ISLAND PONDS MITIGATION
MONITORING AND REPORTING
YEAR 4 - 2009

Prepared by

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EXECUTIVE SUMMARY

The Santa Clara Valley Water District (District) and the U.S. Fish and Wildlife Service Don Edwards National Wildlife Refuge (Refuge) implemented the Island Ponds Restoration Project to fulfill two goals: 1) to initiate ecological restoration activities as described in the South Bay Salt Pond Initial Stewardship Plan (ISP), and 2) to satisfy the tidal marsh mitigation needs of both the Refuge for the ISP, and the District for the Stream Maintenance Program and the Lower Guadalupe River Project.

Breaching of the Island Ponds A19, A20, and A21 occurred in March 2006. Five breaches were cut to allow tidal waters to inundate the ponds and begin the process of restoration. In the Restoration and Mitigation Monitoring Plan for the Island Pond Restoration Project (RMMP), the District and the Refuge agreed to conduct monitoring to track the progress of the restoration. This report presents the Year 4 (2009) monitoring results for both the District and the Refuge.

The following is a summary of the monitoring results:

Sediment is continuing to accumulate in all three Ponds. The highest average rate of accretion occurred at Pond A20, closely followed by Pond A21. Pond A19 had the least amount of sediment deposition. Across all Ponds, the sediment pins with the highest accretion rates were typically located closest to the breaches. All sampling locations accumulated an average of roughly 0.1 ft (30 mm) of sediment since the 30 month post-breach depth measurements. Since tidal restoration in 2006, one sediment pin at Pond A19, and three pins at both Ponds A20 and A21 have accreted over 0.6 ft of sediment. Between the 30 and 43 month sampling dates, two sediment pins at Pond A19 and one pin at both Ponds A21 and A20 reached the annual sediment projection, accreting more than 0.2 ft of sediment.

Levee breach widths have continued to widen at Pond A19, however the breaches at both Pond A21 and A20 have remained virtually the same since 2008. A small amount of scour has continued in some areas of the fringe marsh along Coyote Creek, while accretion has occurred in others. Total loss of fringe marsh since 2006 is approximately 0.96 acres and total gain of fringe marsh is approximately 0.48 acres since 2006. As in previous years, no signs of scour have been detected in any of the levees opposite the breaches at Ponds A15, A17, and A18.

Since the breaching of the Island Ponds, both Ponds A19 and A20 have shown an increase in channel development. In 2009 however, channel acreage increased by 1 to 3 percent in all three ponds.

Monitoring vegetation establishment is a biennial requirement and was done in 2008, therefore, it was not formally done in 2009. However, notes on vegetation establishment were taken during data collection efforts for the sediment monitoring task. Generally speaking, vegetation has established at all three Ponds, with Pond A21 displaying the most vegetation coverage. No invasive plants were identified within the Island Ponds in 2009.

Not enough acreage of contiguous marsh vegetation has developed to monitor for California clapper rail and salt marsh harvest mouse, however, monitoring of shorebirds and waterfowl indicates that many bird species are utilizing these ponds for foraging and roosting habitat.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

In March 2006 the Santa Clara Valley Water District (District) and U.S. Fish and Wildlife Service (USFWS) Don Edwards National Wildlife Refuge (Refuge) restored tidal inundation to the 475-acre Island Pond Complex (the ponds). Five breaches were cut by an amphibious excavator along the south side of the ponds to allow tidal waters to inundate the ponds and begin the process of restoration. Two breaches (west and east) were cut in Pond A19 on March 7, 2006. A single breach was cut in Pond A20 on March 13, 2006. Two breaches (west and east) were cut in Pond A21, on March 21 and March 29, 2006, respectively. This restoration approach is a minimally engineered, passive design, which relies on the natural sedimentation processes to restore the ponds to tidal marsh habitat and meet the project goals and objectives. The overall restoration goal is to successfully reestablish vegetation, promote re-colonization by benthic organisms and provide habitat for various wildlife species.

Restoration of the Island Ponds is a component of the Initial Stewardship Plan (ISP) for the larger South Bay Salt Pond Restoration Project (Life Science!, 2003). The District and the Refuge implemented the Island Ponds Restoration Project to fulfill two goals:

1. To initiate ecological restoration activities as described in the South Bay Salt Pond ISP
2. To satisfy the tidal marsh mitigation needs of both the Refuge for the ISP and the District for the Stream Maintenance Program (SMP) and Lower Guadalupe River Project (LGRP).

In the Restoration and Mitigation Monitoring Plan for the Island Pond Restoration Project (RMMP), the District and the Refuge agreed to conduct long-term monitoring to track the progress of the restoration and to evaluate whether there are adverse effects from the project (USFWS et al., 2006). Mitigation monitoring activities are anticipated to continue for 15 years. This report presents the Year 4 (2009) monitoring results.

1.2 PROJECTS WHICH REQUIRED MITIGATION

1.2.1 Initial Stewardship Plan

The ISP was created as an interim step to manage the ponds while a long-term plan is developed for the entire South Bay Salt Pond area. The main objectives of the ISP are to:

- cease commercial salt operations,
- introduce tidal hydrology to the ponds where feasible,
- maintain existing high quality open water and wetland wildlife habitat, including habitat for migratory and resident shorebirds and waterfowl,
- assure ponds are maintained in a restorable condition to facilitate future long-term restoration,
- minimize initial stewardship management costs,

- meet all regulatory requirements, especially discharge requirements to maintain water quality standards in the South Bay.

Taking into account the environmental effects of implementing the ISP based on the assessment in the EIR/EIS (Life Science!, 2004) and the associated permit requirements, the Refuge has agreed to restore unimpeded tidal inundation to approximately 475 acres at the Island Ponds and restore nine acres of tidal marsh specifically at Pond A21.

The permit file number for ISP activities which requires tidal wetland mitigation is San Francisco Bay Regional Water Quality Control Board - Order # R2-2004-0018.

1.2.2 Stream Maintenance Program

The SMP allows the District to implement routine stream and canal maintenance projects to meet the District's flood protection and water supply mandates in a feasible, cost-effective, and environmentally-sensitive manner. This program is also intended to assist the District in obtaining multi-year permits for these activities, which have currently been issued through 2012. The SMP applies to all of the District's routine stream maintenance, including three major types of activities: sediment removal, vegetation management, and bank protection. SMP activities commenced soon after the District received its final SMP permit in August 2002.

The SMP compensatory mitigation package includes mitigation for impacts to 30 acres of tidal wetlands; 29 acres from sediment removal activities and one acre from vegetation management activities. Taking into account the assessment in the EIR/EIS and the associated permit requirements, the District has agreed to restore 30 acres within the Island Ponds to tidal marsh habitat as mitigation for implementation of the SMP.

Permit file numbers for SMP activities which require tidal wetland mitigation are:

- San Francisco Bay Regional Water Quality Control Board - Order # R2-2002-0028
- U.S. Army Corp of Engineers - Permit # 22525S
- California Department of Fish and Game – 1601 Lake and Streambed Alteration Agreement # R3-2001-0119
- U.S. Fish and Wildlife Service – Biological Opinion 1-1-01-F-0314

1.2.3 Lower Guadalupe River Project

The LGRP was constructed to convey design flood flows in the lower Guadalupe River between Interstate 880, in downtown San Jose, and the Union Pacific Railroad Bridge in Alviso. The project was designed to balance the needs for flood-control structures and channel maintenance with the goal of protecting and enhancing environmental conditions and public access. LGRP construction began in April 2003.

The LGRP compensatory mitigation package includes mitigation for both temporary and permanent impacts to wetland vegetation. Taking into account the assessment in the EIR/EIS and the associated permit requirements, the District has agreed to restore 35.54 acres to tidal marsh within the Island Ponds to mitigate for LGRP impacts.

Permit file numbers for LGRP activities which require tidal wetland mitigation are:

- San Francisco Bay Regional Water Quality Control Board - Order # R2-2002-0089
- U.S. Army Corp of Engineers - Permit # 24897S
- California Department of Fish and Game – 1601 Lake and Streambed Alteration Agreement # R3-2002-0732

1.3 ISLAND PONDS MITIGATION SITE

1.3.1 Site Description

The Island Ponds (Ponds A19, A20, and A21) are located at the extreme southern extent of the San Francisco Bay within Coyote Creek. The ponds are in Alameda County immediately north of the Santa Clara County line, in the City of Fremont (Figure 1). These ponds are part of a larger 25-pond system known as the Alviso Complex. Prior to their 2006 breaching, this complex contained 7,364 acres of pond habitat, 420 acres of saltmarsh outboard of the pond levees, 896 acres of brackish marsh in the adjacent sloughs and creeks, as well as associated upland (levee) and subtidal habitats (HTH et al., 2005).

Solar salt production began at the Alviso Complex in 1929 and continued until the ponds were purchased by State and Federal Agencies in 2003. The Island Ponds were middle stage salt evaporator ponds with intermediate salinity levels. In March 2006, the District and the Refuge cut five breaches on the south side of the ponds to permit full tidal inundation and allow the ponds to passively restore to tidal marsh habitat.

1.3.2 Mitigation Monitoring

The District and the Refuge agreed to conduct a long-term monitoring program to track the progress of the Island Ponds restoration. The RMMP details the monitoring activities, which are designed to track mitigation performance over a 15-year period (USFWS et al., 2006). The monitoring data will be compared from year to year to determine trends with respect to meeting performance criteria, permit requirements, and provide data for adaptive management actions, if necessary.

Table 1-1 describes the monitoring schedule for the Island Ponds, including monitoring duration, frequency and timing. Table 1-1 also depicts the division of monitoring responsibilities between the District and the Refuge.

Table 1-1. Mitigation Monitoring Schedule for the Island Ponds – Responsible Party, Monitoring Duration, Frequency and Timing.

Responsible Party	Monitoring Activity	Year(s) for Each Monitoring Activity [1]	Frequency	Seasonal Timing
On-Site Monitoring				
District	Inundation regime	Years 1, 2, 3, 5, 10, and 15 (or until two monitoring cycles indicate that full tidal exchange has been achieved)	Completed Task 2006 - 2007	---
District	Substrate development	a) Years 1 and 2	Completed Task 2006-2007	---
District	Substrate development	b) Years 3 to 5	Annual	Oct
District	Substrate development	c) Year 6 to 30 acres of vegetation	Biennial	Oct
District	Levee breach and outboard marsh channel geometry[3]	Years 1, 2, 3, 5, 10, and 15	Annual	With aerial
District	Aerial photo	a) Year 1 to 5, 10, and 15	Annual	Jul - Aug
District	Aerial photo	b) Year 7, 9, 11 … to end	Biennial	Jul - Aug
Refuge	Channel network evolution[3]	Years 1, 2, 3, 5, 10, and 15	Annual	With aerial
Refuge	Vegetation mapping[3]	Until mitigation achieved	Biennial	Jul - Aug[2]
Refuge	Ground-based quantitative vegetation sampling	Once 30 acres of vegetated area is established until 75 acres of 75% vegetation cover is achieved	Biennial	Jul - Aug[2]
Refuge	Invasive *Spartina* monitoring and control	Year 1 to 75% native vegetation cover	Annual	Sept - Nov
Refuge	Wildlife use (CLRA)	Begin when 30 acres native vegetation to detection	Annual	Jan - Apr 15
Refuge	Wildlife use (SMHM)	Begin at five acres contiguous suitable habitat, end at SMHM detected	Once every 5 years	Jun - Aug
Refuge	Wildlife use (shorebirds & waterfowl)	Years 1 to 5	Quarterly	Win, Spr, Sum, Fall

Off-Site Monitoring				
District	Rail bridge pier scour[4]	a) Years 1 to 5	Completed Task 2006-2008	---
		b) Years 1 to 5	Once per 10-yr storm event	
		c) Begin at implementation of corrective measures, end five years after	Quarterly	Win, Spr, Sum, Fall
	Fringing marsh scour in Coyote Creek[3]	a) Years 1 to 5, Final year	Annual	With aerial
	Scour of levees opposite breaches[3]	a) Years 1 to 3	Completed Task 2006 – 2008	---
		b) If outboard marsh retreats to levees opposite breach, then three additional years from occurrence	Annual	---
	Rail line erosion	a) Years 1 to 5	Annual	Apr - Jun
		b) Years 1 to 5	Once per 10-yr storm event	
	Deterioration of Town of Drawbridge structures	a) Years 1 to 5	Annual	Apr - Jun
Refuge	Water Quality	a) Adjacent to breaches – Year 1	Completed Task 2006	---
		b) Upstream & downstream of ponds – Year 1	Completed Task 2006	---

* (Grayed out tasks above are considered complete)

1 Projected time estimates to achieve performance criteria. Actual duration is dependent upon performance criteria and may vary.

2 If CLRA are detected, on-site vegetation monitoring is only allowed from Sept 1 to Jan 31.

3 Monitoring to use annual aerial photograph.

4 Bridge pier scour will continue to be monitored twice a year by the Union Pacific Railroad staff instead of additional monitoring being performed by this Project. (See Year 3-2008 monitoring report for additional details.)

This report presents the monitoring results collected during the Year 4 (2009) monitoring period. The data are presented in detail and are compared to pre-breach and Year 1 -3 results as well as the overall project performance criteria identified in the RMMP (USFWS et al., 2006). Since the District and the Refuge divided the responsibility for the monitoring activities, the District's results and conclusions are presented in the main body of this report (and Appendices B & C), while the Refuge's results and conclusions are attached as Appendix A.

1.3.3 Performance Criteria

The performance criteria for the Island Ponds are specific to the mitigation needs of the Refuge and the District.

The performance criteria for the ISP mitigation are:

- Restore unimpeded tidal action to approximately 475 acres,
- Restore nine acres of vegetated tidal marsh located within a larger marsh area in Pond A21,
- Vegetation covers no less than 75% of the nine acres,
- Plant species composition consists of native tidal marsh species appropriate to the salinity regime,
- Targets achieved within 15 years following levee breach.

The performance criteria for the SMP mitigation are:

- Restore 30 acres of vegetated tidal marsh located within a larger marsh area on the three Island Ponds,
- Vegetation covers no less than 75% of the 30 acres,
- Plant species composition consists of native tidal marsh species appropriate to the salinity regime,
- Presence of California clapper rail at the Island Ponds as detected by a positive response to rail call counts using USFWS Endangered Species Office approved survey protocols. This performance criterion for the clapper rail mitigation requirement was established by the District through negotiations with the USFWS Endangered Species Office in December 2005,
- Targets achieved within 15 years following levee breach.

The performance criteria for the LGRP mitigation are:

- Restore 35.54 acres of vegetated tidal marsh located within a larger marsh area on the three Island Ponds,
- Vegetation covers no less than 75% of the 35.54 acres,
- Plant species composition consists of native tidal marsh species appropriate to the salinity regime,
- Targets achieved within 15 years following levee breach.

1.4 CONTACTS

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The Refuge contact is Melisa Helton, Don Edwards San Francisco Bay National Wildlife Refuge, 9500 Thornton Ave., Newark, CA 94560. Tel: (510) 792-0222ext. 124.

2.0 MONITORING METHODS (DISTRICT ACTIVITIES)

This section describes the methods used to carry out the Year 4 monitoring activities for the District. The monitoring responsibilities of the Refuge are described in Appendix A rather than being reported here.

2.1 ON-SITE MONITORING

2.1.1 Substrate Development/Sedimentation

To meet the project objective of restoring tidal marsh habitat, sedimentation must occur within the Island Ponds. Estuarine sediment deposition will form the substrate that is essential for plant colonization and growth, and will provide the environment required by benthic organisms.

Prior to breaching in 2006, a total of 30 sedimentation pins were installed in the three ponds (15, 5, and 10 pins for Ponds A19, A20, and A21, respectively). The pins, made of 2-inch diameter, Schedule 80 PVC, were disbursed throughout each pond and were to be used to measure sediment deposition over time. Each pin was tagged with a unique ID number. The tag number and pin coordinates are presented in Appendix C.

The Year 1 and 2 sediment monitoring activities utilized two sampling methods: 1.) measuring the distance from the top of each sediment pin to the ground surface, and 2.) the "Depth Probe" method, which consisted of taking measurements of the average sediment thickness (distance between the gypsum layer and the sediment surface) adjacent to each sediment pin. Sediment modeling efforts were also attempted in Year 2 but were unfortunately not accurate enough to discern annual variation. It was determined that the depth probe method provided a more accurate picture of pond accretion than taking a single measurement at each sediment pin and performing sediment modeling efforts. Therefore, it was determined that future sampling efforts would exclusively utilize the depth probe method at all sediment pin locations.

This sampling technique has been used successfully at Pond A21 by Dr. John Callaway (University of San Francisco) and Lisa Schile (University of California at Berkeley). The method involves taking multiple measurements of sediment thickness approximately 1 meter away from each sediment pin and sampling in a circular fashion around each pin. Sediment depth is measured by inserting a finely scaled ruler through the fresh mud until the hard gypsum layer is encountered. Eight measurements are taken around each pin to achieve a representative average of the sediment depth in each location.

Per the timeline in the RMMP, the annual sediment monitoring for Year 4 took place on October 9th, 12th, and 26th. Sediment depths could not be measured at pin A1912 in Pond A19, as the pin is on a section of a collapsing creek bank and the gypsum has eroded.

Data generated from the sampling events are presented in both map and graphical form. Eight month, 12 month, 30 month, and 43 months post-breach data are compared to show sediment accretion rates, across each pond, over time.

2.1.2 Levee Breaches

The levee breaches are expected to erode in response to tidal scour, until equilibrium conditions are achieved. The levee breach monitoring was not required in this 4th year of monitoring, however, we thought it would be useful to continue the annual comparison through year 5.

The width of each of the five levee breaches was measured in ArcMap (an ArcView GIS product) using the 2009 aerial photographs. Section 2.1.3 below provides details about the aerial photographs. The width of each breach was measured from east bank to west bank at the centerline of each levee.

2.1.3 Aerial Photography

Aerial photographs were obtained for use in the Year 4 monitoring activities at the Island Ponds. Photographs were taken by an airplane-mounted and calibrated camera to achieve a scale of six inch resolution. Images were captured during the mid-day hours, at low tide on August 10, 2009. The photos were timed to capture peak vegetation production, minimize shadows and glare from sunlight, and maximize visibility of vegetation and tidal channels. Photographs were orthorectified and geo-referenced to ensure spatial comparability from year to year. Images were taken in both color and infrared. The spatial extent of the images included all three Island Ponds as well as the northern and southern banks of Coyote Creek.

2.2 OFF-SITE MONITORING

2.2.1 Fringe Marsh Scour in Coyote Creek

In the RMMP, it was predicted that the larger tidal prism and associated increased velocities created by the breaches at the Island Ponds could result in scour of the fringing marsh along the margins of Coyote Creek and cause erosion of the levees adjacent to the creek. This monitoring task investigates the spatial changes in fringe marsh area and documents changes in the fringing marsh and mudflat interface.

The extent of scour of the outboard fringe marsh along Coyote Creek was investigated by comparing the post-breach aerial imagery from Years 1 and 4. The analysis covered the eastern end of Pond A19 to the western end of Pond A21 and included marsh on both sides of Coyote Creek as well as approximately 200 feet of marsh upstream in Artesian Slough and the Coyote Creek Bypass Channel.

ArcMap was utilized to delineate and depict the marsh boundaries. The 2009 delineation was superimposed over the 2006 and 2008 delineations to highlight any changes in post-breach marsh boundaries and highlight any annual variability. These changes in marsh boundaries were then calculated using ArcMap.

2.2.2 Rail Levee Erosion

On June 23, 2009, a Civil Engineer from the District visually inspected the railway levee and took a series of photographs of the adjacent Pond A20 western levee and Pond A21 eastern levee. These photographs were compared to the Year 1 (2006) photographs to evaluate whether scour is occurring at the pond levees or along the railway levee.

2.2.3 Accelerated Deterioration of the Town of Drawbridge

The RMMP states that Deterioration of the Town of Drawbridge will be assessed visually and that any evidence of accelerated erosion will be reported. The monitoring activities undertaken for this requirement consist of monitoring the integrity of the pond levees adjacent to the Town of Drawbridge. The western levee of Pond A20 and the eastern levee of Pond A21 are monitored to detect any signs of levee erosion which could potentially lead to an undermining of the historical structures.

In 2008, a benchmark and location stakes were installed in the southeast corner of Pond A21 to enable more accurate tracking of erosion advancement along this levee which has been caused by wave action and levee overtopping. An elevation was assigned to the benchmark which references the northwest abutment of the Coyote Creek railroad bridge. (The top of the benchmark is 4.55 ft lower than the bridge abutment.) Location stakes were installed to form a series of eight cross sections along the top of the levee and baseline elevations were gathered immediately adjacent to each stake. Annual site visits obtain elevations at each stake and changes are documented in the annual monitoring reports.

On June 23, 2009, a Civil Engineer from the District walked the Pond A20 and Pond A21 levees adjacent to the Town of Drawbridge, inspecting them for signs of erosion. In addition, the surveying work discussed above was performed to collect surface elevation data at the eight cross section locations.

3.0 MONITORING RESULTS (DISTRICT ACTIVITIES)

This section describes the results of the District's 2009 (Year 4) monitoring activities. The results of the Refuge's monitoring activities are described in Appendix A.

3.1 ON-SITE MONITORING

3.1.1 Substrate Development/Sedimentation

Sedimentation data has been collected at the Island Ponds on 8, 12, 30, and 43-month post-breach intervals. These results are compared to each other to estimate sediment accretion over that period and discern trends within and between ponds (Appendix C). The data are visually presented in the following ways:

1. A map of the ponds depicting the sediment monitoring locations and the average sediment depth 8, 12, 30 and 43-months post-breach at each location (Figure 2).
2. Graphs depicting average sediment accretion, plotted against the distance from the nearest breach (Figures 3 to 8).

All three Ponds have accumulated substantial sediment in the 43 months since they were breached (Figures 2 and 3). Pond A19 had the lowest accretion rates of the three Ponds (Figure 4). After the first year following the levee breaches, Pond A19 accumulated an average of 0.17 feet (52 mm). Accretion rates slowed between 12 and 30 months to 0.05 ft (15 mm) but increased again between months 30 and 43 to an average of 0.09 ft (29 mm). Erosion has occurred around one pin, A1912, which was positioned in a location near a breach where the gypsum layer is cracking and eroding. Two of the fifteen pins in Pond A19 accumulated more than 0.2 ft of sediment (the annual projected accretion rate) since the 30 month post-breach measurements; the depth changes around the other pins ranged from 0 to 0.11 ft. A small reduction in sediment of 0.01 ft was documented around one pin, A1908. The three sediment pins located farthest from the breaches had the lowest deposition rates; however, there was no statistically significant trend between distance from the nearest breach and deposition.

Pond A20 has accumulated the highest average rate of sedimentation of all three Ponds (Figures 3 and 5). During the first year following breach, an average of 0.36 ft (110 mm) of sediment accumulated, and between 12 and 30 months and 30 and 43 months, Pond A20 accumulated an average of 0.28 ft (85 mm), and 0.10 ft (31 mm), respectively. One out of the five pins in Pond A20 accreted more than 0.2 ft between the 30 and 43 month post-breach sampling dates. No significant signs of erosion have occurred in Pond A20, although the accretion rate has slowed over time (Figure 3). Deposition was significantly higher at pins located closest to the breach (R^2 = 0.87, p = 0.02; Figure 6).

Sediment has continually accreted at Pond A21 (Figures 3 and 7). Similar to the other Ponds, deposition was the greatest during the first 12 months (0.28 ft; 85 mm), and slowed between 12 and 30 months (0.19 ft; 58 mm) and 30 to 43 months (0.09 ft; 28 mm). One out of the ten sediment pins accreted more than 0.2 ft of sediment in Pond A21 between the 30 and 43 month post-breach sampling dates. No signs of erosion were detectable around any of the sediment pins in Pond A21; although the small strip of land enabling access to pin A2105 is no longer covered in gypsum and is eroding. Pins located closest to the breaches had greater deposition than pins away from the breaches (R^2 = 0.46, p = 0.03; Figure 8), excluding pin A2110, which had significantly greater deposition than any other pin across all Ponds.

3.1.2 Levee Breaches

The excavated breaches in the levees and outboard marshes were designed to have the same top width (40 feet), bottom width (6 feet), and invert elevations (2.7 feet NAVD88). Side slopes were variable due to large height differences between the top of the levee and the design invert (average difference of 7.0 feet), as well as smaller height differences between the top of the marsh and the design invert (average difference of 2.5 feet) (SCVWD, 2006a, b).

The 2009 aerial photographs were analyzed and the current width of each breach was compared to the 2006 widths (Table 3-1). The two breaches at Pond A19 continued to scour in 2009 but at a slower rate than previous years (A19 East: scoured 7 feet in 2009, 18 feet in 2008 and 12 feet in 2007; A19 West: scoured 2 feet in 2009, 4 feet in 2008 and 6 feet in 2007). The breach at Pond A20 did not show additional signs of scour in 2009. The west breach of Pond A21 scoured by one additional foot in 2009, while the east breach remained stagnant from 2008 to 2009.

Table 3-1. Breach Widths (feet)

Breach	Breach Widths 2006*	Breach Widths 2007	Breach Widths 2008	Breach Widths 2009	Breach Widening 2006-2009
A19 East	110	122	140	147	37
A19 West	22	28	32	34	12
A20	76	82	89	89	13
A21 East	32	37	45	45	13
A21 West	76	79	95	96	20

*number inclusive of constructed width and subsequent breach widening, 6 months post-breach in 2006

3.2 OFF-SITE MONITORING

3.2.1 Fringe Marsh Scour in Coyote Creek

The fringe marshes of Coyote Creek that are adjacent to the island ponds are showing signs of scour in some locations and accretion in others (Figures 2). Total marsh loss since 2006 is 0.96 acres, and total marsh accretion is 0.48 acres. The north bank of Coyote Creek is showing more accretion than the south bank with 0.32 acres and 0.16 acres of accretion respectively. The south bank is showing more signs of scour than the north bank with 0.52 acres and 0.44 acres of scour respectively. Collectively (i.e., calculating scour minus accretion) the north bank has lost 0.12 acres of marsh, while the south bank has lost 0.36 acres.

The breaches appear to be having no localized effect on the levees opposite the island ponds. Ponds A15, A17, and A18 levees were evaluated by both visual inspection and by comparing the 2006 and 2009 aerial images. The outboard marshes adjacent to these levees are providing a buffer from any scour that could potentially undermine these existing levees.

3.2.2 Rail Levee Erosion

The June 23, 2009 field inspection revealed no apparent signs of rail levee erosion or erosion of the adjacent Pond A20 levee. However, the southeast corner of the Pond A21 levee has lost additional earthen material; see Section 3.2.3 for details. Appendix B-1 provides a comparison of the 2006 and the 2009 photographs of the rail levee and the adjacent Pond A20 and A21 levees.

3.2.3 Accelerated Deterioration of the Town of Drawbridge

In previous years, it was observed that overtopping had occurred on the southeast levee of Pond A21, located adjacent to the railroad alignment and near several Town of Drawbridge structures. In December 2008, a surveyed benchmark was installed to assist with collecting surveying measurements and enable more accurate tracking of erosion advancement along this levee from wave action and levee overtopping.

On June 23, 2009, District staff performed basic surveying work to collect surface elevation data at the 8 cross sections previously identified in December 2008. The data collected is shown in Appendix B-2. A comparison of the data collected in June 2009 and December 2008 shows very little change in the surface elevations at this location. However, other measurements taken at this location show a loss of material along the inboard slope of Pond A21. This slope consists of a vertical edge, approximately 2 - 3 feet in height, with debris, slumped material, and newly growing pickleweed along the toe. The offset measurements taken in this location show an overall reduction in levee width. The loss of material ranges from a few inches to almost 1.5 feet at one of the cross sections. These measurements confirm that there has been some deterioration of the inboard slope during the 7 months between the 2008 and 2009 surveys.

In addition, visual observations of the site reveal that a large deposition of debris has collected in the southeast corner of the pond, along the inboard levee slope. The debris was made up of decaying vegetation, litter and other floating objects. Since this observation occurred on a single site visit, it is unclear whether or not this debris has contributed and will continue to contribute to future slope erosion (wave break) or if the debris is a temporary condition.

4.0 DISCUSSION (DISTRICT ACTIVITIES)

Across all three ponds, sediment has continued to accumulate 43 months post-breach, indicating that subsided ponds have the potential for rapid sediment accumulation and substrate development. Sediment accumulation rates remain higher in Ponds A20 and A21 than in A19, though rates in A19 appear to have increased between the 30 and 43 month sampling dates. Regardless, sedimentation rates in all Ponds have far exceeded sedimentation rates in natural salt marshes in the South Bay (3-4 mm/yr at Greco Island, John Callaway, personal observations since 2000). Roughly 23% of the pin locations in the Ponds have exceeded the accretion prediction for year 3 (0.6 ft), a decrease from more than 33% of the pins which exceeded the year 2 projection (0.4 ft). Sediments are beginning to consolidate and form acceptable substrate for vegetation colonization in some parts of the Ponds, while in other areas, the sediment remains soupy and mudders are required to access pins.

Previous studies have shown that sedimentation rates slow as restored areas reach higher elevation (including data from Pond A21 collected by Callaway for the State Coastal Conservancy). The reduction in deposition rates at the Island Ponds support the hypotheses of Krone (1987) and French (1993), which state that areas at higher elevations experience shorter periods of inundation and therefore accumulate less sediment. Vertical or volumetric measurement of sediment accumulation may also accentuate this reduction over time, as previously deposited sediment consolidates and compacts. Measuring the bulk density of accumulated sediment would give additional insight into these dynamics. This may be especially important because it appears that vegetation, especially pickleweed, establishes successfully primarily in sediments that are relatively consolidated.

The Ponds appear to be at the high end of sediment accumulation rates (especially ponds A20 and A21), and this may be a result of their proximity to the south end of San Francisco Bay where re-suspended sediment from local mudflats is carried into the Ponds by wind and wave action. This effect may be attenuated upriver in Pond A19, accounting for the slower sedimentation rate in this Pond. Pond A19 is also considerably larger than the other Ponds and could have a smaller tidal prism, which would restrict the amount of water and, thus, sediment, entering the Pond. Measuring suspended sediment concentrations in Ponds and in the water entering through the breaches could provide more insight into the disparity between sedimentation rates at A20/A21 and A19. Although the high rates of sedimentation at these Ponds may indicate that rapid restoration of salt ponds is possible in the South Bay, it should be noted that there is historical evidence that the shallow subtidal areas south of the Dumbarton bridge, like Ponds A19-A21, are generally depositional, while other areas in the South Bay may be erosional or oscillate between depositional and erosional states (Foxgrover et al. 2004, Jaffe and Foxgrover 2006). Restoration projects in other regions of the South Bay may not accumulate sediment as quickly as the Island Ponds.

As more salt pond levees are breached for restoration efforts, it will be important to understand South Bay sediment dynamics and the impacts of multiple pond breaches in proximity and also the fate of gypsum in these Ponds. The gypsum layer remains intact underneath the developing marsh plain in all three Ponds.

However, all three Ponds are showing some thinning and break down of gypsum on the channel edges and some gypsum thinning in areas of small channel development on the developing marsh plain.

Analyses of the 2009 aerial photographs confirm that both levee breaches at Pond A19 have continued to widen since 2006. Pond A20 and Pond A21 have shown minimal to no additional scour in 2009.

The fringe marshes on both sides of Coyote Creek are showing signs of both scour and accretion in various locations. Since the 2008 measurements, an additional 0.27 acres of fringe marsh scour has occurred, while only 0.08 acres has accreted.

Data collected from 2008 to 2009 indicates there is some deterioration occurring along the southeast levee of pond A21. The inboard levee slope is starting to recede; however, there has been virtually no change to the levee height. Since the timeframe between the two site visits was only 7 months and considering that the 2009 winter season was relatively light, more data is needed to understand the long term prognosis of the erosion occurring at this location. This site will again be monitored in 2010.

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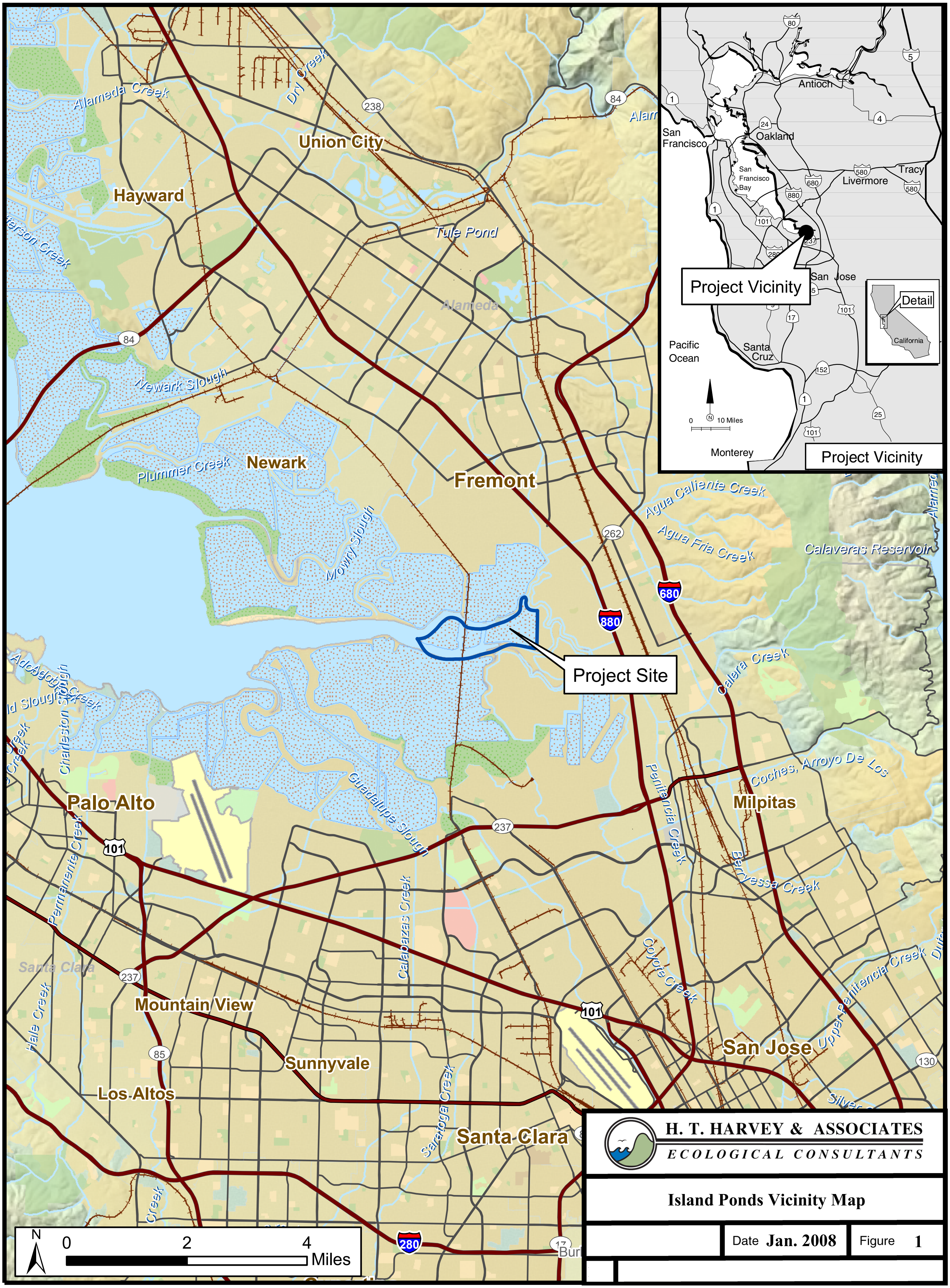
7.0 FIGURES



Alameda Creek
Dry Creek
238
84
Union City
Hayward
Tule Pond
Alameda
Newark Slough
Plummer Creek
Newark
Fremont
Mowry Slough
Agua Caliente Creek
Agua Fria Creek
Calaveras Reservoir
262
880
680
Project Site
Calera Creek
Charleston Slough
Coches, Arroyo De Los
Milpitas
Penitencia Creek
Palo Alto
101
237
Guadalupe Slough
Berryessa Creek
Permanente Creek
Calabazas Creek
Santa Clara
Mountain View
Coyote Creek
Upper Penitencia Creek
Hale Creek
85
Sunnyvale
San Jose
130
Los Altos
Saratoga Creek
Santa Clara
280
0
2
4
Miles
N
80
5
Antioch
1
4
24
San Francisco
Oakland
San Francisco Bay
580
Tracy
680
Livermore
880
101
237
280
Project Vicinity
San Jose
Detail
California
17
Pacific Ocean
Santa Cruz
152
1
25
101
10 Miles
Monterey
Project Vicinity
H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS
Island Ponds Vicinity Map
Date Jan. 2008
Figure 1

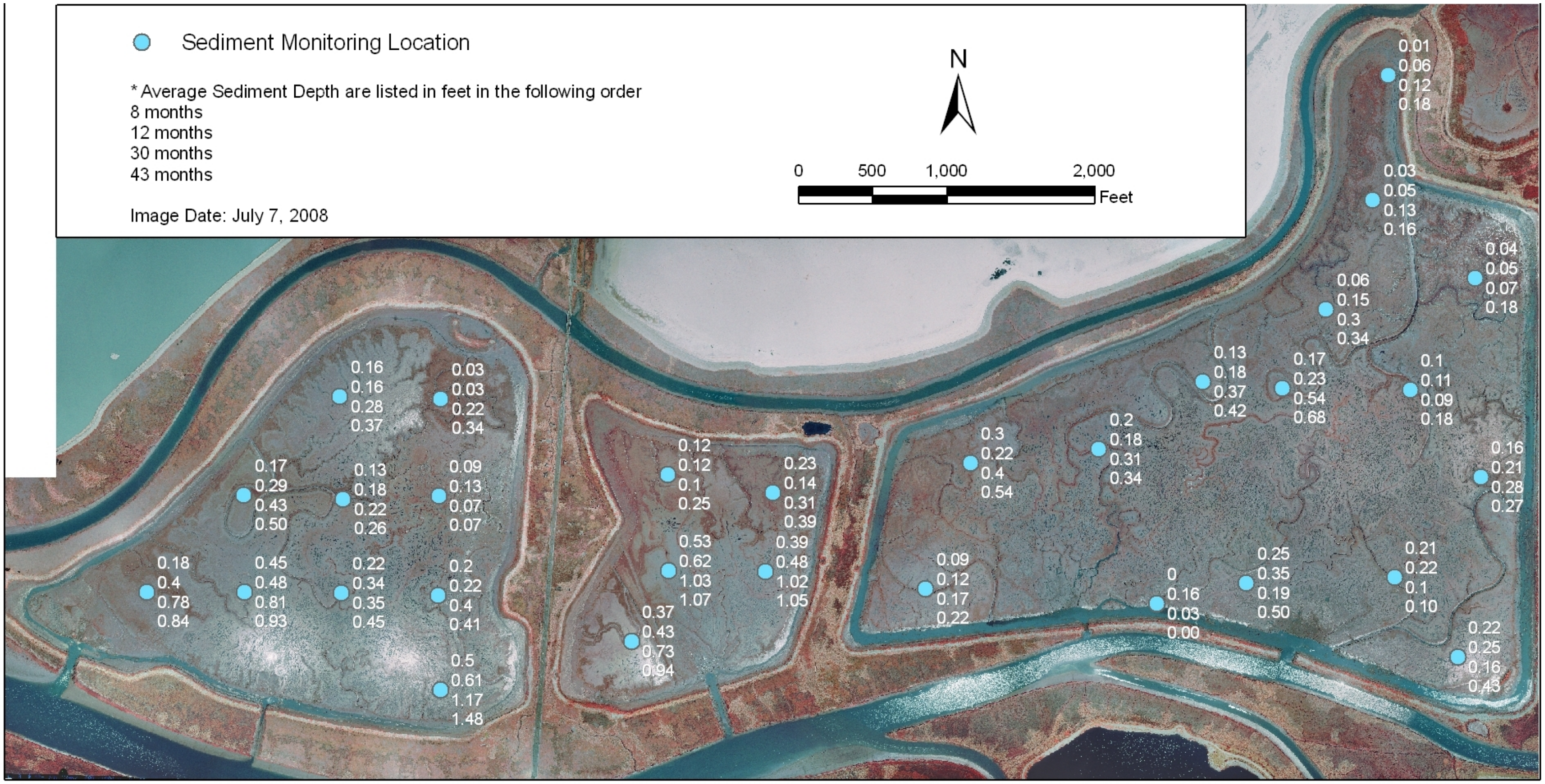


Figure 2. Average sediment depths at 8, 12, 30 and 43 months post-breach.

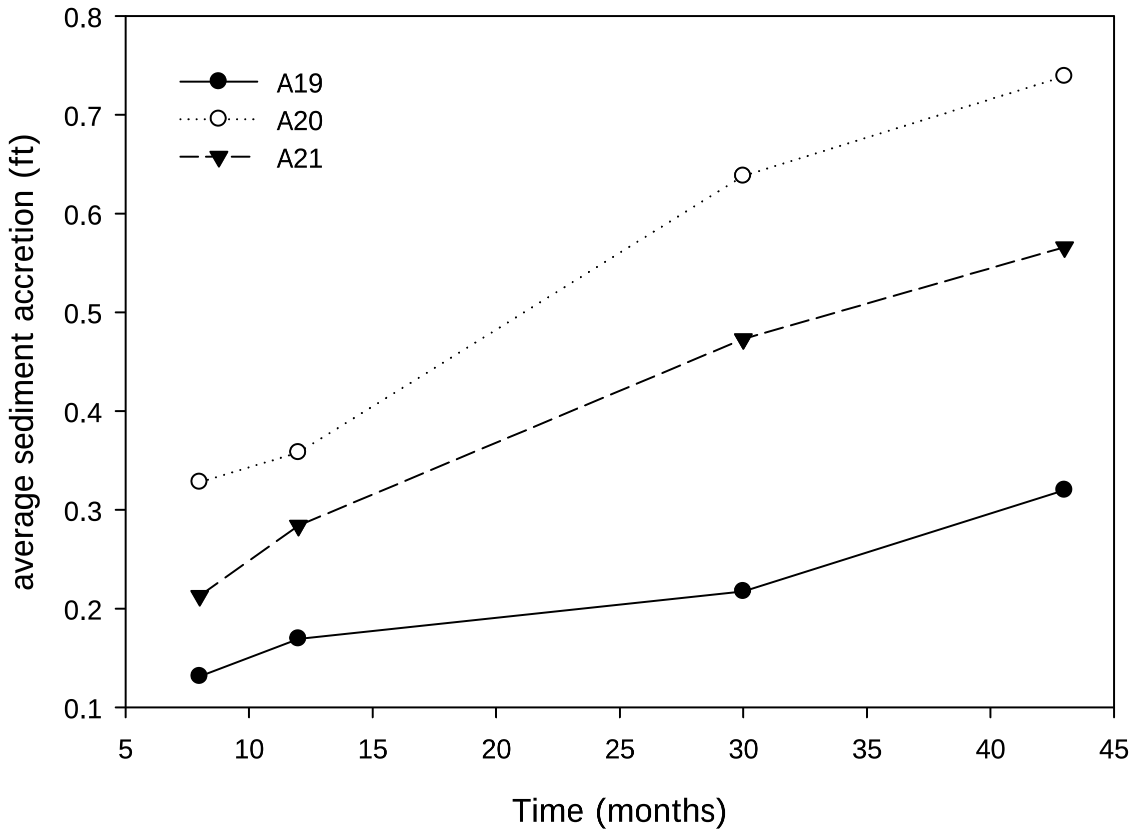


Figure 3. Sediment accretion averaged across all pins increased over time at Ponds A19, A20, and A21 (error bars not shown).

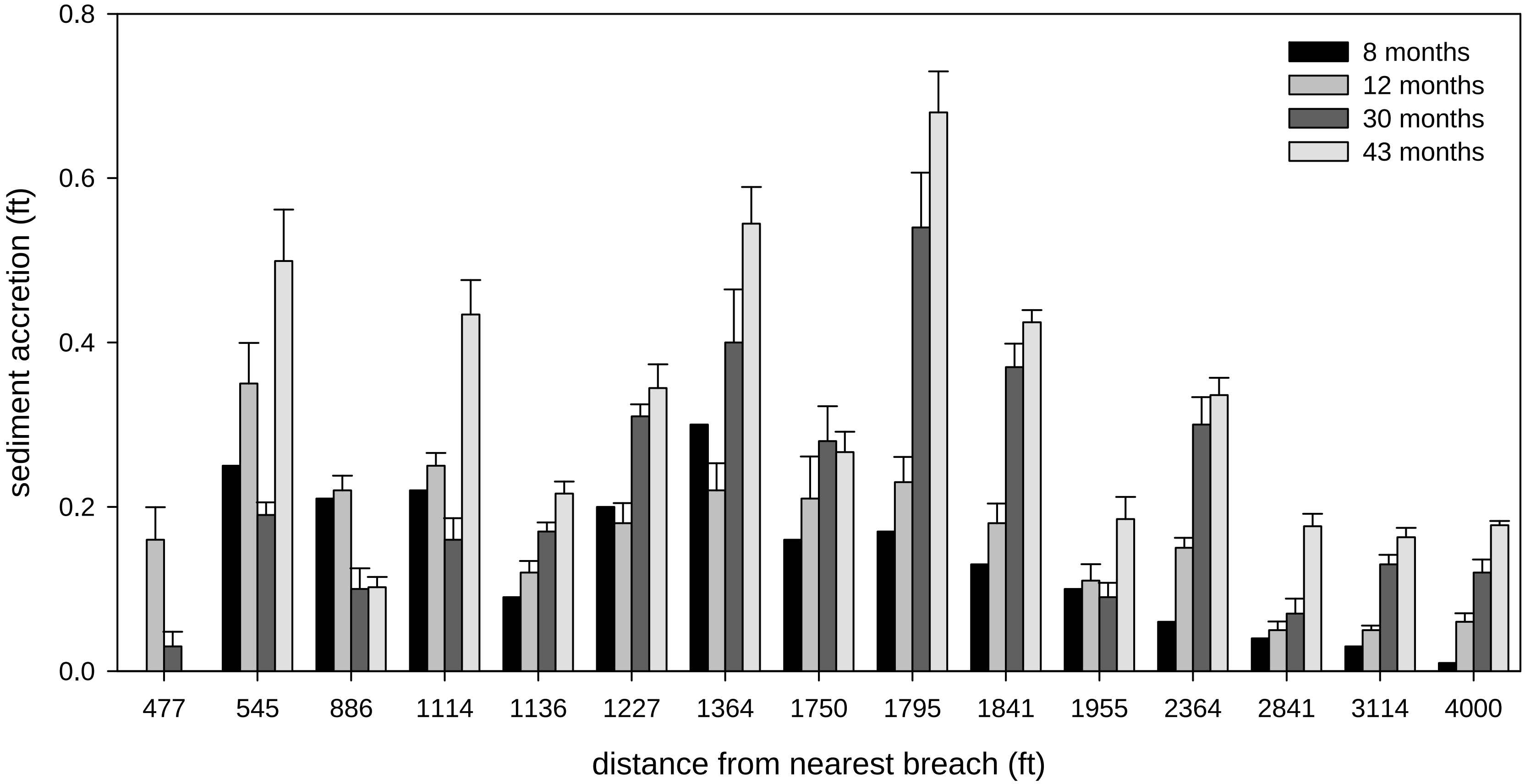


Figure 4. Average sediment deposition over time at each pin location in Pond A19 (error bars represent ±1 standard error; 8 month data represent average of 3 measurements; all other data represent the average of 8 measurements).

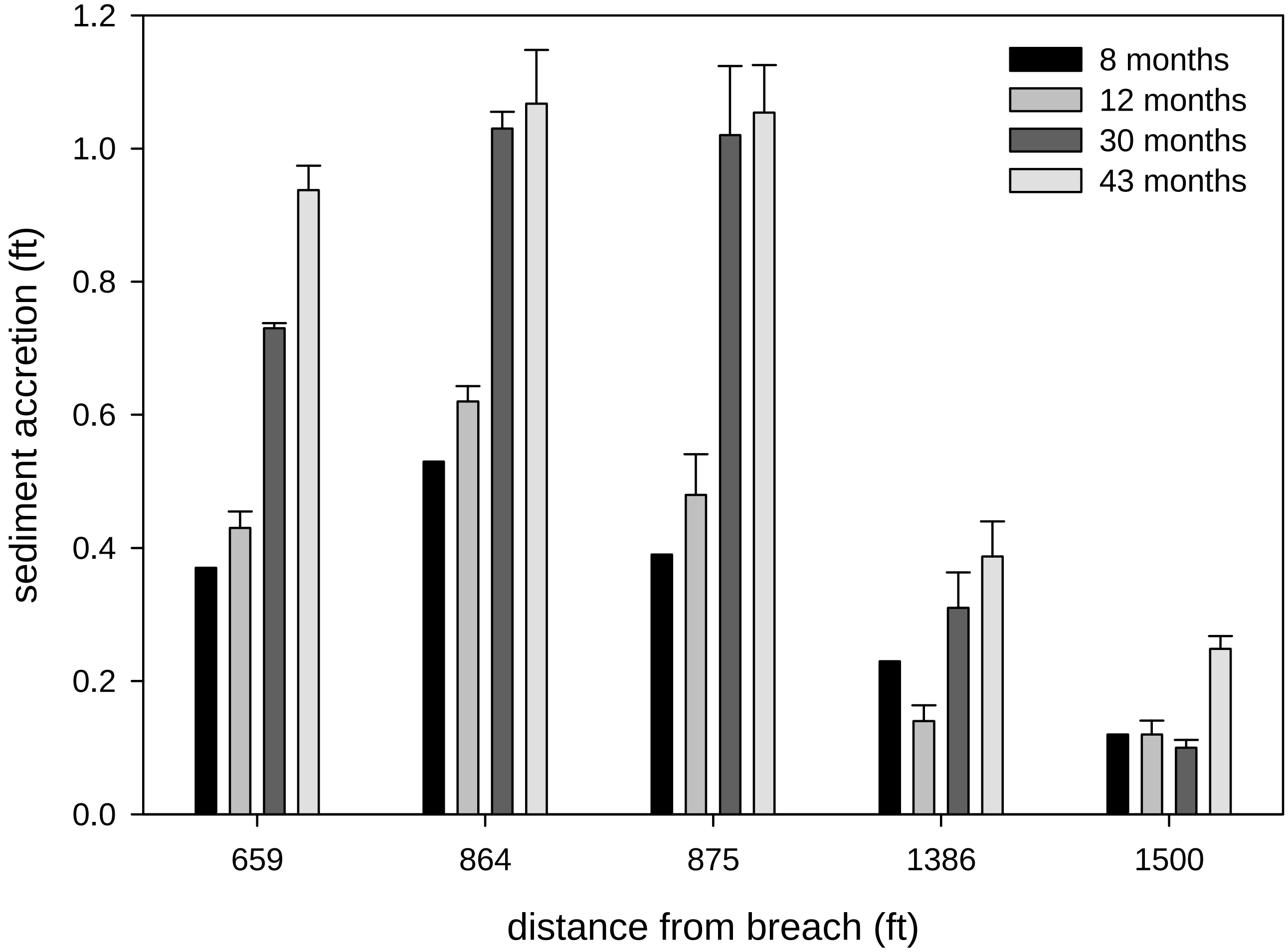


Figure 5. Average sediment deposition over time at each pin location in Pond A20 (error bars represent ±1 standard error; 8 month data represent average of 3 measurements; all other data represent the average of 8 measurements).

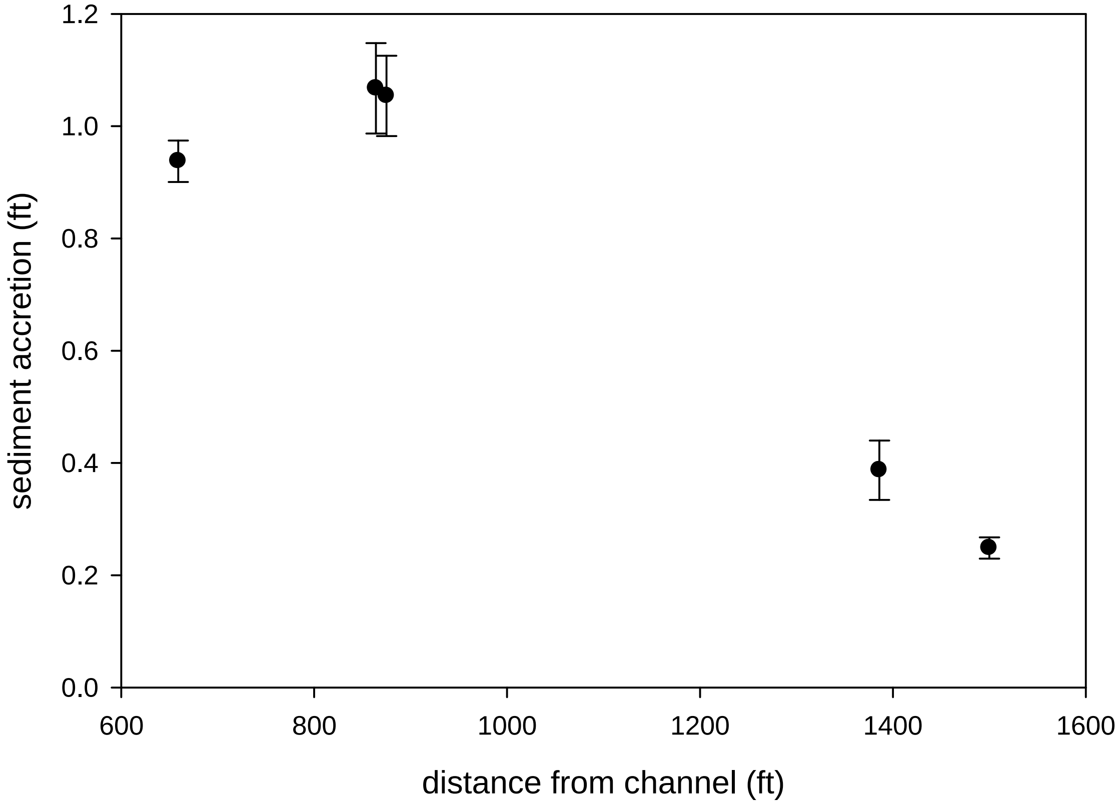


Figure 6. At Pond A20, sediment deposition 43 months post-breach decreased with increasing distance from the breach (error bars represent ±1 standard error).

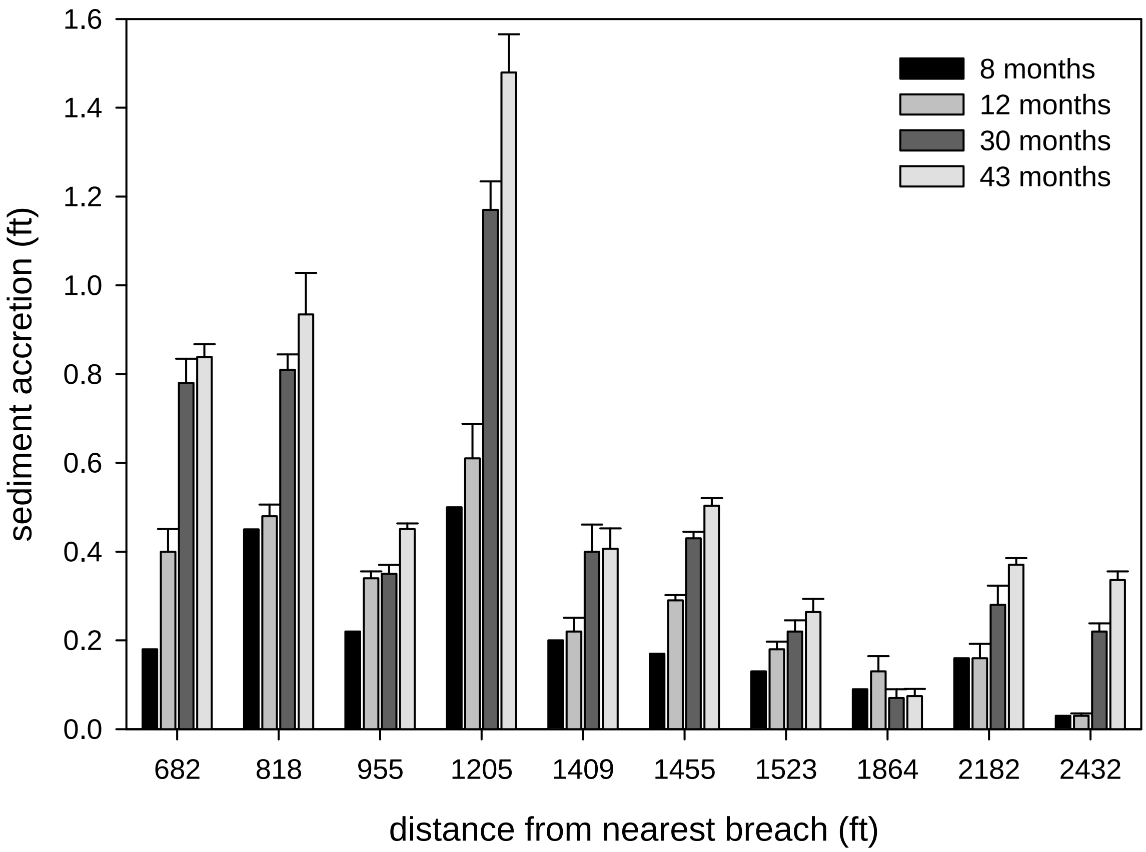


Figure 7. Average sediment deposition over time at each pin location in Pond A21 (error bars represent ±1 standard error; 8 month data represent average of 3 measurements; all other data represent the average of 8 measurements).

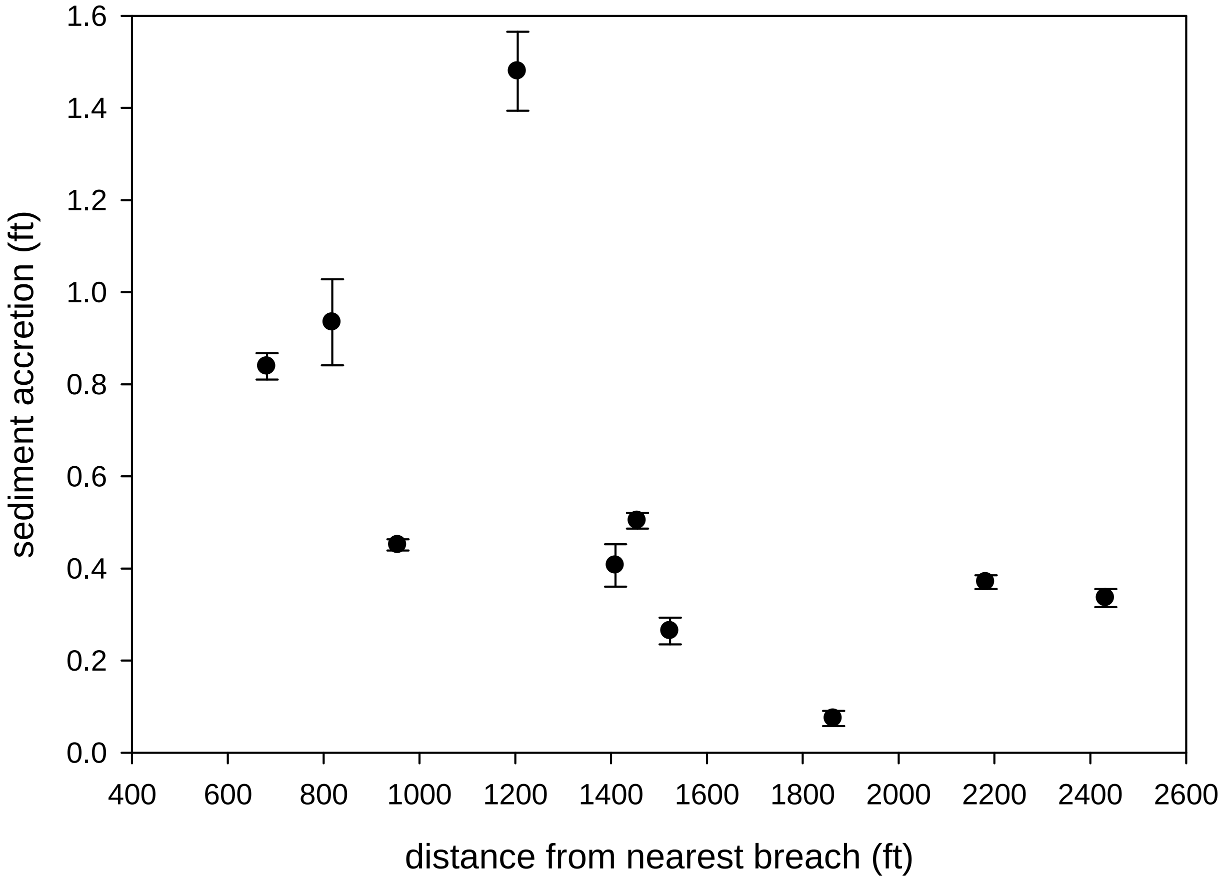


Figure 8. Excluding pin A2110 (point with the largest sediment accretion), sediment depth decreased with increasing channel distance at Pond A21.

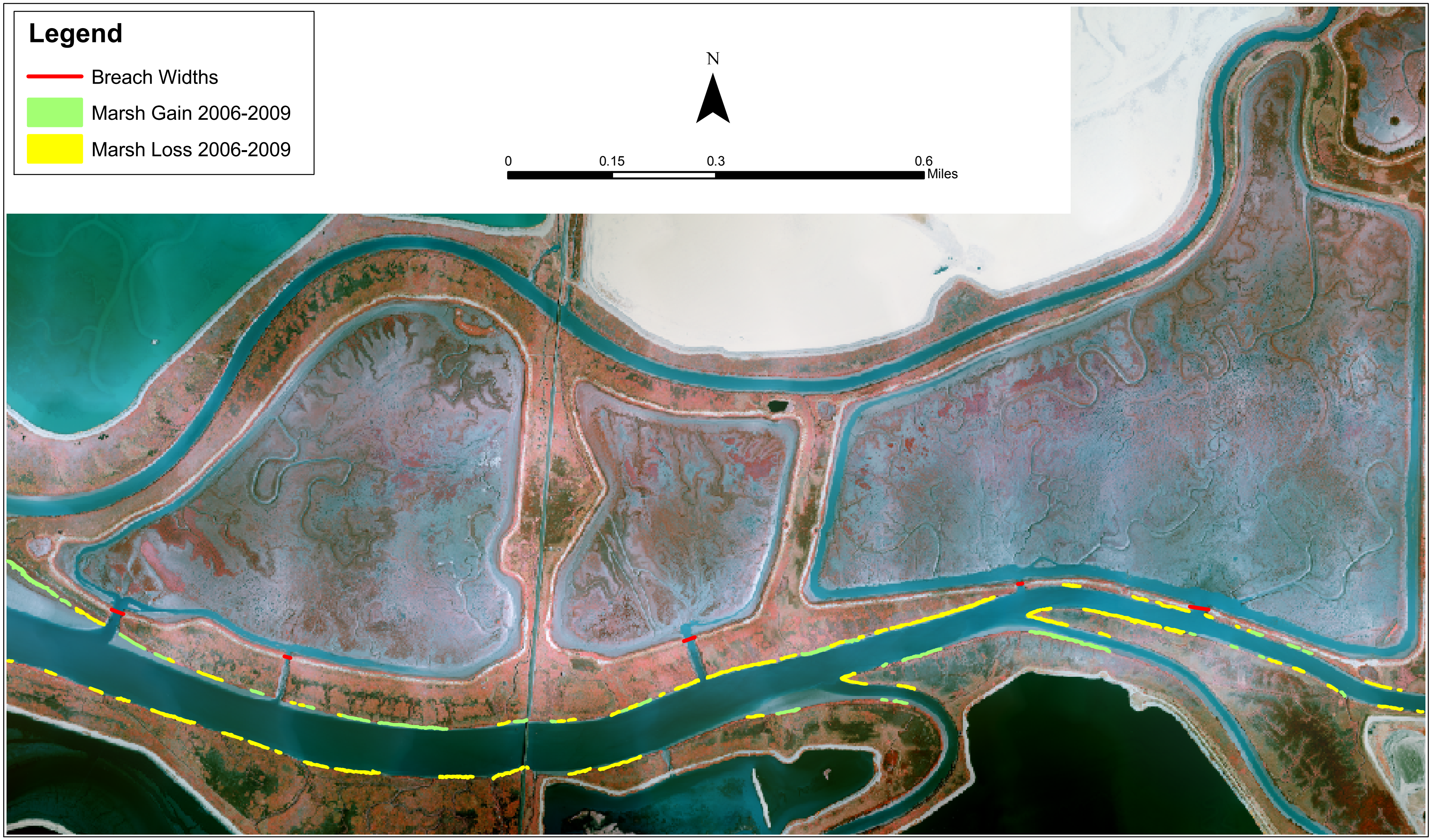


Figure 9. Breach and Fringe Marsh Scour

APPENDIX. A.
REFUGE MONITORING

APPENDIX A

SAN FRANCISCO BAY NWR MONITORING REQUIREMENTS FOR ISLAND PONDS TIDAL WETLAND RESTORATION

San Francisco Bay NWR Monitoring Requirements for Island Ponds Tidal Wetland Restoration Year 4

Summary of Tasks

During Year Four (Y4) of the Island Ponds Tidal Wetland Restoration program, Tasks 5.2.3, 5.2.4, 5.2.6, and 5.2.7 were conducted. The following provides a brief description of these tasks and their Y4 results.

Task 5.2.3: Since the breaching of the Island Ponds, Ponds A19 and A20 have both shown an increase in channel development. In 2009, Island Pond channels were very similar to past years, however, in 2009, some new channels were added the Ponds, increasing channel acreage by about 1 to 3 percent.

Task 5.2.4: Monitoring vegetation establishment is a requirement and was done in 2008, therefore, it was not done in 2009. However, some notes on vegetation establishment were taken during data collection for the sediment measurements and the results are presented in Task 5.2.4.

Task 5.2.6: The Invasive *Spartina* Project (ISP) did not treat invasive *Spartina alterniflora* hybrids in Pond A19, Pond A20 or Pond A21 in 2009

Task 5.2.7: Not enough acreage of marsh vegetation has developed to monitor for California clapper rail and salt marsh harvest mouse, however, monitoring of shorebirds and waterfowl on the Island Ponds indicates that many bird species are utilizing these ponds for foraging and roosting habitat.

Task 5.2.3 – Channel Network Evolution Monitoring

The Channel Network Evolution Monitoring Task (Task 5.2.3) for the Island Ponds is described in the Mitigation and Monitoring Plan (MMP) as follows: "Monitoring will consist of extracting channel planform morphology from the aerial photographs collected periodically and rectified to ensure spatial comparability from photo to photo (see Aerial Photography, Section 5.2.8). Evolution of channel networks will be measured over time. Parameters to be measured include total surface area of channels and areas of expansion and loss. Monitoring results will be incorporated into a table showing, for each pond, the total pond acreage, total channel coverage, and percent of pond as channel. Maps will show the channel network in each year, the change from prior year that an aerial image was taken, and the change from the baseline."

Island Pond channels were very similar to past years. However, in 2009, some new channels were added the ponds, increasing channel acreage by about 1 - 3 percent (Table 1).

Figures 1-3 show the GIS generated channels from previous years along with the new channels added in 2009.

Table 1: Channel Networking in Island Ponds

Year	Pond	Pond Acreage	Total Channel Acreage	Percent Pond as Channel	% Change in Acreage from Previous Year
2006	A19	265	8.74	3.30	
	A20	63	0.85	1.35	
	A21	147	3.02	2.05	
2007	A19	265	8.74	3.30	0
	A20	63	0.85	1.35	0
	A21	147	3.02	2.05	0
2008	A19	265	9.06	3.42	3.64
	A20	63	1.01	1.60	18.52
	A21	147	3.02	2.05	0
2009	A19	265	9.20	3.47	1.55
	A20	63	1.04	1.65	2.97
	A21	147	3.05	2.07	1.0

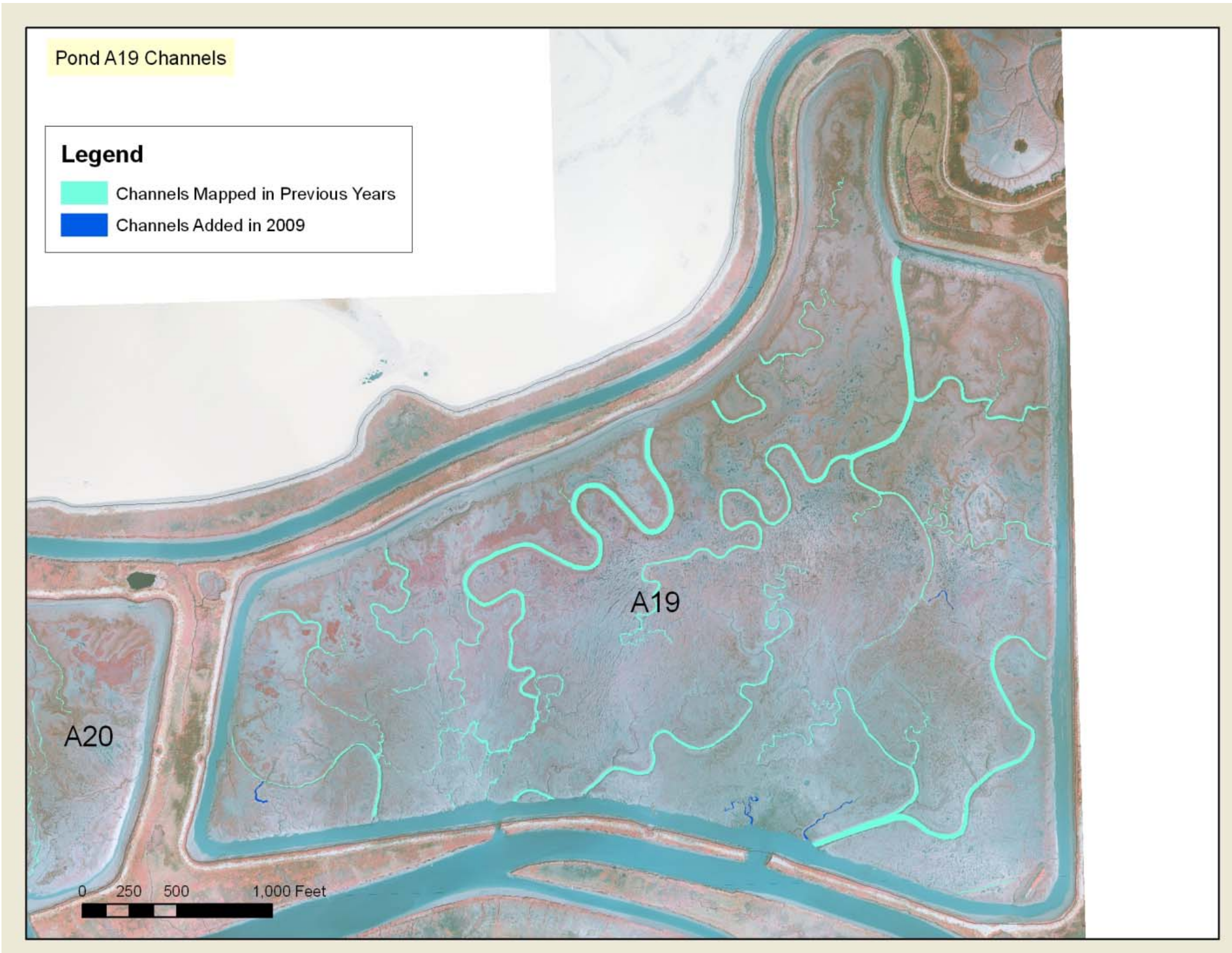


Figure 1: Channel Networking in Pond A19 during 2009 and in Previous Years.

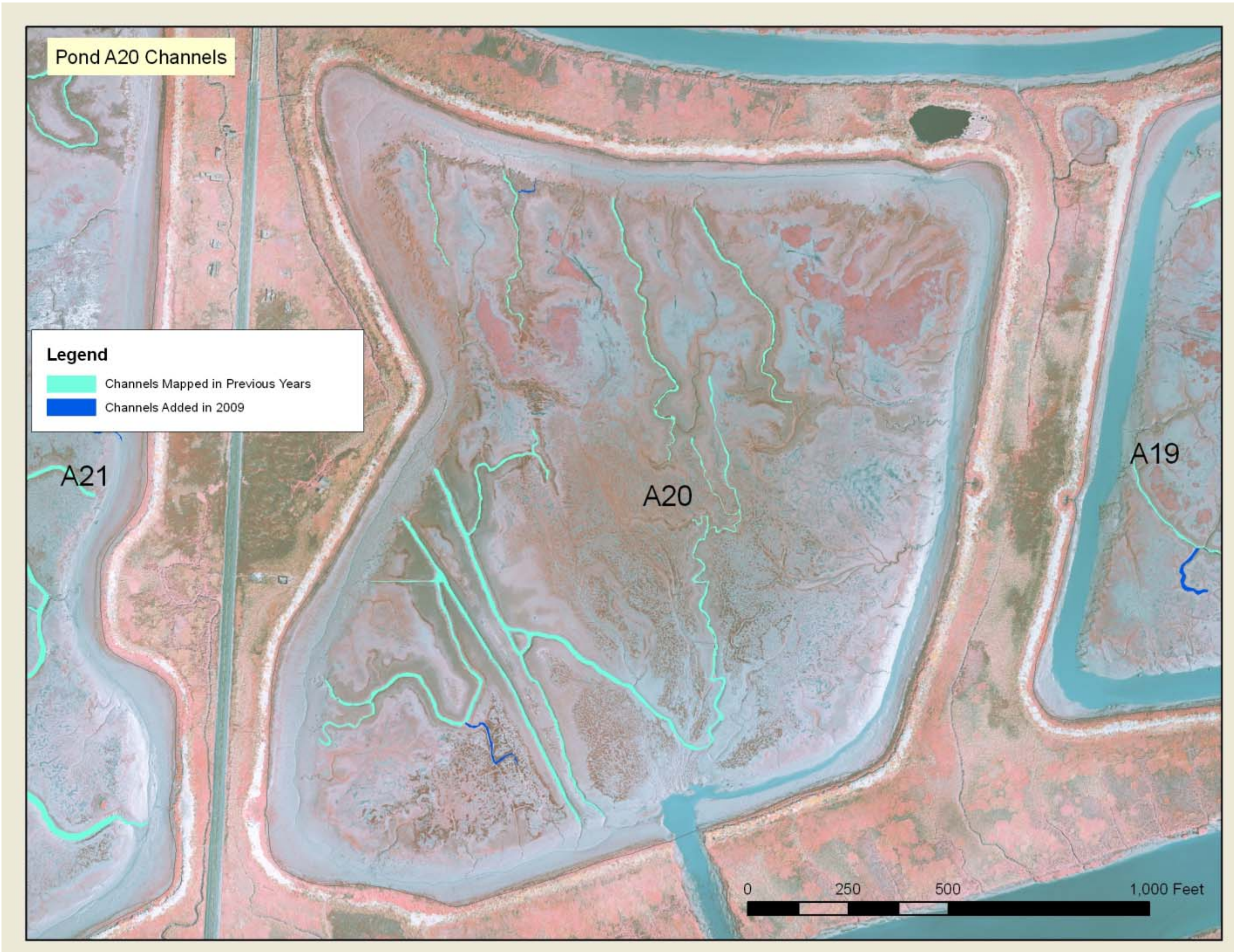


Figure 2: Channel Networking in Pond A20 during 2009 and in Previous Years.

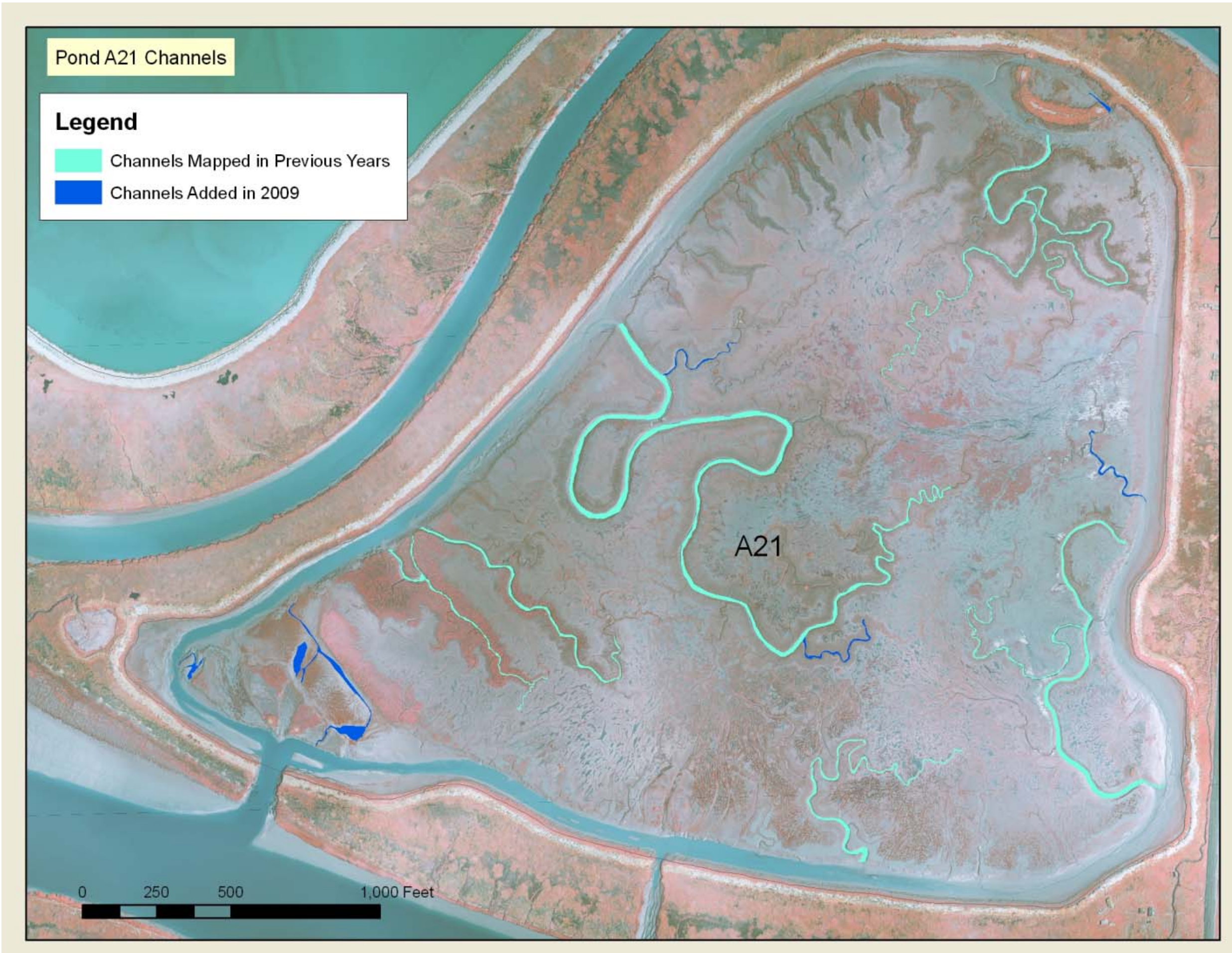


Figure 3: Channel Networking in Pond A21 during 2009 and in Previous Years.

Task 5.2.4 – Native Vegetation Development

The Native Vegetation Development Task (Task 5.2.4) for the Island Ponds is described in the MMP as an evaluation of the "progress in achieving the success criteria for tidal marsh restoration." To do so, vegetation establishment is monitored using aerial photographs and field sampling. This is a biennial requirement and was done in 2008. Therefore, it was not done in 2009. However, some notes on vegetation establishment were taken during data collection for the sediment measurements. The results are presented below:

Vegetation Establishment
(By Lisa Schile, John Callaway and Ellen Herbert)

Methods

At each pin we recorded the presence of vegetation, if any, and estimated cover. Additionally, we took photographs of all pins and the area adjacent to them. Photographs were taken from the south of each pin, facing north.

Results

Vegetation has established at all three Ponds, although Pond A21 has the most vegetation coverage out of all three Ponds. At Pond A19, two of the 15 sediment pins (pins A1901 and A1902) had sparse cover of short *Sarcocornia pacifica* (pickleweed; formerly known as *Salicornia virginica*) nearby. Most, if not all, of the vegetation across the Ponds was highly dispersed and showed signs of over-inundation. No vegetation was recorded around any of the five sediment pins at Pond A20, but *S. pacifica* and *Spartina foliosa* (California cord grass) were documented while visiting the Ponds. Vegetation cover at Pond A21 has increased substantially over the past four years (L. Schile, personal observation). Six of the ten sediment pins had *S. pacifica* growing within 5 m (pins A2101, A2104, A2105, A2107, A2108, and A2109). The majority of the southwest corner of Pond A21 is covered in dense, healthy *S. pacifica* (see Appendix B), and much of the area along the western and northern borrow ditches of this Pond is vegetated. Pickleweed is also colonizing along major channel edges within the western and northern parts of Pond A21, where elevations appear to be slightly higher due to naturally-formed levees. Large stands of *S. foliosa* are also evident across the central and southern regions of this Pond, ranging in size from one plant to a solid stand, 5 meters in diameter.

Discussion

Vegetation has colonized all three Ponds. The majority of vegetation that we observed in Ponds A20 and A19 was recently established pickleweed (*S. pacifica*) seedlings, sparsely distributed across areas of consolidated sediment. There were also small patches of *S. foliosa* and several *Atriplex triangularis* seedlings. Pickleweed establishment has been most successful at Pond A21, possibly due to combination of rapid substrate development near the breaches and substantial consolidation of sediment at this Pond. Pickleweed establishment at all Ponds seems to correspond with consolidated sediment and the formation of natural levees along the creek edges, indicating that the natural berms observed in natural salt marshes are forming in the newly restored Ponds.

Finally, there were photos that were taken using a kite-mounted camera in 2007, 2008 and 2009. See Figures 4, 5 and 6 of Pond A21 to illustrate the dramatic increase in vegetative cover.

Task 5.2.6 – Invasive Plant Species Establishment

The Invasive Plant Species Establishment Task (Task 5.2.6) is described in the MMP as follows: “Colonization of the Island Ponds restoration site by non-native invasive species would jeopardize the success of the Island Ponds mitigation and restoration. Many of the important ecological benefits of restored tidal marsh vegetation will not be provided by invasive species. In particular, invasive non-native plant species may prevent establishment of native tidal marsh vegetation. Annual monitoring for invasive smooth cordgrass and its hybrids will occur for the duration of the mitigation project (i.e., until vegetation covers 75% of 75 acres). This effort will provide early detection and trigger prompt control efforts, before invasive cordgrass can dominate any portion of the Island Ponds. Other non-native plant species that may occur with increasing frequency in high marsh zones include Perennial Peppergrass, Russian thistle (*Salsola soda*), and New Zealand spinach (*Tetragonia tetragonioides*). Observations of these and other non-native species will be recorded during the aerial photo monitoring and field-truthing, conducted under the native vegetation development section (see Section 5.2.4).”

The ISP did not treat invasive *Spartina alterniflora* hybrids in Pond A19, Pond A20 or Pond A21 in 2009. Results from one sample taken from Pond A19 in 2008 was determined to be a native Spartina foliosa (Erik Grijalva - ISP, pers. comm.). While there are invasive species such as *Lepidium latifolium* (Perennial Pepperweed) atop the levee and the outboard marshes, no invasive species were confirmed inside the Island Ponds during Y4.

Task 5.2.7 – Wildlife Monitoring

The Wildlife Monitoring Task (Task 5.2.7) for the Island Ponds is described in the Mitigation Monitoring Plan as follows: “The Initial Stewardship Project anticipates that restoration of the Island Ponds to tidal marsh will provide long-term ecological benefits to native birds (particularly California clapper rails) and mammal species (particularly salt marsh harvest mice). In addition, the Santa Clara Valley Water District (SCVWD) has chosen presence of California clapper rail as a performance criterion to measure success of their SMP mitigation requirements. Although there are no performance criteria or success criteria associated with the presence of other wildlife species, the project partners agreed it was prudent to incorporate a wildlife component into this monitoring program. Monitoring for bird and mammal species will reveal whether restoration of tidal exchange at the Island Ponds produce the anticipated benefits to native wildlife species.”

Figure 4: Pond A21 Vegetative Cover in April 2007 and September 2009.

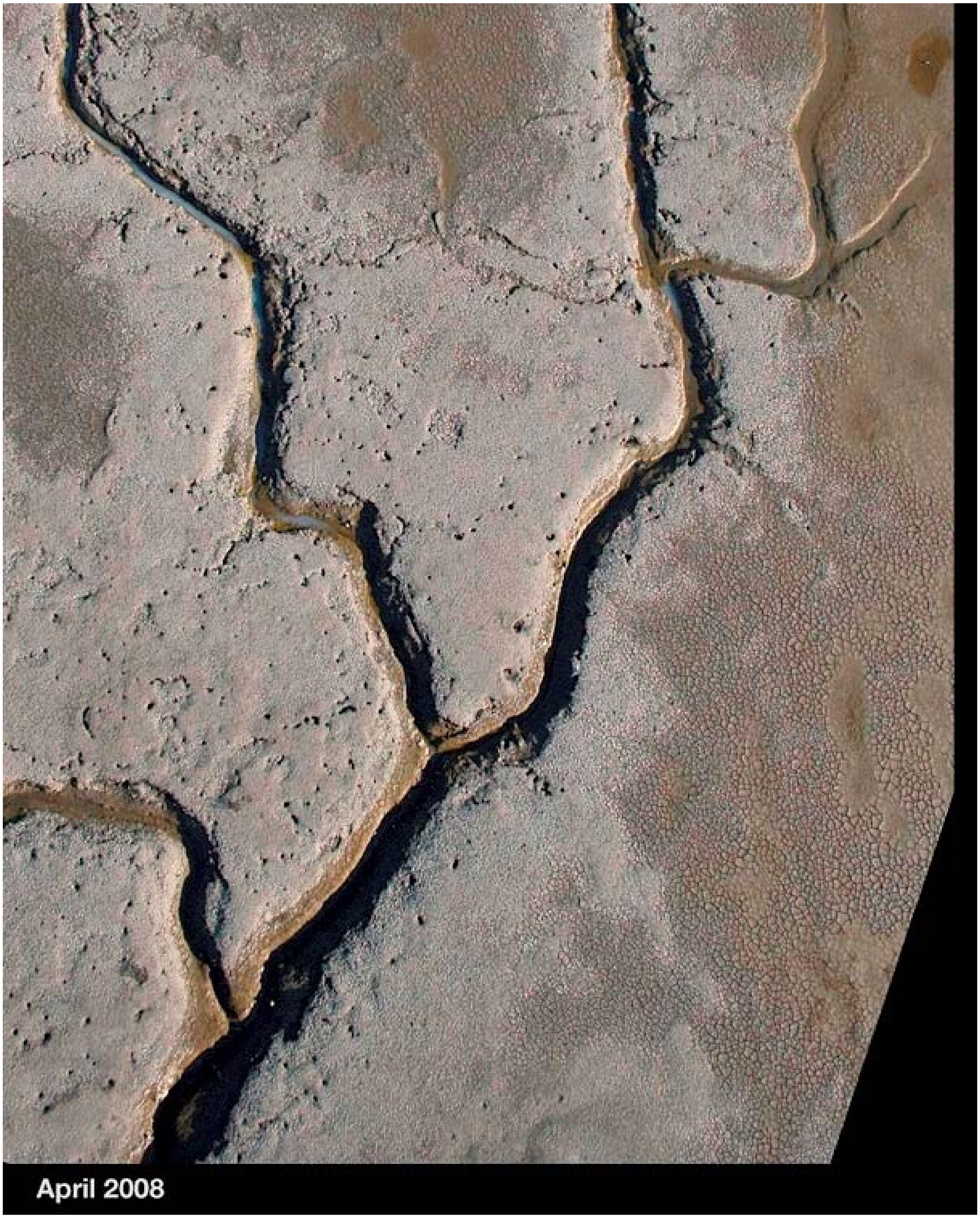


Figure 5: Pond A21 Vegetative Cover in April 2008.

Figure 6: Pond A21 Vegetative Cover in September 2009.

A) California clapper rail monitoring – The Refuge will monitor for California clapper rail within the Island Ponds as soon as 30 acres of native vegetation develop. As of Y4, there was not enough suitable habitat available for the California clapper rail.

B) Salt marsh harvest mouse monitoring – The Refuge will monitor for salt marsh harvest mice in the Island Ponds as soon as five acres of contiguous suitable habitat develop. As of Y4, there was not enough suitable habitat available for the salt marsh harvest mouse.

C) Waterfowl and shorebird species – The U.S. Geological Survey (USGS) has been counting waterbirds at the Island Ponds monthly since October 2002 (with the exception of September 2005) and will continue to do so until five years after the first breach. Before the ponds were breached, their standard protocol was to conduct counts within three hours of high tide when bird numbers in ponds would be at their peak (Takekawa et al. 2005, 2006). After the Island Ponds were breached in March 2006, USGS conducted monthly low tide surveys in addition to the high tide surveys to document changes in bird-use coincident with changing water levels and habitat evolution (Takekawa et al. 2006).

Birds were identified to species with the exception of some similar species that cannot be readily distinguished in the field (e.g., dowitchers and scaup). To facilitate analysis of bird species with similar habitat requirements, USGS assigned species to foraging guilds (Takekawa et al. 2005, 2006). These included: 1) dabbling ducks – e.g., northern shovelers (*Anas clypeata*); 2) diving ducks – e.g., ruddy ducks (*Oxyura jaimaicensis*); 3) eared grebes (*Podiceps igricollis*); 4) fish eaters – e.g., double-crested cormorants (*Phalacrocorax auritis*); 5) gulls – e.g., ring-billed gulls (*Larus delawarensis*); 6) herons – e.g., great egrets (*Ardea alba*); 7) medium shorebirds – e.g., marbled godwits (*Limosa fedoa*); 8) phalaropes – e.g., Wilson's phalaropes (*Phalaropus tricolor*); and 9) small shorebirds – e.g., western sandpipers (*Calidris mauri*).

Since the breach of the Island Ponds in March 2006, overall waterbird use has increased in almost all guilds of birds with the exception of eared grebes. The decline in eared grebe use can be attributed to a loss of high-salinity foraging areas when the Island Ponds were changed from salt making ponds into tidal ponds. Use of the Island Ponds by dabbling ducks continued to increase in 2009 during high tide surveys while numbers of small and medium shorebirds and gulls and tern decreased. Numbers of small and medium shorebirds increased during low tide surveys, however. The decline in the numbers of birds in the gulls and tern guild could be due to abatement measures taken at the landfills adjacent to these ponds rather than to any process occurring within the ponds themselves.

Tables 2 - 4 document the monthly totals of waterbird use at the Island Ponds during high and low tide surveys from January to December 2009.

Table 2: Monthly totals of waterbird-use during high and low tide surveys at Pond A19.

Pond #	Tide height	Survey date	Dabbling Ducks Total	Diving Ducks Total	Eared Grebes Total	Fish-Eaters Total	Geese Total	Gulls & Terns Total	Herons Total	Medium Shorebirds Total	Small Shorebirds Total	Grand Total
A19	High	1/22/2009	807	75		2		99	2			985
		2/19/2009	1198	78			5	466	7	793	110	2657
		3/31/2009	2187	30			8	599		171	16	3011
		4/27/2009	140	26				81	1		45	293
		5/26/2009	58			10	6	67	2	81		224
		6/23/2009	50			73	9	24	3	50		209
		7/21/2009		8			9		1			18
		8/21/2009						11	1			12
		9/18/2009	2939					4	3			2946
		10/28/2009	1023	9				10		150		1192
		11/16/2009	656	105				140				901
		12/9/2009	1113	283		103		22	15			1536
	High Total		10171	614		188	37	1523	35	1245	171	13984
	Low	1/22/2009	66				2	1469		857		2394
		2/19/2009					3	2371		507		2881
		3/31/2009	2	1			227	495		58	35	818
		4/27/2009	2				395	164			346	907
		5/26/2009	8					181				189
		6/23/2009	6			41		91		75		213
		7/21/2009				80		221		131	1	433
		8/21/2009	32					165	8	926	426	1557
		9/18/2009	189					651	1	1036	94	1971
		10/30/2009	176	45				2083	1	231	176	2712
		11/16/2009	428	2				1308	2	595	67	2402
		12/9/2009	78					1		824	65	968
	Low Total		987	48		121	627	9200	12	5240	1210	17445
A19 Total			11158	662		309	664	10723	47	6485	1381	31429

Table 3: Monthly totals of waterbird-use during high and low tide surveys at Pond A20.

Pond #	Tide height	Survey date	Dabbling Ducks Total	Diving Ducks Total	Eared Grebes Total	Fish-Eaters Total	Geese Total	Gulls & Terns Total	Herons Total	Medium Shorebirds Total	Small Shorebirds Total	Grand Total
A20	High	1/22/2009	666	45				2				713
		2/19/2009	302	11			1	9		102	3	428
		3/30/2009	907	22			7	80		53		1069
		4/27/2009	92	6		1				1		100
		5/26/2009	21	2		2		1				26
		6/23/2009	6			1		1				8
		8/21/2009						5	1			6
		9/18/2009	252						2	333	133	720
		10/28/2009	348									348
		11/16/2009	454	44				3				501
		12/9/2009	916	46				33		119		1114
	High Total		3964	176		4	8	134	3	608	136	5033
	Low	1/22/2009						112		94		206
		2/19/2009					2	402		90		494
		3/30/2009					9			21		30
		4/27/2009	2				10	30		1	10	53
		5/26/2009	4					13		2		19
		6/23/2009						9		15		24
		7/21/2009						114		47		161
		8/21/2009						61	2	127	87	277
		9/30/2009	12					136		128	9	285
		10/30/2009	40					204	1	92	26	363
		11/16/2009	70					887	1	84	58	1100
		12/9/2009	71					20		287	85	463
	Low Total		199				21	1988	4	988	275	3475
A20 Total			4163	176		4	29	2122	7	1596	411	8508

Table 4: Monthly totals of waterbird-use during high and low tide surveys at Pond A21.

Pond #	Tide height	Survey date	Dabbling Ducks Total	Diving Ducks Total	Eared Grebes Total	Fish-Eaters Total	Geese Total	Gulls & Terns Total	Herons Total	Medium Shorebirds Total	Small Shorebirds Total	Grand Total
A21	High	1/22/2009	922	162		3		49	2	115		1253
		2/19/2009	762	114			7	94	3	477	74	1531
		3/30/2009	983	29			5	1116	3	70		2206
		4/27/2009	169	5		14	1	1	7	65	1900	2162
		5/26/2009	41					10	16	54		121
		6/23/2009	10			16		10	5	294		335
		7/21/2009						1	3	187		191
		8/21/2009	3			3		23	1			30
		9/18/2009	2933					4	20	410	30	3397
		10/28/2009	1079		5			257		365		1706
		11/16/2009	2958	41					1	1		3001
		12/9/2009	1267	316				136	1	583	30	2333
	High Total		11127	667	5	36	13	1701	62	2621	2034	18266
	Low	1/22/2009	95					569		200		864
		2/19/2009					255	1920		45		2220
		3/30/2009					7	146		40		193
		4/27/2009	2				1	3		2	95	103
		5/26/2009	1	1				11		1		14
		6/23/2009						43	5	94		142
		7/21/2009						8	5	236	103	352
		8/21/2009						2	2	304	619	927
		9/30/2009	29					1		427	168	625
		10/30/2009						370		158	38	566
		11/16/2009	646	2				447		357	66	1518
		12/9/2009	67							763	135	965
	Low Total		840	3			263	3520	12	2627	1224	8489
A21 Total			11967	670	5	36	276	5221	74	5248	3258	26755

References:

Takekawa, J. Y., A. K. Miles, D. H. Schoellhamer, B. Jaffe, N. D. Athearn, S. E. Spring, G. G. Shellenbarger, M. K. Saiki, and F. Mejia. 2005. South Bay Salt Ponds Restoration Project Short-term Data Needs, 2003-2005. Unpubl. Draft Final Rep., U. S. Geological Survey, Vallejo, CA. 267 pp.

Takekawa, J. Y., N. D. Athearn, B. Hattenbach, and A. K. Schultz. 2006. Bird Monitoring for the South Bay Salt Pond Restoration Project. Unpubl. Final Prog. Rep., U. S. Geological Survey, Vallejo, CA. 85pp.

APPENDIX B.
PHOTOGRAPHS

APPENDIX B-1.
RAIL LEVEE PHOTOGRAPHS

APPENDIX B-1
RAIL LEVEE PHOTOGRAPHS
2006 VS. 2009

Photo 1. Pond A21 Levee located west of Rail Levee, view looking north - July 13, 2006.

Photo 2. Same location as above – June 23, 2009.

Photo 3. Pond A21 Levee located west of Rail Levee, view looking south – July 13, 2006.

Photo 4. Same location as above – June 23, 2009.

Photo 5. West Rail Levee adjacent to Pond A21, view looking north – July 13, 2006.

Photo 6. Same location as above – June 23, 2009.

Photo 7. West Rail Levee adjacent to Pond A21, view looking south – July 13, 2006.

Photo 8. Same location as above – June 23, 2009.

Photo 9. Pond A20 Levee located east of Rail Levee, view looking north – July 13, 2007.

Photo 10. Same location as above – June 23, 2009.

Photo 11. Pond A20 Levee located east of Rail Levee, view looking south – July 13, 2006.

Photo 12. Same location as above – June 23, 2009.

Photo 13. East Rail Levee adjacent to Pond A20, view looking north – July 13, 2006.

Photo 14. Same location as above – June 23, 2009.

Photo 15. East Rail Levee adjacent to Pond A20, view looking south – July 13, 2006.

Photo 16. Same location as above – June 23, 2009.

APPENDIX B-2.
POND A21 LEVEE EROSION DATA & PHOTOGRAPHS

Pond A21 Levee Erosion Data & Photographs

date of survey 06/23/2009 survey data by: S. Katric and L. Porcella

Notes:

1. spreadsheet represents elevations taken to monitor Pond 21 levee height where wave action is overtopping southeastern corner of pond

2. Eight sections are being monitored, all within 100 +/- feet of each other

3. Wooden stakes (usually 2, 3 at one location) were installed at each section where elevations adjacent to the stakes were taken

4. Measurements were taken between stakes and the pond side edge of levee in order to monitor how quickly the pond side of the levee is eroding.

5. Photos of each section were taken to identify stake locations and section numbers.

6. A benchmark was installed using a metal "T" stake.

7. The T-stake elevation was established by surveying an "X" on the northwest railroad bridge abutment, calling the abutment elevation 10.00 (ten)

8. If RR abutment is elev 10.0, then T-stake benchmark elevation is 5.45 feet

	Stake Nearest Pond						Middle Stake				Stake furthest from Pond/closest to outboard Marsh			
Section #	2008 ground surface elevation (ft)	2009 ground surface elevation (ft)	change in elevation between 2008 and 2009 (ft)	2008 offset between pond and stake (ft)	2009 offset between pond and stake (ft)	change in offset between 2008 and 2009 (ft)	2008 ground surface elevation (ft)	2009 ground surface elevation (ft)	change in elevation between 2008 and 2009 (ft)	2009 offset between pond and middle stake (ft)	2008 ground surface elevation (ft)	2009 ground surface elevation (ft)	change in elevation between 2008 and 2009 (ft)	offset between pond (ft)
1	6.53	6.55	0.02	5.25	5.08	(0.17)					5.69	5.73	0.04	16.50
2	6.31	6.44	0.13	7.33	7.58	0.25					5.61	5.68	0.07	20.83
3	6.32	6.37	0.05	2.83	1.58	(1.25)	6.43	6.48	0.05	8.25	5.54	5.58	0.04	17.42
4	6.39	6.42	0.03	5.00	4.17	(0.83)					5.44	5.5	0.06	20.17
5	6.39	6.31	(0.08)	1.83	1.67	(0.17)					5.5	5.54	0.04	14.33
6	6.44	6.48	0.04	3.17	2.92	(0.25)					5.45	5.5	0.05	13.00
7	6.68	6.73	0.05	8.00	7.25	(0.75)					5.58	5.65	0.07	17.50
8	6.94	6.95	0.01	6.00	5.17	(0.83)					5.49	5.5	0.01	18.42

NOTES/OBSERVATIONS:

1. most elevations were slightly higher (only one lower) indicating no substantial change in levee elevation
2. most offsets indicate a loss of levee on pond side with max loss at 1.25 feet at station 3
3. we should expect offsets between first stake and pond should continue to decrease from erosion (see photos)

2008 photo looking northerly
Benchmark "T-stake" location

2008 photo looking westerly
Benchmark "T-stake" location

2009 photo looking northerly
with section 4 and 5 in the background

2009 photo looking westerly
of marking stakes and debris pile inboard of levee

APPENDIX C.
SEDIMENTATION DATA

Pond	ID	Date	Rep 1 (mm)	Rep 2 (mm)	Rep 3 (mm)	Rep 4 (mm)	Rep 5 (mm)	Rep 6 (mm)	Rep 7 (mm)	Rep 8 (mm)	Average Depth (mm)	SE (mm)	Average Depth (ft)	SE (ft)
A19	A1901	10/9/09	47	49	54	57	59	53	55	59	54.13	1.55	0.18	0.01
A19	A1902	10/9/09	48	65	58	34	40	45	53	54	49.63	3.53	0.16	0.01
A19	A1903	10/9/09	73	39	63	47	57	34	55	62	53.75	4.61	0.18	0.02
A19	A1904	10/9/09	76	129	84	118	97	114	109	92	102.38	6.41	0.34	0.02
A19	A1905	10/9/09	47	36	49	52	36	45	94	92	56.38	8.24	0.18	0.03
A19	A1906	10/9/09	209	156	185	174	172	233	285	236	206.25	15.24	0.68	0.05
A19	A1907	10/9/09	142	137	113	107	125	136	138	137	129.38	4.59	0.42	0.02
A19	A1908	10/9/09	68	56	99	78	57	77	114	101	81.25	7.57	0.27	0.02
A19	A1909	10/9/09	84	89	136	113	139	94	115	70	105.00	8.79	0.34	0.03
A19	A1910	10/9/09	208	189	148	217	176	107	129	154	166.00	13.57	0.54	0.04
A19	A1911	10/9/09	69	51	68	78	76	81	54	50	65.88	4.45	0.22	0.01
A19	A1912	10/12/09	no data	no data	no data	no data	no data	no data	no data	no data	no data	nd	no data	nd
A19	A1913	10/12/09	240	170	154	147	164	183	62	97	152.13	19.05	0.50	0.06
A19	A1914	10/12/09	15	40	18	32	40	39	41	24	31.13	3.78	0.10	0.01
A19	A1915	10/12/09	155	67	134	132	179	108	114	169	132.25	12.84	0.43	0.04
A20	A2001	10/12/09	96	95	50	65	89	73	74	64	75.75	5.80	0.25	0.02
A20	A2002	10/12/09	68	60	99	118	167	195	123	114	118.00	16.14	0.39	0.05
A20	A2003	10/12/09	257	275	255	300	329	337	404	413	321.25	21.83	1.05	0.07
A20	A2004	10/26/09	164	340	353	369	344	326	316	391	325.38	24.52	1.07	0.08
A20	A2005	10/12/09	287	235	268	260	337	304	309	286	285.75	11.22	0.94	0.04
A21	A2101	10/9/09	109	83	110	75	95	119	105	123	102.38	5.96	0.34	0.02
A21	A2102	10/9/09	116	125	130	102	118	118	102	92	112.88	4.58	0.37	0.02
A21	A2103	10/9/09	39	34	24	5	28	36	12	3	22.63	5.03	0.07	0.02
A21	A2104	10/9/09	77	76	49	55	132	84	83	88	80.50	8.87	0.26	0.03
A21	A2105	10/9/09	163	138	141	178	169	148	142	149	153.50	5.19	0.50	0.02
A21	A2106	10/9/09	88	94	93	116	197	109	171	123	123.88	14.01	0.41	0.05

Pond	ID	Date	Rep 1 (mm)	Rep 2 (mm)	Rep 3 (mm)	Rep 4 (mm)	Rep 5 (mm)	Rep 6 (mm)	Rep 7 (mm)	Rep 8 (mm)	Average Depth (mm)	SE (mm)	Average Depth (ft)	SE (ft)
A21	A2107	10/9/09	147	139	148	121	131	126	140	148	137.50	3.70	0.45	0.01
A21	A2108	10/9/09	235	236	262	273	243	263	287	479	284.75	28.49	0.93	0.09
A21	A2109	10/9/09	294	237	239	222	278	276	246	253	255.63	8.70	0.84	0.03
A21	A2110	10/9/09	378	429	460	411	434	462	621	413	451.00	26.13	1.48	0.09

Note: The gypsum layer surrounding pin A1912 had subsided and cracked. No measureable sediment deposition was detectable.