2005 - 2006, Project Year 8 Monitoring Report
Martin Luther King, Jr. Regional Shoreline
Wetlands Project
Oakland, California

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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 (divided further into “lower” and “higher” marsh with about 0.5ft difference in constructed elevation), seasonal ponds, and uplands. These elements are shown in Figure 2. Figure 3 shows monitoring locations used during most or all of the project monitoring. A complete site description is presented in the Six-Month Monitoring Report (LFR 1999b).

Report purpose and organization. The purpose of this report is to summarize monitoring results from Project Year 8 (from Fall 2005 through Fall 2006), to evaluate project performance relative to criteria contained in the Consent Decrees, and to identify the lessons learned from the project. This report is organized into the following sections:

- Aerial photography (Section 2)
- Hydrology and geomorphology (Section 3)
- Ecology (Section 4)
- Maintenance (Section 5)
- Project performance (Section 6)
- Major lessons learned (Section 7)
- Appendices incorporating vegetation lists (Appendix A), avian monitoring analysis (Appendix B), and Golden Gate Audubon Society avian monitoring volunteers list (Appendix C).

This report does not repeat all the detailed monitoring data collected over the initial five-year period (1999-2003); refer to individual monitoring reports listed below for the complete data set.

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

1. **Revised Preliminary Design Report** presents the project design which formed the basis for conditions to be monitored (LFR 1996).
2. **Monitoring and Maintenance Plan** (the “MMP”) presents the Project objectives, performance criteria, and monitoring protocols developed to assess Project progress (LFR 1999a).
3. **Six-Month Monitoring Report** presents the results of the first six months of monitoring, encompassing the period from introduction of tidal action through February 1999 (LFR 1999b). This report includes results from data collected on sediment accretion; tidal hydrology; channel morphology; seasonal pond depth and acreage; seasonal pond morphology; and bird use of the site.

4. **Year 1 (1998-1999) Monitoring Report** presents the first year's monitoring period of the Project Site (LES 1999). This report includes data collected on the vegetation colonization of 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.
5. **Year 1 (1998-1999) Bird Use Report** presents results of bird monitoring conducted by the Golden Gate Audubon Society from October 1998 to April 1999 (HNEC 2000).
6. **Year 2 (1999-2000) Monitoring Report** presents the second year's monitoring period of the Project Site (WWR 2001). This report includes results from the continued monitoring of sediment accretion; tidal hydrology; channel morphology; seasonal pond depth and acreage; vegetation dynamics; and bird use.
7. **Year 2 (1999-2000) Bird Use Report** presents the results of bird monitoring conducted by the Golden Gate Audubon Society from August 1999 to April 2000 (HNEC 2001).
8. **Macroinvertebrate Study Year 2000** (Jones and Stokes 2000) presents results of benthic macroinvertebrate population monitoring performed by Jones and Stokes in May 2000.
9. **Year 3 (2000-2001) Monitoring Report presents results of the third monitoring year (WWR 2002a).** This report includes results from the continued monitoring of sediment accretion; tidal hydrology; channel morphology; seasonal pond depth and acreage; vegetation dynamics; and bird use.
9. **Year 3 (2000-2001) Bird Use Report** presents the results of bird monitoring conducted by the Golden Gate Audubon Society from August 2000 to April 2001 (HNEC 2002).
10. **Vegetation Monitoring Results** (Bishop O'Dowd High School 2001) present vegetation species and percent cover data collected by the Environmental Studies class at Bishop O'Dowd High School in April 2001.
11. **Year 4 (2001-2002) Monitoring Report presents results of the fourth monitoring year (WWR 2002b).** This report includes results from the continued monitoring of sediment accretion; tidal hydrology; channel morphology; seasonal pond depth and acreage; vegetation dynamics; and bird use.
12. **Year 4 (2001-2002) Bird Use Report** presents the results of bird monitoring conducted by the Golden Gate Audubon Society from August 2001 to April 2002 (HNEC 2003).
13. **Year 5 (2002-2003) Monitoring Report presents results of the fifth monitoring year (WWR 2003).** This report includes results from the continued monitoring of sediment accretion; tidal hydrology; channel morphology; seasonal pond depth and acreage; vegetation dynamics; and bird use.
14. **Year 5 (2002-2003) Bird Use Report** presents the results of bird monitoring conducted by the Golden Gate Audubon Society from August 2002 to April 2003 (HNEC 2003).

15. **5-Year Summary Report (2004)** presents a summary of monitoring results and lessons learned during the period from 1998 – 2003 (WWR 2004).

Monitoring Entities

- **EBRPD** directed monitoring, performed maintenance, and executed contracts for monitoring through Project Year 5.
- **Port of Oakland** reviewed monitoring results and provided the underlying fiscal basis under the Consent Decree.
- **Golden Gate Audubon Society** monitored bird use throughout the monitoring period, reviewed monitoring results, and obtained a generous grant from The San Francisco Foundation's Bay Fund program to fund the Project Year 8 monitoring and reporting.
- **Lenington Ecological Services** conducted project monitoring (except birds) and reporting from Year ½ to 1.
- **Levine-Fricke-Recon** monitored from construction to Year ½ and prepared the project design and monitoring plan.
- **Wetlands and Water Resources** conducted project monitoring (except birds) and reporting for Years 2-5 and Year 8.
- **Henkel and Neuman Ecological Consulting** analyzed and reported on bird use data throughout the monitoring period, including this Year 8 report.
- **Save San Francisco Bay Association** in collaboration with EBRPD developed and implemented community-based restoration activities beginning in Year 2.

2.0 Aerial Photography

A series of five aerial photographs document the site since site restoration. The date, the figure number in this report, and the photo image scale are presented below:

Photo Date	Figure Number	Scale
9/25/2000	Figure 4	1:6,000
7/24/2001	Figure 5	1:12,000
8/22/2002	Figure 6	1:6,000
8/29/2003	Figure 7	1:9,600
9/12/2006	Figure 8	1:9,600

These photos were obtained and shared by two entities to support their respective efforts – MLK monitoring (photos 2, 4) and the Invasive Spartina Project (photos 1, 3, 5). Data sharing in this manner conserves scarce monitoring dollars but differences in image scale and rectification complicate inter-annual comparisons.

3.0 Hydrology and Geomorphology

The monitoring plan (LFR 1999a) included seven hydrogeomorphic monitoring activities (Table 1). This section discusses six of these seven monitoring activities (the seventh is the aerial photography described in Section 2.0) and is organized in the following manner:

- Section 3.1, Channel network
- Section 3.2, Tidal inundation
- Section 3.3, Sediment accretion
- Section 3.4, Channel velocity, turbidity, and water quality
- Section 3.5, Seasonal pond depth and acreage

3.1 Channel Network

The constructed network of channels at the site serves a critical function by transporting the tides into and out of the site. The channels therefore serve both ecological and hydrogeomorphic functions. The design of the tidal channel network intended to provide full, unimpeded tidal exchange at project outset. 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 MMP (LFR 1999a).

3.1.1 Cross Sectional Morphology

Methods. To assess changes in channel cross section morphology, the MMP calls for annual topographic surveys at established cross sections. Five cross sections were established at the site: two at first-order channels, two at second order channels, and one at a third-order channel (just inside the breach). During annual field surveys, each cross section was surveyed into the permanent benchmark provided by the Port of Oakland near the breach at the north end of the site; the Port of Oakland provided these benchmarks and data. Details of prior cross sectional morphology methods can be found in prior monitoring reports.

Year-8 field cross section surveys were performed on 25 January 2006 (optical level) and 14 June 2006 (total station). For both surveys, a transect tape measured horizontal distance along cross section. Prior survey dates include: June 4, 2003; July 12 and August 24, 2001; September 27, 2000 and January 3, 2001. During the first year of monitoring (1998-1999) Levine-Fricke-Recon and Lenington Ecological Services conducted surveys on July 18, 1998 and January 23 and 29, 1999.

Results and Discussion. Figure 3 shows the cross section locations. Figure 9 shows the two first-order channel cross sections, Figure 10 shows the two second-order channel cross sections, and Figure 11 shows the single third-order cross section. These figures plot all cross section survey data collected during the prior monitoring years.

All cross sections plot data 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. All cross sections plot data with matching horizontal and vertical scales so that relative channel sizes are visually evident between cross sections.

In general, the topographic data for all five monitored channels did not indicate substantial change in channel size, morphology, or position within the past eight years. Three of the five channels experienced slight sediment accretion of approximately 0.3 feet (XS-1W, XS-1E, and XS-2W; see Figures 9 and 10). Two of the channels experienced minor scouring (XS-2E and XS-3; see Figures 10 and 11). XS-2E scoured at the thalweg approximately 0.10 ft, while XS-3 experienced 1.0 foot of scouring, with approximately 0.50 ft occurring between 2003 and 2006.

The relatively minor changes observed in channel morphology over the first five years suggest the channel network was either: (1) constructed at an appropriate size for the tidal prism at the site, or (2) if undersized at construction, it did not enlarge because flows were not substantial enough to erode the hard channel substrate during the first five years. The increased scour observed at XS-3 between 2003-2006 suggests that either: (1) changes may be occurring at slow rates not readily detectable over shorter time frames by survey methods employed, or (2) the initially resistant hard substrate is becoming more susceptible to erosion. The tidal exchange data presented below in Section 3.2 indicate unimpeded tidal exchange, suggesting that the channels were appropriately sized at the outset.

3.1.2 Planform Morphology

Methods. Lateral migration of a channel occurs by bank erosion and accretion. Monitoring channel planform migration can occur through field topographic cross section surveys as described in Section 3.1.1 and through rectified time series aerial photography described in Section 2.0.

Results via cross sections. All five cross sections exhibited little if any lateral migration (Figures 9, 10 and 11). XS-3 shows a slight widening of the channel, on the order of a few feet, with channel top widths roughly 27 feet.

Results via aerial photography. There is no air photograph taken shortly after construction, so we elected to use a digitized and rectified version of the restoration design drawing from LFR (1999a) (Figure 2); this baseline is an approximate representation of as-built conditions. Comparing this baseline channel network configuration to the 2003 photograph (Figure 12), from a qualitative perspective the channels were constructed as designed and have remained stable with minimal lateral movement and head ward expansion or retreat. The channel cross sections shown in Figures 9 through 11 confirm this observation.

Field observations indicate that small channels are beginning to form in several places on the marsh plain. These channels are small, generally less than 0.3 m (1 ft) wide. These channels appear to drain partially 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.

3.1.3 Lessons Learned

Lessons learned on monitoring methods. Prior to initiating monitoring activities, horizontal and vertical control need to be established, documented, and effectively monumented in the field so that all cross section surveys over time are repeated precisely and therefore can be overlaid quantitatively.

Lessons learned on channel network design. The MLK design was based on the as-built tidal prism and, based on the data presented here and that in the next section on tidal inundation, indicate that they were appropriately sized at construction.

3.2 Tidal Hydrology

With any restoration project, tidal inundation 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. Tides in the San Francisco Estuary are mixed semidiurnal, or twice-daily tides of unequal height with a meso-tidal range of roughly 6 ft (2 m) at the Golden Gate amplifying to roughly 9 ft (3 m) in the South Bay; spring tidal range at the nearby Alameda NOS station is amplified 0.75 ft (0.23 m).

The MLK site has two separate tidal wetland types – tidal marsh and intertidal pond. All wetlands are defined in large part by their hydroperiod – the frequency, duration, and depth of inundation, (Mitsch and Gosselink 2000). Their hydroperiod in turn depends on water source(s), flow characteristics, and wetland geomorphology including distributary channels. Tidal marsh hydrology consists of high frequency, short duration, generally shallow events and exposed marsh plain between high tides (i.e., twice daily wetting and exposure). Intertidal pond hydrology, in contrast, consists of low frequency, long duration, shallow events (i.e., generally wet) overlaid by high frequency, short duration, shallow high tides (i.e., daily fluctuating shallow depths), with no exposed pond bottom. Low water pond depth at ebb tide is set by pond berm elevations, approximately at 5.6 ft Port Datum.

3.2.1 Methods

We monitored tidal inundation at two locations with data logging pressure transducers: (1) near the head ward reach of the eastern first-order channel, at cross section 1E, and (2) within the intertidal pond. Monitoring took place five times: January 2001 (Figure 13), July-August 2001 (Figure 14), June-July 2003 (Figure 15), January-March 2006 (Figure 16), and June-July 2006 (Figure 17). We also downloaded tides for the nearby National Ocean Service continuous recording station in Alameda (NOS Station 941-4750) and plotted alongside site data for comparison. Details about tidal inundation monitoring methods and results can be found in the prior monitoring reports.

3.2.2 Results and Discussion

These monitoring data yield three outcomes. First, the height of high tides and the daily rise and fall of the tide “wave” within the site matched the Alameda reference tides closely within about 0.2 ft or less from 1998 – 2003, with similar though slightly greater variability observed in 2006, and a uniform lag time of about 1.5 hours, indicating unimpeded tidal exchange throughout the site. Second, the tide heights remained relatively constant between monitoring periods, indicating that unimpeded tidal exchange has occurred since initial monitoring in 2000 (and likely since restoration) and is functioning effectively and as designed. Third, the Intertidal Pond lower tide levels fluctuated up to 0.25 ft during some of the periods monitored, indicating that the amount of pond drainage varies over time with no pattern detectable in the data (Figures 13 to 17). EBRPD repaired a small breach in the pond berm in 2001 that had been open for roughly one year.

3.2.3 Lessons Learned

Tidal exchange has worked effectively and as designed at this project. The monitoring results indicate that the channel network geometry was properly sized. The monitoring itself yielded data effective for evaluating this performance criterion.

3.3 Sediment Accretion

Section 2.3 of the MMP (LFR 1999a) required annual sediment accretion monitoring during the 5-year monitoring period. Sediment accretion is a very important process for tidal wetlands in general and for Project success at this site. The project design incorporated marsh surface elevations lower than that of reference sites to facilitate accretion of natural sediments in order to provide a better substrate for salt marsh vegetation establishment.

The project design (LFR 1996) estimated sedimentation rates for the project site using nomographs developed by the San Francisco Estuary Institute (Collins 1994). The predicted sedimentation rate for high marsh areas was calculated to be 0.006 ft/yr or 0.002 m/yr. The predicted sedimentation rate for low-marsh areas was calculated to be 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. Details about these predictions can be found in prior monitoring reports.

3.3.1 Methods

Through monitoring year three (2001), monitoring relied upon fixed sediment pins measured annually to document sedimentation rates at the site. The data obtained through this method proved to be unreliable for a number of reasons: insensitivity of the method relative to the small quantities of sediment accumulation; human disturbance to the sediment pins and/or the immediately surrounding ground surface; and measurement of incorrect PVC marker due to lack of labeling when installed during project construction combined with very large numbers of PVC markers installed by a variety of entities for multiple purposes.

For the 2001-2002, 2002-2003, 2005-2006 monitoring periods, we used an alternative approach to estimate sediment accretion: utilizing data from channel topographic cross sections that covered 15-35 ft of marsh plain adjacent to the channels (see Figures 9 to 11). Vertical accuracy of each cross section is fairly high (±0.02 m) and depends largely upon the surveyor holding the rod carefully at the ground surface. However, since the cross section surveys did not have a stated intention to quantify sediment accretion, we cannot know for sure whether the exact path was reoccupied from year to year. This unknown introduces a between-year comparative uncertainty of perhaps ±0.03 m but potentially more. Therefore, we must limit our interpretation of quantitative results to a qualitative assessment. We have used the five cross sections in this report to provide estimates of tidal marsh accretion rates.

An additional coarse resolution sediment accretion monitoring method was adopted for 2005-2006. This approach involved measuring depth to resistance at numerous locations across the site as an indicator of sedimentation. This method is possible at the MLK due to the hard underlying substrate remnant from the site’s prior fill. Depth was measured with a ruler and position recorded using a GPS handheld instrument (Trimble GeoXT). Sampling locations were selected to provide a range low and high marsh. This method provides a simple alternative to more effective yet more costly approach of installing and measuring periodically Sediment Elevation Tables (SETs).

3.3.2 Results and Discussion

Sediment Pin Sedimentation Data. Table 2 presents the limited sediment pin data that we presume to be valid. Sedimentation rates in the seasonal wetlands (5 sediment pins) varied from -0.035 to 0.025 m/yr. Rates in the high tidal marsh (3 sediment pins) varied from 0.006 to 0.038 m/yr; these rates exceed the predicted 0.002 m/yr. No data are available for the low tidal marsh areas.

Cross Section Sedimentation Data. Table 3 shows the sediment accretion estimates derived from the topographic survey data. The sediment accretion estimates derived from the topographic survey data indicate accretion rates ranged from 0.01 to 0.04 m/yr and -0.01to 0.03 m/yr in low and high marsh, respectively, ±0.03 m/yr. To the extent that these rates are valid given the coarse nature of the field method, they suggest that where accretion is occurring, the rates reasonably reflect if not exceed predictions.

Depth to Resistance Data. Figure 18 present the sediment accretion as indicated by depth to resistance at the 30 locations sampled in June 2006. This coarse method was employed to determine the extent to which accretion varied across representative portions of the site. The results presented below summarize the low marsh and high marsh location sampling results.

2007 Depth to Resistance Measurements

	Depth (m)	**Depth (ft)**	**Marsh Zone**
Mean	0.10	0.31	High
	0.12	0.39	Low
Minimum	0.05	0.15	High
	0.06	0.20	Low
Maximum	0.21	0.70	High
	0.24	0.80	Low
Std. Dev.	0.04	0.14	High
	0.06	0.19	Low

At time of construction, depth to resistance was not measured therefore this method was not intended to provide an evaluation of accretion over time but rather to provide coarse levels comparison across the Site. Results indicate accretion does not vary dramatically spatially across the site and depths are greater, as expected, in the low marsh locations.

Conclusions. In spite of the limited results from the quantitative approach, qualitative field observations clearly show a thin layer of mud deposited over the constructed marsh plain surface, establishing that deposition is occurring throughout most if not all of the tidal portions at the MLK site. Given the low predicted rates, it is reasonable to conclude that accretion is meeting or exceeding the predictions.

3.4 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. These measurements are useful diagnostics if problems develop in tidal marsh physical evolution. Section 2.6 of the MMP (LFR 1999a) required velocity and turbidity monitoring in the five-year mandated monitoring period. Velocity and turbidity measurements were made during 1998-1999 (LFR 1999b), 1999-2000 (WWR 2001), and 2000-2001 (WWR 2002). Water quality indicators of pH, dissolved oxygen, conductivity, and redox potential can be helpful to evaluate marsh chemical and biological processes. The MMP did not require water quality monitoring; we performed this testing during 2000-2001 only when we had the instruments for separate EBRPD tidal marsh restoration monitoring at Oro Loma Marsh in Hayward (WWR 2002c).

Many of these parameters fluctuate based on a number of externally-driven cycles, such as tidal stage, range of tides each day, season, extent of sunlight, and so forth. The comprehensive testing of these parameters necessary to provide data for evaluating potential marsh evolution problems was beyond the scope of the monitoring program. Monitoring of these parameters ceased after the third monitoring year for two reasons: first, they showed no adverse conditions warranting any corrective action; and second, the monitoring intensity was too limited to provide any information about marsh. Full data are presented in the prior monitoring reports.

3.5 Seasonal Pond Depth and Acreage

The seasonal ponds constructed in the southern portion of the Site were designed primarily as habitat for shorebirds. The three ponds fill by rainfall captured by small drainage basins (Figure 3). To minimize water percolating into the soil and thereby draining the ponds, construction included covering the pond basins with Bay muds excavated from the Project Site. Section 2.4 of the MMP (LFR 1999a) requires monitoring pond depth and acreage.

3.5.1 Methods

Pond depth and acreage were monitored four times during the wet seasons of the first four monitoring years, and five times in 2003 and 2006. Pond depths were determined by reading water levels on staff gauges installed in the seasonal ponds. Pond acreages were determined by walking the pond perimeters with a handheld GPS unit that recorded position once every three seconds and calculating the area of the polygon. As the data set became large, we developed a stage-area relationship for each pond (Figure 19) and used it to estimate pond areas based upon depth readings only. The California Department of Water Resources Division of Flood Management (http://cdec.water.ca.gov) online database provided rainfall data. 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.

3.5.2 Results and Discussion

Table 4 presents the pond acreage and depth data and Table 5 presents the monthly rainfall totals for all prior monitoring years (California water years run from October 1 to the following September 30). The 37.46 inches of rainfall in the 2005-2006 was significantly greater (140 – 200%) than any of the prior monitoring years.

Based on field measurements and values predicted from the stage-area curve, all three seasonal ponds held water very well during each monitoring period. During the peak of each period's wet season, total pond acreage always exceeded the performance criterion of 4.5 acres with total acreage reaching up to almost 17 acres. Water levels exceeding the target range are beneficial because they translate into far larger surface area and, combined with the gradual pond slopes, provide a large area of desired water levels and longer pond persistence.

Maximum ponding extent in 2006 was 16.9 acres, 2 acres greater than prior measurements and indicative of the wettest year monitored.

4.0 Ecology

The underlying purpose of the tidal and seasonal wetland restoration at MLK is to provide ecological support functions for species that depend upon these systems for part or all of their life cycles. The Monitoring and Maintenance Plan (LFR 1999a) presents the criteria for evaluating whether this purpose is achieved and the biological monitoring activities to gather data for evaluating performance. Wetlands and Water Resources and its predecessor, Lenington Ecological Services, carried out all monitoring except for bird use; the Golden Gate Audubon Society (GGAS) monitors bird use and Henkel-Neuman Ecological Consulting analyzes these data. This section is organized in the following manner:

- Section 4.1, Vegetation

- Section 4.2, *Spartina foliosa* transplants
- Section 4.3, Weed invasion
- Section 4.4, Loafing island vegetation
- Section 4.5, Bird use

4.1 Vegetation

The restored tidal marsh portion of the site is expected to support three habitat zones typical of San Francisco Bay marshes, including a narrow upper zone of peripheral halophytes at the site edge, a middle zone of perennial pickleweed (*Salicornia virginica*), and a lower zone of Pacific 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. The restored seasonal wetlands and ponds portion of the site is expected to support vegetation cover of less than 20 percent in the pond bottoms and at least 80 percent across two-thirds of the area and between 20 and 80 percent on the remaining one-third. Additionally, no large patches of invasive species should be present.

4.1.1 Methods

Vegetation was monitored through a combination of transect sampling and aerial photography. Details about the monitoring methods can be found in prior monitoring reports. In summary, in the tidal marsh we established five permanent transects once enough vegetation had established and in the seasonal ponds and wetlands we established six permanent transects, two per pond for the three ponds, extending from the pond center outward to the drainage divides between each pond. Along these transects we measured species composition, cover, and height once annually, in the summer for tidal marsh and in spring for the seasonal wetlands. Additionally for the tidal marsh, we obtained a new aerial photograph each year and used image analysis software to develop a vegetation map which we field-checked to produce a final map for each year.

4.1.2 Results and Discussion - Tidal Marsh

Annual tidal marsh vegetation transect surveys were conducted for the current monitoring period on 18 September 2006. Table 6 presents the vegetation transect data. Appendix A provides a list of species occurring along the tidal transects. A total of twelve species were identified along all transects. The dominant species along each transect represent those typical of a tidal salt marsh in the San Francisco Bay. Specifically, perennial pickleweed (*Sarcocornia pacifica*, formerly *Salicornia virginica*), salt grass (*Distichlis spicata*), marsh gumplant (*Grindelia stricta*), fleshy jaumea (*Jaumea carnosa*), and alkali heath (*Frankenia salina*). The annual pickleweed (*Salicornia europaea*) was also present at the site. No effort was made to try and distinguish between the native *Spartina foliosa*, the non-native *S. alterniflora*, and the hybridized *Spartina*. This decision was based on the advise of the ISP due to the difficultly of positive identification of these three species in the field and because ISP conducted sampling for laboratory analyses as part of their regional monitoring. The Invasive Spartina Project and EBRPD are actively managing the non-native *Spartina* species at the site with herbicide spraying.

The 2006 transect sampling results in Table 6 present the species, percent cover, and average height for the low and high tidal marsh. The field transect data support the conclusion that the site has met and exceeded its five-year performance criteria of 50% vegetation cover, though this includes the undesirable invasive *Spartina* (Figure 20, 21). Although several of the species recorded for the transects are not target species, i.e. mustard (*Hirschfeldia incana*), plantago (*Plantago coronopsis*), and the annual grasses, these represented minor components of the transects where they were found. Most notable change since the last monitoring in 2004 is that the annual pickleweed (*Salicornia europaea*) is no longer the dominant plant species at the site. For all transects except for V1 the perennial pickleweed species (*Salicornia virginica*) had higher percent cover across the whole transect (Figure 21).

Below are some basic patterns of vegetation colonization at the site as evidenced by the field data (Tables 6, 7, 8, 9, Figure 21), the vegetation maps (Figure 20), and the data summarized from the vegetation maps:

- The dominant plant species at the site is the hybridized *Spartina*.

- Perennial pickleweed (*Sarcocornia pacifica*) is now more common than annual pickleweed *(Salicornia europaea)*.

- There is greater vegetation colonization near to the tidal source (the north end of the site) than there is farthest from the tidal source.

- Vegetation now dominates the site overall, though bare ground still dominates at the southern end of the site farthest from the tidal source. During 2006, vegetation cover continued to increase along the five field transects ranged 75-94%, up from 26-95% in 2003, 11-74% in 2002, 2-53% in 2001, and 2-34% in 2000 (see Figure 21).

- 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. Save the Bay conducted extensive plantings in these areas (see Appendix C for more details).

- The bare ground areas are often covered with algae mats and/or standing water at low tide.

Invasive *Spartina* expansion. The most significant vegetation concern is colonization by smooth cordgrass, *Spartina alterniflora* and its hybrids with the native cordgrass. At the conclusion of the Consent Decree-mandated five-year monitoring period, *S. alterniflora* invasion had occurred yet had not progressed to more than perhaps 5% cover. In 2004, six years after construction and one year after monitoring ceased, *S. alterniflora* cover increased significantly, coarse visual estimates at the end of summer 2004 and ISP monitoring maps estimate invasive coverage at 30-60% (ISP 2004). 2006 surveys indicate *Spartina* spp. as the dominant vegetation (29% cover overall) in the both the low (35%) and high (25%) marsh. The site is included as one of the target sites for the regional Invasive Spartina Project, which characterize the site as highly infested due to the heavy predominance of hybrids. MLK is subject to on-going control efforts include herbicide application. This significant shift in conditions following monitoring completion indicates that a five-year monitoring period does not yield a "final" outcome view. A lower frequency, longer duration monitoring program may provide a more meaningful view of project outcome.

Shift in relative dominance from Annual to Perennial Pickleweed. At the conclusion of the 5-year mandated monitoring period in 2003, annual pickleweed (*Salicornia europaea*), a native yet comparatively uncommon species, was the dominant species. Between 2003 and 2006, there was a shift in the relative abundance of perennial pickleweed (*Sarcocornia pacifica*) over annual pickleweed. Perennial pickleweed is increasing in cover in the high marsh where it is primarily expected. A similar shift in dominance was observed at other restoration projects (e.g., Muzzi Marsh, built in 1976 in Marin County) had the annual species grow initially, replaced gradually by the perennial species (Phyllis Faber, pers. comm. 2003). Annual pickleweed is believed to help solidify the substrate in rapidly accreting sites or in locations of standing water, creating conditions favorable for cordgrass or perennial pickleweed to achieve dominance (PWA and Faber 2004).

4.1.3 Results and Discussion – Seasonal Wetlands and Ponds

Annual vegetation surveys of the seasonal wetlands were conducted for the current monitoring period on 5 May 2006. Table 8 presents the vegetation transect data for the seasonal ponds, Table 9 summarizes vegetation percent cover outside the ponds, and Appendix A presents a complete list of vegetation species observed at the site. Due to heavy rains, pond levels were especially high this year and the length of the transect under water was longer than any previous monitoring year. Elevated pond levels potentially contributed to the decrease in percent of bare ground in the vegetated portion in all transects, except T3-2, from previous years. A decrease in bare ground could occur with elevated pond levels because larger patches of bare ground tend to occur in the transition zone, characterized by wetland vegetation, ringing each pond. The decrease in bare ground may be attributable to an overall increase vegetation surrounding the ponds.

The transition zone ringing the pond characterized by wetland vegetation had more native species occurring, specifically, *Sarcocornia pacifica, Bolboschoenus maritimus* (formerly *Scirpus maritimus*), *Juncus bufonus, Limosella acaulis, Typha angustifolia,* and *Frankenia salina* than the surrounding upland dominated vegetation zone. Dominant non-native species in this zone were *Cotula coronopifolia, Lythrum hyssopifolium,* and *Plantago coronopus.*

The upper zone surrounding the ponds is dominated by non-native herbaceous and grass species typical of disturbed upland habitat, specifically *Bromus hordeaceus, Carduus pycnocephals, Geranium dissectum, Hordeum marinum* ssp. *gussonianum, Lolium multiflorum, Lotus corniculatus, Melilotus indica, Picris echioides, Plantago coronopus, Plantago lanceolata, Vicia sativa* ssp. *nigra,* and *Vulpia myuros*. The only native species occurring within this zone were *Hordeum brachyantherum* and *Juncus bufonus*. For all recorded species only *Limosella acaulis*, a native species, had not been previously recorded in the seasonal wetland pond transects.

4.3 Weed Invasions (other than Spartina)

Excluding invasive *Spartina*, weed invasion within the tidal marsh area is largely restricted to marsh upland edges and appears minimal. None of the invasive vegetation targeted for removal: peppergrass (*Lepidium latifolium*), pampas grass (*Cortaderia selloana*), French broom (*Genista monspessulana*), star thistle (*Centaurea solstitialis*), or smooth Cordgrass (*Spartina alterniflora*) were detected in the seasonal wetland/pond transects. None of these species was present in dense patches and these species were largely restricted to the southern end of the site near the fence line. EBRPD staff managed invasive vegetation, with some assistance from volunteers. Most of the work was done by hand.

4.4 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, which is consistent with the project goal of maintaining an unobstructed view for resting shorebirds on these islands. Perennial pickleweed (*Sarcocornia pacifica*) and annual pickleweed *(Salicornia europaea)* appear on the edges of the islands. EBRPD has not performed any vegetation removal/maintenance on the loafing islands over the 8-year monitoring period. Island A shows slightly greater vegetation growth than Island B (see Figure 20).

4.5 Summary of 8-Year Waterbird Use

From October to April throughout the eight-year monitoring period (1998-2006), GGAS volunteers have monitored waterbird use at MLK and at two nearby reference sites (the Eastern and Western Reference Sites). Following each monitoring period, GGAS volunteers provided the updated database to Henkel-Neuman Ecological Services, which analyzed these data and prepared an appendix to each year's monitoring report. Their findings are presented in the paper *Waterbird Response to Tidal and Supratidal Wetland Restoration in San Francisco Bay*, presented in Appendix B of this report. The following material summarizes the findings.

The tidal and seasonal wetlands at the MLK restoration site has provided important additional wetland habitat for waterbirds in the San Leandro Bay area. For shorebirds, San Leandro Bay is a site of regional importance (Stenzel et al. 2002) and MLK has substantially augmented the available wetlands, particularly alternate high-tide habitat, in the region. Mean shorebird abundance at MLK (which supported more shorebirds than other study areas) was about 44 birds/ha, within the range of spring and fall densities for natural tidal wetlands in San Francisco Bay reported by Stenzel et al. (2002) and similar to densities reported at restored tidal wetlands in upper Newport Bay (Wilcox 1986). Achievement of densities comparable to natural and other restored wetlands indicates that the MLK tidal wetlands have functional similarity to established wetlands and are performing similarly to other restoration sites over a large time span.

In every year, the tidal wetlands supported many more shorebirds than any other portion of the study site, even as it became more vegetated over the eight-year monitoring period (Section 4.1 above). The marsh plain supported the most shorebirds and the intertidal pond supported the second greatest number of shorebirds. However, the marsh plain is significantly larger than any other habitat feature and the difference in size relative to other sub-areas may account for the differences in shorebird abundance. Shorebird abundance at the Seasonal Ponds increased over the course of this study, possibly due to generally greater pond depths that provide a greater linear area for foraging or safe loafing.

Within the MLK restoration site, species diversity increased slightly over the eight-year study period. Of 22 common shorebird species recorded in San Francisco Bay-wide surveys, all but two (spotted sandpiper *Actitis macularia*, snowy plover *Charadrius alexandrinus*) were recorded at the Restoration Sites in this study.

Mean abundance of all birds showed moderate annual variability at all sites. Relative to the reference sites, abundance at the MLK tidal wetlands remained fairly constant; slight declines at the MLK tidal wetlands were also observed for both the reference sites. In contrast, abundance at the seasonal ponds increased relative to the reference sites. Seasonal abundance of waterfowl was similar to typical patterns in the San Francisco Bay region (Shuford et al. 1989, Accurso 1992), with annual peaks during mid-winter. At the reference sites, seasonal abundance of shorebirds peaked during April. Shorebird abundance at the MLK tidal wetlands peaked during September/October and again in April. Shorebirds were virtually absent at the seasonal ponds until winter rainfall commenced in December. As expected, at the seasonal ponds, annual variability in total bird abundance was significantly related to variability in total pond size. As pond acreage increased, shorebird abundance also increased, and a relatively high proportion of the variance (75%) in shorebird abundance was explained by pond acreage.

Seasonal abundance of shorebirds at the reference and MLK restoration site varied with species composition: at the tidal wetlands, small sandpipers of the genus *Calidris* were dominant, and abundance peaked during migration periods; at all other sites, larger shorebirds were dominant, and abundance peaked during winter and spring. As expected, shorebird abundance was lowest at all sites at low tide, indicating that shorebirds moved out of the study area at low tide to forage elsewhere in the region. All sites provided important high-tide roosting habitat for shorebirds. Within the restoration site, important high-tide roosting sites included Islands A and B, the intertidal pond, and the seasonal ponds. The channels received some use by shorebirds.

Seasonal abundance of waterfowl peaked at all sites during winter, a pattern which is similar to bay-wide patterns of waterfowl abundance. The Restoration and Reference Sites supported different waterfowl communities; most waterfowl at Restoration Sites were diving ducks (e.g., Scaup) but most waterfowl at Reference Sites were dabbling ducks (e.g., American Wigeon). Waterfowl use at the Seasonal Ponds was similar at all tidal stages, suggesting water fowl use was independent of the tides external to the site. In contrast, waterfowl used the Tidal Wetlands primarily during high and outgoing tides, probably because water levels during other tides were insufficient.

California Clapper Rails occurred in both reference sites throughout the study period and at the MLK tidal wetlands in the three final years of the study. At all sites, mean Clapper Rail abundance increased during the eight monitoring years. Maximum abundance from any one survey at each site was 11 at the eastern reference site (January 2004), 34 at the western reference site (January 2006), and four at the MLK tidal wetlands (December 2005 and January 2006). Maximum counts at the reference sites were during high tides; maxima at the MLK tidal wetlands were during low and outgoing tides suggesting the MLK tidal wetlands may be functioning as forage habitat.

Burrowing Owls were recorded in all monitoring years except 1998-1999, but were confirmed breeding only during spring/summer 2001. Destruction and occupation of the constructed burrowing owl nest chambers by ground squirrels may have inhibited the rate of burrow occupancy by nesting owls.

Bird communities were compared among years and among sites using the Percent Similarity Index (PSI). Over time, bird communities at the MLK restoration site became more similar to the communities at the reference sites. Species composition within each of the four sites was similar among years. The PSI analysis revealed that as habitat evolved at MLK restoration site, species composition gradually became more similar to the restoration sites. At high tide, when birds were more abundant, bird communities were less similar between years at the restoration sites than at the reference sites. After five years, PSI values between the restoration sites and the reference sites were greater than average PSI values among years at the reference sites (a measure of natural variability). During the last two years of the study, PSI was greater than 80%, although a linear relationship between PSI and year explained only 36% of the variance in PSI. These comparisons provide evidence that the MLK restoration sites now support bird communities that are roughly similar to the reference sites. These comparisons, however, cannot state whether these communities derive equal function between restoration and reference sites.

See Appendix B for the complete bird monitoring analyses.

5.0 Maintenance

A summary of all EBRPD maintenance activities performed at the site during prior monitoring years is shown below.

Activity	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2005-2006
Fence repair			X	X	X	X
Intertidal pond levee repair				X		
Graffiti removal from fence posts	X					X
Invasive vegetation removal		X	X	X	X	X
Irrigation system repair/maintenance	X	X	X	X	X	X
Litter removal	X	X	X	X	X	X
Mosquito abatement consultation	X	X	X	X	X	X
Mowing in marsh/landscape areas	X		X	X	X	X
Native seed collection/propagation			X	X		X
Plant/shrub replacement		X	X	X	X	X
Shrub pruning	X			X	X	X
Soil replacement			X			X
Spartina alterniflora identification	X	X	X	X	X	X
Sprayed herbicide to kill weeds			X	X	X	X
Spread mulch around shrubs in landscaped areas			X	X	X	X

6.0 Project Performance

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 was required to meet within the five-year mandated monitoring period and the stressor indicators that were intended to identify problems early on that may hinder the ability of the project to meets its performance criteria for this Year 8 review.

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

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 1999a, pp.3-4).

Project performance on criterion 1-1. Vegetation colonization in the tidal marsh vegetation continues to progress evident by increased coverage in 2006, relative to 2003, 2002, 2001 and 2000 (Table 8). The primary constraint on meeting this performance criterion is the predominance of the invasive smooth cordgrass and hybrids, as they are not considered optimal. The prevalence of *Spartina* hybrids preclude the Project from continuing to meet this performance criterion and, until the efficacy of regional control measures are established, little if any further progress can be expected.

Stressor indicator 1-1. Alkali bulrush (*Bolboschoenus maritimus*) should not be present in large continuous patches (LFR 1999a, 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. Percent cover increased from 5% in 2000 to 25% in 2002 within this small area (less then 6m of transect length), with no increase observed since then. No *Bolboschoenus maritimus* has been observed elsewhere in the tidal portion of the site.

6.2 Ecological Objective 2: Support Waterfowl and Shorebirds

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.

Project performance on criterion 2-1. Comparable numbers and species of shorebirds were found on the “loafing peninsula” in the eastern reference site and the restoration sites. Therefore, performance criterion 2-1 continues to be met.

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

Project performance on criterion 2-2. Shorebird species richness and abundance in the restored tidal marsh are comparable to reference sites. In recent monitoring years, waterfowl species richness and abundance in the tidal marsh was somewhat lower than that of the reference sites. This difference is due to the fact that the restoration site supports a greater percent of diving ducks whereas the reference sites support mainly dabbling ducks. In the seasonal ponds, shorebird and waterfowl species richness and abundance were comparable to both reference sites.

6.3 Ecological Objective 3: Support Intertidal Plant Communities

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

Project performance on criterion 3-1. At the conclusion of the 5-year monitoring period, the high tidal marsh vegetation cover was progressing appropriately, with the desired species and the criterion was achieved. The 2003 vegetation surveys (Figure 21) indicates total high marsh cover at 58% overall. The 2006 vegetation map (Figure 20, 21) indicates total high marsh cover at 60% overall. However, the invasive *Spartina* dominates high marsh cover (Table 7). Therefore, although the coverage target is achieved, the performance criterion is not due to the dominance of the undesirable invasive *Spartina*.

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 native cordgrass (*Spartina foliosa*) (LFR 1999a, p.9).

Project performance on criterion 3-2. At the conclusion of the 5-year monitoring period, the low tidal marsh vegetation cover was progressing appropriately. However, the 2006 surveys indicate the primary constraint on meeting this progress is establishment of the invasive *Spartina* hybrids. The 2006 vegetation map (Figure 20) indicates total low marsh coverage at 69% overall, up from 47% in 2003, 43% in 2002 and 39% in 2001 (Figure 21). However, as observed in the high marsh, this increase in cover is in part due to the increase in *Spartina* hybrids thus the project no longer achieves this performance criterion.

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 1999a, p.9).

Project performance on criterion 3-3. Though accurate sedimentation data are limited it appears that low marsh has already accreted to 5.75 ft Port Datum or above (*e.g.*, Figure 18). The depth to resistance measured at the 30 locations sampled in June 2006 presented in Figure 18 indicate the average accretion in the low marsh (0.39 ft, 0.12 m), thus achieved this criterion.

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 1999a, p.9).

Field evidence of stressor indicator 3-1. Between 2003 and 2006, invasive *Spartina* hybrids expanded significantly and are the dominant species in the tidal marsh. Percent bare ground is rapidly diminishing (see Figure 21). Other than *Spartina*, no large patches of exotic, invasive species have established.

6.4 Ecological Objective 4: Support Seasonal Ponds and Seasonal Vegetated Wetlands

Performance criterion 4-1: Seasonal ponds 1 and 2 (see Figure 3) should develop a vegetation cover during the wet season (December through April) of less than 20 percent cover and consisting of annual species (LFR 1999a, p.12).

Project performance on criterion 4-1. Both seasonal ponds met this criterion (Table 4). In addition, Pond 3 also met this criterion though it is not required to do so under the MMP (LFR 1999a).

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 1999a, pp.12-13).

Project performance on criterion 4-2. All three seasonal ponds are meeting this performance criterion. See Table 4.

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

Project performance on criterion 4-3. The ponds are meeting this criterion as over 4.5 acres of water remains in the ponds at least into, and sometimes well beyond, the April requirement. See Table 4. Minimal April pond area measured was 9.0 acres and peak annual pond extent ranged from 9.5 to 16.9 acres.

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

Project performance on 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 1999a, p.13).

Project performance on 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 1999a, p.13).

Project performance on criterion 4-6. Vegetations surveys for 2006 indicate a general increase in seasonal pond vegetative cover relative to 2003 and 2002 (Tables 9 and 10). Monitoring methods prescribed in the MMP plus budget limitations did not provide extensive quantitative data to confirm this criterion, but the vegetation transects (Table 9) indicate the criterion will be met. Percent of bare ground along the vegetated portion of the transects was less than 20% for all transects except for T3-2 thus meeting the performance criterion although, due to elevated pond levels, the length of the vegetated portion of the transects was lower than in previous monitoring years. EBRPD does implement mowing and other management in these areas during the dry months.

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

Project performance on criterion 4-7. Insufficient monitoring resources are available to gather data for assessment of vegetation acreage. Transect surveys indicate that, as of 2006, there is an average of 91% vegetative cover between the six transects in the seasonal wetlands.

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 A). None of the invasive vegetation targeted for removal: peppergrass (*Lepidium latifolium*), pampas grass (*Cortaderia selloana*), French broom (*Genista monspessulana*), star thistle (*Centaurea solstitialis*), or smooth Cordgrass (*Spartina alterniflora*) were detected in the seasonal wetland/pond transects.

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

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 1999a, p.16).

Project performance on criterion 5-1. Total vegetation cover in 2006 was higher than 2003 and is in the range to meet this criterion (Tables 7 and 8).

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

Project performance on criterion 5-2. Shrub survival has not been quantified in any of the monitoring reports, but EBRPD inspects shrub health and replaces dead plants during routine maintenance of the site (Section 5.0).

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

The MMP (LFR 1999a) 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 1999a, p.17).

Project performance on criterion 6-1. Tidal inundation monitoring since 2000 indicates unrestricted tidal exchange (see Figures 13-17).

6.7 Maintenance Objective 1: Prevent Excessive Levee Erosion

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

Project performance on criterion 7-1. No significant levee erosion was observed at the site, based on walking the site perimeter and viewing aerial photographs.

6.8 Maintenance Objective 2: Maintain Plantings and Habitat Features

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

Project performance on criterion 8-1. EBRPD performed irrigation system repairs throughout the last 8 years (Section 5).

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

Field evidence of stressor indicator 8-1. EBRPD replaced dead or dying shrubs several times throughout the last 8 years (Section 5).

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

Field evidence of stressor indicator 8-2. Due to colonization by the invasive *S. alterniflora* and hybrids and legal restrictions on control measures during the monitoring period, native cordgrass transplants were not tracked nor replaced. The Invasive Spartina

Project and EBRPD are actively conducting control measures, including herbicide application.

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

Field evidence of stressor indicator 8-3. EBRPD pruned shrubs throughout the last 8 years.

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 1999a, 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. Controlling invasive Spartina and yellow star thistle was a main focus of weed removal activities (Section 5).

6.9 Maintenance Objective 3: Routine Park Operation

EBRPD staff maintained park amenities as needed. During the monitoring period, EBRPD removed litter from the marsh, removed invasive vegetation, planted native vegetation, mowed, watered and mulched around shrubs, replaced dead shrubs, maintained the irrigation system for the shrubs, and repaired damaged fence.

6.10 Maintenance Objective 4: Control Mosquito Breeding

EBRPD provides full access to the Alameda County Mosquito Abatement District for mosquito monitoring and control.

6.11 Maintenance Objective 5: Control Predators on California Clapper Rail

EBRPD has had no occurrences of red fox and thus has not had to implement any predator control efforts for that species. Park staff carry out ongoing control of cats and dogs at the site as part of routine park operations.

7.0 Major Lessons Learned

This section summarizes the major lessons learned from eight years of monitoring at the Martin Luther King Jr. Regional Shoreline Wetland Restoration Project. Prior sections presented other, less major lessons learned. These lessons fall into three categories: restoration design, monitoring, and possible upcoming adaptive management and maintenance activities.

7.1 Restoration Design

The first and foremost lesson learned regarding restoration design is that the design succeeded in creating the target systems as measured by the performance criteria.

Tidal Marsh. For the tidal marsh component of the project, the questions faced during restoration design included target land surface elevations, substrate, and channel network configuration.

- **Land surface elevations.** The design opted to construct "low" and "high" marsh, which differed in elevation by approximately 0.5 ft. Both of these areas have performed to expectation and are likely to continue meeting performance criteria, albeit with the caveat for the invasive smooth cordgrass. Vegetation colonization stratified far more on distance from tidal source than it did on this elevation difference. Elevation does, however, tie into the substrate question.

- **Substrate.** The MLK site was filled tidal wetlands and mudflats. The post-construction marsh surface consisted of very compacted, gravelly soils, which are quite different from the low bulk density, fine grained soils typically found in natural tidal marshes. The project envisioned natural sedimentation over time depositing a layer of low bulk density, fine grained soils atop this substrate and thereby providing a more naturalistic substrate for plant and benthic organism colonization. Sedimentation has occurred, though the rates are relatively slow (as expected) due to low suspended sediment concentrations in tidal waters at this location. The substrate, land surface elevations, and patterns of vegetation colonization together suggest that constructing the marsh entirely at the "low" marsh elevation would have been more beneficial to the long-term outcome by leading to a thicker surface layer of naturally deposited marsh soils. However, the "high" marsh has not to date caused any detectable impediment and thus a better conclusion will likely be evident several more years from now.

- **Channel network configuration and geometry.** The data show that the channel network as designed and constructed has provided full, unimpeded tidal circulation across the site. Of particular interest during project design was the size of the channel at its connection to San Leandro Bay. At the time of design, two empirical models were considered, both using hydraulic geometry relationships that relate channel size to tidal prism (volume of water at high tide). These models (Collins, 1991 and PWA, 1995) yield large differences in channel top width and moderate differences in channel depth. Design engineers primarily based their final design on the Collins model, modified with 2:1 side slopes to improve geotechnical stability and ease of construction.

Intertidal Pond. For the intertidal pond component of the project, the questions faced during restoration design included pond bottom elevation and pond berm size that together define the hydroperiod of the pond. Apparently not addressed in design were the side slopes of the pond and the extent of shallow water habitat at different tide stages; the pond was built with relatively steep sides (roughly 3:1 to 5:1). The pond has succeeded in retaining shallow water at low tide continuously, providing important habitats for birds and their prey items. The only problem with the pond was a break in the berm about six feet wide that allowed greater low-tide drainage than intended; EBRPD repaired this break. The lesson from the berm failure is to examine the details of design and construction to determine whether greater strength could have been achieved to prevent a break, such as through greater compaction, a wider berm, gentler berm slopes, or other forms of reinforcement. The berm was constructed with a geotextile strengthening material that was not sufficient to prevent berm breaching.

Seasonal Wetlands and Ponds. For the seasonal wetlands and ponds component of the project, the questions faced during restoration design included substrate permeability, drainage area, and avoidance of vegetation encroachment into the ponds. The design compacted the underlying soils and added and compacted bay mud soils excavated from the tidal marsh component of the project in order to maximize impermeability. These ponds have performed well beyond expectation in that they were consistently larger in size (peak total acreage each year ranged from 9.5 to 17 acres vs. criterion of 4.5 acres) and longer in duration (holding water into June or July each year vs. criterion of April) than required and should be considered a very positive example of how to provide non-tidal seasonal wetlands and ponds. Rainfall at the reference station (U.S. Forest Service Oakland South Station) during the 1999–2003 monitoring period varied from 18.5 to 27.1 inches; the 2006 rainfall amount (37 inches) was above average. The long-term (1888–2003) average annual rainfall at a nearby station in Berkeley is 24.19 inches. This 1999 – 2003 comparison suggests that the seasonal pond performance results observed are reflective of the longer-term conditions.

EBRPD manages vegetation in the seasonal wetlands to promote the target conditions; the site's setting within an actively maintained park allows for this level of ongoing management. The only concern with the ponds has been a small amount of alkali bulrush (*Bolboschoenus maritimus*) colonization, which results from the extended hydroperiod and the lack of ability to drain the ponds proactively (except with portable pumps). The bulrush, however, has been grazed by waterfowl, most likely Canada goose, which is keeping it under control.

Burrowing Owl Mounds. The constructed mounds and burrows were sporadically used by burrowing owls. This may be less indicative of poor design than it is of the owls' historical reluctance to use man-made burrows, even if the owls are "imprinted" on burrows (DiDonato, 2004, pers. comm.). This tendency was not helped by the destruction of some of the burrows by ground squirrels.

7.2 Monitoring

The monitoring approach itself has provided a number of lessons learned. The purpose of monitoring in projects like MLK is to gather the data necessary to determine whether the restoration is meeting prescribed performance criteria. Questions that arise when establishing a monitoring program include budget, indicators selected for monitoring, methods of gathering data for those indicators, and frequency and duration of monitoring. We have mentioned several lessons learned on the physical monitoring throughout Section 3.0; here we summarize these and other lessons.

- **Monitoring frequency and duration.** The initial monitoring program conducted annual monitoring of all parameters over the five-year period following reintroduction of tidal action and concluded after these five years. However, a single site visit in 2004, or year 6, indicated a significant change in vegetation conditions. The resumption of monitoring in 2006 (Year 8) confirmed the major expansion in percent cover of invasive *Spartina*. At the conclusion of the five-year monitoring period, invasive *Spartina* cover was on the order of 5%, whereas by 2006 cover increased to 30%. Project performance criteria relating to establishing habitats for the endangered California clapper rail hinge on the native cordgrass establishing effectively, which it has not. Had the monitoring program reduced the monitoring frequency and increased the duration while maintaining overall level of effort, these post-monitoring conditions would be more effectively documented, with more up to date information available for informing corrective measures.

- **Aerial photography** is a very useful tool used in this monitoring effort. To conserve monitoring funds, photos were shared between different programs, in this case the Invasive Spartina Project. The main issues that arose were differences in photograph scale between years complicating interannual quantitative comparisons, highly variable accuracy of image rectification that could have been resolved with placement of permanent ground control points around the site perimeter, and differing times of year stemming from sharing photos between monitoring programs. But given all the limitations, the results have proven to be very effective in tracking site evolution.

- **Horizontal and vertical control for topographic data** presented some problems. The horizontal control issue arose in large part from the very large amount of marker poles installed at the site by many entities for a variety of purposes and few if any of these poles being labeled. The vertical control issue arose from disturbance of secondary benchmarks and early data not being clear on how it addressed vertical control. Both issues are readily fixed by setting out well-marked control at monitoring outset.

- **Sediment accretion** was the single greatest challenge to measure and the methods applied all came up short. The site experiences relatively low sedimentation rates, which requires a sensitive method to quantify the rates accurately. The monitoring plan called for sediment pins, a simple and low-cost yet comparatively insensitive method that is not well suited to such conditions. We applied channel cross section topographic data, which provided some insight but was not intended for this purpose. The site also experienced relatively high public use for monitoring, maintenance, and education. This use had two effects: first, it may have inadvertently trampled monitoring locations thereby altering results; and second, it placed numerous marker poles across the marsh plain, none of which were labeled, leading to confusion with unlabeled monitoring markers. The former problem could have been resolved by creating exclusion areas and the latter problem could have been resolved with permanent labeling of marker poles. Finally, alternative methods may have been appropriate; the low-cost rough approach is to measure thickness of deposited sediment with a measuring stick which would work reasonably well with the hard underlying substrate. The high-cost precise approach is Sediment Elevation Tables, which can yield very high-resolution, accurate data but are very complex and comparatively costly to install and utilize.

- **Water quality** monitoring needs to have better defined purposes and a methodology consistent with meeting that purpose. The single annual data point for five locations provides marginal utility. At MLK, water quality sampling may have been most useful as a diagnostic tool for other problems such as widespread soil discoloration, poor vegetation establishment, etc. Alternatively, a more comprehensive water quality monitoring effort could have been implemented if a budget were available, to address temporal patterns on several time scales from tidal cycle to spring-neap tides to seasonal.

7.3 Adaptive Management and Maintenance

Adaptive management is a tool that provides feedback to site management activities based on monitoring data and the lessons those data provide. For example, if monitoring results indicated site progress on vegetation colonization was not going to meet performance criteria, a series of actions would ensue, first to determine the nature of the problem then to identify and implement solutions and finally to inform future restoration design efforts. In the maintenance context, adaptive management provides monitoring data to identify what maintenance items are necessary and it provides a means to determine whether an alternate approach could be used to minimize maintenance effort.

During the mandated five-year monitoring period, there were no significant adverse outcomes requiring application of adaptive management tools to resolve. Efforts during that period focused on a number of maintenance items, all anticipated. Weed removal has been required, shrub replacement has been necessary, and some facilities have required repair (fences, irrigation systems, etc.).

However, the most significant current adaptive management challenge is addressing the significant increase in invasive *Spartina* cover. ISP sampling at MLK indicates that MLK is heavily infested by *Spartina* hybrids. ISP is currently conducting analyses on their 2006 sampling data to assess the efficacy of the herbicide treatment control program. These results will assist in determining the most suitable adaptive management response to this on-going regional problem.

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Tables

Table 1
Schedule of Monitoring Activities, 1999 - 2003, 2006
Martin Luther King, Jr. Shoreline Regional Park Wetland Restoration

Monitoring Activities Completed in Fall 2005 to Fall 2006 Monitoring Period

		2005			2006										
Description		**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
1. Ecology															
A	Vegetation survey								5				18		
B	Plant community acreage														5
C	Weed invasion								5				18		
D	Loafing island vegetation														5
E	Birds (Audubon)[1]	four surveys per month during this period													
2. Hydrology and geomorphology															
A	Channel cross sections				25					14					
B	Sediment accretion										25				
C	Seasonal pond size				25		1,21		12		25				
D	Tidal circulation				25		1			14	25				
E	Velocity, turbidity and water quality			data not collected this monitoring year											
F	Channel meander			data not collected this monitoring year											
G	Air photo												12		

Monitoring Activities Completed in Fall 2002 to Fall 2003 Monitoring Period

		2002			2003										
Description		**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
1. Ecology															
A	Vegetation survey								14					5	
B	Plant community acreage													5	
C	Weed invasion								14					5	
D	Loafing island vegetation													5	
E	Birds (Audubon)[1]	four surveys per month during this period													
2. Hydrology and geomorphology															
A	Channel cross sections									4					
B	Sediment pins			data not collected this monitoring year											
C	Seasonal pond size			19	22		12		2	4					
D	Tidal circulation									6	29				
E	Velocity, turbidity and water quality			data not collected this monitoring year											
F	Channel meander											29			
G	Air photo											29			

Monitoring Activities Completed in Fall 2001 to Fall 2002 Monitoring Period

		2001			2002										
Description		**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
1. Ecology															
A	Vegetation survey							24							5
B	Plant community acreage											26			
C	Spartina transplants		not applicable this year												
D	Weed invasion							24							5
E	Loafing island vegetation														5
F	Birds (Audubon)[1]														
2. Hydrology and geomorphology															
A	Channel cross sections											1			
B	Sediment pins		not applicable this year												
C	Seasonal pond size			7		1	1	24							
D	Tidal circulation		not applicable this year												
E	Velocity, turbidity and water quality		not applicable this year												
F	Channel meander											26			
G	Air photo											26			

Table 1, continued
Schedule of Monitoring Activities, 1999 - 2003
Martin Luther King, Jr. Shoreline Regional Park Wetland Restoration

Monitoring Activities Completed in Fall 2000 to Fall 2001 Monitoring Period

		2000			2001								
Description		Oct	Nov[3]	Dec	Jan[3]	Feb[3]	Mar	Apr	May	Jun	Jul	Aug	Sep
1. Ecology													
A	Vegetation survey		2				22	26					6
B	Plant community acreage												6
C	Spartina transplants												6
D	Weed invasion		2					26					6
E	Loafing island vegetation												6
F	Birds (Audubon)	X	X	X	X	X	X	X					
2. Hydrology and geomorphology													
A	Channel cross sections				3						12	24	
B	Sediment pins											24	
C	Seasonal pond size				3	1	22	26			12		
D	Tidal circulation				3	1					12	24	
E	Velocity, turbidity and water quality											24	
F	Channel meander												
G	Air photo										24		

Monitoring Activities Completed in Fall 1999 to Fall 2000 Monitoring Period

		1999			2000								
Description		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1. Ecology													
A	Vegetation survey												X
B	Plant community acreage												X
C	Spartina transplants												X
D	Weed invasion												X
E	Loafing island vegetation												X
F	Birds (Audubon)												
2. Hydrology and geomorphology													
A	Channel cross sections												X
B	Sediment pins												X
C	Seasonal pond size[2]					X					X		
D	Tidal circulation												
E	Velocity and turbidity												X
F	Channel meander												X
G	Air photo												X

Notes:

1 Grey-shaded boxes denote data collected at multiple intervals during period indicated.
2 Seasonal pond area measurements by EBRPD.

Table 2
Sediment Accretion from Sediment Pins 1998-2001
MLK Jr. Regional Shoreline Wetlands Project
Oakland, California

Location	Sample Date	Time Since Baseline (yr)	Distance from Top of Pin to Ground Surface[1] (m)	Sediment Deposition, m — Calculated[2,3]		Deposition Rate, m/yr — From Calculated Deposition ±0.007		Comments
				Interval	Cumulative	Interval	Cumulative	
A. Sediment Pins Located at Edge of Seasonal Ponds (see locations in Figure 2)								
SP-1	7-Jan-99		Data Problem[4]					East Edge of Pond 1
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.800					
	24-Aug-01	0.81	0.798	0.002	0.002	0.002	0.002	
SP-2	7-Jan-99		Data Problem[4]					North Edge of Pond 1
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.850					
	24-Aug-01	0.81	0.854	-0.004	-0.004	-0.005	-0.005	
SP-3		--	--	--	--	--	--	** Pin Missing **
SP-4	7-Jan-99		Data Problem[4]					North Edge of Pond 2
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.900					
	24-Aug-01	0.81	0.928	-0.028	-0.028	-0.035	-0.035	
SP-5	7-Jan-99		Data Problem[4]					West Edge of Pond 3
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.800					
	24-Aug-01	0.81	0.780	0.020	0.020	0.025	0.025	
SP-6	7-Jan-99		Data Problem[4]					North Edge of Pond 3
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.690					
	24-Aug-01	0.81	0.686	0.004	0.004	0.005	0.005	
Statistics:								
1. **Mean**				**-0.001**	**-0.001**	**-0.001**	**-0.001**	
2. Median				0.002	0.002	0.002	0.002	
3. Maximum				0.020	0.020	0.025	0.025	
4. Minimum				-0.028	-0.028	-0.035	-0.035	
B. Sediment Pins Located within Tidal Marsh (see locations in Figure 2)								
Low Marsh								
SP-7	18-Jul-98		Data Problem[4]					
	7-Jan-99		Data Problem[4]					
	10-Oct-99		Data Problem[4]					
	2-Nov-00		Data Problem[5]					
	24-Aug-01		Data Problem[5]					
SP-9	18-Jul-98		Data Problem[4]					
	7-Jan-99		Data Problem[4]					
	10-Oct-99		Data Problem[4]					
	2-Nov-00		Data Problem[5]					
	24-Aug-01		Data Problem[5]					
Statistics:								
1. **Mean**				**n/a**	**n/a**	**n/a**	**n/a**	
2. Median				n/a	n/a	n/a	n/a	
3. Maximum				n/a	n/a	n/a	n/a	
4. Minimum				n/a	n/a	n/a	n/a	

Table 2
Sediment Accretion from Sediment Pins 1998-2001
MLK Jr. Regional Shoreline Wetlands Project
Oakland, California

Location	Sample Date	Time Since Baseline (yr)	Distance from Top of Pin to Ground Surface[1] (m)	Sediment Deposition, m — Calculated[2,3] Interval	Sediment Deposition, m — Calculated[2,3] Cumulative	Deposition Rate, m/yr — From Calculated Deposition ±0.007 Interval	Deposition Rate, m/yr — From Calculated Deposition ±0.007 Cumulative	Comments
High Marsh								
SP-8	18-Jul-98		Data Problem[4]					
	7-Jan-99		Data Problem[4]					
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.440					
	12-Aug-01	0.78	0.435	0.005	0.005	0.006	0.006	
SP-10	18-Jul-98		Data Problem[4]					
	7-Jan-99		Data Problem[4]					
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	bent					
	24-Aug-01	0.81	0.688					
SP-11	18-Jul-98		Data Problem[4]					
	7-Jan-99		Data Problem[4]					
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.910					
	24-Aug-01	0.81	0.890	0.020	0.020	0.025	0.025	
SP-12	18-Jul-98		Data Problem[4]					
	7-Jan-99		Data Problem[4]					
	10-Oct-99		Data Problem[4]					
	2-Nov-00	0.00	0.640					
	24-Aug-01	0.81	0.609	0.031	0.031	0.038	0.038	
Statistics:								
1. **Mean**				**0.019**	**0.014**	**0.023**	**0.023**	
2. Median				0.020	0.020	0.025	0.025	
3. Maximum				0.031	0.031	0.038	0.038	
4. Minimum				0.005	0.005	0.006	0.006	

Notes:
1. Uncertainty in measurement of sediment pin to ground surface distance is approximately ±0.005 m (0.5 cm); therefore, any chang less than this value must be considered no change
2. Calculated sediment deposition that denotes loss of sediment could be attributed to measurement error, not actual sediment los
3. Calculated sediment deposition is difference of sequential measurements of distance from top of sediment pins to ground surfac
4. Baseline and six-month data reported in the year-one monitoring report (LES 1999) did not match that reported in six-month monitorin report (LFR 1999b). Problems included unit conversion (meters-feet) errors and reported field measurements that computed unreasonabl results. Original field notes are not available to determine what values should be reported, so all suspect data from 1998 and 1999 have bee removed from this table
5. Sediment pin measurements at SP-7 and SP-9 for 2000 and 2001 showed unreasonably large amounts of erosion (approximately 0.5 n difference), which leads us to believe that during one of those two sampling events, we took measurements from other markers instead of th sediment pins installed by LFR. The sediment pins had no distinctive identification markings and were located amongst many simi unmarked PVC pipes in the area set out by other monitoring groups

Table 3
Tidal Marsh Sediment Accretion Estimates from Marsh Plain Topography, 2001-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Marsh Type[1]	Cross Section Location	Average Elevation[2] (m)				Port Datum (ft)				Elevation Difference (m)				Interval Sediment Accretion Rate (m/yr)[3]			Cummulative Sediment Accretion Rate[4] (m/yr)
		2001	2002	2003	2006	2001	2002	2003	2006	2001-02	2002-03	2003-06	2001-06	2001-02	2002-03	2003-06	2001-06
Low:																	
XS-1E	Left Bank	1.674	1.704	1.697	1.878	5.489	5.589	5.566	5.874	0.030	-0.007	0.181	0.204	0.029	-0.007	0.063	0.041
XS-1W	Right Bank	1.780	1.787	1.779	1.811	5.839	5.860	5.835	5.664	0.006	-0.008	0.032	0.030	0.006	-0.008	0.011	0.006
XS-2E	Left Bank	1.785	1.791	1.765	1.855	5.856	5.874	5.791	5.802	0.006	-0.026	0.089	0.069	0.005	-0.026	0.031	0.014
XS-2W	Left Bank	1.750	1.797	1.799	1.919	5.741	5.895	5.901	6.004	0.047	0.002	0.120	0.169	0.044	0.002	0.042	0.034
XS-2W	Right Bank	1.714	1.740	1.742	1.896	5.622	5.706	5.713	5.931	0.026	0.002	0.154	0.182	0.024	0.002	0.054	0.037
XS-3	Left Bank	1.717	1.739	1.721	1.830	5.632	5.703	5.645	5.724	0.022	-0.018	0.109	0.113	0.021	-0.018	0.038	0.023
Statistics:																	
	Mean:	1.737	1.760	1.751	1.865	5.697	5.771	5.742	5.833	0.023	-0.009	0.114	0.128	0.022	-0.009	0.040	0.026
	Minimum:	1.674	1.704	1.697	1.811	5.489	5.589	5.566	5.664	0.006	-0.026	0.032	0.030	0.005	-0.026	0.011	0.006
	Maximum:	1.785	1.797	1.799	1.919	5.856	5.895	5.901	6.004	0.047	0.002	0.181	0.204	0.044	0.002	0.063	0.041
	Standard Deviation:	0.043	0.038	0.038	0.041	0.142	0.123	0.124	0.128	0.016	0.011	0.052	0.069	0.015	0.011	0.018	0.014
High:																	
XS-1E	Right Bank	1.880	1.900	1.953	1.896	6.168	6.233	6.406	5.931	0.020	0.053	-0.057	0.016	0.019	0.053	-0.020	-0.012
XS-1W	Left Bank	1.913	1.920	1.926	2.010	6.274	6.296	6.318	6.286	0.007	0.007	0.083	0.097	0.007	0.001	0.029	0.017
XS-2E	Right Bank	1.880	1.875	1.846	1.985	6.168	6.151	6.056	6.208	-0.005	-0.029	0.138	0.104	-0.005	-0.006	0.048	0.028
XS-3	Right Bank	1.859	1.862	1.856	1.988	6.096	6.106	6.088	6.219	0.003	-0.005	0.132	0.130	0.003	-0.001	0.046	0.027
Statistics:																	
	Mean:	1.883	1.889	1.895	1.970	6.176	6.197	6.217	6.161	0.006	0.006	0.074	0.087	0.006	0.012	0.026	0.015
	Minimum:	1.859	1.862	1.846	1.896	6.096	6.106	6.056	5.931	-0.005	-0.029	-0.057	0.016	-0.005	-0.006	-0.020	-0.012
	Maximum:	1.913	1.920	1.953	2.010	6.274	6.296	6.406	6.286	0.020	0.053	0.138	0.130	0.019	0.053	0.048	0.028
	Standard Deviation:	0.022	0.026	0.052	0.050	0.073	0.085	0.172	0.157	0.010	0.034	0.091	0.049	0.010	0.028	0.032	0.018

Notes:
1. Marsh type (low or high) used to separate data for calculating respective accretion estimates.
2.Tidal marsh sediment accretion estimates are based on 2001, 2002, 2003 and 2006 channel cross section survey data.
3. Interval accrection rate measures from one year to the next.
4. Cumulative accretion rate measures from first measurement to most recent measurement.

Table 4
Seasonal Ponds Depths and Acreages 1998-2003, 2005-06
MLK Jr. Regional Shoreline Wetlands Project
Oakland, California

Date	Pond 1		Pond 2		Pond 3		Total Ponded Area (acres)
	Depth (ft)	Area (acres)	Depth (ft)	Area (acres)	Depth (ft)	Area (acres)	
2005-2006 Monitoring Year							
Water Year 2005-2006 Total Rainfall = 37.46 inches (see Table 5)							
25-Jan-06	2.50	6.8	3.28	5.7	1.91	1.4	13.90
1-Mar-06	2.54	6.8	3.25	5.6	1.88	1.4	13.8
21-Mar-06	2.90	8.3	3.65	7.2	1.9	1.4	16.90
12-May-06	2.75	7.9	3.33	5.9	1.5	1.1	14.90
26-Jul-06	1.17	2.6	1.38	0.3	n/a	Dry	2.90
2002-2003 Monitoring Year							
Water Year 2002-2003 Total Rainfall = 25.89 inches (see Table 5)							
19-Dec-02	2.05	6.20	2.63	5.04	1.62	1.40	12.63
22-Jan-03[4]	2.55	7.0	3.25	5.5	1.89	1.6	14.1
12-Mar-03	2.34	6.20	2.99	4.82	1.75	1.31	12.32
2-May-03	2.17	5.42	2.70	3.02	1.58	1.15	9.59
4-Jun-03	1.53	5.50	1.91	3.90	0.83	1.20	10.60
2001-2002 Monitoring Year							
Water Year 2001-2002 Total Rainfall = 24.32 inches (see Table 5)							
7-Dec-01[4]	1.90	5.0	2.40	3.6	1.42	1.1	9.7
1-Feb-02[4]	2.54	6.9	3.19	5.5	1.88	1.6	14.0
1-Mar-02[5]	2.40	6.61	3.20	5.53	1.7	1.38	13.52
24-Apr-02[4]	2.30	6.3	2.86	3.9	1.50	0.6	10.8
2000-2001 Monitoring Year[3]							
Water Year 2000-2001 Total Rainfall = 18.53 inches (see Table 5)							
3-Jan-01	0.60	0.56	0.91	0.35	n/a	Dry	0.91
1-Feb-01	1.22	2.87	1.75	1.01	0.75	0.37	4.25
22-Mar-01	2.21	5.28	2.76	4.01	1.72	0.64	9.94
26-Apr-01[4]	1.76	4.7	2.29	3.3	1.30	1.0	9.0
12-Jul-01	n/a	Dry	n/a	Dry	n/a	Dry	0
1999-2000 Monitoring Year[1]							
Water Year 1999-2000 Total Rainfall = 27.12 inches (see Table 5)							
9-Feb-00	1.87	4.73	2.43	3.60	0.66	1.13	9.46
6-Jul-00	n/a	2.40	n/a	0.82	n/a	Dry	3.22
1998-1999 Monitoring Year[1]							
Water Year 1998-1999 Total Rainfall = 24.08 inches (see Table 5)							
28-Nov-98	0.92	2.63	1.80	2.87	0.46	0.78	6.28
19-Dec-98	1.05	2.71	2.03	3.15	0.59	0.97	6.83
20-Jan-99	1.57	3.00	2.43	3.58	0.66	1.20	7.78
23-Mar-99	3.28	7.11	Overtopped[2]	6.40	1.41	1.42	14.93
17-Apr-99	2.79	6.32	Overtopped[2]	5.61	0.66	1.18	13.11
7-May-99	2.17	5.62	3.15	4.90	0.66	1.06	11.58
24-Jun-99	0.72	2.40	0.85	0.82	n/a	Dry	3.22
16-Jul-99	n/a	Dry	n/a	Dry	n/a	Dry	0

Notes:
1. 1998-1999 and 1999-2000 data provided by previous monitoring efforts.
2. Pond 2 staff gauge is 3.49 ft tall in 1999.
3. All staff gauges replaced between fall and winter 2000.
4. Pond acreages estimated from stage-area curves.
5. Pond depths estimated from stage-area curves (Figure 20)

Grey-shaded boxes indicate depths and/or acreages which have been recalculated based on stage area curves which have been revised with new data.

Table 5
Rainfall Totals, October to September 1998-2003, 2005-2006
MLK Jr. Regional Shoreline Wetlands Project
Data from U.S. Forest Service Oakland South Station, Oakland, California

	Monthly rainfall totals (inches)												
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1998-99	0.00	3.57	1.59	5.07	8.26	3.54	1.71	0.00	0.00	0.00	0.13	0.21	**24.08**
1999-01	0.20	4.10	0.63	7.73	10.24	1.89	0.99	1.34	0.00	0.00	0.00	0.00	**27.12**
2000-01	1.67	0.78	1.34	3.54	7.01	1.55	2.25	0.00	0.18	0.00	0.00	0.21	**18.53**
2001-02	0.47	4.52	10.07	1.85	2.35	4.14	0.32	0.58	0.02	0.00	0.00	0.00	**24.32**
2002-03	0.00	3.29	12.80	1.12	1.73	1.51	4.35	1.06	0.00	0.00	0.00	0.03	**25.89**
2005-06	0.37	2.2	13.28	4.83	2.51	9.78	4.49	0.00	0.00	0.00	0.00	0.00	**37.46**

Notes :

1. Data source: http://cdec.water.ca.gov/queryCSV.html, OSO station, sensor 45. The data is provisional and unverified.
2. Rainfall for 12 Sep 2003 was reported as 23.91 inches by CDEC. We excluded this value from our rainfall calculations and labelled it as a missing data value, as empirical evidence suggests the excessively high rainfall value during the dry season was recorded in error.

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transects V1, V2 and V3, all start from "center stake" located in tidal marsh immediately north of intertidal pond. Transects V4 and V5 cross marsh to the north of other transects. All transect locations shown in Figure 2. 2006 surveys conducted by The Watershed Nursery, prior surveys by Vir McCoy.					
Transect V1, 18-Sep-06, 0-159m					Bearing 250 deg from center stake in line with park bench
0	12.2	*Salicornia europea*	26	0.35	
		Spartina sp.	53	1.12	
		Salicornia virginica	6	0.65	
		Bare	15		
12.2	43.7	*Spartina sp.*	5	1	pond + 5 new seedling growth
		Salicornia virginica	3	0.4	(hummocks)
		Salicornia virginica	1	0.25	
		Salicornia europea	1	0.2	
		Water	91		pond water
43.7	78	*Jaumea carnosa*	6	0.3	
		Spartina sp.	45	1.2	
		Salicornia virginica	7	0.3	
		Salicornia europea	28	0.3	
		Bare	14		
78	81	*Spartina sp.*	73		
		Channel	27		
81	92	*Spartina sp.*	82	1.1	
		Salicornia virginica	8	0.3	
		Salicornia europea	3	0.4	
		Bare	7		
92	159	*Spartina sp.*	9	1	
		Salicornia europea	24	0.3	
		Salicornia virginica	15	0.3	
		Distichlis spicata	5	0.25	
		Jaumea carnosa	1	0.2	
		Bare	51		
Bare Ground (excluding channel):			**25%**		
Bare Ground (excluding channel) Low Marsh:			**8%**		
Bare Ground (excluding channel) High Marsh:			**43%**		
Transect V1, 5-Oct-2003					Bearing 250 deg from center stake in line with park bench
0	2	*Salicornia europaea*	80		
		Bare ground	20		
2	36	*Salicornia europaea*	15		
		Bare ground	85		
36	50.5	*Salicornia europaea*	95		
		Spartina spp.	1		One plant, likely *S. alterniflora*. Indeterminant hybrids possible
		Bare ground	5		
50.5	52.5	Small channel	100		
52.5	94.5	*Salicornia europaea*	85		
		Spartina spp.	1		Indeterminant hybrids possible
		Bare ground	15		
94.5	100	Small channel	100		
100	157	*Salicornia europaea*	80		
		Spartina spp.	1		Indeterminant hybrids possible
		Bare ground	20		
157	159	*Polypogon monspeliensis*	2		Edge species
		Spartina spp.	10		Indeterminant hybrids possible. Edge species
		Distichlis spicata	50		Edge species
		Triglochin concinna	5		Edge species
		Spartina spp.	10		Edge species.
		Bare ground	25		
Bare Ground (excluding channel):			**32%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V1, 5-Nov-2002					Bearing 250 deg from center stake in line with park bench
0	1.8	*Salicornia europaea*	70	0.2	Average height
		Bare ground	30		
1.8	36	Bare ground	70		Open area
		Salicornia europaea	30		
36	50.5	*Salicornia europaea*	75		
		Bare ground	25		
50.5	52.5	Small channel	100		
52.5	75.7	*Salicornia europaea*	90	0.2	
		Salicornia virginica	5		
		Spartina spp.	1		Indeterminant hybrids possible.
		Bare ground	5		
75.7	86	Bare ground	100		Open area
86	94.5	*Salicornia europaea*	95		
		Spartina spp.	1		Indeterminant hybrids possible.
		Bare ground	5		
94.5	99	Channel	100		
99	157	*Salicornia europaea*	75		
		Salicornia virginica	1		
		Bare ground	25		
157	159	*Salicornia europaea*	40		Edge species
		Distichlis spicata	25		Edge species
		Spartina spp.	20		Indeterminant hybrids possible. One clump at edge
		Salicornia virginica	5		One clump at edge
Bare Ground (excluding channel):			**36%**		
Transect V1, 6-Sep-2001					
0	40	Bare ground	95		
		Salicornia virginica	1		Edge
		Salicornia europaea	2		Spreading
40	78	*Salicornia europaea*	50		
		Bare ground	50		
78	88	Bare ground	100		
88	94	*Salicornia europaea*	50		
		Bare ground	50		
94	96	Channel	100		
96	159	*Salicornia europaea*	55		
		Bare ground	40		
Bare Ground (excluding channel):			**61%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V1, 2-Nov-2000					
0	94	Bare ground/algae	95		Constructed low marsh to channel
		Salicornia virginica	1		
		Salicornia europaea	2		
94	96	Channel	100		
96	159	Bare ground/algae	95		Minimal algae, constructed high marsh to end
		Salicornia europaea	2		Few scattered
		Salicornia virginica	2		Mostly on edge
		Distichlis spicata	1		
Bare Ground (excluding channel):			**95%**		
Transect V2, 18-Sep-06, 0-179m					Transect location= Bearing 70 degrees from center stake
0	13	*Spartina sp.*	18	1.1	
		Salicornia europea	68	0.4	
		Salicornia virginica	0	0.55	
		Bare	13		
13	54.3	*Salicornia europea*	1	0.3	
		Spartina sp.	0	0.5	
		Water	96		
54.3	56	*Spartina sp.*	71	0.6	
		Salicornia virginica	29	0.25	
		Bare	0		
56	63	*Jaumea carnosa*	20	0.1	
		Salicornia virginica	46	0.45	
		Grindelia stricta	0	0.1	
		Distichlis spicata	6	0.15	
		Frankenia salina	3	0.2	
		Plantago coronopsis	2	0.2	
		Bare	22		
63	82	*Salicornia virginica*	3	0.1	
		Plantago coronopsis	24	0.03	
		Dead annual grasses	5	0.05	
		Bare	68		
82	90.1	*Jaumea carnosa*	7	0.03	
		Salicornia virginica	23	0.2	
		Dead annual grasses	8	0.03	
		Distichlis spicata	0	0.1	
		Bare	62		
90.1	93.5	*Salicornia virginica*	18	0.25	
		Distichlis spicata	25	0.15	
		Bare	57		
93.5	95	*Spartina sp.*	27	0.45	
		Salicornia virginica	67	0.3	
		Bare	7		
95	116.6	*Salicornia virginica*	45	0.3	
		Distichlis spicata	23	0.3	
		Jaumea carnosa	31	0.15	
		Spartina sp.	13	0.8	
		Bare	0		
116.6	124	Channel			
124	179	*Salicornia virginica*	27	0.35	
		Jaumea carnosa	7	0.15	
		Spartina sp.	29	1.2	
		Salicornia europea	6	0.15	
		Distichlis spicata	4	0.3	
		Bare/ponded	27		
Bare Ground (excluding channel):			**22%**		
Bare Ground (excluding channel) Low Marsh:			**20%**		
Bare Ground (excluding channel) High Marsh:			**27%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V2, 5-Oct-2003					
0	55.5	*Salicornia europaea*	63		
		Spartina spp.	2		Indeterminant hybrids possible
		Bare ground	40		
55.5	60	Channel	100		
60	99	*Salicornia europaea*	75		This section of transect runs along edge of veg/open area
		Spartina spp.	2		Indeterminant hybrids possible
		Bare ground	20		
		Salicornia virginica	3		
99	103	Channel	100		
103	179	*Spartina* spp.	5		Indeterminant hybrids possible
		Salicornia europaea	75		
		Bare ground	20		
Bare Ground (excluding channel):			**27%**		
Transect V2, 5-Nov-2002					Bearing 70 deg from center stake, in line with PVC in distance
0	31	*Salicornia europaea*	60	0.2	Average height
		Bare ground	40		
31	47.5	Bare ground	70		
		Salicornia europaea	30		
47.5	55.5	*Salicornia europaea*	100		
		Spartina spp.	1		Indeterminant hybrids possible
55.5	73.5	Bare ground	50		This section of transect runs along edge of veg/open area
		Salicornia europaea	45		
		Salicornia virginica	5		
73.5	99	*Salicornia europaea*	80		
		Spartina spp.	1		Indeterminant hybrids possible
		Salicornia virginica	5		
		Bare ground	10		
99	103	Channel	100		
103	179	*Salicornia europaea*	70		
		Salicornia virginica	5		
		Spartina spp.	5		Indeterminant hybrids possible
		Spartina spp.	1		Indeterminant hybrids possible. Along bank
		Bare ground	20		
Bare Ground (excluding channel):			**29%**		
Transect V2, 6-Sep-2001					
0	46.8	Bare ground	100		
46.8	100	*Salicornia europaea*	60	0.25	
		Salicornia virginica	5	0.35	
		Bare ground	35		
100	102	Channel	100		
102	135	*Salicornia europaea*	70		
		Salicornia virginica	5		
		Bare ground	25		
		Spartina foliosa	1		Indeterminant hybrids possible
135	145.5	*Salicornia europaea*	5		
		Bare ground	95		
145.5	162	*Salicornia europaea*	90		
		Spartina foliosa	3	0.2	Indeterminant hybrids possible
		Bare ground	5		
162	177	Bare ground	100		
177	179	*Spartina alterniflora*	10	0.4	Indeterminant hybrids possible
		Salicornia virginica	65	0.2	
		Spartina foliosa	5		Indeterminant hybrids possible
		Bare ground	20		
Bare Ground (excluding channel):			**56%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	Distance (m) End	Species	Percent cover	Height (m)	Comments
Transect V2, 2-Nov-2000					
0	47.7	Bare ground/algae	100		Pockets of water, constructed low marsh to channel
47.7	100	*Salicornia europaea*	35	0.2	Mostly dead w/ new sprouts
		Salicornia virginica	4	0.3	
		Distichlis spicata	1		
		Bare ground	60		
100	102	Channel	100		
102	119.6	*Salicornia europaea*	20		Constructed high marsh to end
		Salicornia virginica	10		
		Bare ground	70		
119.6	145	*Salicornia europaea*	5		
		Bare ground	95		
145	176	*Salicornia europaea*	15		
		Spartina foliosa	3	0.2	Approx. 25 plants. Indeterminant hybrids possible
		Bare ground	80		
176	179	*Spartina alterniflora*	35	0.4	Dense strip along edge. Indeterminant hybrids possible
		Salicornia virginica	65	0.2	Edge of marsh
Bare Ground (excluding channel):			**79%**		
Transect V3, 18-Sep-2006, 0-169m					Bearing 150 deg from center stake, in line with flag in distance
0	12.9	*Spartina sp.*	10%	0.9	
		Salicornia europea	81%	0.4	
		Bare	9%		
12.9	19.8	Bare	100%		
19.8	21.8	*Spartina sp.*	10%	0.5	
		Salicornia europea	8%	0.3	
		Bare	83%		
21.8	37.5	Water (Channel)	100%		channel n of intertidal pond
37.5	41.1	*Salicornia virginica*	100%	0.2	Berm, n side of interidal pond
41.1	126	Intertidal pond, water	100%		
126	131.7	*Jaumea carnosa*	1%	0.1	
		Salicornia virginica	96%	0.4	
		Spartina sp.	0%	0.2	
		Bare	3%		
131.7	142.5	*Salicornia virginica*	0%	0.1	
		Water	100%		with *enteropmorpha*
142.5	169	*Salicornia virginica*	20%	0.3	
		Salicornia europea	0%	0.1	
		Bare	76%		mud and waer
Bare Ground (excluding channel):			**20%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V3, 5-Oct-2003					Bearing 150 deg from center stake, in line with flag in distance
0	2.5	*Salicornia europaea*	95	0.2	
2.5	35.5	Bare ground	100		
35.5	40.6	*Salicornia europaea*	5	0.2	
		Salicornia virginica	70		
		Bare ground	25		Channel bank
40.6	114.5	Bare ground/pond	100		Intertidal pond (not in bare ground calc)
114.5	120	*Salicornia virginica*	60		
		Frankenia salina	5		
		Distichlis spicata	5		
		Bare ground	30		
120	163	*Salicornia europaea*	15	0.2	
		Bare ground	85		
		Salicornia virginica	2		
163	169	*Scirpus maritimus*	25		Edge species
		Triglochin concinna	5		Edge species
		Spartina spp.	20		Indeterminant hybrids possible. Edge species
		Distichlis spicata	25		Edge species
		Typha latifolia	5		Edge species
		Salicornia virginica	5		Edge species
		Salicornia europaea	10	0.2	Edge species
Bare Ground (excluding channel):			**74%**		
Transect V3, 5-Nov-2002					Bearing 150 deg from center stake, in line with flag in distance
0	2.5	*Salicornia europaea*	75	0.2	
		Bare ground	25		
2.5	35.5	Bare ground	100		
35.5	40.6	*Salicornia virginica*	35		Bank
		Spartina spp.	1		Indeterminant hybrids possible. Bank
		Salicornia europaea	15		Bank
		Bare ground	50		Bank
40.6	114.6	Bare ground/ pond water	100		
114.6	163	Bare ground	85		Marsh
		Salicornia virginica	10		Marsh
		Salicornia europaea	2		Marsh
		Jaumea carnosa	1		Marsh
163	168.6	*Triglochin concinna*	15		Edge
		Scirpus maritimus	25		Edge
		Distichlis spicata	30		Edge
		Spartina spp.	20		Indeterminant hybrids possible. Edge
		Typha latifolia	10		Edge
Bare Ground (excluding channel):			**89%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V3, 6-Sep-2001					
0	35.6	Bare ground	100		
35.6	40.6	*Salicornia europaea*	10		
		Salicornia virginica	10		
		Bare ground	80		
40.6	114.6	Bare ground/pond water	0		
114.6	163.6	Bare ground	95		
		Salicornia europaea	5		
163.6	168.6	*Triglochin concinna*	10		
		Scirpus maritimus	10		
		Distichlis spicata	20		
		Cotula coronopifolia	10		
		Spartina alterniflora	25		Indeterminant hybrids possible
		Typha latifolia	5		
		Bare ground	20		
Bare Ground (excluding channel):			**98%**		
Transect V3, 2-Nov-2000					
0	35.6	Bare ground	100		Constructed low marsh to intertidal pond
35.6	40.6	*Salicornia europaea*	5		Berm forming northern edge of intertidal pond
		Salicornia virginica	5		
		Bare ground	80		
40.6	114.6	Bare ground/pond water	100		Intertidal pond
114.6	163.6	Bare ground/algae	98		Minimal algae, constructed high marsh to end
		Salicornia europaea	2		
163.6	168.6	*Triglochin coccina*	10		
		Scirpus maritimus	5	0.5	Small patch
		Distichlis spicata	15		
		Cotula coronopifolia	20		
		Spartina alterniflora	20		Indeterminant hybrids possible.
		Bare ground	30		
168.6	end				Seasonal wetlands -- see Table 10
Bare Ground (excluding channel):			**98%**		
Transect V4, 18-Sep-06, 0-83m					Bearing 70 deg from gate at south end of main parking lot
0	5.5	*Distichlis spicata*	5	0.2	Bank from parking lot
		Hirschfeldia incana	2	0.1	to path along edge of wetland
		Frankenia salina	5	0.2	
		Bare	87		
5.5	34	*Salicornia virginica*	24	0.3	
		Salicornia europea	2	0.3	
		Spartina sp.	75		
		Bare	0		
34	41.8	Channel	100		
41.8	83	*Salicornia europea*	14	0.3	
		Salicornia virginica	13	0.4	
		Spartina sp.	84	1.0	
		Distichlis spicata	10	0.4	
		Bare	0		
Bare Ground (excluding channel):			**0%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m)				Height	
Start	**End**	**Species**	**Percent cover**	**(m)**	**Comments**
Transect V4, 6-Oct-2003					Bearing 70 deg from gate at south end of main parking lot
0	3	*Avena fatua*	50		Weedy edge.
		Bromus spp.	50		Weedy edge.
3	33	*Salicornia europaea*	80	0.2	
		Salicornia virginica	10	0.3	
		Spartina spp.	5		Indeterminant hybrids possible.
		Bare ground	5		
33	41	Channel	100		
41	79	*Salicornia europaea*	80	0.2	
		Spartina spp.	5		Indeterminant hybrids possible
		Distichlis spicata	5		
		Bare ground	5		
		Salicornia virginica	5	0.3	
79	83	*Spartina* spp.	85		Indeterminant hybrids possible
		Salicornia virginica	10	0.3	
		Distichlis spicata	5		
		Grindelia stricta	2		
Bare Ground (excluding channel):			**5%**		
Transect V4, 5-Nov-2002					Bearing 70 deg from gate at south end of main parking lot
0	3	*Bromus hordeaceous*	35		Ruderal to edge of Wetland
		Avena fatua	20		
		Hirschfeldia incana	10		
		Bare ground	35		
3	33	*Salicornia europaea*	85		
		Salicornia virginica	5		
		Spartina spp.	2		Indeterminant hybrids possible
		Distichlis spicata	1		
		Bare ground	10		
33	41	Channel	100		
41	80	*Salicornia europaea*	50		
		Salicornia virginica	5		
		Spartina spp.	5		Indeterminant hybrids possible
		Bare ground	40		
80	82.7	*Salicornia virginica*	15		
		Salicornia europaea	5		
		Spartina spp.	80		Indeterminant hybrids possible
Bare Ground (excluding channel):			**26%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V4, 6-Sep-2001					
0	3	*Bromus* spp.	70		Gate to marsh edge
3	6.3	Bare ground	80		
		Salicornia virginica	20		
6.3	33	*Salicornia europaea*	25		
		Bare ground	70		
		Salicornia virginica	3		
		Spergularia marina	2		
33	40.5	Channel	100		
40.5	61	*Salicornia virginica*	5		
		Salicornia europaea	65		
		Spartina foliosa	5		Indeterminant hybrids possible
		Spergularia marina	2		
		Bare ground	25		
61	73	Bare ground	100		
73	80	*Spartina foliosa*	5		Indeterminant hybrids possible
		Salicornia virginica	5		
		Grindelia stricta	5		
		Salicornia europaea	80		
		Bare ground	5		
80	82.7	Bare ground	50		
		Bromus spp.	50		
Bare Ground (excluding channel):			**53%**		
Transect V4, 3-Jan-2001 (2000 Survey)					
0	3	*Bromus* spp.	70		Gate edge to marsh edge
3	6.3	Bare ground	100		Marsh edge
6.3	15.3	*Salicornia europaea*	40	0.2	Dead (annual), constructed high marsh to slope break
		Bare ground	55		
		Distichlis spicata	2	0.2	
		Salicornia virginica	3		
		Spergularia marina	2	0.05	
15.3	33	*Salicornia europaea*	10	0.2	Constructed low marsh to channel
		Spergularia marina	2		
		Bare ground	85		Algae throughout
33	40.5	Bare ground/ open water	0		Channel
40.5	49	*Salicornia virginica*	5	0.2	Constructed high marsh to end
		Salicornia europaea	20	0.2	
		Spartina foliosa	5	0.3	Indeterminant hybrids possible.
		Spartina alterniflora	2	1	Most plants were recently pulled from ground by others
		Spergularia marina	2		
		Bare ground	65		Algae throughout
49	56.8	Open water/ bare ground	100		Pockets of water
56.8	64.3	*Salicornia europaea*	20		
		Spartina foliosa	5		Indeterminant hybrids possible
		Salicornia virginica	1		
		Bare ground	75		Algae throughout
64.3	73	*Salicornia europaea*	5		
		Salicornia virginica	1		
		Bare ground	95		Water 2-3" no algae
73	75	*Spartina foliosa*	30	1	Indeterminant hybrids possible
		Salicornia virginica	30	0.2	
		Grindelia stricta	5	0.2	
		Jaumea carnosa	5	0.05	
		Spartina alterniflora	20	0.4	Indeterminant hybrids possible
		Salicornia europaea	10	0.2	
75	77.8	Bare ground	90		
		Cotula coronopifolia	5	0.02	Sprouts
		Unknown grass	5	0.05	Brome?
77.8	80	*Bromus* spp.	100		Fence
Bare Ground (excluding channel):			**66%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V5, 18-Sep-06, 0-240m					100 degree compass heading
0	41.4	*Salicornia europea*	11	0.3	
		Spartina sp.	46	1.0	
		Distichlis spicata	14	0.2	
		Salicorni virginica	16	0.4	
		Jaumea carnosa	12	0.1	
		Bare	1		
41.4	46.8	Channel	100		
46.8	90.3	*Salicornia europea*	5	0.3	From channel to edge of pond
		Salicornia virginica	10	0.4	
		Distichlis spicata	1	0.3	
		Spartina sp.	80	1.1	
		Bare	5		
90.3	99.3	Pond	100		
99.3	110.7	*Spartina sp.*	100	1.2	some lying flat
110.7	123.3	Pond	100		
123.3	169.3	*Spartina sp.*	71	1.1	
		Salicornia virginica	16	0.4	
		Salicornia europea	2	0.4	
		Bare	11		
169.3	174.6	Channel	100		
174.6	197.6	*Salicornia virginica*	36	0.3	
		Salicornia europea	0	0.1	dead
		Distichlis spicata	6	0.3	
		Jaumea carnosa	21	0.3	
		Spartina sp.	22	0.9	
		Bare	16		
197.6	223.1	*Distichlis spicata*	3	0.2	Marsh, bare, shallow, ponded
		Jaumea carnosa	2	0.2	
		Spartina sp.	55	1.0	
		Salicornia virginica	11	0.3	
		Bare	29		
223.1	226.9	*Salicornia virginica*	33	0.3	Edge of marsh
		Spartina sp.	13	0.6	
		Jaumea carnosa	20	0.2	
		Grindelia stricta	4	1.2	
		Bare	30		
226.9	230.6	*Grindelia stricta*	27	1.2	Bank & upland
		Distichlis spicata	1	0.5	
		Baccharis pilularis	51	1.6	
		Grasses	43	0.3	Bromus diandrus, Lolium, Brho, Avena
		Bare	0		
Bare Ground (excluding channel):			**8%**		
Bare Ground Low Marsh			**5%**		
Bare Ground High Marsh			**15%**		
Transect V5, 6-Oct-2003					
0	41	*Salicornia europaea*	80		
		Spartina spp.	8		Indeterminant hybrids possible
		Salicornia virginica	5		
		Bare ground	7		
41	46.5	Channel	100		
46.5	170	*Jaumea carnosa*	2		
		Salicornia europaea	50		
		Spartina spp.	10		Indeterminant hybrids possible
		Salicornia virginica	5		
		Bare ground	35		
170	183	Channel	100		
183	232	*Spartina* spp.	5		Indeterminant hybrids possible
		Salicornia virginica	5		
		Bare ground	5		
		Salicornia europaea	85		
232	240	*Frankenia salina*	5		
		Salicornia virginica	50		
		Spartina spp.	45		Indeterminant hybrids possible
Bare Ground (excluding channel):			**22%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V5, 5-Nov-2002					From SP-8 (west end) through SP-10 to marsh edge (east end)
0	41	*Salicornia europaea*	80		
		Salicornia virginica	5		
		Spartina spp.	2		Indeterminant hybrids possible
		Bare ground	15		
41	46.5	Channel	100		
46.5	84	*Salicornia europaea*	85		
		Spartina spp.	3		Indeterminant hybrids possible
		Bare ground	15		
84	161	*Salicornia europaea*	45		
		Spartina spp.	3		Indeterminant hybrids possible
		Salicornia virginica	2		
		Bare ground	50		
161	170	Bare ground	20		
		Salicornia europaea	75		
		Spartina spp.	5		Indeterminant hybrids possible
170	183	Channel	100		
183	235	*Salicornia europaea*	75	0.20 m	
		Spergularia marina	1		
		Spartina spp.	3		Indeterminant hybrids possible
		Salicornia virginica	5		
		Bare ground	15		
235	240	*Salicornia virginica*	75		Bank
		Spartina spp.	10		Indeterminant hybrids possible. Bank
		Bromus spp.	5		Bank
Bare Ground (excluding channel):			**27%**		

Table 6
Tidal Marsh Vegetation Transects, 2000-2003, 2005-2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Transect V5, 6-Sep-2001					
0	41	*Salicornia europaea*	75		
		Salicornia virginica	5		
		Spergularia marina	1		
		Bare ground	20		
41	46.5	Channel	100		
46.5	83	Bare ground	45		
		Salicornia europaea	55		
83	163	Bare ground	80		
		Salicornia europaea	20		
163	170	*Salicornia europaea*	65		
		Spartina foliosa	30		Indeterminant hybrids possible
170	183	Channel	100		
183	227	*Salicornia europaea*	65		
		Salicornia virginica	5		
		Spartina foliosa	5		Indeterminant hybrids possible
		Bare ground	25		
227	233	*Salicornia europaea*	45		
		Salicornia virginica	45		
		Spartina foliosa	5		Indeterminant hybrids possible
233	236	Bare ground	100		
236	239	*Bromus* spp.	60		
Bare Ground (excluding channel):			**47%**		
Transect V5, 3-Jan-2001 (2000 Survey)					
0	21.2	*Salicornia europaea*	5	0.2	Slightly elavated bench, constructed high and low marsh to channel
		Salicornia virginica	5	0.4	
		Spergularia marina	1	0.05	
		Bare ground	90		Algae
41	46.5	Channel	100		Channel
46.5	83	Bare ground	97		Algae, constructed low marsh to next channel
		Salicornia europaea	3		
83	163	Bare ground	95		2" water
		Salicornia europaea	5		Red Pvc Pipe@163
163	170	*Salicornia europaea*	10		
		Spartina foliosa	5		Indeterminant hybrids possible
		Bare ground	85		Algae
170	183	Channel	100		
183	200	*Salicornia europaea*	50	0.2	Constructed high marsh to end
		Salicornia virginica	4		
		Spartina foliosa	1		Indeterminant hybrids possible
		Bare ground	50		Algae
200	227	*Salicornia europaea*	10		
		Spartina foliosa	2		Indeterminant hybrids possible
		Bare ground	90		Water 3"
227	233	*Salicornia europaea*	45	0.2	
		Salicornia virginica	45	0.3	
		Spartina foliosa	5	0.4	Indeterminant hybrids possible
		Distichlis spicata	2		
233	236	Bare ground	100		Litter
236	239	*Bromus spp.*	60		
		Hirschfeldia incana	30		Mustard
239		Fence			2m south of "keep out" sign
Bare Ground (excluding channel):			**78%**		

Table 7
Tidal Marsh Vegetation Map Patch Composition, 2001, 2002, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

2006 Map, Surveyed 18-Sep-06, 5-Nov-06[1,2]					
Type	**Patch**	**Species**	**Percent cover**	**Height (m)**	**Notes**
High	1	*Distichlis spicata*	5.2	0.20	
		Grindelia stricta	0.2	1.16	
		Jaumea carnosa	3.5	0.17	
		Salicornia europaea	8.1	0.38	
		Salicornia virginica	14.3	0.39	
		Spartina spp.	25.0	1.21	
		Grasses	0.3	0.25	
		Ponded water	20.2		
		Bare ground	26.2		
Low	2	*Distichlis spicata*	1.6	0.35	
		Frankenia salina	0.1	0.20	
		Grindelia stricta	0.0	0.10	
		Jaumea carnosa	3.6	0.16	
		Plantago coronopsis	1.4	0.04	
		Salicornia europaea	7.9	0.34	
		Salicornia virginica	10.7	0.33	
		Spartina spp.	35.2	1.10	
		Grasses	0.5	0.04	
		Ponded water	26.3		
		Bare ground	10.8		
2002 Map, Surveyed 5-Nov-02[1,3]					
Type	**Patch**	**Species**	**Percent cover**	**Height (m)**	**Notes**
High	1	*Distichlis spicata*	2		
		Jaumea carnosa	1		
		Salicornia europaea	40	0.2	
		Salicornia virginica	10		
		Scirpus maritimus	2		
		Spartina spp.	2		Some are hybrids
		Triglochin concinna	1		
		Typha latifolia	1		
		Bare ground	41		
Low	2	*Distichlis spicata*	0.02		
		Salicornia europaea	47	0.2	
		Salicornia virginica	1.1		
		Spartina spp.	1.2		
		Bare ground	50		
2001 Map, Surveyed 6-Sep-0[1,3]					
Type	**Patch**	**Species**	**Percent cover**	**Height (m)**	**Notes**
High	1	*Salicornia europaea*	65	0.15	Spreading
		Salicornia virginica	5	0.25	South to first main channel
		Spartina foliosa	2	0.35	
		Spergularia marina	1		
		Bare ground	30		
High	2	*Salicornia europaea*	40	0.15	
		Salicornia virginica	5	0.25	
		Spergularia marina	5	0.2	
		Spartina foliosa	1		
		Bare ground	50		
High	3	*Salicornia europaea*	10	0.1	
		Salicornia virginica	5	0.15	
		Bare ground	85		
High	4	*Salicornia europaea*	58	0.2	
		Salicornia virginica	5	0.15	
		Spartina foliosa	2	0.8	
		Bare ground	40		
High	5	*Salicornia europaea*	60	0.2	
		Salicornia virginica	5	0.3	
		Spartina foliosa	5	0.4	
		Spartina alterniflora	5		
		Bare ground	25		
Low		*Salicornia europaea*	35		
		Salicornia virginica	5		
		Spartina foliosa	5		
		Bare ground	55		

Notes:
1. Percent cover derived from tidal marsh vegetation transects, Table 8.
2. Surveys conducted by the Watershed Nursery (D. Benner, L. Hauston).

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
2006 SURVEY, 5-May-06					
POND 1					
T1-1	**Transect location = 94 degress E from rebar**				rebar @ N 37° 44.157 W 122° 12.550 accuracy= 7.8'
0	76.8	water	100		
71	76.8	water w/ *Enteromorpha intestinalis*			patches of Enteromorpha w/ 5-20 cm wide open patches disbursed within
					Water depth @ rebar ~10 cm water
					Water depth @ 71 m ~20 cm
% Bare ground in vegetation section of transect			**0%**		
T1-2	**Transect location= 244 degress W from rebar**				rebar @ N 37° 44.174 W 122° 12.461 accuracy 13.8'
0	62.8	water	99.7		
		water w/ *Enteromorpha intestinalis*			~4.8 m
		Frankenia salina	0.3	0.05	
62.8	64.58	Bare ground	93.3		
		Frankenia salina	6.7	0.05	
64.58	73	Bare ground	18.4		
		Plantago coronopus	80.2	0.025	
		Frankenia salina	1.2	0.05	
		Melilotus indica	0.2	.02,.04	
					water depth @ center 85 cm
% Bare ground in vegetation section of transect			**16.9**		
POND 2					
T2-1	**Transect location = 238 degress SW from rebar**				Rebar @ N 37° 44.220 W 122° 12.334 accuracy 12.0'
0	85	Water	99.2		
		Lythrum hysopifolium	0.0	0.05	
		water w/ *Enteromorpha intestinalis*			
% Bare ground in vegetation section of transect			**0**		
T2-2	**Transect location = 340 degress N from rebar**				Rebar @ N37° 44.156 W 122° 12.360 accuracy 8.8'
0	80.45	Water	99.9		
		water w/ *Enteromorpha intestinalis*			
		Scirpus maritmus	0.1	avg.=0.36	
80.45	84.4	Bare ground	85.3		
		Lotus corniculatus	7.1	avg.=0.042	
		Hordeum brachyantherum	7.6	.001,.002	Hordeum laying down, covered w/ mud and algae
84.4	88	Bare ground	3.1		
		Lotus corniculatus	32.5	0.07	
		Picris echioides	1.9	0.05	
		Geranium dissectum	2.8	0.05	
		Hordeum murinum	52.8	0.08	
		Lolium multiflorum	6.9	0.1	water @ staff gauge 102 cm
% Bare ground in vegetation section of transect			**4.8**		

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
POND 3					
T3-1	**Transect location = 310 degress NW from rebar**				GPS: N 209545.5 E 6068992.3
0	34.55	Water	100		
34.55	38.32	Bare ground	1.3		
		Scirpus maritimus	26.5	0.15,0.45	
		Typha angustifolia	13.3	avg.=0.5	
		Juncus bufonis	26.5	0.04	
		cute little plant	26.5	0.03	
		Lythrum hysopifolia	5.3	0.08	
		Cotula coronopifolia	0.5	0.05	
38.32	50.9	*Lolium multifloum*	12.3	0.12	
		Picris echioides	5.4	0.05	
		Carduus pycnocephalus	0.2	0.05	no flowering parts, fuzzy leaves
		Gnaphlium sp.	2.5	0.07	
		Hordeum brachyantherum	0.6	0.15	
		Hordeum murinum	51.7	0.09	
		Lotus corniculatus	22.1	0.08	
		Melilotus indica	2.8	0.07	
		Bromus hordeaceus	1.9	0.12	
		Vicia sativa	0.4	0.1	
		Geranium dissectum	0.2	0.07	
% Bare ground in vegetation section of transect			**0.3**		
T3-2	**Transect location = 94 degress E from rebar**				GPS: N 2095476.9 E 6068666.4
0	49.6	Water	100		
49.6	55	Bare ground	81.9		
		Scirpus maritimus	1.5	0.25	
		Plantago coronopus	2.4	0.05	
		Cotula coronopifolia	6.5	0.05	
		Juncus bufonus	2.4	0.04	
		Salicornia virginica	0.7	0.07	
		cute little flower	4.6	0.03	
55	63.6	*Hordeum murinum*	24.4	0.07	
		Vicia sativa ssp. nigra	0.2	0.08	
		Plantago lanceolata	5.1	0.12	
		Lotus corniculatus	44.2	0.1	
		Melilotus indica	7.6	0.08	
		Lolium multiflorum	28.5	0.14	
		Bromus hordeaceus	0.0	0.12	
		Geranium dissectum	0.5	0.07	
		Juncus bufonus	1.7	0.03	
		Plantago coronopus	0.6	0.05	
		Carduus pycnocephalus	1.0	0.08	
		Vulpia myuros	0.6	0.07	
		Hordeum brachyantherum	1.3	0.12	
% Bare ground in vegetation section of transect			**31.6**		

Surveys conducted by: Laura Hanson, Diana Benner

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	Distance (m) End	Species	Percent cover	Height (m)	Comments
2003 SURVEY, 14-May-03					
Pond 1					
T1-1		**Transect location = 94 degrees E. from rebar**			Total transect distance = 77.2 m
0	3.2	*Anagallis arvensis*	5		
		Cotula coronopifolia	1		
		Melilotus indica	35		
		Plantago coronopus	50		
		Polypogon monspeliensis	10		
3.2	9.2	*Atriplex triangularis*	5		
		Carex spp.	5		
		Cotula coronopifolia	1		
		Crypsis vaginiflora	35		
		Lythrum hyssopifolium	7		
		Bare ground	50		
9.2	77.2	Pond water			
% Bare ground in vegetated section of transect:			**33%**		
T1-2		**Transect location = 244 degrees W. from rebar**			Total transect distance = 73 m.
0	13.3	*Cotula coronopifolia*	5		
		Frankenia salina	5		
		Melilotus indica	5		
		Plantago coronopus	30		
		Spergularia marina	10		
		Bare ground	40		
13.3	16.9	*Atriplex triangularis*	10		
		Crypsis vaginiflora	15		
		Bare Ground	75		
16.9	73	Pond water			
% Bare ground in vegetated section of transect:			**47%**		
Pond 2					Water depth at staff gauge = 2.6 ft.
T2-1		**Transect location = 238 degrees SW from rebar**			Total transect distance = 85 m.
0	4.5	*Melilotus indica*	50		
		Ballardia trixago	2		
		Geranium dissectum	5		
		Hordeum marinum gussoneanum	10		
		Lolium multiflorum	10		
		Lotus corniculatus	10		
		Trifolium microcephalum	3		
4.5	10	*Cotula coronopifolia*	5		
		Crypsis vaginiflora	15		
		Lythrum hyssopifolia	25		
		Melilotus indica	1		
		Plantago coronopus	10		
		Unknown #1	30		very small no flower
		Bare Ground	15		
10	85	Pond water			
% Bare ground in vegetated section of transect:			**8%**		
T2-2		**Transect location = 340 degrees N. from rebar**			Total transect distance = 88 m.
0	19	*Hordeum marinum gussoneanum*	10		
		Lolium multiflorum	25		
		Lotus corniculatus	30		
		Melilotus indica	20		
		Plantago lanceolata	5		
		Polypogon monspeliensis	5		
		Vulpia myuros	10		
19	27	*Carex* spp.	5		
		Cotula coronopifolia	5		
		Lythrum hyssopifolia	30		
		Plantago coronopus	10		
		Unknown #1	30		
		Bare Ground	20		
27	88	Pond water			
% Bare ground in vegetated section of transect:			**6%**		

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Pond 3					Water depth on staff gauge = 1.4 ft.
T3-1		**Transect location = 310 degrees NW from rebar**			Total transect distance = 50.9 m.
0	13.1	*Bellardia trixago*	1		
		Hordeum marinum gussoneanum	5		
		Lolium multiflorum	20		
		Lotus corniculatus	25		
		Melilotus indica	25		
		Vulpia myuros	25		
13.1	22.4	*Carex* spp.	30		
		Cotula coronopifolia	5		
		Crypsis vaginiflora	5		
		Lythrum hyssopifolia	5		
		Plantago coronopus	5		
		Salicornia virginica	5		
		Typha latifolia	5		
		Unknown #1	5		
		Bare Ground	35		
22.4	50.9	Pond water			
% Bare ground in vegetated section of transect:			**15%**		
T3-2		**Transect location = 94 degrees E from rebar**			Total transect distance = 63.6 m.
0	7.36	*Bellardia trixago*	1		
		Bromus hordeaceus	5		
		Hordeum marinum gussoneanum	5		
		Lolium multiflorum	10		
		Lotus corniculatus	15		
		Lupinus bicolor	5		
		Melilotus indica	50		
		Plantago lanceolata	5		
		Sonchus spp.	5		
7.3	12.8	*Cotula coronopifolia*	20		
		Melilotus indica	10		
		Plantago coronopus	30		
		Polypogon monspeliensis	10		
		Bare Ground	20		
12.8	18.5	*Carex* spp.	40		
		Bare Ground	60		
18.5	63.6	Pond water			
% Bare ground in vegetated section of transect:			**24%**		

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
2002 SURVEY, 24-April-02					
Pond 1					Water depth at staff gauge = 2.3 ft.
T1-1		**Transect location = 94 degrees E. from rebar**			Total transect distance = 77.2 m.
0	3.2	*Cotula coronopifolia*	40	0.01	Very small
		Juncus bufonius	5	0.01	Very small
		Plantago spp.	5	0.02	Very small
		Anagallis arvensis	5	0.02	
		Melilotus indica	1	0.07	
		Bare ground	45		
3.2	6	*Crypsis vaginiflora*	10	0.01	
		Carex spp.	1	0.02	Too small to identify species
		Cotula coronopifolia	5	0.01	
		Spergularia marina	5	0.01	Small white flower
		Lythrum hyssopifolium	2	0.01	
		Bare ground	75		
6	77.2	Pond water			
% Bare ground in vegetated section of transect:			**59%**		
T1-2		**Transect location = 244 degrees W. from rebar**			Total transect distance = 73 m.
0	14.7	*Melilotus indica*	2	0.04	Mostly bare
		Plantago spp.	5	0.01	Small sprouts
		Cotula coronopifolia	5	0.01	
		Frankenia salina	1	0.04	
		Cynodon dactylon	1	0.01	
		Bare ground	85		
		Spergularia marina	1	0.01	
14.7	73	Pond water			
% Bare ground in vegetated section of transect:			**85%**		
Pond 2					Water depth at staff gauge = 2.86 ft.
T2-1		**Transect location = 238 degrees SW from rebar**			Total transect distance = 85 m.
0	4.5	*Lotus corniculatus*	10		Misidentified this in 2001 as scotch broom
		Lythrum hyssopifolium	5		
		Plantago lanceolata	15		
		Hordeum brachyantherum	10		
		Unknown species #1	15		Small white flower
		Nassela spp.	2		Small bunch grass; no flower.
		Cynodon dactylon	10		
		Bare ground	40		
		Carex spp.	2		
4.5	12	*Cynodon dactylon*	5		
		Carex spp.	1		
		Lythrum hyssopifolium	5		
		Bare ground	90		
12	85	Pond water			
% Bare ground in vegetated section of transect:			**71%**		
T2-2		**Transect location = 340 degrees N. from rebar**			Total transect distance = 88 m.
0	19	*Lotus corniculatus*	20		Weedy
		Melilotus indica	20		
		Hordeum brachyantherum	50		
		Hordeum marinum ssp. *gussoneanum*	10		
		Lythrum hyssopifolium	5		
		Bare ground	5		
19	30	*Lythrum hyssopifolium*	3		Upper water level is at 19 m along transect
		Spergularia marina	2		
		Bare ground	95		
30	88	Pond water			
% Bare ground in vegetated section of transect:			**38%**		

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Pond 3					Water depth on staff gauge = 1.5 ft.
T3-1		**Transect location = 310 degrees NW from rebar**			Total transect distance = 50.9 m.
0	12.2	*Hordeum brachyantherum*	70		
		Lotus corniculatus	10		
		Hordeum marinum ssp. *gussoneanum*	30		
		Bromus hordeaceus	5		
		Melilotus indica	5		
		Lolium perenne	5		
12.2	19.4	*Carex* spp.	25		
		Bare ground	65		
		Lythrum hyssopifolium	5		
		Unknown species	5		
19.4	50.9	Pond water			
% Bare ground in vegetated section of transect:			**24%**		
T3-2		**Transect location = 94 degrees E from rebar**			Total transect distance = 63.6 m.
0	7	*Hordeum brachyantherum*	40	0.1	
		Lupinus spp.	20	0.1	
		Melilotus indica	15		
		Hordeum marinum ssp. *gussoneanum*	15		
		Vulpia myuros	10		
7	12	*Cotula coronopifolia*	25		Nesting avocets
		Plantago lanceolata	25		
		Bare ground	50		
		Picris echioides	1		
12	14.8	*Carex* spp.	20	0.1	
		Bare ground	80		
14.8	63.6	Pond water			
% Bare ground in vegetated section of transect:			**32%**		
2001 SURVEY #1, 22-Mar-01					
Pond 1					Depth at staff = 2.21 ft.
T1-1		**Transect location = 94 degrees E. from rebar**			Total transect distance = 77.2 m.
0	7.5	*Melilotus indica*	5	0.4	
		Crypsis vaginiflora	10	0.05	
		Lythrum hyssopifolia	1	0.1	
		Cotula coronopifolia	5	0.2	
		Polypogon monspeliensis	10	0.1	
		Juncus bufonius	10	0.1	
		Unknown #1	10	0.05	Too small to I.D.
		Bare ground	50		
7.5	77.2	Open water			Edge of water to staff gauge
% Bare ground in vegetated section of transect:			**50%**		
T1-2		**Transect location = 244 degrees W. from rebar**			Total transect distance = 73 m.
0	15.9	*Crypsis vaginiflora*	5		
		Cotula coronopifolia	10		
		Frankenia salina	2		
		Unknown #1	15		No flower
		Melilotus indica	5		
		Spergularia marina	5		Purple
		Bare ground	55		
15.9	73	Open water			
% Bare ground in vegetated section of transect:			**55%**		

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Pond 2					Depth at staff = 2.76 ft.
T2-1		**Transect location = 238 degrees SW from rebar**			Total transect distance = 85 m.
0	7	*Melilotus indica*	70	0.4	
		Nassella spp.	5	0.2	Small clump, possibly *N. cernua*
		Polypogon monspeliensis	2	0.1	
		Crypsis vaginiflora	2	0.05	
		Cotula coronopifolia	1	0.02	
		Bare ground	10		
7	13.6	*Melilotus indica*	5		
		Cotula coronopifolia	50	0.01	Small sprouts
		Nassella spp.	2		
		Spergularia marina	1		
		Cyperus involucratus	2		Dead
		Bare ground	45		
13.6	85	Open water			
% Bare ground in vegetated section of transect:			**27%**		
T2-2		**Transect location = 340 degrees N. from rebar**			Total transect distance = 88 m.
0	12	*Bromus hordeaceus*	3		
		Lolium multiflorum	2		
		Unknown grass #1	10		
		Genista monspessulana	70		French broom
		Crypis vaginiflora	5		
		Sonchus spp.	1		Sprout
		Polypogon monspeliensis	5		
		Bare ground	5		
		Hordeum brachyantherum	2		
12	22.6	*Cotula coronopifolia*	5		
		Melilotus indica	5		
		Lythrum hyssopifolia	15		
		Polypogon monspeliensis	5		
		Unknown grass #1	10		
		Nassella spp.	1		No floret
		Crypis vaginiflora	10		
		Bare ground	50		
22.6	88	Open Water			
% Bare ground in vegetated section of transect:			**26%**		
Pond 3					Depth at staff = 1.72 ft.
T3-1		**Transect location = 310 degrees NW from rebar**			Total transect distance = 50.9 m.
0	12.1	*Hordeum murinum glaucum*	45	0.1	
		Unknown grass #1	35	0.2	
		Picris echiodes	1	0.05	
		Plantago lanceolata	1	0.1	
		Melilotus indica	5	0.1	
		Lythrum hyssopifolia	1	0.05	
		Edge Pool Species	10	0.02	Too small to I.D.
12.1	15	*Scirpus robustus*	5	3	
		Typha latifola	10	0.5	
15	50.9	Open Water			
% Bare ground in vegetated section of transect:			**0%**		
T3-2		**Transect location = 94 degrees E from rebar**			Total transect distance = 63.6 m.
0	7.5	*Melilotus indica*	60		
		Hordeum murinum	5		
		Picris echiodes	2		
		Polypogon monspeliensis	10		
		Unknown grass #1	25		
7.5	13	*Melilotus indica*	10	0.1	
		Scirpus robustus	10	0.2	
		Typha latifolia	10	0.3	
		Salicornia virginica	2	0.1	
		Edge Pool Species	5	0.1	Approx. 3 species. Too small to I.D.
		Crypsis vaginiflora	2	0.02	
		Lythrum hyssopifolium	2	0.05	
		Bare Ground	50		
		Polypogon monspeliensis	5	0.03	
13	63.6	Open water			
% Bare ground in vegetated section of transect:			**21%**		

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
2001 SURVEY #2, 26-Apr-01					
Pond 1					Depth at staff = 1.76 ft.
T1-1		**Transect location = 94 degrees E. from rebar**			Total transect distance = 77.2 m.
0	7	*Melilotus indica*	10	0.2	
		Bare ground	10		
		Crypsis vaginiflora	25	0.02	
		Anagallis arvensis	5	0.05	
		Cotula coronopifolia	15	0.02	
		Plantago lanceolata	35	0.02	
7	11	Bare ground	95		
		Cynodon dactylon	5	0.01	
11	77.2	Open water			
% Bare ground in vegetated section of transect:			**41%**		
T1-2		**Transect location = 244 degrees W. from rebar**			Total transect distance = 73 m.
0	15.9	*Atriplex triangularis*	2		
		Plantago lanceolata	20		
		Frankenia salina	5		
		Melilotus indica	10		No flower
		Spergularia marina	10		Purple
		Bare ground	45		
15.9	73	Open water			
% Bare ground in vegetated section of transect:			**45%**		
Pond 2					Depth at staff = 2.29 ft.
T2-1		**Transect location = 238 degrees SW from rebar**			Total transect distance = 85 m.
0	12.3	*Melilotus indica*	50	0.5	
		Anagalis arvensis	5	0.05	
		Plantago lanceolata	5	0.05	
		Taraxicum officinale	2	0.1	
		Cotula coronopifolia	2	0.05	
		Nassella spp.	3	0.2	
		Cyperus involucrata	3	0.2	
		Genista monspessulana	5	0.1	
		Gnaphalium spp.	1	0.05	
		Lythrum hyssopifolim	1	0.05	
		Cynodon dactylon	3	0.02	
		Bare ground	10		
		Geranium dissectum	1		
12.3	19.5	*Cyperus involucrata*	1		
		Cynodon dactylon	10		
		Unknown sp.	10		
		Bare Ground	79		
19.5	85	Open water			
% Bare ground in vegetated section of transect:			**35%**		
T2-2		**Transect location = 340 degrees N. from rebar**			Total transect distance = 88 m.
0	14	*Hordeum brachyantherum*	5		
		Vulpia myuros	5		
		Hordeum murinum ssp. glaucum	5		
		Melilotus indica	65		
		Genista monspessulana	15		
		Plantago lanceolata	5		
14	36.5	*Genista monspessulana*	5		
		Plantago lanceolata	5		
		Cotula coronopifolia	5		
		Lythrum hyssopifolia	20		
		Unknown sp.	20		
		Bare ground	45		
36.5	88	Open water			
% Bare ground in vegetated section of transect:			**28%**		

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m) Start	End	Species	Percent cover	Height (m)	Comments
Pond 3					Depth at staff = 1.30 ft.
T3-1		**Transect location =310 degrees NW from rebar**			Total transect distance = 50.9 m.
0	11	*Hordeum murinum ssp. glaucum*	25	0.1	
		Hordeum brachyantherum	25	0.5	
		Lolium perenne	25	0.3	
		Melilotus indica	15	0.3	
		Bromus hordeaceus	5	0.2	
		Genista monspessulana	5		
11	19	*Melilotus indica*	5		
		Unknown grass	10		
		Scirpus robustus	15	0.2	
		Typha latifola	10	0.2	
		Hordeum murinum glaucum	5		
		Cotula coronopifolia	10		
		Bare ground	35		
19	50.9	Open water			
% Bare ground in vegetated section of transect:			**6%**		
T3-2		**Transect location = 94 degrees E from rebar**			Total transect distance = 63.6 m.
0	7.4	*Vulpia myuros*	20		
		Hordeum brachyantherum	20		
		Picris echiodes	5		
		Lupinus spp.	5		
		Genista monspessulana	5		
		Lolium perenne	15		
		Bromus hordeaceus	5		
		Geranium dissectum	20	0.1	
7.4	Unv**	*Melilotus indica*	10		
		Plantago lanceolata	10		
		Scirpus robustus	10		
		Cotula coronopifolia	10		
		Unknown grass	5		Small *Polypogon* spp.?
		Salicornia virginica	5		
		Bare Ground	50		
	63.6	Open water			
% Bare ground in vegetated section of transect:					

Table 8
Seasonal Wetland and Pond Vegetation Transects, 2000-2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Distance (m)			Percent	Height	
Start	**End**	**Species**	**cover**	**(m)**	**Comments**
2000 Survey, 2-Nov-00					
		Transect location = continuation of tidal wetland Transect V3 (see Figure 2)			
0	168.6				Tidal wetland -- See Table 8.
168.6	200	*Plantago coronopus*	10		
		Frankenia salina	1		Road to edge of pond 2
		Genista monspessulana	5		
		Melilotus indica	5		
		Picris echiodes	1		
		Bare ground	80		
		Heliotropium curassavicum	1		
200	217	Bare ground	70		
		Plantago coronopus	5		
		Lythrum hyssopifolium	5		
		Crypsis vaginiflora	20		
217	290	Pond/ Open water	60		pond w/ water 230-255
		Bare ground	38		
		Crypsis vaginiflora	2		
290	331	*Lythrum hyssopifolium*	10		to edge of algae matting
		Scirpus robustus	5		
		Crypsis vaginiflora	10		
		Bare ground	75		
331	380	*Plantago coronopus*	70		Species to fence
		Melilotus indica	10		
		Picris echioedes	2		
		Salsola tragus	1		
% Bare ground in vegetated section of transect:			**25%**		

Notes:

* The rebar at T2 which indicates transect start could not be found, so the transect is based on angle and distance from staff gauge consistent with previous transect surveys.

** Unverified.

*** 2006 surveys conducted by the Watershed Nursery, all prior surveys by Vir McCoy.

Table 9
Seasonal Wetland Vegetation Percent Cover Summary, 2001 – 2003, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

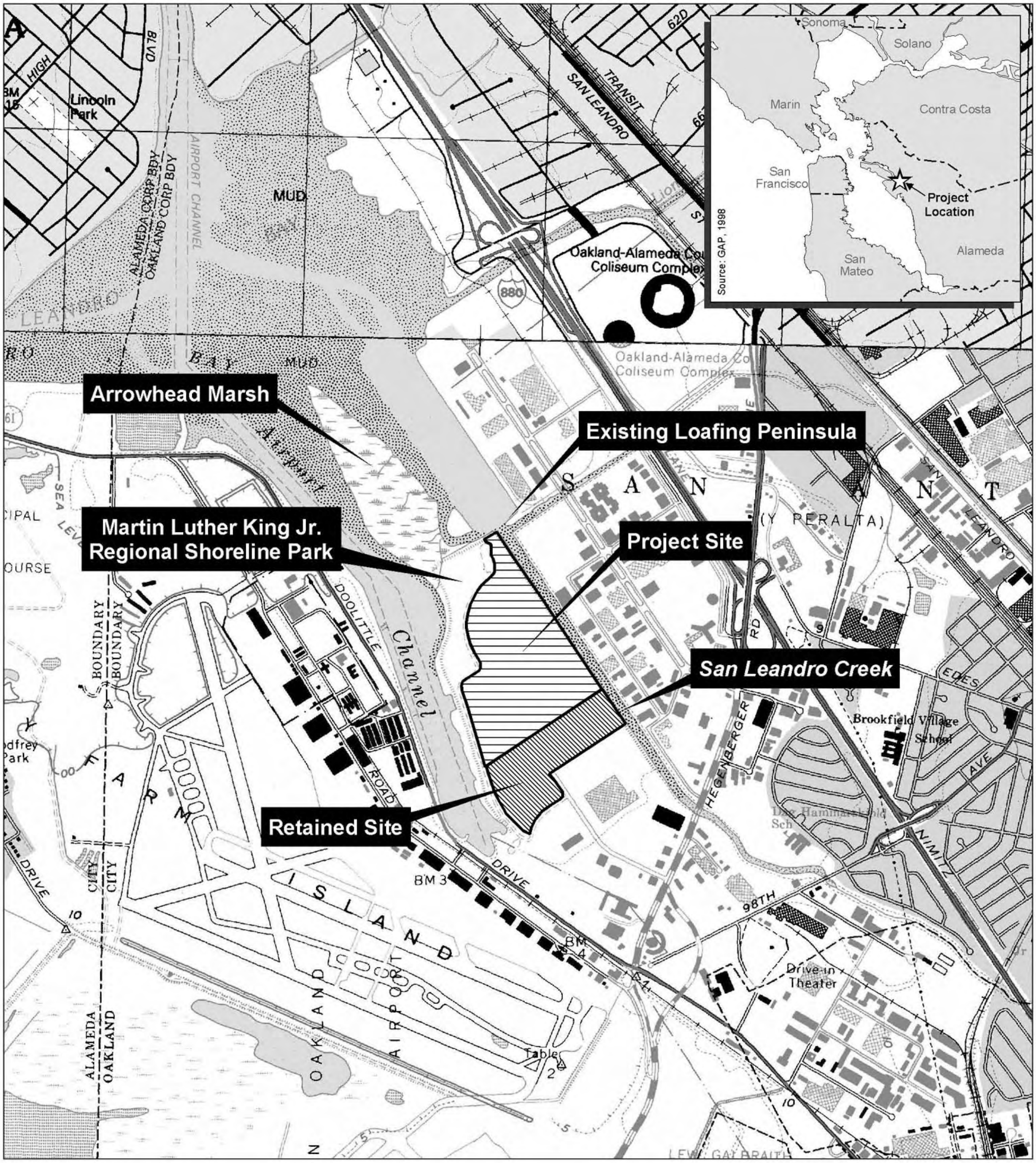
	Percent cover outside ponds			
Transect	**2006**	**2003**	**2002**	**2001***
T1-1	**100%**	**67%**	**41%**	**54%**
T1-2	**83%**	**53%**	**15%**	**50%**
T2-1	**100%**	**92%**	**29%**	**69%**
T2-2	**95%**	**94%**	**62%**	**73%**
T3-1	**99%**	**85%**	**76%**	**97%**
T3-2	**68%**	**76%**	**68%**	**79%**

Note: Surveys performed on May 5, 2006; May 14, 2003; April 24, 2002; March 22, 2001; April 26, 2001.
* 2001 values are averaged from the two 2001 surveys.

Table 10
Relative Shorebird Use of Habitat Sub-areas at the Project, 1998-2003.
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California

Tidal Stage	Intertidal Pond	Marsh Plain	Channels	Islands	Seasonal Ponds
Incoming	high	high	low	low	low
High	moderate	moderate	low	moderate	moderate
Outgoing	moderate	high	low	low	low
Low	low	low	low	low	low

Figures

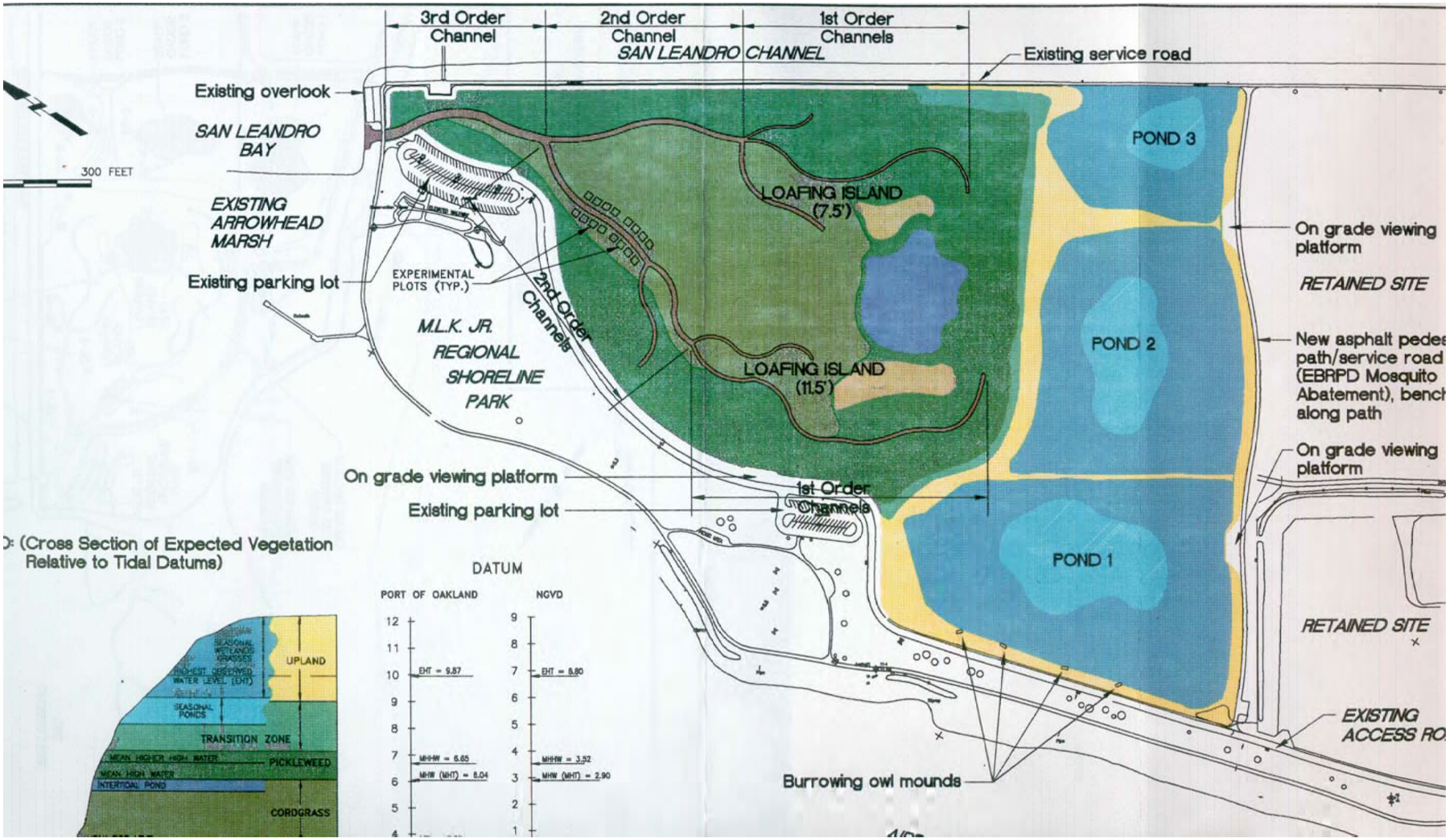


Data Sources: USGS (San Leandro & Oakland East Quads), 1959 & 1996
Map File: Site_1044_LT-P_010204.mxd

WETLANDS AND WATER RESOURCES

SITE VICINITY MAP
MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

September 2004	Project No. 1044	**Figure 1**

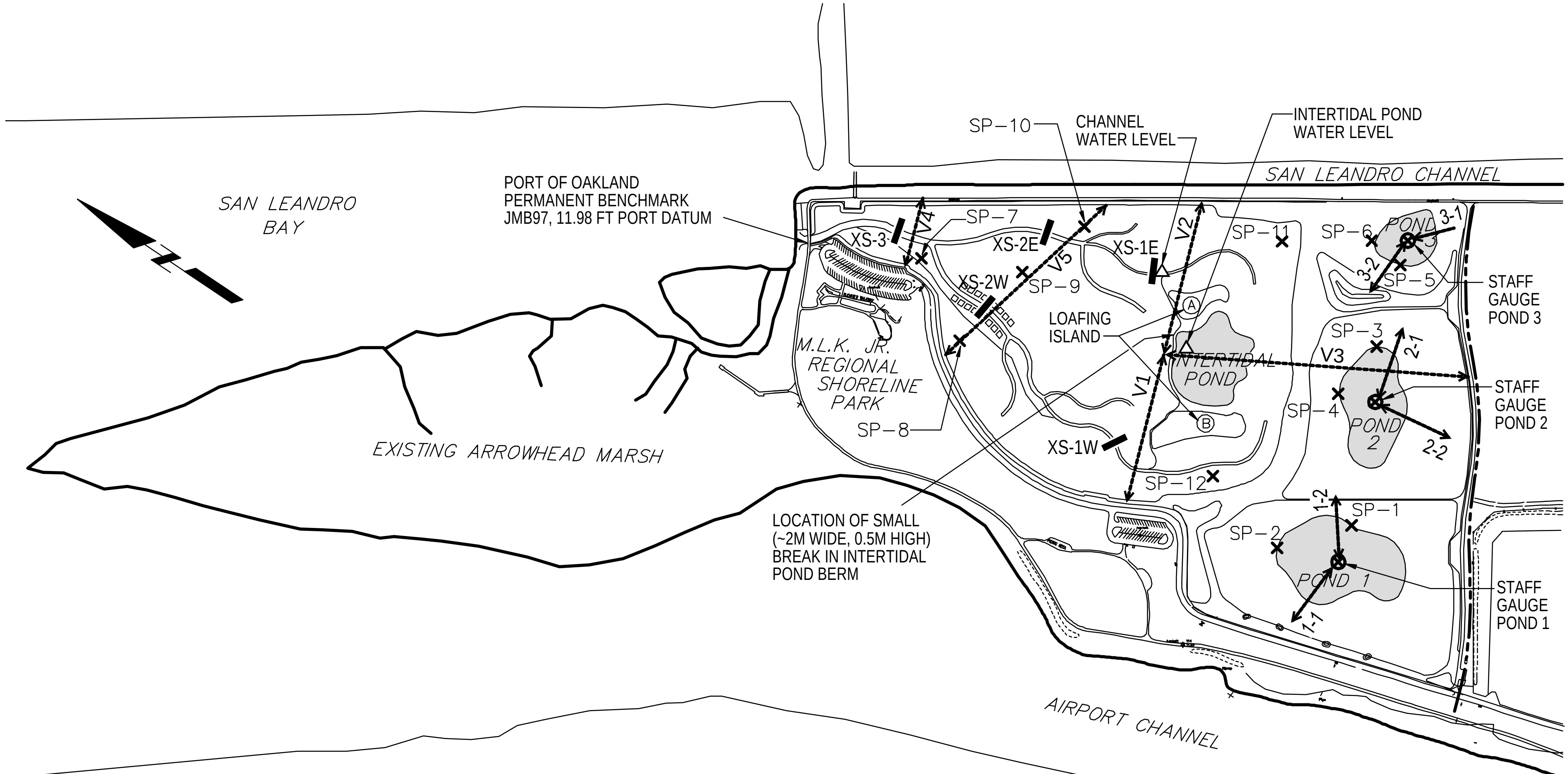


WETLANDS AND WATER RESOURCES

RESTORATION DESIGN

MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

September 2004	Project No. 1044	Figure 2



LEGEND

- Property line
- SP−1 ✕ Sedimentation pin
- XS-3 Cross-section locations
- ⊗ Staff gauge location
- V4 Vegetation transect line
- △ Water level measurement location

All elevations relative to Port of Oakland
Datum, which is 3.20 feet below NGVD

*Original Figure Courtesy of Levine-Fricke LFR

0 600 FEET

WETLANDS AND
WATER RESOURCES

SITE PLAN

MLK Jr. Regional Shoreline Wetlands Project
Oakland, California
East Bay Regional Park District

September 2004	Project No.1044	Figure 3

1044_MLK-5yr_Fig3_2004-0902.ai

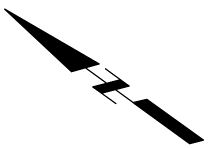
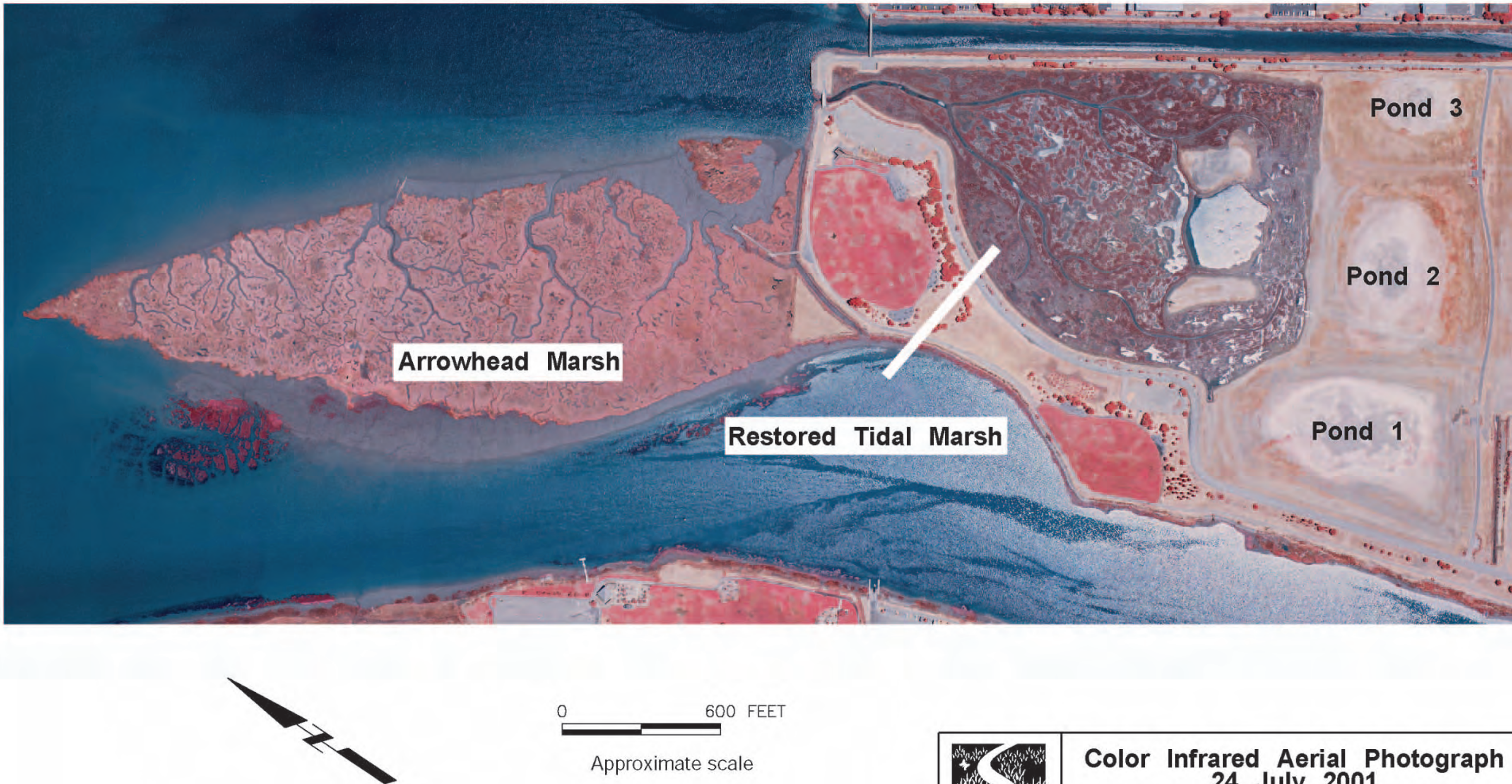


Photo courtesy of Spartina Control Group, California State Coastal Conservancy
Orthorectification courtesy of San Francisco Estuary Institute

WETLANDS AND WATER RESOURCES

Color Infrared Aerial Photograph
25 September 2000
MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

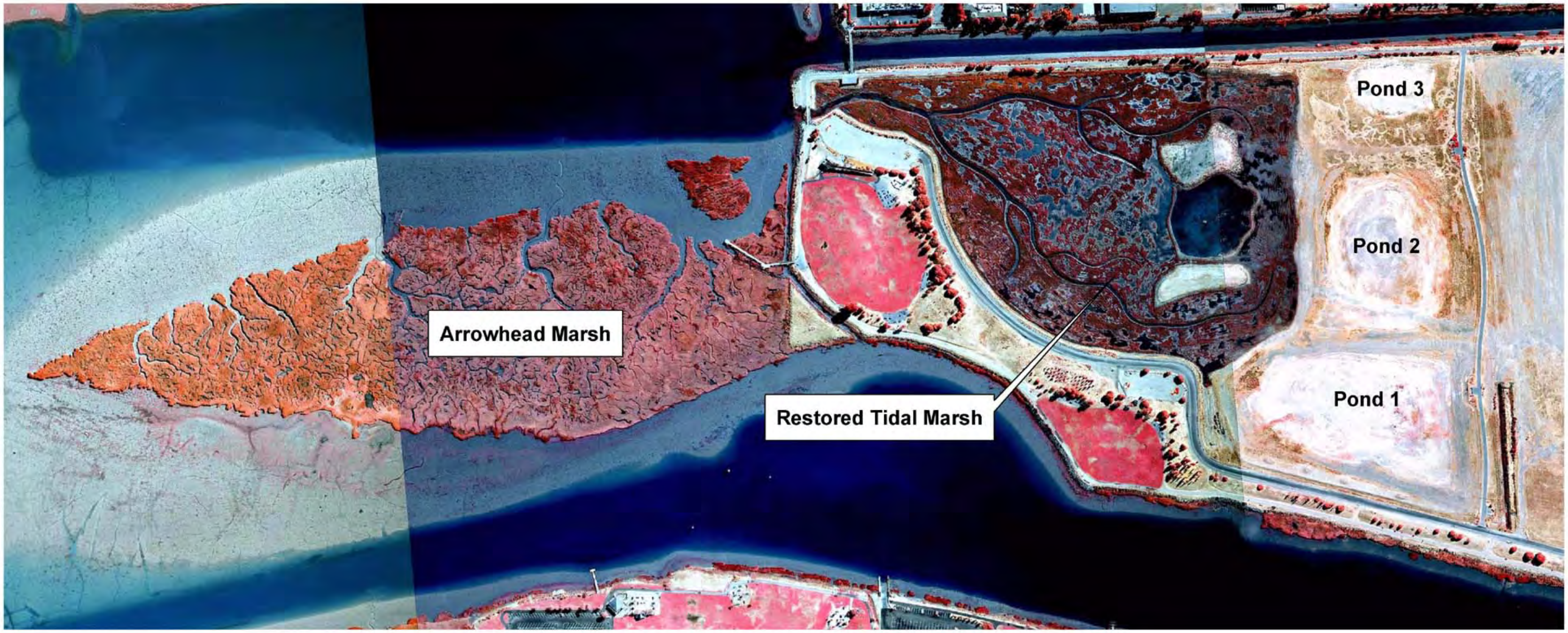
September 2004	Project No.1044	Figure **4**



Color Infrared Aerial Photograph
24 July 2001

MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

September 2004	Project No.1044	Figure **5**



N

0 162.5 325 Meters

1:7,800 (1" = 650', at Letter-size)

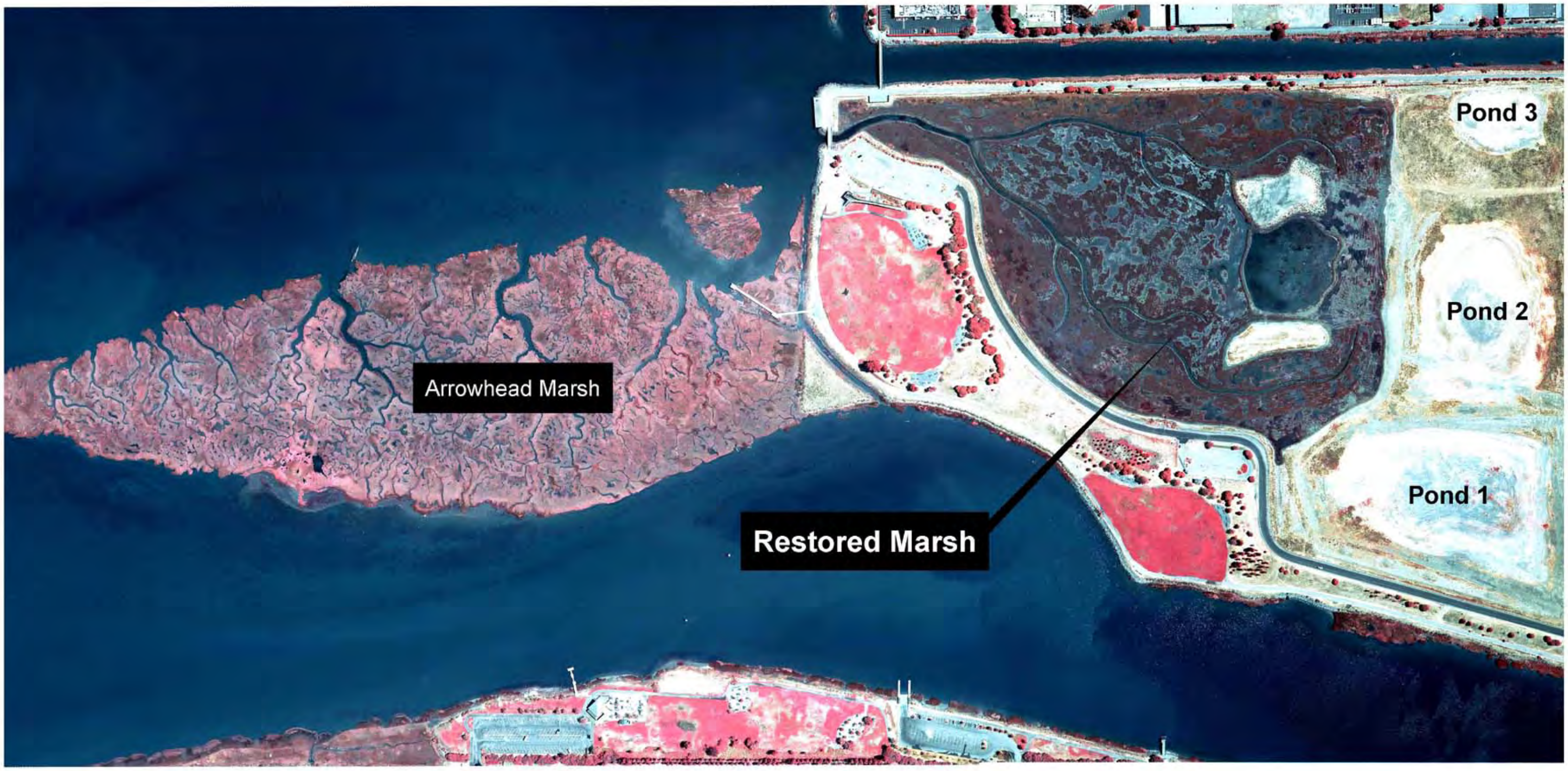
0 325 650 1,300 Feet

Data Sources: Air Flight Service (photo date 08/26/02)
Map File: Figure-12_02_1044_11-22-02.mxd

WETLANDS AND WATER RESOURCES

COLOR INFRARED AERIAL PHOTOGRAPH
26 AUGUST 2002
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California
East Bay Regional Park District

September 2004	Project No. 1035	**Figure 6**



N

0 100 200 300 Meters

1:7,200 (1in = 600ft, at Letter-size)

0 300 600 1,200 Feet

Data Sources: WWR, 2003; HJW (photo date 08/29/03)
Map File: Photo-Map_1044_A-L_111003.mxd

WETLANDS AND WATER RESOURCES

COLOR INFRARED AERIAL PHOTOGRAPH 19 AUGUST 2003

Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California
East Bay Regional Park District

September 2004	Project No. 1044	**Figure 7**

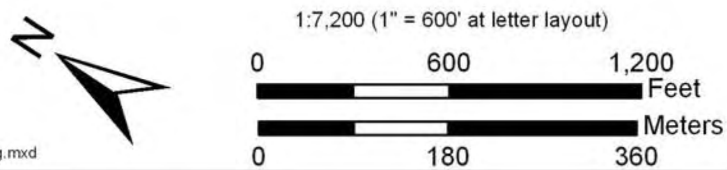


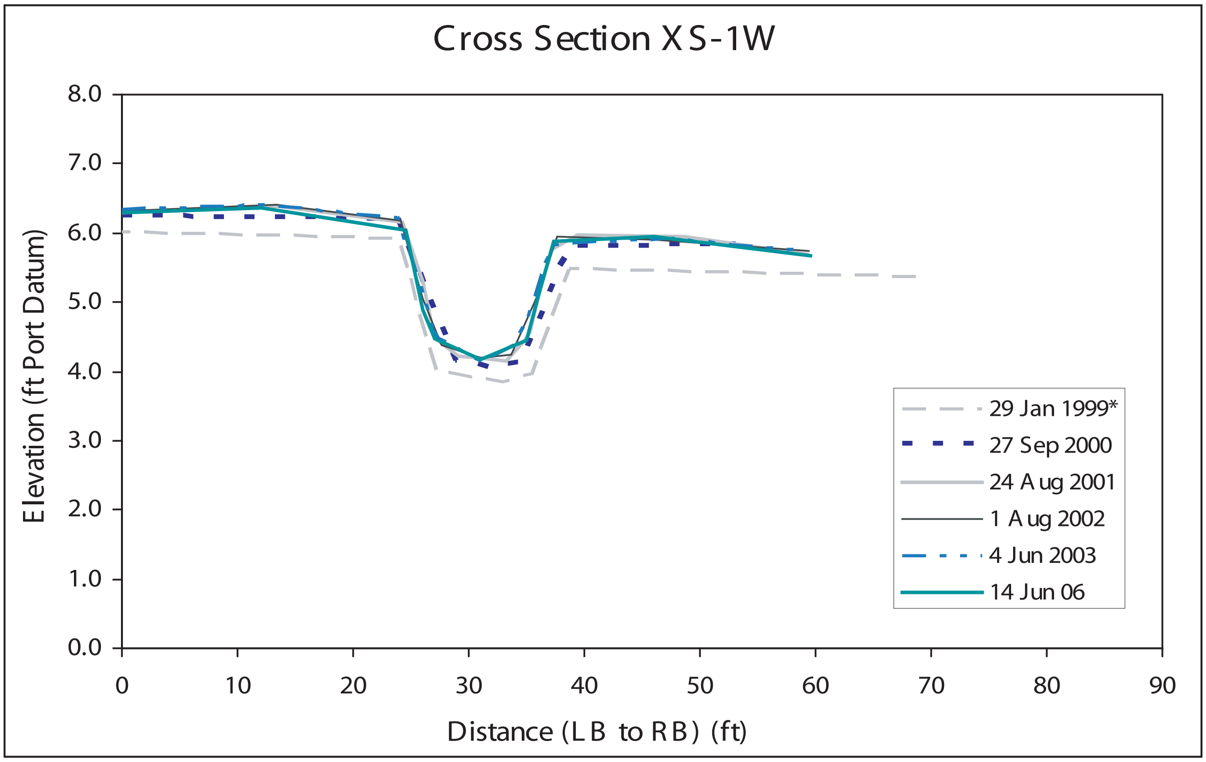
Photo source: HJW (2006)
Map file: 2006-air-photo_1044_2007-0204dg.mxd

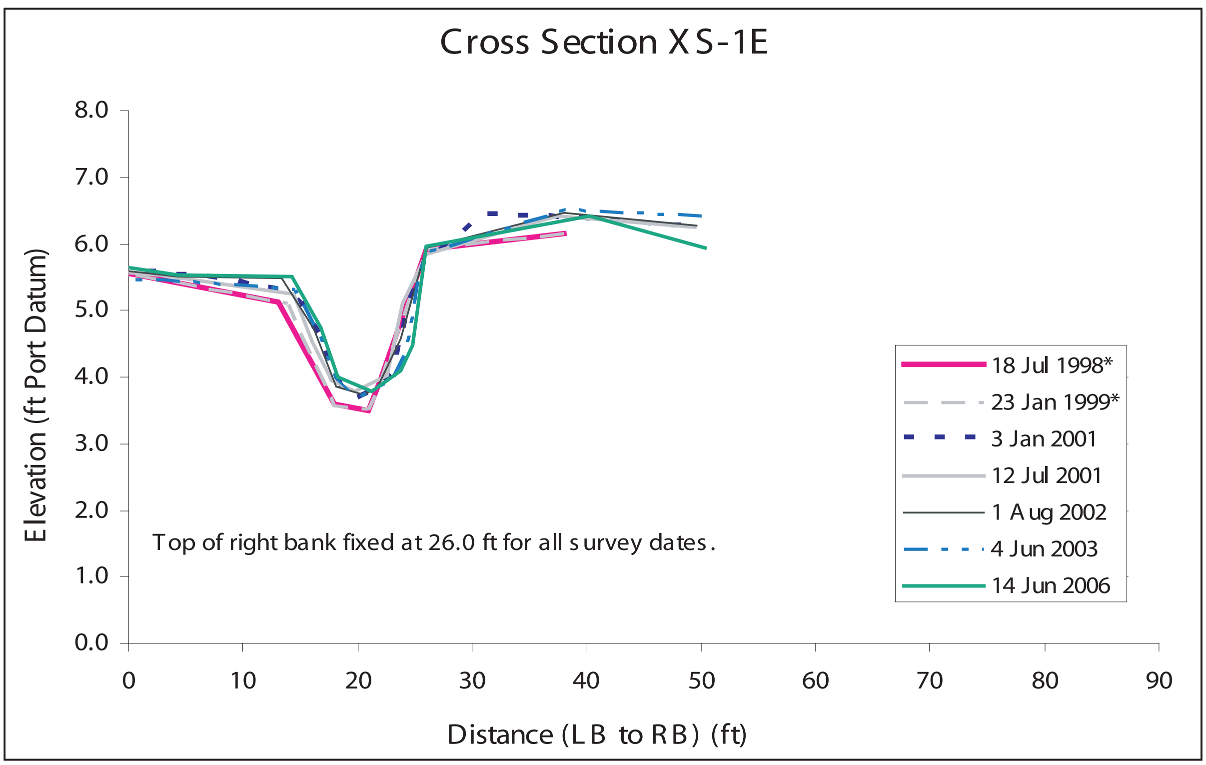
WETLANDS AND WATER RESOURCES

COLOR INFRARED AERIAL PHOTOGRAPH
12 SEPTEMBER 2006

Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California
East Bay Regional Park District

January 2007	Project No. 1044	**Figure 8**





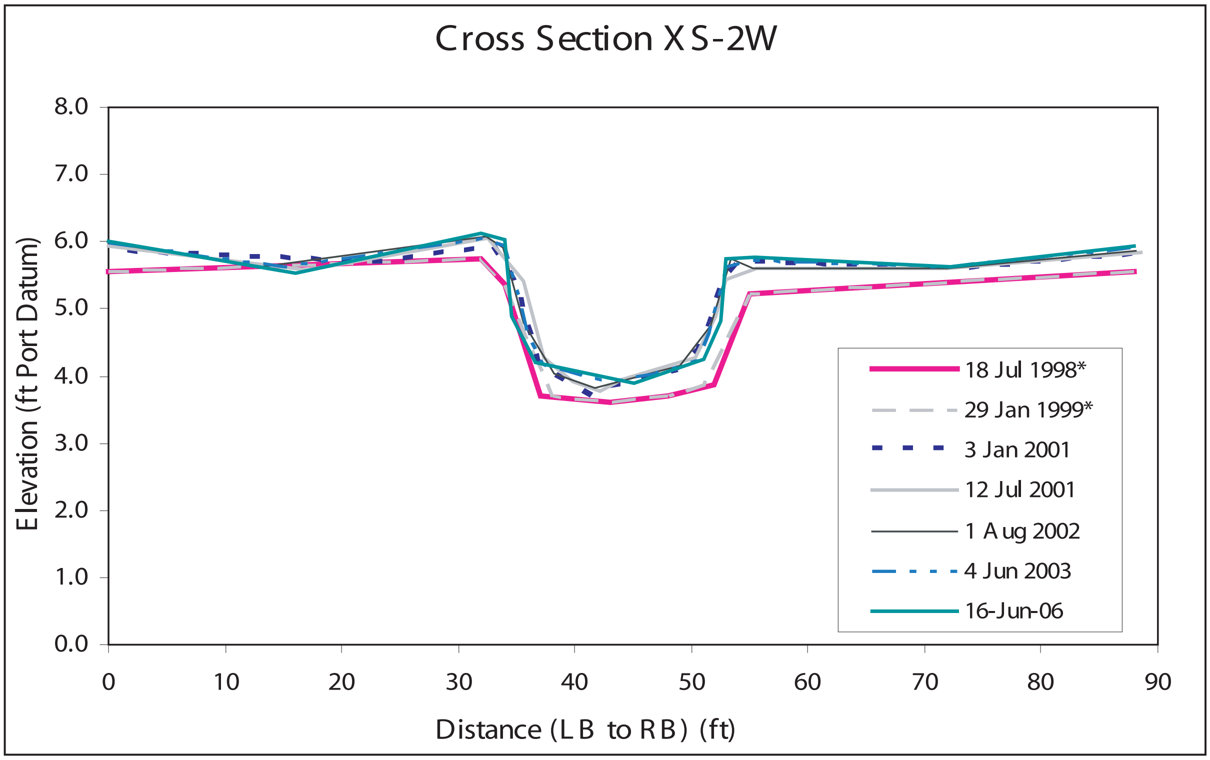
Notes: * Previous surveys from LFR 1999a. Data not validated.

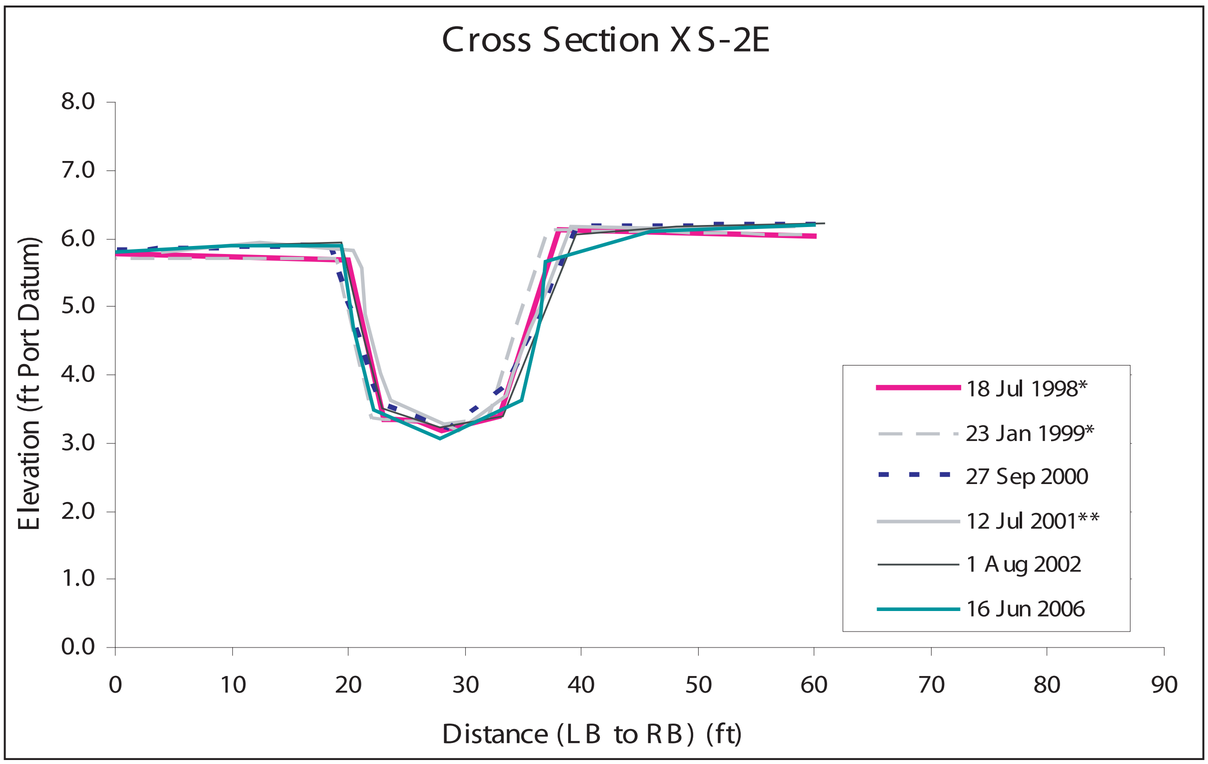
WETLANDS AND WATER RESOURCES

FIRST-ORDER CHANNEL CROSS SECTIONS, 1998-2003, 2006

MLK Jr. Regional Shoreline Wetlands
East Bay Regional Park District

January 2007	Project No. 1044	Figure 9





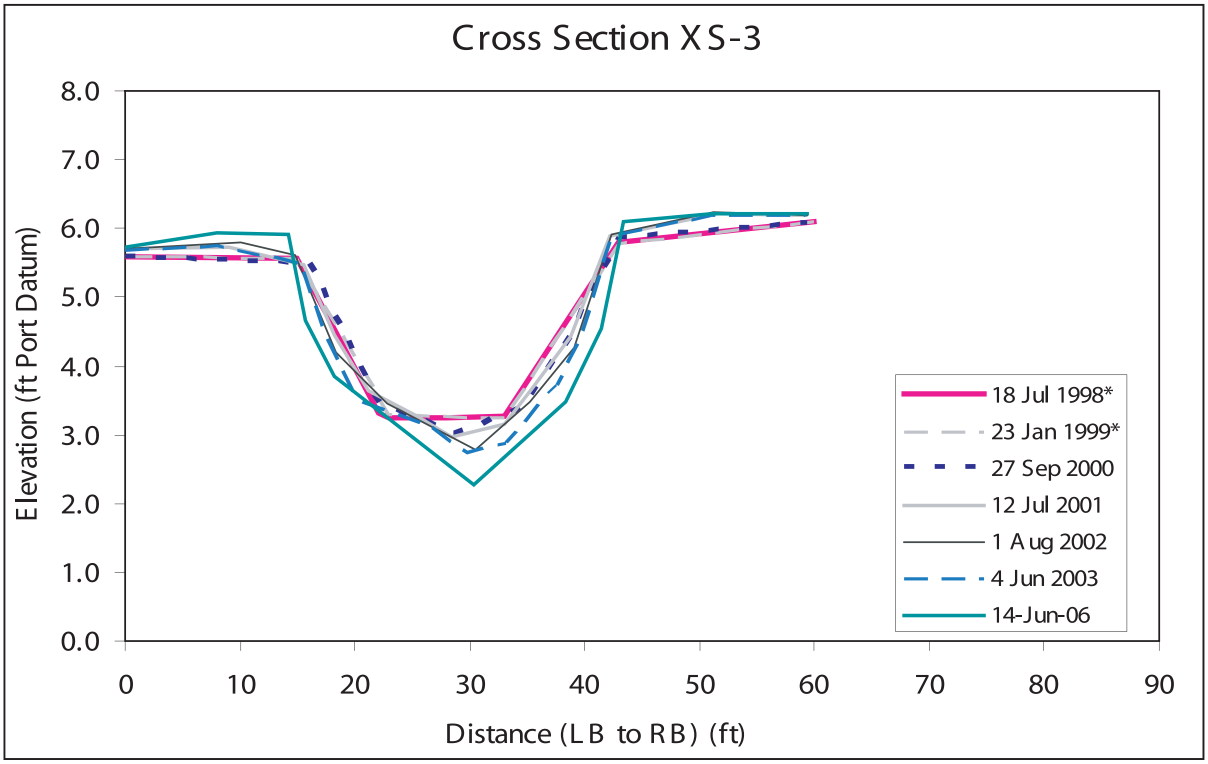
Notes: * Previous surveys from LFR 1999a. Data not validated.

WETLANDS AND WATER RESOURCES

SECOND-ORDER CHANNEL CROSS SECTIONS, 1998-2003, 2006

MLK Jr. Regional Shoreline Wetlands
East Bay Regional Park District

January 2007	Project No. 1044	Figure 10



Notes: * Previous surveys from LFR 1999a. Data not validated.

WETLANDS AND WATER RESOURCES

THIRD-ORDER CHANNEL CROSS SECTION, 1998-2003, 2006

MLK Jr. Regional Shoreline Wetlands
East Bay Regional Park District

January 2007	Project No. 1044	Figure 11

2003 Air Photo, No Overlay
Photo Date: 08/29/03

1998 vs 2003 Channel Networks
Photo Date: 08/29/03

Legend

- 1998 Channel Network
- 2003 Channel Network
- Site Boundary

Note: Channel bank from 1998 based on schematic of a different scale and with differing rectification method, therefore overlay of channel network does not provide quantitative measure of change.

1:3,000
(1in = 250ft at tabloid layout)

0 125 250 500 Feet

(Scale applies to each frame individually)

0 125 250 Meters

N

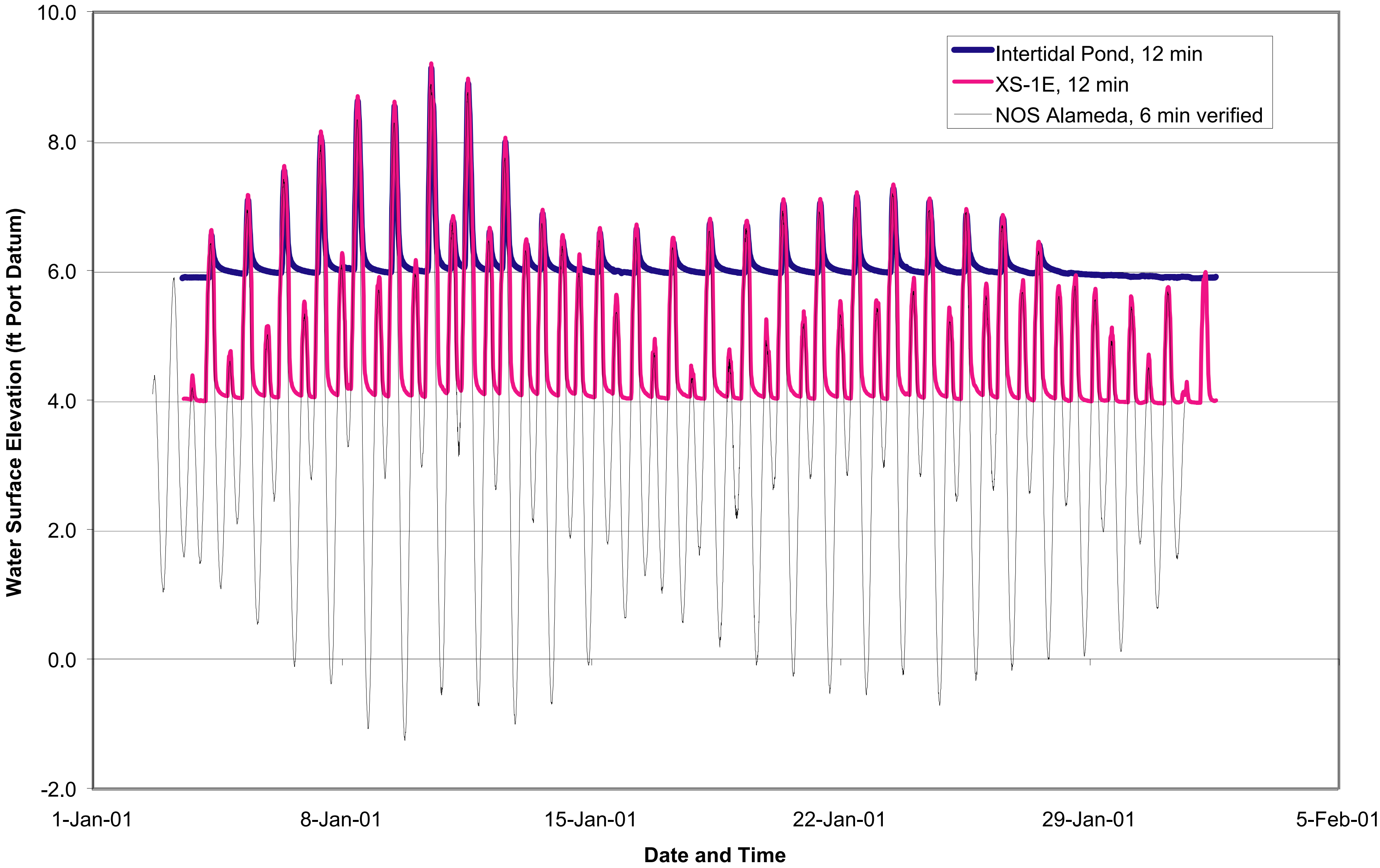
WETLANDS WATER RESOURCES

Channel Network Evolution, 1998 (construction) to 2003

Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California
East Bay Regional Park District

August 2004	Project No. 1044	**Figure** 12

Data Sources: WWR, 2003; Levine-Fricke, 1998 (published 1999)
Map File: Channels_98-03_1044_B-L_072704.mxd



Period of Data Record: Jan 3 - Feb 1, 2001

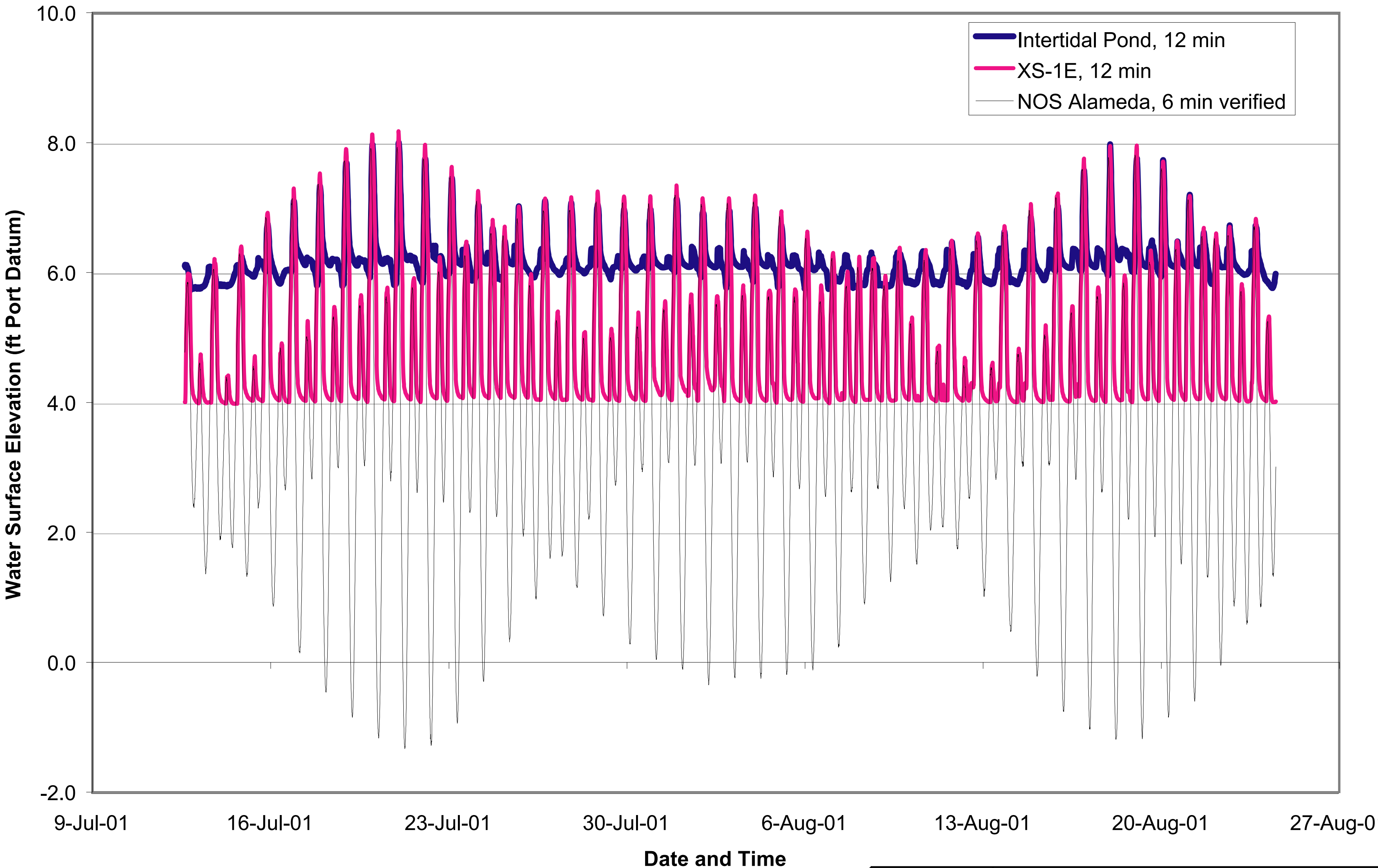
WETLANDS AND WATER RESOURCES

WATER LEVELS
January 2001

MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

September 2004	Project No.1044	Figure 13

1044 Fig 12 WaterLevels-Jan2001 2004-0902



Period of Data Record: Jul 12 - Aug 24, 2001

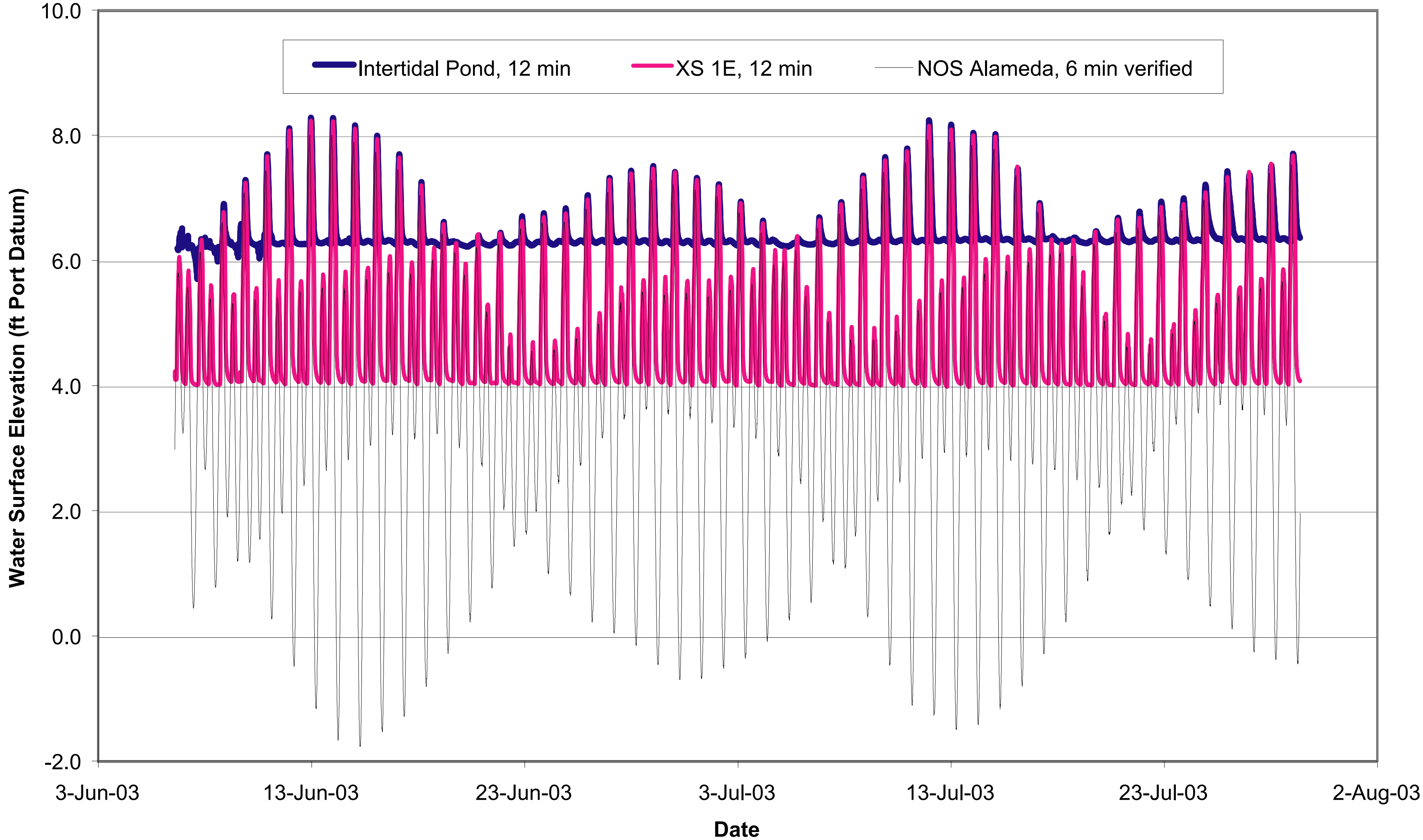
WETLANDS AND WATER RESOURCES

WATER LEVELS
July-August 2001

MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

August 2004	Project No.1044	Figure 14

1044_Fig 13_WaterLevels-JulAug2001_2004-0816



Period of Data Record: Jun 6 - Jul 29, 2003

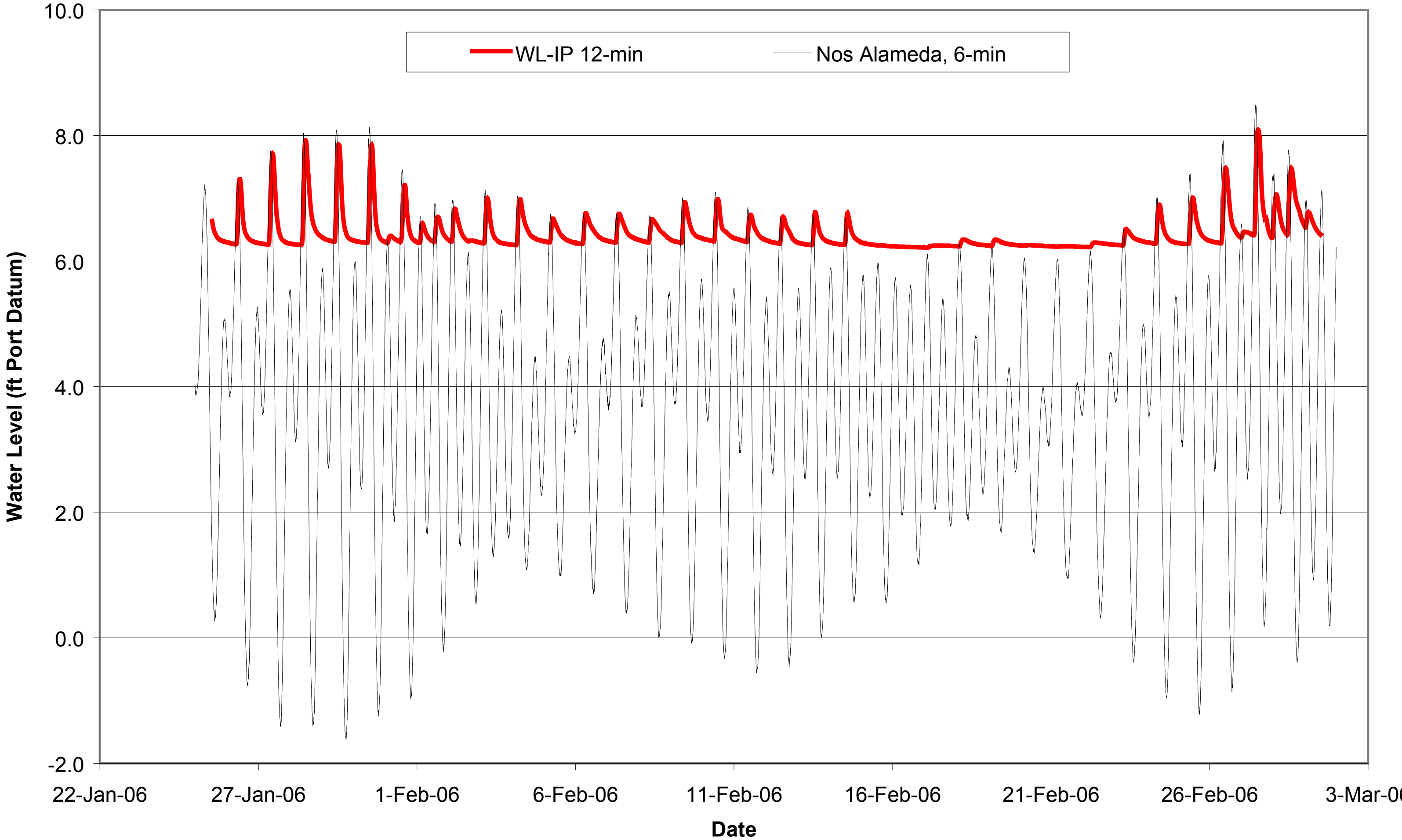
WETLANDS AND WATER RESOURCES

WATER LEVELS
June-July 2003

MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

August 2004	Project No.1044	Figure 15

1044_Fig 14_WaterLevels-JunJul2003_2004-0816



Period of Data Record: Jan 22 - Mar 1, 2006

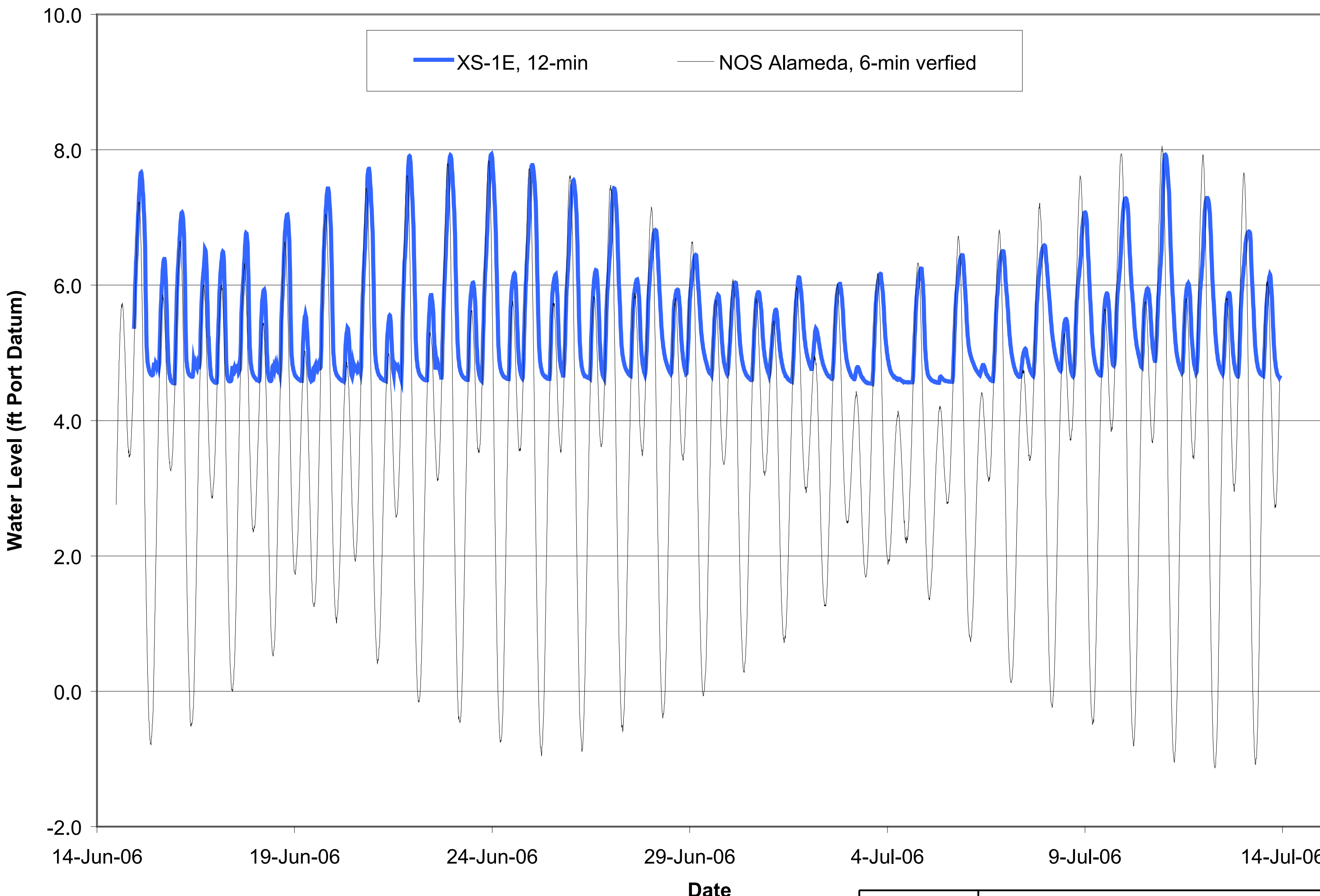
WETLANDS AND WATER RESOURCES

INTERTIDAL POND WATER LEVEL
JANUARY- MARCH 2006

MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

January 2007	Project No.1044	Figure 16

1044_Water Level Calibrations-Plots_2006-1116trc.xls



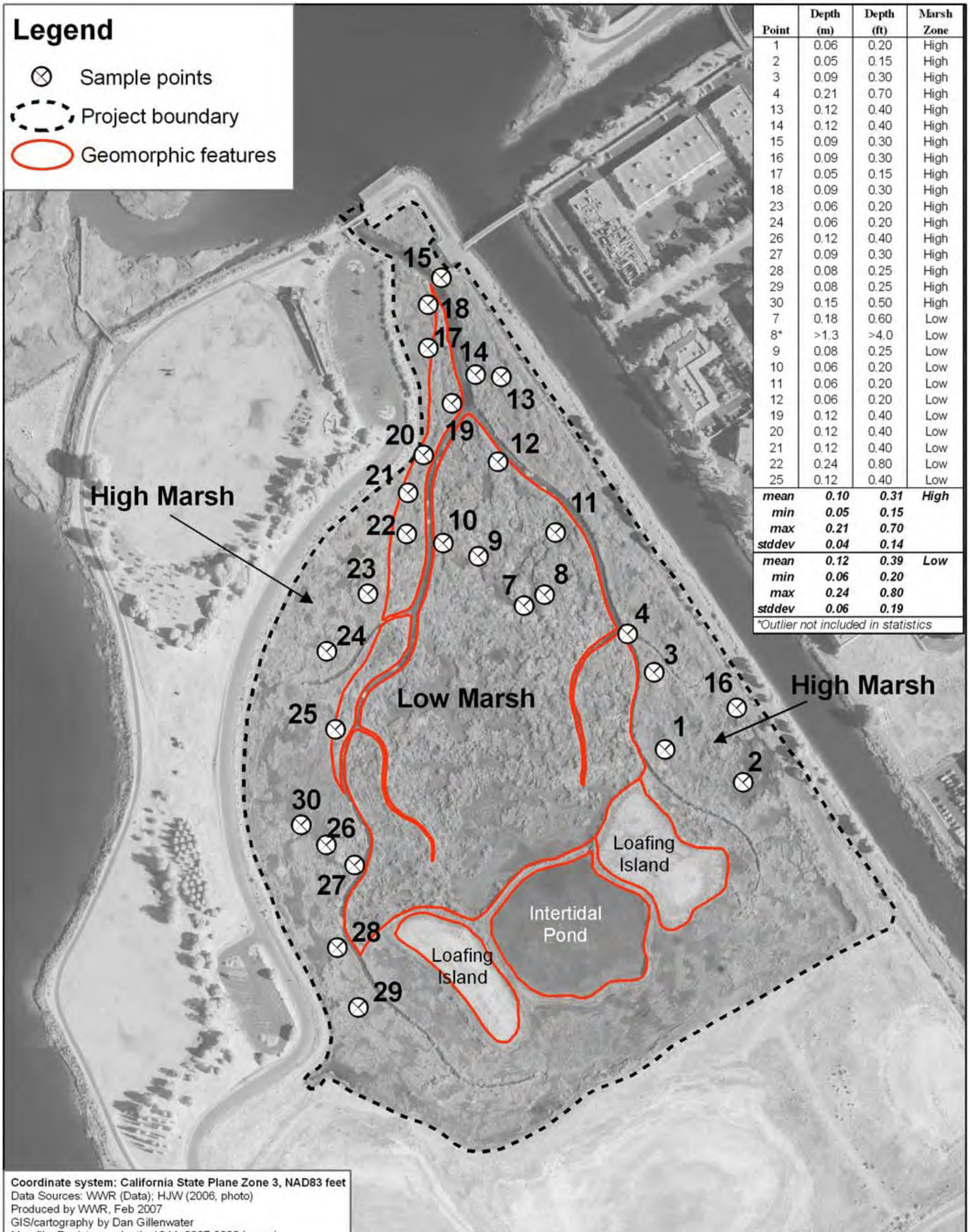
Period of Data Record: Jun 15 - Jul 12, 2006

WETLANDS AND WATER RESOURCES

CHANNEL (XS-1E) WATER LEVEL
JUNE - JULY 2006

MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

August 2004	Project No.1044	Figure 17



Point	Depth (m)	Depth (ft)	Marsh Zone
1	0.06	0.20	High
2	0.05	0.15	High
3	0.09	0.30	High
4	0.21	0.70	High
13	0.12	0.40	High
14	0.12	0.40	High
15	0.09	0.30	High
16	0.09	0.30	High
17	0.05	0.15	High
18	0.09	0.30	High
23	0.06	0.20	High
24	0.06	0.20	High
26	0.12	0.40	High
27	0.09	0.30	High
28	0.08	0.25	High
29	0.08	0.25	High
30	0.15	0.50	High
7	0.18	0.60	Low
8*	>1.3	>4.0	Low
9	0.08	0.25	Low
10	0.06	0.20	Low
11	0.06	0.20	Low
12	0.06	0.20	Low
19	0.12	0.40	Low
20	0.12	0.40	Low
21	0.12	0.40	Low
22	0.24	0.80	Low
25	0.12	0.40	Low
mean	***0.10***	***0.31***	***High***
min	***0.05***	***0.15***	
max	***0.21***	***0.70***	
stddev	***0.04***	***0.14***	
mean	***0.12***	***0.39***	***Low***
min	***0.06***	***0.20***	
max	***0.24***	***0.80***	
stddev	***0.06***	***0.19***	

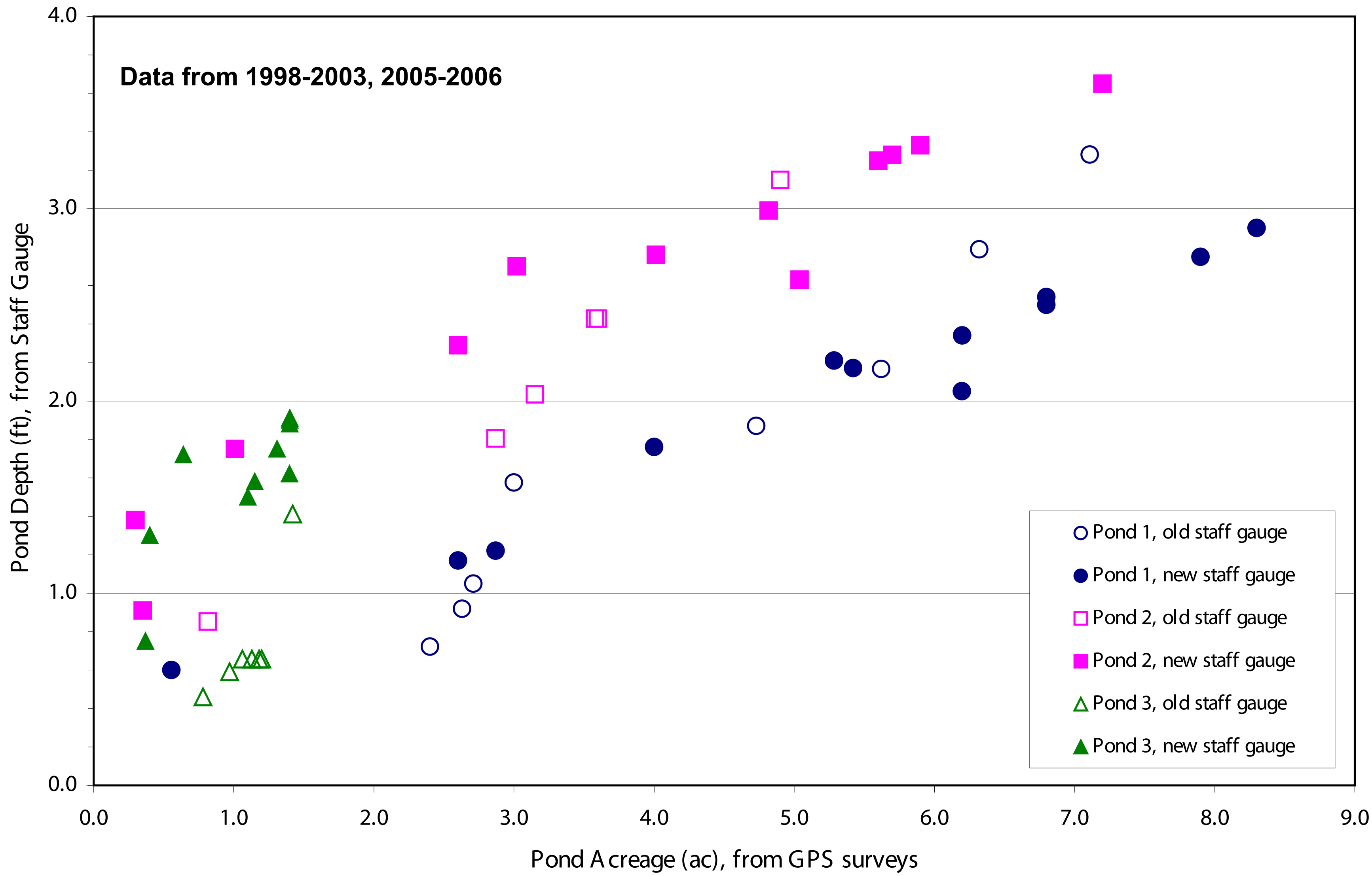
**Outlier not included in statistics*

WETLANDS AND WATER RESOURCES

DEPTH TO RESISTANCE MEASUREMENTS

Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California
East Bay Regional Park District

January 2007 | Project No. 1044 | **Figure 18**



WETLANDS AND WATER RESOURCES

STAGE-AREA CURVES
Seasonal Ponds

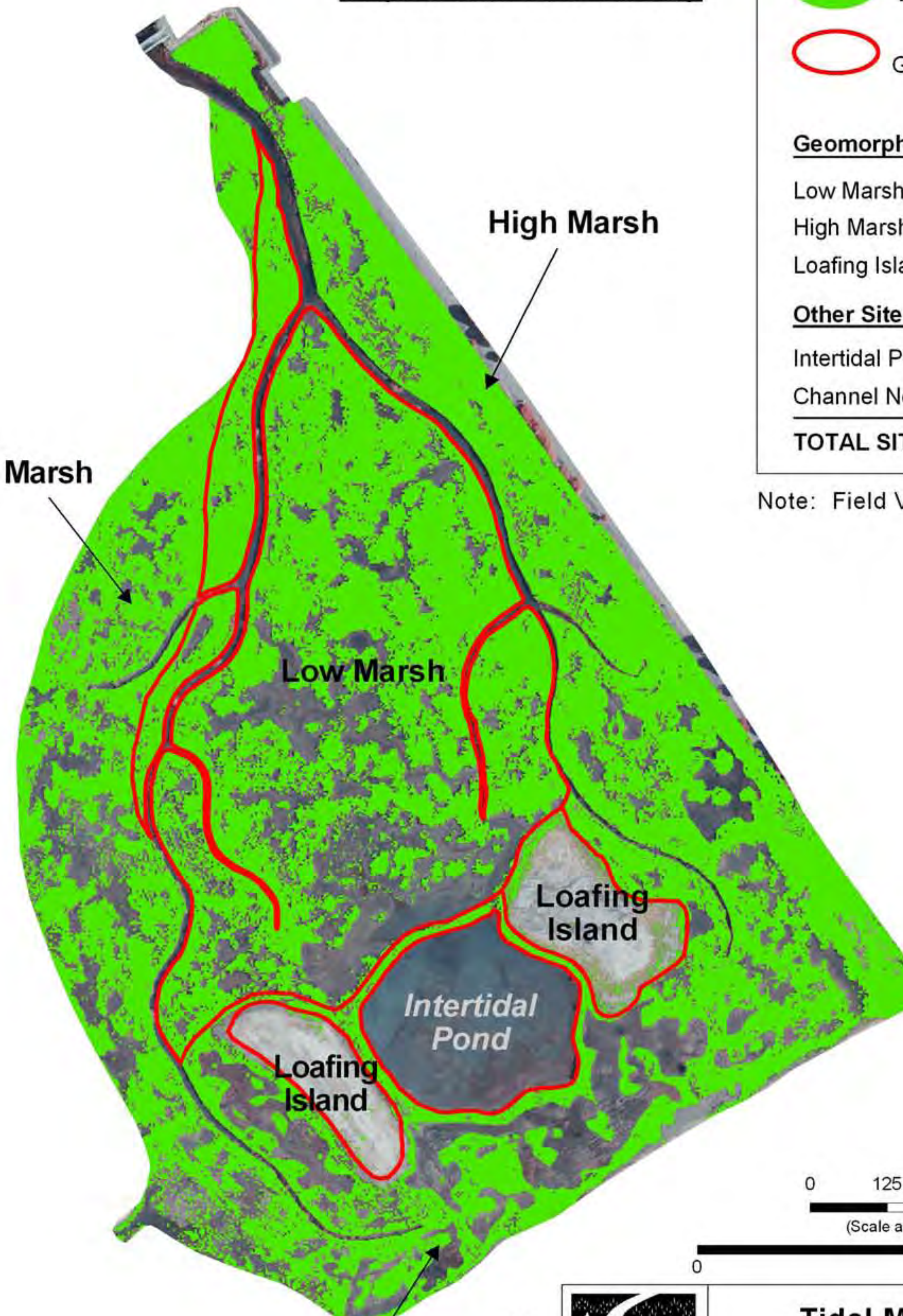
MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

January 2007	Project No.1044	Figure 19

Photo Used in Data Digitization
Photo Date: 09/12/06

Data Sources: WWR, 2003; HJW (photo date 09/12/2006)
Map File: Vegetation06_1044_B-L_2006-1112dg.mxd.mxd

Vegetation Data Overlay



Legend

Vegetation Cover 2006

Geomorphic Features

Geomorphic Feature	Acres	% Vegetation Cover
Low Marsh, Topographic	11.42	68.2% (7.79 ac.)
High Marsh, Topographic	19.03	69.3% (13.19 ac.)
Loafing Islands	1.87	0.1% (0.20 ac.)
Other Site Features		
Intertidal Ponds	1.77	
Channel Network	1.37	
TOTAL SITE AREA	35.46	59.7% (21.18 ac.)

Note: Field Verification: 11/05/06

1:3000

0 125 250 500 Feet

(Scale applies to each frame individually)

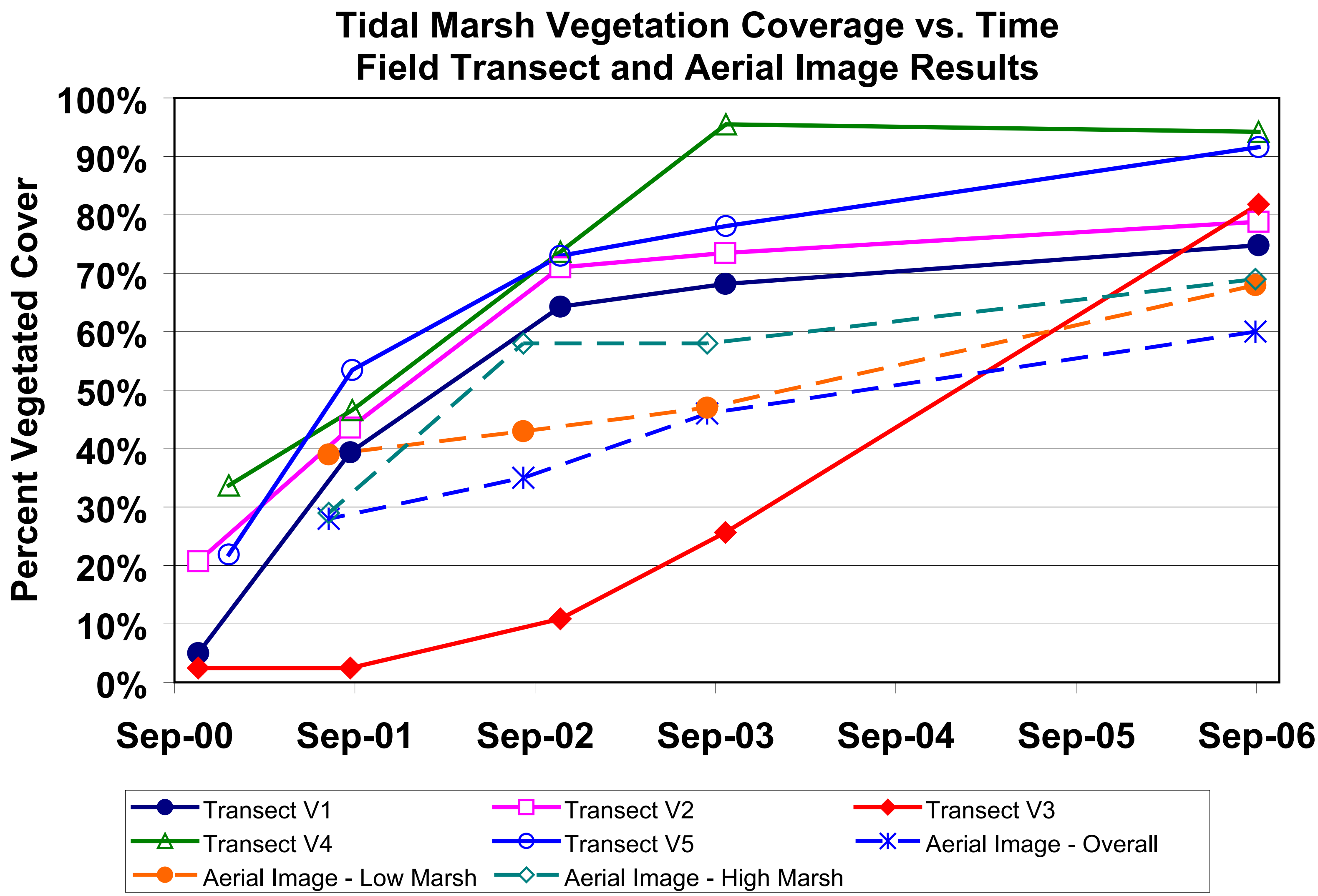
0 125 250 Meters

N

WETLANDS AND WATER RESOURCES

Tidal Marsh Vegetation Map, 2006
Martin Luther King Jr. Regional Shoreline Wetlands Project
Oakland, California
East Bay Regional Park District

November 2006 | Project No. 1044 | Figure 20

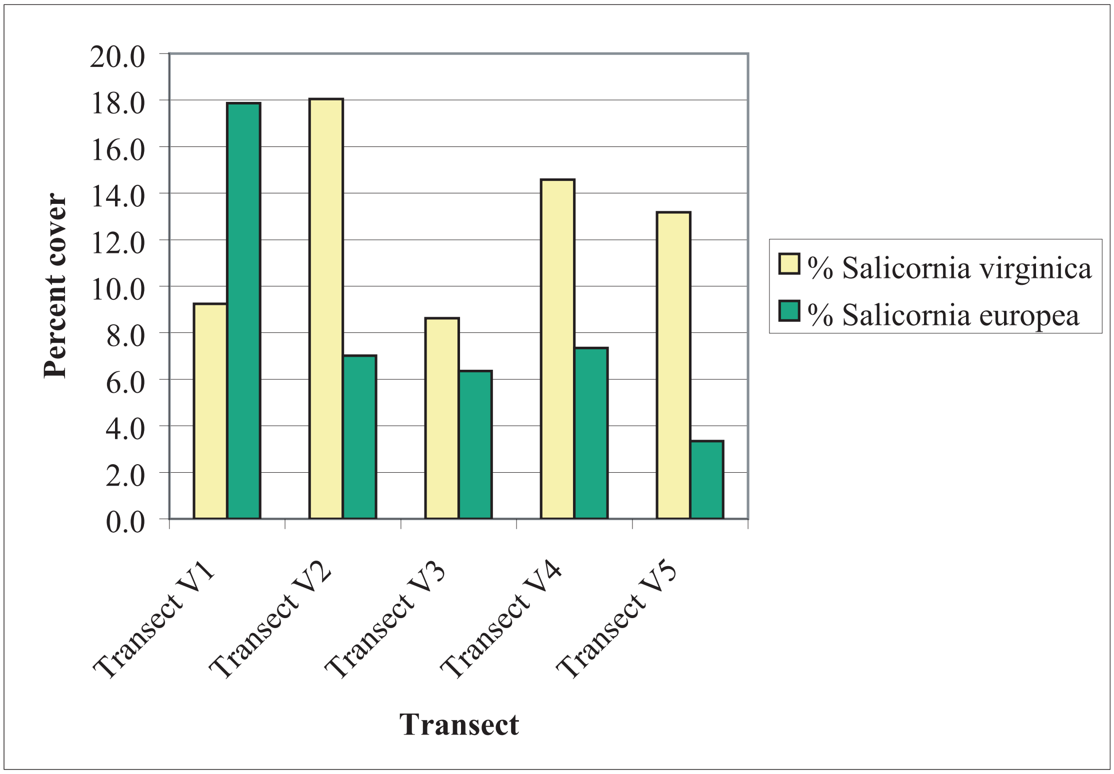


WETLANDS AND WATER RESOURCES

Tidal Marsh Vegetation Cover vs. Time
Transect and Aerial Image Results 2000 - 2006
MLK Jr. Regional Shoreline Wetlands Project
East Bay Regional Park District

January 2007	Project No.1044	Figure 21

1044_Year-8_Monitoring_Report_2007-0129trc.xls



WETLANDS AND WATER RESOURCES

ANNUAL vs. PERINNIAL *Salicornia*

TIDAL MARSH TRANSECTS

MLK Jr. Regional Shoreline Wetlands
East Bay Regional Park District

January 2007	Project No. 1044	Figure 22

Appendices

Appendix A – Vegetation Species List

Appendix A
Vegetation Species List, 2000-2006
MLK Jr. Regional Shoreline Wetlands Project
Oakland, California

Family	Species	Common Name	Habitat Type	2000	2001	2002	2003	2006
Apiaceae	*Foeniculum vulgare*	Sweet Fennel	S	X				
Asteraceae	*Carduus pychnocephalus*	Italian Thistle	S	X				
	Centaurea solstitialis	Yellow Star-thistle	S	X				
	Conyza bonariensis	South American Horseweed	S	X				
	Conyza canadensis	Horseweed	S	X				
	Cotula coronopifolia	Brass-Buttons	T,S	X				
	Gnaphaleum palustre	Lowland Cudweed	S	X				
	Grindelia stricta* var. *angustifolia	Marsh Gumplant	T	X				
	Hemizonia pungens ssp. maritima	Common Spikeweed	S	X				
	Jaumea carnosa	Fleshy Jaumea	T	X				
	Picris echioides	Bristly Ox-Tongue	S	X				
	Sonchus spp.	Sow Thistle	S		X			
	Taraxacum officinale	Common Dandelion	S		X			
Boraginaceae	***Heliotropium curassavicum***	Seaside Heliotrope	S	X				
Brassicaceae	*Hirschfeldia incana*	Black Mustard	S	X				
	Brassica rapa	Field Mustard	S	X				
Carophyllaceae	***Spergularia marina***	Sand Spurrey	T		X			
Chenopodiaceae	***Atriplex patula***	Spear Oracle	T	X				
	Atriplex triangularis	Spearscale	S	X				
	Salicornia europaea	Annual Pickleweed	T	X				
	Salicornia virginica	Pickleweed	T,S	X				
	Salsola soda	Opposite leaf Russian Thistle	T,S	X				
	Salsola tragus	Prickly Russian Thistle	S	X				
Convolvulaceae	*Convovulus arvensis*	Bindweed	S	X				
Cyperaceae	*Carex* spp.	Sedge	S			X		
	Cyperus involucratus	African Cyperus	S	X				
	Scirpus maritimus	Alkali Bulrush	S	X				
	Scirpus robustus		S		X			
Fabaceae	*Genista monspessulana*	French Broom	S	X				
	Lotus corniculatus	Birdfoot Trefoil	S			X		
	Lupinus spp.	Lupine	S		X			
	Melilotus indica	Sour Clover	S	X				
	Trifolium microcephalum	Small-head Clover	S				**X**	
Frankeniaceae	***Frankenia salina***	Alkali Heath	T,S	X				
Geraniaceae	*Geranium dissectum*		S		X			

Appendix A
Vegetation Species List, 2000-2006
MLK Jr. Regional Shoreline Wetlands Project
Oakland, California

Family	Species	Common Name	Habitat Type	2000	2001	2002	2003	2006
Juncaceae	***Juncus bufonious***	Toad Rush	S		X			
Juncaginaceae	***Triglochin concinna***	Salt marsh arrow grass	T	X				
Lythraceae	***Lythrum californicum***	California Loosestrife	S	X				
	Lythrum hyssopifolium	Loosestrife	S	X				
Malvaceae	*Malva neglecta*	Common Mallow	S	X				
Onagraceae	*Epilobium ciliatum*	Common Willowherb	S	X				
Plantaginaceae	*Plantago coronopus*	Cutleaf Plantain	S	X				
	Plantago lanceolata	English Plantain	S	X				
Polygonaceae	***Polygonum lapathifolium***	Willow Weed	S	X				
	Rumex crispus	Curly Dock	S	X				
Poaceae	*Avena fatua*	Wild Oat	S	X				
	Bromus carinatus	California Brome	S	X				
	Bromus hordeaceus	Brome	S		X			
	Cortaderia jubata	Pampas Grass	S	X				
	Crypsis vaginiflora	Prickle Grass	S	X				
	Cynodon dactylon	Bermuda Grass	S		X			
	Distichlis spicata	Saltgrass	T	X				
	Hordeum brachyantherium	California Barley	S	X				
	Hordeum jubatum	Foxtail Barley	S	X				
	Hordum marinum ssp *gussoneanum*	Mediteranean Barley	S			X		
	Hordeum murinum ssp. *Glaucum*		S		X			
	Lolium perenne	Perennial Ryegrass	S	X				
	Lolium multiflorum	Perennial Ryegrass	S		X			
	Nassella **spp.**	Needlegrass	S		X			
	Polypogon monspeliensis	Annual Beard Grass	S	X				
	Spartina alterniflora	Smooth Cordgrass	T	X				
	Spartina foliosa	California Cordgrass	T	X				
	Vulpia myuros	Rat-tail Fescue	S		X			
Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel	S		X			
Scrophulariaceae	*Bellardia trixago*	Mediterranean Lineseed	S				X	
	Limosella acaulis	Broad-Leaved Mudwort	S					X
Typhaceae	***Typha latifolia***	Broad-leaved Cattail	S	X				

Notes:

Bold indicates California native species

S = Seasonal Wetlands; T = Tidal Wetlands

Appendix B –Avian Monitoring Analysis

WATERBIRD RESPONSE TO TIDAL AND SUPRATIDAL WETLAND RESTORATION IN SAN FRANCISCO BAY

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INTRODUCTION

San Francisco Bay wetlands are of great importance to migratory shorebirds and waterfowl. More than half a million shorebirds use bay wetlands each winter, leading to the designation of the bay as a Western Hemisphere Shorebird Reserve Network site of international importance (Page et al. 1999, Stenzel et al. 2002). For 11 shorebird species, San Francisco Bay supports at least 50% of the total population during one or more season (Page et al. 1999). San Francisco Bay is also an important area for waterfowl, with more than 50% of the diving ducks in the Pacific Flyway wintering in the shallow wetlands of the bay (Accurso 1992). More than 90% of historic wetlands in San Francisco Bay have been lost or altered, creating a need for wetland restoration (Goals Project 1999).

In June 1998, the Port of Oakland completed construction for the restoration of wetlands on an approximately 71.5-acre (29.0-ha) site on San Leandro Bay, Alameda County, California. The restoration site includes 68 acres to mitigate for historic fill at the Oakland Airport's Air Cargo Site and the Port of Oakland's Distribution Center (the site of restoration), and 3.5 acres to mitigate for proposed fill on an adjacent site. The site is now managed by the East Bay Regional Park District as part of the Martin Luther King Jr. Regional Shoreline Park. The project was designed to include a mixture of wetland habitats, including tidal and seasonal wetlands. Key objectives of the restoration project included providing foraging and resting habitat for migratory shorebirds and waterfowl and suitable breeding habitat for the federally-endangered California Clapper Rail (*Rallus longirostris obsoletus*).

To determine the effectiveness of the restoration, a study of waterbird use of the site was initiated in 1998. From 1998 through 2006, trained volunteers from the Golden Gate Audubon Society have conducted systematic bird surveys at the site. We used these data to assess the response of avian communities to the restoration project. Prior to restoration, habitats at the site were non-tidal and consisted of seasonal ponds and upland vegetation, and waterbird use of the site was minimal.

METHODS

For the purpose of this study, the Restoration Site was divided into two areas: Tidal Wetlands and Seasonal Ponds (Fig. 1). The Tidal Wetlands, composing approximately 32.9 acres (13.3 ha), was subdivided into five areas: Marsh Plain, Intertidal Pond, Island A, Island B, and Channels. The largest of these areas, the Marsh Plain, is expected to develop over time into a mixture of low tidal marsh, dominated by cordgrass (*Spartina* spp.), and high tidal marsh, dominated by pickleweed (*Salicornia* spp.). By year eight of this study, approximately 70% of the Marsh Plain had been colonized, the dominate species are invasive cordgrass hybrids (*Spartina foliosa x. alterniflora*) and pickleweed. The Seasonal Ponds consisted of three seasonal ponds surrounded by ruderal upland vegetation. The Seasonal Ponds remained dry from summer through fall until winter rains commenced.

To provide an index of ongoing waterbird use of natural tidal saltmarsh nearby, two Reference Sites were monitored concurrently: the Eastern Reference Site and Western Reference Site (Fig. 1). Sub-areas in both Reference Sites included portions of Arrowhead Marsh (a natural intertidal saltmarsh in San Leandro Bay), exposed mudflat, open water, rocky shoreline, and channels. The Western Reference Site contained a wooden pier, and the Eastern Reference Site contained a rocky peninsula, both of which were used for roosting by shorebirds. At low tide, significantly more mudflat was exposed at the Eastern than at the Western Reference Site. Motorized watercraft were allowed in the Western, but not the Eastern Reference Site. Because habitats at the Reference Sites differed somewhat from the Restoration Sites (most notably in the large expanse of open water in the Reference Sites), waterbird use at the Reference and Restoration Sites also was expected to differ somewhat.

Surveys were conducted from October 1998 through April 1999, and in the six subsequent years (through April 2005) from August through April so that each "monitoring year" is composed of a fall-winter-spring cycle. During the 2005-2006 monitoring year, data were collected only during the period November through March. Because data from this most recent year were limited seasonally, these data were used only for selected analyses (as noted). Observers conducted one survey each month at each of four stages of the tidal cycle (high, low, incoming, and outgoing), at each of the four study areas, for a total of 1,056 scheduled surveys. Occasional surveys were missed due to logistical problems; of the scheduled surveys, 979 surveys were conducted. No surveys were conducted during summer months, when waterbird abundance is generally lowest.

Observers surveyed each site using binoculars, and recorded abundance and location of all waterbird and raptor species within the study area while. Percent of shorebirds that were foraging was estimated during surveys at the Intertidal Pond (within the Tidal Wetlands) and Seasonal Ponds. The time required to survey a particular site varied from approximately 0.5 hr to 1.5 hr, depending on the number of birds present, visibility, size of the site, and other factors. Large flocks were carefully estimated, and care was taken to avoid double-counting flocks that moved within a site during the survey period. When calculating species richness (number of species recorded), we included unidentified species only if it was clear they did not overlap with identified species (e.g. Tern sp. contributed to species richness only if no other species of tern were recorded at that site). Community composition initially was assessed by comparing proportions of species-groups (shorebirds, waterfowl, gulls and terns, and other waterbirds). Shorebirds were further analyzed after subdividing species into four groups (Charadriidae: all plover species, Recurvirostridae: stilts and avocets, Small Scolopacidae: sandpipers of the genus *Calidris*, and Large Scolopacidae: all other shorebirds).

We compared avian community composition between the Reference and Restoration Sites using the Percentage Similarity Index (PSI). This index is the sum of all the minimums of either 1) percentage of a given taxon (out of the total) in sample 1, or 2) the percentage of that taxon in sample 2 (Krebs 1998). Comparisons that result in greater PSI values (i.e., >70%) are more similar than comparisons that result in low values. Because many birds were identified only to general taxon (e.g., unidentified duck, or small shorebird), we conducted PSI analyses using five taxa: small shorebird (sandpipers of the genus *Calidris*), large shorebird (all other shorebirds regardless of size), waterfowl, gulls, and other waterbirds. These analyses potentially could be biased by missing survey data, so PSI analyses were limited to a subset of data that was virtually complete: December through March, high and low tide only, including the 2005-2006 monitoring year.

We also calculated the Shannon-Wiener function (*H'*) by year and by species group, to provide an assessment of species diversity that incorporates relative abundance of each species as well as richness. *H'* is calculated as the sum, for all species, of the product of the proportion of the total sample belonging to that species, and the base 2 log of that proportion (Krebs 1998). *H'* increases with increasing diversity, and is greater when species abundance is more evenly distributed, rather than dominated by one or two species.

To assess the effect of pond acreage on waterbird use of the Seasonal Ponds, we used linear regression to test for effects of total pond acreage for a given month on mean abundance of waterbirds for that month. This analysis was limited to six years (pond size was not measured in 2003/2004 or 2004/2005), in which pond size was measured during one to five months of the bird monitoring season. During these six years, pond depth prior to November was considered to be zero, before the onset of winter rains. Thus, this analysis included 20 pond measurements, in addition to 10 monthly values presumed to be zero, for a total sample size of 30.

RESULTS

Abundance

Mean abundance of all birds showed moderate annual variability at all sites (Fig. 2). Relative to the Reference Sites, abundance at the Tidal Wetlands remained fairly constant; although the Tidal Wetlands declined slightly, so did both Reference Sites combined. In contrast, abundance at the Seasonal Ponds increased relative to the Reference Sites. Seasonal abundance of waterfowl was similar to typical patterns in the San Francisco Bay region (Shuford et al. 1989, Accurso 1992), with annual peaks during mid-winter. At the Reference Sites, seasonal abundance of shorebirds peaked during April (Fig. 3). Shorebird abundance at the Tidal Wetlands peaked during September/October and again in April. Shorebirds were virtually absent at the Seasonal Ponds until winter rainfall commenced in December.

At the Seasonal Ponds, annual variability in total bird abundance was significantly related to variability in total pond size ($P < 0.001$, $n = 30$). As pond acreage increased, shorebird abundance also increased, and a relatively high proportion of the variance (75%) in shorebird abundance was explained by pond acreage (Fig. 4).

California Clapper Rails occurred in both Reference Sites throughout the study period and at the Tidal Wetlands in the three final years of the study. At all sites, mean Clapper Rail abundance increased during the five monitoring years. Maximum abundance from any one survey at each site was 11 at the Eastern Reference Site (January 2004), 34 at the Western Reference Site (January 2006), and four at the Tidal Wetlands (December 2005 and January

2006). Maximum counts at the Reference Sites were during high tides; maxima at the Tidal Wetlands were during low and outgoing tides.

Community Composition

Species composition within each of the four sites was similar among years (Table 1). However, the PSI analysis revealed that species composition at the two Restoration Sites evolved throughout the study period, becoming gradually more similar to the Reference Sites (Fig. 5). During the last two years of the study, PSI was greater than 80%, although a linear relationship between PSI and year explained only 36% of the variance in PSI.

Total species richness (number of species) and diversity (*H'*) were similar among the four sites (Table 1). Among sites, richness and diversity also were similar within three of the five species groups (Shorebirds, Waterfowl, and Gulls and Terns). Other Waterbird species diversity was considerably greater at the Reference than the Restoration Sites, and was greater at the Tidal Wetlands than at the Seasonal Ponds. Diversity of Other Waterbirds at the Restoration Sites increased throughout the study period. Diversity of Raptors and Owls was greater at the Restoration Sites than at the Reference Sites. In general, species richness corresponded to species diversity; one exception was at the Eastern Reference Site, where Waterfowl diversity was low despite high Waterfowl species richness. Here, three taxa, scaups (*Aythya* spp.), Ruddy Duck (*Oxyura jamaicensis*), and American Wigeon (*Anas Americana*) were much more abundant than other species, resulting in a lower value for *H'*.

Shorebirds were the dominant species group at Tidal Wetlands and the Western Reference Site whereas Waterfowl dominated at the Eastern Reference Site (Fig. 6). At the Seasonal Ponds Shorebirds and Waterfowl shared dominance followed by Gulls and Terns. Among shorebirds, Large Scolopacids were numerically dominant at the Reference Sites and Small Scolopacids were dominant at the Restoration Sites (Fig. 7, Table 1). At the Seasonal Ponds, Small Scolopacids were most abundant but Recurvirostrids comprised the majority of individuals in some years (Table 1). Overall, Willet (*Catoptrophorus semipalmatus*) was the most abundant species at both Reference Sites, and *Calidris* sandpipers were the most abundant taxa at both Restoration Sites. When analyzing shorebird group dominance by mean biomass, these patterns were consistent at the Reference but not at the Restoration Sites (Fig. 8). At the Tidal Wetlands, Large Scolopacids dominated mean biomass and at the Seasonal Ponds Recurvirostrids emerged as the dominant group.

Influence of Tide on Shorebirds

Shorebird abundance at all four sites was lowest at low tide (Fig. 9). Tide had a similar influence on shorebird occurrence at the Eastern Reference Site and the Tidal Wetlands, where mean abundance of all shorebird groups combined was greatest at changing tides (incoming and outgoing) followed by high tide. There also were similar patterns between the Western Reference Site and Seasonal Ponds, where mean abundance was greatest at high tide, followed by changing tides. Within sites, patterns of use by shorebird groups were fairly consistent among tides. At the two Reference Sites where Large Scolopacids dominated, the proportion of Small Scolopacids decreased and the proportion of Large Scolopacids increased as tidal height increased. The proportion of Small Scolopacids increased markedly at incoming tide at the Tidal Wetlands and at high tide at the Seasonal Ponds.

Within the Tidal Wetlands, the majority of shorebirds occurred on the Marsh Plain, although this pattern was less pronounced at high tide (Fig. 10). The Intertidal Pond was the second-most used habitat at all tides except high tide when Island A supported a similar proportion of shorebirds. Tide also influenced behavior at the Tidal Wetlands and the Seasonal Ponds (Fig. 11). At the Intertidal Pond (within the Tidal Wetlands), the proportion of shorebirds foraging was greatest at incoming tide. In contrast, at the Seasonal Ponds, shorebird foraging was greatest at high and outgoing tides. At both the Intertidal Pond and the Seasonal Ponds, the majority of these foraging shorebirds were Small Scolopacidae (Table 2).

DISCUSSION

Bird Abundance and Community Composition

The Restoration Sites have provided important additional wetland habitat for waterbirds in the San Leandro Bay area. For shorebirds, San Leandro Bay is a site of regional importance (Stenzel et al. 2002) and the Restoration Sites have substantially augmented the available wetlands, particularly the alternate high-tide habitat, in the region. Mean shorebird abundance at the Tidal Wetlands (which supported more shorebirds than other study areas) was about 44 birds/ha, within the range of spring and fall densities for natural tidal wetlands in San Francisco Bay reported by Stenzel et al. (2002) and similar to densities reported at restored tidal wetlands in upper Newport Bay (Wilcox 1986). Achievement of densities comparable to natural and other restored wetlands indicates that the Tidal Wetlands have become functionally similar to established wetlands and are performing similarly to other restoration sites over a large time span.

Although high annual waterbird densities occurred at the Tidal Wetlands, mean abundance of all waterbirds and of shorebirds decreased somewhat during the study, possibly because the site has become more heavily vegetated over time. The primary habitat used by Small Scolopacids, the dominant shorebird group at the Tidal Wetlands, was the Marsh Plain, and reduction in the amount of exposed mudflat in this heavily-used habitat may have reduced the number of birds using the site. Alternatively, the slight decline may be attributable to regional-scale population dynamics; a slight decline in both total waterbird and shorebird numbers also was apparent at both Reference Sites where the percentage of vegetative cover was stable. Relative to the Reference Sites, bird abundance increased at the Seasonal Wetlands. Annual and seasonal changes in pond size, and thus the availability of foraging habitat, explained 75% of the variability in bird abundance at the Seasonal Ponds, and pond size did generally increase during the study period, due to rainfall patterns. However, macroinvertebrates also likely increased in the Seasonal Ponds over time as they colonized the site, providing an increasing prey base for waterbirds.

Invertebrate prey sampling conducted in study area in 2001 (Jones & Stokes 2001) revealed that invertebrate abundance and diversity were considerably lower in the Intertidal Pond and the Tidal Channels in the Tidal Wetlands than in similar habitats in the Reference Sites. However, invertebrate diversity and abundance in the Seasonal Ponds were similar to those in a pre-existing seasonal pond at an off-site location, at Coyote Hills Regional Park. Other studies that have assessed macroinvertebrate colonization of restored tidal wetlands have found that abundance quickly increased to levels comparable to natural habitats. Havens et al. (1995) found that after five years, invertebrate abundance and diversity in a restored marsh in Virginia were similar to that in nearby natural marshes. Zedler (1996), working in Southern California, similarly found that after only two years, invertebrate abundance in restored tidal mudflats surpassed abundance in reference sites, although invertebrate diversity remained lower in restored sites than in reference sites for at least six years.

Of 22 common shorebird species recorded in San Francisco Bay-wide surveys by Stenzel et al. (2002), all but two, Snowy Plover (*Charadrius alexandrinus*) and Spotted Sandpiper (*Actitus macularia*), were recorded in this study. Snowy Plovers are found in San Francisco Bay almost exclusively south of Hayward, and Spotted Sandpipers, relatively uncommon migrants, are uncommon outside of freshwater habitats. In this study, the general increase in number of species at the restoration sites probably was related to improving habitat quality (e.g., greater prey diversity and abundance), but variability in species richness was largely a function of presence or absence of very rare species. Patterns in species-group composition were directly influenced by variation habitat composition among sites. Among shorebird groups, Large Solopacids dominated at the Reference Sites and Small Scolopacids dominated at both Restoration Sites, due to habitat differences between the two areas. Larger shorebirds typically roost in the heavily vegetated high marsh areas that are common at the Reference Sites whereas smaller species roost in more open habitats (Kelly and Cogswell 1979, Warnock and Takekawa 1995) such as those found at the Seasonal Ponds and the Tidal Wetlands. Smaller species also are more likely to be precluded from areas by tidal inundation (Davidson and Evans 1986) and are forced to locate drier alternate roosting areas. The relative scarcity of larger shorebirds at the Restoration Sites may be explained by a lack of larger prey species having colonized these sites; lager shorebirds such as Willets forage on substantially larger prey than Small Scolopacids (Lowther et al. 2001).

Habitat differences also likely explain the difference in seasonal patterns in shorebird abundance between the Reference Sites and the Restoration Sites. The Tidal Wetlands supported the greatest number of Small Scolopacids and these numbers peaked in fall and spring, coinciding with peak migration of *Calidris* sandpipers (Storer 1951, Page et al. 1979, Shuford et al. 1989). In contrast, shorebird numbers at the Reference Sites peaked in winter, suggesting that the Reference Sites may be more important for wintering than migrating shorebirds. Page et al. (1979) found that abundance of Willets (the dominant shorebird at the reference sites) peaked in August, but was then fairly consistent through the winter.

Influence of Tide on Shorebird Use Patterns

At the Restoration Sites, maximum bird use occurred at tides other than low tide, indicating that although shorebirds may move to mudflats out of the study area for foraging, the Restoration Sites provided valuable foraging and roosting habitat at other tidal stages. This is especially true for small sandpipers which are excluded from flooding tidal areas sooner than larger species (Davidson and Evans 1986). During low tide, Small Scolopacidae and other shorebirds primarily forage on large exposed mudflats in San Francisco Bay, outside of the study area (Stenzel et al. 2002). In the San Francisco Bay area, delayed tidal action (e.g., due to dikes), and adjacent non-tidal habitats (e.g., salt ponds) provide a mosaic of habitats available to waterbirds at various tidal stages (Holway 1990, Stenzel et al. 2002, Warnock et al. 2002).

Although shorebirds in the San Francisco Bay area may move more than 20 km between foraging and roosting areas (Shuford et al. 1989), the proximity of alternate high-tide habitat can help to maintain high densities of shorebirds on nearby tidal mudflats (Masero et al. 2000). Studies of other supra-tidal and peripheral wetlands suggest that these habitats may increase shorebird survival during periods of food or weather stress, which may enhance regional abundance of shorebirds (Davidson and Evans 1986). In the San Francisco Bay area, diked wetlands and salt ponds provide high-tide habitat for many species of shorebirds, and some shorebirds forage at these alternate habitats at both high and low tides (Warnock et al. 2002). In this study, the habitat features of the Tidal Wetlands were part of a functional mosaic that probably contributed to enhanced use of tidal wetlands in adjacent San Leandro and San Francisco Bay.

In other San Francisco Bay wetlands, Warnock et al. (2002) found that although fewer birds at salt ponds during low tide, a greater proportion of birds foraged at low tide, especially Western Sandpiper (*Calidris mauri*), Dunlin (*Calidris alpina*), and Black-bellied Plover (*Pluvialis squatarola*). In contrast, we found that the proportion of shorebird foraging was greatest when they were most abundant: at the Intertidal Pond during incoming tides, and at the Seasonal Ponds during high tide. Thus, the Seasonal Ponds provided important habitat at high tide not only for roosting, but as alternate foraging habitat. At the Intertidal Pond, the greater abundance of shorebirds and the high proportion feeding during incoming tides were probably the product of delayed tidal action at the pond. Water levels in this pond are lowest at incoming tides, providing the greatest expanse of shallow foraging habitat for shorebirds.

Lessons Learned

The restoration project and bird-use monitoring data provide important information to inform the design of other restoration projects, including the large-scale South Bay Salt Pond Restoration project currently planned for South San Francisco Bay. Relatively few other studies are available regarding the response of waterbirds to intertidal restoration projects (Davidson and Evans 1986, Wilcox 1986). The habitat features in the Restoration Sites, including evolving intertidal salt marsh, the intertidal pond with muted and delayed tidal action, roosting/nesting islands, and non-tidal seasonal ponds, are features that may be considered in restoration planning for other projects.

The Marsh Plain and Channels habitats of the Restoration Site together comprise what will become tidal salt marsh habitat. Initially, the exposed mudflat at this site provided excellent foraging habitat for small shorebirds. As the site becomes more vegetated, however, habitat quality for foraging shorebirds will decrease. As vegetation becomes more established, larger shorebird will likely roost and forage here, and eventually, California Clapper Rails are expected to colonize this site. Few Clapper Rails were seen in the Restoration Sites during this study, but as *Spartina* becomes established here, this species is expected to use the site more frequently.

The Intertidal Pond provided roosting habitat throughout the tidal cycle, but more importantly, provided unique foraging habitat during incoming tides. Due to delayed tidal action, birds were able to forage at the Intertidal Pond during incoming tides, when preferred intertidal mudflat habitat elsewhere would have been lost to inundation. Although shorebirds may be able to meet their energetic requirements by foraging on intertidal mudflats throughout much of the year, additional foraging provides supplemental energy that may be needed during inclement weather and during migration and pre-migration periods when additional fat reserves are needed (Davidson 1981, Masero et al. 2000).

The loafing islands (Islands A & B) performed as expected in providing high-tide roosting habitat for waterbirds (Fig. 10). Shorebirds, in particular, require safe roosting or alternate foraging habitat during high-tide, when intertidal mudflat foraging habitat becomes fully inundated. Several recent studies have indicated that shorebirds may be constrained in their use of intertidal foraging areas by proximity to safe roosting habitat (Dias et al. 2006, Rogers et al. 2006). By providing a safe roosting area in close proximity to the extensive tidal mudflats of San Leandro and San Francisco Bays, the Restoration Site may further contribute to enhanced regional abundance of shorebirds. In addition, the loafing islands provided nesting habitat for waterbirds, including American Avocets (*Recurvirostra americanus*), Black-necked Stilts (*Hemantopus mexicanus*), Killdeer (*Charadrius vociferus*), and waterfowl during the summer.

The Seasonal Ponds also provided important supratidal habitat. These ponds were used extensively during high tides by both roosting and foraging waterbirds. Similarly, in the South Bay, shorebirds use salt pond levees as high-tide roosting habitat, but also often forage at these ponds (Warnock and Takekawa 1995, Stenzel et al. 2002). The Seasonal Ponds were virtually unused each year before the first winter rains and pond size and depth were critical factors affecting use of this site. Colwell and Taft (2000) also found that water depth was an important factor affecting bird use of managed wetlands. As with the Intertidal Pond, the availability of roosting and foraging habitat at the Seasonal Ponds at tides other than low tide is critical for many waterbird species. Supratidal habitats such as salt ponds or seasonal ponds provide buffers against loss of tidal foraging habitat and help to ameliorate losses of historic wetlands in the region (Davidson and Evans 1986, Masero 2003).

Ideally, other tidal restoration efforts in the San Francisco Bay area and in similar sites will include a mosaic of different habitats available for waterbirds. In the San Francisco Bay area, tidal salt marsh is needed to support the federally-endangered California Clapper Rail, as well as the federally-endangered salt marsh harvest mouse (*Reithrodontomys raviventris*). However, for migrating and wintering waterbirds, San Francisco Bay also provides crucial habitat, some of which will be lost as historic salt ponds are converted to tidal salt marsh (Stenzel et al. 2002, Warnock et al. 2002). To continue to support the waterbirds that rely on San Francisco Bay wetlands and supratidal habitats, restoration efforts should include a mosaic of habitats, including intertidal mudflats, diked wetlands with delayed tidal action, non-tidal ponds, and suitable high-tide roosting habitat, as well as tidal salt marsh.

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Table 1. Abundance and diversity of bird species. Mean abundance of all bird species recorded per survey at the four monitoring areas, 1998-2006.
An "x" indicates a value of greater than 0 but less than 0.1. Surveys recorded only shorebirds, waterfowl, waterbirds, raptors, and owls.

			REFERENCE SITES																		RESTORATION SITES																	
			Eastern Reference									Western Reference									Seasonal Ponds									Tidal Wetlands								
Common Name	**Genus**	**Species**	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	**mean**	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	**mean**	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	**mean**	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	**mean**
SHOREBIRDS																																						
American Avocet	*Recurvirostra*	*americana*	13.9	10.7	17.5	2.1	4.5	2.1	0.7	1.5	**6.6**	1.7	7.3	2.7	1.2	3.8	3.9	1.1	15.7	**4.7**	12.0	4.2	19.2	54.5	27.7	48.9	59.8	59.1	**35.7**	23.8	6.4	12.2	17.9	22.6	7.1	13.2	1.3	**13.1**
Black Turnstone	*Arenaria*	*melanocephala*	1.3	0.9	4.3	1.0	1.2	1.2	x	1.8	**1.7**	1.0	0.8	3.4	0.3	0.3	x	0.2		**1.0**					x					0.4	1.3	1.4	1.7	0.2	0.2	0.2		**0.8**
Black-bellied Plover	*Pluvialis*	*squatarola*	1.7	2.0	2.5	0.8	1.1	0.6	1.2	2.2	**1.5**	0.3	1.9	1.6	1.6	0.7	0.5	0.7	1.5	**1.1**	0.2		0.1		0.1		x		**0.1**	26.8	37.6	49.9	75.0	64.5	48.0	34.1	2.8	**42.3**
Black-necked Stilt	*Himantopus*	*mexicanus*	17.9	9.7	9.6	5.1	4.2	12.9	5.3	11.5	**9.5**	3.0	7.3	6.9	5.2	4.2	1.7	1.8	2.1	**4.0**	7.3	0.5	2.4	9.0	8.0	0.9	6.2		**4.9**	2.1	16.8	17.1	8.1	24.9	12.9	5.8	2.9	**11.3**
Dowitcher Sp.	*Limnodromus*		43.7	17.5	23.3	50.3	30.2	27.3	18.5	16.7	**28.4**	23.7	13.9	1.7	30.5	9.5	6.6	11.6	4.8	**12.8**	2.3	0.8	0.6	1.3	8.0		7.8	2.2	**3.3**	10.2	58.5	37.2	21.7	26.9	16.1	9.3	1.5	**22.7**
Dunlin	*Calidris*	*alpina*	20.2	9.6	3.3	0.8	0.5	0.9	3.4	0.4	**4.9**	1.4	3.9	2.9	1.3	6.5	0.0	26.7	9.4	**6.5**	7.8		0.1	0.4	23.1	6.5	13.2		**8.5**	62.9	79.9	63.5	42.3	60.1	10.4	4.2	0.2	**40.4**
Greater Yellowlegs	*Tringa*	*melanoleuca*									**0.0**										0.8								**0.8**	0.1	0.1							**0.1**
Killdeer	*Charadrius*	*vociferus*		0.2		0.1	0.3	0.1	0.6		**0.3**	x	0.1	0.2		0.2		0.8	0.2	**0.3**	0.7	0.8	2.0	2.5	4.7	9.1	11.7	2.3	**4.2**	2.5	8.7	5.5	4.5	5.9	2.4	3.7	0.7	**4.2**
large shorebird			46.0	11.7	12.2	3.3	0.1	x			**14.7**		7.9	6.4	1.0	2.9			0.7	**3.8**			1.7	0.9					**1.3**	0.9	0.6	0.4	5.6	22.3	0.3	2.9		**4.7**
Least Sandpiper	*Calidris*	*minutilla*	1.2		0.6		0.1	1.3	2.2		**1.1**	1.1		0.1	1.0	0.3	x	3.6	1.6	**1.3**	1.2	0.8			0.9	3.9	22.2	8.3	**6.2**	6.6	34.0		4.1	4.2	8.7	3.2		**10.1**
Long-billed Curlew	*Numenius*	*americanus*	0.6	1.3	1.9		0.1		0.2		**0.8**	0.2	0.5	1.4	x		x			**0.7**		0.4		1.7	0.6	2.7	6.2	1.5	**2.2**	5.0	4.9	5.4	6.6	8.6	8.8	4.4	1.8	**5.7**
Marbled Godwit	*Limosa*	*fedoa*	33.9	20.3	17.1	43.9	26.6	37.6	4.8	0.8	**23.1**	30.3	44.2	71.2	115.5	68.5	56.8	23.6	7.1	**52.1**				0.8	0.1	0.3	1.3		**0.6**	7.7	94.2	68.7	33.9	125.8	41.3	11.8	1.3	**48.1**
Pacific Golden Plover	*Pluvialis*	*fulva*	0.1								**0.1**																				x							
Pectoral Sandpiper	*Calidris*	*melanotos*									**0.0**		x																									
Red Knot	*Calidris*	*canutus*	x								**0.0**					0.3				**0.3**														0.1				**0.1**
Red Phalarope	*Phalaropus*	*fulicaria*									**0.0**						x														x					0.5		**0.5**
Ruddy Turnstone	*Arenaria*	*interpres*	0.1			x	0.1				**0.1**			0.1	x					**0.1**											x	x						
Sanderling	*Calidris*	*alba*									**0.0**																			0.6								**0.6**
Semipalmated Plover	*Charadrius*	*semipalmatus*		x		0.1			0.2		**0.1**			x				0.5	x	**0.5**			0.2	1.1	1.5		0.4		**0.8**	0.9	10.1	4.4	0.7	0.3	1.5	7.7		**3.7**
small shorebird			3.5	55.9	18.3	0.2	13.8	3.3			**15.8**	30.4	20.3	18.5	15.5	2.9			0.5	**14.7**	61.9		16.1	0.2	2.9	33.5	11.0		**20.9**	246.3	66.1	112.3	55.0	65.4	19.3	66.8		**90.2**
Western Sandpiper	*Calidris*	*mauri*	8.8		0.1		0.2	0.2	17.6		**5.4**				3.3	1.5	2.5	4.4	4.6	**3.3**	1.8			0.4	1.5	13.6	0.8	3.6	**3.6**	6.3	17.1		3.5	0.6	17.5	2.2	5.0	**7.5**
Western/Least Sandpiper	*Calidris*		53.8	23.4	32.7	18.4	3.3	6.6	37.2	21.2	**24.6**	18.6	46.2	30.5	9.7	20.7	11.4	43.4	10.1	**23.8**	4.4	0.8	15.8	36.6	83.0	33.6	84.2	25.9	**35.5**	105.7	476.8	180.3	162.1	177.9	168.0	72.3	29.5	**171.6**
Whimbrel	*Numenius*	*phaeopus*	0.3	0.1	0.2	x	0.1	0.1	0.1		**0.2**			0.2		0.1	0.1			**0.1**				0.2	x		0.6		**0.4**	0.9	0.6	0.5	1.0	0.9	0.4	0.3		**0.7**
Willet	*Catoptrophorus*	*semipalmatus*	87.0	41.2	54.2	106.7	55.3	123.6	49.8	40.3	**69.8**	68.4	86.2	198.0	174.8	115.5	83.8	147.0	116.7	**123.8**	0.2	0.1		1.9	2.1	0.4	7.9	x	**2.1**	16.8	83.4	49.7	32.1	81.8	22.1	89.9	15.2	**48.9**
Wilson's Snipe	*Gallinago*	*delicata*									**0.0**							x															x			0.2	x	**0.2**
Yellowlegs Sp.	*Tringa*		3.6	1.1	1.5	1.2	0.4	0.3	1.3	0.9	**1.3**	0.6	0.3	0.7	0.1	0.2	0.6	0.3	0.1	**0.4**	0.4	0.1		5.8	2.5	1.7	2.1	0.8	**1.9**	3.7	9.0	11.3	13.5	11.3	12.2	6.2	5.3	**9.1**
Mean Shorebirds			**337.6**	**205.6**	**199.3**	**234.0**	**142.1**	**218.1**	**143.0**	**97.2**	**197.1**	**180.7**	**240.8**	**346.5**	**361.0**	**238.1**	**167.8**	**265.5**	**175.1**	**246.9**	**101.0**	**8.5**	**58.2**	**117.3**	**166.7**	**155.1**	**235.4**	**103.7**	**118.2**	**530.2**	**1006.1**	**619.8**	**489.3**	**704.3**	**397.1**	**338.7**	**67.3**	**519.1**
No. Shorebird Species			**16**	**14**	**13**	**14**	**15**	**13**	**15**	**10**	**13.8**	**13**	**13**	**15**	**13**	**14**	**14**	**14**	**14**	**13.8**	**10**	**8**	**8**	**12**	**15**	**10**	**14**	**8**	**10.6**	**16**	**18**	**15**	**16**	**16**	**15**	**17**	**12**	**15.6**
Shorebird Diversity (H')			**3.1**	**3.0**	**3.1**	**2.1**	**2.5**	**2.0**	**2.6**	**2.3**	**2.6**	**2.5**	**2.7**	**2.0**	**2.0**	**2.1**	**1.8**	**2.1**	**1.9**	**2.1**	**2.0**	**2.4**	**2.2**	**2.2**	**2.4**	**2.6**	**2.8**	**1.8**	**2.3**	**2.5**	**2.8**	**3.0**	**3.1**	**3.2**	**3.0**	**3.0**	**2.5**	**2.9**
WATERFOWL																																						
American Wigeon	*Anas*	*americana*	66.8	39.2	30.1	31.2	16.3	33.1	9.8	42.4	**33.6**		16.3	1.9	15.1	7.1	11.0	0.3	0.1	**7.4**	64.4	38.0	23.4	42.4	61.4	54.2	52.6	109.6	**55.8**	0.8	1.8	4.2	26.6	36.3	22.9	7.2	6.2	**13.2**
Barrow's Goldeneye	*Bucephala*	*islandica*	0.1	0.3	0.1	0.2	0.1		x		**0.2**	x	0.1	0.2	0.1	x	0.1			**0.1**							x	0.2	**0.2**				0.1					**0.1**
Blue-winged Teal	*Anas*	*discors*	0.1	1.6	0.1			x		0.4	**0.5**		0.2		x				0.3	**0.3**														0.2				**0.2**
Bufflehead	*Bucephala*	*albeola*	7.4	4.6	3.0	4.3	2.5	0.8	0.9	19.0	**5.3**	5.5	4.3	2.7	1.6	4.2	2.8	3.4	14.1	**4.8**	1.4	1.3	2.1	3.6	4.6	4.0	4.3	4.8	**3.3**	0.7	1.0	0.3	0.5	1.4	0.7	2.4	1.4	**1.0**
Canada Goose	*Branta*	*canadensis*	5.1	1.5	1.8	3.3	1.7	4.4	3.5	0.9	**2.8**	3.5	3.6	9.7	8.3	18.9	6.9	6.1	5.7	**7.8**	1.2	3.5	13.5	4.1	18.1	4.9	6.0	7.7	**7.4**	6.8	3.3	10.2	1.8	4.2	6.7	1.8	0.6	**4.4**
Canvasback	*Aythya*	*valisineria*	3.5	2.8	3.3	8.8	6.0	4.1	5.2	5.2	**4.9**	1.8	0.4	0.9	0.1	0.8		0.4	1.8	**0.9**					x		x	0.2	**0.2**									
Cinnamon Teal	*Anas*	*cyanoptera*	3.8	2.0	0.5	0.3	0.1	x		1.9	**1.4**	0.5	0.1	0.1					0.7	**0.3**	0.1			0.1					**0.1**							x		
Common Goldeneye	*Bucephala*	*clangula*	2.8	1.2	6.0	1.2	1.0	1.8	1.7	6.7	**2.8**	0.3	0.3	2.1	1.0	0.6	0.7	0.6	4.2	**1.2**	0.2	0.2		0.3	0.3	x		x	**0.3**	x	0.1		0.5	0.1	0.3	0.3	0.5	**0.3**
Common Merganser	*Mergus*	*merganser*									**0.0**						x	x																				
Duck Sp.			28.7	117.3	16.3	1.0	0.5	x	0.6	2.2	**23.8**	1.0	10.1	3.7	0.5	0.2				**3.1**	0.1	3.0	0.2	x	x		0.1		**0.9**	1.7	0.1	0.4	0.1	0.4				**0.5**
Eurasian Wigeon	*Anas*	*penelope*	x	0.1			x				**0.1**	6.0	x							**6.0**	0.2						x	0.1	**0.2**									
Gadwall	*Anas*	*strepera*	0.9	0.5	0.1	0.3	0.1	0.3	0.1	0.6	**0.4**			0.8		0.2	x	0.2	0.2	**0.3**	2.9	2.8	2.1	4.7	5.5	6.2	5.1	11.1	**5.0**		0.1	0.2	0.5			x	0.3	**0.3**
Greater Scaup	*Aythya*	*marila*	14.8								**14.8**	0.5								**0.5**		0.1							**0.1**									
Greater White-fronted Goose	*Anser*	*albifrons*					0.3		0.4		**0.3**					0.2				**0.2**					0.3	x	1.7	1.1	**1.0**						0.0			**0.0**
Green-winged Teal	*Anas*	*crecca*	5.7	3.7	5.3	2.9	2.6	3.9	1.1	7.1	**4.0**	0.8	0.9	2.2	0.3	0.1	0.2		0.2	**0.7**	0.3			1.9	3.0	5.3	13.3	15.8	**6.6**			0.2	0.3	0.2	x			**0.2**
Lesser Scaup	*Aythya*	*affinis*		x							**0.0**																											
Mallard	*Anas*	*platyrhynchos*	12.3	13.5	8.3	7.1	6.7	6.4	5.8	9.4	**8.7**	5.6	4.8	5.8	3.1	1.9	3.0	2.2	3.1	**3.7**	1.4	2.2	3.3	4.1	5.5	13.3	7.9	4.8	**5.3**	2.0	0.7	2.1	21.6	23.3	27.7	14.0	15.7	**13.4**
Northern Pintail	*Anas*	*acuta*	3.4	2.9	3.0	3.5	3.7	1.7	0.9	8.9	**3.5**	0.5	2.3	0.4	x	0.8	1.4	x	0.3	**1.0**	0.2	1.3	1.2	2.4	7.8	8.7	5.4	14.6	**5.2**		0.4	1.4	8.3	8.2	6.3	2.2	4.9	**4.5**
Northern Shoveler	*Anas*	*clypeata*	9.0	3.2	1.2	3.7	2.4	1.8	1.1	1.5	**3.0**	0.2	0.3	0.8	0.2	2.7	0.6	3.1		**1.1**	33.6	1.3	5.7	11.2	14.9	28.0	34.5	34.1	**20.4**	3.2	0.5	0.1	x	0.7	0.7	0.7	1.7	**1.1**
Redhead	*Aythya*	*americana*			x						**0.0**																											
Ruddy Duck	*Oxyura*	*jamaicensis*	43.5	59.5	68.3	41.4	24.8	115.1	117.4	97.5	**70.9**	5.4	1.1	2.5	4.9	5.3	3.4	3.5	3.1	**3.6**	0.1	0.2		0.3	0.9	0.1	3.3	3.7	**1.2**				x			x	x	
Scaup Sp.	*Aythya*		292.5	125.5	279.5	76.8	111.0	213.1	77.0	345.8	**190.2**	10.3	8.8	16.5	44.8	27.3	14.8	35.1	65.6	**27.9**		0.1		2.7	0.1	0.4	2.3	0.2	**1.0**	x	0.2		5.7	5.4	3.2	5.0	2.9	**3.7**
Snow Goose	*Chen*	*caerulescens*									**0.0**					x									x					0.1							x	**0.1**
Surf Scoter	*Melanitta*	*perspicillata*	0.1	2.2	0.6	12.0	6.8	5.2	3.2	11.3	**5.2**	x	0.1		1.3	2.0	0.2	1.2	3.7	**1.4**											0.3		0.1		0.1			**0.2**
Mean Waterfowl			**500.5**	**381.6**	**427.5**	**198.0**	**186.6**	**391.6**	**228.6**	**560.7**	**359.4**	**41.9**	**53.7**	**50.3**	**81.3**	**72.3**	**45.1**	**56.0**	**103.0**	**63.0**	**106.1**	**54.0**	**51.5**	**77.8**	**122.4**	**125.2**	**136.7**	**208.1**	**110.2**	**15.3**	**8.5**	**19.1**	**66.1**	**80.4**	**68.6**	**33.5**	**34.1**	**40.7**
No. Waterfowl Species			**17**	**17**	**17**	**15**	**17**	**15**	**15**	**15**	**16.0**	**14**	**16**	**14**	**14**	**16**	**14**	**13**	**14**	**14.4**	**12**	**10**	**7**	**12**	**14**	**12**	**14**	**15**	**12.0**	**8**	**10**	**8**	**13**	**10**	**11**	**11**	**12**	**10.4**
Waterfowl Diversity (H')			**2.2**	**2.5**	**1.8**	**2.7**	**2.2**	**1.8**	**1.9**	**2.0**	**2.1**	**3.1**	**2.9**	**3.0**	**2.1**	**2.6**	**2.6**	**2.0**	**1.9**	**2.5**	**1.4**	**1.7**	**2.2**	**2.3**	**2.3**	**2.4**	**2.6**	**2.3**	**2.2**	**2.2**	**2.6**	**2.0**	**2.1**	**2.1**	**2.1**	**2.3**	**2.3**	**2.2**
GULLS AND TERNS																																						
Bonaparte's Gull	*Larus*	*philadelphia*		x							**0.0**		x								0.4								**0.4**		0.1							**0.1**
California Gull	*Larus*	*californicus*	0.1	0.1	0.1	0.7		0.1	x	0.1	**0.2**	1.2	0.2	0.1	0.3	0.2	0.8		0.4	**0.5**	2.1	0.4	1.4		1.4	12.4	0.6	4.9	**3.3**	4.4	1.7		0.4	1.4		0.3		**1.6**
Caspian Tern	*Sterna*	*caspia*		0.1		0.3		0.0	0.2		**0.1**		0.1	0.1		0.1	0.2	0.4	0.1	**0.2**	0.2	0.1	0.2	0.1	0.2	2.2	4.0	2.6	**1.2**	0.1	0.4	0.2	0.4	0.9	0.3	0.2	x	**0.4**
Forster's Tern	*Sterna*	*forsteri*	0.6	0.8	1.9	0.9	1.9	1.4	1.3	0.4	**1.1**	0.6	1.4	1.6	0.9	0.8	0.8	0.8	0.4	**0.9**		x		0.1	0.1		0.2	0.0	**0.1**	0.3	0.3	1.0	1.1	1.9	0.8	0.4	0.4	**0.8**
Glaucous-winged Gull	*Larus*	*glaucescens*	0.3	0.3	0.4	0.2	x	0.2	x	0.1	**0.3**	1.2	0.1	x	0.1	0.1	0.1	0.3	0.7	**0.4**		0.1	0.2	x	0.1		0.2	0.4	**0.2**	0.2	3.2	0.1	x					**1.2**
Gull Sp.	*Larus*		11.8	37.6	13.4	5.7	13.3	16.1	7.9	15.1	**15.1**	3.1	12.3	30.5	18.8	28.9	15.6	10.2	8.2	**16.0**	63.3	14.0	15.2	42.5	58.1	38.4	39.1	69.0	**42.4**	74.0	28.9	30.8	20.9	19.6	2.9	0.3	2.8	**22.5**
Heermann's Gull	*Larus*	*heermanni*									**0.0**				0.1					**0.1**	0.1								**0.1**	0.1	0.1							**0.1**
Herring Gull	*Larus*	*argentatus*	x			x					**0.0**			2.3			x		0.2	**1.2**	1.6					x	x		**1.6**	0.1	x	0.6						**0.4**
Least Tern	*Sterna*	*antillarum*		x							**0.0**				0.1	x				**0.1**																		
Mew Gull	*Larus*	*canus*									**0.0**			x			x		0.2	**0.2**	1.0		1.0			0.2	0.4		**0.6**	0.1								**0.1**
Ring-billed Gull	*Larus*	*delawarensis*	1.7	6.3	1.1	1.6	1.3	1.4	0.5	0.9	**1.9**	0.6	3.8	1.4	2.4	0.7	3.8	1.7	2.7	**2.1**	23.4	5.2	9.1	9.8	6.5	2.9	22.8	2.4	**10.3**	11.6	5.1	1.0	4.5	3.5	1.2	0.9	0.6	**3.5**
Tern sp.				0.1							**0.1**		x	0.1						**0.1**										0.1	0.1		0.3					**0.2**
Thayer's Gull	*Larus*	*thayeri*									**0.0**															x												
Western Gull	*Larus*	*occidentalis*	0.7	5.0	3.8	2.3	3.9	1.0	1.5	1.1	**2.4**	2.3	3.6	2.7	7.3	1.4	2.8	2.0	2.5	**3.1**	15.2	6.8	11.5	18.4	3.9	13.7	9.2	8.6	**10.9**	7.5	12.0	0.4	1.2	1.4	0.7		0.4	**3.4**
Mean Gulls and Terns			**15.2**	**50.3**	**20.7**	**11.7**	**20.4**	**20.4**	**11.3**	**17.7**	**21.0**	**9.0**	**21.5**	**38.8**	**30.0**	**32.2**	**24.2**	**15.5**	**15.3**	**23.3**	**107.3**	**26.6**	**38.6**	**70.9**	**70.3**	**69.8**	**76.4**	**87.9**	**68.5**	**98.5**	**51.9**	**34.1**	**28.8**	**28.7**	**5.8**	**2.1**	**4.1**	**31.8**
No. Gull and Tern Species			**6**	**8**	**5**	**7**	**4**	**6**	**6**	**5**	**5.9**	**5**	**7**	**8**	**7**	**7**	**8**	**5**	**8**	**6.9**	**8**	**6**	**6**	**5**	**6**	**7**	**8**	**6**	**6.5**	**9**	**9**	**6**	**6**	**5**	**5**	**4**	**4**	**6.0**
Gull and Tern Diversity (H')			**1.2**	**1.2**	**1.5**	**2.1**	**1.4**	**1.1**	**1.4**	**0.4**	**1.3**	**2.3**	**1.7**	**1.2**	**1.5**	**0.7**	**1.6**	**1.6**	**2.0**	**1.6**	**1.6**	**1.6**	**1.9**	**1.4**	**0.9**	**1.8**	**1.7**	**1.2**	**1.5**	**1.3**	**1.8**	**0.7**	**1.4**	**1.6**	**1.9**	**2.1**	**1.4**	**1.5**
OTHER WATERBIRDS																																						

REFERENCE SITES

Common Name	Genus	Species	Eastern Reference 1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	mean	Western Reference 1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	mean
American Coot	*Fulica*	*americana*	66.4	49.6	40.1	20.4	12.7	13.1	10.8	17.0	**28.8**	26.0	29.2	22.9	11.8	4.7	2.6	5.0	25.3	**15.9**
American White Pelican	*Pelecanus*	*erythrorhynchos*					x	0.2			**0.2**					0.3	0.2			**0.3**
Belted Kingfisher	*Ceryle*	*alcyon*	x			x	x	x			**0.0**	x		0.1			x			**0.1**
Black-crowned Night-heron	*Nycticorax*	*nycticorax*		x	0.1	0.1	0.5	x	0.2		**0.2**		0.2	x	x				x	**0.2**
Brown Pelican	*Pelecanus*	*occidentalis*	0.3	0.1	2.4	0.3	0.5	0.4	0.9	x	**0.7**	0.2	0.2	1.9	0.3	0.2	0.1	1.9	0.4	**0.7**
Clapper Rail	*Rallus*	*longirostris*	0.7	1.4	0.4	0.9	1.4	1.6	2.0	2.1	**1.3**	0.6	0.6	0.3	0.4	0.8	1.3	1.6	4.4	**1.2**
Clark's Grebe	*Aechmophorus*	*clarkii*	0.8	1.1	0.7	0.6	2.6	0.3	0.3	0.2	**0.8**	0.5	0.4	0.2	0.3	0.6	x	x	0.1	**0.4**
Common Loon	*Gavia*	*immer*	x	0.1							**0.1**	0.1								**0.1**
Double-crested Cormorant	*Phalacrocorax*	*auritus*	1.0	7.0	3.1	4.9	5.6	8.1	8.1	2.9	**5.1**	0.8	0.4	6.0	2.4	6.8	3.1	14.2	30.2	**8.0**
Eared Grebe	*Podiceps*	*nigricollis*	1.5	1.1	1.8	1.2	1.5	1.1	1.5	5.1	**1.9**	0.8	0.7	0.9	0.8	1.0	1.0	0.9	2.0	**1.0**
Great Blue Heron	*Ardea*	*herodias*	x	0.5	0.3	0.4	0.2	0.4	0.3	0.5	**0.4**	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.6	**0.3**
Great Egret	*Ardea*	*alba*	x	0.5	0.9	0.5	0.4	0.7	0.4	0.4	**0.5**	0.2	0.6	1.3	2.0	0.9	0.9	0.5	1.2	**1.0**
Green Heron	*Butorides*	*vivescens*									**0.0**									
Horned Grebe	*Podiceps*	*auritus*	2.3	0.9	0.7	0.7	1.3	1.3	2.2	6.4	**2.0**	2.5	2.5	0.1	1.1	0.7	0.5	0.3	3.1	**1.4**
Marbled Murrelet	*Brachyramphus*	*marmoratus*									**0.0**					x				
Pacific Loon	*Gavia*	*pacifica*		0.1							**0.1**		x					0.0		**0.0**
Pied-billed Grebe	*Podilymbus*	*podiceps*	1.0	1.4	2.1	1.7	2.2	1.6	0.8	1.9	**1.6**	0.2	0.4	1.3	0.6	0.4	0.6	0.5	1.2	**0.7**
Red-throated Loon	*Gavia*	*stellata*		x							**0.0**	0.1								**0.1**
Snowy Egret	*Egretta*	*thula*	2.1	2.3	2.1	1.6	1.4	3.5	2.7	2.8	**2.3**	1.0	1.4	3.8	3.1	4.2	4.0	2.9	4.1	**3.1**
Sora	*Porzana*	*carolina*		x	x		x	x	x	0.2	**0.2**							0.1	0.6	**0.4**
Virginia Rail	*Rallus*	*limicola*		0.1		x	x			0.1	**0.1**					x		x	0.3	**0.3**
Western Grebe	*Aechmophorus*	*occidentalis*	4.6	5.5	4.8	6.4	3.7	1.0	2.2	3.9	**4.0**	4.5	7.6	0.4	1.7	3.7	0.8	1.8	0.3	**2.6**
Mean Other Waterbirds			**80.7**	**71.7**	**59.5**	**39.7**	**34.0**	**33.3**	**32.5**	**43.5**	**49.4**	**37.7**	**44.4**	**39.5**	**24.8**	**24.5**	**15.4**	**30.2**	**73.6**	**36.3**
No. Waterbird Species			**14**	**18**	**14**	**15**	**17**	**16**	**14**	**14**	**15.3**	**15**	**14**	**14**	**13**	**15**	**14**	**15**	**14**	**14.3**
Waterbird Diversity (H')			**1.2**	**1.8**	**1.9**	**2.4**	**2.9**	**2.6**	**2.8**	**2.8**	**2.3**	**1.8**	**1.8**	**2.1**	**2.6**	**2.9**	**3.0**	**2.5**	**2.3**	**2.4**
RAPTORS & OWLS																				
American Kestrel	*Falco*	*sparverius*		x							**0.0**									
Bald Eagle	*Haliaeetus*	*leucocephalus*									**0.0**						x			
Burrowing Owl	*Athene*	*cunicularia*									**0.0**									
Cooper's Hawk	*Accipiter*	*cooperi*									**0.0**					x	x			
Golden Eagle	*Aquila*	*chrysaetos*									**0.0**									
Merlin	*Falco*	*columbarius*									**0.0**		x							
Northern Harrier	*Circus*	*cyaneus*	x	0.3	0.1	0.1	0.1	0.1	x		**0.1**	0.2	0.1	0.1	0.1	x	0.1	0.2	x	**0.1**
Osprey	*Pandion*	*haliaetus*	x					x	x	x	**0.0**		x		x					
Peregrine Falcon	*Falco*	*peregrinus*	x					x		x	**0.0**						x			
Red-shouldered Hawk	*Buteo*	*lineatus*									**0.0**				x					
Red-tailed Hawk	*Buteo*	*jamaicensis*	0.1	x	0.1	0.1	x	x		0.2	**0.1**	0.1	0.1	0.2	0.1	0.1	x		0.2	**0.1**
Sharp-shinned Hawk	*Accipiter*	*striatus*					x		x		**0.0**									
Turkey Vulture	*Cathartes*	*aura*	x	0.2	0.4	0.4	x	x	x	0.1	**0.3**	0.1	0.2	0.3	0.1	0.1		x		**0.2**
White-tailed Kite	*Elanus*	*leucurus*									**0.0**						x	x		
Mean Raptors			**0.1**	**0.5**	**0.6**	**0.6**	**0.1**	**0.1**	**0.0**	**0.3**	**0.3**	**0.4**	**0.4**	**0.6**	**0.3**	**0.2**	**0.1**	**0.2**	**0.2**	**0.3**
No. Raptor Species			**5**	**4**	**3**	**3**	**4**	**5**	**4**	**4**	**4.0**	**3**	**5**	**3**	**5**	**4**	**6**	**3**	**2**	**3.9**
Raptor Diversity (H')			**0.0**	**1.0**	**1.3**	**1.3**	**0.0**	**0.2**	**0.0**	**1.0**	**0.6**	**1.5**	**1.5**	**1.5**	**1.6**	**1.0**	**0.7**	**0.1**	**0.1**	**1.0**
Mean All Birds			**934.1**	**709.7**	**707.6**	**484.0**	**383.2**	**663.5**	**415.5**	**719.4**	**627.1**	**269.7**	**360.8**	**475.7**	**497.4**	**367.3**	**252.7**	**367.5**	**367.2**	**369.8**
No. Species			**58**	**61**	**52**	**54**	**57**	**55**	**54**	**48**	**54.9**	**50**	**55**	**54**	**52**	**56**	**56**	**50**	**52**	**53.1**
Diversity (H')			**3.8**	**4.1**	**3.6**	**3.9**	**3.9**	**3.2**	**3.6**	**3.1**	**3.6**	**3.8**	**4.0**	**3.3**	**3.2**	**3.6**	**3.4**	**3.3**	**3.7**	**3.5**

RESTORATION SITES

Common Name	Seasonal Ponds 1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	mean	Tidal Wetlands 1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	mean
American Coot	x	x		6.0	8.0	2.5	0.4	47.5	**12.9**	6.6	10.2		11.9	4.4	3.8	7.3	5.6	**7.1**
American White Pelican															0.2			**0.2**
Belted Kingfisher										x	0.1			0.1	x	0.1	0.1	**0.1**
Black-crowned Night-heron										x								
Brown Pelican													0.1	x		x		**0.1**
Clapper Rail															x	x	1.1	**1.1**
Clark's Grebe																		
Common Loon																		
Double-crested Cormorant			0.1		x	0.7	0.8		**0.5**	0.7	0.1	2.7		0.9	x	0.2	0.2	**0.8**
Eared Grebe				0.1	x		0.2	0.1	**0.1**					0.1		x	0.3	**0.2**
Great Blue Heron					0.1	0.0		0.2	**0.1**	0.2				0.1	0.3	0.2	0.4	**0.2**
Great Egret	0.1	x		0.1		x	x	0.1	**0.1**	0.4	1.0	1.4	0.7	0.5	1.9	1.2	1.1	**1.0**
Green Heron														x				
Horned Grebe				x	x			0.2	**0.2**					0.1			0.4	**0.2**
Marbled Murrelet																		
Pacific Loon																		
Pied-billed Grebe							x	0.2	**0.2**	0.3	0.1		0.1		0.1	x	0.2	**0.2**
Red-throated Loon																		
Snowy Egret				0.1	x	0.1	x		**0.1**	4.2	7.3	10.3	11.4	12.5	15.0	9.5	7.7	**9.7**
Sora																		
Virginia Rail																		
Western Grebe											x		0.1			x		**0.1**
Mean Other Waterbirds	**0.1**	**0.0**	**0.1**	**6.3**	**8.1**	**3.4**	**1.3**	**48.3**	**8.5**	**12.4**	**18.8**	**14.4**	**24.3**	**18.7**	**21.3**	**18.4**	**16.8**	**18.1**
No. Waterbird Species	**2**	**2**	**1**	**5**	**6**	**5**	**6**	**6**	**4.1**	**8**	**7**	**3**	**6**	**10**	**9**	**11**	**10**	**8.0**
Waterbird Diversity (H')	**0.0**	**0.0**	**0.0**	**0.4**	**0.1**	**1.0**	**1.3**	**0.2**	**0.4**	**1.6**	**1.4**	**1.1**	**1.3**	**1.4**	**1.3**	**1.4**	**2.0**	**1.4**
RAPTORS & OWLS																		
American Kestrel	0.1	0.1			0.1	x	x		**0.1**			x	0.1				0.2	**0.1**
Bald Eagle															x			
Burrowing Owl		0.2	0.6	1.2	0.3	x			**0.6**				x					
Cooper's Hawk															x	x		
Golden Eagle		x									x				x			
Merlin								x					x			x		
Northern Harrier	x	0.2		0.2	0.1	0.1	x		**0.2**	x	0.3	0.1	0.1	0.3	0.4	0.2	0.3	**0.2**
Osprey							x	x		x								
Peregrine Falcon		x	0.1			x	x	0.2	**0.1**	x	x	0.1	0.8	0.1		x		**0.3**
Red-shouldered Hawk																		
Red-tailed Hawk		0.3	0.1	0.1	x		x	0.1	**0.2**	0.1	0.4	0.5	0.1	0.2	0.1	0.2	0.3	**0.2**
Sharp-shinned Hawk																		
Turkey Vulture	x	0.5	0.4	0.7	0.2	0.5	0.3	0.5	**0.4**	0.2	1.1	1.1	1.2	0.3	0.2	0.3	0.7	**0.6**
White-tailed Kite		x		x									x			x		
Mean Raptors	**0.1**	**1.3**	**1.2**	**2.2**	**0.7**	**0.6**	**0.3**	**0.8**	**0.9**	**0.3**	**1.8**	**1.8**	**2.3**	**0.9**	**0.7**	**0.7**	**1.4**	**1.2**
No. Raptor Species	**3**	**8**	**4**	**5**	**5**	**5**	**6**	**5**	**5.1**	**5**	**5**	**4**	**8**	**4**	**6**	**7**	**4**	**5.4**
Raptor Diversity (H')	**0.0**	**2.1**	**1.6**	**1.5**	**1.8**	**0.7**	**0.2**	**1.3**	**1.2**	**0.9**	**1.3**	**1.4**	**1.6**	**1.9**	**1.4**	**1.6**	**1.7**	**1.5**
Mean All Birds	**314.6**	**90.4**	**149.6**	**274.5**	**368.2**	**354.2**	**450.0**	**448.7**	**306.3**	**656.7**	**1087.1**	**689.2**	**610.8**	**833.0**	**493.5**	**393.4**	**123.5**	**610.9**
No. Species	**35**	**34**	**26**	**39**	**46**	**39**	**48**	**40**	**38.4**	**46**	**49**	**36**	**49**	**45**	**46**	**50**	**42**	**45.4**
Diversity (H')	**3.3**	**3.1**	**3.7**	**3.7**	**3.7**	**3.9**	**4.0**	**3.6**	**3.6**	**3.2**	**3.2**	**3.5**	**3.9**	**3.8**	**3.7**	**3.6**	**4.0**	**3.6**

Table 2. Mean proportion and number (n) foraging of four shorebird groups at Intertidal Pond (Tidal Wetlands) and the Seasonal Ponds, 1998-2006.

	Intertidal Pond									Seasonal Ponds							
	Incoming	n	High	n	Outgoing	n	Low	n		Incoming	n	High	n	Outgoing	n	Low	n
Charadriidae	0.38	1.5	0.04	0.2	0.30	2.17	0.34	0.9		0.34	1.4	0.50	2.7	0.35	0.6	0.30	1.1
Recurvirostridae	0.36	5.1	0.63	0.7	0.44	1.64	0.63	3.4		0.24	7.1	0.18	8.2	0.20	7.0	0.67	1.4
Large Scolopacidae	0.53	12.7	0.18	1.1	0.17	3.89	0.35	0.8		0.29	1.8	0.19	3.3	0.45	1.9	1.00	0.4
Small Scolopacidae	0.70	99.6	0.16	5.7	0.43	16.91	0.96	5.2		0.46	22.4	0.72	76.3	0.67	32.6	1.00	1.0

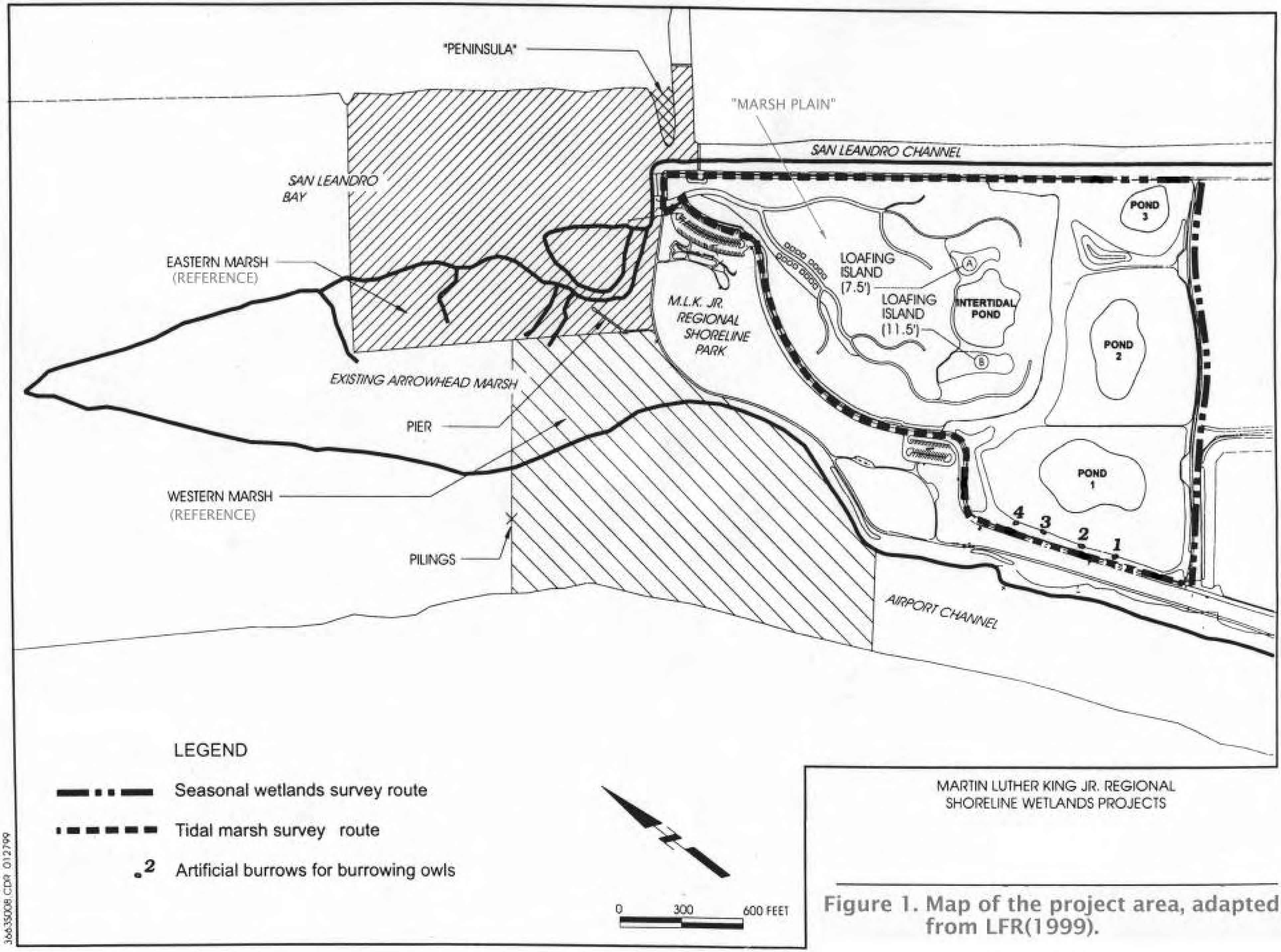


Figure 1. Map of the project area, adapted from LFR(1999).

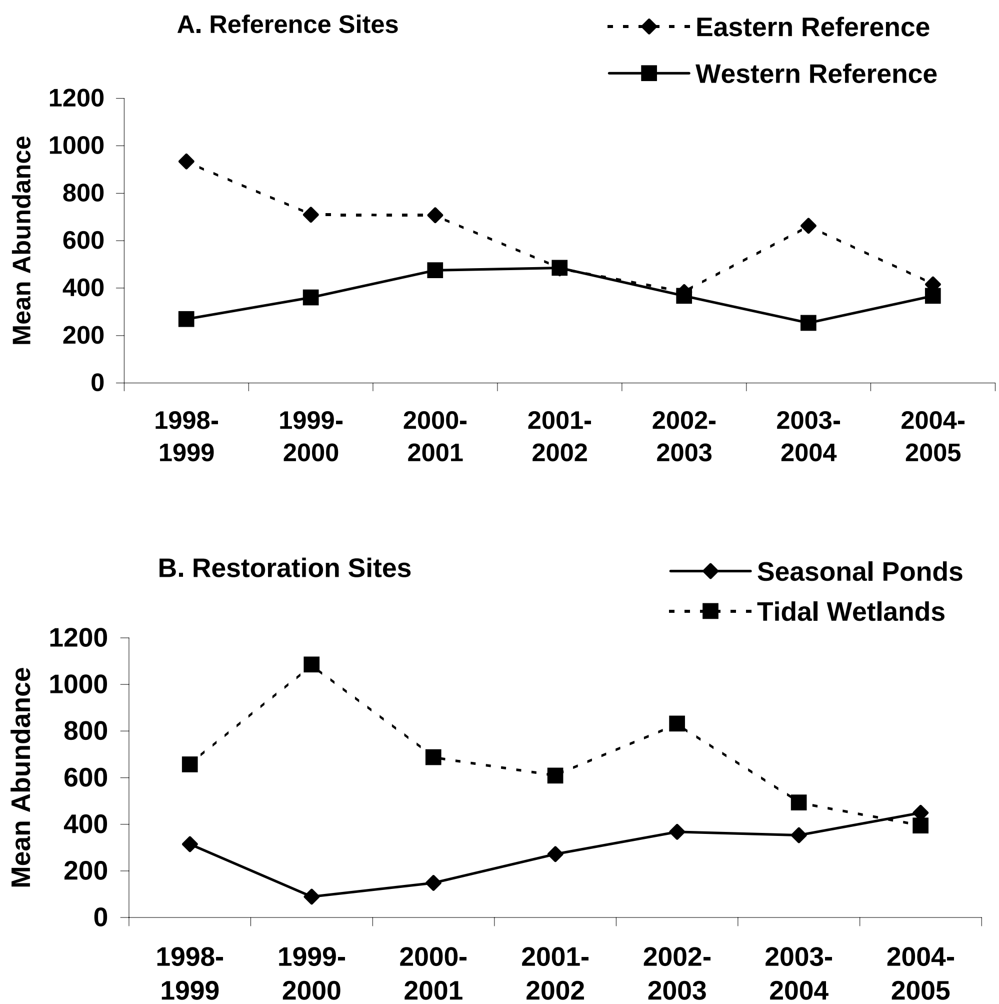


Figure 2. Mean waterbird abundance at the Reference (A) and Restoration (B) Sites, 1998-2005.

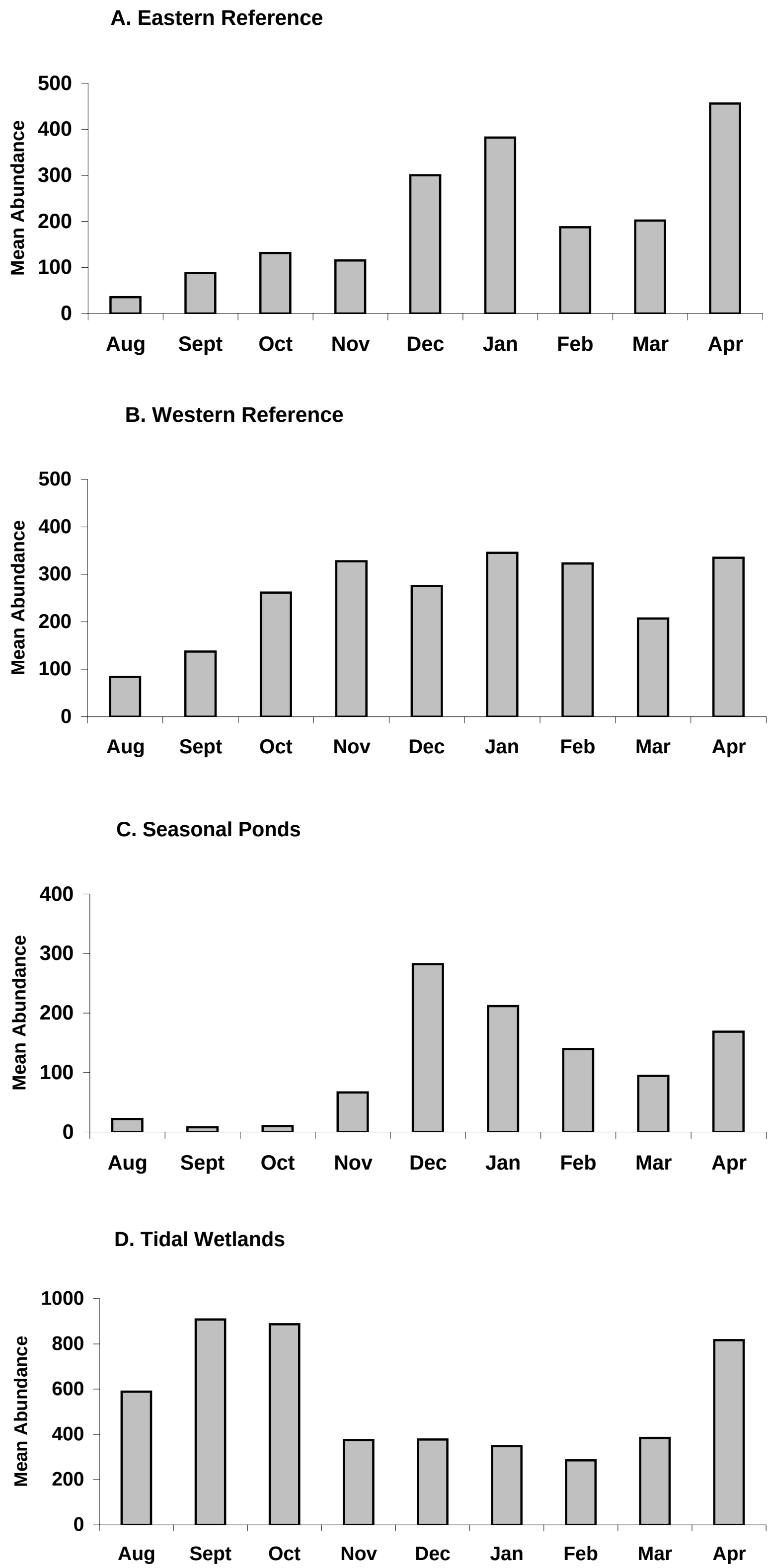


Figure 3. Mean monthly shorebird abundance at two Reference (A and B) and two Restoration (C and D) Sites, 1998-2005. Note large differences in y-axes.

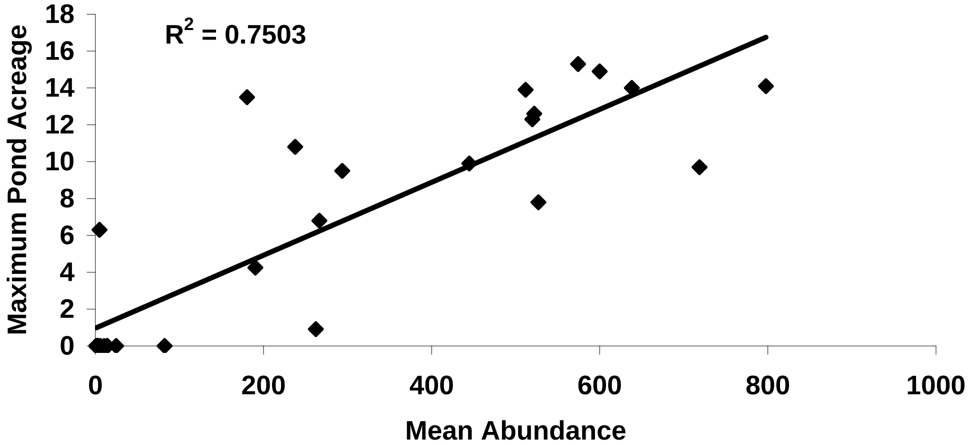


Figure 4. Mean waterbird abundance at the Seasonal Ponds as a function of maximum pond acreage (monthly means of all ponds combined).

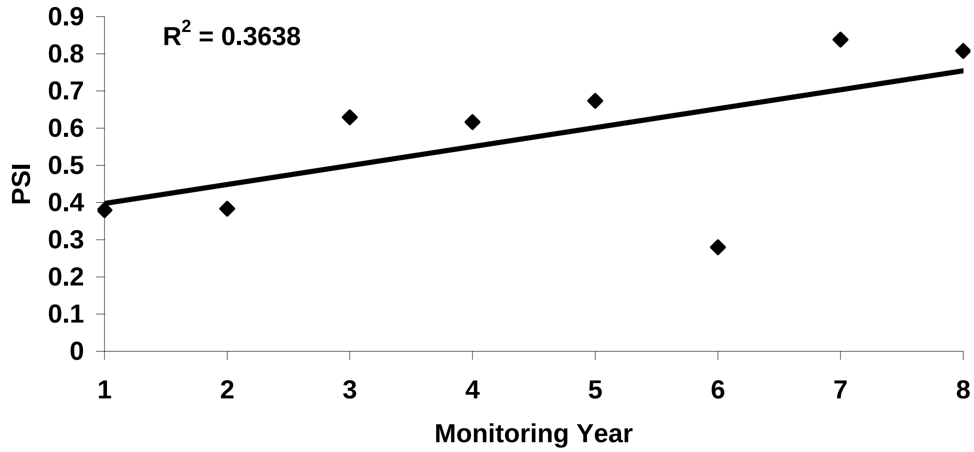


Figure 5. Percent Similarity Index (PSI) values for each of the eight monitoring years, 1998-2006.

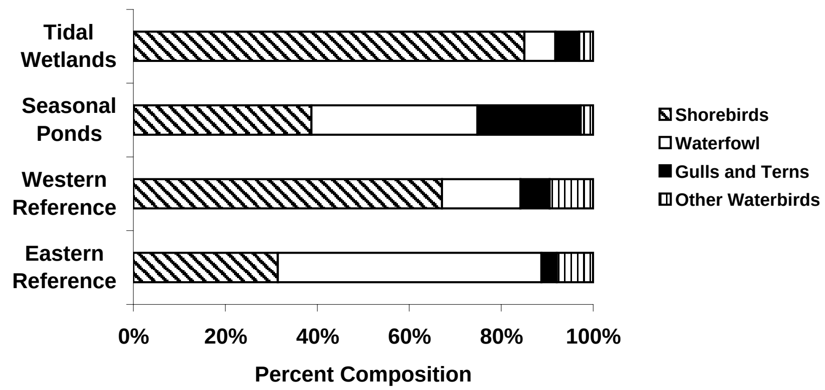


Figure 6. Species-group composition at two Restoration (top two) and two Reference Sites.

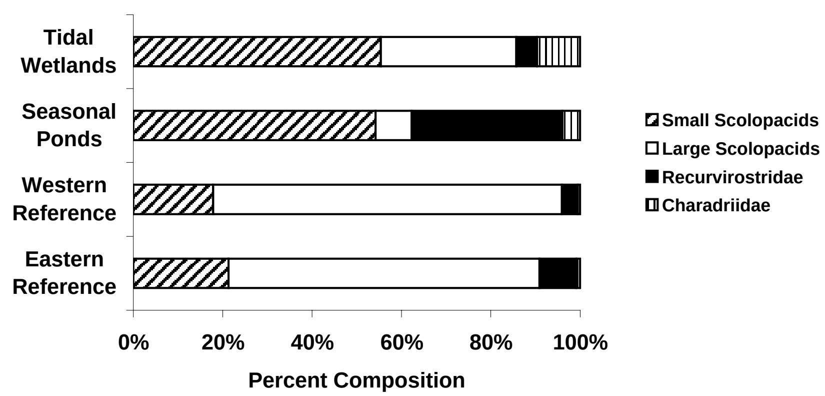


Figure 7. Shorebird-group composition at two Restoration (top two) and two Reference Sites.

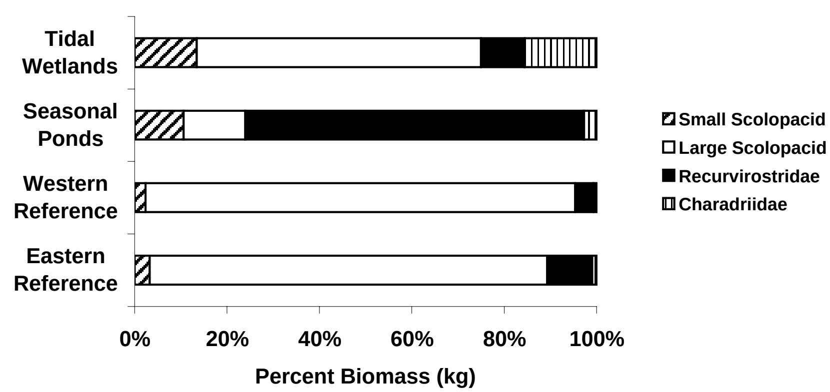


Figure 8. Shorebird-group composition by biomass at two Restoration (top two) and two Reference Sites.

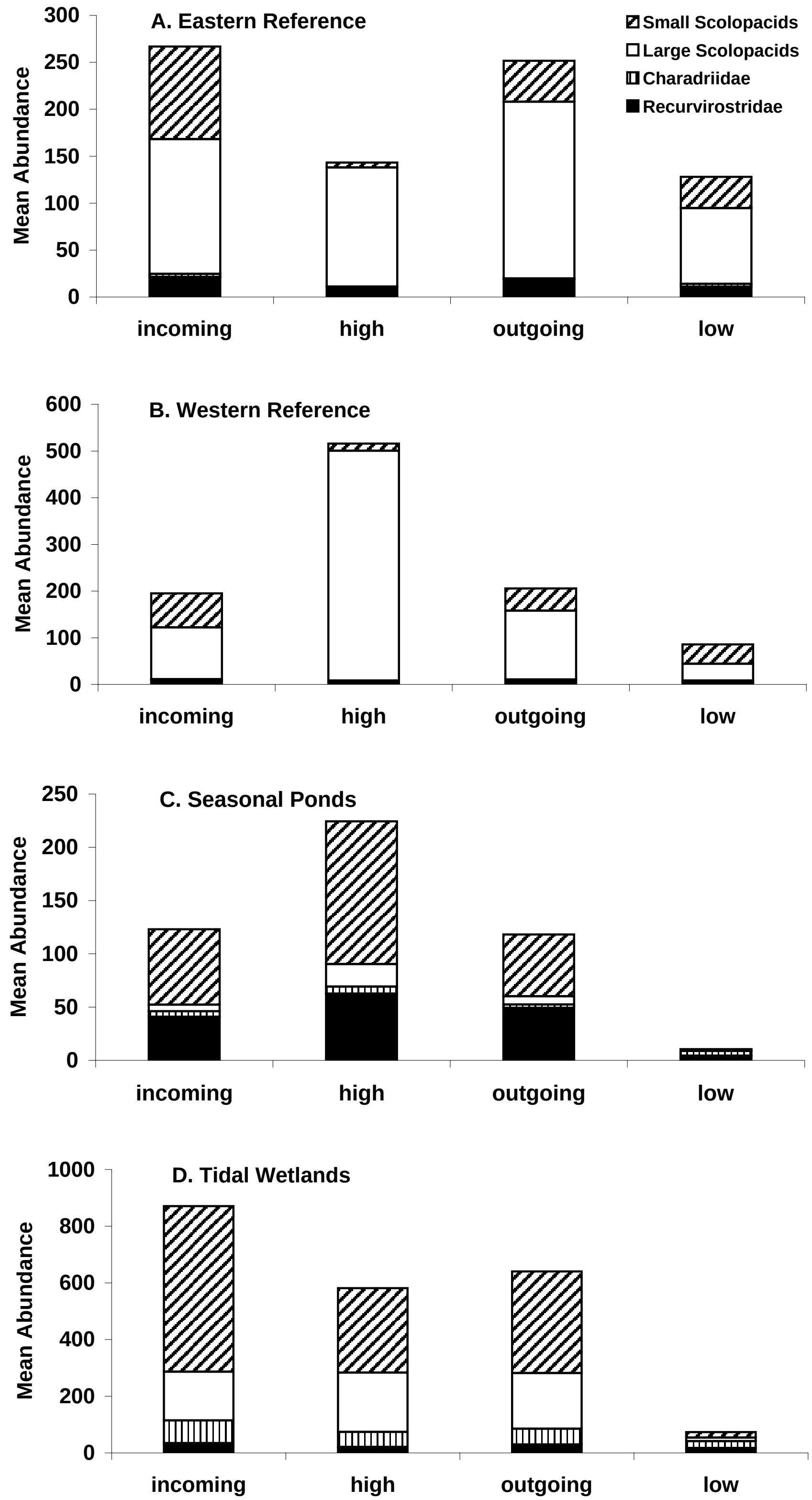


Figure 9. Shorebird abundance as a function of tidal stage at two Reference (A and B) and two Restoration (C and D) areas, 1998-2005. Note large differences in y-axes.

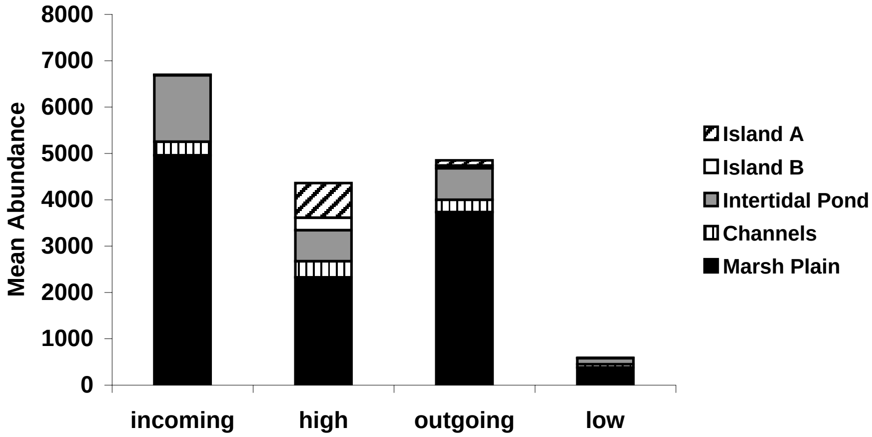
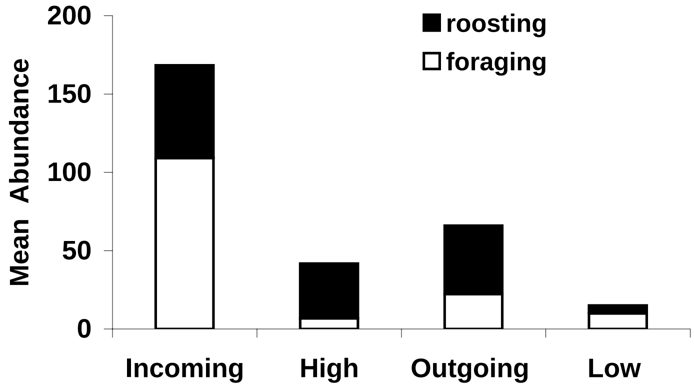


Figure 10. Mean abundance of shorebirds at five habitat sub-areas at four tidal stages within the Tidal Wetlands Restoration Site, 1998-2005.

A. Intertidal Pond (Tidal Wetlands)



B. Seasonal Ponds

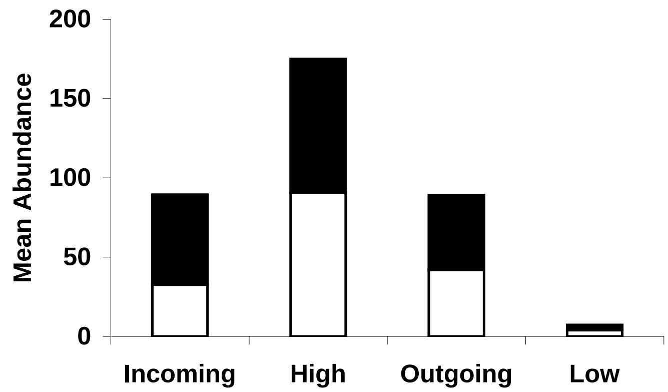


Figure 11. Mean abundance of foraging and roosting shorebirds at two Restoration Sites, 1998-2005.

Appendix C – Golden Gate Audubon Society Avian Monitoring Volunteers List

2003-2007
Eddie Bartley
Bob Battagin
Betty Berenson
Marjorie Blackwell
Kathryn Blake
Kay Bloom
Andree Breaux
Howard E Brownson
Andrea Burhoe
Brenda Buxton
Virginia Choiniere
Timothy J Cleere
Bruce & Myra Cobbledick
Joan Collignon
Susana Conde
Judith Corning
Kristin Doner
Judith L Dunham
Melissa Dyer
Sue Gallagher
Brad Goya
Barbara A Haley
Susan Hampton
Michelle Harrison
Gene B Herman
Anne Hoff
Cathy Hubbard
Richard Kaufmann
Evelyn Kennedy
Caroline H Kim
Carolyn Kolka
Holly Kramer
Scott Lambert
James Langan
Ruth W Langer
Jill Lawrence
Robert & Hannelore Lewis
Rachel Lipsky
Melanie P Lutz
Jocelyn McFaul
Horacio & Mona Mena
Timothy I Molter
Sue Moyles
Collin G Murphy
Samantha J Murray
Marilyn Nasatir
Kris Neumann
Roger & Audre Newman
Charlotte Nolan
Carol Oda
Kristin A Ohlson
Nancy Page

2003-2007 continued
Courtenay Peddle
Jean & Dennis Perata
Karen Peterson
Lory Poulson
Douglas H Pryne
Judith A Radocha
Mike Richter
Phila Witherell Rogers
Ruth E Sayre
Mary Schaefer
Elizabeth Sojourner
Virginia Sorgi
Douglas Stewart
Inge Svoboda
Carol A Thorp
Sarah Toas
Ruth Tobey
Robert & Veronica Vaughan
Ed Walker
Joanne Sarg Wallin
Noreen Weeden
Herta Weinstein
Marian Whitehead
Joye Beth Wiley
Rhea Williamson
Sophia L Wong
Tara Zuardo

2002-2003
Bob Battagin
Betty Berenson
Kathryn Blake
Kay Bloom
Andree Breaux
Howard Brownson
Virginia Choiniere
Timothy Cleere
Joan Collignon
Kristin Doner
Judith Dunham
Arthur Feinstein
Sue Gallagher
Brad Goya
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Anne Hoff
Cathy Hubbard
Richard Kaufmann
Carolyn Kolka
Scott Lambert
Jill Lawrence
Melanie Lutz
Mona Mena
Collin Murphy
Marilyn Nasatir
Charlotte Nolan
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Phila Witherell Rogers
Ruth Sayre
Elizabeth Sojourner
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Ed Walker
Joanne Wallin
Herta Weinstein
Marian Whitehead
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Sophia Wong

2001-2002
Bob Battagin
Betty Berenson
Kathryn Blake
Kay Bloom
Andree Breaux
Howard Brownson
Virginia Choiniere
Timothy Cleere
Joan Collignon
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Inge Svoboda
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2000-2001
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