Year 2 Monitoring Report for the Western Stege Marsh Restoration Project

DTSC Order I/SE- RAO 06/07-004 Section 5.16

University of California, Berkeley
Richmond Field Station, Richmond, California

November 15, 2007

Prepared for
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January 8, 2008

Jim Browning
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825

Re: University of California, Berkeley, Richmond Field Station
Western Stege Marsh Restoration Project
Year 2 Monitoring Report

Dear Mr. Browning:

On behalf of the University of California, Berkeley, Tetra Tech EM Inc. is submitting the enclosed *Year 2 Monitoring Report for the Western Stege Marsh Restoration Project*. This report has been prepared to summarize field monitoring events and data analyses conducted during 2005 and 2006 to monitor progress of the restored portion of the Western Stege Marsh at the Richmond Field Station site. Submission of this document fulfills the reporting requirements outlined in the following permits:

- United States Army Corps of Engineers Nation Wide Permit #38 (File #2617S and #28135S) and the associated United States Fish and Wildlife Services Biological Opinion (#1-1-03-F-0228; Letter #1-1-02-I-2866);
- Regional Water Quality Control Board, San Francisco Region Clean Water Act Section 401 Water Quality Certification (File #2199.1185);
- San Francisco Bay Conservation and Development Commission Permit No. M01-52(b); and
- East Bay Regional Parks District Encroachment Permits #029E-02-601 and #049E-030601.

If you have any questions or need additional information, please contact me at jason.brodersen@ttemi.com or (415) 222-8283; or Greg Haet of the University of California, Berkeley at (510) 642-4848 or gjhaet@berkeley.edu.

Sincerely,

Jason Brodersen, P.G.
Project Manager

Enclosure

cc:

Molly Martindale, United States Corps of Engineering
Cecil Felix, Regional Water Quality Control Board, San Francisco Bay Region
Bob Batha, San Francisco Bay Conservation and Development Commission
Pat O'Brien, East Bay Regional Parks District

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ACRONYMS AND ABBREVIATIONS

AWQC	Ambient water quality criteria
Bay Trail	East Bay Regional Park District Bay Trail
BBL	Blasland, Bouck & Lee, Inc.
CAD	Computer-aided design
CAL-IPC	California Invasive Plant Council
CAMN	Collaborative Adaptive Management Network
DGPS	Differential global positioning system
DTSC	Department of Toxic Substances Control
ER-M	Effects range-median
FAMP	Feral Animal Management Program
GPS	Global positioning system
NGVD	National Geodetic Vertical Datum
NWP 38	Nationwide Permit 38
PCB	Polychlorinated biphenyl
RFS	Richmond Field Station
RGR	Relative growth rate
Tetra Tech	Tetra Tech EM Inc.
UC Berkeley	University of California, Berkeley
USFWS	U.S. Fish and Wildlife Service
Water Board	San Francisco Bay Regional Water Quality Control Board
WSMRP	Western Stege Marsh Restoration Project

EXECUTIVE SUMMARY

This Year 2 Monitoring Report for the Western Stege Marsh Restoration Project (WSMRP) at the University of California, Berkeley, Richmond Field Station (RFS) has been prepared on behalf of the Regents of the University of California in compliance with remediation permits issued for prior remediation activities conducted under San Francisco Bay Regional Water Quality Control Board (Water Board) Order No. 01-102 (Water Board 2001, rescinded October 2005). The remediation permits require restoration monitoring of the remediated marsh area. The WSMRP Monitoring Plan defines the post-remediation monitoring required under the permits at the WSMRP site (Blasland, Bouck & Lee, Inc. [BBL] 2004c). The current Department of Toxic Substances Control (DTSC) Site Investigation and Remediation Order I/SE-RAO 06/07-004 for the RFS issued September 15, 2006 requires (Section 5.16) continued implementation of the WSMRP Monitoring Plan. The portions of the marsh subject to this monitoring program are the marsh and ecotone areas remediated in 2002 to 2004 (areas formerly designated 2A, M3 and M1a). The purpose of post-remediation monitoring is to assess the results of the WSMRP and to adaptively manage the site to aid the restoration processes. The objectives of monitoring are to (1) quantitatively assess the hydrological functions within the site, (2) assess progress toward or deviation from defined project goals, (3) provide regulatory agencies with information on restoration efforts, and (4) initiate contingency measures as necessary. Monitoring events are to be conducted on a semiannual basis for five years (BBL 2004c). The WSMRP Monitoring Plan outlines the four project targets:

- Project Target 1: Restore the hydrologic complexity to the WSMRP site
- Project Target 2: Improve water quality by increasing the time water resides within the WSMRP site
- Project Target 3: Restore low salt marsh (Pacific cordgrass), middle salt marsh (pickleweed), and the emergent and coastal scrub native plant communities within the WSMRP site
- Project Target 4: Establish a compositionally and structurally complex ecosystem within the WSMRP site with attributes important to wildlife, specifically focused on increasing habitat functions for the California clapper rail

Overall, based on data collected in 2006, the WSMRP site is progressing toward providing the functions of a tidal marsh typical of San Francisco Bay. Project Target 1 standards were mostly achieved (standards were not achieved in three of the eight cross-sections measured). The hydrology is sufficient to inundate the marsh portions of the WSMRP daily and support vegetative communities designed in the WSMRP Monitoring Plan. Project standards for Target 2 have not yet been established. Year 2 data indicated that metals concentrations in some surface water, sediment, and stormwater samples exceeded some federal and state screening criteria for the protection of aquatic life but more sampling is necessary to assess the significance of these results. Data collected in support of Project Target 2 were established as a baseline in Year 2 and these results will be combined with future monitoring to assess water quality over time. The project standards for Project Target 3 were achieved. The total acreage of Pacific cordgrass (*Spartina foliosa)* was less than the project standard, while the total acreage of pickleweed (*Salicornia virginica*) was greater than the project standard. The overall native plant cover exceeded the Year 2 standards. The Project Target 4 standards have not yet been achieved. The California clapper rail was not using the WSMRP site for nesting or foraging during protocol-level surveys, although individuals were detected near the edge of the site and are expected to use habitat as it matures.

An adaptive management approach is being used for restoration of the WSMRP site. The adaptive management process is flexible, allows for review of monitoring results, and considers adjustments to monitoring plans in response to previous results. The table below presents the adaptive management recommendations or options for the upcoming Year 3 monitoring of the WSMRP site.

Project Target	**Recommended Changes in Site Management and Data Collection**	**Recommended Changes in Data Interpretation**
1	On-site tide gage information is not critical to evaluate site inundation, and is therefore not recommended to be collected in Year 3.	No Change.
2	No Change.	Finalize criteria (in cooperation with DTSC).
3	No Change. Options for increasing the rate of Pacific cordgrass colonization include increasing the rate of transplanting salvaged plants, genetically testing volunteer seedling for hybridization so that only hybrids are removed, and applying soil amendments.	No Change.
	No change to plant identification task.	Combine Pacific cordgrass and pickleweed acreage to evaluate success of marsh revegetation.
	Determine areal extent of land suitable for development of a plant community dominated by Pacific cordgrass.	Report established acreage of Pacific cordgrass as proportion of acreage potentially suitable; redefine target acreage as proportion of what is available at correct elevation and distance from water.
4	No Change.	No Change. Consider adding an additional monitoring station in the eastern portion of the marsh as the site vegetation matures.

1.0 INTRODUCTION

This Year 2 Monitoring Report for the Western Stege Marsh Restoration Project (WSMRP) at the University of California, Berkeley (UC Berkeley) Richmond Field Station (RFS) has been prepared on behalf of the Regents of the University of California in compliance with remediation permits issued for prior remediation activities conducted under San Francisco Bay Regional Water Quality Control Board (Water Board) Order No. 01-102 (Water Board 2001, rescinded October 2005). Remediation activities at the RFS have been performed in phases. Remediation within the Western Stege Marsh included Phase 1, completed in 2002; Phase 2, completed in 2003 and 2004; and Phase 3, completed in 2004. The remediation permits require restoration monitoring of the remediated marsh area. The WSMRP Monitoring Plan defines the post-remediation monitoring required under the permits at the WSMRP site ("monitoring plan," "WSMRP Monitoring Plan," Blasland, Bouck & Lee, Inc. [BBL] 2004c). The current Department of Toxic Substances Control (DTSC) Site Investigation and Remediation Order I/SE-RAO 06/07-004 for the RFS issued September 15, 2006 requires (Section 5.16) continued implementation of the WSMRP Monitoring Plan. The portions of the marsh subject to this monitoring program are the marsh and ecotone areas remediated in 2002 to 2004 (areas formerly designated 2A, M3 and M1a). The purpose of post-remediation monitoring is to assess the results of the WSMRP and to adaptively manage the site to facilitate the restoration processes. The WSMRP Monitoring Plan outlines the four project targets related to hydrology, water quality, restoration of salt marsh and coastal scrub communities, and establishment of a compositionally and structurally complex ecosystem. The monitoring plan defines a set of performance criteria, or project standards, to assess the success of each of the project targets. Field measurements and indicators—such as hydrological cross sections, vegetation surveys, and California clapper rail (*Rallus longirostris obsoletus*) surveys—are collected to evaluate whether the project standards are being achieved (BBL 2004c).

The objectives of monitoring are to (1) quantitatively assess the hydrological functions within the site, (2) assess progress toward or deviation from defined project goals, (3) provide regulatory agencies with information on restoration efforts, and (4) initiate contingency measures as necessary. Monitoring events are to be conducted on a semiannual basis for five years (BBL 2004c).

This report summarizes the results of Year 2 monitoring conducted at the WSMRP site in 2006 and recommends contingency measures to increase the likelihood restoration will be successful. Contingency measures are an important facet of the adaptive management approach taken for restoration of the WSMRP site. The adaptive management process is flexible, allows for review of monitoring results, and considers adjustments to monitoring plans in response to previous results. The site background and the organization of this report are summarized in the following sections.

1.1 SITE BACKGROUND

This section discusses the site location, site history, and the regulatory framework for monitoring of the WSMRP site.

1.1.1 Site Location and History

The RFS is located at 1301 South 46th Street in Richmond, California (see Figure 1). The RFS is bordered by Meade Street off Interstate 580 to the north, by South 46th Street to the east, by the East Bay Regional Park District Bay Trail (Bay Trail) to the south, and by Meeker Slough and Regatta Boulevard to the west (see Figure 2). Prior to UC purchasing the RFS property, the California Cap Company used the property for industrial manufacturing of explosives from the late 1800s until 1948. In 1950, UC purchased the property primarily for research facilities for the College of Engineering and later other campus departments used portions of RFS.

RFS consists of the Upland Area, containing areas developed for academic teaching and research and a remnant coastal terrace prairie, a tidal salt marsh known as Western Stege Marsh, and the Transition Area between the Upland Area and Western Stege Marsh. Western Stege Marsh extends across the southern portion of the RFS and the adjacent properties between the Transition Area and the Bay Trail (a former rail spur). Most of Western Stege Marsh is located within the RFS property boundary; the eastern portion of the marsh, Eastern Stege Marsh, is located on the adjacent property, formerly owned by Zeneca Inc. (and referred to as the former Zeneca site). The Connector Trail to the Bay Trail prevents tidal interaction between Western and Eastern Stege Marshes.

The Western Stege Marsh occupies approximately 9 acres and is bounded by the Transition Area to the north, the Connector Trail and Eastern Stege Marsh (Zeneca's marsh) to the east, the Bay Trail to the south, and Meeker Slough and Marina Bay (a residential community) to the west. The portions of the marsh subject to this monitoring program, the Western Stege Marsh Restoration Project (WSMRP), are the five-acre marsh and ecotone area created during 2002 to 2004 remediation activities (areas formerly designated 2A, M3 and M1a). Figure 3 shows the WSMRP area. The marsh habitat in the project area consists of tidal sloughs, low marsh, middle to high marsh and an ecotone transition from marsh to upland coastal prairie and coastal scrub. Low marsh is typically dominated by Pacific cordgrass (*Spartina foliosa*) which grows from above the mean tide line (0.43 National Geodetic Vertical Datum [NGVD]) to slightly above the mean hightide line (2.6 NGVD). Middle marsh is typically dominated by pickleweed (*Salicornia virginica*) which grows between the mean hightide line (2.6 NGVD) and the mean high-high tide line (3.2 NGVD). High marsh is typically dominated by salt grass (*Distichlis spicata*), marsh gum plant (*Grindelia stricta angustifolia*), jaumea (*Jaumea carnosa*), and alkali bulrush (*Scirpus robustus*) at an elevation ranging from 3.5 to 5.0 NGVD. The ecotone is a vegetated strip about 10 to 30 feet wide between the edge of the marsh (5.0 NGVD) and uplands that provides cover habitat for California clapper rails during high tides. The surrounding uplands is mostly ruderal with the exception of the earthen berm, which was restored in 2005 and 2006, and a one-hundred-foot-wide section in the Transition Area that was planted with native vegetation in 2006 and 2007. The upper marsh edge is defined as the five-foot contour in the project area.

Historical industrial operations conducted at the RFS site prior to UC ownership, and historical industrial operations conducted at adjacent properties, have contaminated sediments in the Western Stege Marsh. As a result, UC Berkeley implemented and completed remediation activities at the Western Stege Marsh. These activities were performed in three phases beginning in 2002 in response to the Water Board Order (No. 01-102) issued to UC Berkeley and Zeneca in October 2001 (Water Board 2001). The construction schedule was designed to avoid disturbing the site during the breeding season (February 1 to August 31) of the California clapper rail. Remediation within Western Stege Marsh included Phase 1, completed in 2002; Phase 2, completed in 2003 and 2004; and Phase 3, completed in 2004.

Recognizing the need for establishing a baseline for the WSMRP, UC Berkeley defined January 2004 to be "time zero" for the restoration project (BBL 2005, see Section 1.1). Monitoring data collected during fall 2004 and the California clapper rail surveys conducted in early 2005 were presented in the Year 1 Monitoring Report (BBL 2005); no other monitoring data were collected during 2005. Data collected during 2006 are considered Year 2 and are presented in this report. Regulatory oversight of the RFS is now provided by the Department of Toxic Substances Control (DTSC) under Site Investigation and Remediation Order, Docket No. ISE-RAO 06/07-004, dated September 15, 2006.

1.1.2 Regulatory Framework

Federal, state, and local governments have jurisdiction over waters and wetlands affected by remediation and restoration activities conducted at the RFS. The table below summarizes the environmental permits issued for remediation and restoration of the Western Stege Marsh during Phase 1, 2, and 3 remediation activities. Monitoring of the WSMRP site is a requirement of these permits.

Agency	Permit
U.S. Army Corps of Engineers	Clean Water Act Section 404 Nationwide Permit (NWP) 38 #26417S and NWP 38 #28135S
U.S. Fish and Wildlife Service	Biological Opinion #1-1-03-F-0228 Letter #1-1-02-I-2866
Water Board	Clean Water Act Section 401 Water Quality Certification File #2199.1185(CSF)
San Francisco Bay Conservation and Development Commission	Number M01-52(b)
East Bay Regional Parks District	Encroachment Permit #029E-02-601 and 049E-03-601

A complete summary of the regulatory processes and permits associated with the WSMRP is provided in the WSMRP Monitoring Plan (BBL 2004c).

1.1.3 Year 1 Marsh Monitoring Summary

The WSMRP Year 1 Monitoring Report was prepared to assess the results of restoration activities in areas of Western Stege Marsh and establish baseline conditions for future monitoring events (BBL 2005). Overall, the monitoring report concluded that the WSMRP site was progressing toward providing the functions of a tidal marsh typical of San Francisco Bay. Project standards for Project Target 1, restore hydrological complexity, were being achieved: hydrology was sufficient to inundate the WSMRP site and flush sloughs at least once a day. Project Target 2, improve water quality, was not assessed during Year 1. At that time, a separate groundwater and surface water monitoring plan was under regulatory agency review. The Year 1 Monitoring Report indicated that future monitoring reports would include water quality data. The project standards for Project Target 3, restore salt marsh and coastal scrub communities, were not achieved. Pacific cordgrass had not begun to colonize the site and the total acreage of pickleweed was slightly less than the project standard; however, the Year 1 Monitoring Report concluded that the project standards for Project Target 3 are expected to be met by Year 5. The project standards for Project Target 4, establish a compositionally and structurally complex ecosystem, likewise were not achieved. The California clapper rail was not sighted within the WSMRP site during the two surveys performed, and detrital material had not accumulated because of the absence of substantial vegetative cover; however, the report concluded that the clapper rail's use of the WSMRP site was expected to increase as the habitats continued to develop.

1.1.4 Year 2 Marsh Monitoring Summary

Year 2 marsh monitoring was conducted following the project standards outlined in the WSMRP Monitoring Plan (BBL 2004c). In addition, the following management recommendations suggested in the Year 1 Monitoring Report were completed: (1) three additional vegetation monitoring quadrats (C-0, D-0 and E-0) were established in the ecotone area (the vegetated strip between the marsh and upland that provides cover for the California clapper rail during high tides); (2) active planting of the desired Pacific cordgrass and removal of undesired smooth cordgrass (*Spartina alterniflora)* or subsequent hybrids (*S. alterniflora* x *S. foliosa*) was conducted to prevent these invasive species from colonizing the WSMRP site; (3) an assessment of the appropriate frequency for active trapping as part of the Feral Animal Management Program (FAMP) was completed, including a consultation with the U.S. Fish and Wildlife Service (USFWS) at Don Edwards National Wildlife Refuge; and (4) public outreach meetings about ongoing activities at the WSMRP site were continued.

In accordance with the USFWS Biological Opinion (USFWS 2003), and the DTSC Order (Section 5.16), UC Berkeley continued implementation of the Invasive/Exotic Vegetation Management program begun in January 2004 and the FAMP begun in August 2004. The Watershed Project is performing native species planting and non-native, invasive weed removal activities in accordance with the Invasive/Exotic Vegetation Management Program (BBL 2004b). Avian Pest Control is performing trapping activities in accordance with requirements of the FAMP (BBL 2004a).

1.2 REPORT ORGANIZATION

The remainder of this monitoring report is organized as summarized below.

- Section 2.0, Project Targets and Standards—this section describes the project targets, standards, and field indicators and measurements.
- Section 3.0, Methods—this section presents the data collection and analysis methods used during the Year 2 monitoring event.
- Section 4.0, Results—this section presents the Year 2 monitoring data and assesses the success of each of the project targets by evaluating whether the project standards are being achieved.
- Section 5.0, Additional Monitoring and Management—this section summarizes activities conducted in 2006 as part of UC Berkeley's FAMP and the Invasive/Exotic Vegetation Management Program.
- Section 6.0, Conclusions and Recommendations—this section summarizes the results of Year 2 monitoring, draws conclusions based on these results, and makes recommendations for improving the likelihood of successfully meeting the project targets.
- Section 7.0, References—this section lists the documents used to prepare this report.

Figures and tables follow Section 7.0. In addition, the following appendices and attachments are included in this monitoring report:

- Appendix A, Analytical Data and Vegetation Monitoring Results
- Appendix B, Site Photographs
- Appendix C, Soil Fertility Recommendations for Richmond Field Station
- Attachment 1, Richmond Field Station Tide Gauge Installation, Land, and Bathymetric Survey, November 2006, Sea Engineering, Inc.
- Attachment 2, Results of California Clapper Rail Survey, Avocet Research Associates
- Attachment 3, Summary of Feral Animal Trapping Activities, Gary Beeman, Avian Pest Control
- Attachment 4, Summary of Invasive/Exotic Plant Management Activities, The Watershed Project and the San Francisco Estuary Invasive Spartina Project

2.0 PROJECT TARGETS AND STANDARDS

Restoration monitoring of a marsh site must be designed to detect changes in marsh dynamics in the years after the initial restoration events. At the WSMRP site, four project targets were developed in 2004 (BBL 2004c) and are used to monitor the restoration efforts:

- Project Target 1: Restore the hydrologic complexity to the WSMRP site
- Project Target 2: Improve water quality by increasing the time water resides within the WSMRP site
- Project Target 3: Restore low salt marsh (Pacific cordgrass), middle salt marsh (pickleweed), and the emergent and coastal scrub native plant communities within the WSMRP site
- Project Target 4: Establish a compositionally and structurally complex ecosystem within the WSMRP site with attributes important to wildlife, specifically focused on increasing habitat functions for the California clapper rail

Project standards, which are criteria used to guide restoration or monitoring, are defined for each project target. Additionally, each of the project standards has an associated field indicator or measurement. These field indicators are measured once a year (fall) or twice a year (spring and fall), as described in the monitoring plan (BBL 2004c). The field indicators or measurements are used to determine if project standards are being met and to evaluate whether management of each project target should be revised. Table 1 presents the project standards and field indicators or measurements for each project target presented in the WSMRP Monitoring Plan (BBL 2004c).

3.0 METHODS

The following sections describe the methods for collecting and analyzing data to evaluate each project target. Deviations from the monitoring plan are explained below, as applicable.

3.1 METHODS FOR EVALUATING PROJECT TARGET 1

Project Target 1, restore hydrologic complexity to the WSMRP site, was assessed by monitoring tidal inundations, as recorded from tide gauge data, and marsh elevation and bathymetric data collected during land and bathymetric surveys in November 2006. The methods for collecting data for the various project standards identified for Project Target 1 (see Table 1) are summarized below and are described in detail in Attachment 1. Monitoring results for Project Target 1 are presented in Section 4.1.

A tide gauge was installed on November 16, 2006, during a low ebb tide. The tide gauge monitored fluctuations in water level (via a pressure transducer) during the bathymetric survey and was used for post-survey correction of the bathymetric sounding data. Water level data were downloaded after the bathymetric surveys were completed on November 22, 2006. Tide data continued to be collected over a 4-month interval (November 2006 to February 2007), with 10-minute averaged water levels corrected for atmospheric pressure and adjusted to National Geodetic Vertical Datum (NGVD) 29.

A land survey of Western Stege Marsh and Meeker Slough was performed on November 21 and 22, 2006. The transect and quadrat system, installed and first surveyed in October 2004, was used to establish marsh elevations for Project Target 1. Previously surveyed locations and channel crossings were resurveyed during the Year 2 monitoring survey. A Leica Geosystems global positioning system (GPS) 1200 system provided highly accurate Real-Time Kinematic positioning measurements, with estimated positioning errors of less than 0.2 feet. Individual points were surveyed with the GPS antenna mounted on a rigid staff. Individual points were surveyed in the marsh at the low of the spring tide. Approximately 140 individual and channel crossing points were surveyed in the marsh on November 21, 2006. On November 22, 2006, the land survey began at higher elevations, while the tide was high. Upland transitional area locations were surveyed in approximated grids. Approximately 200 individual elevations and channel crossing locations were surveyed on November 22, 2006.

Bathymetric surveys were conducted on November 21 and 22, 2006, at the high of the spring tide. The survey vessel included a single-beam sonar transducer and digital global positioning system (DGPS) for positioning. The bathymetric data was collected continuously. Hypack software was used to time-synchronize the DGPS and sonar data on a laptop computer. On November 21, the surveyed region extended from the south side of the Bay Trail bridge over Meeker Slough to the San Francisco Bay. On November 22, 2006, the region surveyed extended from the north side of the bridge as far up the main channel of Meeker Slough as possible, including a section of a smaller channel that extends eastward toward the restored marsh.

Channel crossing widths and depths were measured using the land and bathymetric survey data. Channel widths were measured as the distance from the lowest channel shoulder to a point on the opposite channel wall at the same elevation (see Appendix C of Attachment 1). Channel shoulders are defined as the point at which the channel wall slope is less than 0.1 feet. Channel depths were measured as the distance from the lowest channel shoulder elevation to the deepest part of the channel (see Appendix C of Attachment 1).

On February 5, 2007, a field team surveyed three control points at RFS and two National Geodetic Survey benchmarks. In July and August, 2007, two additional surveys were conducted for quality control comparisons to ascertain the reason for a vertical discrepancy with previous surveys. An approximate 0.3-foot vertical offset was identified in the upland topographic survey data causing many 2006 upland surveyed elevations to be 0.3-feet lower than the confirmed elevations. The reason for the offset was a GPS receiver that incorrectly processed the incoming RTK reference station elevation. The 2006 elevations were corrected and six data points were eliminated without compromising the overall survey data needs.

3.2 METHODS FOR EVALUATING PROJECT TARGET 2

To evaluate Project Target 2, water quality within the WSMRP site, surface water, sediment, and stormwater samples were collected in accordance with the "Field Implementation Plan for Surface Water, Stormwater, and Sediment Monitoring" (Tetra Tech EM Inc. 2006), as adapted from the original Groundwater, Surface Water, and Sediment Monitoring Plan (BBL 2004d). The methods for collecting data for Project Target 2 are summarized below from the "Surface Water, Sediment, and Stormwater Sampling Summary Report" (Tetra Tech EM Inc. 2007). Monitoring results for Project Target 2 are presented in Section 4.2.

Four grab surface water and three sediment samples were collected from Western Stege Marsh on October 30, 2006 (see Figure 4). Grab surface water samples were collected using a clean dipper in an upstream direction. The dipper was submerged slowly into the surface water to minimize sediment disturbance. After surface water samples were collected, sediment samples were collected by pushing a 6-inch-long by 2-inch-diameter brass liner to a depth of 6 inches below ground surface. The liner was extracted with an intact core and capped with Teflon sheeting and plastic end caps. All surface water and sediment samples were analyzed for metals, pesticides, polychlorinated biphenyls (PCB), and pH. In addition, surface water samples were also analyzed for total dissolved solids, nitrate, total nitrogen, and phosphorus. Dissolved oxygen, conductivity, and temperature, also listed as field measurements for Project Target 2, are typically associated with groundwater sampling and were not included in the monitoring for surface water, stormwater, or sediments.

The weather forecast for RFS was monitored before mobilizing to RFS to collect stormwater samples during a rain or storm event. Five stormwater samples were collected on November 2, 2006 (see Figure 4). The sampling locations were located at the lowest point of the drainage area in order to obtain samples where the stormwater conveyance discharges stormwater to Meeker Slough or Western Stege Marsh. Grab stormwater samples were collected using a clean dipper in an upstream direction. The dipper was submerged carefully into the stormwater to minimize inclusion of debris. The stormwater samples were analyzed for metals, polychlorinated biphenyls, and pH.

Groundwater samples were not collected during Year 2. A groundwater monitoring plan for RFS is currently being developed under the DTSC order.

3.3 METHODS FOR EVALUATING PROJECT TARGET 3

As part of Project Target 3, development of the restored plant communities is monitored by measuring various parameters of the native and non-native plants. Plant cover is an important vegetation and hydrologic characteristic of a site and is generally referred to as the percentage of ground surface covered by vegetation. Plant cover is a commonly measured attribute of plant community composition because the cover percentiles are comparable for small abundant species and large rare species.

Total acreage and plant stock vigor of specified plants are also field indicators and measurements for Project Target 3. Two plants specifically identified in Project Target 3 as project standards for measurement are Pacific cordgrass and pickleweed. Pacific cordgrass requires a daily flushing of surface salts from its aboveground parts (Josselyn and others 1993), which restricts its range to areas around the upper intertidal areas (Daehler and Strong 1995; Callaway and Josselyn 1992). Perennial pickleweed typically is able to tolerate full sun, alkaline soils, salinity, poor drainage, and seasonal flooding (Calflora 2004). The differences in the salinity, elevation, and inundation habitat requirements between the two plant species make them suitable indicators of ecosystem fitness for the low marsh (Pacific cordgrass) and middle marsh (perennial pickleweed) restoration areas of the WSMRP site (BBL 2004c).

The success of plant communities in the restoration area is evaluated using semiannual quadrat surveys, annual vegetation mapping, and annual evaluation (by visual inspection) of plant vigor. Each of these methods is discussed below. Monitoring results for Project Target 3 are presented in Section 4.3.

3.3.1 Quadrat Surveys

A total of 47 quadrats were surveyed during the Year 2 monitoring. In 2004, 44 quadrats were established within and adjacent to the remediated area of Western Stege Marsh to monitor vegetative growth (BBL 2004c). The monitoring quadrats were placed along transects that extend through the marsh into areas outside the boundary of the WSMRP site (see Figure 4), including low marsh, high marsh, and transitional areas. As recommended in the Year 1 Monitoring Report (BBL 2005), three additional quadrats (C0, D0, and E0) were established to monitor plant growth in the ecotone (see Figure 4) of the WSMRP site, which was not represented in the original set of quadrats.

The WSMRP site monitoring quadrats are shown against a backdrop of plant communities on Figure 5. All of the quadrats shown were surveyed in 2006.

On September 26 and 27, 2006, a field team of two ecologists conducted quadrat surveys throughout the WSMRP site. The field team recorded all plant species, total percent cover, and average plant height in each quadrat. Plants were identified using the *Jepson Manual: Higher Plants of California* (Hickman 1993). In addition, the percentage of native plant cover was estimated by visual inspection using midpoint classes of percent cover, as specified in the WSMRP Monitoring Plan and shown in Table 2. The field team also took photographs at the stations established in Year 1 (shown on Figure 4). Appendix B presents the Year 2 photographic log. The results of the quadrat surveys are presented in Section 4.3.1.

3.3.2 Vegetation Mapping

The WSMRP Monitoring Plan specifies that percent vegetative cover and percent cover by dominant vegetation groups be calculated and shown on a computer-aided design (CAD) drawing. Dominant plant communities at the WSMRP were identified in fall 2006 by visual inspection and were mapped using CAD techniques. The results of the vegetation mapping for percent vegetative cover and percent cover by dominant species are reported in Section 4.3.2 and shown on Figure 5.

3.3.3 Vigor of Planted Stock

Vigor of the planted stock in the WSMRP site was defined in the WSMRP Monitoring Plan as the intensity of stress caused by pests or pathogens, as assessed by visual inspection (BBL 2004c). Vigor of plants in all monitoring quadrats and RFS reference quadrats was visually assessed using the qualitative guidelines described in the WSMRP Monitoring Plan and summarized in Table 3. Additionally, the field team measured the average height of the most dominant species in each of the quadrats as an independent measure of plant health. Results of the vigor assessment are presented in Section 4.3.3.

3.4 Methods for Evaluating Project Target 4

Project Target 4 evaluates the creation of a compositionally and structurally complex ecosystem in the WSMRP site with attributes important to wildlife. This project target specifically focuses on increasing the quantity and quality of habitat functions for the California clapper rail.

The California clapper rail is a year-round resident of emergent salt and brackish tidal marshlands in the San Francisco Bay. It requires direct tidal circulation and areas of sparse or no vegetation for foraging on estuarine invertebrates in small tidal sloughs. For nesting, the California clapper rail prefers dominant stands of pickleweed with extensive stands of Pacific cordgrass, as reported in the Goals Project (Albertson and Evens 2000). Early studies indicated that cordgrass was essential for successful nesting; however, more recent work has shown that other tall monocots, including bulrush (*Scirpus robustus*), can be used as nest canopy when cordgrass declines. Other elements of an essential habitat include dense vegetation above the high tide line to provide shelter from overhead predators such as raptors, as well as ground predators such as the red fox (Albertson and Evens 2000).

Because of its secretive nature, the California clapper rail is surveyed aurally (by listening for the birds' call) during the breeding and non-breeding seasons using methods prescribed by USFWS (2000), which favor the use of listening stations to detect passive (spontaneous) vocalizations. Four listening stations were established during the Year 1 monitoring event (BBL 2005); the same stations were used to survey California clapper rails during the Year 2 monitoring event (see Figure 6).

The protocol-level survey of California clapper rails was not conducted as planned during the 2006 breeding season. Instead, nonprotocol-level (non-breeding) surveys were conducted on December 1 and 12, 2006, and on January 5, 2007, in accordance with USFWS (2000) guidance. Attachment 2 provides a detailed description of the methods used to survey California clapper rails during Year 2.

The WSMRP Monitoring Plan specifies that Project Target 4 be evaluated by monitoring both the number of California clapper rails using the site and the percent litter or detrital matter (BBL 2004c). However, in Year 2, the percent of litter or detrital material was not measured because aboveground plant biomass (which would eventually become litter or detrital matter) was inadequate to justify the field effort at that time. This measurement will be included in Year 3. Monitoring results for Project Target 4 are presented in Section 4.4.

4.0 RESULTS

The following sections describe the monitoring results for each project target, including analysis of data and graphical representations of results.

4.1 PROJECT TARGET 1 MONITORING RESULTS

Data collected in support of Project Target 1 (restore hydrologic complexity to the WSMRP site) includes tidal data, marsh elevation data, and measurements of channel width, depth, and width-to-depth ratios. Each of these data sets was evaluated against the project standards presented in Table 1 and is discussed below.

Tide elevations for November 16, 2006, to January 23, 2007, are shown on Figure 7. Tidal elevations were measured using a pressure transducer installed on the Bay Trail bridge that spans Meeker Slough. A survey of the pressure transducer indicated that the instrument is capable of measuring tidal elevations above -3.094 feet (NGVD 29). As shown on Figure 7, maximum daily tidal elevations typically range from 3.3 to 4.1 feet NGVD 29. Minimum daily predicted tidal elevations range between -3.5 to -4.3 feet NGVD 29. One anomalous measurement is seen on November 22, 2006, due to the brief time period when data were transferred from the transducer after the survey. Current tidal data and observations indicate that water ponds in Meeker Slough during low tides below approximately -2 feet NGVD 29. Marsh elevation surveys and channel bathymetric surveys were conducted in November 2006. Figure 4 shows the surveyed quadrat locations and channel crossing locations. Quadrat elevation data collected in 2006 are presented in Table 4. Eight channel cross sections and bathymetric transects were surveyed in 2006. Table 5 presents the Year 2 channel characteristics. Cross-sectional and bathymetric surveys for CS-1, CS-2, CS-4, CS-5, and CS-6 conformed to the project standards presented in Table 1. Cross sections CS-3, CS-7, and CS-8 show width-to-depth ratios that are outside of the project standard range. These channels appear to be accreting; further monitoring is required before proposing design modifications. Top-of-bank measurements surveyed at cross sections along slough channels ranged between 1.5 and 2.4 feet NGVD 29. Cross-sectional profiles and bathymetry of the WSMRP site during fall 2006 are presented in Attachment 1. A quantitative comparison of changes in elevation and bathymetry between the Base Year, Year 2, and Year 3 will be conducted and presented in a future monitoring report.

Channel morphology and marsh plain elevation affect hydrodynamic function in Western Stege Marsh. Data for tidal elevations, along with the slough and marsh plain survey data, indicate that the WSMRP site is inundated regularly by tidal waters. The hydrologic function of the restored slough channels will be further assessed during Year 3 through analysis of morphologic changes and review of the vegetation and marsh elevation data collected through Year 3.

4.2 PROJECT TARGET 2 MONITORING RESULTS

Surface water, sediment, and stormwater samples were collected to evaluate Project Target 2, Improve Water Quality within the WSMRP Site. Surface water and sediment samples were analyzed for metals, pesticides, PCBs, and pH. In addition, surface water samples were also analyzed for total dissolved solids, nitrate, total nitrogen, and phosphorus. Stormwater samples were analyzed for metals, PCBs, and pH. Complete analytical results are presented in Appendix A for surface water (see Table A-1), sediment (see Table A-2), and stormwater (see Table A-3).

Three surface water samples were collected from channels within the restored marsh and one from Meeker Slough, as shown on Figure 4. These samples were non-detect for PCBs and pesticides. Most metals were not detected at concentrations exceeding the reported sample detection limits, although many detection limits were greater than the screening criteria. Copper concentrations exceeded the screening criterion (3.1 µg/L) in the samples collected in the central marsh (SW101) and in Meeker Slough at the Bay Trail bridge sample (SW104). The estimated concentration of silver exceeded the screening criterion (0.19 µg/L) in the sample collected in the central marsh (SW104).

Three sediment samples were collected from within the WSMRP site, as shown on Figure 4. Total concentrations of chemicals in sediment were compared with effects range-median (ER-M) values, screening criteria based primarily on toxicity to estuarine invertebrates, and with the Tier 2 ecological site-specific target levels (E-SSTL) derived for the California clapper rail. Mercury, nickel, and selenium exceeded their respective ER-M value in one or more samples (see Table 8); however, nickel concentrations in all three sediment samples were less than the San Francisco Bay ambient concentration established by the Water Board (1998). Compounds of dichlorodiphenyltrichloroethane (DDT) were detected in one sample at low concentrations. No other pesticides, including the Zeneca proprietary pesticides, were detected. None of the samples exceeded the E-SSTL for any chemical.

Five stormwater samples were collected from the following locations that drain directly into Meeker Slough or into Western Stege Marsh before draining to Meeker Slough: the eastern and western stormdrain outfalls (samples STW105 and STW106), two off-site outfalls draining to Meeker Slough (samples STW107 and STW108), and from Meeker Slough at the Bay Trail (sample STW104). The dissolved concentrations of metals in the samples were compared with screening criteria appropriate for San Francisco Bay estuarine waters, as shown in Table 6. Analytical results (see Table 7) show that these samples were non-detect for pesticides and PCBs. Concentrations of copper exceeded the screening criterion in all five samples. Mercury exceeded the San Francisco Basin Plan Criterion of 0.025 µg/L in four samples (STW104, STW105, STW106, and STW108), although no samples exceeded the National Recommended Water Quality Criterion of 0.94 µg/L. Silver exceeded the screening criterion of 0.19 µg/L in one sample (STW104). Zinc exceeded the screening criterion of 81 µg/L in three samples (STW105, STW106, and STW108).

The effect of these metal concentrations on the success of the marsh restoration will be evaluated in future reports after more data is collected in order to better understand existing conditions and trends. Future monitoring reports will include additional evaluation of water quality parameters based on collection of additional data over a longer period of time. Continued monitoring of chemical concentrations in surface water, sediment, and stormwater will reveal trends over time that may help direct future restoration activities.

4.3 PROJECT TARGET 3 MONITORING RESULTS

The evaluation of Project Target 3, the restoration of Pacific cordgrass, pickleweed, and other native plant communities, requires data on species and percent cover. This data was collected during quadrat surveys, site-wide vegetative mapping, and inspection of the vigor of planted stock. The Year 2 results of each of these elements are described below.

4.3.1 Quadrat Survey Results

Vegetation surveys were conducted in 47 quadrats on September 26 and 27, 2006. Quadrat surveys included the following: the 44 monitoring quadrats in the WSMRP site established in 2004, and the 3 newly established ecotone quadrats in the WSMRP site.

Quadrat survey data are provided in Appendix A—Table A-4 presents the WSMRP site data. The photographic survey is provided in Appendix B.

Native vegetation covered approximately 44 percent of the ground (excluding tidal mudflats) within the 47 monitoring quadrats. Thus, percent cover by native vegetation was double the project standard of at least 20 percent native plant cover (see Table 1 and the table below). Pickleweed was the dominant species (see Figure 5); Pacific cordgrass and marsh gumplant were other desirable species noted. The California state grass, purple needlegrass (*Nassella pulchra*) appeared in quadrat E-10. Purple needlegrass is a medium to large, long-lived bunchgrass that thrives in deep clayey soil; its 20-foot-long root makes it tolerant of summer drought. Expansion of purple needlegrass would provide desirable cover in the upland habitat represented by transect E.

	Target	***Achieved***	**Target**	***Achieved***
	Year 1 (2004)	***Year 1 (2004)***	**Year 2 (2006)**	***Year 2 (2006)***
Native species	0.0 acre	*0.0 acres*	20%	*44%*

Overall, the project standard of 20 percent plant cover is being met; however, percent and type of cover varied among quadrats. In the upland of transect E, native vegetation covered 50 percent of the ground, but was unevenly distributed. Quadrat E-5 contained between 46 and 75 percent salt grass, but quadrats E-6 and E-8 contained between 16 and 25 percent salt grass. In contrast, quadrat E-10 was at least 90 percent salt grass.

4.3.2 Vegetation Mapping Results

Vegetation mapping in fall 2006 documented about 0.01 acre of Pacific cordgrass, which is below the target acreage, and about 2.1 acres of pickleweed in the WSMRP site (see Figure 5), which is well beyond the 0.5 acre targeted for Year 2 in the WSMRP Monitoring Plan.

Cordgrass colonies in the restoration area are expansions of spartina divisions planted in the low marsh in 2003 and 2006. Divisions were planted in clusters of 3 – 10 individuals. Figure 5 represents the current distribution of these cluster plantings; each point depicts the location of a surviving planting cluster. Approximately 65% of the original 2003 plantings and approximately 90% of the 2006 plantings survived and exhibit healthy new vigorous growth. On average, each of the 2003 planting clusters have expanded to cover an area of approximately 6 by 9 feet. Vegetative cover within those areas varies between 5% and 25% absolute cover, with spartina typically intermixed with pickleweed. The surviving 2006 planting clusters have expanded to cover an area of approximately 4 by 6 feet. Vegetative cover within those areas varies between 1% and 15% absolute cover.

The combined acreage of pickleweed and Pacific cordgrass far exceeded the target, as shown in the table below.

	Target	***Achieved***	**Target**	***Achieved***
Species	**Year 1 (2004)**	***Year 1 (2004)***	**Year 2 (2006)**	***Year 2 (2006)***
Pacific Cordgrass (*Spartina foliosa)*	0.4 acre	*0.0 acre*	0.8 acre	*0.01-acre*
Perennial Pickleweed (*Salicornia virginica)*	0.3 acre	*0.2 acre*	0.5 acre	*2.1 acres*
Total native cordgrass/pickleweed	0.7 acre	*0.2 acre*	1.3 acre	*2.11 acres*

4.3.3 Plant Vigor

In fall 2006, plant vigor was measured on the stock planted in 47 monitoring quadrats at the WSMRP site. Vigor was evaluated using qualitative measures of the visual effect of pests or pathogens, as set forth in the WSMRP Monitoring Plan and presented in Table 3. Table 9 summarizes the evaluation of plant vigor for the WSMRP site. All but two of the WSMRP quadrats showed signs of pests or pathogens; only quadrats E-9 and E-10 were rated “excellent.” Four monitoring quadrats were rated “good.” Vigor was considered “poor” in most quadrats. The project target of 80 percent of the quadrats with planted stock showing good or excellent vigor was not met in Year 2.

4.4 PROJECT TARGET 4 MONITORING RESULTS

This section provides the results of monitoring to measure and evaluate progress toward establishing a compositionally and structurally complex ecosystem with important attributes for wildlife, especially the California clapper rail. Two surveys were performed in December 2006 and one in early January 2007 to estimate the number of California clapper rails present at the Western Stege Marsh. California clapper rails were detected 14 times during the December 2006 surveys, and were not detected during the January 2007 survey. Based on the standard methods of estimating number of individuals using the number of detections during the survey, it was estimated that six California clapper rails (or three pairs) occur in the tidal marsh and slough habitat adjacent to the WSMRP site. The Project Target 4 standards have not yet been achieved. The California clapper rail was not using the WSMRP site for nesting or foraging during the protocol-level surveys, although individuals were detected near the edge of the site and are expected to use the WSMRP habitat as it matures.

The distribution of California clapper rail detections, shown on Figure 6, suggests that the birds are using all emergent tidal marsh habitat associated with the undisturbed marsh adjacent to the WSMRP site, regardless of the plant community present. This finding is consistent with the San Francisco Bay Area Wetlands Ecosystem Goals Project (Anderson and Evens 2000) recommendation of a predominant pickleweed marsh with cordgrass, gumplant, and other high marsh plants as ideal habitat for the California clapper rail. The California clapper rail is associated with the major and tributary slough systems that wind through the vegetated portion of the marsh. Given the tendency of the California clapper rail to be sedentary during the winter and spring, it is expected that the birds detected during the December 2006 surveys will remain at the site through the nesting season. Attachment 2 provides a detailed summary of the December 2006 and January 2007 surveys of the California clapper rail.

An additional measure of habitat suitability for the California clapper rail that was not specified in the WSMRP Monitoring Plan is plant height. The average height of the dominant plants in each quadrat was measured during the evaluation of vigor described in Section 4.3.3 (see also Table 9). The California clapper rail is known to prefer vegetation that is tall enough to form a canopy over its nest during the breeding season and to provide shelter from predators throughout the year, but especially during high winter tides when it is vulnerable to overhead attacks by raptors (Anderson and Evens 2000). No requirements for measuring plant height were established in the Monitoring Plan; however, these exploratory data on variability in plant height will prove valuable as the WSMRP habitat develops and use patterns by the California clapper rail become better understood. Measures of percent litter and detrital material will also help in the evaluation of Project Target 4 during Year 3.

5.0 ADDITIONAL MONITORING AND MANAGEMENT

In accordance with the USFWS Biological Opinions (USFWS 2003), and in compliance with NWP 38, UC Berkeley implemented the Feral Animal Management Program and the Invasive/Exotic Vegetation Management Program in 2004 (BBL 2004a, 2004b). These programs were designed to reduce the temporary loss of habitat for the California clapper rail and to assist in reducing the occurrence of invasive and exotic vegetation at the WSMRP site to preserve the quality of habitat for the California clapper rail. The activities conducted during each of these programs are discussed below.

5.1 FERAL ANIMAL MANAGEMENT PROGRAM

The FAMP was developed to reduce predation by feral animals on all life stages (egg, young, and adult) of the California clapper rail, with the goal of making the WSMRP site more suitable for sustaining a population of the California clapper rail. Major predators are the domestic and feral cat (*Felix domesticus)*, Norway rat (*Rattus norvegicus)*, red fox (*Vaupés fulva)*, raccoon (*Procyon lotor*), and skunks (Family Mephitidae) (Anderson and Evens 2000).

Biologist Gary Beeman of Avian Pest Control conducted four animal trapping events in and around the northern boundary of the WSMRP site between 2005 and 2006. The number of animals trapped during these events fluctuated. Results of recent trapping events appear to show a decrease in local predator populations after intensive trapping and a rebound after trapping is completed. During 37 trapping days in 2005 and 2006, 39 skunks, 20 raccoons, 9 feral cats, and 1 fox were trapped, in addition to small numbers of other predators. A summary of the trapping effort provided by Mr. Beeman is presented in Attachment 3. Due to the presence of a managed feral cat colony at Marina Bay, skunk, raccoon, and feral cat populations are likely higher than would naturally be expected, because there is a constant source of cat food supplied by the colony's managers.

5.2 INVASIVE/EXOTIC VEGETATION MANAGEMENT PROGRAM

The Watershed Project, under contract to UC Berkeley, is implementing the Invasive/Exotic Vegetation Management Program and conducting three interrelated tasks: (1) controlling the colonization of targeted invasive non-native plant species by removing them from within the marsh and ecotone area and adjacent areas; (2) revegetating the marsh, ecotone, and upland habitats consistent with approved habitat reference sites and standard restoration planting practices; and (3) preparing marsh upland areas to place plant material (and mulch) where appropriate. Attachment 4 presents The Watershed Project's reports and figures.

The Invasive/Exotic Vegetation Management Program was designed to control establishment of priority invasive and exotic plants, as classified by the California Invasive Plant Council (CAL-IPC) (also known as the "Weed List"; [CAL-IPC 2005]). This list is tailored to the characteristics of the site, such as proximity to sensitive or endangered species habitat, proximity to roads, and so forth. The Invasive/Exotic Vegetation Management Program evaluates the risk of each plant species present in and around the site and assigns a priority rating of between I and III (high to low), depending upon the magnitude of the threat to the site. The identification of priority species and the removal of invasive exotic plants are discussed below.

5.2.1 Priority Species

This report identifies two Priority I species: pepperweed (*Lepidium latifolium*), brought in from Europe or Asia in the early 19th century; and smooth cordgrass, a native of the Atlantic and Gulf coasts of North America. Both species are known to occur near the WSMRP site, are highly invasive, and are expected to interfere with restoration of native marsh vegetation at the site. Mechanisms of interference include displacement of the native Pacific cordgrass or perennial pickleweed through competition for space, and genetic contamination of native cordgrass stock by smooth cordgrass, with which it readily hybridizes.

Pepperweed infestations occur in all of the western states, covering hundreds of thousands of acres of wildlands as well as managed pastures. Its aggressive growth and woody stems reduce the suitability of vegetation for nesting birds, cover over space once occupied by native vegetation, and even interfere with livestock foraging. Pepperweed grows in a wide variety of habitats, including saline soils. Periodic tidal inundation restricts this weed from areas of the lower intertidal marsh, where Pacific cordgrass grows. Above the high tide line, however, the ecotone habitat is vulnerable to pepperweed invasion.

Pepperweed is extremely difficult to control by mechanical or chemical means. Top growth responds to herbicides, especially during the blooming season (summer through fall); however, stands readily regenerate from creeping rhizomes. Even when 98 percent of the top growth was affected by the herbicide, plants resprouted the next spring and dominated the landscape by the end of the growing season (Young and others 1997). Purposeful revegetation with desirable species can be effective in controlling the spread of pepperweed; pepperweed dominates the land, precluding establishment by natives, during the time required for natural colonization of native plants to occur. Pepperweed roots can remain dormant in soil for several years, making early detection monitoring and removal the most cost-efficient and best control measures.

A colony of pepperweed was found on the Bay side of the Bay Trail (on East Bay Regional Park District property) in August 2005 (see map in Attachment 4). The Watershed Project removed flowers and pulled the pepperweed plants in 2005 and 2006. This colony of pepperweed will require continued control to prevent it from becoming established in Meeker Slough and Western Stege Marsh.

Smooth cordgrass is valued in its native habitat for its ability to trap sediment and to grow rapidly into low marshes and is largely responsible for much of the marsh accretion that occurs on the Gulf and Atlantic coasts of North America (Simenstad and Thom 1995; Landin 1991). However, this trait—as well as its wide tolerances for salinity and flooding—makes smooth cordgrass an aggressive invader in San Francisco Bay and elsewhere in California. Historical records show that many Californian estuaries consisted primarily of bare, gently sloping mudflats with shallow tidal channels before the colonization by smooth cordgrass (Ebasco Environmental 1992). Fully developed smooth cordgrass marshes have steeply sloping seaward edges and deep steep-sided tidal channels. The elevation of the marsh rises above the surrounding tidal flat as sediment accretes around the smooth cordgrass (Ebasco Environmental 1992). The high stem densities of smooth cordgrass dissipate wave action, resulting in greater sediment deposition and steeper beach profiles (Gleason and others 1979). The higher rate of accretion associated with smooth cordgrass may change the fundamental nature of portions of the California coastline, thus influencing the quality and quantity of habitat for sensitive and endangered species such as the California clapper rail (Project Target 4). Unvegetated mudflats, which are the favored foraging spots for a variety of shorebirds, can be quickly covered by smooth cordgrass.

Control of smooth cordgrass is just as problematical as control of pepperweed described above. In addition to its rapid growth, wide physiological tolerances, and physical growth forms that alter historical landscapes, the smooth cordgrass contaminates the gene pool of the native Pacific cordgrass. Smooth cordgrass produces abundant pollen that can swamp the stigma of the native plants; therefore, the negative traits of the resulting hybrids may be even more exaggerated than the original invader.

Current control methods focus on physical removal of smooth cordgrass plants, as well as known or suspected hybrids. During Year 2, The Watershed Project hand pulled 43 cordgrass plants in the vicinity of the WSMRP site because it was suspected that they were not the native cordgrass species. None of the pulled seedlings was genetically tested and positive identification of the seedlings was not attempted. In 2004, the risk of invasion of the WSMRP site by smooth cordgrass was evaluated as being low by the San Francisco Estuary Invasive Spartina Project (December 17, 2004 letter from Erik Grijalva, Invasive Spartina Project to Wendy Strickland, The Watershed Project, Attachment 4). However, due to the presence of invasive smooth cordgrass in the area and risk to the WSMRP if invasive smooth cordgrass or hybrids became established, it was decided to continue to manage smooth cordgrass by removal of volunteer seedlings. As reported in the Year 1 Monitoring Report, an attempt to destroy an area of invasive smooth cordgrass on the Bay-side of the Bay Trail was to place a tarp over the area for a year starting in 2004. It was not completely successful because the tarp tore. In 2005, the Invasive Spartina Project attempted to eradicate the invasive smooth cordgrass with glyphosate herbicide, but it was not successful because the herbicide washed off during high tides. The Invasive Spartina Project followed up with Imazapyr treatment around this area in September 2006.

The Watershed Project has also removed numerous non-native plant species. Plants targeted for removal include bristly oxtongue (*Picris echioides*), sweet clover (*Melilotus indica*), Russian thistle (*Salsola soda*), rabbitsfoot grass (*Polypogon monspeliensis*), spiny sowthistle (*Sonchus asper*), knotweed (*Polygonum* sp.), sweet fennel (*Foeniculum vulgare*), ice plant (*Carpobrotus edulis*), and five-hook bassia (*Bassia hyssopifolia*, also called fivehorn smotherweed). A full list of species targeted for removal is provided in Attachment 4. During Year 2, The Watershed Project removed 11 15-gallon bags, or 22 cubic feet, of weeds. Hand pulling has not been effective in controlling the establishment of weedy annual species in some areas, such as the southeast corner of the MSMRP. The Watershed Project began trying the use of herbicides in 2006 to better control non-native plant species. They also have considered removal of the top 6 inches of soil, which contains the seed bank, and backfilling with seed-free soil. Details of The Watershed Project's weed removal activities are provided in Attachment 4.

5.2.2 Ecotone Creation and Enhancement of Marsh Habitat

Two overall methods of achieving a specific assemblage of plants in an area are typically used: removal of unwanted plants and direct planting of desired species. The Watershed Project used both of these methods at the WSMRP site.

Invasive and exotic plants were removed from the marsh and grasslands by The Watershed Project during 2005 and 2006 (see Attachment 4). In addition to manual removal of plants and covering with weed fabric, three herbicide spraying events (September 19, 2005; February 24, 2006; and September 29, 2006) were conducted at or adjacent to the WSMRP site. In September 2005 an outboard population of non-native, hybrid *Spartina* was treated with glyphosate by the Invasive Spartina Project. This application was not considered effective, and the following year, September 2006, the Invasive Spartina Project followed up with an application of imazaypyr. In spring 2007, The Watershed Project staff observed the same non-native population of hybrid *Spartina* as well as at least two additional, new populations of non-native *Spartina* between the pier and Meeker Slough. The Invasive Spartina Project has been notified and follow-up measures will be taken to treat the non-native *Spartina* for a third time. In February 2006, The Watershed Project staff coordinated an application of glyphosate herbicide to treat the southeast corner of the marsh. This area contained a much higher than average number of invasive, non-native plants such as rabbitsfoot grass (*Polypogon monspeliensis*) Italian wild rye (*Lolium multiflorum*), and brass buttons (*Cotula coronopifolia)* which has lead to high mortality of upland outplants in this area. Shelterbelt contractors completed the work and Nancy Brownfield, IPM Manager of the East Bay Regional Parks District supervised the work. Following the herbicide, the area was replanted with upland species, and mulched with rice straw. The herbicide was effective for the remainder of the season; these weeds were largely suppressed and natives were able to establish. However, following the winter season 2006-2007 a new flush of weeds emerged and this area is once again more problematic than other restored areas of the marsh. Until shrub species become large enough that they shade out the invasive annual plants, this area will require more management through hand removal or additional herbicide.

The second method used to bias the plant assemblage at the WSMRP site toward native species was to plant seedlings of desired species. The Watershed Project planted native species in the ecotone area, as described in Attachment 4. Establishment of natives in these areas has been mixed across various sub-sites, very good in areas such as the eastern edge of the marsh, and poor in plots 1 and 2, along the marsh's northern edge. Poor survivorship in plots 1 and 2 was initially attributed to high salinity from imported bay mud fill material and/or lack of nutrients in the soil. However, subsequent chemical analysis showed that the soils contained sufficient micro- and macronutrients to support the seedlings (see Appendix C). Additionally, it was presumed that salinity levels would have likely lowered following the first winter rain season. It is possible however that the lack of organic matter and subsequent poor soil structure may have impaired the ability of seedlings to colonize the ecotone area by reducing their ability to establish root systems. As the soil dries, a hardpan forms that may prohibit plant roots from becoming established. The Watershed Project has been selecting low-cost methods to improve the hardpan layer, thus increasing the survivorship of seedlings. These methods include amending the soil with straw; rototilling the straw into the soil; further covering the ground with more straw to act as a barrier to weeds; covering the edges of the planting area with weed block fabric; and adding fertilizer and soil inoculated with mycorrhizae. The results of these ongoing efforts will be included in future monitoring reports.

Native plants were also sown in the tidal marsh. During early 2006, The Watershed Project planted 3,575 Pacific cordgrass divisions, as well as other marsh species (see Attachment 4). It is too soon to tell how these plantings will fare over time. If the plants become established but do not show adequate growth, it may be possible to amend the soil to boost their growth. Studies from southern California suggest that growth of Pacific cordgrass in restored marshes can be enhanced by the addition of organic amendments to establish proper substrate conditions (Boyer and others 2000). The same method may work in WSMRP to boost Pacific cordgrass production.

6.0 CONCLUSIONS AND RECOMMENDATIONS

In fall 2006, UC Berkeley assessed the WSMRP site for Year 2 compliance monitoring using four project targets and their respective standards and field indicators/measurements (see Table 1). Analysis and interpretation of the Year 2 monitoring results lead to several conclusions and recommendations, which are discussed below with respect to each Project Target. The results are interpreted in the context of adaptive management, as was the intent of the Monitoring Plan. Restoration, by its nature, is a long-term process that seeks to manipulate and influence natural processes in combination with taking direct action to achieve a desired outcome. Monitoring is designed to measure selected aspects of the restoration so that adjustments to the manipulations can be made during early, sensitive stages of restoration. This section discusses the conclusions and recommendations for each project target, and Table 10 summarizes project target recommendations. An updated five-year monitoring frequency is provided in Table 11.

Overall, based on data collected in 2006, the WSMRP site is progressing toward providing the functions of a tidal marsh typical of San Francisco Bay. Project Target 1 standards were mostly achieved (standards were not achieved in three of the eight cross-sections measured). The hydrology is sufficient to inundate the marsh portions of the WSMRP daily and support vegetative communities designed in the WSMRP Monitoring Plan. Project standards for Target 2 have not yet been established. Year 2 data indicated that metals concentrations in some surface water, sediment, and stormwater samples exceeded some federal and state screening criteria for the protection of aquatic life but more sampling is necessary to assess the significance of these results. Data collected in support of Project Target 2 were established as a baseline in Year 2 and these results will be combined with future monitoring to assess water quality over time. The project standards for Project Target 3 (restore salt marsh and coastal scrub communities) were achieved. Total acreage of Pacific cordgrass was slightly less than the project standard and pickleweed was greater than the project standard. The overall native plant cover exceeded the combined Year 2 standard. The project standards for Project Target 4 (establish a compositionally and structurally complex ecosystem) have not yet been achieved. The California clapper rail was not using the WSMRP site for nesting or foraging during the surveys, although individuals were detected near the edge of the site and are expected to use habitat as it matures. Sufficient detrital material had not accumulated in Year 2 to justify the field effort to quantify it, but is expected to be present in Year 3.

An adaptive management approach has been taken for restoration of the WSMRP site. The adaptive management process is flexible and allows for review of monitoring results and considers adjustments to monitoring plans in response to previous results. The adaptive management recommendations for Year 3 of the WSMRP are detailed below and summarized in Table 10.

Project Target 1: The hydrologic functioning of the restored slough channels has not yet been fully assessed. The function will be assessed through morphology change analysis and review of vegetation and marsh elevation data collected during monitoring events in Years 2 and 3.

Predicted, measured, and observed tidal elevations indicate that the WSMRP site is inundated regularly by tidal waters. The predicted versus measured tidal levels depicted on Figure 7 indicates that predicted and observed tidal levels can adequately assess WSMRP inundation conditions. On-site tide gage information is not critical to evaluate site inundation and is therefore not recommended to be collected in Year 3.

No other changes to the monitoring plan for Project Target 1 in the Year 3 field season are recommended.

Project Target 2: Current data show that several metals concentrations exceeded screening criteria in some surface water, sediment, and stormwater samples. However, data are not sufficient at this time to support conclusions about the quality of water at WSMRP. Future monitoring reports will include additional evaluation of water quality parameters based on collection of additional data over a longer period of time. Surface water, sediment, and stormwater samples will be collected in 2007 in accordance with the "Field Implementation Plan for Surface Water, Stormwater, and Sediment Monitoring" (Tetra Tech 2006), as adapted from the original monitoring plan (BBL 2004c). A groundwater monitoring plan will also be developed in 2008. Water quality data will be compared to proposed screening criteria, and criteria will be finalized in conjunction with DTSC.

Project Target 3: The combined goal of Pacific cordgrass and pickleweed was exceeded; however, the acreage of Pacific cordgrass alone was measured at only half of the project target standard. Growth of transplanted Pacific cordgrass has been slower than the proposed project standard, although it is uncertain whether this is a normal or slower than normal growth rate due to site specific conditions (soil structure or nutrients, for example). Options for increasing the rate of expansion of Pacific cordgrass include increasing the rate of transplantation of plants salvaged from other locations, genetically testing *Spartina* seedlings to determine whether natural recruitment would be acceptable, and applying soil amendments (fertilizers). Currently, *Spartina* seedlings are removed based on the recommendation of the San Francisco Estuary Invasive Spartina Project due to concerns of possible spread of non-native smooth cordgrass or hybrids. The seedlings are being removed at a life stage where they are phenotypically indistinguishable from the native species and it is not known whether any native *Spartina* individuals are being inadvertently removed during the process. If it were determined through genetic testing that the seedlings are native, they could be allowed to grow, thereby increasing the rate of colonization of native Pacific cordgrass. UC Berkeley will evaluate the need to test some individual seedlings to assess the risk posed by hybridization.

At this time, the project standard for the acreage of Pacific cordgrass should be reevaluated within an adaptive management framework, taking into account the uncertainty posed by the potential *Spartina* hybrids and the currently approved removal of all *Spartina* seedlings. The overarching goal is to provide high-quality habitat for the California clapper rail, and it is known that the California clapper rail can function well without large stands of Pacific cordgrass. Therefore, evaluating the project targets by combining the acreage of pickleweed and Pacific cordgrass is a reasonable approach.

Project Target 4: The goal to increase the suitable habitat for the California clapper rail by increasing the complexity of the ecosystem was met during Year 2. The establishment of a compositionally and structurally complex ecosystem within the WSMRP site, with emphasis on the increased habitat function for the California clapper rail, is strongly influenced by Project Targets 1 and 3. The restoration of hydrological complexity to the marsh by enhancing water depth, channel width, channel depth, and the width-to-depth ratio is expected to improve habitat by increasing the amount of tidal flushing through the marsh. The tidal flushing allows for the import and export of seeds and detritus and provides the periodic inundation required by the desired plant communities.

The plants discussed in Project Target 3 (Pacific cordgrass and pickleweed) are desired for their role in supporting foraging, nesting, and sheltering habitat for the California clapper rail. The clapper rail can travel between the thin stems of Pacific cordgrass, but not as easily through the more robust, denser stems of some other marsh plants. Pacific cordgrass also provides refugia during high tides, as the birds can escape to the vegetated mounds and hide among the stems. Portions of the WSMRP site are submerged during high tides and currently lack sufficient escape habitat for the California clapper rail. The newly established acreage of Pacific cordgrass and pickleweed has increased the amount of suitable habitat for the California clapper rail.

During the 2005 protocol-level surveys for California clapper rails, several individuals were noted in the outer portion of the Western Stege Marsh, but none were detected on the inner portions of the marsh. California clapper rails were noted in the inboard portion of the site during Year 2 nonprotocol-level surveys. The increase in suitable vegetation cover and the flushing of tidal waters appear to have increased the amount of potential breeding habitat for the California clapper rail. This population will continue to be monitored, and further analysis will be presented in the Year 3 monitoring report. No changes to the monitoring plan for Target 4 in the Year 3 field season are recommended.

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FIGURES

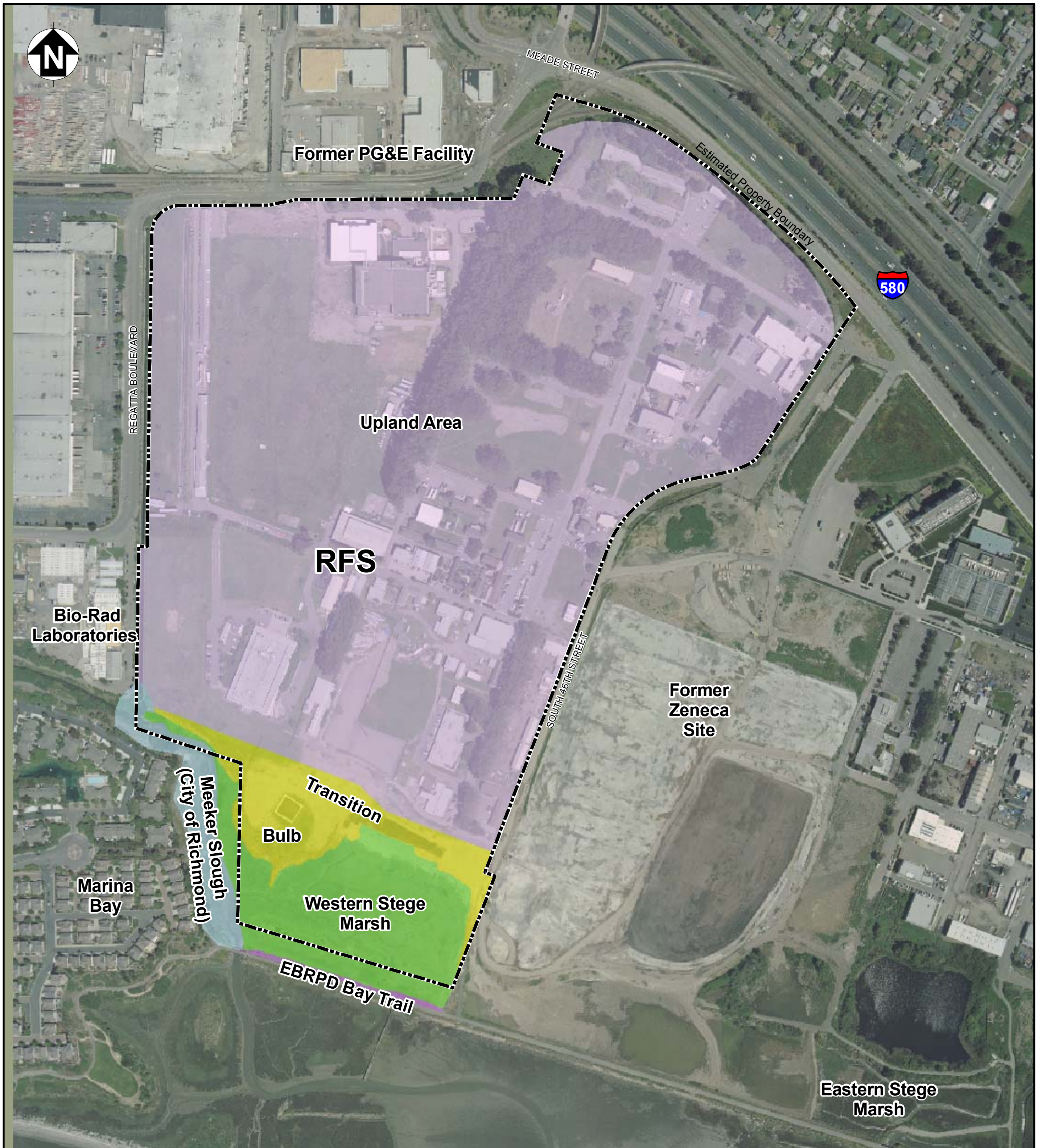
TETRA TECH EM INC.

Richmond Field Station
University of California, Berkeley

FIGURE 1
SITE LOCATION MAP

Draft Year 2 Monitoring Report for
Western Stege Marsh Restoration Area

2007-10-31 V:\Misc_GIS\Richmond_Field_Station\Projects\Marsh_Grid_Sampling\Site_Location_Map_szA.mxd TtEMI-SF Kevin Ernst



0 500

Feet

Property Boundary

Notes:

EBRPD East Bay Regional Park District
PG&E Pacific Gas and Electric Company
RFS Richmond Field Station

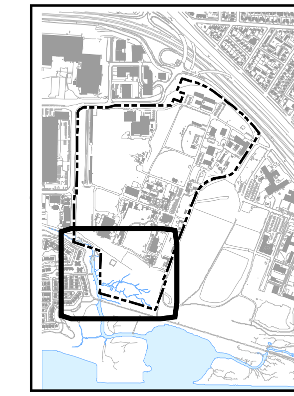
Image date March 2005, courtesy of BBL Inc.

TETRA TECH EM INC.

Richmond Field Station
University of California, Berkeley

FIGURE 2
SITE BOUNDARIES

Draft Year 2 Monitoring Report for
Western Stege Marsh Restoration Project



Marsh Monitoring Area
Ecotone Area (as Designed in BBL's August 2004 Marsh Monitoring Plan)
Richmond Field Station Property Boundary
Biologically Active Permeable Barrier Wall
Slurry Wall

Image date March 2005, courtesy of BBL Inc.

EBRPD	East Bay Regional Park District
RFS	Richmond Field Station

100 0 100
Feet

TETRA TECH EM INC.

Richmond Field Station
University of California, Berkeley

FIGURE 3
WESTERN STEGE MARSH RESTORATION PROJECT AREA

Draft Year 2 Monitoring Report for
Western Stege Marsh Restoration Project

2007-07-25 V:\Misc_GIS\Richmond_Field_Station\Projects\Marsh_Grid_Sampling\Marsh_Project_Area.mxd TtEMI-SF Kevin Ernst

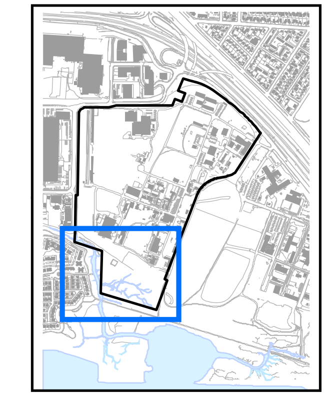


Photo Stations

Channel Crossing

Sampling Location

Vegetation Survey Quadrats

Transects

Richmond Field Station Property Boundary

Marsh Monitoring Area

Ecotone Area (as Designed in BBL's August 2004 Marsh Monitoring Plan)

Surface Water Samples	SW101 SW102 SW103 SW104
Stormwater Samples	STW104 STW105 STW106 STW107 STW108
Sediment Samples	SED101 SED102 SED103

Image date March 2005, courtesy of BBL Inc.

EBRPD East Bay Regional Park District
RFS Richmond Field Station

100 0 100
Feet

TETRA TECH EM INC.

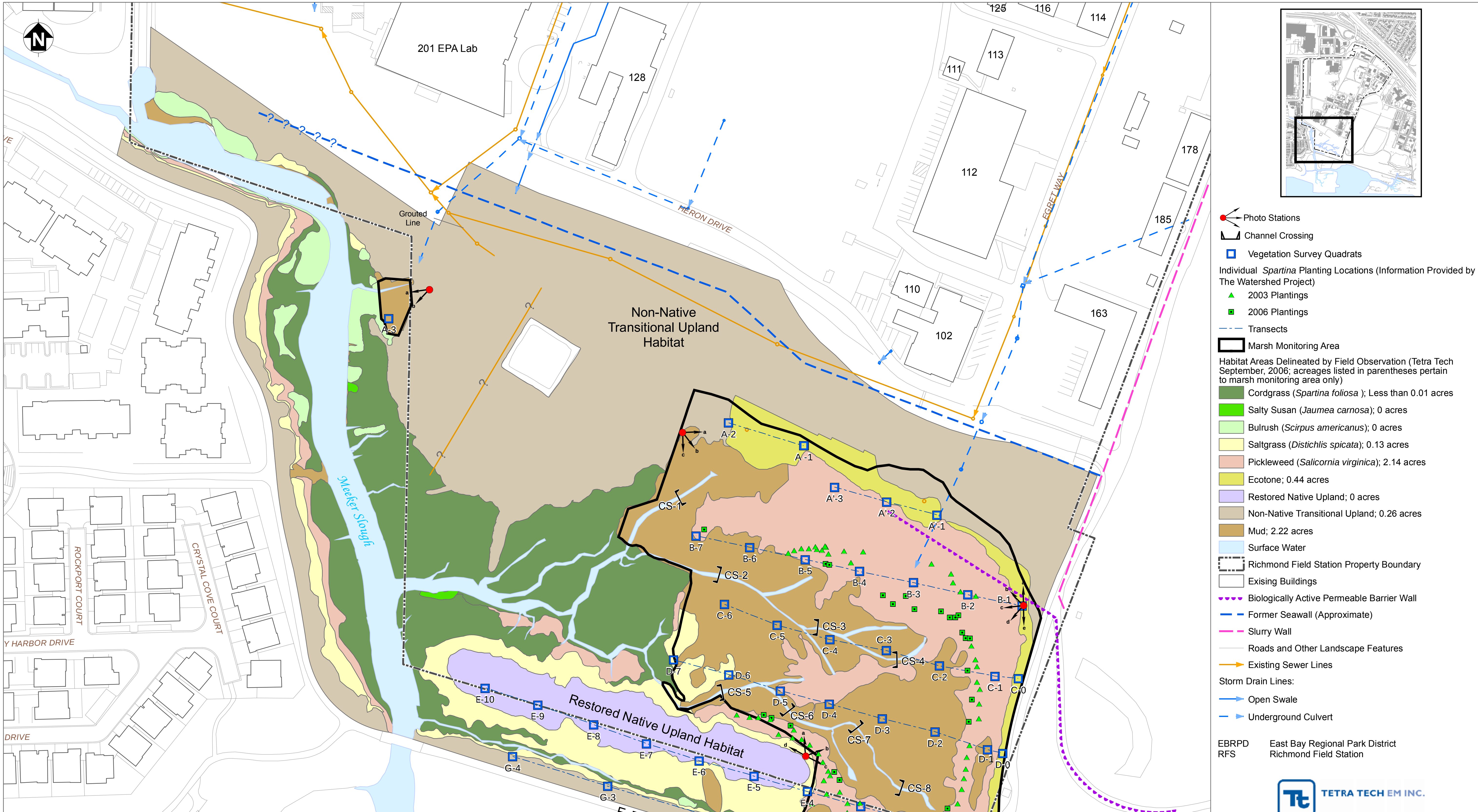
Richmond Field Station
University of California, Berkeley

FIGURE 4

MONITORING LOCATIONS

Draft Year 2 Monitoring Report for Western Stege Marsh Restoration Project

2007-10-31 V:\Misc_GIS\Richmond_Field_Station\Projects\Marsh_Grid_Sampling\Marsh_Survey_design.mxd TtEMI-SF Kevin Ernst



Richmond Field Station
University of California, Berkeley

FIGURE 5
MAJOR PLANT COMMUNITIES PRESENT AT WESTERN STEGE MARSH, SEPTEMBER 2006

Draft Year 2 Monitoring Report for Western Stege Marsh Restoration Project

2007-10-31 V:\Misc_GIS\Richmond_Field_Station\Projects\Marsh_Grid_Sampling\Marsh_Survey_vegetation_communities.mxd TtEMI-SF Kevin Ernst

Estimated Location of Clapper Rail, December 3, 2006 (15:00 - 17:10 hours)

Estimated Location of Clapper Rail, December 12, 2006 (16:00 - 17:20 hours)

4 Listening Stations

Location of a Large Feral Orange Cat Seen December 12, 2006

Marsh Monitoring Area

Richmond Field Station Property Boundary

Image date March 2005, courtesy of BBL Inc.

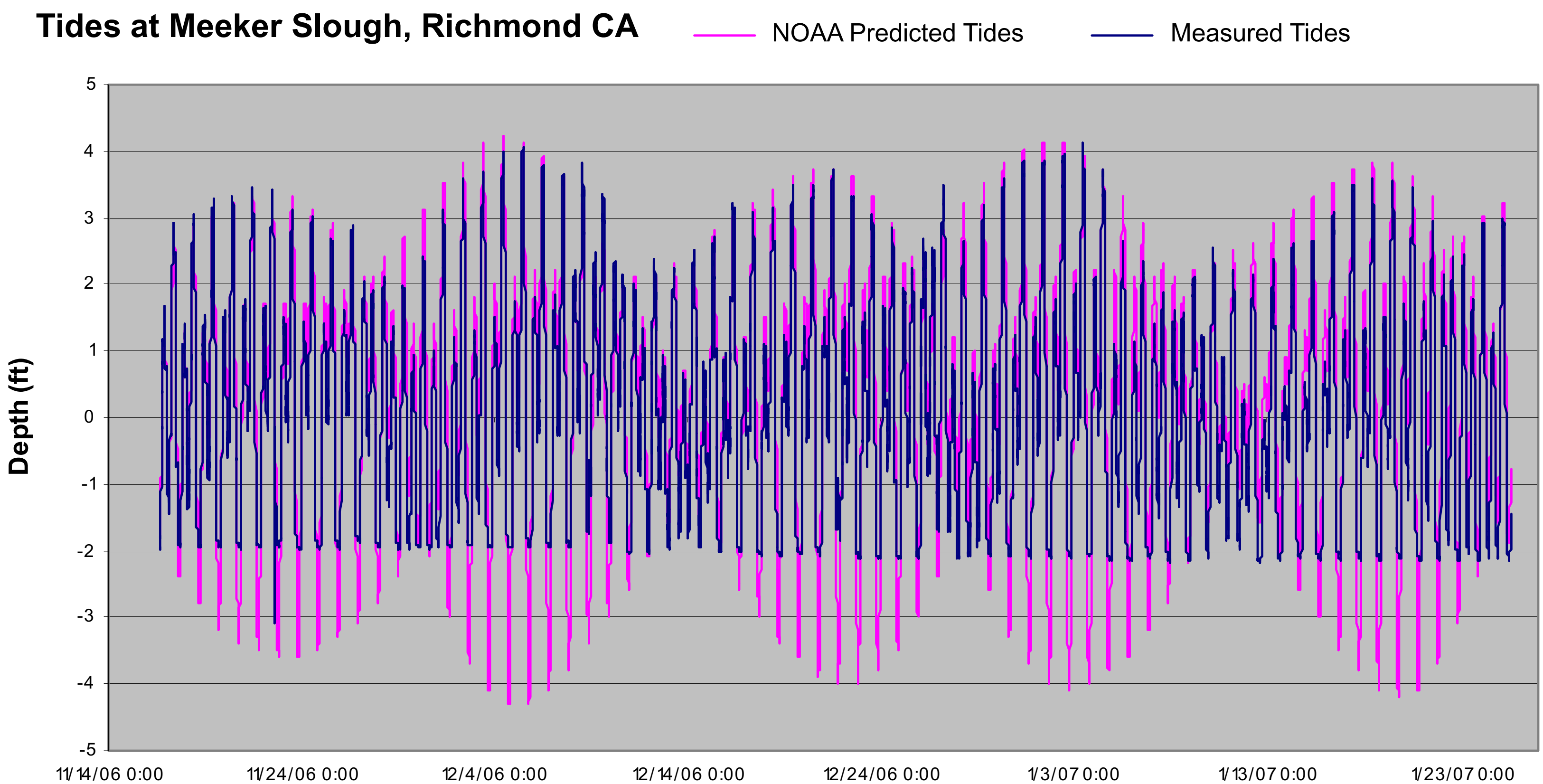
TETRA TECH EM INC.

Richmond Field Station
University of California, Berkeley

FIGURE 6
DISTRIBUTION OF CALIFORNIA CLAPPER RAILS IN WESTERN STEGE MARSH DECEMBER 2006

Draft Year 2 Monitoring Report for
Western Stege Marsh Restoration Project

2007-11-21 V:\Misc_GIS\Richmond_Field_Station\Projects\Marsh_Grid_Sampling\Clapper_Rail_Sightings.mxd TtEMI-SF Kevin Ernst



NNOAA National Oceanic and Atmospheric Administration

TETRA TECH EM INC.

Richmond Field Station
University of California, Berkeley

FIGURE 7
MEASURED AND NOAA-PREDICTED TIDES AT MEEKER SLOUGH NOVEMBER 16, 2006 THROUGH JANUARY 23, 2007

Draft Year 2 Monitoring Report for Western Stege Marsh Restoration Project

TABLES

Table 1: Western Stege Marsh Restoration Project – Project Standards[a]

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Project Standard	Field Indicator/Measurement
Project Target 1: Restore hydrologic complexity to the WSMRP	
Tidal inundation: water depth during low- and high-tide events	Slough channels, tidal mudflats, and Pacific cordgrass areas exhibit an adequate tidal range based on best professional judgment and values available in current literature
Marsh elevation in relation to mean high tide	Adequate elevations based on best professional judgment and values available in current literature
Bankfull Width	Between 4.0 and 12.0 feet
Bankfull Depth	Between 0.25 and 1.25 feet at thalweg
Bankfull Width:Depth Ratio	Between 9.6 and 16 feet at thalweg
Project Target 2: Improve water quality by increasing residence time of water within the WSMRP	
pH	To be determined.
Conductivity	To be determined.
Dissolved oxygen	To be determined.
Turbidity	To be determined.
Project Target 3: Restore low salt marsh (such as Pacific cordgrass), middle salt marsh (such as pickleweed), emergent and coastal scrub native plant communities within the WSMRP	
Percent cover of native vegetation (excluding tidal mudflats)	Year 2: Greater than or equal to 20% Year 3: Greater than or equal to 40% Year 4: Greater than or equal to 60% Year 5: Greater than or equal to 80%
Total acreage of Pacific cordgrass	Target Acreage: 2.6 acres Year 1: Greater than or equal to 15% of target acreage (0.4 acres) Year 2: Greater than or equal to 30% of target acreage (0.8 acres) Year 3: Greater than or equal to 50% of target acreage (1.3 acres) Year 4: Greater than or equal to 65% of target acreage (1.7 acres) Year 5: Greater than or equal to 85% of target acreage (2.2 acres)
Total acreage of pickleweed	Target Acreage: 1.7 acres Year 1: Greater than or equal to 15% of target acreage (0.3 acres) Year 2: Greater than or equal to 30% of target acreage (0.5 acres) Year 3: Greater than or equal to 50% of target acreage (0.9 acres) Year 4: Greater than or equal to 65% of target acreage (1.1 acres) Year 5: Greater than or equal to 85% of target acreage (1.5 acres)
Vigor of planted stock	Greater than or equal to 80% of vegetation plots assessed as “Good” or “Excellent”

Table 1: Western Stege Marsh Restoration Project – Project Standards[a] (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Project Standard	Field Indicator/Measurement
Project Target 4: Establish a compositionally and structurally complex ecosystem within the WSMRP with attributes important to wildlife, specifically focused on increasing habitat functioning for the California clapper rail	
% litter/detrital matter	Based on best professional judgment and values available in current literature
Annual California clapper rail survey	Restoration sites continue to provide suitable habitat to support the California clapper rail based on best professional judgment

Notes:

a Information provided in the table above is from Table 2 in the WSMRP Monitoring Plan (Blasland, Bouck & Lee, Inc. 2004c)

WSMRP Western Stege Marsh Restoration Project

Table 2: Cover Class Midpoints[a]

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

% Cover Range	Field Indicator/Measurement
<1%	0.5
1 to 5%	3
6 to 15%	10.5
16 to 25%	20.5
26 to 45%	38
46 to 75%	63
76 to 90%	85.5
>90%	98

Notes:

a Information provided in the table above is from Table 3 in the WSMRP Monitoring Plan (Blasland, Bouck & Lee, Inc. 2004c)

Table 3: Qualitative Score for Assessing the Vigor of Planted Stocks[a]

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Score	Description of Score
Excellent	No evidence of stress; minor pest or pathogen damage may be present
Good	Some evidence of stress; pest or pathogen damage present
Fair	Moderate level of stress; high levels of pest or pathogen damage
Poor	High level of stress; high levels of pest or pathogen damage

Notes:

a Information provided in the table above is from Table 4 in the WSMRP Monitoring Plan (Blasland, Bouck & Lee, Inc. 2004c)

Table 4: Year 2 Quadrat Elevations

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Quadrat	Fall 2006 Elevation (feet)	Quadrat	Fall 2006 Elevation (feet)
A-1	NA	D-4	2.54
A-2	5.32	D-5	2.35
A-3	1.98	D-6	2.43
A'-1	NA	D-7	2.69
A'-2	NA	E-0	6.35
A'-3	NA	E-1	4.10
B-1	6.30	E-2	2.14
B-2	3.55	E-3	2.75
B-3	2.85	E-4	3.36
B-4	2.34	E-5	4.35
B-5	2.40	E-6	4.17
B-6	2.27	E-7	5.20
B-7	2.59	E-8	4.92
C-0	7.24	E-9	5.59
C-1	NA	E-10	5.47
C-2	NA	F-1	5.29
C-3	1.87	F-2	3.24
C-4	2.12	F-3	2.98
C-5	2.22	F-4	3.04
C-6	2.56	G-1	4.88
D-0	7.40	G-2	4.13
D-1	4.10	G-3	3.67
D-2	2.29	G-4	4.55
D-3	2.32		

Note: Elevations are based on National Geodetic Vertical Datum 29

NA: Not available. Survey elevations not available for Quadrats A-1, A’-1, A’-2, A’-3, C-1, and C-2 due to survey equipment failure.

Table 5: Year 2 Channel Characteristics

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Cross Section Number	Year	Channel Width (feet)	Channel Depth (feet)	Width:Depth Ratio
CS-1	Fall 2006	15.04	1.02	14.82
CS-2	Fall 2006	8.93	0.93	9.61
CS-3	Fall 2006	6.58	0.73	9.02
CS-4	Fall 2006	5.79	0.42	13.95
CS-5	Fall 2006	9.02	0.89	10.14
CS-6	Fall 2006	5.29	0.40	13.22
CS-7	Fall 2006	9.09	0.51	17.78
CS-8	Fall 2006	13.93	0.27	50.72

Note: Measurements are based on National Geodetic Vertical Datum 29

Table 6: Surface Water Screening Criteria for the Protection of Aquatic Life

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Pseudonym	San Francisco Bay Basin Plan[a] (µg/L)		California Toxics Rule Criteria for Enclosed Bays and Estuaries[e] (µg/L)								National Recommended Water Quality Criteria[k] (µg/L) Saltwater Aquatic Life						National Ambient Water Quality Criteria (AWQC) for Protection of Saltwater Aquatic Life[i] (µg/L) Lowest Observed Effect Level (LOEL)								Selected Toxicity Screening Criteria (µg/L)
				Chronic[g]		Acute[g]			Instantaneous Maximum			Chronic[g]		Acute[g]				Chronic[h]		Acute[i]				Other[j]		
		Conc.	Footnotes	Conc.	Footnotes	Conc.	20 Percent of Conc.[f]	Footnotes	Conc.	10 Percent of Conc.[f]	Footnotes	Conc.	Footnotes	Conc.	20 Percent of Conc.[f]	DTSC-Recommended Screening Value[n]	Footnotes	Conc.	Footnotes	Conc.	20 Percent of Conc.[f]	DTSC-Recommended Screening Value[s]	Footnotes	Conc.	Footnotes	
Arsenic		36	b	36	(1, 4), ii, kk	69	--	(1, 4), ii, kk	--	--	--	36	A,B,bb	69	--	--	A,B,bb	--	--	2,319	--	--	(3)	13	(2)	36
Cadmium		9.3	b	9.3	(1, 4)	42	--	(1, 4)	--	--	--	8.8	B,bb,gg	40	--	--	B,bb,gg	--	--	--	--	--	--	--	--	8.8
Chromium (total)		50 (VI)	b,m	50 (VI)	m	1,100 (VI)	--	--	--	--	--	50 (VI)	B,bb,m	1100 (VI)	--	--	B,bb,m	--	--	--	--	--	--	--	--	50
Copper		4.9	c	3.1	(1, 4), jj, kk	4.8	--	(1, 4), jj, kk	--	--	--	3.1	B,cc,ff	4.8	--	--	B,cc,ff	--	--	--	--	--	--	--	--	3.1
Lead		5.6	b	8.1	(1, 4), m	210	--	(1, 4), l	--	--	--	8.1	B,bb	210	--	--	B,bb	--	--	--	--	--	--	--	--	5.6
Mercury	Mercury, inorganic	0.025	b	--	--	--	--	--	--	--	--	0.94	B,ee,hh	1.8	--	--	B,ee,hh	--	--	--	--	--	--	--	--	0.025
Nickel		8.3	b	8.2	(2, 4), kk	74	--	(1, 4), kk	--	--	--	8.2	B,bb	74	--	--	B,bb	--	--	--	--	--	--	--	--	8.2
Selenium		--	--	71	(1, 4)	290	--	(1, 4)	--	--	--	71	B,bb,dd	290	--	--	B,bb,dd	--	--	--	--	--	--	--	--	71
Silver		2.3	d	--	--	1.9	--	(1, 4)	--	--	--	--	--	1.9	0.38	0.19	B,C	--	--	--	--	--	--	--	--	0.19
Thallium		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,130	426	1,065	--	--	--	426
Zinc		58	c	81	(1, 4), ii, kk	90	--	(4), ii, kk	--	--	--	81	B,bb	90	--	--	B,bb	--	--	--	--	--	--	--	--	81
Aroclor-1248	Polychlorinated biphenyls (PCBs)	--	--	0.03	(5, 6) ll	--	--	--	--	--	--	0.03	aa	--	--	--	--	--	--	10	--	--	--	--	--	0.03
Aroclor-1260	Polychlorinated biphenyls (PCBs)	--	--	0.03	(5, 6) ll	--	--	--	--	--	--	0.03	aa	--	--	--	--	--	--	10	--	--	--	--	--	0.03

Notes: Values shaded are those selected as screening criteria.

µg/L Microgram per liter

DTSC Department of Toxic Substances Control

-- No criterion available

Footnotes:

a California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region (Water Board). 1995. "San Francisco Bay Basin Plan Water Quality Control Plan." June 21. Table 3-3 Water Quality Objectives for Toxic Pollutants for Surface Water With Salinities Greater Than 5 Parts Per Billion.

b From Water Board "Basin Plan" 4-Day Average (Chronic)

c From Water Board "Basin Plan" 24-Hour and 1-Hour Average (Acute)

d From Water Board "Basin Plan" Instantaneous Maximum

e From "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (CTR) (EPA 2000) and "Water Quality Control Plan, San Francisco Bay Basin Region" (Water Board 1995). The most appropriate criteria were used.

f Criterion made more suitably protective by means of standard convention of lowering acute values by 80 percent and instantaneous values by 90 percent to make them more appropriate for use under chronic exposure scenarios.

g An acute criterion (EPA identified as Criteria Maximum Concentration [CMC]) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The chronic concentration (EPA identified as Criterion Continuous Concentration [CCC]) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The CMC and CCC are just two if the six parts of an aquatic life criterion; the other four parts are the acute averaging period, chronic averaging period, acute frequency of allowed exceedence, and chronic frequency of allowed exceedence. Because 304(a) aquatic life criteria are national guidance, they are intended to be protective of the vast majority of the aquatic communities in the United States (EPA 2002a).

h EPA National "AWQC Lowest Observed Effect Level (Chronic)" (Water Board 2000)

i EPA National "AWQC Lowest Observed Effect Level (Acute)" (Water Board 2000)

j EPA National "AWQC Lowest Observed Effect Level (Other)" (Water Board 2000)

k From "National Recommended Water Quality Criteria: 2002" (EPA 2002a) and "Revision of National Recommended Water Quality Criteria." (EPA 2002b), unless otherwise noted.

l In instances where criteria from "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (EPA 2000) refer to the "Water Quality Control Plan, San Francisco Bay Basin Region" (Water Board 1995), Water Board 1995 criteria were used. The Water Board 1995 criteria are distinguished by an "m" in the footnote column.

m Detailed application of this toxicity criterion may require the review and/or summation of analyte isomer, congener, or speciation results, as applicable. Please see applicable regulatory agency source document for additional detail.

n Derived using uncertainty factors (UF) from DTSC (For acute values: divide acute LOAEL by 10 to get a chronic LOAEL)

The following lettered footnotes are derived from EPA "National Recommended Water Quality Criteria: 2002" (EPA 2002b), Table 1 - Priority Toxic Pollutants:

A This recommended water quality criterion was derived from data for arsenic (III), but is applied here to total arsenic, which might imply that arsenic (III) and arsenic (V) are equally toxic to aquatic life and that their toxicities are additive. In the arsenic criteria document (EAP 440/5-84-033, January 1985), Species Mean Acute Values (SMAVs) are given for both arsenic (III) and arsenic (V) for five species, and the ratios of the SMAVs for each species range from 0.6 to 1.7. Chronic values are available for both arsenic (III) and arsenic (V) for one species; for the fathead minnow, the chronic value for arsenic (V) is 0.29 times the chronic value for arsenic (III). No data are known to be available concerning whether the toxicities of the forms of arsenic to aquatic organisms are additive.

B Freshwater and saltwater criteria for metals are expressed in terms of the dissolved metal in the water column. The recommended water quality criteria value was calculated by using the previous 304(a) aquatic life criteria expressed in terms of total recoverable metal, and mulitplying it by a conversion factor (CF). The term "Conversion Factor" (CF) represents the recommended conversion factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. (Conversion Factors for saltwater CCCs are currently unavailable. Conversion factors derived for saltwater CMCs have been used for both saltwater CMCs and CCCs). See "Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria," October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water, available from the Water Resource center, USEPA, 401 M St., SW, mail code RC4100, Washington DC 20460; and 40CFR 131.36(b)(1). Conversion Factors applied in the table can be found in Appendix A to the Preamble - Conversion Factors for Dissolved Metals.

C The criterion is based on 304(a) aquatic life criterion issued in 1980 and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), Dichlorodiphenyltrichloroethane (DDT) (EPA 440/5-80-38), Endosulfan (EPA 440/5-80-046), Endrin (EPA 440/5-80-047), Heptachlor (EPA 440/5-80-052), Hexachlorocyclohexane (EPA 440/5-80-054), Silve (EPA 440/5-80-071). The minimum data requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a "CMC" derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

aa This criterion is based on a 304(a) aquatic life criterion issued in 1980 or 1986, and was issued in one of the following documents : Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endrin (EPA 4405-80-047), Heptachlor (EPA 440/5-80-052), Polychlorinated biphenyls (EPA 440/5-80-068), Toxaphene (EPA 440/5-86-006). This CCC is currently based on the Final Residue Value (FRV) procedure. Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60 FR 15393-15399, March 23, 1995), the EPA no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria. Therefore, the EPA anticipates that future revisions of this CCC will not be based on FRV procedure.

bb This water quality criterion is based on a 304(a) aquatic life criterion that was derived using the 1985 Guidelines *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, PB85-227046, January 1985) and was issued in one of the following criteria documents: Arsenic (EPA 440/5-84-033), Cadmium (EPA 882-R-01-001), Chromium (EPA 440/5-84-029), Copper (EPA 440/5-84-031), Cyanide (EPA 440/5-84-028), Lead (EPA 440/5-84-027), Nickel (EPA 440/5-86-004), Pentachlorophenol (EPA 440/5-86-009), Toxaphene (EPA 440/5-86-006), Zinc (EPA 440/5-87-003).

cc When the concentration of dissolved organic carbon is elevated, copper is substantially less toxic, and use of Water-Effect Rations might be appropriate.

dd The selenium criteria document (EPA 440/5-87-006, September 1987) provides that if selenium is as toxic to saltwater fishes in the field as it is to freshwater fish in the field, the status of the fish community should be monitored whenever the concentration of selenium exceeds 5.0 mg/L in salt water because the saltwater CCC does not take into account uptake via the food chain.

Table 6: Surface Water Screening Criteria for the Protection of Aquatic Life (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project, University of California, Berkeley, Richmond Field Station, Richmond, California

Footnotes (Continued):

ee This recommended water quality criterion was derived on page 43 of the mercury document (EPA 440/5-84-026, January1985). The saltwater CCC of 0.025 µg/L given on page 23 of the criteria document is based on the Final Residue Value procedure in the 1985 Guidelines. Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60 FR 15393-15399, March 23, 1995), the Agency no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria.

ff This recommended water quality criterion was derived in Ambient Water Quality Criteria Saltwater Copper Addendum (draft, April 14, 1995) and was promulgated in the Interim final National Toxics Rule (60 FR 22228-222237, May 4, 1995).

gg EPA is actively working on this criterion, and so this recommended water quality criterion may change substantially in the near future.

hh This recommended water quality criterion was derived from data for inorganic mercury (II), but is applied here to total mercury. If a substantial portion of the mercury in the water column is methylmercury, this criterion will probably be under protective. In addition, even though inorganic mercury is converted to methylmercury, and methylmercury bioaccumulates to a great extent, this criterion does not account for uptake via the food chain because sufficient data were not available when the criterion was derived.

The following lettered footnotes are derived from EPA "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (EPA 2000).

ii Criteria for these metals are expressed as a function of the water-effect ratio (WER) (originally footnote I in the CTR).

jj No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such calculations were not shown in the document.

kk These freshwater and saltwater criteria for metals are expressed in terms of dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in 131.36(b)() and (2).

ll PCBs are a class of chemicals that include Aroclors 1242,1254,1221,1232,1248,1260, and 1016. The aquatic life criteria apply to the sum of this set of seven Aroclors.

The following numbered footnotes are derived from "A Compilation of Water Quality Goals" (Water Board 2000). These footnotes directly correlate with the source document.

1 Expressed as dissolved

2 Pentavalent arsenic [As(V)] effects on plants.

3 For the pentavalent form

4 Criteria do not apply to waters subject to water quality objectives in Tables III-2A and III-2B of the San Francisco Bay Regional Water Quality Control Board's 1986 Basin Plan.

5 Developed as 24-hour average using 1980 EPA guidelines, but applied as 4-day average in the National Toxics Rule and/or Proposed California Toxics Rule.

6 Applies separately to Aroclors 1242, 1254, 1221, 1232, 1248, 1260, and 1016; based on carcinogenicity at 1-in-a-million risk level.

References:
San Francisco Bay Regional Water Quality Control Board (Water Board). 1995. "San Francisco Bay Basin Plan." San Francisco Bay Region. June 21.
Water Board. 2000. "A Compilation of Water Quality Goals." Prepared by Jon B. Marshack, Central Valley Region. August.
Water Board. 2001. "Water Quality Goals Update." Central Valley Region. April 18.
U.S. Environmental Protection Agency (EPA). 2000. "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California." 40 CFR Part 131, RIN 2040-AC44. May 18.
EPA. 2002a. "National Recommended Water Quality Criteria: 2002." EPA-822-R-02-047. November.
EPA. 2002b. "Revision of National Recommended Water Quality Criteria." FRL-OW-7431-3. December 27.

Table 7: Summary Analysis for 2006 Surface Water and Stormwater

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Surface Water Screening Criteria (µg/L)	Analytical Results (µg/L)[1, 2]								
		SW101	SW102	SW103	SW104	STW104	STW105	STW106	STW107	STW108
Aluminum	NC	100 U	100 U	100 U	100 U	100 U	420	33.0 J	100 U	100 U
Antimony	NC	60.0 U	60.0 U	60.0 U	60.0 U	60.0 U	60.0 U	60.0 U	60.0 U	60.0 U
Arsenic	36	15.0	15.0	18.0	9.1	6.3	1.2 J	5.0 U	5.0 U	3.3 J
Barium	NC	38.0	54.0	41.0	43.0	32.0	82.0	17.0	22.0	38.0
Beryllium	NC	1.0 J	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Cadmium	8.8	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Calcium	NC	310,000	290,000	310,000	220,000	180,000	15,000	11,000	11,000	76,000
Chromium	50	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	3.4 J	10.0 U	10.0 U	10.0 U
Cobalt	NC	20.0 U	20.0 U	20.0 U	20.0 U	20.0 U	2.3 J	20.0 U	20.0 U	20.0 U
Copper	3.1	**6.1 J**	10.0 U	10.0 U	**7.4 J**	**9.9 J**	**23.0**	**58.0**	**13.0**	**14.0**
Iron	NC	100 U	100 U	100 U	100 U	40.0 J	730	89.0 J	64.0 J	66.0 J
Lead	5.6	3.0 U	2.7 UJ	3.0 U	3.0 U	3.0 U	2.6 J	3.0 U	3.0 U	3.0 U
Magnesium	NC	940,000	880,000	980,000	650,000	550,000	3,800	12,000	8,300	220,000
Manganese	NC	930 J	2,600 J	1,200 J	86.0 J	88.0	590	64.0	25.0	75.0
Mercury	0.025	0.13 UJ	0.20 U	0.20 U	0.20 U	**0.08 J**	**0.26**	**0.03 J**	0.20 U	**0.03 J**
Molybdenum	NC	20.0 U	20.0 U	20.0 U	20.0 U	4.6 J	20.0 U	24.0	2.2 J	3.6 J
Nickel	8.2	20.0 U	20.0 U	20.0 U	20.0 U	4.7 J	**13.0 J**	4.1 J	3.5 J	6.8 J
Potassium	NC	320,000	230,000	260,000	180,000	170,000	5,400	5,200	3,800	71,000
Selenium	71	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Silver	0.19	**3.2 J**	5.0 U	5.0 U	5.0 U	**1.5 J**	5.0 U	5.0 U	5.0 U	5.0 U
Sodium	NC	7,000,000	6,900,000	7,900,000	5,100,000	4,300,000	13,000	110,000	50,000	1,700,000

Table 7: Summary Analysis for 2006 Surface Water and Stormwater (Continued)

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Surface Water Screening Criteria (µg/L)	Analytical Results (µg/L)[1, 2]								
		SW101	**SW102**	**SW103**	**SW104**	**STW104**	**STW105**	**STW106**	**STW107**	**STW108**
Thallium	426	9.4 UJ	8.4 UJ	7.3 UJ	4.8 UJ	7.7	5.0 U	5.0 U	5.0 U	6.0
Vanadium	NC	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	4.8 J	10.0 U	3.2 J	2.6 J
Zinc	81	20.0 U	12.0 J	20.0 U	13.0 J	38.0	**470**	**240**	60.0	**87.0**
4,4’-DDD	NC	0.0008 U	0.0008 U	0.0008 U	0.0008 U	NA	NA	NA	NA	NA
4,4’-DDE	NC	0.0007 U	0.0007 U	0.0007 U	0.0007 U	NA	NA	NA	NA	NA
4,4’-DDT	NC	0.008 U	0.02 U	0.02 U	0.008 U	NA	NA	NA	NA	NA
Aldrin	NC	0.0006 U	0.0006 U	0.0006 U	0.0006 U	NA	NA	NA	NA	NA
Alpha-BHC	NC	0.0005 U	0.0005 U	0.0005 U	0.0005 U	NA	NA	NA	NA	NA
Alpha-chlordane	NC	0.0006 U	0.0006 U	0.0006 U	0.0006 U	NA	NA	NA	NA	NA
Beta-BHC	NC	0.0008 U	0.0008 U	0.0008 U	0.0008 U	NA	NA	NA	NA	NA
Butylate	NC	0.009 U	0.009 U	0.009 U	0.009 U	NA	NA	NA	NA	NA
Chlordane	NC	0.002 U	0.002 U	0.002 U	0.002 U	NA	NA	NA	NA	NA
Cycloate	NC	0.006 U	0.006 U	0.006 U	0.006 U	NA	NA	NA	NA	NA
Delta-BHC	NC	0.0007 U	0.0007 U	0.0007 U	0.0007 U	NA	NA	NA	NA	NA
Dieldrin	NC	0.0006 U	0.0006 U	0.0006 U	0.0006 U	NA	NA	NA	NA	NA
Endosulfan I	NC	0.0008 U	0.0008 U	0.0008 U	0.0008 U	NA	NA	NA	NA	NA
Endosulfan II	NC	0.0009 U	0.0009 U	0.0009 U	0.0009 U	NA	NA	NA	NA	NA
Endosulfan Sulfate	NC	0.0006 U	0.0006 U	0.0006 U	0.0006 U	NA	NA	NA	NA	NA
Endrin	NC	0.003 U	0.003 U	0.003 U	0.003 U	NA	NA	NA	NA	NA
Endrin Aldehyde	NC	0.0009 U	0.0009 U	0.0009 U	0.0009 U	NA	NA	NA	NA	NA
Endrin Ketone	NC	0.005 U	0.005 U	0.005 U	0.005 U	NA	NA	NA	NA	NA

Table 7: Summary Analysis for 2006 Surface Water and Stormwater (Continued)

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Surface Water Screening Criteria (µg/L)	Analytical Results (µg/L)[1, 2]								
		SW101	SW102	SW103	SW104	STW104	STW105	STW106	STW107	STW108
EPTC	NC	0.02 U	0.02 U	0.02 U	0.02 U	NA	NA	NA	NA	NA
Fonofos	NC	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA	NA	NA	NA
Gamma-BHC (Lindane)	NC	0.0008 U	0.0008 U	0.0008 U	0.0008 U	NA	NA	NA	NA	NA
Gamma-chlordane	NC	0.0008 U	0.0008 U	0.0008 U	0.0008 U	NA	NA	NA	NA	NA
Heptachlor	NC	0.0005 U	0.0005 U	0.0005 U	0.0005 U	NA	NA	NA	NA	NA
Heptachlor epoxide	NC	0.0006 U	0.0006 U	0.0006 U	0.0006 U	NA	NA	NA	NA	NA
Methoxychlor	NC	0.001 U	0.001 U	0.001 U	0.001 U	NA	NA	NA	NA	NA
Mirex	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA
Molinate	NC	0.01 U	0.01 U	0.01 U	0.01 U	NA	NA	NA	NA	NA
Napropamide	NC	0.02 U	0.04 U	0.04 U	0.02 U	NA	NA	NA	NA	NA
Pebulate	NC	0.008 U	0.008 U	0.008 U	0.008 U	NA	NA	NA	NA	NA
Toxaphene	NC	0.03 U	0.03 U	0.03 U	0.03 U	NA	NA	NA	NA	NA
Vernolate	NC	0.02 U	0.02 U	0.02 U	0.02 U	NA	NA	NA	NA	NA
Aroclor-1016	NC	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Aroclor-1221	NC	1 U	1 U	0.9 U	1 U	1 U	1 U	1 U	1 U	1 U
Aroclor-1232	NC	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Aroclor-1242	NC	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Aroclor-1248	0.03	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Aroclor-1254	NC	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Aroclor-1260	0.03	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 7: Summary Analysis for 2006 Surface Water and Stormwater (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Surface Water Screening Criteria (µg/L)	Analytical Results (µg/L)[1, 2]								
		SW101	SW102	SW103	SW104	STW104	STW105	STW106	STW107	STW108
Total PCBs	NC	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Nitrate (as N)	NC	0.50 U	0.50 U	0.50 U	NA	NA	NA	NA	NA	NA
Nitrite (as N)	NC	5.0 U	5.0 U	5.0 U	NA	NA	NA	NA	NA	NA
pH	NC	8.0	8.1	8.3	7.9	7.7	6.5	6.9	7.1	7.5
Total Dissolved Solids	NC	25,000	25,000	29,000	NA	NA	NA	NA	NA	NA
Total Kjeldahl Nitrogen	NC	0.6	3	1	NA	NA	NA	NA	NA	NA
Phosphorus	NC	0.3	0.7	0.6	NA	NA	NA	NA	NA	NA

Note: 1 Analytical results for metals represent dissolved metals.
2 Bolded values exceed screening criteria

µg/L Microgram per liter
BHC Hexachlorocyclohexane
DDD Dichlorodiphenyldichloroethane
DDE Dichlorodiphenyldichloroethene
DDT Dichlorodiphenyltrichloroethane
EPTC s-Ethyl dipropylthiocarbamate
J Estimated value
mg/L Milligram per liter
NA Not analyzed
NC No criterion available
PCB Polychlorinated biphenyl
U Not detected at given detection limit

Table 8: Summary Analysis for 2006 Sediment
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	ER-M (mg/kg)	E-SSTL (mg/kg)	Sample Results SED101 (mg/kg)	SED102 (mg/kg)	SED103 (mg/kg)
Aluminum	NC	NC	30,300	33,900	28,100
Antimony	25	NC	0.47	0.23	0.26
Arsenic	70	688	36.6	11.2	19.8
Barium	NC	NC	125	73.8	70.9
Beryllium	NC	NC	0.56	0.70	0.64
Cadmium	9.6	57	0.75	0.45	0.79
Calcium	NC	NC	4,930	3,900	3,270
Chromium	370	NC	87.4	103	90.5
Cobalt	NC	NC	14.5	18.7	16.4
Copper	270	630	148	94.2	133
Iron	NC	NC	47,200	48,800	42,900
Lead	218	576	45.8	32.6	45.6
Magnesium	NC	NC	13,200	15,800	13,600
Manganese	NC	NC	470	877	519
Mercury	0.71	3.8	**2.3**	0.51	**1.6**
Molybdenum	NC	NC	0.92	0.56	0.80
Nickel	51.5	2,778	**79.6**	**107**	**91.6**
Potassium	NC	NC	4,740	4,500	3,810
Selenium	1.4	16	**2.0**	1.2	**2.0**
Silver	3.7	NC	0.38	0.33	0.43
Sodium	NC	NC	11,500	9,570	9,510
Thallium	NC	NC	0.22	0.18	0.21
Vanadium	NC	NC	83.2	92.3	80.2
Zinc	410	5,378	265	167	225
4,4'-DDD	0.02	14	0.002 U	0.002 U	0.002 U
4,4'-DDE	0.027	NC	0.008	0.0007 U	0.0007 U
4,4'-DDT	0.007	NC	0.007	0.002 U	0.002 U
Aldrin	NC	NC	0.002 U	0.001 U	0.001 U
Alpha-BHC	NC	2.4	0.0004 U	0.0004 U	0.0004 U
Alpha-chlordane	NC	NC	0.002 U	0.002 U	0.002 U
Beta-BHC	NC	NC	0.002 U	0.002 U	0.002 U
Butylate	NC	NC	0.005 U	0.005 U	0.005 U
Chlordane	NC	NC	0.02 U	0.02 U	0.02 U

Table 8: Summary Analysis for 2006 Sediment (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	ER-M (mg/kg)	E-SSTL (mg/kg)	Sample Results		
			SED101 (mg/kg)	SED102 (mg/kg)	SED103 (mg/kg)
Cycloate	NC	NC	0.005 U	0.005 U	0.005 U
delta-BHC	NC	2.1	0.002 U	0.002 U	0.002 U
Dieldrin	0.008	NC	0.0003 U	0.0003 U	0.0003 U
Endosulfan I	NC	NC	0.0004 U	0.0004 U	0.0004 U
Endosulfan II	NC	NC	0.0005 U	0.0005 U	0.0005 U
Endosulfan Sulfate	NC	NC	0.0007 U	0.0007 U	0.0007 U
Endrin	0.045	NC	0.0004 U	0.0004 U	0.0004 U
Endrin Aldehyde	NC	NC	0.0005 U	0.0005 U	0.0005 U
Endrin Ketone	NC	NC	0.0004 U	0.0004 U	0.0004 U
EPTC	NC	NC	0.005 U	0.005 U	0.005 U
Fonofos	NC	NC	0.03 U	0.03 U	0.03 U
Gamma-BHC (Lindane)	NC	NC	0.001 U	0.001 U	0.001 U
Gamma-chlordane	NC	NC	0.0005 U	0.0005 U	0.0005 U
Heptachlor	NC	NC	0.0005 U	0.0004 U	0.0004 U
Heptachlor epoxide	NC	NC	0.0008 U	0.0008 U	0.0008 U
Methoxychlor	NC	NC	0.002 U	0.002 U	0.002 U
Mirex	NC	NC	0.0004 U	0.0004 U	0.0004 U
Molinate	NC	NC	0.005 U	0.005 U	0.005 U
Napropamide	NC	NC	0.005 U	0.005 U	0.005 U
Pebulate	NC	NC	0.005 U	0.005 U	0.005 U
Toxaphene	NC	NC	0.04 U	0.04 U	0.04 U
Vernolate	NC	NC	0.005 U	0.005 U	0.005 U
Aroclor-1016	0.18	4.2	0.01 U	0.01 U	0.01 U
Aroclor-1221	NC	NC	0.03 U	0.03 U	0.03 U
Aroclor-1232	NC	NC	0.02 U	0.02 U	0.02 U
Aroclor-1242	NC	NC	0.007 U	0.007 U	0.007 U
Aroclor-1248	0.18	5.9	0.04 U	0.04 U	0.04 U
Aroclor-1254	0.18	24	0.009 U	0.009 U	0.009 U
Aroclor-1260	NC	NC	0.01 U	0.01 U	0.01 U

Table 8: Summary Analysis for 2006 Sediment (Continued)

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Notes: Bolded values exceed ER-M; no concentrations exceeded E-SSTLs.

BHC	Benzene hexachloride
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
EPTC	s-Ethyl dipropylthiocarbamate
ER-M	Effects range-median
E-SSTL	Ecological site-specific target level
mg/kg	Milligram per kilogram
NC	No criterion available
U	Not detected

Table 9: Vigor of Planted Stock at WSMRP Site Quadrats

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Transect	Quadrat[a]	Height (inches)[b]	Score[c]
Planted Stock in WSMRP Site			
A	A-1	26	Poor
	A-2	4	Poor
	A-3	8	Poor
A'	A’-1	28	Poor
	A’-2	15.75	Fair
	A’-3	11.5	Poor
B	B-1	N/A	Poor
	B-2	15	Fair
	B-3	2	Poor
	B-4	7	Poor
	B-5	9	Poor
	B-6	0	Poor
	B-7	14	Poor to Fair
C	C-0	N/A	Fair
	C-1	13	Poor
	C-2	0	Poor
	C-3	0	Poor
	C-4	0	Poor
	C-5	0	Poor
	C-6	10	Poor
D	D-0	N/A	Poor
	D-1	3	Poor
	D-2	0	Poor
	D-3	0	Poor
	D-4	13	Fair
	D-5	11	Poor to Fair
	D-6	12	Poor
	D-7	15	Poor to Fair
E	E-0	N/A	Poor
	E-1	8	Poor
	E-2	4	Poor
	E-3	19	Poor to Fair
	E-4	13.5	Good
	E-5	10	Good
	E-6	7	Poor
	E-7	22	Good
	E-8	14	Fair
	E-9	N/A	Excellent
	E-10	N/A	Excellent

Table 9: Vigor of Planted Stock at WSMRP Site Quadrats (Continued)

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Transect	Quadrat[a]	Height (inches)[b]	Score[c]
Planted Stock in WSMRP Site (Continued)			
F	F-1	10	Poor
	F-2	0	Poor
	F-3	12	Poor
	F-4	13	Poor
G	G-1	32	Poor
	G-2	34	Poor
	G-3	0	Good
	G-4	24	Poor to Fair

Notes:

a Locations of quadrats are shown on Figure 4.
b Average height of dominant plant species in the quadrat.
c See Table 3 for plant vigor definitions

N/A Not available
WSMRP Western Stege Marsh Restoration Project

Table 10: Summary of Year 2 Recommendations

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Project Target	Recommended Changes in Site Management and Data Collection	Recommended Changes in Data Interpretation
1	On-site tide gage information is not critical to evaluate site inundation, and is therefore not recommended to be collected in Year 3.	No Change.
2	No Change.	Finalize criteria (in cooperation with DTSC).
3	No Change. Options for increasing the rate of Pacific cordgrass colonization include increasing the rate of transplanting salvaged plants, genetically testing volunteer seedling for hybridization so that only hybrids are removed, and applying soil amendments.	No Change.
	No change to plant identification task.	Combine Pacific cordgrass and pickleweed acreage to evaluate success of marsh revegetation.
	Determine areal extent of land suitable for development of a plant community dominated by Pacific cordgrass.	Report established acreage of Pacific cordgrass as proportion of acreage potentially suitable; redefine target acreage as proportion of what is available at correct elevation and distance from water.
4	No Change.	No Change. Consider adding an additional monitoring station in the eastern portion of the marsh as the site vegetation matures.

Table 11: Frequency of Monitoring Efforts over the 5-Year Monitoring Interval

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

	Year 1		Year 2		Year 3		Year 4		Year 5	
Monitoring Activity	**Spring 2004**	**Fall 2004**	**Spring 2005**	**Fall 2006**	**Spring 2007**	**Fall 2007**	**Spring 2008**	**Fall 2008**	**Spring 2009**	**Fall 2009**
Establishment of Transects, Quadrats, Cross-section Locations, and Pressure Transducer	a									
Project Target #1										
Tidal Inundation	b	b		b	b	b	c	c	c	c
Marsh Elevation (Land Survey)	d	•		•		•		•		•
Marsh Elevation (Aerial Survey)										•
Project Target #2										
Surface Water Sampling				•	•	•	•	•	•	•
Sediment Sampling				•	•	•	•	•	•	•
Stormwater Sampling				•	•	•	•	•	•	•
Project Target #3										
Vegetation Quadrat Surveys (Ecotone Quadrats Only)					•		•		•	
Vegetation Quadrat Surveys (All Quadrats)		•		•		•		•		•
Vegetation Dominance Mapping		•		•		•		•		•
Project Target #4										
Vegetation Quadrat Surveys (Ecotone Quadrats Only)					•		•		•	
Vegetation Quadrat Surveys (All Quadrats)		•		•		•		•		•
Vegetation Dominance Mapping		•		•		•		•		•
California Clapper Rail Use			e		e		e		e	
Photodocumentation		•		•	•	•	•	•	•	•
Annual Monitoring Report					f		f		f	

Notes:

a Transects, quadrats, slough cross-section locations, and the pressure transducer were established in summer 2004.

b Data regarding tidal inundation were collected continuously at 15-minute intervals using a pressure transducer or through visual observations.

c Data regarding tidal inundation for Year 4 and 5 will be collected continuously at 15-minute intervals through visual observations.

d Baseline data regarding marsh elevation were collected following establishment of the transects, quadrats, and slough cross-section locations.

e Protocol surveys of California clapper rail use of Western Stege Marsh will occur between January and April each year.

f An annual report will be submitted to the appropriate agencies during the year following completion of the previous year's monitoring activities (the annual report for the fifth year of the program will be submitted in the first half of 2010).

APPENDIX A
ANALYTICAL DATA AND VEGETATION MONITORING RESULTS

TABLE A-1: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR SURFACE WATER SAMPLES

Richmond Field Station, Richmond, California

Sample Location ID	**SW101**	**SW102**	**SW103**	**SW104**
Sample ID	SW001	SW002	SW003	SW004
Sample Date	10/30/2006	10/30/2006	10/30/2006	10/30/2006
Matrix	SURFACE WATER	SURFACE WATER	SURFACE WATER	SURFACE WATER
DISSOLVED METALS (ug/L)				
ALUMINUM	100 U	100 U	100 U	100 U
ANTIMONY	60.0 U	60.0 U	60.0 U	60.0 U
ARSENIC	15.0	15.0	18.0	9.1
BARIUM	38.0	54.0	41.0	43.0
BERYLLIUM	1.0 J	2.0 U	2.0 U	2.0 U
CADMIUM	5.0 U	5.0 U	5.0 U	5.0 U
CALCIUM	310,000	290,000	310,000	220,000
CHROMIUM	10.0 U	10.0 U	10.0 U	10.0 U
COBALT	20.0 U	20.0 U	20.0 U	20.0 U
COPPER	6.1 J	10.0 U	10.0 U	7.4 J
IRON	100 U	100 U	100 U	100 U
LEAD	3.0 U	2.7 UJ	3.0 U	3.0 U
MAGNESIUM	940,000	880,000	980,000	650,000
MANGANESE	930 J	2,600 J	1,200 J	86.0 J
MERCURY	0.13 UJ	0.20 U	0.20 U	0.20 U
MOLYBDENUM	20.0 U	20.0 U	20.0 U	20.0 U
NICKEL	20.0 U	20.0 U	20.0 U	20.0 U
POTASSIUM	320,000	230,000	260,000	180,000
SELENIUM	5.0 U	5.0 U	5.0 U	5.0 U
SILVER	3.2 J	5.0 U	5.0 U	5.0 U
SODIUM	7,000,000	6,900,000	7,900,000	5,100,000
THALLIUM	9.4 UJ	8.4 UJ	7.3 UJ	4.8 UJ
VANADIUM	10.0 U	10.0 U	10.0 U	10.0 U
ZINC	20.0 U	12.0 J	20.0 U	13.0 J
PESTICIDES (ug/L)				
4,4'-DDD	0.0008 U	0.0008 U	0.0008 U	0.0008 U
4,4'-DDE	0.0007 U	0.0007 U	0.0007 U	0.0007 U
4,4'-DDT	0.008 U	0.02 U	0.02 U	0.008 U
ALDRIN	0.0006 U	0.0006 U	0.0006 U	0.0006 U
ALPHA-BHC	0.0005 U	0.0005 U	0.0005 U	0.0005 U

Notes to table on page 4

TABLE A-1: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR SURFACE WATER SAMPLES (Continued)

Richmond Field Station, Richmond, California

Sample Location ID	**SW101**	**SW102**	**SW103**	**SW104**
Sample ID	SW001	SW002	SW003	SW004
Sample Date	10/30/2006	10/30/2006	10/30/2006	10/30/2006
Matrix	SURFACE WATER	SURFACE WATER	SURFACE WATER	SURFACE WATER
PESTICIDES (ug/L)				
ALPHA-CHLORDANE	0.0006 U	0.0006 U	0.0006 U	0.0006 U
BETA-BHC	0.0008 U	0.0008 U	0.0008 U	0.0008 U
BUTYLATE	0.009 U	0.009 U	0.009 U	0.009 U
CHLORDANE	0.002 U	0.002 U	0.002 U	0.002 U
CYCLOATE	0.006 U	0.006 U	0.006 U	0.006 U
DELTA-BHC	0.0007 U	0.0007 U	0.0007 U	0.0007 U
DIELDRIN	0.0006 U	0.0006 U	0.0006 U	0.0006 U
ENDOSULFAN I	0.0008 U	0.0008 U	0.0008 U	0.0008 U
ENDOSULFAN II	0.0009 U	0.0009 U	0.0009 U	0.0009 U
ENDOSULFAN SULFATE	0.0006 U	0.0006 U	0.0006 U	0.0006 U
ENDRIN	0.003 U	0.003 U	0.003 U	0.003 U
ENDRIN ALDEHYDE	0.0009 U	0.0009 U	0.0009 U	0.0009 U
ENDRIN KETONE	0.005 U	0.005 U	0.005 U	0.005 U
EPTC	0.02 U	0.02 U	0.02 U	0.02 U
FONOFOS	0.5 U	0.5 U	0.5 U	0.5 U
GAMMA-BHC (LINDANE)	0.0008 U	0.0008 U	0.0008 U	0.0008 U
GAMMA-CHLORDANE	0.0008 U	0.0008 U	0.0008 U	0.0008 U
HEPTACHLOR	0.0005 U	0.0005 U	0.0005 U	0.0005 U
HEPTACHLOR EPOXIDE	0.0006 U	0.0006 U	0.0006 U	0.0006 U
METHOXYCHLOR	0.001 U	0.001 U	0.001 U	0.001 U
MOLINATE	0.01 U	0.01 U	0.01 U	0.01 U
NAPROPAMIDE	0.02 U	0.04 U	0.04 U	0.02 U
PEBULATE	0.008 U	0.008 U	0.008 U	0.008 U
TOXAPHENE	0.03 U	0.03 U	0.03 U	0.03 U
VERNOLATE	0.02 U	0.02 U	0.02 U	0.02 U
PCBs (ug/L)				
AROCLOR-1016	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1221	1 U	1 U	0.9 U	1 U
AROCLOR-1232	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1242	0.5 U	0.5 U	0.5 U	0.5 U

Notes to table on page 4

TABLE A-1: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR SURFACE WATER SAMPLES (Continued)

Richmond Field Station, Richmond, California

Sample Location ID	SW101	SW102	SW103	SW104
Sample ID	SW001	SW002	SW003	SW004
Sample Date	10/30/2006	10/30/2006	10/30/2006	10/30/2006
Matrix	SURFACE WATER	SURFACE WATER	SURFACE WATER	SURFACE WATER
PCBs (ug/L)				
AROCLOR-1248	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1254	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1260	0.5 U	0.5 U	0.5 U	0.5 U
TOTAL PCBS	0 U	0 U	0 U	0 U
ANIONS AND SOLIDS (mg/L)				
NITRATE (AS N)	0.50 U	0.50 U	0.50 U	NA
NITRITE (AS N)	5.0 U	5.0 U	5.0 U	NA
pH				
PH	8.0	8.1	8.3	7.9
ANIONS AND SOLIDS (mg/L)				
TOTAL DISSOLVED SOLIDS	25,000	25,000	29,000	NA
TOTAL KJELDAHL NITROGEN (mg/L)				
TOTAL KJELDAHL NITROGEN	0.6	3	1	NA
PHOSPHORUS (mg/L)				
PHOSPHORUS	0.3	0.7	0.6	NA

Notes to table on page 4

Notes:	Inorganic results less than 10 are reported to two significant figures, and results greater than 10 are reported to three significant figures.
	Organic results less than 10 are reported to one significant figure, and results greater than 10 are reported to two significant figures.
ug/L	Micrograms per liter
BHC	Hexachlorocyclohexane
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
ID	Identification
J	Estimated value
mg/L	Milligrams per liter
NA	Not analyzed
PCB	Polychlorinated biphenyl
U	Not detected at given detection limit

TABLE A-2: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR SEDIMENT SAMPLES

Richmond Field Station, Richmond, California

Sample Location ID	SED101	SED102	SED103
Sample Depth (feet bgs)	0.0 - 0.5	0.0 - 0.5	0.0 - 0.5
Sample Date	10/30/2006	10/30/2006	10/30/2006
Matrix	SEDIMENT	SEDIMENT	SEDIMENT
METALS (mg/kg)			
ALUMINUM	30,300	33,900	28,100
ANTIMONY	0.47	0.23	0.26
ARSENIC	36.6	11.2	19.8
BARIUM	125	73.8	70.9
BERYLLIUM	0.56	0.70	0.64
CADMIUM	0.75	0.45	0.79
CALCIUM	4,930	3,900	3,270
CHROMIUM	87.4	103	90.5
COBALT	14.5	18.7	16.4
COPPER	148	94.2	133
IRON	47,200	48,800	42,900
LEAD	45.8	32.6	45.6
MAGNESIUM	13,200	15,800	13,600
MANGANESE	470	877	519
MERCURY	2.3	0.51	1.6
MOLYBDENUM	0.92	0.56	0.80
NICKEL	79.6	107	91.6
POTASSIUM	4,740	4,500	3,810
SELENIUM	2.0	1.2	2.0
SILVER	0.38	0.33	0.43
SODIUM	11,500	9,570	9,510
THALLIUM	0.22	0.18	0.21
VANADIUM	83.2	92.3	80.2
ZINC	265	167	225
PESTICIDES (mg/kg)			
4,4'-DDD	0.002 U	0.002 U	0.002 U
4,4'-DDE	0.008	0.0007 U	0.0007 U
4,4'-DDT	0.007	0.002 U	0.002 U
ALDRIN	0.002 U	0.001 U	0.001 U
ALPHA-BHC	0.0004 U	0.0004 U	0.0004 U

Notes to table on page 4

TABLE A-2: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR SEDIMENT SAMPLES (Continued)

Richmond Field Station, Richmond, California

Sample Location ID	SED101	SED102	SED103
Sample Depth (feet bgs)	0.0 - 0.5	0.0 - 0.5	0.0 - 0.5
Sample Date	10/30/2006	10/30/2006	10/30/2006
Matrix	SEDIMENT	SEDIMENT	SEDIMENT
PESTICIDES (mg/kg)			
ALPHA-CHLORDANE	0.002 U	0.002 U	0.002 U
BETA-BHC	0.002 U	0.002 U	0.002 U
BUTYLATE	0.005 U	0.005 U	0.005 U
CHLORDANE	0.02 U	0.02 U	0.02 U
CYCLOATE	0.005 U	0.005 U	0.005 U
DELTA-BHC	0.002 U	0.002 U	0.002 U
DIELDRIN	0.0003 U	0.0003 U	0.0003 U
ENDOSULFAN I	0.0004 U	0.0004 U	0.0004 U
ENDOSULFAN II	0.0005 U	0.0005 U	0.0005 U
ENDOSULFAN SULFATE	0.0007 U	0.0007 U	0.0007 U
ENDRIN	0.0004 U	0.0004 U	0.0004 U
ENDRIN ALDEHYDE	0.0005 U	0.0005 U	0.0005 U
ENDRIN KETONE	0.0004 U	0.0004 U	0.0004 U
EPTC	0.005 U	0.005 U	0.005 U
FONOFOS	0.03 U	0.03 U	0.03 U
GAMMA-BHC (LINDANE)	0.001 U	0.001 U	0.001 U
GAMMA-CHLORDANE	0.0005 U	0.0005 U	0.0005 U
HEPTACHLOR	0.0005 U	0.0004 U	0.0004 U
HEPTACHLOR EPOXIDE	0.0008 U	0.0008 U	0.0008 U
METHOXYCHLOR	0.002 U	0.002 U	0.002 U
MIREX	0.0004 U	0.0004 U	0.0004 U
MOLINATE	0.005 U	0.005 U	0.005 U
NAPROPAMIDE	0.005 U	0.005 U	0.005 U
PEBULATE	0.005 U	0.005 U	0.005 U
TOXAPHENE	0.04 U	0.04 U	0.04 U
VERNOLATE	0.005 U	0.005 U	0.005 U
PCBs (mg/kg)			
AROCLOR-1016	0.01 U	0.01 U	0.01 U
AROCLOR-1221	0.03 U	0.03 U	0.03 U
AROCLOR-1232	0.02 U	0.02 U	0.02 U

Notes to table on page 4

TABLE A-2: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR SEDIMENT SAMPLES (Continued)

Richmond Field Station, Richmond, California

Sample Location ID	SED101	SED102	SED103
Sample Depth (feet bgs)	0.0 - 0.5	0.0 - 0.5	0.0 - 0.5
Sample Date	10/30/2006	10/30/2006	10/30/2006
Matrix	SEDIMENT	SEDIMENT	SEDIMENT
PCBs (mg/kg)			
AROCLOR-1242	0.007 U	0.007 U	0.007 U
AROCLOR-1248	0.04 U	0.04 U	0.04 U
AROCLOR-1254	0.009 U	0.009 U	0.009 U
AROCLOR-1260	0.01 U	0.01 U	0.01 U
pH			
PH	7.4	7.3	7.3

Notes to table on page 4

TABLE A-2: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR SEDIMENT SAMPLES (Continued)

Richmond Field Station, Richmond, California

Notes:	Inorganic results less than 10 are reported to two significant figures, and results greater than 10 are reported to three significant figures.
	Organic results less than 10 are reported to one significant figure, and results greater than 10 are reported to two significant figures.
bgs	Below ground surface
BHC	Hexachlorocyclohexane
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
ID	Identification
J	Estimated value
mg/kg	Milligrams per kilogram
PCB	Polychlorinated biphenyl
U	Not detected at given detection limit

TABLE A-3: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR STORMWATER SAMPLES

Richmond Field Station, Richmond, California

Sample Location ID	STW104	STW105	STW106	STW107	STW108
Sample ID	STW005	STW001	STW002	STW003	STW004
Sample Date	11/02/2006	11/02/2006	11/02/2006	11/02/2006	11/02/2006
Matrix	STORMWATER	STORMWATER	STORMWATER	STORMWATER	STORMWATER
DISSOLVED METALS (ug/L)					
ALUMINUM	100 U	420	33.0 J	100 U	100 U
ANTIMONY	60.0 U	60.0 U	60.0 U	60.0 U	60.0 U
ARSENIC	6.3	1.2 J	5.0 U	5.0 U	3.3 J
BARIUM	32.0	82.0	17.0	22.0	38.0
BERYLLIUM	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
CADMIUM	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
CALCIUM	180,000	15,000	11,000	11,000	76,000
CHROMIUM	10.0 U	3.4 J	10.0 U	10.0 U	10.0 U
COBALT	20.0 U	2.3 J	20.0 U	20.0 U	20.0 U
COPPER	9.9 J	23.0	58.0	13.0	14.0
IRON	40.0 J	730	89.0 J	64.0 J	66.0 J
LEAD	3.0 U	2.6 J	3.0 U	3.0 U	3.0 U
MAGNESIUM	550,000	3,800	12,000	8,300	220,000
MANGANESE	88.0	590	64.0	25.0	75.0
MERCURY	0.08 J	0.26	0.03 J	0.20 U	0.03 J
MOLYBDENUM	4.6 J	20.0 U	24.0	2.2 J	3.6 J
NICKEL	4.7 J	13.0 J	4.1 J	3.5 J	6.8 J
POTASSIUM	170,000	5,400	5,200	3,800	71,000
SELENIUM	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
SILVER	1.5 J	5.0 U	5.0 U	5.0 U	5.0 U
SODIUM	4,300,000	13,000	110,000	50,000	1,700,000
THALLIUM	7.7	5.0 U	5.0 U	5.0 U	6.0
VANADIUM	10.0 U	4.8 J	10.0 U	3.2 J	2.6 J
ZINC	38.0	470	240	60.0	87.0
PCBs (ug/L)					
AROCLOR-1016	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1221	1 U	1 U	1 U	1 U	1 U
AROCLOR-1232	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1242	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1248	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Notes to table on page 3

TABLE A-3: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR STORM WATER SAMPLES (Continued)

Richmond Field Station, Richmond, California

Sample Location ID	**STW104**	**STW105**	**STW106**	**STW107**	**STW108**
Sample ID	STW005	STW001	STW002	STW003	STW004
Sample Date	11/02/2006	11/02/2006	11/02/2006	11/02/2006	11/02/2006
Matrix	STORMWATER	STORMWATER	STORMWATER	STORMWATER	STORMWATER
PCBs (ug/L)					
AROCLOR-1254	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
AROCLOR-1260	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
TOTAL PCBS	0 U	0 U	0 U	0 U	0 U
pH					
PH	7.7	6.5	6.9	7.1	7.5

Notes to table on page 3

TABLE A-3: SUMMARY OF COMPLETE ANALYTICAL RESULTS FOR STORM WATER SAMPLES (Continued)

Richmond Field Station, Richmond, California

Notes:	Inorganic results less than 10 are reported to two significant figures, and results greater than 10 are reported to three significant figures.
	Organic results less than 10 are reported to one significant figure, and results greater than 10 are reported to two significant figures.
ug/L	Micrograms per liter
bgs	Below ground surface
ID	Identification
J	Estimated value
PCB	Polychlorinated biphenyl
U	Not detected at given detection limit

Table A-4: Vegetation Survey Results for the Western Stege Marsh Restoration Project Site

Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Location				% Cover							
Transect	**Quadrat**	**Scientific Name**	**Common Name**	**<1**	**1 to 5**	**6 to 15**	**16 to 25**	**26 to 45**	**46 to 75**	**76 to 90**	**>90**
A	A-1	*Achillea millefolium*	Yarrow		X						
		Artemisia douglasiana	Mugwort		X						
		Atriplex triangularis	Salt Bush	X							
		Distichlis spicata	Salt Grass	X							
		Elymus trachycaulus var. trachycaulus	Slender Wheatgrass		X						
		Grindelia stricta var. angustifolia	Marsh Gumplant			X					
		Spergularia marina	Annual Sand-Spurrey	X							
		Polypogon monspliensis	Rabbits Foot Grass	X							
		Sonchus asper var. asper	Sow Thistle	X							
A	A-2	*Atriplex triangularis*	Salt Bush		X						
		Distichlis spicata	Salt Grass		X						
		Salicornia virginica	Pickleweed				X				
		Polypogon monspliensis	Rabbits Foot Grass		X						
		Spergularia sp.	Sand Spurrey species			X					
A	A-3	*No Vegetation*									
A'	A'-1	*Distichlis spicata*	Salt Grass		X						
		Grindelia stricta var. angustifolia	Marsh Gumplant				X				
		Jaumea carnosa	Salty Susan	X							
		Salicornia virginica	Pickleweed	X							
		Polypogon monspliensis	Rabbits Foot Grass		X						

Table A-4: Vegetation Survey Results for the Western Stege Marsh Restoration Project Site (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Location		Scientific Name	Common Name	% Cover							
Transect	Quadrat			<1	1 to 5	6 to 15	16 to 25	26 to 45	46 to 75	76 to 90	>90
A’	A’-1	*Spergularia sp.*	Sand Spurrey species	X							
A'	A'-2	*Distichlis spicata*	Salt Grass				X				
		Grindelia stricta var. angustifolia	Marsh Gumplant					X			
		Salicornia virginica	Pickleweed		X						
		Polypogon monspliensis	Rabbits Foot Grass				X				
		Sonchus asper var. asper	Sow Thistle		X						
		Cotula coronopifolia	Brass Buttons		X						
A'	A'-3	*Grindelia stricta var. angustifolia*	Marsh Gumplant		X						
		Salicornia virginica	Pickleweed						X		
		Polypogon monspliensis	Rabbits Foot Grass			X					
B	B-1	*Achillea millefolium*	Yarrow	X							
		Artemisia claifornica	California Sagebrush		X						
		Artemisia douglasiana	Mugwort		X						
		Atriplex triangularis	Salt Bush		X						
		Baccharis pilularis	Coyote Brush		X						
		Grindelia hirsutula var. hirsutula	Gumplant	X							
		Sonchus asper	Prickly Sow Thistle		X						
B	B-2	*Salicornia virginica*	Pickleweed							X	
B	B-3	*Salicornia virginica*	Pickleweed		X						
B	B-4	*Salicornia virginica*	Pickleweed			X					

Table A-4: Vegetation Survey Results for the Western Stege Marsh Restoration Project Site (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Location				% Cover							
Transect	Quadrat	Scientific Name	Common Name	<1	1 to 5	6 to 15	16 to 25	26 to 45	46 to 75	76 to 90	>90
B	B-5	*Salicornia virginica*	Pickleweed					X			
B	B-6	*No Vegetation*									
B	B-7	*Salicornia virginica*	Pickleweed						X		
C	C-0	*Achillea millefolium*	Yarrow			X					
		Atriplex triangularis	Salt Bush			X					
		Frankenia salina	Alkali Heath	X							
		Salicornia virginica	Pickleweed					X			
C	C-1	*No Vegetation*									
C	C-2	*No Vegetation*									
C	C-3	*Jaumea carnosa*	Salty Susan		X						
C	C-4	*Salicornia virginica*	Pickleweed			X					
		No Vegetation									
C	C-5	*Salicornia virginica*	Pickleweed				X				
C	C-6	*Artemisia californica*	California Sagebrush		X						
D	D-0	*Artemisia douglasiana*	Mugwort		X						
		Aster chilensis	California Aster		X						
		Atriplex triangularis	Salt Bush		X						
		Frankenia salina	Alkali Heath		X						
		Salicornia virginica	Pickleweed		X						
D	D-1	*No Vegetation*									
D	D-2	*No Vegetation*									
D	D-3	*Salicornia virginica*	Pickleweed							X	
D	D-4	*Salicornia virginica*	Pickleweed					X			

Table A-4: Vegetation Survey Results for the Western Stege Marsh Restoration Project Site (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Location				% Cover							
Transect	Quadrat	Scientific Name	Common Name	<1	1 to 5	6 to 15	16 to 25	26 to 45	46 to 75	76 to 90	>90
D	D-5	*Salicornia virginica*	Pickleweed				X				
D	D-6	*Salicornia virginica*	Pickleweed							X	
D	D-7	*Spartina foliosa*	Pacific Cordgrass		X						
		Artemisia californica	California Sagebrush			X					
E	E-0	*Baccharis pilularis*	Coyote Brush		X						
		Mimulus aurantiacus	Sticky Monkey Flower		X						
		Polypogon monspliensis	Rabbits Foot Grass	X							
		Jaumea carnosa	Salty Susan	X							
E	E-1	*Salicornia virginica*	Pickleweed				X				
		Salicornia virginica	Pickleweed		X						
E	E-2	*Salicornia virginica*	Pickleweed					X			
E	E-3	*Distichlis spicata*	Salt Grass							X	
E	E-4	*Salicornia virginica*	Pickleweed					X			
		Atriplex triangularis	Salt Bush		X						
E	E-5	*Distichlis spicata*	Salt Grass						X		
		Grindelia stricta var. angustifolia	Marsh Gumplant		X						
		Salicornia virginica	Pickleweed		X						
		Scirpus americanus	American Tule	X							
		Distichlis spicata	Salt Grass				X				
E	E-6	*Jaumea carnosa*	Salty Susan	X							
		Salicornia virginica	Pickleweed			X					
		Atriplex triangularis	Salt Bush	X							

Table A-4: Vegetation Survey Results for the Western Stege Marsh Restoration Project Site (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Location				% Cover							
Transect	Quadrat	Scientific Name	Common Name	<1	1 to 5	6 to 15	16 to 25	26 to 45	46 to 75	76 to 90	>90
E	E-7	*Elymus trachycaulus var. trachycaulus*	Slender Wheatgrass		X						
		Grindelia stricta var. angustifolia	Marsh Gumplant			X					
		Jaumea carnosa	Salty Susan			X					
		Nassella pulchra	Purple Needle Grass		X						
		Salicornia virginica	Pickleweed			X					
		Bromus carinatus	California Brome		X						
E	E-8	*Distichlis spicata*	Salt Grass			X					
		Grindelia stricta var. angustifolia	Marsh Gumplant				X				
		Salicornia virginica	Pickleweed				X				
		Polypogon monspeliensis	Rabbits Foot Grass			X					
		Baccharis pilularis	Coyote Brush				X				
E	E-9	*Distichlis spicata*	Salt Grass							X	
		Elymus trachycaulus var. trachycaulus	Slender Wheatgrass	X							
		Grindelia stricta var. angustifolia	Marsh Gumplant		X						
		Elymus trachycaulus var. trachycaulus	Slender Wheatgrass		X						
E	E-10	*Distichlis spicata*	Salt Grass								X
		Nassella pulchra	Purple Needle Grass		X						

Table A-4: Vegetation Survey Results for the Western Stege Marsh Restoration Project Site (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Location				% Cover							
Transect	Quadrat	Scientific Name	Common Name	<1	1 to 5	6 to 15	16 to 25	26 to 45	46 to 75	76 to 90	>90
E	E-10	*Salicornia virginica*	Pickleweed						X		
F	F-1	*Polypogon monspeliensis*	Rabbits Foot Grass		X						
		Salicornia europaea	Slender Glasswort			X					
F	F-2	*Salicornia virginica*	Pickleweed					X			
F	F-3	*Salicornia virginica*	Pickleweed				X				
F	F-4	*Artemisia californica*	California Sagebrush				X				
G	G-1	*Distichlis spicata*	Salt Grass		X						
		Elymus trachycaulus var. trachycaulus	Slender Wheatgrass	X							
		Grindelia stricta var. angustifolia	Marsh Gumplant				X				
		Toxicodendron diversilobum	Poison Oak					X			
		Distichlis spicata	Salt Grass		X						
G	G-2	*Grindelia stricta var. angustifolia*	Marsh Gumplant					X			
		Salicornia virginica	Pickleweed	X							
		Polypogon monspeliensis	Rabbits Foot Grass			X					
		Artemisia californica	California Sagebrush			X					
G	G-3	*Distichlis spicata*	Salt Grass						X		
		Salicornia virginica	Pickleweed		X						
		Distichlis spicata	Salt Grass			X					

Table A-4: Vegetation Survey Results for the Western Stege Marsh Restoration Project Site (Continued)
Year 2 Monitoring Report for the Western Stege Marsh Restoration Project
University of California, Berkeley, Richmond Field Station, Richmond, California

Location				% Cover							
Transect	Quadrat	Scientific Name	Common Name	<1	1 to 5	6 to 15	16 to 25	26 to 45	46 to 75	76 to 90	>90
G	G-4	*Elymus trachycaulus var. trachycaulus*	Slender Wheatgrass		X						
		Grindelia stricta var. angustifolia	Marsh Gumplant				X				
		Jaumea carnosa	Salty Susan			X					
		Salicornia virginica	Pickleweed		X						
		Polypogon monspeliensis	Rabbits Foot Grass			X					

APPENDIX B
SITE PHOTOGRAPHS

Marsh Monitoring Photo Log

September 2006

Photo Station PL-1 a : photo taken facing west

Photo Station PL-1 b : photo taken facing southwest

Photo Station PL-2 a : photo taken facing east

Photo Station PL-2 b : photo taken facing southeast

Photo Station Pl-2 c : photo taken facing south

Photo Station PL-3 a : photo taken facing north

Photo Station PL-3 b : photo taken facing northwest

Photo Station PL-3 c : photo taken facing west

Photo Station PL-3 d : photo taken facing southwest

Photo Station PL-3 e : photo taken facing south

Photo Station PL-4 a : photo taken facing west-northwest

Photo Station PL-4 b : photo taken facing northwest

Photo Station PL-4 c : photo taken facing north

Photo Station PL-5 a : photo taken facing north

Photo Station PL-5 b : photo taken facing east-northeast

Photo Station PL-5 c : photo taken facing southeast

Photo Station PL-5 d : photo taken facing northwest

APPENDIX C
SOIL FERTILITY RECOMMENDATIONS FOR RICHMOND FIELD STATION

TETRA TECH EM INC.

September 28, 2006

Greg Haet
Associate Director, Environmental Protection
Office of Environment, Health & Safety
University of California, Berkeley
317 University Hall #1150
Berkeley, CA 94720

Subject: Fertility Recommendations for Richmond Field Station Wetland Restoration

Dear Mr. Haet:

This letter summarizes the results of Tetra Tech EM Inc.'s (Tetra Tech) evaluation of soil fertility at the Richmond Field Station project site. Additionally, this letter presents Tetra Tech's recommendations to improve soil fertility based on the results of our evaluation.

Poor plant growth has been observed on several plots of the wetland restoration area. As a result, Tetra Tech performed an evaluation of the soil fertility to determine if the soil is responsible for the poor growth conditions. Tetra Tech collected soil samples from six vegetation plots (1, 2, 5, 6, 9, and 10) and took pictures of the vegetation and landscape at the Richmond Field Station mitigation project site. Plots 1, 2, 5, and 6 were revegetated as part of the restoration program. Vegetation growth on Plots 1 and 2 was characterized as poor or very poor. The Watershed Project plans to fill in areas of poor plant growth and coverage with additional plants and to begin revegetating an upland area adjacent to Plots 1 and 2. Plots 9 and 10 are naturally vegetated. The table below summarizes the analytical results of the soil samples collected from each plot.

Plot	Sample	NO_3-N (mg/kg)	NH_4-N (mg/kg)	Total Nitrogen (mg/kg)	PO_4-P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Organic Matter (%)	CEC (me/kg)	Clay (%)
1	RFS-001	5	17	22	36	227	3,041	1,186	3.2	268	33.2
	RFS-002	3	10	13	32	215	3,306	864	2.2	235	31.2
2	RFS-003	3	9	12	44	491	1,694	1,610	2.9	285	51.2
	RFS-004	3	6	9	15	127	2,954	1,044	1.4	249	28.1
5	RFS-005	3	11	14	55	545	2,398	1,619	3.3	301	48.2
6	RFS-006	4	10	14	46	408	2,616	1,158	2.4	254	39.2
9	RFS-007	3	10	13	35	439	1,329	950	5.9	190	15.6
10	RFS-008	4	8	12	16	342	1,631	590	4.3	150	11.2

Notes:

%	Percent	me/kg	Milliequivalent per kilogram	NO_3-N	Nitrogen as nitrate
Ca	Calcium	Mg	Magnesium	PO_4-P	Phosphorus as phosphate
CEC	Cation exchange capacity	mg/kg	Milligram per kilogram		
K	Potassium	NH_4-N	Nitrogen as ammonium		

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www.ttemi.com

The results presented in the table above do not show any obvious fertility imbalance that would explain the observations of poor plant growth. All plots exhibited similar concentrations of nitrogen and phosphorus. The nitrogen concentrations are deficient relative to standards commonly applied for agronomic crops (Otto and others 1983, Tyler and Lorenz 1991). Although those standards do no necessarily apply to restoration projects, it is likely plants in all plots would show a favorable growth response to added nitrogen. Potassium levels in Plots 1 and 2 are lower than potassium levels in other plots, although the variability in potassium levels of Plot 2 masks the trend. Agronomic plants do not typically show a growth response to added potassium when potassium levels are greater than 100 to 150 mg/kg in soil. As a result, Tetra Tech does not believe additional potassium would resolve the growth differences.

The other parameters in the table above relate to physical and chemical properties of the soil. The organic matter content, the CEC, and the clay content are different for the plots that have been revegetated (Plots 1, 2, 5, and 6) compared with the plots with natural vegetation (Plots 9 and 10). The natural plots have more organic matter, lower CEC, and lower clay content. Tetra Tech could not determine if the organic matter and clay content levels are an artifact of grading activities during the restoration project. However, the lower CEC is attributable to the lower clay content.

A higher clay content could have a negative effect on plant growth. During a review of the photographs of vegetation and landscape, Tetra Tech noted several large desiccation cracks at the project site. These cracks indicate the clays have a high shrink-swell capacity, which can reduce the ability of plant roots to extend into the soil and results in a limited root zone. In addition, the plants are not able to use all of the available soil moisture during the growing season because the clays hold the water more tightly. The cracks seemed to be larger and more pronounced in Plot 1 compared with Plot 5. However, other site factors could exacerbate this situation.

Although there is little difference in the fertility status of soil in the revegetated plots (1, 2, 5, and 6) relative to the natural vegetation plots (9 and 10), some physical properties of the soils could negatively affect plant growth. As a result, Tetra Tech recommends amending the soil with a nitrogen fertilizer at the rate of 100 pounds of nitrogen per acre. Amending the soil will help establish the desired plants and provide a vigorous growth to endure the harsh conditions they may encounter during the revegetation phase.

The nitrogen source in the fertilizer should be considered a slow-release material such as sulfur-coated urea, Isobutylidene diurea, or ureaform. The fertilizer material should be applied in two applications of 50 pounds of nitrogen per acre each. One application would occur at planting, and the second application would occur approximately 12 to 16 weeks later. The low total nitrogen application, the split application, and the use of slowly available nitrogen sources for the fertilizer material will all act to help (1) reestablish the nitrogen nutrient cycle on the site, (2) minimize the availability of nitrogen for undesirable plants that might colonize the site, and (3) prevent nitrogen from leaching to adjacent surface water bodies. The decision to incorporate the fertilizer will depend on the final selection of fertilizer.

To prepare soil for seeding or reseeding, Tetra Tech recommends against the use of tillage implements such as rototillers, disk harrows, or moldboard plows in clay soils (greater than 30 percent clay). These implements can cause compaction, smearing, and surface sealing, which can reduce plant growth. Instead, Tetra Tech recommends using a chisel plow to loosen and aerate the soil. The chisel plow allows deep tillage with limited soil disruption and leaves crop residue at the top of the soil. A chain harrow should then be used to level the surface (reduce clods) and prepare the seed bed. Of course, clay soils should not be tilled when wet because of the increased likelihood of compaction and smearing.

If you have any questions or need additional information, please call me at (415) 222-8205.

Sincerely,

Leslie Lundgren

Leslie Lundgren
Project Manager

References:

Otto, H.W., Branson, R., and Tyler, K. 1983. Guide for Fertilizing Vegetables. Publication 1761. Small Farm Center, University of California Cooperative Extension, Davis, California.

Tyler, K.B. and Lorenz, O.A. 1991. Fertilizer Guide for California Vegetable Crops. Vegetable Research and Information Center, University of California Cooperative Extension, Davis, California. (webpage: http://vric.ucdavis.edu/veginfo/topics/fertilizer/fertguide.html)

Copy to:

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ATTACHMENT 1
RICHMOND FIELD STATION TIDE GAUGE INSTALLATION, LAND, AND BATHYMETRIC SURVEY, NOVEMBER 2006, SEA ENGINEERING, INC.

FINAL FIELD REPORT

University of California, Berkeley
Richmond Field Station
Tide Gauge Installation, Land and Bathymetric Survey
August, 2007

Prepared for:
Tetra Tech EM Inc.

Prepared by:
Sea Engineering, Inc.
200 Washington Street, Suite 210
Santa Cruz, CA 95060
Tel: (831) 421-0871
Fax: (831) 421-0875

Executive Summary

Sea Engineering, Inc. (SEI) installed a tide gauge (pressure transducer) and conducted a hydrographic (marine) and topographic (land) survey of Western Stege Marsh and Meeker Slough in November, 2006. The surveys were performed in support of the marsh restoration monitoring and provide comprehensive coverage of site elevations for comparison with past and future monitoring events. The tide gauge monitored water level fluctuation during the bathymetric survey and was used for post-survey correction of the bathymetric sounding data.

The tide gauge was installed on November 16, 2006 (field day 1). The topographic and hydrographic surveys occurred on November 21 and 22, 2006 (field day 2 and 3). The tide gauge installation was conducted during a low ebb tide, and the surveys were conducted during the spring tide to obtain the greatest amount of spatial coverage of elevation.

The bathymetric survey vessel included a single-beam 200 kHz sonar transducer and a differential Global Positioning System (DGPS) receiver for horizontal positioning. A laptop computer was used to synchronize the positioning and sonar data. The topographic surveys were conducted with a Leica Geosystems GPS1200 system. The system provided highly accurate real-time kinematic (RTK) positioning measurements. Individual points were surveyed with the GPS antenna mounted on a rigid staff. Together, the land and bathymetric survey data supplied elevation data encompassing a large area within the project site.

A comprehensive elevation map of the Marsh and Slough was generated by combining the bathymetric and land survey data. During the land-based study approximately 350 individual points were surveyed on land and in shallow regions. The continuous bathymetric survey resulted in a thorough mapping of the north and south Slough channels as well as some data east of the Slough channel, extending toward the remediation site.

In July and August, 2007, SEI conducted two additional surveys for quality control comparisons to ascertain the reason for a vertical discrepancy with previous surveys. SEI discovered an approximate 0.3-foot vertical offset in the upland topographic survey data causing many 2006 upland surveyed elevations to be 0.3-feet lower than the actual elevations. The reason for the offset was a GPS receiver that incorrectly processed the incoming RTK reference station elevation. SEI has corrected the 2006 elevations and omitted six data points for which vertical discrepancies still cannot be explained. The remaining data points comprise a validated and complete survey.

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Introduction

Sea Engineering, Inc. (SEI) installed a tide gauge (pressure transducer) and conducted a hydrographic (marine) and topographic (land) survey of Western Stege Marsh and Meeker Slough in November, 2006. The surveys were performed in support of the marsh restoration monitoring and provide comprehensive coverage of site elevations for comparison with past and future monitoring events. The tide gauge monitored water level fluctuation during the bathymetric survey and was used for post-survey correction of the bathymetric sounding data.

The tide gauge was installed on November 16, 2006 (field day 1). The topographic and hydrographic surveys occurred on November 21 and 22, 2006 (field day 2 and 3). The tide gauge installation was conducted during a low ebb tide, and the surveys were conducted during the spring tide to obtain the greatest amount of spatial coverage of elevation.

The bathymetric surveys were conducted at the high of the spring tide. The survey vessel included a single-beam sonar transducer and used a differential Global Positioning System (DGPS) receiver for horizontal positioning. Hypack® software was used to time-synchronize the GPS and sonar data on a laptop computer.

The land surveys were conducted at the low of the spring tide. Use of a Leica Geosystems GPS1200 system allowed highly accurate Real-Time Kinematic (RTK) vertical and horizontal positioning measurements. Individual points were surveyed with the GPS antenna mounted on a rigid staff. The land survey and bathymetric survey data, combined, provided the means to create a comprehensive elevation map of the project site.

In July and August, 2007, SEI conducted two additional surveys for quality control comparisons to ascertain the reason for a vertical discrepancy with previous surveys. SEI discovered an approximate 0.3-foot vertical offset in the 2006 upland topographic survey data causing many upland surveyed elevations to be 0.3-feet lower than the actual elevations. The reason for the offset was a GPS receiver that incorrectly processed the incoming RTK reference station elevation.

SEI has corrected the 2006 elevations; however, six data points for which vertical discrepancies cannot be explained and were omitted. The omissions do not compromise the completeness of the upland survey; the remaining 2006 elevations were validated with, and are in good agreement with the 2004 and 2007 surveys.

SEI was not scoped to analyze previous data collected during restoration monitoring events, Year 1, and therefore cannot assess whether conditions reflect the permitted restoration design. Tidal gauge information and elevation data collected during fall 2006 are capable of evaluating whether the hydrology in the WSMRP Site is sufficient to support the designed vegetation. If the design build data are available the survey data collected could indicate whether marsh plain elevation and cross sectional geometry and longitudinal slope of slough channels remain within tolerance of the as-built design in the Phase 1 and Phase 2 Remedial Action Plans (Levine Fricke

[LFR], 2002; URS Corporation [URS], 2002; URS, 2003). Fall Year 2 data obtained during 2006 monitoring events are discussed below.

Procedure

Tide Gauge Installation

Water level fluctuation was monitored with a self recording tide gauge installed beneath the East Bay Regional Park District (EBRPD) Bay Trail bridge over Meeker Slough Channel. On field day 1, a Coastal Leasing Inc. Macro Tide recording pressure sensor was attached to a down stream piling at mid channel (Figure 1). The sensor was fitted to an aluminum staff which was attached to the piling with stainless steel hose clamps. The tide gauge was positioned at the bottom of the staff at the sediment surface. A serial I/O cable was installed on the sensor and routed to an existing junction box below the bridge walkway, allowing periodic data retrieval. The elevation of the gauge was surveyed with RTK GPS positioning on day 3. The surveyed elevation of the sensor is -2.727 feet (NGVD 29).

Absolute pressure values from water level fluctuations were corrected for barometric pressure variations. Barometric pressure fluctuations were monitored with a model HOBO U-20-001-04 Water Level Logger from Onset Computer, Inc. The HOBO U-20 is a self recording instrument capable of resolving barometric pressure variations and was installed in the junction box with the tide gauge I/O cable.

Figure 1. Macro Tide installation at Meeker Slough on 11/16/2006.

Tide Data

Water level data were downloaded upon completion of the bathymetric surveys on November 22, 2006, as well as on January 23, 2007. Ten minute averaged water levels were corrected for atmospheric pressure, and referenced to the National Geodetic Vertical Datum of 1929 (NGVD-29) for the final report. Time series tide elevation values were compared to NOAA predicted tide values at Richmond Inner Harbor and found to be in good agreement (Figure 2 and Appendix B).

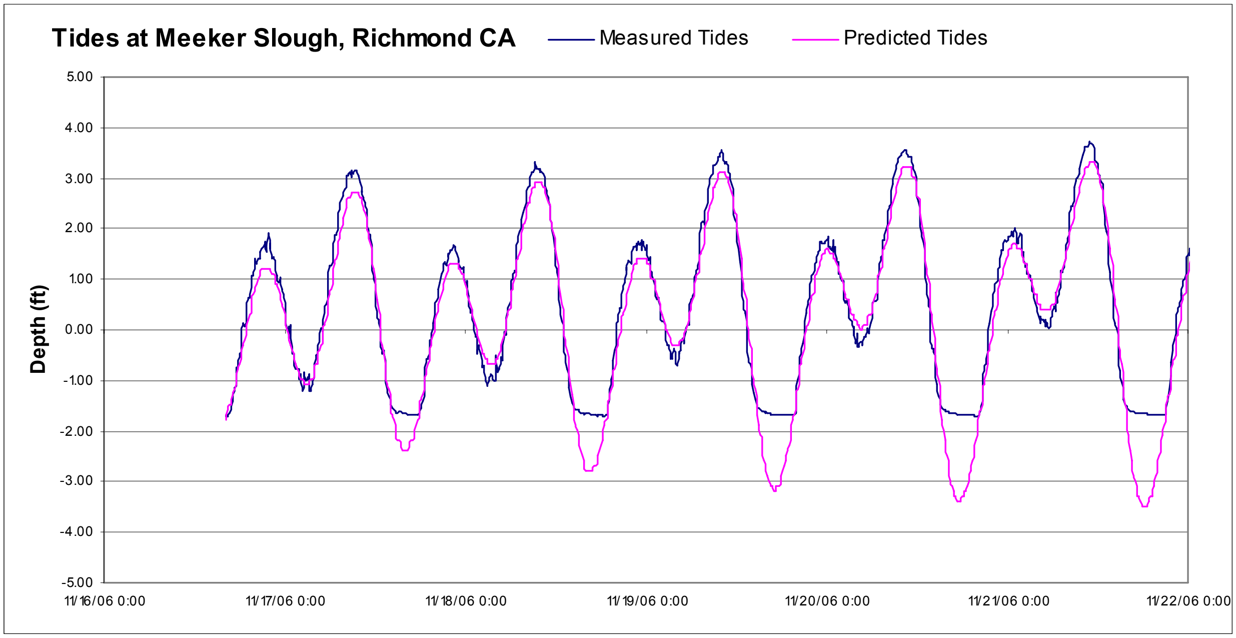


Figure 2. Measured and NOAA predicted tides at Meeker Slough from 11/16/2006 through 11/22/2006. (Depths ref: NGVD-29)

Surveys

The topographic and hydrographic survey elevation data were collected separately on different systems. The data were later reduced to the same reference ellipsoid (NAD-83), and have been converted and combined for analysis to a vertical datum of NGVD-29 for the final report. Each survey procedure is discussed separately below.

Topographic Survey

The topographic survey was conducted with a Leica Geosystems GPS1200 surveying system. The system was setup with the GPS antenna mounted on a rigid pole and connected to the GPS receiver in a backpack. GPS receiver settings and commands were controlled with a pole-mounted keyboard. A CDMA modem was connected to the GPS receiver and provided the means for communicating with a distant RTK reference tower.

The GPS1200 supplied highly accurate horizontal and vertical positioning through the use of RTK positioning. With sufficient satellite visibility (6 or more satellites), the estimated positioning errors are less than 0.1 ft. It is important to note that surveyed elevations from the same location at different times of a day (i.e. under different satellite coverage) can vary by 0.1 ft. Estimated errors in the present study were typically less than 0.2 ft, and, oftentimes, less than 0.1 ft. The RTK transmitting tower used for this project was located in Oakland, California, less than 10 miles from the project site.

On field day 2, previously surveyed locations and channel crossings were re-occupied. These were locations that had been surveyed during previous monitoring efforts of the Marsh restoration progress. The coordinates for the individual points were provided by Tetra Tech (TT) and are plotted in previous monitoring reports (Figure 4-1 from BBL, 2004; or Figure 5-1 BBL, 2005). The previously-surveyed points were aligned in approximately west-east oriented transects and are denoted by green stakes in the marsh (images of transects are presented in Appendix A). The TT-supplied coordinates were sufficient to place the surveyor in close proximity to a green stake. In the present study, when possible, the stake locations were the surveyed locations. All except one stake (A2) existed in the Marsh during the 2006 survey. At location A2, the elevation was surveyed at the coordinate location provided by TT for point A2.

In addition, eight channel crossings that were monitored in a previous surveying effort were re-occupied. The previously-surveyed crossings were approximately 20 feet in length and occupied, roughly, 5-10 individual points along the crossing. For the present study, channel crossing coordinates were not provided; however, green stakes were found to mark the channel centerlines, based on map denotations (Figure 4-1 from BBL, 2004). In the present study, the channel crossings were surveyed approximately perpendicular to the channel thalweg, coincident with the stakes. Channel crossing transects were, again, approximately 20 feet long. Along each transect, elevations were surveyed frequently, when major slope changes were evident. At least 10, up to 20, individual locations were surveyed along each channel crossing.

The land surveys were conducted at lowest tide in the marsh, when the greatest walking coverage was possible. Elevations were surveyed at individual points (as opposed to a continuous walking survey). On field day 2, approximately 140 individual and channel crossing points were re-occupied.

On field day 3, the land survey began at higher elevations, while the tide was high. Upland locations were surveyed in approximated grids. Approximately 60 elevations were surveyed in two areas of higher elevation: 1) the northeastern corner of the restoration area, and, 2) the region west of the restored portion of the marsh and north of the smaller channels (SC) that extend east from the north channel of Meeker Slough. As low tide approached, it was possible to survey additional channel crossings. Eleven more crossings were surveyed (five from north to south across the SC, 6 from west to east across the north channel of Meeker Slough). Since no previously monitored coordinates were supplied for the locations surveyed on field day 3, locations were selected by the surveyor in an attempt to obtain both detailed and spatial coverage. Approximately 200 individual elevations and channel crossing locations were surveyed on field day 3.

Three additional locations were surveyed on field day 3: two marked locations on the EBRPD Bay Trail pathway and the elevation of the pressure transducer under the EBRPD Bay Trail bridge. The marked locations were assumed to be control points used in the previous monitoring effort.

In all, approximately 350 individual locations were surveyed over the 2 field days. The land survey elevations are presented with the bathymetric data in Figure 3 and are easily identified by the larger spatial separation between points.

SEI discovered an approximate 0.3-ft vertical offset in the 2006 upland topographic survey data causing many upland surveyed elevations to be 0.3-ft lower than the 2004 surveyed elevations. An investigation into the explanation for the offset was initiated. In July, 2007, SEI acquired the coordinates of the 2004 control point survey of the region. Twelve control points and four NGS registered benchmarks were reoccupied for quality control measures. Vertical elevations of the control points were in good agreement (differences were less than 0.2 ft). The results implied that procedural and equipment variations (between the 2004 and 2006 surveys) were not the reason for a 0.3 ft offset.

The reason for the offset was a GPS receiver that incorrectly processed the incoming RTK reference station elevation. In August, 2007, when the 0.3 ft offset was discovered in the GPS reference signal, SEI reoccupied the 2006 upland survey locations. Quadrats A-F, cross-sections CS 1-8, and approximately 200 additional upland locations were resurveyed. The 2007 survey elevations agreed well with the 2004 survey elevations.

When the 0.3 ft offset was applied to the 2006 surveyed elevations, they were in good agreement with the 2007 surveyed elevations. A small number (i.e. six) of 2006 elevations which did not agree with the 2004 or 2007 surveyed elevations were omitted from this report as the reason for their discrepancies still cannot be explained. Their omission, though, does not compromise the completeness or the validity of the remaining 2006 surveyed points.

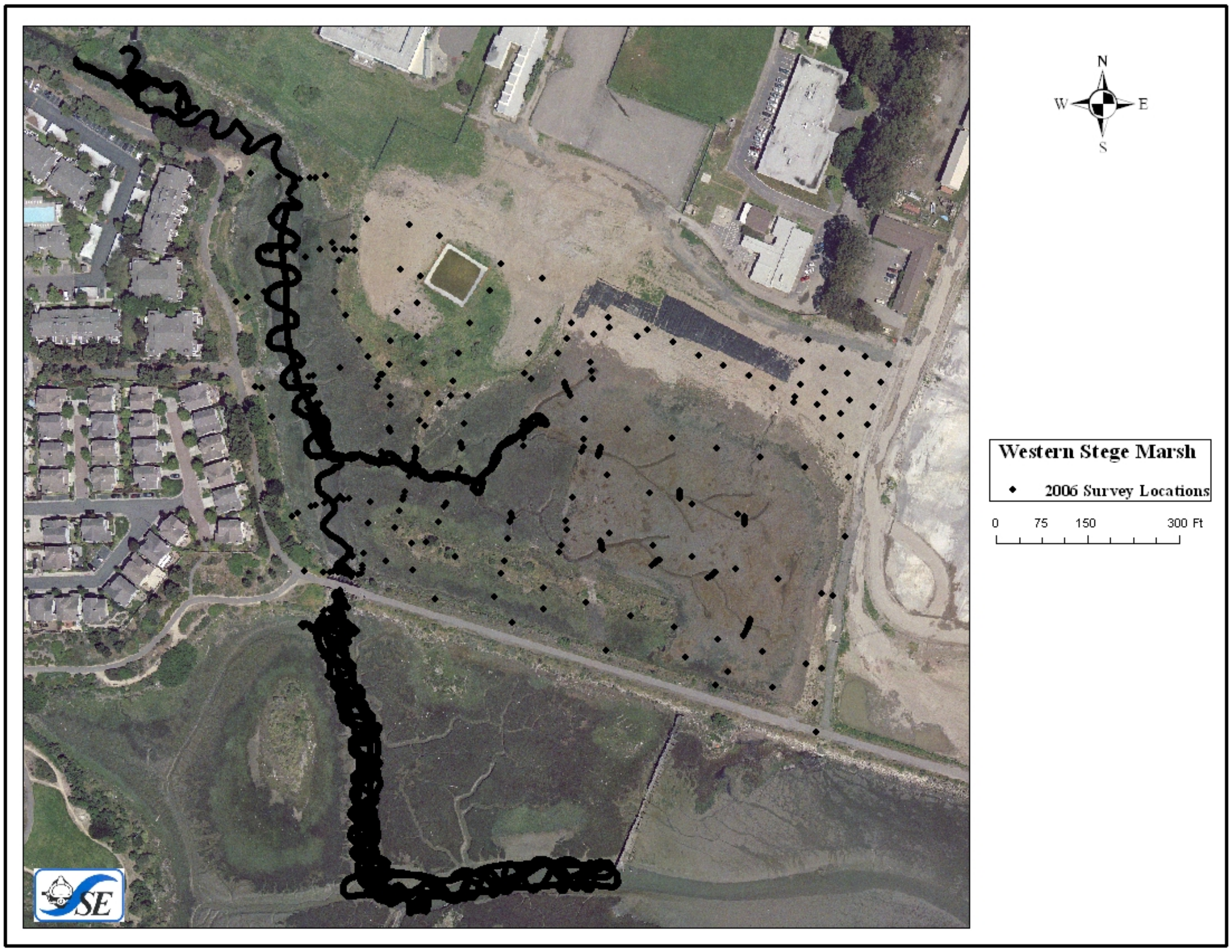


Figure 3. Topographic and bathymetric survey (individual survey locations points marked in black) overlaying an aerial photograph of the project site.

Bathymetric Survey

The bathymetric survey was completed from an inflatable, hard-bottomed Zodiac® vessel. The shallow-draft boat allowed for bathymetric data to be collected far into the shallow channels. A single-beam, 200 kHz sonar transducer was mounted on the stern of the boat and a GPS antenna was mounted vertically above the transducer. Figure 4 shows the system in operation at the project site.

The bathymetric survey was conducted over two days. On both days, the survey commenced as the high tide was approaching. On field day 2 (November 21), the surveyed region extended from the south side of the EBRP path bridge to the San Francisco Bay. On field day 3 (November 22), the surveyed region extended from the north side of the bridge as far up the main channel as possible. The survey on field day 3 also included a section of a smaller channel that extends east toward the restored Marsh. Figure 3 shows the bathymetric survey data points and the land survey data plotted together. The bathymetric data was collected continuously, and are easily identified by the clusters of points.

Figure 4. Bathymetric survey system in operation. Image taken facing northeast from the EBRP path. Survey vessel is in a smaller channel east of the main Meeker Slough channel. Photo dated 11/22/2006.

Bathymetry Results

Figure 5 shows an interpolated contour map referenced to NAD-83 and the NGVD-29 of the combined land and bathymetric surveys overlaying an aerial photograph of the project site. Channel and marsh locations are easily identified by the lower elevations. Contour lines are in 1-foot increments.

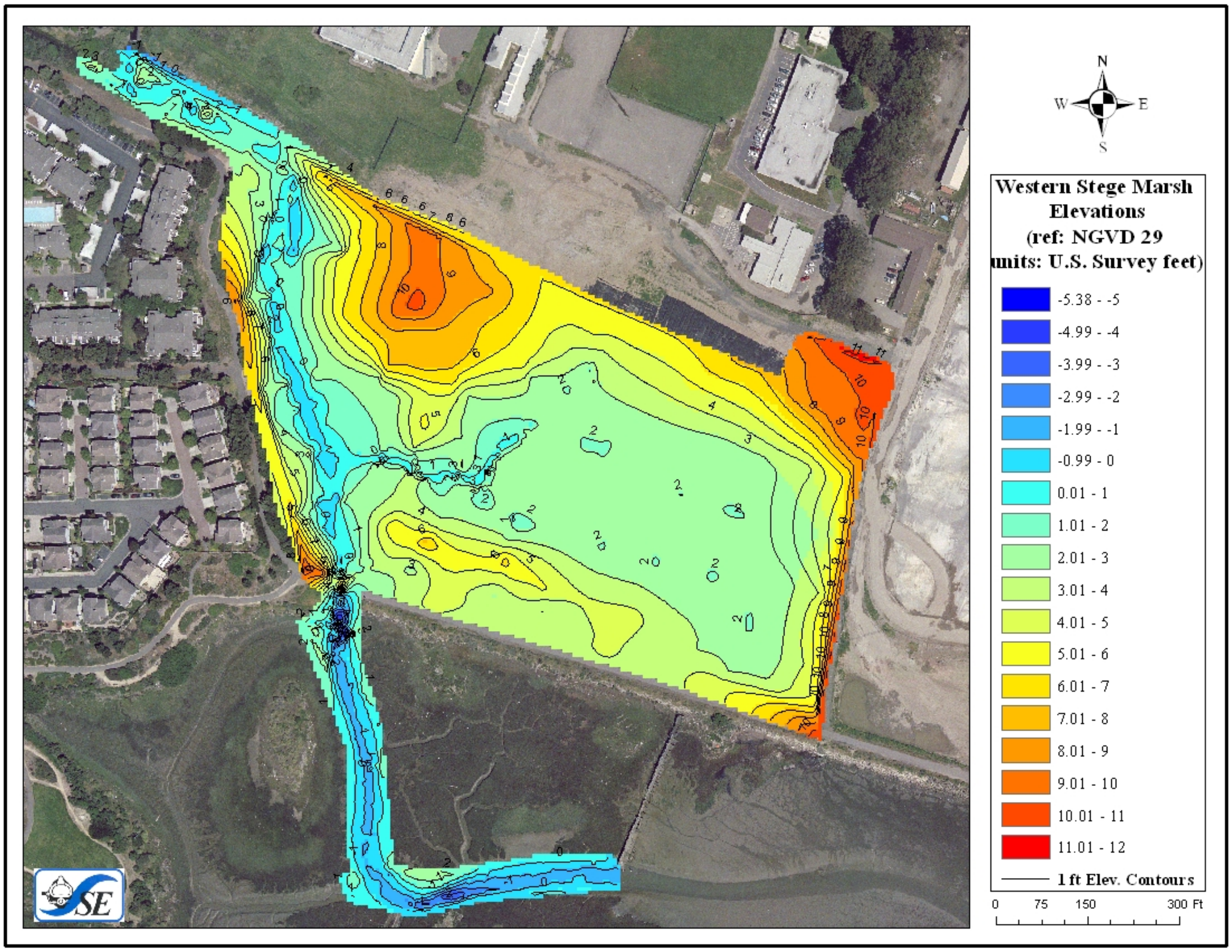


Figure 5. Preliminary map showing one-foot contour intervals of combined land and bathymetric survey data (Vertical datum is NGVD-29).

Results

Restore hydrologic complexity to the WSMRP. The hydrologic functioning of the restored slough channels has not yet been fully assessed. The function will be assessed through geomorphic change analysis and review of vegetation and marsh elevation data collected during monitoring events in Years 2 and 3.

Eight cross-sections and bathymetric transects were surveyed in the fall of 2006. Appendix C represents cross-sectional profiles of the project site during fall 2006. Year 2 cross-sectional, and bathymetric measurements serve as a comparison for previous and future monitoring efforts.

Additionally, the quadrat survey data collected during fall 2006 will allow for assessment of whether marsh plain elevations adequately conform to design specifications (see Table 1 below; compare to Table 5-2 from BBL, 2005). Adequate channel morphology and marsh plain elevation is essential to hydrodynamic function in the marsh. This allows for proper tidal flushing to import and export seed sources and detritus, and allows for adequate hydrology to support plant communities.

Table 1. Quadrat Elevations

Quadrat	Elevation (ft) Fall 2006	Quadrat	Elevation (ft) Fall 2006
A2	5.32	D7	2.69
A3	1.98	E0	6.35
B1	6.30	E1	4.10
B2	3.55	E2	2.14
B3	2.85	E3	2.75
B4	2.34	E4	3.36
B5	2.40	E5	4.35
B6	2.27	E6	4.17
B7	2.59	E7	5.20
C0	7.24	E8	4.92
C3	1.87	E9	5.59
C4	2.12	E10	5.47
C5	2.22	F1	5.29
C6	2.56	F2	3.24
D0	7.40	F3	2.98
D1	4.10	F4	3.04
D2	2.29	G1	4.88
D3	2.32	G2	4.13
D4	2.54	G3	3.67
D5	2.35	G4	4.55
D6	2.43		

Datum: NGVD 29

Tide elevations for November 16, 2006, to January 23, 2007, are shown in Appendix B. Tidal elevations were measured using a pressure transducer installed beneath the EBRPD Bay Trail bridge that spans Meeker Slough. Survey of the pressure transducer indicates that the instrument measures tidal elevations above -2.727 feet NGVD-29 with an estimated error of 0.1 feet. Data for tidal elevations, along with the slough and marsh plain survey data, indicate that the WSMRP Site is inundated regularly by tidal waters. Top of bank measurements surveyed at cross-sections along slough channels range between 1.9 and 2.7 ft NGVD-29 (Appendix C). As shown in Appendix B, maximum daily tidal elevations typically range between 3.3 to 4.1 ft NGVD 29. Minimum daily predicted Bay tidal elevations range between -3.5 to -4.3 ft NGVD. Previous lower tidal stage data collected at this station during the Year 1 monitoring effort indicate that slough channels flush completely at least once per day.

Measurement of channel width, channel depth, and the width to depth ratio are presented in Table 2 (compare to Table 5-1 from BBL, 2005). Survey data for slough cross-sections will be used to assess whether portions of the sloughs channels are slightly wider than designed, and other sections will be evaluated as to whether they are deeper than designed. Bank failures of the slough channels will be evaluated using field inspection notes.

Table 2. Channel characteristics

Cross Section Number	Year	Channel Width (ft)	Channel Depth (ft)	Width:Depth Ratio
CS-1	Fall 2006	15.04	1.02	14.82
CS-2	Fall 2006	8.93	0.93	9.61
CS-3	Fall 2006	6.58	0.73	9.02
CS-4	Fall 2006	5.79	0.42	13.95
CS-5	Fall 2006	9.02	0.89	10.14
CS-6	Fall 2006	5.29	0.40	13.22
CS-7	Fall 2006	9.09	0.51	17.78
CS-8	Fall 2006	13.93	0.27	50.72

Datum: NGVD 29

Summary

SEI installed a tide gauge on November 16, 2006, and conducted a topographic and hydrographic survey of the Richmond Field Station (i.e. Western Stege Marsh and Meeker Slough) on November 21 and 22, 2006. The tide gauge monitored water level fluctuation (via a submarine-mounted pressure transducer) during the bathymetric survey and was used for post-survey correction of the bathymetric sounding data. Pressure data (measured in pounds-force per square inch, absolute) were recorded in 10 minute intervals. Absolute pressure values from the water level data were corrected for barometric pressure variations.

The bathymetric survey vessel included a single-beam 200 kHz sonar transducer and DGPS for positioning. A laptop computer was used to combine the positioning and sonar data. The land surveys were conducted with a Leica Geosystems GPS1200 system. The system allowed highly accurate real-time kinematic (RTK) positioning measurements. Individual points were surveyed with the GPS antenna mounted on a rigid staff. Together, the land and bathymetric survey data supplied comprehensive elevation data for the project site as a whole.

A comprehensive elevation map of the Marsh and Slough was generated by combining the bathymetric and land survey data (Figure 5). During the land-based study approximately 350 individual points were surveyed on land and in shallow regions. The continuous bathymetric survey resulted in a thorough mapping of the north and south Slough channels as well as some data east of the Slough channel toward the Marsh.

References

Blasland, Bouck & Lee, Inc. (BBL). 2004. "Western Stege Marsh Restoration Project Monitoring Plan, University of California, Berkeley, Richmond Field Station, Richmond, California."

BBL. 2005. "Western Stege Marsh Restoration Project Year 1 Monitoring Report, University of California, Berkeley, Richmond Field Station, Richmond, California."

Appendix A

Figure A.1. Panoramic view of the project area. View from left to right is from the south to the west. The RFS Connector Trail is at the left of the image. Photo dated 11/21/2006.

Figure A.2. View from point A1 in transect A, facing west and looking down transect A. Stakes are not visible because stake A2 did not exist. Photo dated 11/21/2006.

Figure A.3. View from point A1' in transect A', facing west and looking down transect A'. Stake A2' is visible near the centerline of the image. Photo dated 11/21/2006.

Figure A.4. View from point B1 in transect B, facing west and looking down transect B. Stakes are visible near the centerline of the image. Photo dated 11/21/2006.

Figure A.5. View from point C0 in transect C, facing west and looking down transect C. Stake C1 is visible in the foreground, near the bottom portion of the image. Transect C stakes are visible in the background, near the centerline of the image. Photo dated 11/21/2006.

**Figure A.6. View from point D0 in transect D, facing west and looking down transect D.
Stake D1 is visible in the foreground, near the bottom portion of the image.
Transect D stakes are visible in the background, near the centerline of the image. Photo dated 11/21/2006.**

Figure A.7. View from point E0 in transect E, facing west and looking down transect E. Stake E1 is visible in the foreground, near the bottom portion of the image. Transect DE stakes are visible in the background, near the centerline of the image. Channel crossing stakes are visible toward the right side of the image. Photo dated 11/21/2006.

Figure A.8. View from point G1 in transect G, facing west and looking down transect G. Transect G stakes are not visible along the slough bank. Stake F4 is visible at the right of the image. Photo dated 11/21/2006.

Figure A.9. View of previously-surveyed point A3 (green stake) toward the west. Meeker Slough main channel is shown in the image background. Photo dated 11/21/2006.

Figure A.10. Example of a stake marking the centerline of a channel.
Channel crossing surveys were conducted perpendicular to the channel thalweg and in line with the stake. Photo dated 11/21/2006.

Figure A.11. Existing survey control point located on the EBRPD Bay Trail at the southeastern corner of the project site. The coordinates of the control point were confirmed with 2004 surveyed coordinates. This location was used as a control point in the November, 2006, and August, 2007 surveys. Photo dated 11/21/2006.

Figure A.12. Existing mark located on the EBRPD Bay Trail. The location was surveyed during the November, 2006 and August, 2007 surveys. No documentation of a previous survey of this mark is available for comparison. The marker is located at the southwestern corner of the study area. Photo dated 11/21/2006.

Figure A.13. View facing north from the EBRP bridge showing the northern section of the Meeker Slough main channel. The image was taken at high tide. Photo dated 11/21/2006.

Figure A.14. View facing south from the EBRP path bridge showing the southern section of the Meeker Slough main channel. The image was taken at high tide. San Francisco Bay is in the background. Photo dated 11/21/2006.

Appendix B

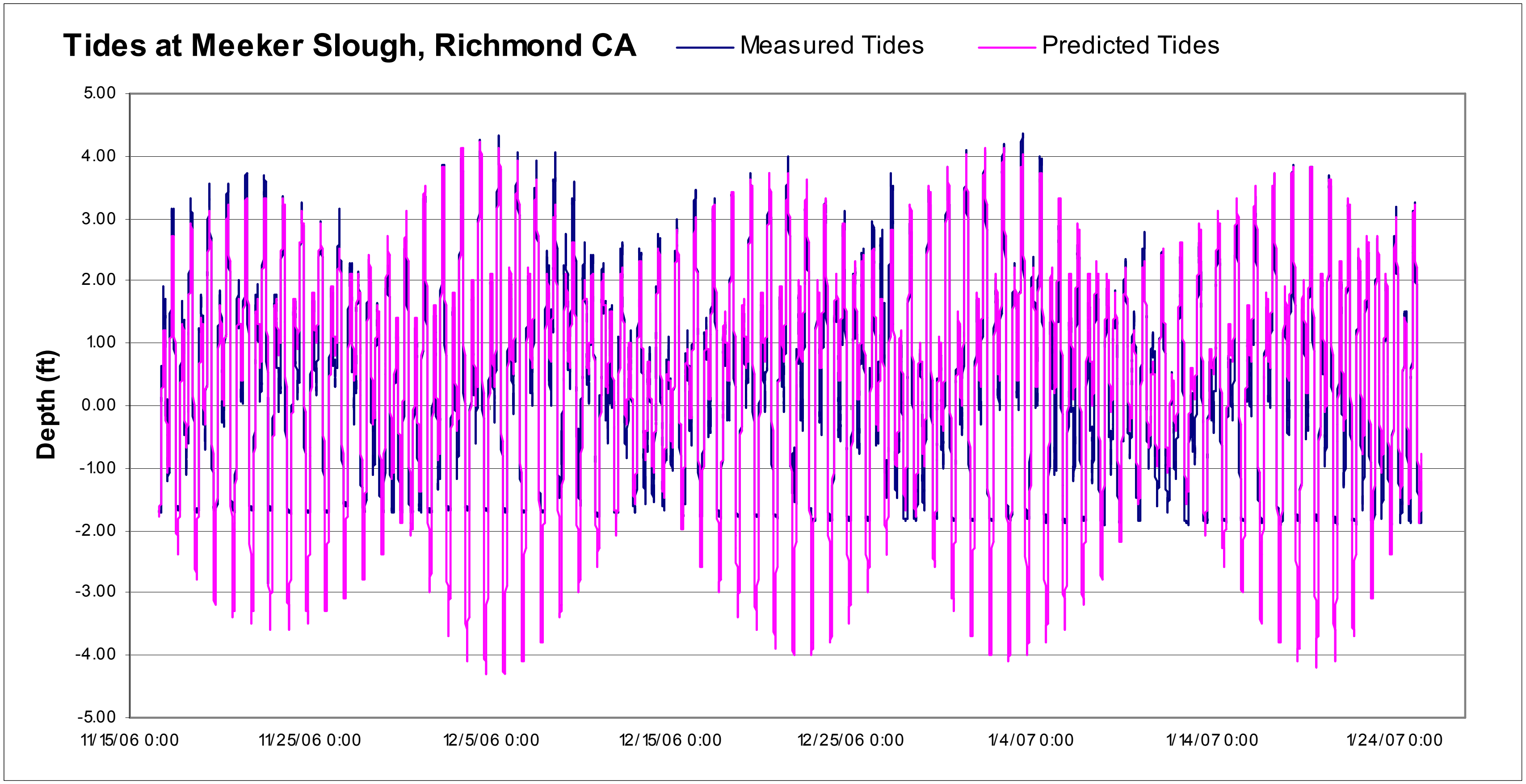


Figure B.1. Graphic representation of tide data (predicted and measured) from 11/2006 to 01/2007. Depths ref: NGVD-29.

APPENDIX C

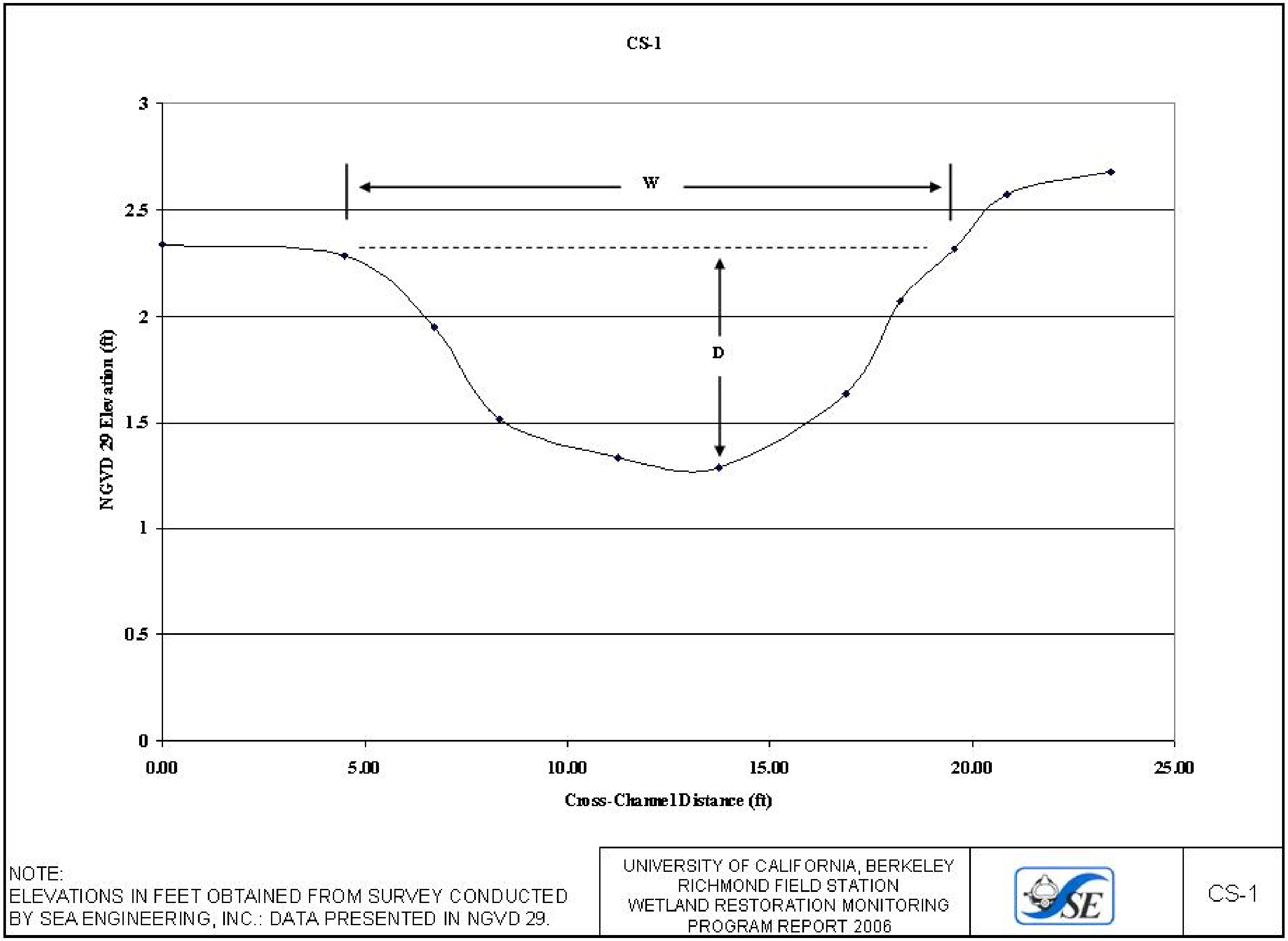
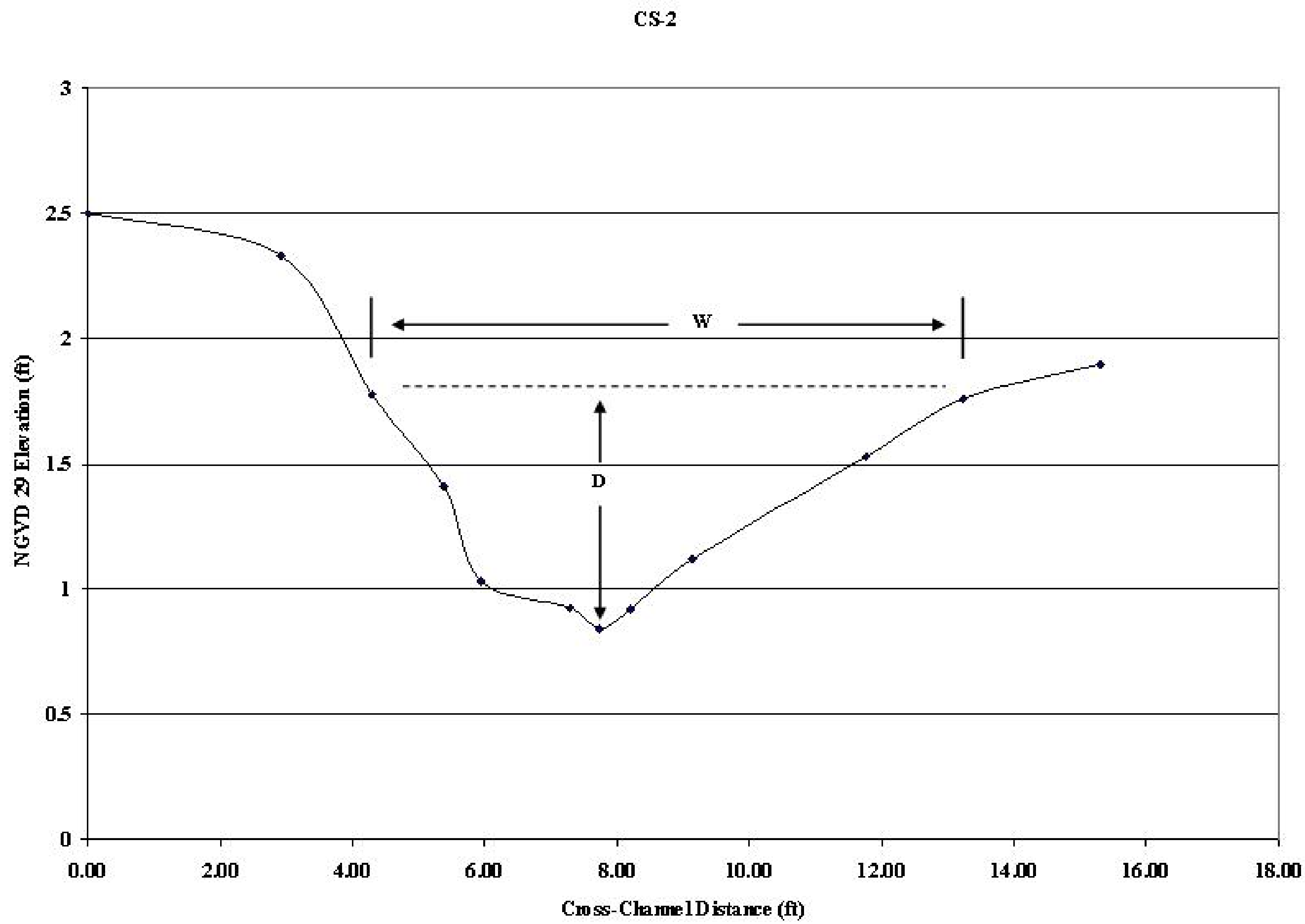


Figure C.1 Graphic representation of CS-1 data. Refer to Table 2 for actual data.



NOTE:
ELEVATIONS IN FEET OBTAINED FROM SURVEY CONDUCTED BY SEA ENGINEERING, INC.: DATA PRESENTED IN NGVD 29.

UNIVERSITY OF CALIFORNIA, BERKELEY RICHMOND FIELD STATION WETLAND RESTORATION MONITORING PROGRAM REPORT 2006	SE	CS-2

Figure C.2. Graphic representation of CS -2 data. Refer to Table 2 for actual data.

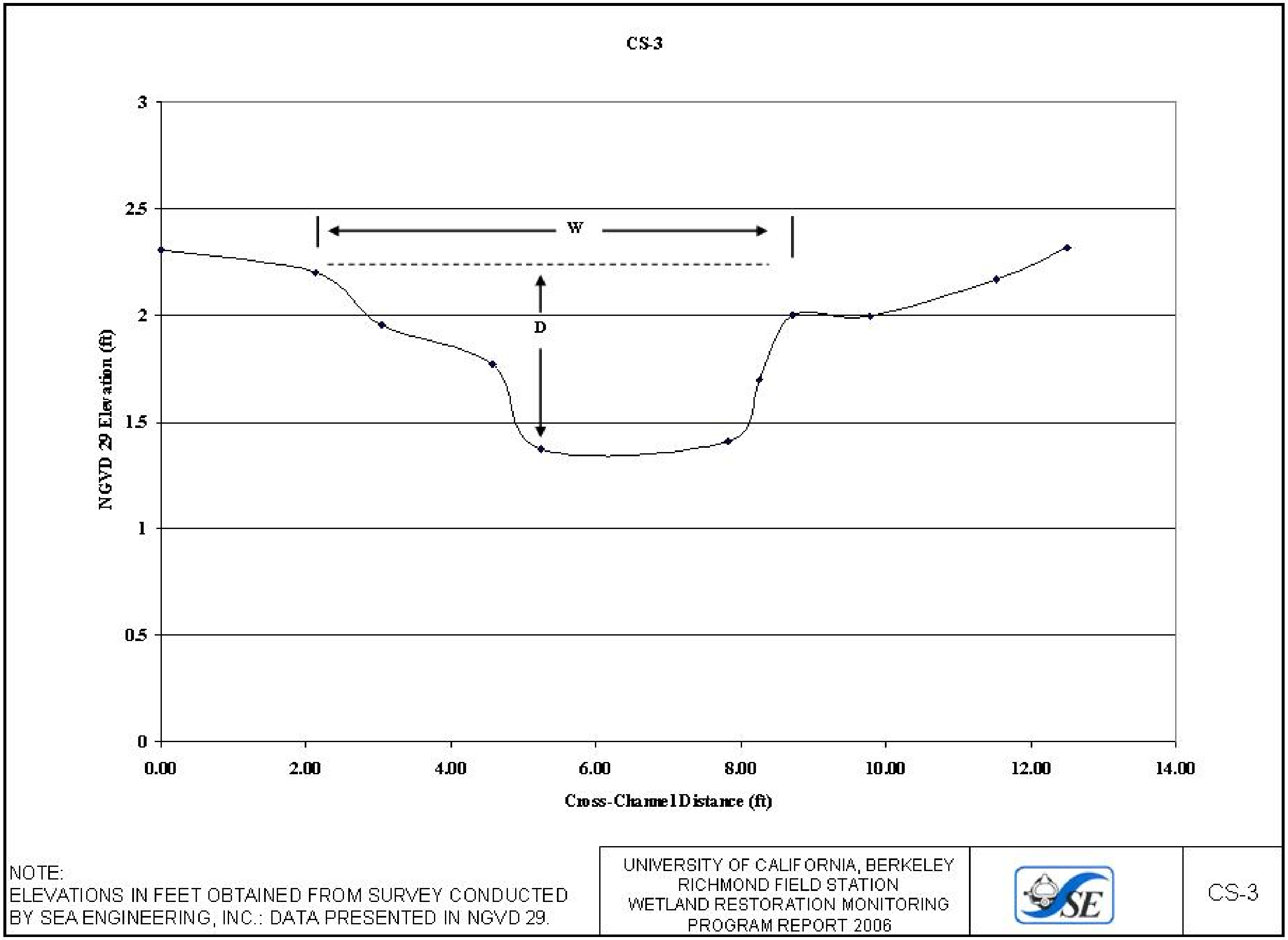
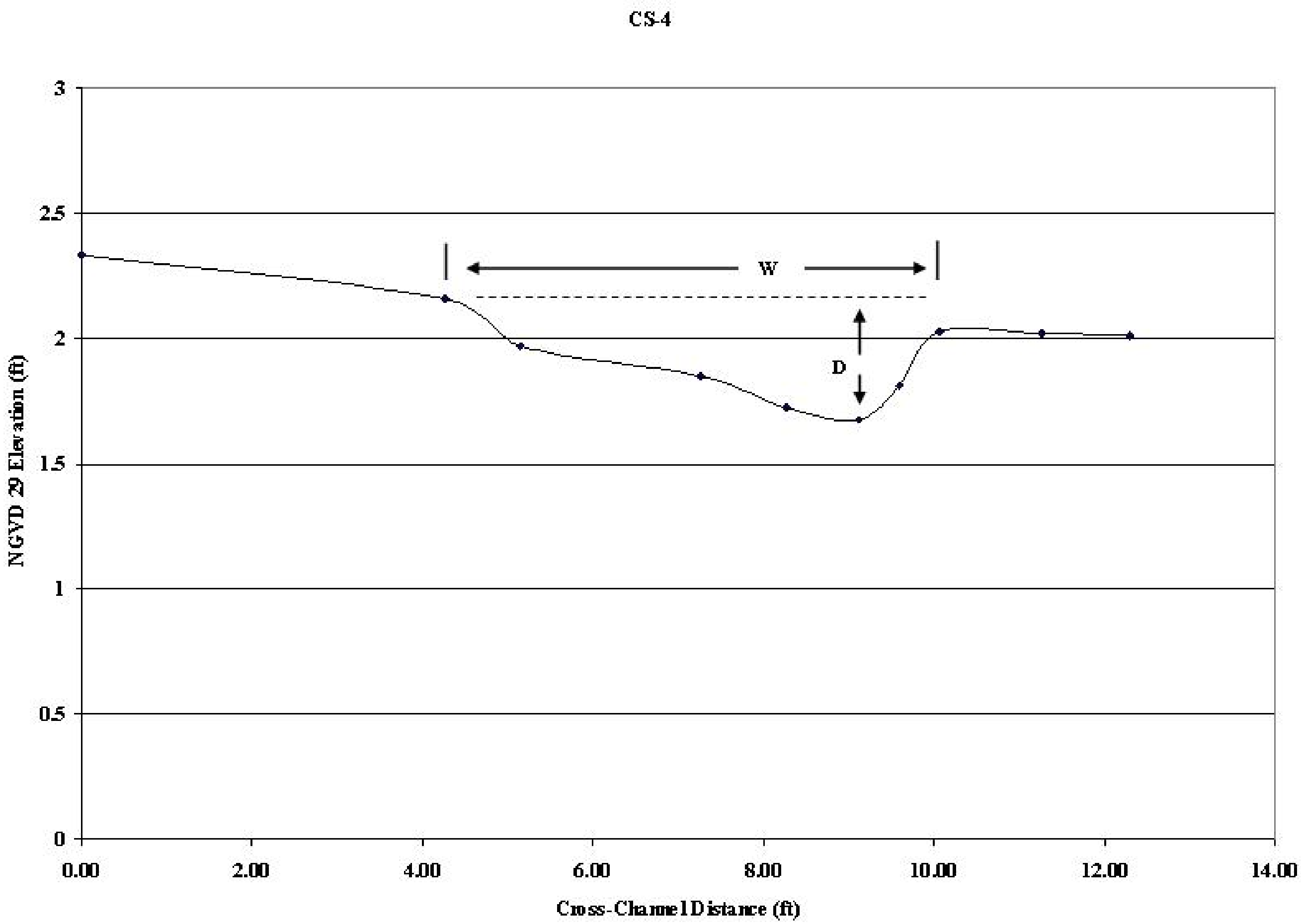


Figure C.3. Graphic representation of CS-3 data. Refer to Table 2 for actual data.



NOTE:
ELEVATIONS IN FEET OBTAINED FROM SURVEY CONDUCTED BY SEA ENGINEERING, INC.: DATA PRESENTED IN NGVD 29.

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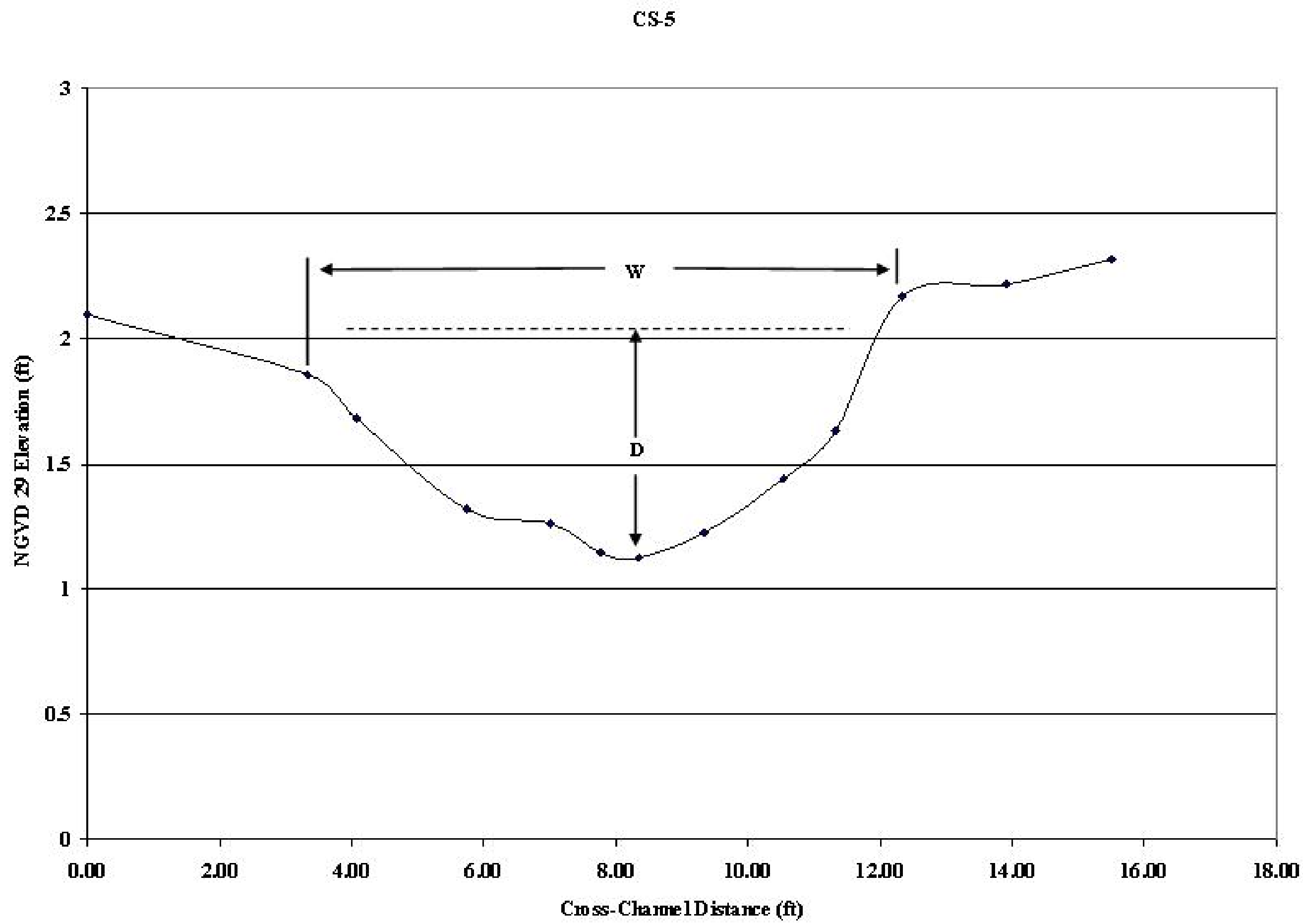
RICHMOND FIELD STATION
WETLAND RESTORATION MONITORING
PROGRAM REPORT 2006

CS-4

Figure C.4. Graphic representation of CS-4 data. Refer to Table 2 for actual data.



NOTE:
ELEVATIONS IN FEET OBTAINED FROM SURVEY CONDUCTED BY SEA ENGINEERING, INC.: DATA PRESENTED IN NGVD 29.

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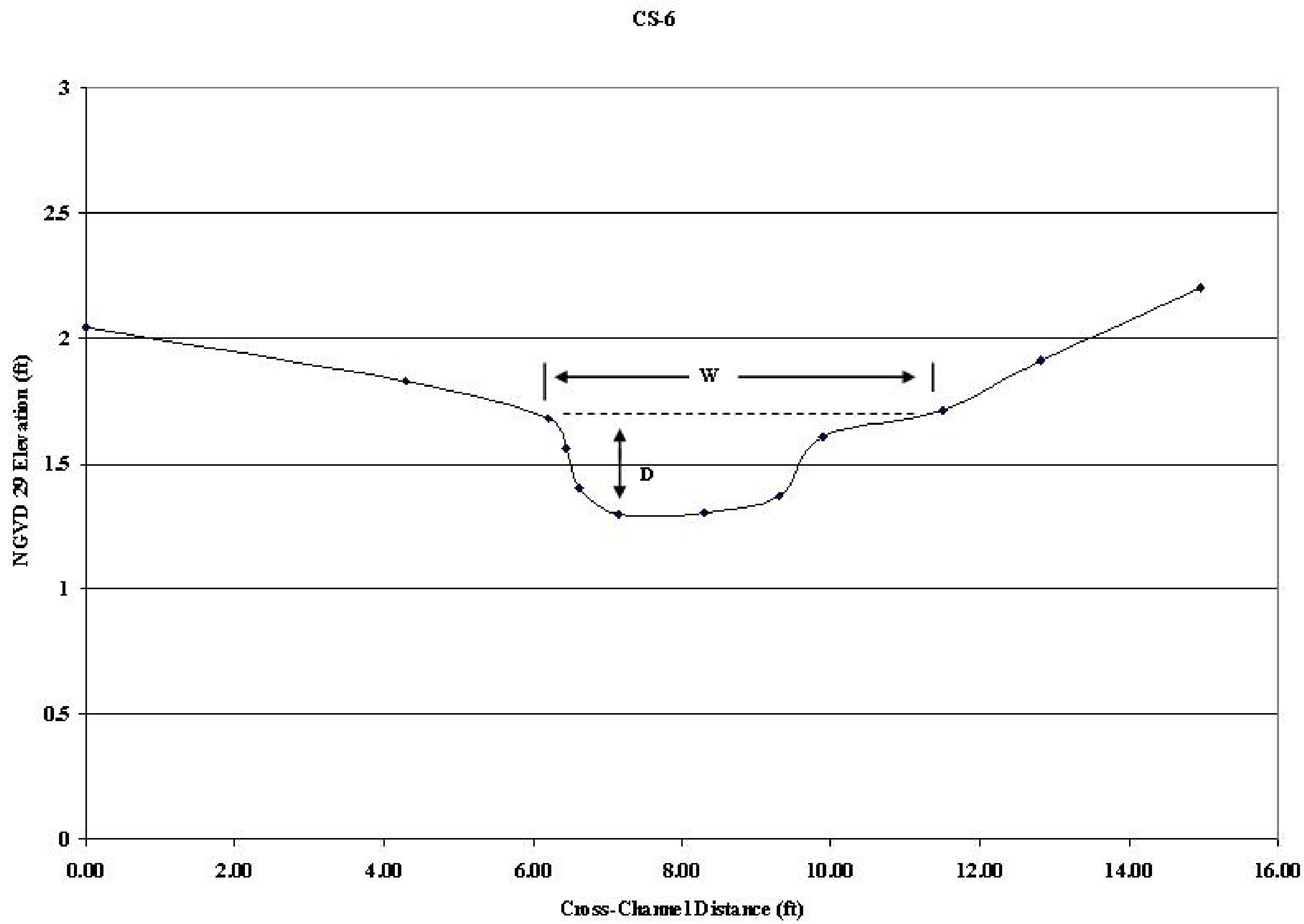
RICHMOND FIELD STATION
WETLAND RESTORATION MONITORING
PROGRAM REPORT 2006

CS-5

Figure C.5. Graphic representation of CS-5 data. Refer to Table 2 for actual data.



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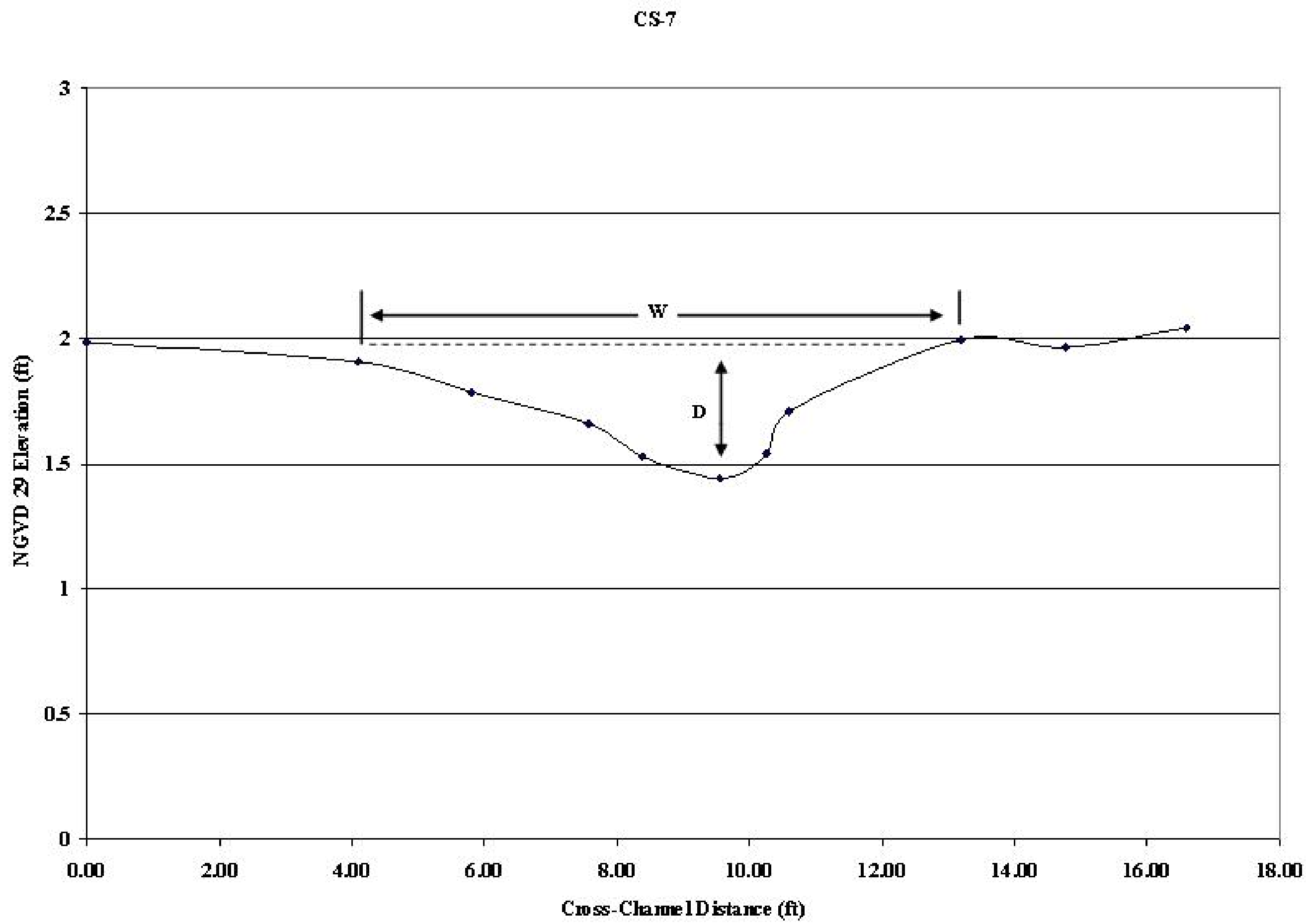
ELEVATIONS IN FEET OBTAINED FROM SURVEY CONDUCTED BY SEA ENGINEERING, INC.: DATA PRESENTED IN NGVD 29.

UNIVERSITY OF CALIFORNIA, BERKELEY RICHMOND FIELD STATION WETLAND RESTORATION MONITORING PROGRAM REPORT 2006	SE	CS-6

Figure C.6. Graphic representation of CS-6 data. Refer to Table 2 for actual data.

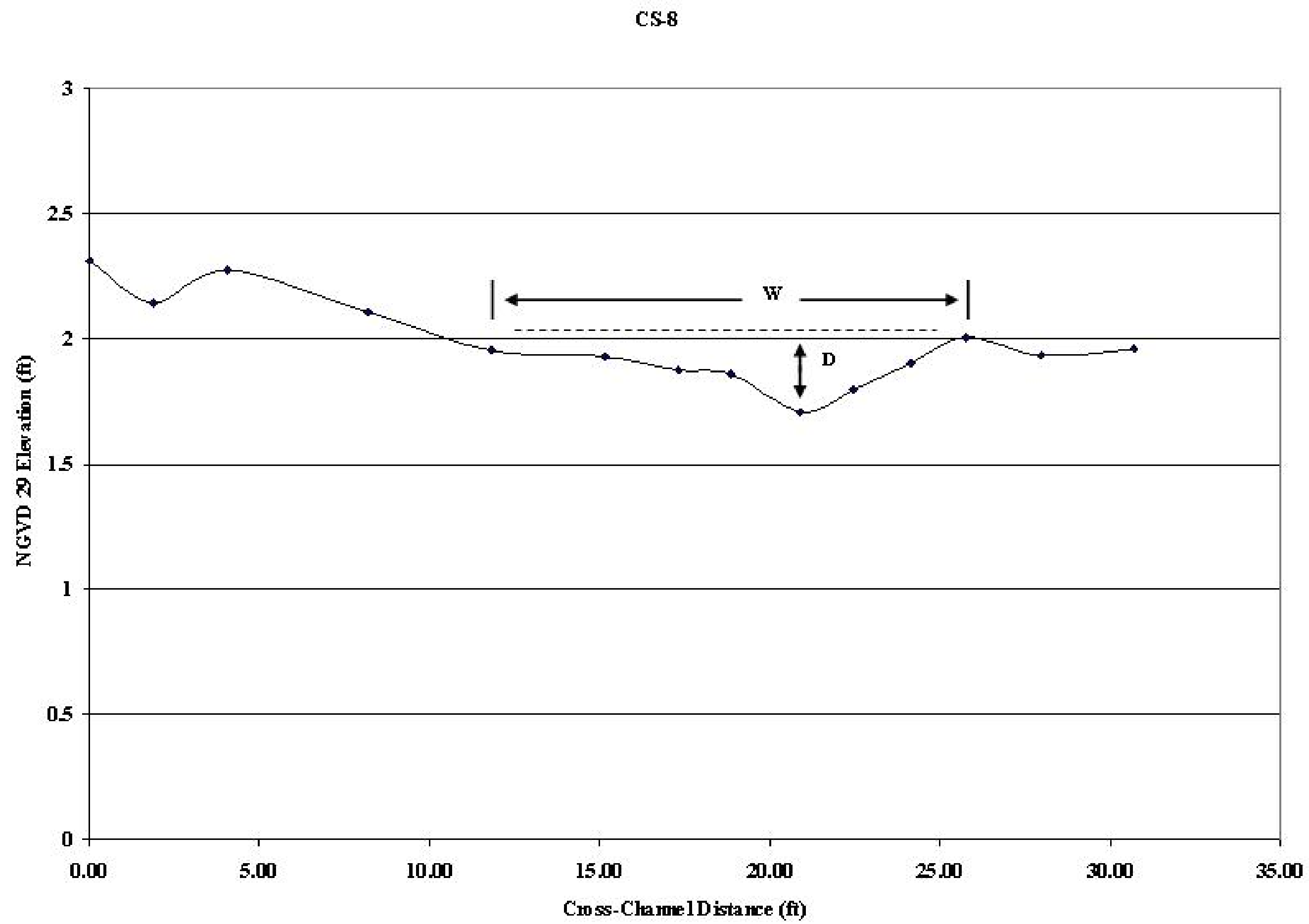


NOTE:
ELEVATIONS IN FEET OBTAINED FROM SURVEY CONDUCTED BY SEA ENGINEERING, INC.: DATA PRESENTED IN NGVD 29.

UNIVERSITY OF CALIFORNIA, BERKELEY
RICHMOND FIELD STATION
WETLAND RESTORATION MONITORING
PROGRAM REPORT 2006

CS-7

Figure C.7. Graphic representation of CS-7 data. Refer to Table 2 for actual data.



NOTE:
ELEVATIONS IN FEET OBTAINED FROM SURVEY CONDUCTED BY SEA ENGINEERING, INC.: DATA PRESENTED IN NGVD 29.

UNIVERSITY OF CALIFORNIA, BERKELEY
RICHMOND FIELD STATION
WETLAND RESTORATION MONITORING
PROGRAM REPORT 2006

CS-8

Figure C.8. Graphic representation of CS-8 data. Refer to Table 2 for actual data.

ATTACHMENT 2
RESULTS OF CALIFORNIA CLAPPER RAIL SURVEY, AVOCET RESEARCH ASSOCIATES

NON-PROTOCOL SURVEYS FOR

CALIFORNIA CLAPPER RAIL (*RALLUS LONGIROSTRIS OBSOLETUS*)

AT THE WESTERN STEGE MARSH RICHMOND FIELD STATION

Prepared for:

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Prepared by:

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Point Reyes Station, CA 94956-0839

12 January 2007

Introduction

Avocet Research Associates (ARA) assessed the status of the California Clapper Rail *(Rallus longirostris obsoletus)* in the lower reach of Meeker Slough known as “Western Stege Marsh,” Contra Costa County, California prior to the onset of the 2007 nesting season. The marsh property, owned by the University of California, is the subject of the Richmond Field Station Western Stege Marsh Restoration Project. The slough proper is the property of the City of Richmond. As part of the permitting phase of the remediation and restoration project, it has been deemed necessary to evaluate potential effects to the California Clapper Rail, a federally endangered species associated with tidal marsh habitat in San Francisco Bay.

The scope of this project was described in a Statement of Work (SOW), issued by Tetra Tech EM Inc. (Tetra Tech) to ARA (Appendix A).

Methods

Four listening stations (census points) were established on surveys conducted by ARA during the 2005 protocol survey period (ARA 2005). The locations of these stations are indicated in Figure 1. In December 2006 and January 2007 we used the same listening stations to conduct passive rail surveys.

On the first survey (01 December 2006) in this study, each of these four stations was occupied by Jules Evens and Cindi Rose for 20 minutes. On the subsequent two censuses, the observer (Jules Evens or Emilie Strauss) occupied station #3 for the entire census period (1.5 hrs). Each of these census efforts was “passive,” that is, the observer simply stood at the station and relied on spontaneous vocalizations to detect rails. An “active survey,” in which rail vocalizations are broadcast with a tape recorder to elicit responses from the birds, is permitted only during the prescribed protocol period, January 15-April 15 (USFWS 2000). Although these censuses were conducted outside the protocol period, all other methods conformed to the USFWS protocols (Appendix B).

The dates and times of the three surveys are provided in Table 1, below.

Table 1. Clapper rail surveys at Western Stege Marsh, 2006-07.

Date	Time (hrs)	Survey type	Tide	Observers*
12/01/06	1500-1711	passive	mod	JE, CR
12/12/06	1605-1735	passive	mod	JE
01/05/07	0545-0715	passive	low	ES

* Observers: Jules Evens (JE), Cindi Rose (CR), Emilie Strauss (ES)

Findings

A total of 14 clapper rail detections were noted during 4.5 hours of observation (Table 2). We estimate 6 individual rails (representing 3 pair) resident in Western Stege Marsh. Rails were detected in the restoration project site and in the marsh outboard of the Bay Trail (Figure 1). All detections were made on the first two surveys; no rails were detected on January 5.

Table 2. Detections of clapper rails at Western Stege Marsh

Date	Station	Time	Dist* (m)	Direction	# rails	type
12/01/06	#4	1539	55	140°	1	visual
12/01/06	#4	1544	>100	180°	1	clatter
12/01/06	#4	1544	65	80°	1	clatter
12/01/06	#3	1550	30	20°	1	visual
12/01/06	#2	1636	120	200°	1-2	clatter
12/01/06	#2	1637	30	30°	1	clatter
12/01/06	#1	1651	100	165°	1	clatter
12/01/06	#1	1658	80	150°	1-2	clatter
12/01/06	#1	1701	80	145	2	clatter
12/01/06	#1	1704	65	150°	1	clatter
12/01/06	#1	1707	100-250	0-180°	3-6	clatter
12/12/06	#3	1639	100	120°	1	kek
12/12/06	#3	1646	55	10°	1	kek
12/12/06	#3	1700	85	195	1	kek

* distance (in meters) from observer.

In protocol-level surveys in 2005, we detected rails only in the outboard marsh (ARA 2005); apparently the birds re-inhabited the inboard marsh in the subsequent time period.

Other species of concern

Several species detected in the course of this study are recognized as "Bird Species of Special Concern" (CDFG & PRBO 2001) or "Birds of Conservation Concern" (USFWS 2002):

(1) "Saltmarsh" Common Yellowthroat (*Geothylypis trichas sinuosa*) was detected on each census; detections were in the taller *Scirpus/Typha* vegetation on the west bank of Meeker Slough and from the ruderal vegetation on the inner slope of the levee near Station #3.

(2) "Alameda" Song Sparrow (*Melospiza melodia pusillula*): two song sparrows thought to be this subspecies were detected on the December 01 census. This obligate saltmarsh race is apparently resident in emergent tidal marsh habitat (ARA 2005), but in relatively low densities.

(3) Merlin (*Falco columbarius*): one male of undetermined race was seen strafing the mudflats near the mouth of Meeker Slough on December 12.

(4) Peregrine Falcon (*Falco peregrinus*): one male was seen on two occasions roosting on the wires adjacent to the study site to the east.

Conclusions

Based on 14 detections on two surveys, we estimate six California Clapper Rails present in the tidal marsh and slough habitat in Western Stege Marsh in December 2006 and early January 2007. We infer that 3 pair of rails were present. The distribution of rail detections indicated in Figure 1 suggests that the birds are utilizing all emergent tidal marsh habitat associated with the study site. The birds are associated with the major and tributary slough systems that wind through the vegetated marsh. Given the tendency of rails to be sedentary during the winter and spring, we expect the birds detected in these censuses will remain through the nesting season. The distribution of rail detections shown in Figure 1 indicates that the birds are widely distributed throughout Western Stege Marsh. Additional protocol-level surveys would probably reveal that birds are using even more of the available tidal marsh habitat.

Caveat

The presence of feral and/or domestic cats and their subsidization by feeding stations along the west bank of Meeker Slough reduces the viability of the habitat for any marsh birds that are using the site. We are concerned that feral cats and other meso-predators may compromised nesting success of rails at this site. We observed one cat in the marsh on December 12. On January 5 a woman was seen distributing cat food near the residential development adjacent to the NW corner of the site. Ms. Strauss talked to the woman, telling her that the cats were predators to the endangered rails. The woman responded that raccoons, not cats, were rail predators. Apparently, she did not recognize the possibility that raccoons are also subsidized by feeding.

References

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Collins, J., J.G. Evens, and B. Grewell. 1994. A synoptic survey of the distribution and abundance of the California clapper rail, *Rallus longirostris obsoletus*, in the northern reaches of the San Francisco Estuary during the 1992 and 1993 breeding seasons. Technical Report to California Department of Fish and Game.

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Permits (Jules Evens, Avocet Research Associates)

Federal Fish and Wildlife Permit TE786728-2

CDFG-SCP #801037-02

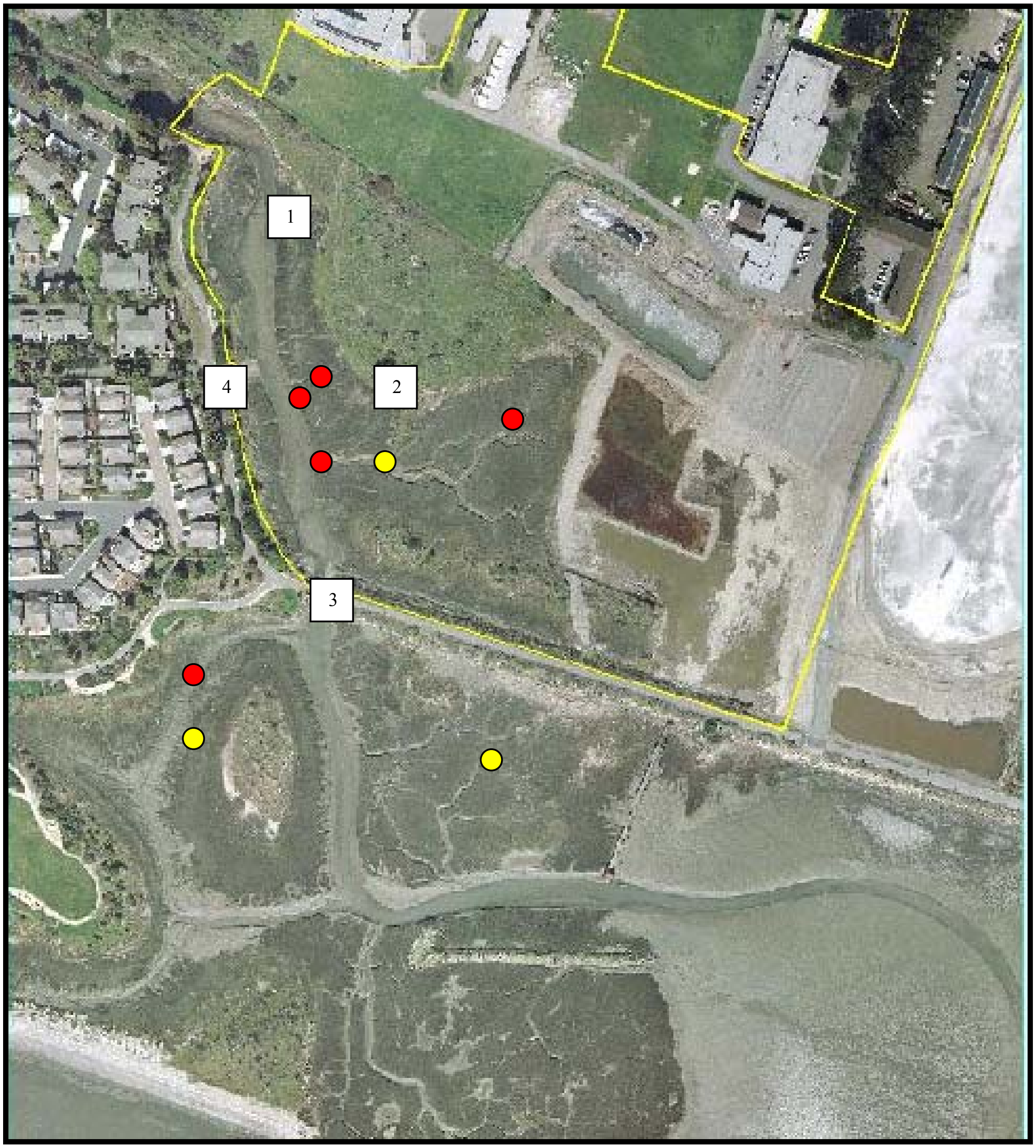

Figure 1. Western Stege Marsh.

White squares represents orange the locations of the listening stations.
Red dots indicate estimated locations of clapper rails 12/03/06 (1500-1710 hrs).
Yellow dots indicate locations of clapper rails 12/12/06 (1600-1720 hrs)

Appendix A.

STATEMENT OF WORK: CLAPPER RAIL SURVEYS AT THE WESTERN STEGE MARSH RICHMOND FIELD STATION

The Statement of Work (SOW) is issued by Tetra Tech EM Inc. (Tetra Tech) to Avocet Research Associates to provide assistance with monitoring the Western Stege Marsh Restoration Project (WSMRP) for areas restored following Phases 1 and 2 of the Richmond Field Station (RFS) remediation in Richmond, California. Tasks shall include up to six non-invasive, non-protocol level CCR surveys to assess CCR presence at the WSMRP site and summary report of findings. First, passive surveys will be performed by establishing listening stations to monitor CCR vocal activity. If CCRs are not detected after three passive surveys, three active surveys may be conducted using recordings of CCR vocalizations to elicit a response. It is understood that these non-protocol surveys cannot confirm the absence of CCRs at the WSMRP site because protocol-level surveys to confirm absence must be conducted during the CCR breeding season (January through April). Deliverables shall include a summary report (up to 8 pages including 1 figure) describing the methods, results, and conclusions. The figure shall show the locations of listening station and clapper rail detections.

Appendix B.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

DRAFT SURVEY PROTOCOL

California Clapper Rail (*Rallus longistrostris obsoletus*)

January 21, 2000

Below is a description of the standard methodology used to detect presence or absence of clapper rail breeding activity. Surveys should be conducted once a week for a minimum of four weeks. The optimal time to conduct call count surveys is mid-January through March. Once a survey protocol has been developed, it should be sent to the Service for final approval prior to implementation. After the results are compiled and submitted to us, we will make a final decision on the possibility of doing any work as described.

Methodology

Surveys should be conducted from January through mid-April, which encompasses the optimum time period of mid-January through March when the frequency of calls is typically highest. Surveys should not be conducted when tides greater than 4.5 feet NGVD as predicted at the Golden Gate occur at the marsh during the survey period or during full moon periods.

Listening stations should be established no more than 150 meters apart along transects in or adjacent to marsh areas. Stations should be established so that the entire marsh is covered by 75 to 100-meter radius circular plots. Listening stations should be placed near marsh features, such as sloughs, but not along slough edges to minimize disturbance to rails. Surveys should be conducted from levee crowns or boardwalks to minimize disturbances to marsh areas where possible. A detailed map depicting sloughs and other marsh landmarks or features should be developed.

Surveys should be conducted at sunset or sunrise. Surveys conducted at sunrise should begin 45 minutes before sunrise and continuing until 1 1/4 hours after sunrise. Surveys conducted at sunset should begin 1 1/4 hours before sunset and continue until 45 minutes after sunset.

An observer should be assigned to each listening station for the duration of each survey. Observers should locate key marsh landmarks or features on a map in relation to teach listening station location.

All rail vocalizations should be recorded, noting the call type, location, and time on a detailed map of the marsh. The call types are coded as C = clapper, D = duet, K = kek, B=kek-burr with a V representing a visual sighting. Other unusual calls also should be noted. The calls of one bird or pair should be marked by circling the calls together. If a rail is moving during the survey, several locations may be noted for the same bird(s). Attention should be focused on accurately mapping the birds that are nearby, especially between observers or towards the edge of the marsh if the station is positioned at the marsh's edge.

At the end of each survey, observers should compare maps to determine overlap in detections and to create a master map showing all pairs and individuals located during the survey. Another master map should be developed once all surveys are completed, showing the dates and locations of detections.

Weather information, including wind velocities and direction, should be recorded. Call count surveys should not be conducted when wind velocities exceed 10 mph or wind gusts exceed 12 mph, or during moderate to heavy rains. Information on disturbances (e.g., dogs or cats in marsh and aircraft flyovers) occurring during the surveys should be recorded.

If a survey of a marsh is conducted over more than one night, observers should be assigned to stations adjacent to their previous night's station if at all possible.

New observers should be trained by an experienced observer. Trainees should familiarize themselves with various calls and with estimating distances to calls before training in the field. In-field training should include ways to minimize disturbance to rails and marsh vegetation. Trainees should be stationed with an experienced observer during a call count for a minimum of 2 nights to assess the trainee's ability to accurately detect and map calls in the field. The Palo Alto Baylands is a marsh with many rails typically calling in the evening and easy access via a boardwalk, thus providing an excellent training opportunity for new observers and their instructors. A recording of clapper rail calls is available for training purposes at the U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, 2800 Cottage Way, Suite W2605, Sacramento, California 95825.

ATTACHMENT 3
SUMMARY OF FERAL ANIMAL TRAPPING ACTIVITIES,
GARY BEEMAN, AVIAN PEST CONTROL

Attachment 3: Matrix Summary of Gary Beeman Trapping Results

Results of mammal trapping at Richmond Field Station in Richmond, CA 2005/2006

	Feral Cat	Fox	Mouse	Opossom	Racoon	Rat	Skunk	Turkey Vulture	Vole
1/19/2005	1						2		
1/20/2005	1						1		
1/21/2005					1				
1/22/2005		1							
1/23/2005									
1/24/2005	1						3		
1/25/2005	1								
1/26/2005							1		
1/27/2005								1	
1/28/2005				1					
Total	**4**	**1**	**0**	**1**	**1**	**0**	**7**	**1**	**0**
10/18/2005					2		1		
10/19/2005					2		2		
10/20/2005					1				
10/21/2005					1		1		
10/22/2005				1			1		
10/23/2005							1		
10/24/2005	1						1		
10/25/2005							1		
10/26/2005							1		
10/27/2005							1		
10/28/2005				1	1				
Total	**1**	**0**	**0**	**2**	**7**	**0**	**10**	**0**	**0**
5/18/2006	2				2	1	1		
5/19/2006							2		1
5/20/2006					1		1		
5/21/2006						1	2		
5/22/2006					1				
5/23/2006							1		1
5/24/2006				1		1			
5/25/2006			2	1					
Total	**2**	**0**	**2**	**2**	**4**	**3**	**7**	**0**	**2**
10/27/2006	1						2		
10/28/2006					1		2		
10/29/2006				1			4		
10/30/2006					3		2		
10/31/2006					2		2		
11/1/2006	1				1		1		
11/2/2006							2		
11/3/2006				1	1				
Total	**2**	**0**	**0**	**2**	**8**	**0**	**15**	**0**	**0**
2005-2006 Total	**9**	**1**	**2**	**7**	**20**	**3**	**39**	**1**	**2**

University of California, Berkeley
Richmond Field Station Remediation and Restoration Project
Feral Animal Management Program
January 31, 2005 Trapping Log Update

Feral Animal Trapping Results:

Date	Result
1/18/05	Set live box traps- 4 large, 3 medium
1/19/05	2 skunks (one male, one female), 1 cat ("Fuzz Fuzz")
1/20/05	1 skunk (male), 1 cat (tortoise)
1/21/05	1 raccoon (male)
1/22/05	1 gray fox
1/23/05	none
1/24/05	3 skunks (1 female, 2 males), 1 cat (black)
1/25/05	1 cat (black and white)
1/26/05	1 skunk (female)
1/27/05	1 turkey vulture
1/28/05	1 opossum (male)

<u>January 2005</u>

10 day totals:	7 skunks
	1 raccoon
	4 cats
	1 gray fox
	1 turkey vulture
	1 opossum

Date	Result
9/1/04	1 male, 1 female skunk
9/2/04	1 male, 1 female skunk, 1 adult male cat
9/8/04	1 male, 1 female skunk
9/9/04	1 male, 1 female raccoon, 1 house mouse (mus)
9/10/04	1 female skunk, 3 mice (mus)
9/13/04	2 female skunks, 5 mice (mus)
9/14/04	2 adult female skunks, 1 mouse (mus)
9/15/04	1 juvenile male skunk and 1 juvenile female raccoon
9/16/04	1 juvenile female skunk and 1 adult male opossum
9/17/04	1 adult male and 1 adult female raccoon, 1 mouse (mus)

<u>September 2004</u>

10 day totals:	13 skunks
	5 raccoons
	1 cat
	1 opossum
	11 mice

AVIAN PEST CONTROL

GARY A. BEEMAN

WILDLIFE RESCUE & CONTROL BIOLOGIST

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U.C. BERKELEY FIELD STATION TRAPPING RESULTS BETWEEN OCT. 17, - 28, 2005.

Oct. 17, 2005
Set 4 large raccoon traps & 3 med. cat traps

Oct. 18, 2005
(!) female adult skunk
(1) female adult raccoon
(1) male subadult raccoon

Oct. 19, 2005
(2) subadult female raccoons
(2) male adult skunks

Oct. 20, 2005
(1) subadult female raccoon

Oct. 21, 2005
(1) Adult female skunk
(1) Adult female raccoon

Oct. 22, 2005
(1) Adult female oppossom
(1) Adult male skunk

Oct. 23, 2005
(1) Adult female skunk

Oct. 24, 2005
(1) Adult female skunk
(1) Adult male grey tabby feral cat

Oct. 25, 2005
(1) Adult male skunk

Oct. 26, 2005
(1) Adult female skunk

Oct. 27, 2005
(1) Adult male skunk

Oct. 28, 2005
Picked up all seven traps
(1) Adult ♀ Raccoon
(1) Adult ♀ Opposom

10 – Stripped Skunks
1 – Feral cat
7 – Raccoon
2 – Opposoms

AVIAN PEST CONTROL

GARY A. BEEMAN

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Animal Trapping at the U.C. Field Station in Richmond May 17 – 25, 2006

May 17, 2006
Set seven large mammal traps & ten "Sherman" rodent traps

May 18, 2006
2 – adult male raccoons
1 – adult black & white feral cat
1 – adult male tabby male feral cat
1 – Juvenile male skunk
1 – adult Norway Rat

May 19, 2006
1 – adult female skunk
1 – juvenile male skunk
1 – adult Calif. Meadow Vole
2 – traps had animals (raccoons and/or cats released by unknown persons

May 20, 2006
1 – adult male skunk
1 – sub-adult female raccoon

May 21, 2006
2 – juvenile male skunks
1 – sub-adult Norway Rat

May 22, 2006
1 adult female raccoon

May 23, 2006
1 – adult female skunk
1 – adult California Meadow Vole

May 24, 2006
1 – adult male opossum
1– sub-adult Norway Rat

May 25, 2006 (Removed all trape)

1 - ♂ adult opossom
2 - House mice (adults)

Total Animals trapped May 17 – 25, 2006

Raccoons –

Skunks –

Feral cats –

Opossoms –

Norway Rats –

California Meadow Voles –

Gary A. Beeman

GARY A. Beeman

AVIAN PEST CONTROL
GARY A. BEEMAN
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November 3, 2006

University of California
% Karl E. Hans
317 University Hall #1150
Berkeley, CA. 94720-1150
(510) 643-9574

Results of mammal trapping at U.C. Field Station in Richmond Oct. 26 - Nov. 3, 2006

Oct. 26, 2006
Set seven large mammal traps

Oct. 27, 2006
2 - adult female skunks
1 - adult black & white feral cat

Oct. 28, 2006
1 - adult male raccoon
1 - adult female skunk
1 - adult male skunk

Oct. 29, 2006
2 - adult male skunks
2 - adult female skunks
1 - adult male opossum

Oct. 30, 2006
3 - adult male raccoons
1 - adult male skunk
1 - adult female skunk

Oct. 31, 2006
2 - adult male raccoons
1 - adult male skunk
1 - adult female skunk

Nov. 1, 2006
1 – sub-adult female skunk
1 – sub-adult male raccoon
1 – adult adult feral black cat

Nov. 2, 2006
1– adult male skunk
1 – adult female skunk

Nov. 3, 2006
1 – ♀ opossum adult
1 – ♀ raccoon subadult

Total mammals trapped Oct. 26 – Nov. 3, 2006

Skunks – 14

Raccoons – 7

Feral cats – 2

Opossums – 2

ATTACHMENT 4
SUMMARY OF INVASIVE/EXOTIC PLANT MANAGEMENT ACTIVITIES, THE WATERSHED PROJECT AND THE SAN FRANCISCO ESTUARY INVASIVE SPARTINA PROJECT

Overview of March and Grassland Restoration Stewardship Activities Performed by the Watershed Project from October 2005 – December 2005

The Watershed Project has completed the following tasks under our contractual agreement with U.C. Berkeley:

MARSH RESTORATION PROJECT:

1. **Remove and control colonizing targeted invasive non-native plant species within defined area that could result in recontamination of restored ecotone and marsh habitats.**

The Watershed Project staff and interns continued to monitor and control invasive non-native species within the defined restoration area. Staff, contractors, volunteers and interns worked 85 hours in the marsh area removing non-native plant species of highest concern. Plants targeted for removal include *Picris echioides, Melilotus indica, Salsola tragus, Polypogon monspeliensis, Sonchus asper, Polygonum sp., Foeniculum vulgare, Carpobrotus edulis*, and *Bassia hyssopifolia* (full list of species in Table 1, attached). The volume of weeds removed totals 11, 15-gallon bags, or 22 cubic ft. One particular area of concern is the southeast corner of the marsh site (plot 6) that continues to have high amounts of weedy annual species despite focused weeding efforts in that area. We are considering different treatment options for this area including herbicide and scraping off the top 6 inches and infilling with clean soil.

In accordance with the strategy that we established with UC Berkeley and the Spartina project, we removed 43 *Spartina sp.* seedlings from the tidal marsh area. At the seedling stage, the non-native, hybrid Spartina canot be differentiated from the native Spartina without genetic testing. Furthermore, both native and non-native / hybrid Spartina populations exist on the outboard side of the marsh that can act as seed and pollination sources. Therefore, a policy has been established to plant divisions of native Spartina in a recognizable pattern throughout the marsh, and to remove any Spartina seedlings that begin to establish.

The non-native population of Spartina on the outbard side of the marsh, south-east of the pier was targeted with herbicide September 19, 2005. Spray work was coordinated by the Spartina Project, and completed by Westcoast Wildlands, Inc. who were contracted by LFR Levine Fricke under an access permit from EBRPD. Though this work was completed in September, before this report's timeframe, it was not included in the last quarterly report.

We also worked with RFS maintenance staff to remove an Acacia tree from the island area in the marsh. This was completed in November.

2. **Revegetate marsh, ecotone and upland habitats consistent with approved habitat reference sites and standard restoration planting practices.**

In October, we completed our end-of-the-year, nursery inventory to prepare for the upcoming planting season. We met or exceeded our goals for the grassland, upland and tidal marsh areas. We also spent 84 hours seed-collecting late flowering species.

Whether or not to salt water tidal marsh plants in the nursery to prevent osmotic shock at planting has been a controversial question. Marsh plants that are watered with very low salt concentrations (we begin treatment with salt concentration levels that are well below the level found in marsh waters) typically have noticeable loss of vigor; a percentage of these plants are expected to die. However, some restoration practitioners believe that the salt water treatment also increases plant survivorship once planted into a marsh, and that the net effect of the treatment is positive. This year, we treated only half the tidal marsh plants in order to compare the outcomes of plants watered with and without salt water. These plants were salt watered at a concentration of 3 ppm, a level well below that of the Bay (the salinity level of San Francisco Bay in the winter is approximately 25 ppm). Our plan was to increase the level of salinity every two weeks by 5 ppm until the salinity level reached 25 ppm. However, the treated plants showed evident signs of distress and mortality at 3 ppm, so we decided not to increase the salinity concentration any further.

3. **Prepare marsh upland area and install (and mulch where appropriate) plant material.**

To prepare for the marsh planting, we marked established a series of "bath-tub rings" around the marsh to mark elevation. We used Richmond Inner Harbor tidal information and marked the three elevational rings with wooden stakes, painting each set of stakes with a different color: 6.8' (white), 5.9' (yellow), and 5.7' (blue). With these elevational lines in place we looked for already-established marsh plant populations so that we could match our new marsh plantings to these established plant populations.

We began planting the upland area of the marsh. Most planting activities are scheduled to occur January through March, 2006.

4. **Coordinate revegetation of native Spartina through the collection and planting of 1200 divisions.**

Planning for the Spartina divisions first included determining an appropriate collection site that is known to have only native species of Spartina and that does not have Clapper Rail, and then contacting the property owner, and providing proof of insurance coverage to the owner. For our collection purposes, we chose the marsh adjacent to Goodman's Lumber, located at 775 Redwood Hwy, Mill Valley, CA. In December, we also completed a trial-run to collect and plant Spartina divisions. The purpose of this trip was to make sure we know how to most effectively organize our hired contractors, what tools we will need, and determine whether we had to plan for other contingencies.

RICHMOND FIELD STATION GRASSLAND MITIGATION PROJECT:

1. **Control and targeted removal of invasive, non-native plants species within the defined grassland mitigation:**

Watershed project staff and volunteers spent more than 51 hours removing invasive plants from the grassland restoration area, totaling 65 15-gallon bags, or 130 cubic feet. See Table 1 for a full list of species removed from the grassland. Herbicide test plots, 1B and 4B, remain mostly free of Harding grass resprouts.

2. **Revegetate grassland habitat consistent with approved habitat reference sites and standard restoration planting practices.**

As stated above, we met or exceeded our initially-established propagation goals for the grassland, upland and tidal marsh areas. We also spent 84 hours seed collecting for late flowering species. In addition to plants we grew in the nursery, we also plan to collect and plant field divisions of several species of sedges and rushes.

3. **Prepare mitigation site and install (and mulch where appropriate) plant material.**

Grassland restoration plots are now ready for planting in January 2006. Two large areas have been treated with herbicide, and mulch as been applied as needed to bare spots and to lessen the chances of Harding grass resprouting.

COMMUNITY INVOLVEMENT AND OUTREACH (THESE ACCOMPLISHMENTS WERE NOT PART OF THE CONTRACT, BUT SUPPORTED THE CONTRACTED WORK)

The Watershed Project hosted ten community work parties in the months of October through December, including both school and adult volunteer programs. In addition, 19 high school and college interns participated in our internship program. High school students were recruited from the City of Richmond's summer youth employment program, Contra Costa County's Youth Development Services, and Oakland High School's Environmental Academy. University students came from UC Berkeley.

Total volunteer activities for all of 2005 are as follows:

20 school groups hosted
21 community work programs hosted
356 students attended volunteer and educational programs
346 community members attended volunteer work programs (includes repeating volunteers)
2282 total volunteer hours spent on restoration activities
19 high school, college, and post-college interns (in fiscal year 2005)
638 intern hours (in fiscal year 2005)

In this time period we also contacted several UC Berkeley professors and staff to advise them of this project's status, and encourage their input and collaboration. These faculty members include William Lidicker, James Bartolome, Jerry Powell, Ellen Simms, as well as Barbara Ertter of the Jepson Herbarium. We also presented a talk about the restoration project at the Jepson Herbarium's regular series of Botany talks.

Table 1. Invasive plants removed from marsh and grassland areas October – December 2005.

Species	Common Name	Site	Notes
Acacia sp.	Acacia	M	
Anagallis arvensis	Scarlet pimpernel	M/G	
Bassia hyssopifolia	Bassia	M	
Beta vulgaris	Beet	M	
Brassica raphanistrum	Mustard	M	
Conyza sp.	Horseweed	M	
Cortaderia selloana	Pampas grass	M	
Digitaria ischaemum	Crab grass	M	
Epilobium sp.	Fireweed	M/G	
Foeniculum vulgare	Fennel	M	
Gnaphalium sp.	Cudweed	M	
Lolium multiflorum	Itialian ryegrass	M	
Lotus sp.	Lotus	M	
Lythrum tribracteatum	Loosestrife	M/G	
Malva sp.	Mallow	M	
Medicago	Burclover		
Melilotus sp.	Sweet clover	M	
Oxalis sp.	Buttercup	M	
Phalaris aquatica	Harding grass	M/G	
Picris echioides	Bristly ox-tongue	M/G	
Plantago lanceolata	Plantain	M/G	
Polygonum sp.	Knotweed	M	
Salsola tragus	Russian thistle	M	
Spartina alterniflora		M	Three from center of marsh. Twenty from Plot 3. Twenty from Plot 6.
Solanum sp.	Nightshade	M	
Sonchus sp.	Sow thistle	G	

Overview of March and Grassland Restoration Stewardship Activities Performed by the Watershed Project from January 2006 – March 2006

The Watershed Project has completed the following tasks under our contractual agreement with U.C. Berkeley:

MARSH RESTORATION PROJECT:

1. **Remove and control colonizing targeted invasive non-native plant species within defined area that could result in recontamination of restored ecotone and marsh habitats.**

Though our work these months focused primarily on outplanting, some invasive species removal continued in the marsh area. Species targeted include fennel, geranium and bristly ox- tongue (see Table 1 for a full list of species), and efforts totaled more than 25.5 hours. The volume of weeds removed totals 3, 15-gallon bags, or 6 cubic ft.

The southeast corner of the marsh area, known as plot 6, was treated with AquaMaster (glyphosphate) herbicide on February 24. Problem weeds targeted for removal include bristly ox-tongue, brass buttons, and rabbit's foot grass as well as other non-native annual grasses. The work was subcontracted to Shelterbelt Builders; Nancy Brownfield, EBRPD IPM Coordinator, provided the pest control recommendation and was on site during the application.

No Spartina seedlings were removed.

2. **Revegetate marsh, ecotone and upland habitats consistent with approved habitat reference sites and standard restoration planting practices.**

The nursery met or exceeded goals for the tidal marsh area as well as the upland areas. We produced 2474 plants for the tidal marsh areas, 3575 Spartina divisions, and 2022 plants for the marsh upland (see Table 2). As discussed in the previous quarterly report (October – December 2005), half the plant species grown for the tidal marsh zone were watered with low concentration of salt water in order to harden them off for planting. Marsh plants were outplanted in pairs, those watered with salt water next to those untreated, to determine whether salt watering treatment increases outplant survivorship.

3. **Prepare marsh upland area and install (and mulch where appropriate) plant material.**

Watershed Project staff, interns and volunteers spent over 334.5 hours on outplanting activities in the marsh and marsh upland areas. Upland plant species were planted throughout this time period.

Plantings in the tidal marsh areas were done in two distinct batches, the first half in early January, and the second in mid March. The purpose of planting in two phases was to ensure that we were planting each species at the appropriate elevation. In November 2005, we marked off "bathtub rings" around the marsh at different high tides. We then looked for naturally established populations of native marsh plants, and based on where these species occurred with relation to our elevational lines, we determined where we would aim to plant each tidal marsh species for our January planting:

	target elevation
Grindelia stricta	just above 6.8' tide line
Jaumea carnosa	5.9 -6.8'
Frankenia salina	5.9 -6.8'
Triglochin maritima	5.9 -6.8'
Limonium californicum	just below 6.8'
Heliotrope curassavicum	just above the 5.9'
Distichlis spicata	5.7- 5.9

Our general assumption is that plant species are restricted at lower elevations by high levels of inundation and salinity, and at upper elevations by competition. While *Distichlis s.* establishes well at higher elevations, it was intentionally planted at this low elevation to reduce the chance that it might out-compete other natives. For the most part, all plantings seemed to establish fairly well, and March plantings were targeted at the same elevations. More than 75% of the *Triglochin maritima* were eaten almost to the ground- possibly by the Canada Geese- and it is unclear whether they will survive. The Heliotrope this time of year is dormant- all above ground plant has died back- so it too difficult to determine whether it is establishing.

In addition to the tidal marsh plants outplanted, there was also some natural recruitment. Much of the marsh area has begun to fill in with *Salicornia virginica*. *Spergularia marina* has also established naturally, and is now ubiquitous throughout most the marsh. Also, one single plant of *Frankenia salina* has established naturally.

The large population of *Grindelia stricta*, established both by outplanting nursery stock and through direct seeding, continues to look robust. The population of *Limonium californicum*, which also seemed to establish very successfully from direct seeding last year (it was also outplanted from nursery stock), this year looks weak. More than half of these small plants look severely stressed or dead.

4. **Coordinate revegetation of native Spartina through the collection and planting of 1200 divisions.**

Our goal was to collect and plant 1200 divisions, but through the support of our intern program, we managed to plant approximately 3575 divisions. Spartina was planted in one ring around the marsh, and also in bands surrounding each of the major sloughs in the marsh. This Spartina material was collected from the marsh adjacent to Goodman's Lumber in Mill Valley. Many of the Spartina plugs also had *Jaumea carnosa* growing in them.

Spartina divisions collected and planted two years ago, in the winter of 2003-2004, are more visible than they were a year ago, but are smaller than expected.

RICHMOND FIELD STATION GRASSLAND MITIGATION PROJECT:

1. **Control and targeted removal of invasive, non-native plants species within the defined grassland mitigation:**

The Watershed Project staff and volunteers spent more than 30 hours removing invasive plants in the grassland area, totaling 7 15-gallon bags of weeds (see Table 1 for complete list of species). Plots 1B and 4B, sprayed with herbicide last May 2005, still appear to be free from Harding grass seedlings and resprouts.

2. **Revegetate grassland habitat consistent with approved habitat reference sites and standard restoration planting practices.**

While this time of year generally involves little propagation, staff and volunteers spent over 100 hours growing plants and 18 hours seed collecting.

3. **Prepare mitigation site and install (and mulch where appropriate) plant material.**

Watershed Project staff and volunteers spent over 221 hours outplanting in the grassland. Areas set aside for restoration in the grassland were categorized as dry or wet. Wet areas become completely inundated with water during much the rainy season and are categorized by a variety of rushes, sedges, and coyote thistle. Dry areas generally do not hold standing water, and are characterized by CA oat grass, blue-eyed grass, and purple needle grass among others. Therefore, we established two separate planting palettes for each area. Dry areas were planted first, in January or February, and wet areas were planted in March, even into April, when these areas drain of standing water.

One year ago, plantings occurred in restoration plots where Harding grass was treated with hand removal, while this season, most plantings occurred in restoration plots where Harding grass was treated with Harding grass. It is too soon to tell whether one method is more successful than the other, but we will monitor these plots over the coming year to compare these two methods.

COMMUNITY INVOLVEMENT (THESE ACCOMPLISHMENTS WERE NOT PART OF THE CONTRACT, BUT SUPPORTED THE CONTRACTED WORK)

We hosted 19 community work parties, including groups from Tehiyah Day School, Harbor Way, Circle K, California Native Plant Society, and One Brick.
Total volunteer activities for the period from January through March of 2006 are as follows:

101 students
94 community members (includes repeating volunteers)
424.5 total volunteer hours spent on restoration activities
approximately 780 hours by interns working on activities related to this restoration project.

Table 1. Invasive plants removed from marsh and grassland areas January - March 2006.

Species	Common Name	Site
Dipsacus fullonum	Teasel	G
Erodium sp.	Stork's bill	M
Foeniculum vulgare	Fennel	M
Geranium sp.	Geranium	M
Lotus sp.	Lotus	M
Lythrum tribracteatum	Loosestrife	M/G
Phalaris aquatica	Harding grass	M/G
Picris echioides	Bristly ox-tongue	M/G
Plantago lanceolata	Plantain	M/G
Senecio sp.	Ragwort	M

Table 2. Total plants outplanted in marsh upland, tidal marsh and grassland, planting season 2005-2006. The majority of plantings occurred in the months from January through March, though a few planting also occurred in April and May.

	Species code	**Upland marsh**	**Grassland**	**Tidal Marsh**	**Total**	**notes**
1	ACMI	169	0		169	
2	ARCA	184	0		184	
3	ARDO	60	0		60	
4	ASCH	71	365		436	
5	BAPI	265	0		265	
6	BRCA	56	502		558	
7	CADE	0	107		107	
8	CASU	0	108		108	
9	DACA	56	588		644	
10	DISP			8	8	
11	ELGL	83	544		627	
12	ELMU	0	43		43	
13	ELTR	0	52		52	
14	ERAR	0	111		111	
15	ERLA	101	0		101	
16	ERST	141	0		141	
17	FRSA			443	443	
18	GNCA	48	0		48	
19	GRHI	159	95		254	
20	GRST			338	338	
21	HECU			172	172	
22	HOBR	27	420		447	
23	JACA			512	512	
24	JUOC	0	60		60	
25	JUPA	0	83		83	
26	JUPH	0	199		199	
27	LAGL			16	16	
28	LICA			466	466	
29	LUAL	0	0		0	90 Seeds through Plots 1-7
30	LUAR	102	0		102	263 Seeds through Plots 1-7
31	LUFO	7	0		7	
32	LUPR	0	0		0	90 Seeds through Plots 1-7
33	MECA	21	0		21	
34	MIAU	198	0		198	
35	NAPU	83	338		421	
36	RACA	27	320		347	
37	SACR	17	17		34	
38	SCCA	140	0		140	
39	SIBE	7	224		231	
40	SPFO			3575	3575	
41	STAJ	0	7		7	
42	TRMA			519	519	

43	WYAN	0	255		255	
	TOTAL	2022	4438	6049	12509	

Overview of March and Grassland Restoration Stewardship Activities Performed by the Watershed Project from April 2006 – June 2006

The Watershed Project has completed the following tasks under our contractual agreement with U.C. Berkeley:

MARSH RESTORATION PROJECT:

1. **Remove and control colonizing targeted invasive non-native plant species within defined area that could result in recontamination of restored ecotone and marsh habitats.**

Watershed Project staff and volunteers totaled over 198.5 hours removing invasive species in areas surrounding the marsh. Over 84 15-gallon bags of plants were removed in this time. See Table 1 for the complete list of species targeted for removal.

Plot 6, treated with glyphosphate herbicide in January, continues to show improvement as natives become established. The island plots were extensively weeded in May. Plots 1 and 2 have had poor outplant survivorship and native plant establishment, and in addition have become heavily covered by weedy species such as *Lythrum sp.* and *Lotus corniculatus.* These weeds were treated first by brushcutting as low to the ground as possible (since both species are prostrate), followed by vacuuming with a shopvac to remove seed heads. Following treatment, the area looked much improved but it remains to be seen whether this method will be successful over the longer term.

2. **Revegetate marsh, ecotone and upland habitats consistent with approved habitat reference sites and standard restoration planting practices.**

Staff and interns spent more than 185 propagating and collecting seed for next year's planting season. Other nursery projects included graveling the nursery area surrounding the greenhouse and shadehouse, and building more tables to hold the nursery's increasing inventory.

Initial results from last season's salt watering experiment indicate that salt watering done in the nursery to harden off marsh plants may not be necessary and in fact may do more harm than good. Salt marsh plants watered with even low concentrations of salt had high rates of dieback in the nursery (approximately greater than 33%). Of those plants that survived the salt watering treatment, they appeared to have no advantage over salt marsh plants that had never been hardened off at all. Only one species, Jaumea carnosa, appeared to be slightly more vigorous months after outplanting when it had received the salt watering treatment, though survivorship did not change.

3. **Prepare marsh upland area and install (and mulch where appropriate) plant material.**

The bulk of marsh plantings were completed in March, however staff and interns spent over 72.5 hours in April and May putting the last plants of the season into the marsh restoration area. See Table 2 in the previous quarterly report, January – March, 2006 for completed list of species outplanted this season.

RICHMOND FIELD STATION GRASSLAND MITIGATION PROJECT:

1. **Control and targeted removal of invasive, non-native plants species within the defined grassland mitigation:**

Watershed Project staff and volunteers spent more than 179.5 hours weeding in the grassland, and removed over 76 15-gallon bags of invasives. In addition, teasel and bristly ox-tongue throughout the four-acre mitigation area were brushcut to prevent them from going to seed. One particular species of concern is *Tragopogon porrifolius*. In past years, this species has occurred only occasionally in the grassland, and only in a few isolated areas. This year, this plant came up throughout the larger grassland area and was fairly common. We hired additional contractors and hand-removed almost the entire population before it went to seed. Based on the population's capacity to expand exponentially from one year to the next within this grassland, this plant should be carefully monitored and controlled as quickly as possible.

The maintenance department at the Richmond Field Station will now begin mowing the grassland annually. The aim of mowing is to simultaneously prevent the plant from producing seed, and reduce the vigor of the population.

Finally, it is becoming evident that restoration plots where Harding grass was removed by hand are more successful than in those plots where Harding grass was treated with glyphoshate herbicide. Hand removal seems to not only remove the plant's perennial root system, but also, because it takes most of the upper soil layer it may remove much of the population's seed bank. Another important factor may be that hand removal effectively removes the top 6" of soil, lowering the ground level, and bringing the ground-water level closer to the surface. As a result, plots treated with Harding grass hand removal became significantly wetter. These restoration plots seem to be too wet for Harding grass, and instead provide a strong competitive advantage to wet-loving, native species; as a general rule these hand removal plots that now become saturated in the winter months seem to be highly successful. Unfortunately, the hand removal method is prohibitively expensive and cannot be applied at a larger scale. Two possible options follow: (1) since one application of herbicide is insufficient to kill Harding grass, the effect of applying two applications of herbicide should be measured, and (2) machinery such as a mini-excavator should be used to scrape the top 6" of soil in an area dominated by Harding grass. The goal would be duplicate the effect of hand-removal without the tremendous time involved.

2. **Revegetate grassland habitat consistent with approved habitat reference sites and standard restoration planting practices.**

Over 184 hours were spent on propagation and seed collection. More than half the grassland species have been grown.

3. Prepare mitigation site and install (and mulch where appropriate) plant material.

Most grassland planting occurred between January and March, however, in May staff spent another 32.5 hours outplanting the wettest areas of the grassland.

SCIENTIFIC MONITORING AND COMMUNITY INVOLVEMENT (THESE ACCOMPLISHMENTS WERE NOT PART OF THE CONTRACT, BUT SUPPORTED THE CONTRACTED WORK)

Using grant funding from the San Francisco Foundation, staff and interns completed the second year of grassland monitoring. The purpose of this monitoring project is to collect data that highlights the distribution and abundance of significant native plants that exist in the grassland, and to see what effects, if any, restoration efforts have had on these populations. This project began in 2002; to complete the second phase of monitoring in 2006, UC Berkeley faculty were recruited to peer review the monitoring protocol, and interns were recruited to conduct monitoring twice a week throughout most of the spring and summer months.

In this time period, we hosted 6 community work days, with 26 students, 23 community members both totaling 118 hours. In addition, we presented our scientific findings regarding Harding grass treatments in a poster presentation at the California Native Grasslands Association Conference. The funding that enabled this presentation also came from the SF Foundation

Table 1. Invasive plants removed from marsh and grassland areas April - June 2006.

Species	Common Name	Site
Acacia sp.	Acacia	M
Avena sp.	Wild oats	M
Bassia hyssopifolia	Bassia	M
Beta vulgaris	Beet	M
Brassica raphanistrum	Mustard	M
Briza maxima	Rattlesnake grass	M
Bromus diandrus	Ripgut brome	M
Cirsium sp.	Thistle	M
Conyza sp.	Horseweed	M
Cotula coronopifolia	Brass-buttons	M
Dipsacus fullonum	Teasel	M/G
Epilobium sp.	Fireweed	M/G
Foeniculum vulgare	Fennel	M
Gnaphalium sp.	Cudweed	M
Hordeum murinum	Hare barley	M
Lolium multiflorum	Itialian ryegrass	M
Lotus sp.	Lotus	M
Lythrum tribracteatum	Loosestrife	M/G
Medicago sp.	Burclover	M
Melilotus sp.	Sweet clover	M
Phalaris aquatica	Harding grass	M/G
Picris echioides	Bristly ox-tongue	M/G
Plantago lanceolata	Plantain	M/G
Polygonum sp.	Knotweed	M
Polygonum sp.	Knotweed	M
Polypogon monspeliensis	Rabbitfoot grass	M
Raphanus sativus	Radish	M
Rumex crispus	Crispy rumex	M/G
Salsola tragus	Russian thistle	M
Sonchus sp.	Sow thistle	G
Tragopogon porrifolius	Salsify	G

Overview of March and Grassland Restoration Stewardship Activities Performed by the Watershed Project from Jul 2006 – September 2006

The Watershed Project has completed the following tasks under our contractual agreement with U.C. Berkeley:

MARSH RESTORATION PROJECT:

1. Remove and control colonizing targeted invasive non-native plant species within defined area that could result in recontamination of restored ecotone and marsh habitats.

Watershed Project staff and volunteers totaled over 38 hours removing invasive species in areas surrounding the marsh. Over 38 15-gallon bags of plants were removed in this time. See Table 1 for the complete list of species targeted for removal. One species of particular concern that has become common in the marsh is an invasive tarweed, *Dittrichia graveolens.*

On September 29th, the Spartina Project sprayed the non-native, hybrid population of Spartina on the outboard side of the marsh (on both east and west sides of the crumbling dock) with Amazopere. This population was also sprayed with glyphosphate herbicide in September 2005, and in the fall season of 2004 this population was covered with weed fabric. The weed fabric cover did not work because the tidal activity tore apart the weed cover. The 2005 application of glyphosphate herbicide also was not effective. This last application of herbicide used Amazopere, which is supposed to be the most effective herbicide against non-native Spartina. However, it is too soon to tell how successful this last treatment will be.

2. Revegetate marsh, ecotone and upland habitats consistent with approved habitat reference sites and standard restoration planting practices.

Staff and interns spent more than 534 hours propagating and collecting seed for next year's planting season. Approximately 80% of propagation goals were met by the end of September.

3. Prepare marsh upland area and install (and mulch where appropriate) plant material.

Spartina divisions completed over the winter of 2003 – 2004, two and a half years ago, finally appear established and robust. One year after these divisions were planted they were barely visible, yet as of August of this year, the band of Spartina plantings has become distinct and is clearly expanding. The Spartina divisions planted last winter- over 3000 of them- are almost entirely invisible as their vegetation has almost completely died back. It is our hope that just as the first set of divisions took over two years to become visibly established, this second set will begin to grow after another year's time.

Marsh plants grown in the nursery and planted in the tidal marsh area continue to generally do well. *Triglochin m.* has rebounded from herbivory successfully.

We are concerned about the soil in the marsh upland where we intend to plant this coming season. Plants placed into this soil over the last two years have established poorly. Soil analysis conducted by Tetratech suggests that the soil contains average nutrients; the issue instead may be poor soil structure and lack of organic matter. The soil becomes hardpan when it dries and may be prohibitively difficult for plant root establishment. In order to prepare for planting the upland area of the marsh, staff members and consultants have been researching methods of improving this hardpan soil before planting. Chosen methods include amending the soil with straw, rototilling the straw into the soil, further covering the ground with more straw to act as a weed barrier, covering the edges of the planting area with weed block fabric, and adding fertilizer and soil inoculated with mychorrhizae.

RICHMOND FIELD STATION GRASSLAND MITIGATION PROJECT:

1. **Control and targeted removal of invasive, non-native plants species within the defined grassland mitigation:**

Watershed Project staff and volunteers spent more than 172.5 hours weeding in the grassland, and removed over 157 15-gallon bags of invasive plants. By mid-spring, all restoration plots appeared to be dominated by natives, however by mid June, Italian wild rye grass had fully grown and came to dominate many restoration areas, particularly plots 1B and 4B. To reduce the amount of seed produced by the Italian wild rye grass, both plots 1B and 4B were brushcut.

2. **Revegetate grassland habitat consistent with approved habitat reference sites and standard restoration planting practices.**

Over 534 hours were spent on propagation and seed collection.

Table 1. Invasive plants removed from marsh and grassland areas July - September 2006.

Species	Common Name	Site
Acacia sp.	Acacia	M
Anagallis arvensis	Scarlet pimpernel	M/G
Bassia hyssopifolia	Bassia	M
Bromus diandrus	Ripgut brome	M
Cotula coronopifolia	Brass-buttons	M
Dipsacus fullonum	Teasel	G
Epilobium sp.	Fireweed	M/G
Foeniculum vulgare	Fennel	M
Gnaphalium sp.	Cudweed	M
Lolium multiflorum	Itialian ryegrass	M
Lotus sp.	Lotus	M
Lythrum tribracteatum	Loosestrife	M/G
Medicago	Burclover	M
Melilotus sp.	Sweet clover	M
Phalaris aquatica	Harding grass	M/G
Picris echioides	Bristly ox-tongue	M/G
Polypogon monspeliensis	Rabbitfoot grass	M
Rumex crispus	Crispy rumex	M/G
Salsola soda	Russian thistle	M
Sonchus sp.	Sow thistle	G
Tragopogon porrifolius	Salsify	G

Overview of March and Grassland Restoration Stewardship Activities Performed by the Watershed Project from October - December 2006

The Watershed Project has completed the following tasks under our contractual agreement with U.C. Berkeley:

MARSH RESTORATION PROJECT:

1. **Remove and control colonizing targeted invasive non-native plant species within defined area that could result in recontamination of restored ecotone and marsh habitats.**

In this quarter, staff worked for over 28 hours removing invasive plant species in the marsh, totaling 14, 30-gallon bags. A non-native tarweed of particular concern, *Dittrichia graveolens*, was noted for the first time in the marsh area. Peter Baye, a marsh ecologist, has urged us to prioritize the control of this highly invasive plant. Staff and interns removed all individuals, and have placed this plant on the list of highest priority species. Staff and interns also spent a significant portion of time laying down straw mulch, used in part to control invasive plant species. This work is detailed below in task #3.

2. **Revegetate marsh, ecotone and upland habitats consistent with approved habitat reference sites and standard restoration planting practices.**

While most activities relating to plant propagation occur in the spring and summer season, in this quarter we nonetheless spent over 60 hours seed collecting and 54 hours propagating marsh and grassland species. In this quarter we met or exceed our propagation goals for 42 different species, totaling over 11,000 plants.

Peter Baye brought to our attention a new native aster, *Aster subulatus var. lingulatus* that has naturally established in the marsh upland. This plant is typically an annual (and is classified as such), yet in the RFS marsh, it exhibits perennial tendencies. Staff collected seed from the small population and will propagate the plant for future outplanting.

Also notable, *Spartina foliosa* divisions planted three seasons ago, finally appear robust. These divisions were almost impossible to detect even a year after planting, and seem to require several years to establish. We planted a second batch of native Spartina earlier in the year (around February '06) which did not appear to have taken; we now hope that the second batch of divisions simply need more time to develop below ground root systems, before we note above-ground development of tillers.

3. **Prepare marsh upland area and install (and mulch where appropriate) plant material.**

This year we took several new steps to prepare the upland marsh area for planting. Outplant survivorship from the previous two years has been highly variable throughout marsh upland areas. While plants have established successfully along the eastern and parts of the northern edges of the marsh upland, in plots 1 and 2 on the northern edge, mortality has been high (up to an estimated 50%) and we have had to replant the area to obtain adequate coverage. Soils in this area were tested and found to have adequate levels of nutrients, but seem to have low organic matter and poor structure. As a result, these areas typically form a hardpan layer at the surface, and plants that do survive seem at least initially stunted.

Because the new upland planting areas are adjacent to plots 1 and 2, and also contain this hardpan soil, we developed a strategy to improve site conditions. We covered the area with certified weed-free rice straw (at a rate of about 31 square meters per bale), and drove a tractor with a rototiller attachment repeatedly across the site to break up the hardpan layer and add in organic matter (John Deere 420 tractor w/ tiller attachment, from CRESCO rentals; we tied a 100 lb log to the rototiller to increase the weight of the rototiller). We also had a hose on hand to water the site as necessary to reduce the amount of dust produced. The soil was even harder than we anticipated, and required approximately 10 passes to churn up approximately four inches. Despite the many needed passes, the treatment did achieve the desired result of breaking up the top inches of hardpan, and amending this soil with organic matter. In the future, we would recommend this approach, but would add straw to the area gradually throughout the day while the area is rototilled rather than all at once in the beginning. The end result of using this high density of straw is a thick layer of churned straw with small amounts of soil, atop several inches of loose soil with mixed fragments of straw. The thick layer of mulch later proved to be very effective at suppressing weeds, and quickly flattened with the onset of the rainy season.

Before rototilling, this upland planting area was also covered with black weed fabric for almost two years, and we believe this cover also helped to reduce the weed seed bank. Between the straw mulch layer and the weed cover, the planting area had significantly fewer weeds than comparable adjacent areas.

Our final measure to increase the success of outplants in the hardpan area was to use both a special fertilizer tablet and also to add a tablespoon of native soil (for mychorrizal inoculation) from the RFS grassland to each planting hole. We used AgSafe 12-8-8 and 20-10-5 tablets that release nutrients on a time-released basis. We recommend this approach for future plantings as opposed to broadcast distribution of fertilizer across the entire site. Fertilizing the entire area would be wasteful and would likely be counter productive as it would encourage more annual, non-native plants that are favored by high levels of nutrients. We are not sure how effective is the use of placing native soil in each planting hole. Future plantings should integrate a control area to evaluate this technique.

Following these site preparations, and the onset of the rainy season, we began planting marsh upland areas in November, logging in 244.5 hours in this quarter. As of this writing in late Spring 2007, site preparations appear to have been very effective. Most outplants have survived and are robust, and compared to adjacent areas, weeds have been greatly reduced.

Adjacent to upland planting areas, we installed weed fabric to reduce adjacent sources of non-native seeds. The weed fabric is also effective as a means to reduce the seed bank of the soil beneath the fabric. We experimented with a different fabric, stiffer and silvery in color, that we do not recommend. Plants continued to grow under the silver fabric (at sometimes greater rates than areas not covered in fabric), and it was difficult to stake and hold down. The more commonly used black weed fabric is more effective. We plan to cover the landscape fabric with Eucalyptus chips later in the year.

Finally, we also installed a fence along the western edge of the upland planting area in order to delineate the edge of the remediated marsh, and keep staff, interns and volunteers out of contaminated areas.

Side note: Because we exceeded our planting goals, in November we contacted Brad Olsen of East Bay Regional Park District, to offer to plant along the Bay trail, outside the RFS marsh fence (at no cost), but for maintenance reasons they did not want us to plant along the trail.

RICHMOND FIELD STATION GRASSLAND MITIGATION PROJECT:

1. **Remove and control mature, targeted invasive non-native plants species within the defined grassland mitigation:**

In this quarter, staff and interns spent over 27 hours removing or controlling invasive plants in the grassland (Table 1 lists plant species targeted). A large portion of this time was spent laying down straw mulch. Species most commonly targeted for invasive plant control include Teasel (*Dipsacus fullonum*) and Harding grass (*Phalaris acquatica*).

In this season we also tested two new ways to control Harding grass, scraping and hydro-mechanical obliteration. On November 1st, we worked with RFS maintenance staff to scrape a dense stand of Harding grass using a mini-excavator. This area was chosen as a priority for control because it borders some of the highest value habitat in the grassland, yet it is covered by at least an estimated 75% cover of Harding grass (some native plants did exist but were mostly salvaged for use as divisions). The elevation of this area also appeared to be artificially high (by about 6") compared to the topography of adjacent areas dominated by natives. Our hypothesis is that stands of non-native Harding grass not only crowd out native grassland species, but also, that they build up the ground level, effectively creating drier conditions that favor Harding grass over the wet-loving, native rush and sedge species. We theorized that by mechanically scraping dense stands of Harding grass we would mimic the success we had in other areas using hand-removal (while hand-removal was effective, it is also prohibitively labor-intensive), and achieve the following: (1) remove the Harding grass plants, roots and seed-bank, (2) expose the underlying native seed-bank, (3) revert the micro-topography to a lower elevation, once again favoring wet-loving, native species over Harding grass and (4) allow adjacent native areas to recolonize scraped area with the help of outplants. As of late December, several weeks past the start of the rainy season, and almost two months after the scraping treatment, we noted in the scraped area a new crop of native seedlings and high number of sprouts from the native, rhizomatous *Juncus phaeocephalus*. The presence of these sprouts and seedlings, whose propagules would have existed about 6" below the Harding grass, as well as the presence of more standing water following rains, indicate that the Harding grass most likely did artificially build up the level of soil in this area. In addition, we found very few numbers of Harding seedlings in the scraped area. This method therefore appears highly promising, though the true success of this technique will be better judged in 18 months time, following another rainy season.

On November 10, Cameron Colson came to the grassland to demonstrate his invention, hydro-mechanical obliteration, which is essentially a hose that delivers jet of water vapor at extremely high pressures (capable of cutting down large trees). We wanted to test whether this method could be used to cut back large stands of Harding grass and pulverize their root systems. This impressive tool quickly, and easily cut back Harding grass plants (much more quickly than could a brushcutter), and then was aimed at the ground to pulverize roots- about 10 seconds per root ball. Unfortunately, once month after treatment, Harding grass root fragments, as small as two inches, began to resprout. For this reason, we did not use this method for further control of Harding grass. We do expect that technique would have other useful applications for restoration or landscape maintenance. Further experiments with Harding grass would also be worthwhile, either to determine whether plants can be killed if more time is spent targeting each root ball, or through a follow-up treatment.

2. **Revegetate grassland habitat consistent with approved habitat reference sites and standard restoration planting practices.**

Please see above, marsh task #2 for description of combined propagation work for marsh and grassland areas. In addition to nursery stock, we also salvaged about 250 grassland divisions from the scraped material.

3. Prepare mitigation site and install (and mulch where appropriate) plant material

With the help of four elementary school programs, we began planting the scraped portion of the grassland (located toward the back of the grassland). These plantings consisted of both nursery plants as well as native divisions salvaged from the scraping. Nursery outplants included both "wet" and "dry" species. The area became inundated with more water than we anticipated, however, and we decided that in January we would continue planting with only wet-loving species.

SCIENTIFIC MONITORING AND COMMUNITY INVOLVEMENT (THESE ACCOMPLISHMENTS WERE NOT PART OF THE CONTRACT, BUT SUPPORTED THE CONTRACTED WORK)

In this quarter, Watershed Project Staff hosted a number of community, volunteer and educational programs. In addition to our regular monthly volunteer workdays, we also hosted our annual community Open House, and workdays with REI, and Vista College. We held four educational programs in the grassland for students from Grant, Highland, Kensington and Harding elementary schools. In this quarter, the Watershed Project made the decision to phase out the school and volunteer program in the marsh due to the misguided perception by the Community Advisory Group (CAG) that the marsh restoration area remains a public safety hazard.

On October 15 we presented the results of our Harding grass experiments at the California Invasive Plant Council's annual conference. This forum was an especially useful means to share the results of our studies with other managers and to learn of new strategies being employed to control Harding grass in other parts of California. One such method was hydro-mechanical obliteration, detailed above in grassland task #1.

In November, John Welsh, an undergraduate student at UC Berkeley installed 20 hollow stakes throughout the grassland to monitor the belowground water table. We hope to use the data collected to increase our understanding of the relationship between belowground water levels and aboveground plant communities, and to inform future grassland restoration efforts.

Table 1. Invasive plants removed from marsh and grassland areas October - December 2006.

Species	Common Name	Site
Acacia baileyana	blackwood acacia	G
Acacia melanoxylon	birdfoot trefoil	M
Acacia sp.	acacia	M
Aira caryophylla	silver hair grass	M
Ambrosia chamissonis	beach-bur	M
Anagallis arvensis	scarlet pimpernel	M
Anthemis cotula	mayweed, dog fennel	M
Atriplex semibaccata		M/G
Avena sp.	wild oats	M
Bassia hyssopifolia	bassia	M
Bellardia trixago		G
Beta vulgaris	beet/wild chard	M
Brassica rapa	field mustard	M
Brassica raphanistrum	mustard	M
Briza maxima	rattlesnake grass	M
Bromus catharticus?	rescue grass	M
Bromus diandrus	ripgut brome	M
Bromus hordeaceus (= *B. mollis*)	soft chess	M/G
Cakile maritima	sea rocket	M/G
Cardamine hirsuta	bitter cress	M/G
Carduus sp.		M
Carpobrotus edulis	ice plant	M
Centranthus ruber		M
Cerastium glomeratum	mouse ear chickweed	M/G
Chamomilla suaveolens	pineapple weed	M
Cirsium sp.	thistle	M
Cotula coronopifolia	brass-buttons	M
Dipsacus fullonum	Teasel	G
Dittrichia graveolens	tarweed	M/G
Epilobium sp.	fireweed	M/G
Foeniculum vulgare	fennel	M
Geranium dissectum	cut-leaved geranium	G/M
Gnaphalium sp.	cudweed	M
Hordeum murinum	hare barley	M
Kickxiaelatine		M
Lolium multiflorum	Itialian ryegrass	M
Lotus sp.	lotus	M
Medicago polymorpha (= *M. hispida*)	California burclover	M
Melilotus sp.	sweet clover	M
Parapholis incurva	sickle grass	M
Phalaris aquatica (= *P. tuberosa* var. *stenoptera*)	Harding grass	G/M
Picris echioides	Bristly ox-tongue	M/G
Plantago lanceolata	plantain	M/G
Polygonum sp.	knotweed	M
Polypogon monspeliensis	rabbitfoot grass	G/M

Raphanus sativus	radish	M
Rumex crispus	curly dock	G
Rumex pulcher	fiddle dock	G
Salsola soda	Russian thistle	M
Salsola tragus	Russian thistle	M
Sonchus asper ssp. *asper*	prickly sow-thistle	G
Sonchus sp.	sow thistle	G
Toxicodendron (*Rhus*) *diversilobum*	poison oak	M
Vulpia bromoides	vulpia	G

M: Tidal and Upland marsh sites
G: Grassland sites

SAN FRANCISCO ESTUARY INVASIVE SPARTINA PROJECT

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December 17, 2004

Wendy Strickland
Executive Director
The Watershed Project
1327 South 46th Street
155 Richmond Field Station
Richmond, CA 94804

Subject: Non-Native Spartina at Steege Marsh, Richmond, CA

Dear Ms Strickland :

As part of the San Francisco Bay-wide *Spartina* Control Program, the Invasive Spartina Project has been working with the Watershed Project (formerly the Aquatic Outreach Institute) since 2003 to control a small patch of non-native, invasive *Spartina alterniflora x foliosa* hybrids located on the bayfront edge of the marsh adjacent to Steege Marsh. The ISP has submitted samples of plant tissue taken from transects done in 2003 and 2004 on both the bayfront edge and the interior marsh to UC Davis for genetic sampling at the Spartina Lab. Thus far, only the previously identified clone on the bayfront shows the genetic signature of the invasive hybrid species. The remainder of the population has tested as the native *Spartina foliosa* (California or Pacific Cordgrass).

As you know, there is currently a large-scale restoration effort underway in Steege Marsh to remove contaminated sediment. The marsh itself will have its vegetative cover removed and sediment elevations will be reestablished to enable natural revegetaion of the site. Typically, native marshland vegetation would be expected to colonize a site of this type, including native *S. foliosa*, *Grindelia* (gumplant), *Salicornia* (pickleweed), *Distichilis* (saltgrass) and other species. However, in the case where there is an adjacent population of hybrid *Spartina*, natural revegetation patterns can be severely disrupted if the hybrid plants invade the new marsh. Often, the plant diversity of the new marsh is diminished such that non-native hybrid *Spartina* forms the dominant species in the high, mid and low marshes. Typically, native *S. foliosa* would only occupy the low marsh fringe. The predominance of hybrid *Spartina* in the marsh increases sedimentation rates and leads to rapid re-engineering of the marsh as secondary and tertiary channels are filled in and the overall marsh elevation is raised. Habitat values for resident native fauna are also consequently reduced.

There are many instances around the Bay where restoration sites adjacent to expanding stands of hybrid *Spartina* have been partially or completely invaded by the hybrid. This is especially the case when the restored site is graded to elevations suited for seedling recruitment, as will be the case in Steege Marsh. There are several pathways for invasion by the hybrid *Spartina* species. Two are most important in the Steege Marsh case: 1) The hybrid plants may directly produce seeds that colonize the newly restored area, and 2) the hybrid plants, which produce 3-10 times the pollen load of native *S. foliosa*, will 'swamp' native *S. foliosa* plants with hybrid pollen, resulting in native *S. foliosa* plants producing hybrid seeds. The latter is the most dangerous, especially if there is an active program of *S. foliosa* planting occurring at the site.

In coordination with the Watershed Project, the majority of the hybrid *Spartina* at the Steege Marsh site has been controlled. There are however, still a small number of hybrid plants remaining in the marsh. It is the intent of the ISP to work with both the Watershed Project and East Bay Regional Parks District to control the remainder of this infestation during the 2005 treatment season. However, there will remain a constant threat of reinfestation at the site for the foreseeable future, as the Bay-wide hybrid *Spartina* population remains uncontrolled, and since the Steege Marsh site is a high depositional area. The ISP is dedicated to reversing the spread of this invader by 2006 and reducing the non-native *Spartina* in the Bay to easily managed levels by 2010.

In the short term, however, any plans for restoration at the Steege Marsh site must contain specific provisions aimed at monitoring the site for non-native *Spartina* hybrid colonization, including conducting periodic transect plant sampling for genetic testing, as well as targeted maintenance protocols in the event that the marsh is colonized by hybrid *Spartina*. The ISP will be available at need for assistance in developing both monitoring and maintenance protocols as part of our overall Project.

The ISP has been involved in several projects where restored marsh became invaded with non-native *Spartina*, and the cost of discerning native from non-native at the seedling stage became so cost-prohibitive that all *Spartina* on the site, native and non-native were eradicated. This methodology changes natural marsh successional patterns, is labor-intensive, and can undermine success criteria of the proposed restoration design. It is always easier to preclude the colonization of the marsh in the first place.

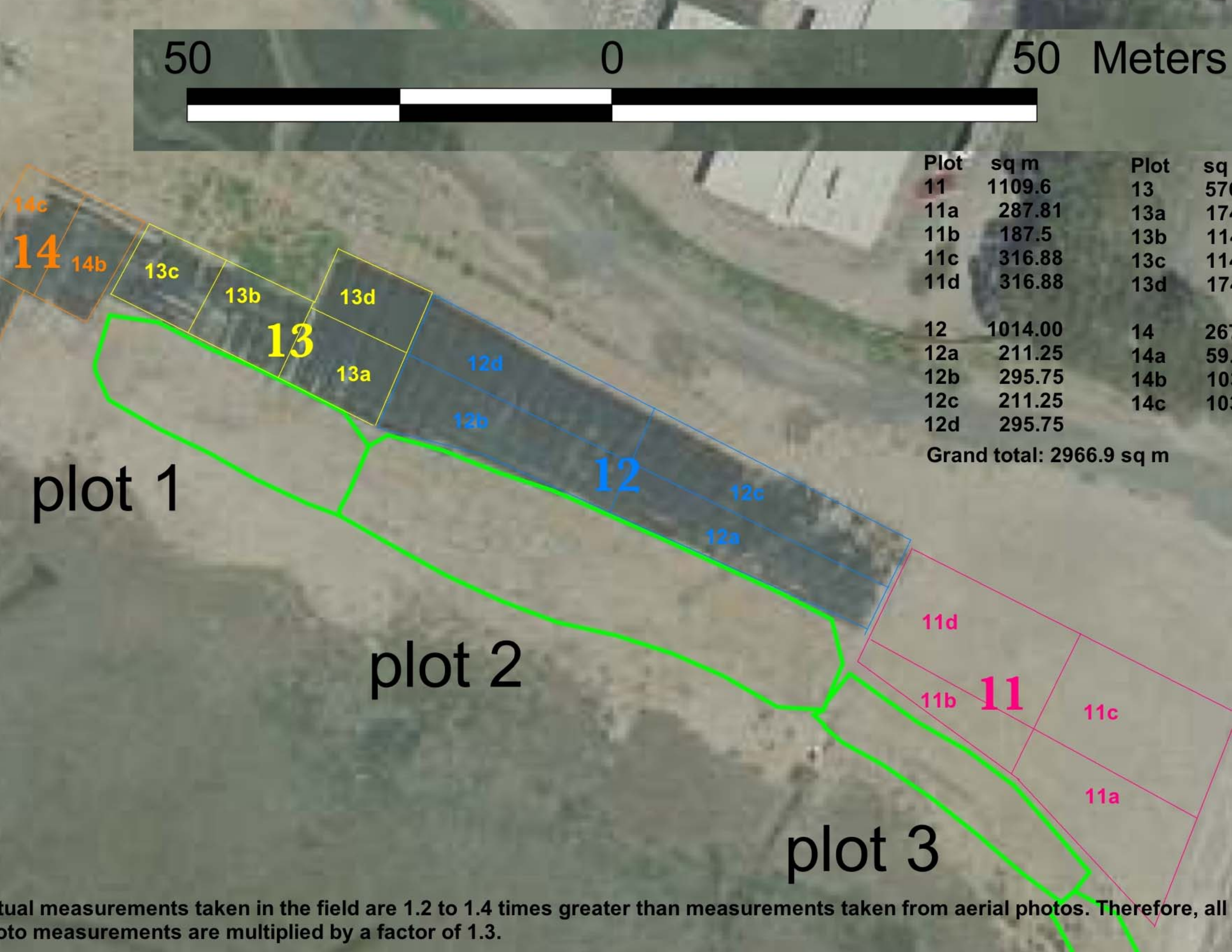
In the case of Steege Marsh, there exists very little non-native *Spartina* adjacent to the restoration area. There is a low chance of infestation from this source, especially given the planned treatment work for 2005. However, as stated above, the site remains an area of high deposition, and any non-native seeds from other sites in the bay that find their way to the restoration site will quickly colonize the new marsh. The ISP suspects that given the current native *Spartina* populations in the area, native stands of *S. foliosa* will develop in the new marsh. However, regular monitoring of the site, with perhaps yearly sampling of plants, will be necessary for the next 4-6 years to assure that no non-native *Spartina* plants colonize the new marsh.

Sincerely,

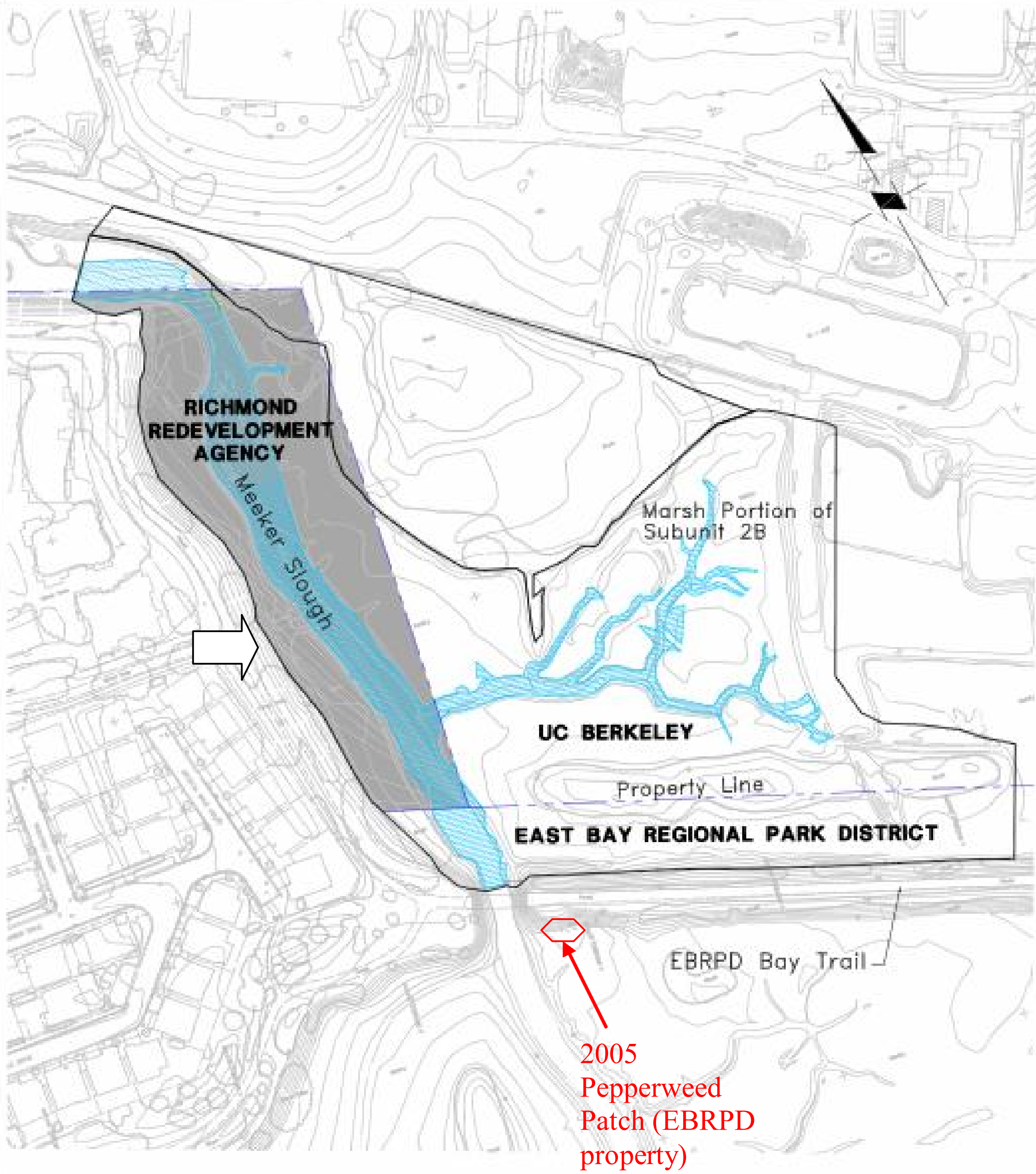
Erik Grijalva
Field Operations Manager

Cc: Karl Hans, Senior Environmental Scientist

Marsh Restoration Plots
Richmond Field Station, UCB



tual measurements taken in the field are 1.2 to 1.4 times greater than measurements taken from aerial photos. Therefore, all
oto measurements are multiplied by a factor of 1.3.



0 150' 300'
GRAPHIC SCALE

NOTE:
1) BASE MAP SUPPLIED BY URS ON 7/9/03 AT A SCALE OF 1"=100'.

L: OFF=REF
P: PAGESET/PLT-AP
8/4/03 IRV-80-JMS
F:/BM/CAD/2003PROJ/24210/24210010.DWG

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PROPERTY OWNERSHIP
MARSH PORTION OF SUBUNIT 2B

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EXHIBIT
A