Wetlands and Water Resources

The MMP (LFR 1999b) included seven performance criteria and one stressor indicator for this objective.

5.4.1 Performance Criteria

Performance criterion 4-1: Seasonal ponds 1 and 2 (see Figure 2) should develop a vegetation cover during the wet season (December through April) of less than 20 percent cover and consisting of annual species (LFR 1999b, p.12).

Progress toward performance criterion 4-1. Both seasonal ponds met this criterion (Table 8).

Performance criterion 4-2: The seasonal ponds should maintain 3 to 18 inches (10 to 59 cm) of water lasting 10 days after each of four storm events during the months of December through April in average rainfall years (LFR 1999b, pp.12-13).

Progress toward performance criterion 4-2. All three seasonal ponds are meeting this performance criterion admirably. See Tables 3 and 4.

Performance criterion 4-3: The total seasonal pond acreage should average 4.5 acres during the months of December through April (LFR 1999b, p.13).

Progress toward performance criterion 4-3. The ponds are meeting this criterion as water remains in the ponds at least into, and sometimes well beyond, the April requirement.

Performance criterion 4-4: The seasonal ponds should have no significant erosion or sedimentation (LFR 1999b, p.13).

Progress toward performance criterion 4-4. None detected.

Performance criterion 4-5: The drainage basin divides should remain intact and not wash out during extreme storm events (LFR 1999b, p.13).

Progress toward performance criterion 4-5. Drainage basin divides remain intact.

Performance criterion 4-6: The seasonal vegetated wetlands surrounding the ponds should demonstrate, over the first five years, a positive trend increasing toward the long-term goal of at least 80 percent cover for two-thirds of the seasonal wetlands and 20 to 80 percent cover for the remaining one-third of the seasonal wetlands (LFR 1999b, p.13).

Progress toward performance criterion 4-6. Vegetation surveys to date indicate positive progress toward meeting this performance criterion.

Performance criterion 4-7: Seasonal wetland vegetation surrounding ponds 1 and 2 should total at least 4.7 acres during average rainfall years (LFR 1999b, p.13).

Progress toward performance criterion 4-7. Insufficient monitoring resources are available to gather data for assessment of vegetation acreage. Percent cover of vegetation and bare ground were surveyed along transects from the centers of each pond (2 transects/pond) (Table 9). These surveys indicate vegetative growth occurs around the pond. In order to obtain area, one of three new, costly methods must be used: additional air photography and vegetation map; topographic data and GIS extrapolation; multiple vegetation perimeter GPS surveys.

5.4.2 Stressor Indicator

Stressor indicator 4-1: There should be no large (greater than 10 square meters), continuous patches of exotic, invasive species, or bare patches of ground (defined as having less than 10 percent cover of vegetation) present.

Field evidence of stressor indicator 4-1. This stressor indicator is difficult to evaluate because seasonally wet areas in California are commonly occupied and often dominated by introduced species. Such is the case for the seasonal wetlands (see Appendix C). Whether or not the species present are a problem is more difficult to determine. Species that are clearly problematic and were found in the seasonal wetland area (Pond 2 area) include French broom, sweet fennel, pampas grass, and yellow star thistle. None of these species were present in dense patches and were largely restricted to the southern end of the site near the fence line.

5.5 Ecological Objective 5: Provide Upland Buffer and Upland Drainage Divide Habitat

The MMP (LFR 1999b) included two performance criteria and no stressor indicators for this objective.

Performance criterion 5-1: Vegetation cover of the upland buffer and drainage divide areas should have values of at least 40 percent, measured at the end of the growing season (LFR 1999b, p.16).

Progress toward performance criterion 5-1. Vegetation colonization is progressing toward meeting this criterion.

Performance criterion 5-2: The shrub plantings should have a survival rate of at least 70 percent during the first five years (LFR 1999b, p.16).

Progress toward performance criterion 5-2. Shrub survival was not evaluated quantitatively during this monitoring year. EBRPD inspects shrub health during routine maintenance of the site (Section 4.0). Shrub survival rates may be determined in the future if EBRPD documents shrub populations at the beginning and end of the monitoring period, and keeps record of how many shrubs are replaced due to death.

5.6 Engineering Objective 1: Maintain Required Hydraulic and Tidal Circulation within the Restored Tidal Marsh

The MMP (LFR 1999b) included one performance criterion and no stressor indicators for this objective.

Performance criterion 6-1: Monitor and evaluate the hydraulic circulation within the marsh (LFR 1999b, p.17).

Progress toward performance criterion 6-1. This monitoring was performed and indicated full and appropriate tidal circulation within the restored tidal marsh. The one problem that has occurred is that the small berm isolating the Intertidal Pond has breached in 1999 or 2000 along about a 2-m (6-ft) section at its very eastern end adjacent to loafing island A. During 2001, a small channel began forming between the pond and nearby constructed channel that has led to increased, but not full, draining of the pond at low tide. EBRPD has let a contract to repair this berm.

5.7 Maintenance Objective 1: Prevent Excessive Levee Erosion

The MMP (LFR 1999b) included one performance criterion and no stressor indicators for this objective.

Performance criterion 7-1: Erosion of the perimeter levee shall result in a levee slope no greater than 1.5:1 (LFR 1999b, p.19)

Progress toward performance criterion 7-1. No significant levee erosion was observed at the site.

5.8 Maintenance Objective 2: Maintain Plantings and Habitat Features

The MMP (LFR 1999b) included one performance criterion and four stressor indicators for this objective.

5.8.1 Performance Criteria

Performance criterion 8-1: Monitor, adjust water supply, and repair or replace damaged drip irrigation system components (LFR 1999b, p.20).

Progress toward performance criterion 8-1. EBRPD maintained the irrigation system including repairing damaged components. Staff also removed poorly draining soils (100 yards) and replaced them with better draining materials (Section 4).

5.8.2 Stressor Indicators

Stressor indicator 8-1: Replace dead or dying shrubs promptly (LFR 1999b, p.20).

Field evidence of stressor indicator 8-1. EBRPD replaced dead or dying shrubs several times during the monitoring period (Section 4).

Stressor indicator 8-2: Replace cordgrass if survival rates drop below 70 percent (LFR 1999b, p.20).

Field evidence of stressor indicator 8-2. Significant efforts to control the invasive smooth cordgrass *Spartina alterniflora* have so altered *S. foliosa* populations that tracking its survival rate is no longer feasible.

Stressor indicator 8-3: Prune shrubs as needed (LFR 1999b, p.21).

Field evidence of stressor indicator 8-3. No pruning took place (see Section 4).

Stressor indicator 8-4: The Site will be kept free of invasive vegetation with the following species targeted for removal: peppergrass (*Lepidium latifolium*), pampas grass (*Cortaderia selloana*), french broom (*Genista monspessulana*), star thistle (*Centaurea solstitialis*), and smooth cordgrass (*Spartina alterniflora*) (LFR 1999b, p.21).

Field evidence of stressor indicator 8-4: Removal of the above invasive plant species was done by EBRPD staff, with the assistance of volunteers. Invasive vegetation was primarily hand-pulled or grubbed, but on two occasions was sprayed with an herbicide (Section 4).

5.9 Maintenance Objective 3: Routine Park Operation

EBRPD park staff maintained park amenities as needed. During the monitoring period, EBRPD removed litter from the marsh, removed invasive vegetation, planted native vegetation, replaced dead shrubs, maintained the irrigation system for the shrubs, and repaired over 150 feet of damaged fence.

5.10 Maintenance Objective 4: Control Mosquito Breeding

These objectives pertain to maintaining access for Alameda County Mosquito Abatement District activities and therefore are not covered in this monitoring report.

5.11 Maintenance Objective 5: Control Predators on California Clapper Rail

These objectives pertain to expanding existing EBRPD predator control programs and therefore are not covered in this monitoring report.

6.0 Recommended Modifications of Monitoring Program

Monitoring results, in the context of a restoration program, have two main functions. The first is to track the progress of the site, especially in terms of whether or not performance criteria are being or will be met within an established time frame. In this capacity, monitoring results can inform corrective measures as needed. The second is to serve as indicators of the ability of the chosen monitoring methods to capture useful information. In the event that a monitoring method appears to be ineffective at detecting certain changes, we will recommend that the monitoring program be modified. This section has been added to address such recommendations.

6.1 Sediment Accretion

The monitoring plan relied upon fixed sediment pins measured annually to document sedimentation rates at the site. Field data collected to date from these sediment pins shows a high degree of variability and inconsistency (see wide range of results in Table 2 for many of the pins). This variability can be due to two factors: insensitivity of the method relative to the small quantities of sediment accumulation (i.e., measurement uncertainties of 0.007 m/yr are similar to actual sedimentation of 0.002 m/yr) and human disturbance to the sediment pins and/or the immediately surrounding ground surface.

Human disturbance is likely due to the many volunteer monitoring and management efforts at MLK marsh. Those efforts are geared toward achieving a successful outcome, so we recommend they continue.

The discrepancy between the method and the rates of sediment accumulation is a more significant concern, rendering the method fairly ineffective at this site to produce the desired monitoring data necessary for evaluating project performance. This shortcoming is already replaced, in part, by the channel topographic cross sections. Vertical accuracy of those cross sections is fairly high and depends largely upon the care of the rod-person in holding the rod base carefully at the ground surface. We have used the five cross sections in this report to evaluate tidal marsh accretion rates.

An alternative monitoring methodology is use of Sediment Erosion Tables (SETs; Boumans and Day 1993). SETs allow very high precision monitoring of integrated changes in ground surface elevation. SETs consist of a fixed vertical pipe (e.g., galvanized steel) set into the ground surface to a solid depth; onto that pipe a measurement “table” is affixed at each monitoring period and the distance from that table to the ground surface accurately measured at numerous points.

The primary source of error with SETs would be the potential for human disturbance of the ground surface within the measurement area. If SETs are placed in areas where human disturbance was minimal, measurements will be more accurate and thus yield more consistent sedimentation rates than sediment pins. The use of this new method may change the relative sedimentation rates found in previously collected data, since they will be more accurate. The primary difficulty in setting up SETs at MLK would be pounding the support pipes into the ground to a sufficient depth to assure temporal stability.

Note to report reviewers: Depending on the interest and need to track sedimentation more closely, we can figure out what the cost would be to install and use SETs and whether it would be practical to pound in the pipes.

6.2 Vegetation Management

The Monitoring Plan established performance criteria for vegetation dynamics during the first five years following restoration at this site, with the intention that meeting these criteria would signal long-term progress towards restoration success (MMP, LFR 1999b). EBRPD actively practices vegetation management at the site to achieve yearly performance goals, especially to control weeds and tall, emergent vegetation in the seasonal wetland and pond area, and islands within the tidal marsh (Sections 4.0 and 5.0). It is unclear, however, from previous and current EBRPD maintenance reports: (a) to what extent vegetation management has been implemented to attain current outcomes, (b) specific methods and precise locations where maintenance efforts have occurred, and (c) whether lower-effort management practices have been or are being sought. Without this detailed information, we cannot understand the ecological factors that are controlling vegetation on the site. The concern is that if EBRPD and other participating organizations reduce their maintenance efforts after the end of the five-year monitoring period, there may follow a reduced likelihood of the restoration project achieving success over the long term.

Steve Granholm of LSA, who reviewed the draft Monitoring Report and brought this issue forward for consideration, has offered two recommendations for modifying the monitoring and maintenance program. The Consent Decree parties will meet in early 2002 to discuss these recommendations and the results of those discussions will be implemented in 2002.

Additional Record Keeping

Dr. Granholm recommended additional record keeping by those working in the field. The purpose of the additional record keeping would be to improve our understanding about the relationship between maintenance effort and vegetation conditions at the site.

Examples of additional information include, but are not limited to:

1) Type of management activities performed (e.g., mowing, spot treatment of selected plant species with herbicides, hand-pulling, etc.);
2) Exact dates and duration of time over which these activities took place (for understanding of frequency, level of effort, and seasonal timing);

3) Specific location(s) on the site where the activities took place (e.g. around perimeter of seasonal pond 2, on both loafing islands, etc.). Larger scale maps could be produced for notation during field maintenance efforts.

Experiment with Management Methods

The five-year monitoring period provides a critical time for experimenting within an adaptive management framework. The purpose of such experimentation would be to identify the most effective and least cost long-term management methods for vegetation maintenance to achieve restoration success. Dr. Granholm recommended that the EBRPD experiment with different techniques for controlling weeds and tall emergent vegetation in the seasonal wetland and pond areas, and the two tidal marsh islands for the remaining two years of the five-year monitoring period. Actual methods would be identified by the Consent Decrees parties during 2002.

References

Boumans, R.M.J. and J.W. Day, Jr. 1993. High precision measurements of sediment elevation in shallow coastal areas using a Sedimentation-Erosion Table. *Estuaries* 16: 375-380.

California Department of Water Resources, Division of Flood Management. 1999. http://cdec.water.ca.gov/cgi-progs/queryF?OSO

Collins, J.N. 1994. Suspended Sediment Nomographs. Unpublished document.

Guy, H.P. and V.W. Norman. 1970. Field Methods for Measurement of Fluvial Sediment. Chapter C2 in Book 3 Application of Hydraulics, Techniques of Water Resource Investigations of the United States Geological Survey. U.S. Department of the Interior, Washington, D.C.

Harvey, H.T., P.B. Williams, J. Haltiner, Madrone Associates, and Bay Conservation and Development Commission. 1982. Guidelines for Enhancement and Restoration of Diked Historic baylands. Technical Report, Bay Conservation and Development Commission, San Francisco. 38 pp.

Henkel and Neuman Ecological Consulting (HNEC). 2000. Bird Use of Martin Luther King Jr. Regional Shoreline Wetlands Project, 1998-1999 Monitoring Report. November.

Lenington Ecological Services (LES). 1999. Monitoring and Maintenance Report Year 1, MLK Jr. Regional Shoreline Wetlands Project, Alameda, California. December 16.

Leventhal, R.D., Lenington, K.A., and J.N. Collins. The Importance and Methodology of Tidal Reckoning for Tidal Restoration. Unpublished Manuscript.

Levine-Fricke LFR. 1999a. Six-Month Monitoring Report, Martin Luther King Jr. Regional Shoreline Wetlands Project. April 16.

Levine-Fricke LFR. 1999b. Monitoring and Maintenance Plan, Martin Luther King Jr. Regional Shoreline Wetlands Project. March 25.

Levine-Fricke-Recon. 1996. Revised Preliminary Design Report, Port of Oakland’s Arrowhead Wetland Restoration Project. August 26.

Wetlands and Water Resources. 2001. Monitoring Report, Fall 1999 to Fall 2000, Project Year 2, Martin Luther King Jr. Regional Shoreline Wetlands Project. Prepared for the East Bay Regional Park District, Oakland, CA. April 17.

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