Sears Point Tidal Marsh Restoration Project

Monitoring and Management Status Report

October 2015 to June 2017

SONOMA LAND TRUST

San Francisco Bay National Estuarine Research Reserve

Prepared July 20, 2017

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Monitoring and Management Status Report, Year 1

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1 Introduction

The Sears Point Restoration Project is located in southern Sonoma County, on the northern shore of San Pablo Bay (Figure 1). The restoration project, led by Sonoma Land Trust (SLT), consisted of a variety of features (Figure 2) intended to promote development of emergent tidal marsh over time as sedimentation reverses subsided site elevations, provides tidal flood protection to diked lands to the north, and provides transition zone habitat along the newly constructed levee, known as a “habitat levee.” Breaching of the historic Bayfront levee took place on October 25, 2015, restoring tidal action to the restoration site. Table 1 provides the performance objectives being monitored for the project, as established in the permits. Table 2 provides the monitoring requirements established in the permits for assessing achievement of those performance objectives.

In 2016, SLT entered into a contract with the National Estuarine Research Reserve (NERR) to carry out five years of monitoring. The monitoring has been organized into three broad categories, reflecting why the monitoring is being done:

1) ***Compliance monitoring*** – as required by agency permits
2) ***Site adaptive management monitoring*** – information to inform site conditions and whether additional management and/or restoration actions are warranted
3) ***Lessons learned monitoring*** – information about the restoration project outcomes that can be applied to future restoration projects, especially those relating design, construction, and management approaches and scientific experiments carried out on the site to restoration outcomes

Monitoring and site experiments are being carried out by several entities:

1) ***Sonoma Land Trust*** – levee planting, photo monitoring
2) ***San Francisco Bay National Estuarine Research Reserve*** – vegetation, tides, air photos, geomorphology, bathymetry, and synthesis of findings across the monitoring efforts in collaboration with the monitoring teams so as to place the Sears Point restoration outcomes into a broad context to support regional restoration and management-relevant monitoring and assessment needs directly
3) ***San Francisco State University*** – marsh mound plantings and erosion
4) ***Shelterbelt Builders*** – invasive species monitoring and management
5) ***Helix Environmental Planning, Inc.*** – fish use across the restoration site
6) ***U.S. Army Corps of Engineers*** – baseline topography
7) ***Ducks Unlimited*** – levee erosion
8) ***Daniel Edelstein Consulting*** – citizen science bird monitoring

This Year-1 Monitoring Status Report for the Sears Point Tidal Marsh Restoration Project provides an overview of baseline and Year-1 monitoring data collected, upcoming Year-2 monitoring to be conducted, and a summary of the qualitative monitoring findings to date. The complete monitoring results for years 1 and 2 will be combined into a single monitoring report to be completed in March 2018. This approach reflects the significant changes that took place during the 2016/2017 winter season as well as reflecting the seasonal realities of field data collection at a 1,000-acre restoration site that is inundated continuously in its early, low-elevation post-breach period. The SF Bay NERR will be taking the lead on the project and helping to organize partners along with the SLT.

This report is organized into the following sections:

- Section 2 summarizes the site management actions undertaken by Sonoma Land Trust since restoration was completed in October 2015.
- Section 3 summarizes the baseline data collected prior to the levee breach which will be used to assess restoration progress.
- Section 4 summarizes the Year-1 monitoring data collected
- Section 5 summarizes the upcoming Year-2 monitoring data to be collected
- Section 6 provides a qualitative assessment of restoration outcomes to date.

Sears Point Tidal Restoration Area

County Land Boundary

Sears Point
Site Location Map
Figure 1

San Francisco Bay National Estuarine Research Reserve

SONOMA LAND TRUST

Data: Sonoma Land Trust, watershed delineation by Camp Dresser & McKee | Aerial Imagery: (c) ESRI, i-cubed 15m eSAT | Map Date: May 2017 | Map Created by J. Kinyon, Sonoma Land Trust

Figure 2. Restoration Plan

BAR SCALE
0 500 1000 1500
US FEET

UNAUTHORIZED CHANGES & USES
THE ENGINEER PREPARING THESE PLANS WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR, UNAUTHORIZED CHANGES TO OR USES OF THESE PLANS. ALL CHANGES MUST BE IN WRITING AND MUST BE APPROVED BY THE PREPARER OF THESE PLANS.

REGISTERED PROFESSIONAL ENGINEER
AUSTIN G PAYNE
NO. C71212
EXP. 06/30/13
CIVIL
STATE OF CALIFORNIA

100% DESIGN SET

REVISIONS			
REV. NO.	DESCRIPTION	DATE	APPROVED
5			
4			
3			
2			
1			

DUCKS UNLIMITED INC. WESTERN REGIONAL OFFICE	PROJECT NO. US-CA-461-1 SEARS POINT WETLAND RESTORATION PROJECT OVERVIEW	DESIGNED BY: AP DRAWN BY: JS SURVEYED BY: CHECKED BY:
DATE: 8.15.12 / SHEET NO. 3 OF 32	APPROVED BY:	APPROVED BY:

Table 1. Performance Objectives from San Francisco Bay Regional Water Quality Control Board (RWQCB), the Bay Conservation and Development Commission (BCDC) and the United States Army Corps of Engineers (USACE) Permits

Number	Objective	Agency
PO-1	Development of 30 acres of predominately native tidal marsh vegetation over a 5-year period	RWQCB, USACE
PO-2	Development of approximately 940 acres of predominately native tidal marsh over a 30-year period	RWQCB
PO-3	Preserve and restore a large continuous band of tidal marsh along the Bayfront between the Petaluma River and Tolay Creek. [For the purposes of Sears Point monitoring, this is interpreted to mean restore approximately 955 acres of tidal marsh at Sears Point over 30 years as defined in the BCDC permit project description.]	BCDC
PO-4	Establish a natural wetlands-uplands transition to the greatest extent possible and provide an upland buffer outside the baylands boundary. [For the purposes of Sears Point monitoring, this is interpreted to mean create the habitat transition levee alongside the railroad alignment.]	BCDC
PO-5	Provide recreational opportunities, public access (including the Bay Trail), and environmental education compatible with protecting and restoring ecological and cultural resources. [For the purposes of Sears Point monitoring, this is interpreted to mean create the bay trail atop the new levee alongside the railroad alignment.]	BCDC
PO-6	To ensure public health and safety, including flood protection for Highway 37, Lakeville Highway, Reclamation Road, and the SMART railroad right of way, and mosquito abatement. [For the purposes of Sears Point monitoring, this is interpreted to mean ensure the long-term integrity of the new tidal flood control levee alongside the railroad alignment.]	BCDC

Table 2. BCDC, RWQCB and Corps Permit Monitoring Requirements Through Year 5 and Relationship to Monitoring Purposes Fulfilled

Updated: 7/11/2016				Year						Monitoring Purposes Fulfilled		
Monitoring Activity	Frequency Years 1-5	Method Summary	Mandatory	Pre-Construction	1 2016	2 2017	3 2018	4 2019	5 2020	Effectiveness	Site Adaptive Management	Lessons Learned
BCDC (Permit M2012.022.00)	**4 monitoring events total in years 1, 5, 10, and 15**											
Monitoring Report	1x/req yr		Y									
Sedimentation	1x/req yr	Sed plates, pins or staff gauges until MSL+1'	Y							X		X
Tidal channel development	1x/req yr	Air photos + GIS analysis	Y							X	X	X
Vegetation	1x/req yr	Fixed photo stations, descriptive summary	Y							X	X	X
Avian surveys[1]	1x/req yr	USFWS, USGS, or Audubon methods	Y[2]							X		X
Invasive plant species eradication reporting[1]	NS	Field observations	Y							X	X	X
Field photo monitoring	NS	Once >10% veg cover, photos from 10 points	Y		(only after >10% veg cover)					X		X
RWQCB (Permit R2-2013-0017)	**Monitoring and Adaptive Management Plan**											
Reporting	1x/req yr		Y									
Field photo monitoring	1x/req yr	Fixed photo points	Y							X		X
Aerial or satellite photo		GE or other low cost	Y							X	X	X
Methylmercury[1,3]	TBD	Protocol TBD w/RWQCB	Y[3]									X
Birds	≤4x/yr	Frequency based on available funds	Y							X		X
Vegetation	Annual	Air photos + ground truthing	Y							X	X	X
SMHM and ornate shrew[1]	1x/req yr	Standard USFWS protocol	If habitat present							X		X
Invasive plant species management[1]	NS	Follow management program	Y							X	X	X
Tidal channel evolution	1x/req yr	Air photos + GIS analysis	Y							X		X
Sedimentation	1x/req yr	Sed plates, pins, erosion tables, LiDAR, veg	Y							X		X
Seasonal Wetlands[1]	1x/req yr	CRAM or equivalent	Y							X		
Corps (Permit 2011-00152N)	**Mitigation and Monitoring Plan**											
Reporting	1x/req yr		Y									
Same as RWQCB MAMP		Years 1 to 5 required	Y							X	X	X

Notes

1. *Avian, invasive vegetation, small mammal, and methyl mercury monitoring at tidal restoration site, and seasonal wetlands monitoring, to be conducted separately from NERR monitoring. Findings to be included in NERR-prepared monitoring reports.*
2. *BCDC permit ambiguous on whether avian monitoring mandatory.*
3. *Methyl mercury monitoring plan must be developed upon request of RWQCB after it reviews results from nearby restoration sites.Thus, no monitoring at this time.*

2 Management Actions to Date

2.1 Invasives Control

Sonoma Land Trust contracted Shelterbelt Builders to provide invasive species monitoring and management services at Sears Point. A report on the 2016 work is provided in Appendix A.

2.2 Plantings of Transition Zone

Sonoma Land Trust has initiated several efforts to vegetate the new levee at Sears Point in order to create high tide refugia as well as upland habitat. These efforts are detailed in Appendix **B**. Quantitative monitoring efforts to assess the success of the efforts will begin in summer 2017.

2.3 Plantings of Mounds

The Sears Point restoration site utilizes marsh mounds to diffuse wave energy, facilitate mudflat sedimentation, and reduce erosion throughout the site. The original project design by Wetlands and Water Resources, Inc.[1] incorporated establishment of sacrificial vegetation on the marsh mounds prior to breaching the levee in order to protect the mounds from erosion following the return of tidal action to the site. For a variety of reasons, this was not completed before the breach and mounds have experienced significant erosion primarily due to wind-wave action since October 2015 (see Section 4.5), potentially hindering their ability to achieve the above functions. An experiment was conducted by a San Francisco State graduate student (Ms. Margot Buchbinder) to determine whether planting native salt marsh vegetation on the mounds can protect them from further erosion and support sediment accretion, and whether protecting plantings with physical barriers to erosion can enhance this effect. Additionally, the experiment explored whether planting vegetation in the compacted mound sediments can make conditions more hospitable to invertebrates, enhancing the mounds' value for the return of normal ecosystem function as the restoration site progresses towards becoming a mature marsh.

The experimental installation occurred on 36 mounds in six different treatment groups, including vegetative, physical and control treatments. Vegetative treatments consist of planted plots of *Spartina foliosa* (hereafter Spartina), a native marsh plant characteristic of lower-elevation tidal marsh. Physical barrier treatments consisted of coir erosion logs oriented to intercept wind-waves (from the WNW) or tidal currents (from the primary breach to the SW). These treatments were mixed to produce six treatment types: Spartina alone, coir alone facing the prevailing winds, coir alone facing the breach, combinations of Spartina with coir facing the winds or the breach, and untreated control mounds (Figure 3). Sediment pins were installed at the apex of each mound and in each cardinal direction, 0.5 m lower than the apex. Experimental treatments were randomly assigned to mounds arranged in blocks to account for local differences in conditions throughout the site (Figure 4). The experiment was monitored quarterly during the growing season (spring, summer and fall) for erosion and vegetation establishment;

[1] https://www.sonomalandtrust.org/publications/plans_reports.html

and cores were taken to quantify soil properties and soil invertebrates, and trapping is conducted to characterize epibenthic mound communities.

The installation of the experiment began in April 2016. Seven blocks of six mounds were selected via aerial imagery (Google Earth) in locations dispersed throughout the southwestern portion of the site, and treatments were randomly assigned to mounds within each block. Sediment pins, coir and Spartina sourced from the Invasive Spartina Project's (ISP) propagation beds were installed on the mounds during this period. In late April, goose exclosures were installed on vegetated mounds after herbivory was observed within plantings. At that time, it was discovered that some mounds had lost Spartina plugs, coir logs, or both; some of these mounds had been planted just five days prior to this observed damage. All mounds were evaluated for destructive erosion, and mounds were rearranged throughout May to locations where plantings and coir logs could persist. Through this process, two entire blocks were removed, and one new block was created in an area evaluated to be more suitable for plantings. Some new vegetated mounds were planted with plugs salvaged from failed mounds, and additional mounds were planted in early June with new plants collected and transplanted directly from the Port Sonoma Marina, which was the original collection location of the plants sourced from ISP's propagation beds.

During this time, coir logs were also reinstalled or replaced on several mounds due to degradation and relocation due to wind-waves and erosional forces. In July, one final Spartina mound was found to have completely eroded, and a new mound was planted adjacent to the existing block. The experimental mound map was finalized at this point (Figure 4). In August 2016, continuing degradation of some coir logs in combination plots with Spartina appeared to physically damage and threaten plantings, and all coir logs were removed from combination treatments with coir facing the breach. No changes were made to experimental mounds after August 2016; as such, Spartina densities and coir presence are subject to change into the future due to erosional forces.

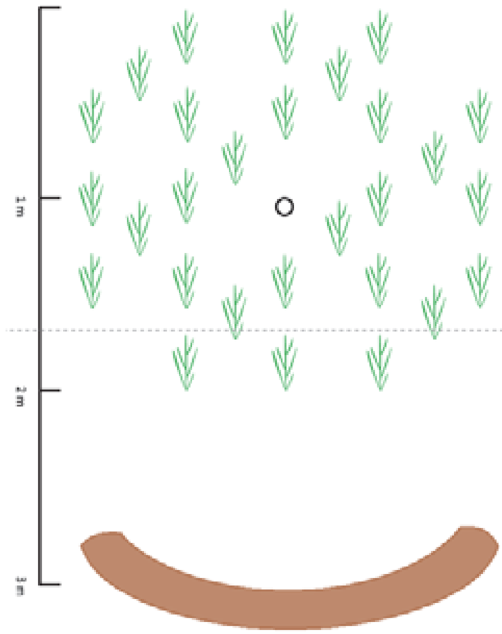


Figure 3. Diagram of Experimental Planting Plots on Marsh Mounds
*Plots all include a sediment pin (**o**), but may have either Spartina (green), coir (brown), both, or neither. Orientation of the plots varied with coir direction and presence.*

Figure 4. Map of Planted Mounds for Experiment

3 Baseline Data Summary

This section summarizes what baseline data is available for inclusion in this and future monitoring reports.

3.1 Air Photos

The as-built air photo is from Google Earth, flown April 1, 2015 (Figure 5). This photo precedes the October 2015 levee breach but follows winter rains and thus has standing water in the excavated large channel network. All the constructed marsh mounds, sidecast ridges, and the habitat levee are visible in the image.

Figure 5. Baseline Air Photo, April 1, 2015 Google Earth

3.2 Field Photos

Baseline field photographs are included in Appendix **C**. Section 4.2 provides further discussion of these and post-restoration field photographs. These photographs were taken at pre-established fixed photograph monitoring points which are reoccupied after construction.

3.3 As-Built Topography

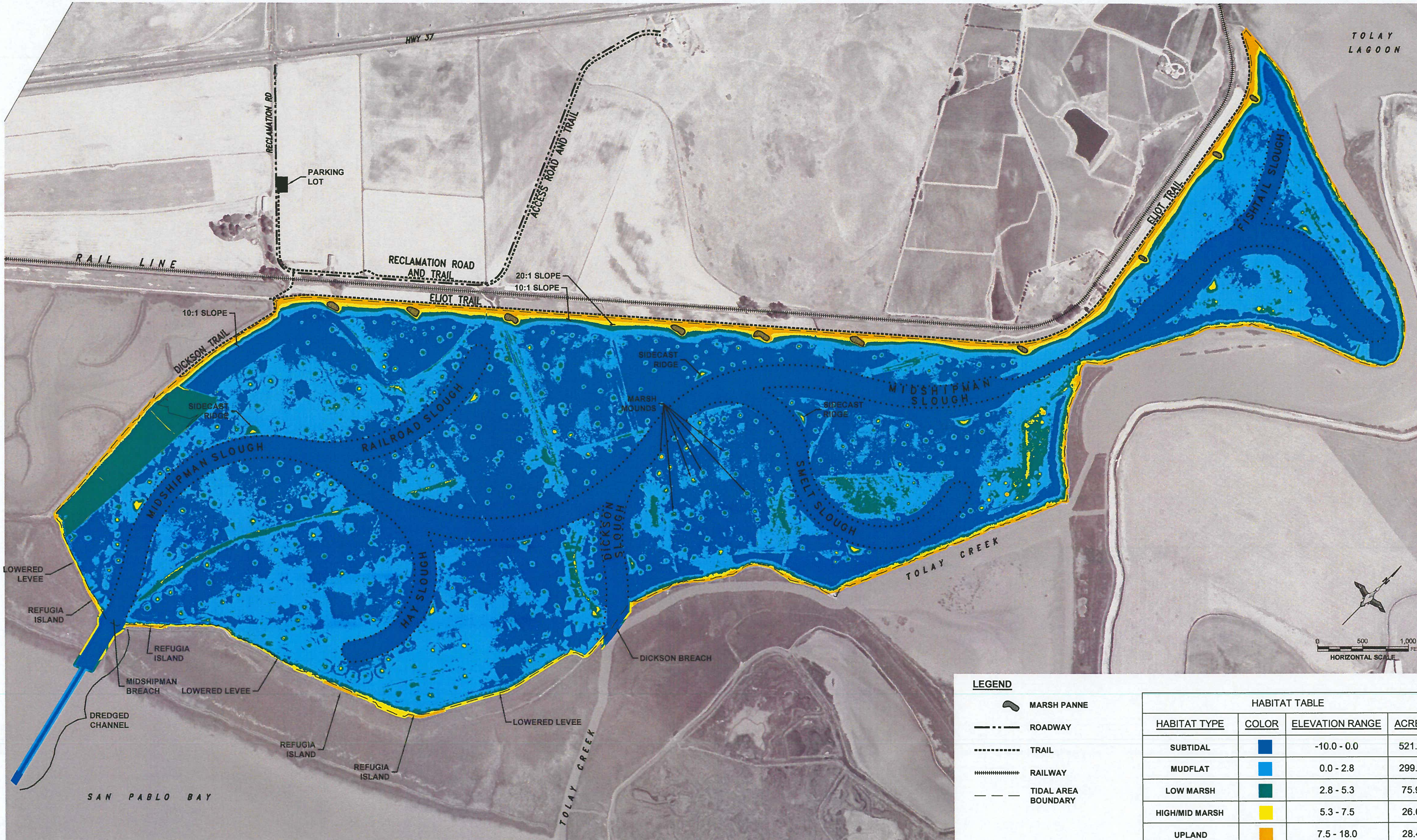
The U.S. Army Corps of Engineers performed a ground-based LiDAR survey in September 2015 (Figure 6) as part of a wind wave study it is conducting at the Sears Point and Hamilton Air Field restoration projects. Following data validation, this data set will serve as the baseline "as-built" topography.

3.4 As-Built Geomorphology

The as-built geomorphic features will be established from heads-up digitizing, spectral signatures from the April 2015 Google Earth air photo, and/or the as-built topography (Figure 6) and compared to engineering construction drawings. This data set will be used to compare evolution of the channels, mounds, sidecast ridges, and levees.

3.5 Sediment Plates

Six sediment plates were established by Ducks Unlimited shortly after breaching. Data collected at these plate locations will be one of a few measures used to track site sedimentation over time.



HABITAT TABLE			
HABITAT TYPE	COLOR	ELEVATION RANGE	ACRES
SUBTIDAL		-10.0 - 0.0	521.3
MUDFLAT		0.0 - 2.8	299.3
LOW MARSH		2.8 - 5.3	75.9
HIGH/MID MARSH		5.3 - 7.5	26.0
UPLAND		7.5 - 18.0	28.4

NOTE: LIDAR ELEVATION DATA PROVIDED BY THE US ARMY CORPS OF ENGINEERS. DATA WAS SUPPLEMENTED WITH AS-BUILT SURVEYS PERFORMED BY DU AND THE CONTRACTOR. HORIZONTAL DATUM IS NAD83 CA ZONE 2, US SURVEY FT. VERTICAL DATUM IS NAVD88, FT.

DUCKS UNLIMITED

SEARS POINT WETLAND RESTORATION PROJECT
POST CONSTRUCTION HABITAT EXHIBIT

Figure 6 As Built Topography (Preliminary)

2/9/16

SEDIMENT PLATE SUMMARY TABLE			
Plate #	Northing	Easting	Elevation (ft, NAVD88)
1	1805474.171	6426278.651	0.13
2	1808755.142	6426311.291	0.22
3	1808217.510	6430883.176	0.11
4	1810391.534	6429697.358	0.10
5	1811300.831	6433351.525	-0.55
6	1814924.391	6434215.012	0.23
Horizontal Datum is NAD83, California Zone 2, US Survey feet.			

SEARS POINT WETLAND RESTORATION PROJECT
SEDIMENT PLATE
SUMMARY MAP

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

Figure 7. Location of Sedimentation Plates

4 Monitoring Activities to Date

4.1 Air photos

Three air photos have been flown since tidal restoration:

1) July 6, 2016 6:41 pm PDT and July 21, 2016 5:26 pm PDT – Terravion, Inc. – natural color and color infrared imagery and automated processing of vegetation and thermal signature. Contracted by NERR on behalf of SLT. See Figure 8 for the natural color image and Figure 9 for the color infrared image.
2) August 23, 2016 12:22 pm PDT – Digital Globe WV02 satellite natural color. Commercially available imagery acquired by SLT. See Figure 10.
3) November 17, 2016 about 3:00 pm PST – Digital Globe WV01 satellite black-and-white. Commercially available imagery acquired by SLT. See Figure 11.

These photos will be used to extract early-stage restoration changes to the extent that features are visible relative to tidal submergence.

Data sources: Aerial Imagery,Terravion July 2016, Satellite Imagery, DigitalGlobe August 2016

Sears Point
Sonoma County, CA

1:36,000 (1" = 3,000' at letter size)

0 1,000 2,000 ft

0 300 600 m

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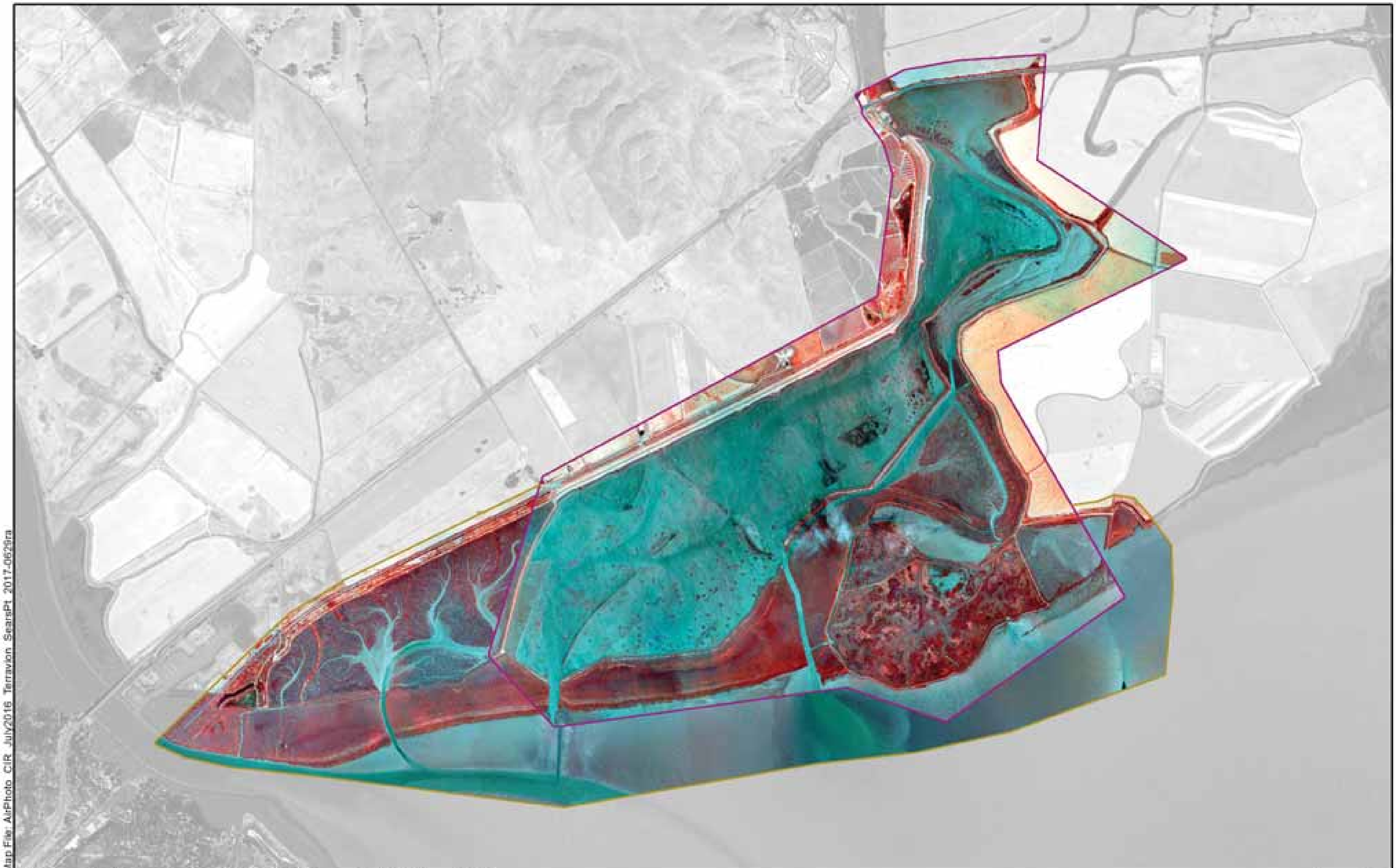
Air Photos:

Figure 8

Terravion, Natural Color, July 06 2016 | 18:41

Terravion, Natural Color, July 21 2016 | 17:26



Map File: AirPhoto_CIR_July2016_Terravion_SearsPt_2017-0629ra

Data sources: Aerial Imagery,Terravion July 2016, Satellite Imagery, DigitalGlobe August 2016

Sears Point
Sonoma County, CA

1:36,000 (1" = 3,000' at letter size)

0 1,000 2,000 ft

0 300 600 m

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Figure 9

Air Photos:

Terravion, Color Infrared, July 06 2016 | 18:41

Terravion, Color Infrared, July 21 2016 | 17:26

Map File: SP Figure 2 Digital Globex

Data sources: Satellite Imagery, DigitalGlobe August 2016

Sears Point
Sonoma County, CA

1:36,000 (1" = 3,000' at letter size)

0 1,000 2,000 ft

0 300 600 m

Figure 10

SONOMA LAND TRUST

Satellite Image:Digital Globe WV02, Natural Color, August 23rd 2016 | 12:22

Map File: SP Figure 3_Digital Globe BW

Data sources: Satellite Imagery, DigitalGlobe November 2016

1:36,000 (1" = 3,000' at letter size)

0 1,000 2,000 ft

0 300 600 m

Sears Point
Sonoma County, CA

Figure 11

SONOMA LAND TRUST

Satellite Image:Digital Globe WV01, Black & White, November 17th 2016 | ~15:00

4.2 Field photos

In 2013, Sonoma Land Trust established eight photo monitoring stations at Sears Point. At each station, staff used a compass to develop between one and four repeatable photo views. There are 25 photos from these eight stations. By 2016, the number of photo stations had been increased to 15 with a total of 45 photos. Appendix **C** provides:

- a table of all photo points with descriptions
- a map of the photo stations with bearing to show the photo direction
- photos from 2013-2016 showing changes at the site

4.3 Bathymetry

A small boat-based bathymetric survey of six transects across the site (Figure 12) was collected in February 2017 during the extreme high tides that took place that month. Findings are presented in Appendix **D**. Data from these transects will be compared to the USACE baseline topographic survey to yield sedimentation data.

Figure 12. Location of Bathymetric Transects Surveyed February 2017

4.4 Marsh Mound Plantings

As mentioned in Section 2.3, in April 2016, Ms. Buchbinder, a graduate student in Dr. Kathy Boyer's lab at the Romberg Tiburon Campus, began her experimental project involving marsh mound plantings as part of her MA research project. The purpose of the study is to assess the potential for plantings of *Spartina foliosa* and wind-wave buffers (coirs) to prevent mound erosion. After implementing the design, by May 2016, there had been major disruption to the coirs and plugs of *Spartina* were lost from the mounds. Based on weather data from the CIMIS weather station located at nearby Black Point[2] extremely high wind events occurred during this time. Subsequent efforts to re-establish *Spartina* plantings also included the installation of Canada Goose exclosures. Efforts were made to re-establish the coir buffers but periodic heavy wind events made this relatively impossible. The original design was modified to include six blocks and efforts to maintain the coir buffers eventually was abandoned.

Ms. Buchbinder led a survey of the marsh mound plantings with SF Bay NERR staff (M. Vasey and A. Deck) in March 2017. We noted that several *Spartina* plots have survived, however, others have eroded away (Appendix E Figure 3). The plots that have survived may be providing some protection against mound erosion. Nevertheless, it appears that wind wave action in the Sears Point lagoon is extremely intense and may be too extreme for most vegetation to survive on the marsh mound surfaces at this time. One hopeful sign is that a dominant wetland species in the North Bay region, alkali bulrush (*Bulboschoenus maritimus*), has established voluntarily on some of the mounds and, according to recent observations, on adjacent intertidal mudflats (P. Baye, personal observation) (Appendix E Figure 11). It is possible that this species might be an alternative for mound planting to Spartina, which appears to be vulnerable to the erosive action of heavy wind waves. Or, possibly planting cordgrass and alkali bulrush on intertidal mudflats could promote marsh plain vegetation at the site.

In observations from the shoreline on April 28, it appears that some of the side-cast ridges are revegetating naturally. For the most part, vegetation along these features appears to be pickleweed (*Salicornia pacifica*).

4.5 Marsh Mound Erosion

Mound erosion pins were examined approximately every three months from December 2015 until December 2016. In that time, approximately 30 cm (one foot) of erosion occurred on mounds that were sampled (without vegetation) (Figure 14). Some mounds developed a "tear drop" effect presumably reflecting wind-wave and current patterns of erosion and deposition.

[2] www.cimis.water.ca.gov

Figure 13. Location of Marsh Mounds Monitored for Erosion

Note that mounds in orange were included in early erosion measurements, but were transferred to use as experimental mounds in spring 2016. Mounds used for erosion monitoring are located on the north side of the channel due to access at the time of installation, and therefore may not represent erosional effects throughout the entire site.

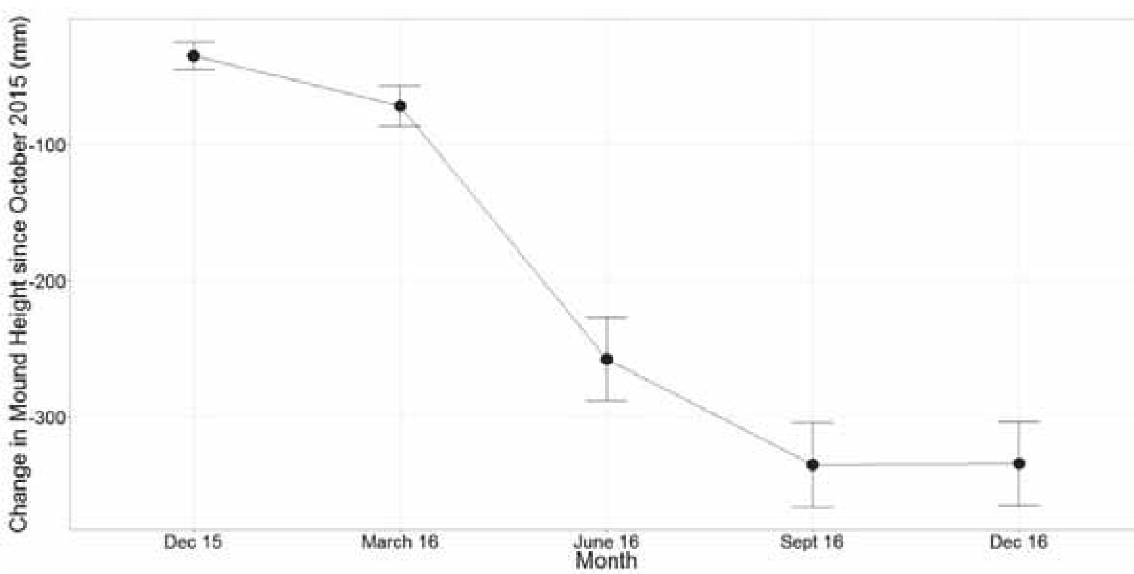

Figure 14. Marsh Mound Erosion Data, Breach to December 2016

Preliminary data suggests that, despite the challenge of sustaining marsh mound plantings, if vegetation can be successfully established on mound surfaces, there may be some reduction of mound surface erosion (Figure 16).

Based on visual observation of the mounds from shore, as the mounds are eroding, sediments are being deposited in the matrix between the mounds and adjacent to the side-cast ridges. Mound sediments contain coarse grained materials not likely to be transported as suspended sediments. These sediments are accumulating adjacent to the mounds and suspended sediments brought in by the tides are depositing rapidly. It appears that some of these coarse sediments have been pushed by wind waves to towards the T-zone and are being deposited in the intertidal zone that otherwise has received considerable wave scour.

On March 16, 2017, M Buchbinder and M Vasey led a wetland ecology class in collecting 89 sediment depth samples in order to estimate max, min and average deposition across the site (Figure 15). Maximum depth was 88 cm, minimum was 12 cm, and the average depth was 43.6 cm. Depths of accumulated sediment appears to be highest towards the T-zone shoreline and in the matrix zone surrounding mounds in wind shadow environments. It appears that the mounds are stimulating rapid sedimentation (such as mound “shadows”), as was part of their design intention. The nucleation potential for mounds to expedite mudflat sedimentation was hypothesized during project planning and appears to be happening. This is an area that will be investigated in the future.

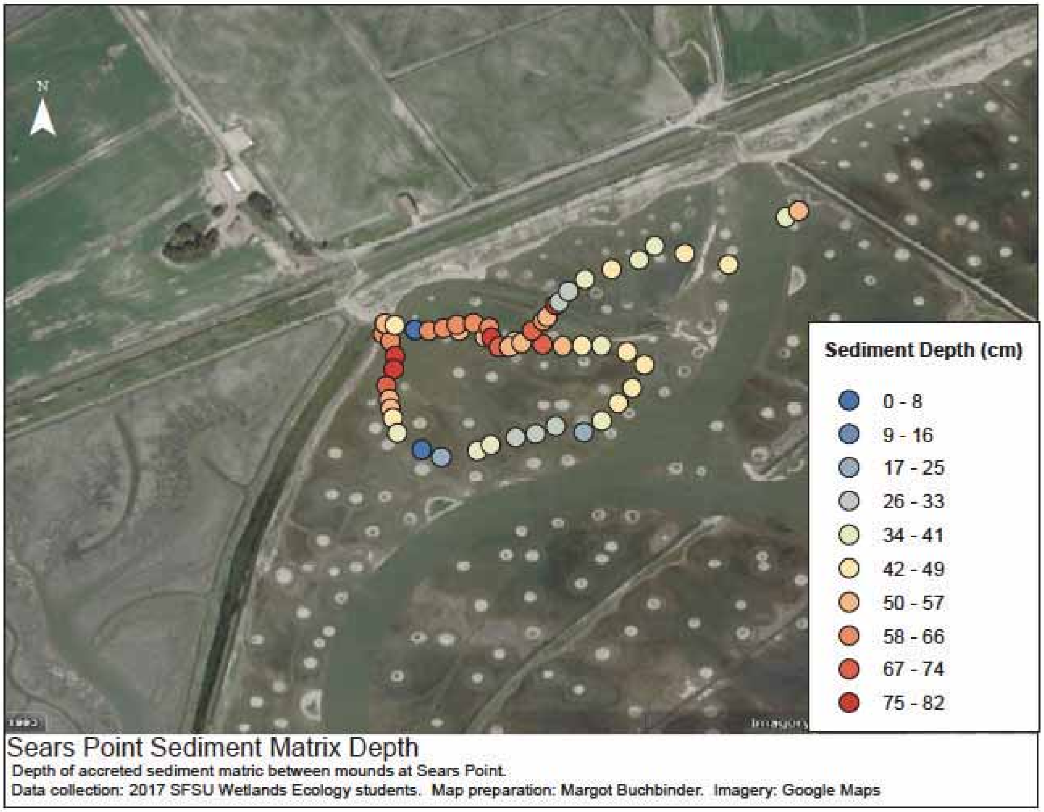

Figure 15. Sedimentation Depth in Northwest Corner, April 2017

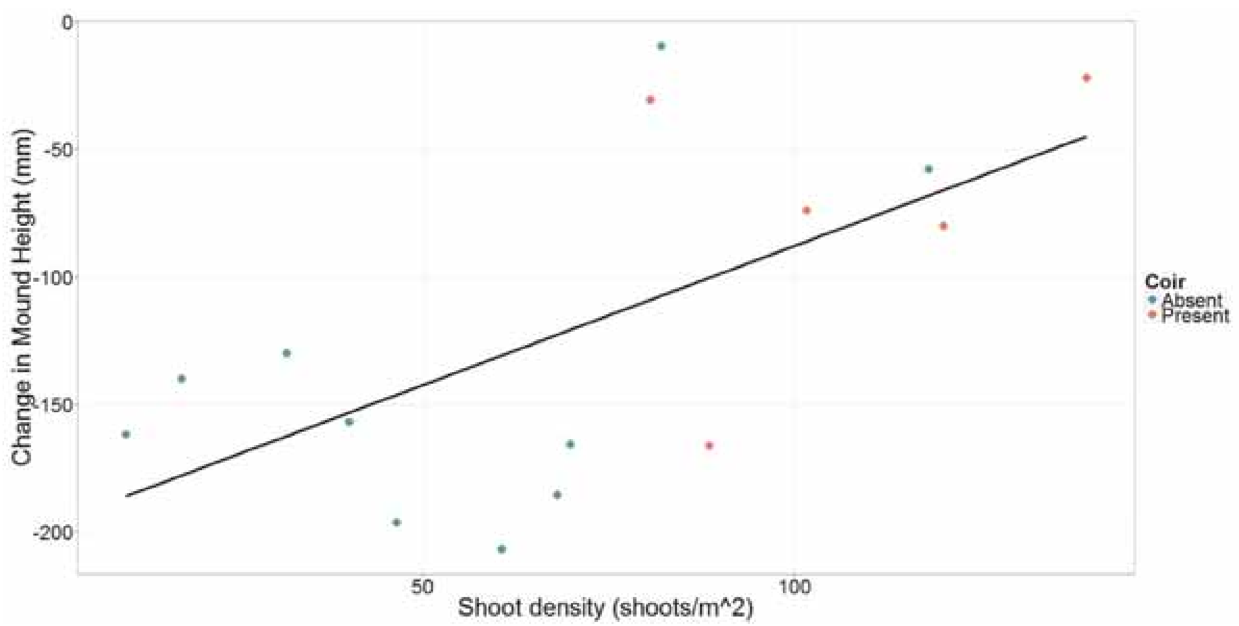

Figure 16. Linear Regression of Mound Spartina Planting and Reduced Mound Erosion Effect
($R^2 = 0.3423$, $p < 0.05$)

4.6 Transition Zone Vegetation

The Sonoma Land Trust researched optimal plantings for the transition zone ("T-zone") graduated levee that provides the northern boundary of the project. This T-zone is intended to provide migration space for the future marsh that is established at this site. The T-zone shoreline is broken up by ten artificial marsh panne features that extend out into the lagoon approximately every 200-300 m. It was recommended that the upper T-zone be initially planted with rhizomes of *Elymus triticoides*, a native perennial mat forming grass that is common in the T-zone around tidal marshes in the region (Appendix E Figure 1). Another species, *Distichlis spicata*, salt grass, is another species that was tried in the upper T-zone because of its ability to bind soil and fill surface space that could otherwise be invaded by non-native plants.

Major plantings of these two species were accomplished, in one case by a volunteer group from Save the Bay. Unfortunately, it appears that extensive wind-wave action after planting scoured away plants installed during this time (Appendix E Figure 2). With tides higher than usual due to this wet year, wind-wave action has been extreme at various times during the past year, and the lower margin of the upper T-zone was largely denuded of vegetation. Above the high energy zone, the SLT planted oat hay that is doing quite well and the upper part of the levee is occupied by a variety of annual plants, including many non-native (e.g., *Spergula arvensis*), as well as disturbance dependent native annuals (e.g., *Calandrinia ciliata*). The middle portion of the intertidal T-zone is accumulating sediment and recently has been recruiting both *Salicornia pacifica* and *Spartina foliosa,* particularly where logs have drifted onto shore and provided some wind protection (Appendix E Figure 5).

During a survey of T-zone vegetation on April 28, 2017, the following observations were made. From the top of the levee to the high tide wrack line, there is practically one hundred percent cover. Thus, there is presumably a good root mass in the soil and little evidence of erosion along this upper T-zone. The top meter near the levee road was not planted. This zone is primarily dominated by *Festuca perennis* and *Spergula arvensis* along with approximately twelve other species (mostly non-native) contributing to this grassland. There is a relatively broad middle zone (3-4 m) that was ploughed and sown with oat hay, an agricultural crop species widely planted around the north bay shoreline. About half the number of non-native species are found in this zone. At the base of the T-zone levee, there is another area about one meter wide between the cultivated middle zone and the upper wrack line. Dominant species in this zone include *F. perennis* and *Cotula coronopifolia.* This band has some interesting recruits. Several young shrubs of *Baccharis pilularis* have established, particularly in the region of the boat ramp. Occasional occurrences of two unusual wetland species, *Ranunculus muricata* and a native species, *Plagiobothrys bracteatus*, were found in this zone. These species are more typical of inland vernal pools and may reflect the fresher conditions at the high tide line during this wet winter.

In the intertidal zone between high tides and low tides, there are some interesting recruitment patterns. Where large logs have been stranded, there are patches of *Salicornia pacifica* in wind protected areas east of these features. Similarly, the eastern areas in the wind shadow of the artificial pannes are generally heavily vegetated with *S. pacifica* as well as *Atriplex prostrata* and in fine clays in the lower zone, *Spartina foliosa.* Within one of these *S. pacifica* patches, there also was a single occurrence of *Sesuvium verrucosum*, more typical of inland pools. Lower in the intertidal zone some patches of *Spartina foliosa* have established (Appendix E Figure 12)

Interestingly, the artificial marsh panne features that were created as extensions into the lagoon (future tidal marsh) seem to break up the wind wave energy. Wetland vegetation has established very nicely on these features (Appendix E Figures 4 and 9). North and eastern outer zones of the pools are dominated by *F. perennis* and dense stands of *Cotula coronopifolia. Salicornia pacifica* and *Spergula arvensis* form mat like vegetation around the south and western outer boundaries. *C. coronopifolia, Jaumea carnosa* and *S. pacifica* dominate the middle and deeper inner zones of the pools. The unusual native annual *Plagiobothrys bracteosa* was found on the low turf like growth on the south outer zone at one of the ponds. It appears that wind wave energy is primarily spent on the south and western boundaries of these features while wave wash then deposits wrack and sediment on the northern and eastern boundary. Again, vegetation in the lower T-zone and intertidal area to the east of these pannes appears to provide protection for vegetation recruitment and establishment (Appendix E Figure 7).

In the northeastern stretch of shoreline that is more protected from currents and wind-wave action, there is extensive establishment of *Salicornia pacifica, Atriplex prostrate,* and *C. coronopifolia*, with occasional shrubs of *Grindelia stricta* var. *angustifolia,* and recruiting *Frankenia salina* and seedlings of *Jaumea carnosa*. These are classic high marsh species and their presence in this region is very encouraging (Appendix E Figure 10).

In summary, while efforts to plant the T-zone with rhizomatous grasses was apparently disrupted by the scouring effects of unusually high tides and wind-wave energy during winter and early spring, the upper T-zone from the top of the levee to the upper tide line is densely covered with non-native annual grassland. Where the oat hay is not planted, *F. perennis* (Italian ryegrass) is a dominant and would likely be the dominant grass on the levee if it were not cultivated with oat hay. Some tidal wetland vegetation is establishing in the lower portion of this area where sediments are beginning to accumulate on top of the hard clay substrate that is a residual of the wind wave scouring events. The artificial panne features are developing vegetation rapidly through natural recruitment. The most successful species in this dynamic environment appears to be brass buttons (*C. coronopifolia*), a non-native plant whose impact on native ecosystems has been categorized as “limited” by the Calweed mapper. Another non-native grass [Italian ryegrass or *Festuca* (formerly *Lolium*)] *perennis* appears tolerant of these conditions. If necessary, these two non-native species might be considered for erosion control services. On the mounds, alkali bulrush (*Bolboschoenus maritimus*) is a native species that might be considered for erosion control services (Appendix E Figure 11).

4.7 Birds

In 2016, Sonoma Land Trust hired a consultant to develop and implement a citizen science protocol for bird monitoring at Sears Point. To date, six surveys are complete – two in fall 2016, two in winter 2017, and two in spring 2017. Two additional surveys will be conducted in summer. The consultant will then repeat the eight surveys with volunteer monitors in the 2017/18 field season. Sonoma Land Trust is working toward developing volunteer leaders to conduct future monitoring. Appendix G provides a summary of survey results.

5 Pending Monitoring Activities

A number of monitoring activities will be completed throughout 2017, timed to appropriate low or high tide needs for access or to biological processes relevant to the monitoring.

5.1 Interior Topography

During summer 2017 when daytime lower low tides permit, we will obtain interior topographic data via aerial survey. Whether this survey is able to cover the entirety of the site or focus on the marsh mounds is being determined based upon available methods and associated data collection costs.

5.2 Tide Levels

During summer 2017, we will install a tide gauge within the project area. This tide gauge will likely remain deployed through Year 5 at a minimum. The tide gauge will be surveyed to NAVD88 to allow direct comparison of tide heights within the project area to those available from the real-time National Ocean Service tide station at Richmond. As data accrue, tide height differences will be computed to allow predictive capacity of future tides using available predictions for Richmond and other tide station locations.

5.3 Geomorphic Data Extraction and Change Detection

Following digitization from air photos, we will develop a change assessment of the channel network (to extent visible in the air photos) and marsh mounds and sidecast ridges.

5.4 Topographic Change Detection

We will have up to three independent measures of sedimentation and topographic change to utilize for assessing change since the levee breach: sediment plates, bathymetric transects, and mound/maybe entire site elevations. Once all data is collected and we have verified the USACE baseline topography, we will develop change detection data.

5.5 Fish

HELIX Environmental Planning, Inc. is designing and implementing seasonal fish monitoring at the site. The project’s three main objectives are: (1) use ARIS technology to perform transect surveys and determine fish use of several engineered habitat types, (2) identify the species using the habitats, and

(3) interpret fish survey data from other restored wetland habitat restoration projects in the San Francisco Estuary and compare with the current project fish survey results, using bio-statistical methodology. HELIX is preparing a tandem fish monitoring design, in collaboration with U. S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and other project team members, to relate results from the Adaptive Resolution Imaging Sonar (ARIS) camera transects to actual species and life stage usage at each habitat type. The accompanying sampling effort is comprised of multiple gear types (e.g., otter trawl, round haul, seine, fyke net, and plankton net). This is designed to efficiently survey five habitat types within the site during both spring and fall, describe fish species and life stage presence and food web relations, and to determine the health of the aquatic community. Data are being collected, analyzed, and reported to inform and improve future wetland restoration projects. A brief summary of the monitoring protocol is provided in Appendix **F**.

5.6 Levee Erosion

We will collect a range of data to examine the extent of wind-wave erosion along the western "separator" and northern levees (Figure 2), to understand relationships between levee slope, outboard wind-wave buffering features, and erosion extent to adjacent features such as marsh mounds, water depth, and past wind data. Data collection will consist of topographic transects of the levee where erosion has been observed, topographic transects of the winter 2017 debris wrack line deposited on the levee slopes by the extreme high tides and wind waves, wind direction and intensity data from publicly available nearby weather stations, levee aspect from maps, water depth from the baseline topographic data, proximity of wind-wave buffering features (mounds, sidecast ridges), computed fetch distances, construction methods and compaction data, and vegetation presence.

6 Qualitative Observations of Outcomes to Date

From a qualitative perspective, there are several early-stage findings.

6.1 Transition Zone and Mound Plantings Challenged by Wind-Wave Erosion

There has been some success with *Spartina foliosa* plantings on the marsh mound surfaces but establishment has been difficult. Nonetheless, over time, survival on some of the mounds is likely to lead to long term clonal spread and these mounds may ultimately serve as reservoirs of *S. foliosa* rhizomes and seeds that will help to spread this species to other mounds and suitable habitat on the T-zone. Wind wave scouring along the upper T-zone has apparently caused unexpected impacts to the planted *Elymus triticoides* and *Distichlis spicata* rhizomes but we will continue to monitor for their presence during the months to come. The middle intertidal area of the T-zone is attracting recruitment by *Salicornia pacifica, Atriplex prostrate,* and other salt marsh species, especially where coarse sediments have been deposited (or fine sediment scoured away leaving coarser materials behind) and are protected by wave buffers (such as drift logs and, particularly, on the lee side of the artificial panne projections. *S. foliosa* is establishing sporadically in fine sediments deposited along the lower intertidal portion of the T-zone.

6.2 Significant Early Deposition

The rate of sedimentation in many parts of Sears Point, especially around mounds and sidecast ridges in the northwestern portion of the project, is very high (up to 3 feet, Figure 15) and some mudflats are emerging above low tides. This sedimentation is derived predominantly from suspended sediment transported into Sears Point on flood tides. A far lesser amount of this sediment probably originates from erosion of the nearby mounds.

6.3 Mound Erosion Has Been Significant, Deposition in "Flow Shadows"

Three aspects of the mounds have been observed. First, mound tops have been significantly eroded – 1 to 2 feet in places (Figure 14). Second, eroded materials appear to be depositing nearby the mounds, in effect widening and flattening the mounds. Third, the mounds appear to be promoting localized deposition in their "flow shadows," an intention of their design. The mounds were built by local excavation of compacted, more coarse-grained sediments (comprised largely of clumped silts and clays) in a matrix of fine sediments from the compacted soils that made up the former pasture and hay field.

6.4 Tidal Flood Protection Levee Remains Intact

Vegetation, both planted and unplanted, has created a dense cover of non-native annual grassland on the north levee T-zone above the high tide wrack line. The upper intertidal T-zone levee was denuded by wind-wave action earlier in the year, however, pickleweed and associates are now establishing in protected areas and where more coarse-grained sediments have been deposited along the shore. In the lower part of this zone, characterized by fine sediment deposition, cord grass is also recruiting, although it shows signs of Canada goose foraging.

6.5 Sheltered Northeast Portion of Site Developing Perimeter Vegetation Rapidly

The northeastern portion of the habitat levee appears more protected from wind-wave scour than the long western area (Figure 5). The intertidal area of this levee reach is vegetating well with *S. pacifica, Jaumea carnosa, Grindelia stricta* var. *angustifolia,* and other salt marsh species. It will be interesting to observe the contrasts in vegetation colonization and rates of vegetation in this area compared to the main section of the habitat levee. It will also be interesting to contrast the establishment of mounds in this area compared to the main area over time.

7 Next Steps

This summer will provide us with the opportunity to do more extensive work including

- The development of a GIS framework for tracking change at the site
- LiDAR data to map elevations of the mounds, emerging mudflats, artificial pannes, and the T-zone – these data were collected in June 2017
- Design of a long-term quantitative vegetation monitoring program
- Collection of levee transects along the west separator levee and main northern habitat levee, and comparison of those findings to as-built conditions so as to assess scour and subsidence.
- Establishment of a tide gauge and/or water quality monitoring station

APPENDIX A

Sears Point Tidal Marsh Levee Weed Management

2016 Summary Report

Prepared for:

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966 Sonoma Avenue
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April 2017

Shelterbelt Builders INC
An Open Land Management & Restoration Company

APPENDIX A

INTRODUCTION

The newly constructed levee system for the Sears Point tidal wetlands project is highly susceptible to invasion from invasive plants. Though a combination of natural native plant recruitment and supplemental planting is planned, much of the levee system remains relatively bare and unvegetated. Shelterbelt Builders was hired by the Sonoma Land Trust in the fall of 2016 to control priority invasive plants to help facilitate the process of natural revegetation.

Controlling invasive plant species has the following priority goals:

- **Enhancing the establishment of perennial native plant species**. The natural and assisted revegetation of the Sears Point tidal wetlands levee system will provide valuable transitional upland habitat for native species and further limit the establishment of invasive species.
- **Minimize the spread of invasive species to neighboring conservation and agricultural areas**. The Sears Pont tidal wetlands levee system connects to the San Pablo Bay National Wildlife Refuge, the Sears Point Wetland and Watershed Restoration Project area and adjacent Sonoma Land Trust lands that are managed for crop and range production. The levees, tidal flow, and a regional rail right-of-way all serve as connection and distribution pathways for invasive plant species to high value conservation and agricultural production areas, including other nearby areas undergoing restoration.
- **Provide safe access and positive experiences for the public**. Many of the most prevalent invasive plants of the Sears Point tidal wetlands have prickles, sticky glands, or thorns. In some years these plants overtop the main access trails and service roads, inhibiting public access and impeding views of restored and preserved native habitats.

The Sears Point tidal wetlands restoration project includes a modern levee design with gentle gradients to support a much wider band of transitional vegetation than older levee designs. These high marsh transitional habitats are found on the outboard sections of levees. As revegetation of these levees occurs, the lower elevations will be dominated by high marsh species such as marsh gumplant (*Grindelia stricta* var. *angustifolia*), salt grass (*Distichlis spicata*), and pickleweed (*Salicornia pacifica*) that transition to upper elevation species such as creeping wildrye (*Elymus triticoides*), common aster (*Symphyotrichum chilense*), bee-plant (*Scrophularia californica*), and coyote brush (*Baccharis pilularis*). As these transition zones mature, their dense canopies will leave little room for the colonization of non-native species.

WEED MANAGEMENT

The Sonoma Land Trust (SLT) and United States Fish & Wildlife Service (USFWS) have been increasing invasive species management actions within the San Pablo Bay National Wildlife Refuge and Sonoma Land Trust properties for many years. The addition of management within the Sears Point tidal wetlands project area will complement the efforts toward invasive species management in the greater region.

The transitional high marsh areas are most susceptible to invasion by non-native species during the early native plant establishment period. Shelterbelt's weed management work focuses on the highest priority invasive species during this establishment period, namely perennial pepperweed (*Lepidium latifolium*), stinkwort (*Dittrichia graveolens*), yellow starthistle (*Centaurea solstitialis*), and Pacific bentgrass (*Agrostis avenacea*). Two additional invasive plants, iceplant (*Carpobrotus* sp.) and New Zealand spinach (*Tetragonia tetragonioides*), are incidentally controlled when found in work areas.

2016 control efforts consisted of broadcast spraying all populations of the target weeds found on the levees, as shown in the attached map. All treatments in 2016 utilized the herbicides imazapyr and/or glyphosate (see table following report). Individual plants were not mapped at this stage as populations are extensive and the annual species will fluctuate from year to year based on weather and management efforts. Backpack sprayers were used for the outer southern levee as it is only accessible via boat. A truck mounted spray rig was used to treat the more accessible western, eastern, and northern levees. During follow-up treatments, individual patches or plants will be treated and mapped and reductions in populations should be visible over time.

The life history and treatment strategy for each invasive species treated are discussed in the following sections.

PERENNIAL PEPPERWEED

Description

Perennial pepperweed (*Lepidium latifolium*) is an herbaceous perennial plant native to Eurasia in the family Brassicaceae. When in flower, it has a dense cluster of white flowers at the top of stems three to eight feet tall. Stems and leaves are dull gray-green and waxy, sometimes with reddish spots (Bossard et al. 2000).

Perennial pepperweed is rated as highly invasive with a high statewide impact by the California Invasive Plant Council (Cal-IPC 2006). The California Department of Food & Agriculture (CDFA) currently lists perennial pepperweed as a class B noxious weed, meaning the plant is known to cause economic or environmental detriment but has limited distribution (CDFA 2016).

Life History

Perennial pepperweed reproduces from seed, as well as vegetatively from intact root systems or from pieces of rootstock. New plants readily grow from pieces of rootstock less than one third of an inch in diameter and less than one inch long. Flowering time varies from May to July in different parts of California. Seeds mature by June or July. Seeds likely spread via wind, water, and wildlife and may be viable for more than two years. Seedlings grow rapidly and can produce flowering stems the first year. In fall and winter aerial stems die back to the ground, and new shoots sprout in the spring (Bossard et al. 2000).

Distribution and Impacts at Sears Point

Perennial pepperweed is widespread throughout San Francisco and San Pablo Bay estuaries and occurs in both saline and freshwater wetland environments and adjacent uplands. Once established, populations can grow rapidly, forming dense mats of tall stems that grow taller than typical native salt marsh vegetation. Patches may spread approximately six to ten feet per year depending on habitat type (Hogle et al. 2007).

Dense stands of perennial pepperweed overtop shorter-statured native salt marsh vegetation, which can ultimately outcompete and displace native species. High densities of large roots also reduce soil compaction (Renz 2000) which can lead to increased soil erosion and instability along levees, further driving the invasion by non-native species and reducing native plant species diversity. Wildilfe impacts are lesser known. PRBO Science monitored the impacts of perennial pepperweed in the South Bay in 2004 and found minimal impacts to native bird species or even enhanced nesting success for some species (Spautz & Nadav 2004). Perennial pepperweed's impact on native salt marsh vegetation is thought to have a much greater impact on the rare species inhabiting tidal habitats, primarily pickleweed-dependant species such as the salt marsh harvest mouse and clapper rail.

At Sears Point, perennial pepperweed numbers are currently small. Since the restoration of tidal wetlands, perennial pepperweed has been treated at a maintenance level in nearby locations by the USFWS to prevent establishment of dense stands. Perennial pepperweed will continue to establish small populations throughout the site as long as tidal influence remains and nearby populations are not controlled. The USFWS intends to continue annual maintenance of this species as part of regular management on the San Pablo Bay National Wildlife Refuge.

Control Strategies

Herbicide

Manual and mechanical methods have been well documented as ineffective at control and often result in increased abundance and density of perennial pepperweed (Young et al. 1995) therefore herbicide methods are currently the best management practice for pepperweed control in most environments. Perennial pepperweed is susceptible to numerous herbicides but only a few products are labeled for use in tidal wetlands. Glyphosate and imazapyr are both amino acid inhibitor herbicides that have similar modes of action and each has several aquatic formulations that are labeled for tidal wetland management (Rodeo™/Roundup Custom™, and Habitat™/Polaris™ respectively). Both are very effective alone and in combination on perennial pepperweed. Imazapyr may have some advantage over glyphosate as in some field trials it appeared to have less impact on native pickleweeds. Imazapyr also has the benefit of residual soil activity in drier areas and soils without tidal flooding (residual activity is moot in tidally flushed soils). This residual activity is especially beneficial when treating a plant like perennial pepperweed whose main means of propagation is vegetative growth, sprouting from its large, branching root masses. Both herbicides are most effective when applied at the time of flowering to allow for maximum translocation into the plant's storage tissues. Since many life stages are generally present during the time of treatment, complete control is challenging and many years of repeated treatments are necessary for full control.

The most challenging element in perennial pepperweed treatment is that it is extremely difficult to find small and non-flowering populations in a tidal marsh. This species can occur over nearly the entire range of elevation and salinity gradients found at the Sears Point, and its seeds are dispersed by tidal flow so it can occur almost anywhere in the marsh environment. Treatments conducted by Shelterbelt Builders have focused on the edges of levees and channels and along the outer wrack line along the San Pablo Bay shoreline.

2016 Control Summary

Shelterbelt controlled pepperweed during three visits from May 24 until June 15. Backpack sprayers were used for the outer southern Bay-front levee as it is only accessible via boat. A truck mounted spray rig was used to treat the more accessible western, eastern and northern levees. All treatments utilized the aquatic formulation of the herbicide imazapyr.

YELLOW STAR THISTLE AND STINKWORT

Description

Yellow star thistle (*Centaurea solstitialis*) is a non-native annual thistle in the family Asteraceae, thought to be one of the most damaging rangeland weeds in California. Yellow star thistle is distinguished by its characteristic inch-long sharp spines that emerge to protect each flower bud in the early spring/summer.

Yellow star thistle is rated as highly invasive with a high statewide impact by the California Invasive Plant Council (Cal-IPC 2006). The CDFA currently lists yellow star thistle as a class C noxious weed, meaning the plant is known to be of economic or environmental detriment and is relatively widespread throughout the state (CDFA 2016). There is no regulatory control action enforced by the CDFA other than for pest cleanliness standards on imported nursery stock.

Stinkwort (*Dittrichia graveolens*) is an annual herb in the family Asteraceae, native to Europe and Asia. The plant is sticky, highly aromatic and poisonous to people and livestock. It generally has one central stem with many branches, and small narrow leaves. The leaves and flowers are sticky glandular and its common name alludes to resulting aromatic qualities similar to camphor. The small flower heads have yellow ray flowers and yellow to red disk flowers, and seeds have a single row of pappus bristles (Jepson Flora Project 2012; DiTomaso and Healy 2007).

Stinkwort is listed as an invasive species with a moderate statewide impact by the California Invasive Plant Council. It is also listed as a red-alert species due to rapid population and range expansion observed in recent years in numerous California counties, so impacts may increase in the future (Cal-IPC 2006; DiTomaso and Healy 2007; Brownsey et al. 2012). The California Department of Food & Agriculture (CDFA) currently lists stinkwort as a class B noxious weed, meaning the plant is known to cause economic or environmental detriment but has limited distribution (CDFA 2016).

Life History

Yellow star thistle reproduces only from seed. Seed dormancy is minimal (one to three years) in California populations of yellow star thistle and 80 to 90 percent of seed germinates during the first year (DiTomaso 2006). Multiple seed germination periods are apparent in the populations at the Sears Point. Seeds begin to germinate in fall or early winter, and young plants grow as tap-rooted rosettes until bolting occurs in late spring or early summer (Bossard et al. 2000).

Adult plants reach varying heights (two to four feet) based on available soil moisture and nutrient availability. Plants generally flower from May to September. When adequate moisture is available, yellow star thistle can survive as a short-lived perennial and flower throughout fall, winter, and spring (Bossard et al. 2000).

Most seed from yellow star thistle is likely to disperse relatively close to the parent plant in a natural system. Long range dispersal mechanisms are currently unknown though they likely have more to do with anthropogenic factors than other abiotic factors such as wind, water, or wildlife. Poor industrial hygiene and agricultural practices are likely to be the main vector for long range dispersal. Plant seed is spread readily on livestock, hay bales, vegetation management along rights-of-way, and the movement of fill soil and gravel.

Stinkwort is a late-season annual, flowering September through November (Jepson Flora Project 2012). Flowering is triggered by a change in photoperiod in early September, as opposed to changes in soil moisture or other triggers. Seedlings can germinate throughout the winter and early spring, then remain in the basal rosette stage until May, with most stem growth occurring in August and September. Stinkwort disperses by seed only and the sticky, barbed pappus and hairy seeds allows seeds be dispersed by wind, water and by attaching to people, animals, and machinery (Parsons and Cuthbertson 2001). This species is likely to have short-lived seeds with no dormancy (Brownsey et al. 2011). Due to stinkwort's presence both along roads and in seasonal wetlands and vernal pools, it appears to have a wide tolerance of soil moisture levels, soil compaction, and flooding (Brownsey et al. 2012).

Distribution and Impacts in the Sears Point

Yellow star thistle is abundant in seasonal wetlands, grasslands, and levee areas in the Sears Point tidal wetlands project area. It is distributed throughout the site's uplands and drier seasonal wetlands with the largest patches occurring along levee slopes and tops and along the SMART railway right-of-way.

Yellow star thistle is a serious pest in grasslands. Untreated, it forms dense stands in annual grassland and disturbed habitats that can often impede pedestrian access. In these grasslands, yellow star thistle steadily outcompetes and displaces other plant species throughout much of its life cycle - from its dense seedling germination phase to its basal rosette phase – resulting in a grassland area with much reduced botanical diversity. Later season yellow star thistle growth still has a relatively open canopy compared with more dense native perennial grassland (such as creeping wild rye) resulting in poor grassland nesting habitat for ducks and other waterfowl.

Stinkwort is commonly observed along roadsides and also invades disturbed fields, pastures, levees, riparian woodlands, disturbed vernal pools, and tidal marsh margins. At Sears Pont, it is currently present along both inboard and outboard slopes of the main levees and along the railroad right-of-way. Regionally, it is currently present along most major roadways, pastures and other disturbed areas.

Surrounding Sonoma Land Trust properties support rangeland and hay production. The unabated growth of both yellow starthistle and stinkwort at Sears Point subjects these valuable agricultural properties to increased weed pressure that ultimately results in reduced crop yields, reduced values in contaminated hay, and reduced forage for beef and dairy cattle.

Control Strategies

Yellow star thistle is a high priority for management in levee and grassland areas where the species restricts access and impedes habitat restoration efforts. Pilot control efforts from 2010-2012 by Shelterbelt Builders and the USFWS tested three methods of landscape-level control on levees in the and in grasslands at the adjacent Sonoma Baylands: mowing, fall herbicide application, and spring herbicide application. Herbicide was selected for control at Sears Point as it is much more efficient than other methods and is more easily combined for the treatment of multiple species during a single maintenance visit.

Herbicide

Both summer/fall and spring herbicide applications can be an effective component of an integrated approach to control large stands of yellow starthistle and stinkwort at the Sears Point. Summer/fall applications with glyphosate or imazapyr, like mowing, must be timed based on the appropriate plant phenology during periods when the plants are cycling stored carbohydrates to their roots. The effectiveness of these applications is subject to many of the same limitations as mowing though it is slightly less limited to a single growth stage. Late-season applications of glyphosate and imazapyr are generally effective from the bolt stage to early flowering stages (DiTomaso et al. 2006). Using glyphosate when plants are in full bloom may still allow some flowering heads to ripen to produce seed.

Spring applications used selective herbicides like aminopyralid (Milestone™) that are active over a greater period of time from germination to seedling life stages. These products are designed to have a small degree of residual soil activity (meaning the plants can take up the products through their roots up several months after the date of application) which makes timing the applications less critical for effective control, even for multiple generations in a single year. These applications are often more effective as they allow for less escapement as the environment rather than the individual plant is treated. Overall, they utilize much less herbicide to cover similar areas than fall applications and often offer increased efficiencies as tractor/truck mounted boom sprayers can be utilized.

Many herbicides have been used for controlling stinkwort in Australia over the last century. In a review of Australian pesticide labels, 2,4-D and MCPA products were the most frequently listed for controlling stinkwort (Dow Agro – Australia, NuFarm/Monsanto – Australia). Newer products such as aminiopyralid, clopyralid, and triclopyr have no label references in either Australia or the United States but they have potential to be effective. The USFWS staff of San Pablo Bay National Wildlife Refuge has successfully used imazapyr (as Habitat™) to control patches of flowering stinkwort without producing viable seeds (Marriott 2010).

2016 Control Summary

As the Shelterbelt contract started after the spring application window, we were limited to treating yellow starthistle with summer/fall application methods. Our treatment window extended from July 1 through August 10; shifting to sites that demonstrated the appropriate plant phenology for each treatment. We used a combination of glyphosate and imazapyr depending on site conditions and other species we were controlling concurrently. Plants matured near the tidal areas much later than plants in interior areas which made for a long window of control.

Stinkwort was found in many of the same locations as yellow starthistle so we treated both species concurrently. Overall, 2016 treatments encountered small populations of both these species diffused over nearly the entire site. Treatment of these species was very labor intensive. Our goal was to reduce the population for 2016 until we could use more efficient spring herbicide methods in early 2017.

PACIFIC BENTGRASS

Description

Pacific bentgrass (*Agrostis avenacea,* synonym: *Lachnagrostis filiformis*) is a tufted annual grass from Australia in the family Poaceae that can occur as a short-lived perennial in wetland environments. The spikelets are in a relatively open, spreading inflorescence with long awns that help to transport seeds via wind. This morphology leads to its habit observed in its native Australia of creating massive accumulations of seedheads that block equipment air intakes, roads, and railways and knock down fences and structures by increasing wind loads.

Pacific bentgrass is rated as an invasive species with limited statewide impact by the California Invasive Plant Council (Cal-IPC 2006). The CDFA does not currently list this species as a noxious weed (CDFA 2016).

Life History

Unlike some *Agrostis* species, Pacific bentgrass does not have rhizomes or stolons so its primary mode of invasion is by seed. This annual species flowers in June and July in California (Jepson Flora Project 2012), with seed presumably dispersing in July and August. Each plant is capable of producing up to 14,000 seeds; approximately half the seeds drop off near the parent plant and the other half remain in the windblown inflorescence to be dispersed over longer distances (Warnock et al. 2008). Pacific bentgrass is a specialist colonizer of disturbed or barren soils associated with seasonal wetlands (Gosney et al. 2006). It is salt and flood tolerant.

Distribution and Impacts in the Sears Point

In California, Pacific bentgrass most often occurs in temporarily-flooded habitats such as vernal pools and seasonal wetlands (DiTomaso and Healy 2007). In the vicinity of the Sears Point, it appears to become most abundant in disturbed habitats such as constructed seasonal wetlands and tidal channels, fallow diked croplands, or edges of farms subject to repeated disturbance (disking, levee and road repairs, etc.) (Meisler 2012; and pers. obs. by Shelterbelt Builders). Currently, the Sears Point population is restricted to the disturbed inboard slopes of the interior levee in active revegetation zones and in three small patches in seasonal wetland areas.

This competitive annual grass is highly exclusive in moist bare ground areas such as vernal pools. As it develops into a thick, heavy thatch, it can exclude native and rare annual forbs that typically populate vernal pools (Bauder 2009). In disturbed restoration areas along levees, it is likely to be ephemeral. Native shrubs would likely exclude it after developing a closed-canopy.

Control Strategies

In Australia, Pacific bentgrass is often considered a nuisance pest plant around seasonally dry lake beds, and it is commonly controlled with herbicides and mowing. Physical barriers, grazing, and mowing have also been used to manage Pacific bentgrass (Warnock et al. 2009). The effectiveness of these methods is discussed below. Since it is a native plant in Australia, this species is generally managed to minimize mass dispersal of seed heads to prevent property damage and other nuisance problems, rather than trying to eliminate the plant completely.

Herbicide

Late-season applications with glyphosate herbicides are also widely used in Australia to manage seed dispersal. The plants are sprayed when flowering spikelets are beginning to produce seed, which kills the plants but allows some seed to ripen – though in much smaller numbers than without any control. Again, this technique is used to restrict the spread of the plant rather than to eliminate populations.

The most effective removal methods for small populations appear to be early spring glyphosate herbicide applications (Warnock 2009) and hand pulling (Bauder 1996). Extremely small populations in Southern California vernal pool systems have been hand weeded with some degree of success but due to the time required, this tool is limited to very small populations or volunteer or low-cost labor.

Early-season glyphosate application is likely the most cost- and biologically-effective means for patch elimination for small- to medium-sized populations. Since standing water may be present in seasonal wetland areas in the early growing season of Pacific bentgrass, aquatic formulations of glyphosate such as Rodeo™ or Roundup Custom™ should be used, along with aquatic-approved surfactants. Generally, established stands of Pacific bentgrass are likely to be monocultures even at early development stages due to large numbers of seed dropped from previous generations, so non-selective herbicides such as glyphosate are expected to have few non-target impacts when applied on existing patches. Glyphosate applications should be applied when most surface water has receded but before the plants have grown more than six inches tall. This allows the herbicide to be effective at the lowest labeled rates. Several spray events may be necessary depending on the late-season rains and seedling emergence.

2016 Control Summary

Shelterbelt's contract started after Pacific bentgrass had gone to seed. We did not control this species in 2016. The first control is planned for spring 2017.

SUMMARY OF WEED MANAGEMENT STRATEGY

The low gradient slopes of Sears Point levees represent an emerging trend in tidal wetland restoration in the San Francisco Bay Region. These larger transition zones have the opportunity to restore larger expanses of diverse native shrub communities that offer high tide refugia to imperiled tidal marsh species such as clapper rail and salt harvest mouse. They also represent a larger challenge to establish viable native plant communities in challenging environments.

Revegetation of the tidal wetlands of the Sears Point will be allowed to occur naturally as tidal plants are fully capable of establishing in restored marshes voluntarily with tidally dispersed propagules with little disruption from invasive species. The levees, however, are unnatural constructs that require much more active management and restoration. Salvaged soils, variable salinities, and high levels of environmental exposure all pose certain challenges. These sites require adequate site preparation, supplemental active revegetation with live plants and seeds, and diligent weed management.

Diligent weed management does not necessarily mean attempting complete eradication of these species. Complete eradication of the species of primary concern is likely impossible due to the configuration of the Sears Point tidal wetlands project and the number of physical elements that contribute weeds onto the site. Currently the site is surrounded by farmland, industrial areas, and San Pablo Bay, and all are intersected by service roads and an active rail right-of-way.

Some weeds may be tenacious and harmful (yellow starthistle) while others may restrict themselves to recently disturbed locations and bare ground areas (Pacific bentgrass). Attempting to control all the non-native species present can be overwhelming and ultimately unsuccessful, so we developed a strategy to ensure the most efficient use of resources. The strategy is built upon two principles. First, instead of managing against weeds, our philosophy is to manage for the native communities we desire. With this spirit, we identified weed species that have the potential to interfere with natural and supplemented revegetation efforts. Second, to minimize the total, long-term weed control workload, our strategy focuses on containing the spread of plants with expanding ranges and controlling smaller, isolated populations. For the next three years, our management will focus on weed populations that are the fastest growing, most disruptive, and affect the most highly valued areas of the site.

Summary of Weed Control Strategies

Perennial Pepperweed. Pepperweed is currently present mostly on the Bay-side southern levee in very low densities. Our strategy is to use spot spraying with backpack sprayers to maintain populations at very low levels so they do not impede native plant establishment on the levees or spread to any other neighboring levees.

Yellow starthistle & Stinkwort. Both of these late summer growing annuals represents the larger challenge for facilitating levee revegetation. Both are opportunistic spreaders when there is bare ground and little push-back from native plant competition. Our strategy is to confine each species to existing areas and manage for small populations. Yellow starthistle offers the greatest chance for control since adjacent populations are limited. Stinkwort is a regional problem and disperses widely over large areas.

Spring applications of aminopyralid will be used early in the control period where we can achieve maximum efficiency and knock-down of the current populations. As native plants begin to fill-in along the levees, we will shift to spot spraying with glyphosate as the populations decrease.

Pacific bentgrass. Our contract started after the bentgrass had seneced so it was not treated in 2016. Treatment will begin in the spring/summer of 2017. We plan to limit its spread in the disturbed levee zones to facilitate native revegetation.

Other weeds. Iceplant and New Zealand spinach were both treated as they were found in the project area. Isolated patches of these plants are mostly found on the Bay-side southern levee system. These species are regarded as a lower priority as they don’t have the tendency to spread to the degree of the higher priority species. They are however treated when found.

APPENDIX A

TABLE: 2016 herbicide use on Sears Point tidal wetland levees by Shelterbelt Builders Inc.

Date	Applicators (last names)	Target species	Net area treated	Gross area treated	Equipment used	Product	Total gal. mix	% mix (v/v)	**Oz used**
5/24/2016	Brubaker, Siram	perennial pepperweed	0.1 acre	4 acres	backpacks	Polaris	0.75	3%	2.88
5/25/2016	Adamo, Heath, Brubaker	perennial pepperweed, yellow starthistle, stinkwort	1.5 acres	25 acres	backpacks, utv spray rig	Polaris	34.5	3%	132.48
6/15/2016	Brubaker, Heath	perennial pepperweed, yellow starthistle, stinkwort	1 acre	35 acres	backpacks	Polaris	2	3%	7.68
7/1/2016	Brubaker, Protos	perennial pepperweed, yellow starthistle, stinkwort	3 acres	75 acres	double reel spray rig	Roundup Custom	73	2.25%	210.24
7/21/2016	Protos, Nolte	perennial pepperweed, yellow starthistle, stinkwort	7 acres	75 acres	double reel spray rig	Roundup Custom	155	2%	396.8
7/25/2016	Brubaker, Protos	perennial pepperweed, yellow starthistle, stinkwort	3 acres	75 acres	double reel spray rig	Roundup Custom	29	2%	74.24
8/4/2016	Brubaker, Jones, Swagler	stinkwort	3 acres	6 acres	Backpacks	Roundup Custom	18	2%	46.08
8/9/2016	Brubaker	yellow starthistle, stinkwort	3 acres	6 acres	Backpacks	Roundup Custom	21	2%	53.76
8/9/2016	Brubaker	yellow starthistle, stinkwort	3 acres	6 acres	Spray rig	Roundup ProMax	19	4%	97.28

APPENDIX A

Shelterbelt Builders INC
Open Land Management & Restoration
415-357-1500

Sears Point Annual Weeds Treated in 2016 for Sonoma Land Trust

Species treated: stinkwort (Dittrichia graveolens) and yellow star thistle (Centaurea solstitialis)

0 200 400 meters

Legend

Early-season 2016 treatment with Polaris (May-June)

Mid-season 2016 treatment with Roundup (July-August)

Sears Point boundary (approximate)

Imagery: Google Satellite

APPENDIX A

REFERENCES

Bauder, E.T., A.J. Bohonak, B.Hecht, M.A. Simovich, D.Shaw, D.G.Jenkins, and M.Rains. 2009. A draft regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of vernal pool depressional wetlands in Southern California. San Diego State University, San Diego, CA.

Bauder, E.T. 1996. Exotics in Southern California Vernal Pool Ecosystems. Proceedings – 1996 California Exotic Pest Council Symposium. San Diego, CA.

Benefield, C.B., J.M DiTomaso, *et al.* 1999. Success of mowing to control yellow starthistle depends on timing and plant's branching form. *CA Agriculture* 53(2): 17-21.

Bossard, C. C., J. M. Randall, and M. C. Hoshovsky, eds. 2000. Invasive Plants of California's Wildlands. University of California Press, Berkeley, California.

Brownsey, R., G. Kyser, and J. DiTomaso. 2011. Germination and growth traits of *Dittrichia graveolens* – a foundation for developing management strategies. Proceedings – 2011 California Invasive Pest Council Symposium. Lake Tahoe, CA.

Brownsey, R., G. Kyser, and J. DiTomaso. 2012. Stinkwort: history, research, and management. Cal-IPC News 20:2, Berkeley, California.

Cal-IPC. 2006. California Invasive Plant Inventory. Cal-IPC Publication 2006-02. California Invasive Plant Council: Berkeley, California.

California Department of Food and Agriculture (CDFA). 2016. *Encycloweedia* (version dated 7/15/2016), https://www.cdfa.ca.gov/plant/IPC/encycloweedia/weedinfo/winfo_table-sciname.html

DiTomaso, J.M., and E.A. Healy. 2007. Weeds of California and Other Western States, vol. 1 and 2. University of California Agriculture and Natural Resources Publication 2488, Oakland, California.

DiTomaso, J.M., G.B. Kyser, and M.J. Pitcairn. 2006. Yellow starthistle management guide. Cal-IPC Publication 2006-03. California Invasive Plant Council: Berkeley, CA. 78 pp. http://www.cal-ipc.org

Gosney, K.E., S.K. Florentine, and C.Hurst. 2006. Dry lakes and drifing seed-heads: the ecology of fairy grass *Lachnagrostis filiformis.* Council of Australasian Weed Societies – Proceedings of 15th Weed Conference.

Hogle, I., R. Spenst, S. Leininger, and G.Block. 2007. San Pablo Bay National Wildlife Refuge Lepidium latifolium Control Plan. U.S. Fish and Wildlife Service, San Pablo Bay National Wildlife Refuge, Petaluma, California.

Jepson Flora Project (eds.) 2012. *Jepson eFlora*, http://ucjeps.berkeley.edu/IJM.html

Meisler, J. 2012. Best laid plans…Australian bentgrass (*Agrostis avenacea*) invades following seasonal wetland enhancement. Cal-IPC News 20:3, Berkeley, California.

Renz, M.J. 2000. Elemental Stewardship Abstract for *Lepidium latifolium*, perennial pepperweed, tall whitetop. The Nature Conservancy, Wildlands Invasive Species Team.

Spautz, H., N. Nadav. 2004. Impacts of non-native perennial pepperweed (*Lepidium latifolium*) on abundance, distribution and reproductive success of San Francisco Bay tidal marsh birds. Point Reyes Bird Observatory, Stinson Beach, California.

APPENDIX A

Thomsen, C.D., M.P. Vayssieres, and W.A. Williams. 1997. Mowing and subclover plantings suppress yellow starthistle. *CA Agriculture* 51(6): 15-20.

Warnock, A.D. 2009. Controlling *Lachnagrostis filiformis* (Fairy Grass) on dry lake beds in Western Victoria, Australia. Honors Thesis, University of Ballarat, Victoria, Australia.

Warnock, A.D., S.K. Florentine, F.P. Graz, and M.E. Westbrooke. 2008. A unique weed problem – the control of fairy grass *Lachnagrostis filiformis* seedheads on Lake Learmonth in western Victoria. Council of Australasian Weed Societies – Proceedings of 16th Weed Conference. Cairns, Queensland.

Young, J.A., D.E. Palmquist, and R.S.Blank. 1995. Ecology and control of perennial pepperweed (*Lepidium latifolium*). Proceedings – 1995 California Exotic Pest Council Symposium. Pacific Grove, CA.

Appendix B. Sears Point Levee Planting

INTRODUCTION

In 2015, Sonoma Land Trust (SLT) completed the construction of a nearly 2.5-mile (12,850 feet) levee as part of the Sears Point Restoration Project. Unlike traditional levees that are singularly designed for flood control, the Sears Point levee is intended to provide habitat and is referred to throughout this report as the Habitat Levee.

It includes a gently sloping front side (facing the bay) with variable 10:1 to 20:1 slopes intended to mimic the topography of a natural ecotone spanning high marsh to upland (Figure 1). Referred to more frequently as the transition zone or t-zone, it will eventually provide critical high-tide refugia for wildlife during extreme tide and storm surge events. Within this zone are ten shallow depressions that were scraped into the levee to create marsh pannes. These fill and hold water during spring tides and winter rains. For clarity in this report, this bayward side of the levee is referred to as the habitat slope.

The backside of the Habitat Levee, which faces away from the bay, has slopes ranging from steep (3:1) to nearly flat and is referred to as the stability berm. By pushing up against the massive weight of the gently sloping habitat slope, it will prevent the levee from slumping backward until the soils of the habitat slope have settled. This requires about two years after which time the stability berm can be used as a borrow source to raise the levee up to seven feet if the need arises.

The Habitat Levee design is generally in accordance with the 2007 *Sears Point Wetland and Watershed Restoration Project: Final Preliminary Plan*, prepared by Wetlands and Water Resources for SLT. The following is an excerpt from the *Plan*:

> The gently sloping habitat levee edges along the marsh side of the new flood control levee, stabilized by vegetation, will dissipate wave energy and minimize erosion potential while maximizing the width of high marsh transition zones, leaving room for greater species diversity than traditional steep levee slopes. The use of gentle, wide, planted slopes (ranging between 10:1 to 20:1) would ensure rapidly forming fringing high marsh zones, which serves as critical habitat for small mammals inhabiting the tidal marsh. The variable slope generates an irregularly sinuous levee shoreline that will form headlands and shallow embayments or coves, similar to natural terrestrial edges. These irregularities would establish variations in debris deposition, wave exposure, and sediment accretion, and would thus enhance diversity of vegetation and habitats.

SLT and others are working to establish locally appropriate native vegetation on both sides of the Habitat Levee. The total acreage for planting is roughly 42 acres: 13 acres on the habitat slope and 29 acres on the stability berm.

In addition to the new Habitat Levee, SLT broadened the slope of an existing levee which separates the Sears Point site from neighboring Sonoma Baylands. Specifically, SLT increased the slope from 3:1 to 10:1 on the Sears Point side of the levee only. No work was done on the Sonoma Baylands side.

APPENDIX B

This report describes the construction, soil amendment and planting efforts conducted on the two levee areas since 2014.

METHODS

The Habitat Levee was constructed from bay mud that was excavated onsite. The first lift of the levee was built in 2014 to an elevation of 12 feet NAVD88. The second lift was built in 2015. The final levee height ranges from 12 feet to 15.8 feet NAVD88, depending on the depth of bay mud beneath. The levee will uniformly settle to 10.6 feet NAVD88 over the coming decades. The 10:1 separator levee slope was built in 2015.

Soil Sampling

Excavated bay mud that is moist or saturated can develop acid sulfate conditions when exposed to open air for drying. To better understand the growing conditions on the Habitat Levee, SLT analyzed the soils in 2014 and 2015.

In 2014, SLT ran 5 cross-sectional transects across the Habitat Levee. On each transect, approximately 10 soil samples were collected and mixed to ensure a representative sample for each transect. These five samples were submitted to a lab for analysis.

In 2015, this effort was modified. Instead of cross-sections, ten individual locations were sampled. Locations were chosen based upon observations of areas that supported vegetation and those that did not, elevation on the levee, and location on the habitat slope *vs*. the stability berm.

Liming

To improve acidic soil conditions, SLT worked with local farmer Craig Jacobsen to spread and shallowly disc lime into the soil of both the Habitat Levee and the separator levee at a rate of approximately 4 tons/acre. In 2015, a total of 175 tons of lime were applied to the two sites. In 2016, a total of 125 tons of lime were applied to the Habitat Levee only.

Planting

2014/15

To prevent weed infestation and minimize soil erosion on the levee between the 2014 and 2015 construction seasons, Jacobsen planted a hay crop on both sides of the unfinished Habitat Levee.

2015/16

In October 2015, with the final lift of the levee complete, SLT worked with Jacobsen to sow native seed on 4,300 feet of the Habitat Levee (both sides) as well as on the entire length of the separator levee (Figure 2). This amounted to five acres on the habitat slope, ten acres on the stability berm, and two acres on the separator levee. The difference in acreage over the same length on the Habitat Levee was due to the fact that the habitat slope seeding extended from the crest to 8 feet NAVD88 while the stability berm seeding extended all the way to the base, which is roughly at elevation 0 feet NAVD88.

Initially, Jacobsen used a seed drill but the uneven sizes of the native seed size caused the drill to jam and it was replaced with a broadcaster. The seed mixes varied slightly between the habitat slope and the stability berm (Table 1). *Elymus X triticum*, a sterile hybrid erosion control grass, was used on the stability berm because the steep and barren slopes were vulnerable to erosion. To minimize seed predation and to reduce the likelihood of seed washing away during the first rains, a hydro-mulch was applied over the seeded areas. The remaining two-thirds of the Habitat Levee were planted with a hay crop.

In May 2016, SLT accepted a donation of approximately 2,300 pickleweed (*Salicornia pacifica*), 200 gumplant (*Grindelia stricta* var. *angustifolia*), and 50 marsh baccharis (*Baccharis glutinosa*) from The Watershed Nursery in Point Richmond. These were immediately planted by volunteers along the shoreline beneath the one-third of the levee that had been seeded in 2015 (Figure 3).

2016/17
Several planting efforts were completed in 2016/17 and are listed here by type and chronology.

- *Hemizonia congesta* ssp. *lutescens,* October 2016:
  SLT staff and volunteers harvested six large debris bags full of *Hemizonia congesta* ssp. *lutescens* from the uplands of Sears Point (located just north of Highway 37). Harvested plants contained both blooming flowers and mature seed. To distribute the seed, we broadcast seed-bearing branches randomly in a two-acre area of the habitat levee (Figure 3). These were left on the surface without an attempt to cover them.

- *Elymus triticoides* and *Distichlis spicata* rhizome planting, November 2016-April 2017:
  1. November 18, 2016: Two SLT staff and one Ducks Unlimited staff member used drain spades to harvest four demo bags full of *E. triticoides* from a large source population located roughly one mile northwest of the Habitat Levee (Figure 3). We separated the rhizomes from the harvested clumps and shallowly buried them several feet apart along 650 feet of the western end of the habitat slope, just above the high tide mark. Weather was cool and clear and no rain had fallen in more than two weeks. The soil was dry and blocky. These were less than ideal conditions but we wanted to get a sense of the required effort.
  2. November 21-22, 2016: SLT staff rented a small excavator and harvested four pickup loads of *E. triticoides* from the same location in less than one hour. Sterile rice straw was spread over harvested areas to reduce risk of weed invasion. Three of the loads were planted at Cullinan Ranch under the direction of Meg Marriott, Wildlife Biologist, San Pablo Bay National Wildlife Refuge. We hosed down the remaining load, covered it with a tarp, and parked it in a barn until the next day, when Donna Ball from Save the Bay brought 4 volunteers. The seven of us planted 2,200 feet of the lower habitat levee in three hours (insert pics of harvesting and levee planting area). The planting area was just above the wrack line from the western end of the levee to the first stormwater pump. It was cool and clear that day and the soils were wet from recent rains totaling more than 1.9 inches.
  3. January-April, 2017. SLT hired Hanford ARC, a local consulting firm, to harvest *E. triticoides* rhizomes from the same location. Because *E. triticoides* was no longer dormant at this time, a weed trimmer was used to cut all standing biomass before the excavation to minimize desiccation. Sterile rice straw was spread over harvested areas to reduce risk of weed invasion. Hanford also used the excavator to harvest *D. spicata* from the edge of the access road leading to the Refuge Headquarters. Because of the location, the surface was scraped rather

than excavated to yield excellent rhizomatous material. This harvest location is less than 100 feet from the Habitat Levee. The following areas were planted (Figure 3).

a. Hanford planted *E. triticoides* along the entire length of the lower habitat slope just above the wrack line. This followed the December/January spring tides and the wrack line was considerably higher than it had been during the November planting by SLT and Save the Bay. The section planted in November was replanted because those rhizomes appeared to have been washed away. Planting included placing fist-sized mud balls embedded with rhizomes into holes dug with shovels or with a gas auger. Spacing was 4.5 feet on center. (Note: SLT was unaware that an auger was used until after the job was complete. We do not recommend use of an auger.)

b. Hanford planted *E. triticoides* and *D. spicata* into the berms surrounding the marsh pannes and along either side of the Bay Trail on the levee's crest. Planting method involved insertion of a drain spade shovel into the soil at a 45-degree angle and gently pushing the shovel handle forward to create a wedge. The rhizomes were inserted in the wedge, the shovel removed and the wedge tamped down with a boot. The crew was trained in this method by Peter Baye (Baye Method).

c. Hanford planted *E. triticoides* in 20-foot diameter patches throughout the same two-acre area that was seeded with *Hemizonia congesta* ssp. *lutescens* in October 2016. This area had an oat hay crop in the 2014/15 year but not in 2016/17. *E. triticoides* patches were spaced roughly 50 feet apart and planted using the Baye Method.

d. Hanford planted *E. triticoides* along 12,850 feet of the base of the stability berm just above the drainage ditch. Of the total length, approximately 6,600 feet beginning at the western end of the stability berm was planted using a shallow ripper on a skid steer to expose a shallow trench. Rhizome mud balls were spaced every 4.5 feet in the trench and covered by hand. While this method was employed in an effort to increase efficiency, it actually required more time and the remaining 6,250 feet were completed with the Baye Method.

APPENDIX B

SLT rented a small excavator to harvest clumps of *Elymus triticoides* from a nearby source population to transplant rhizomes at the Sears Point levee.

Harvested *E. triticoides* was loaded into pickup trucks and transported to the planting site.

Rhizome planting just above the high tide rack line on the Sears Point levee.

APPENDIX B

Table 1. List of species seeded at Habitat Levee and separator levee in October 2015.

Site	Specific Location	Acreage	Seed Mix	
Habitat Levee	Habitat Slope	5	*Bromus carinatus* *Festuca microstachys* *Elymus glaucus* *Hordeum brachyantherum* *Stipa pulchra* *Eschscholzia californica* *Achillea millefolium* *Artemesia douglasiana* *Lasthenia glabrata* *Baccharis pilularis* *Amsinckia menziesii* *Euthamia occidentalis*	Sonoma Coast Brome Small fescue Blue wild rye Meadow barley Purple needlegrass California poppy Common yarrow Mugwort Goldfields Coyote brush Common fiddleneck Western goldenrod
Habitat Levee	Stability Berm	10	*Elymus X triticum* *Bromus carinatus* *Elymus glaucus* *Elymus triticoides* *Hordeum brachyantherum* *Eschscholzia californica* *Achillea millefolium* *Artemesia douglasiana* *Lasthenia glabrata* *Baccharis pilularis*	Regreen sterile hybrid grass Sonoma Coast Brome Blue wild rye Creeping wild rye Meadow barley California poppy Common yarrow Mugwort Goldfields Coyote brush
Separator Levee	10:1 slope facing Sears Point restoration area	1.8	Same as Habitat Slope*	

**Baccharis pilularis* was not included in the separator levee seed mix because it clogged the seed drill.

RESULTS

Soil Sampling

Soil pH averaged 3.4 in 2015 and 4.2 in 2016, and this high acidity represented challenging growing conditions. The higher pH in 2016 may be due to the 2015 lime application but it is impossible to know. More in-depth analysis in 2016 indicated very high sulfate (SO_4), low to very low levels of N, P, K, and Ca. Soluble salts were medium to very high.

Planting

2014/15

The modest hay crop was harvested in May 2015.

2015/16

Based on casual observation in spring of 2016 and 2017, the seeding yielded moderate results. *Stipa pulchra*, *Festuca microstachys, Elymus glaucus, Eschscholzia californica, Amsinckia menziesii* were evident in low numbers but overall the native species were overwhelmed by Italian ryegrass (*Festuca perennis*) and wild oats (*Avena fatua*), which were present in the seed bank or blew in. A moderate hay crop was harvested in May 2016.

2016/17

No data at time of report.

APPENDIX B

RECOMMENDATIONS FOR 2017/18

The tentative schedule for the 2017/18 winter planting includes continued harvest and planting of rhizomes of *E. triticoides* and *D. spicata* with the addition of *Carex barbarae* and other appropriate species. Planting will occur on both the habitat slope and the stability berm just above the 2016/17 planting. The remainder of the levee will again be planted with oat hay. Planting will occur between November 2017-January 2018. This stair stepping protocol will continue until the entire levee is planted. At that time, oat hay farming will cease.

In addition to rhizome planting, native seed will be collected at appropriate times (Table 2) and broadcast onto the levee with the onset of the winter rains.

Table 2. Native species targeted for seed collection and spread.

Common Name	**Scientific name**	**Time of harvest**	**Harvest location**
Fiddleneck	*Amsinckia intermedia*	April-May	Sears Point uplands and roadsides in the vicinity
Checkerbloom	*Sidalcea malviflora*	April-May	Sears Point uplands
Purple needlegrass	*Stipa pulchra*	April-May	Sears Point uplands
Meadow barley	*Hordeum brachyantherum*	April-May	Sears Point uplands and edges of ag fields at Refuge
Narrowleaf mule's ears	*Wyethia angustifolia*	May-June	Sears Point uplands
Western goldenrod	*Euthamia occidentalis*	May-June	Sonoma Baylands
ragweed	*Senecio hydrophilus*	May-June	Sonoma Baylands
Slim aster	*Symphyotrichum subulatum parviflorum*	July-August	Sonoma Baylands
spikeweed	*Centromadia pungens*	October-November	Sonoma Baylands
yellow hayfield tarweed	*Hemizonia congesta* ssp. *lutescens*	October-November	Sears Point uplands
coyotebrush	*Baccharis pilularis*	November-December	Sonoma Baylands and roadside near levee

APPENDIX B

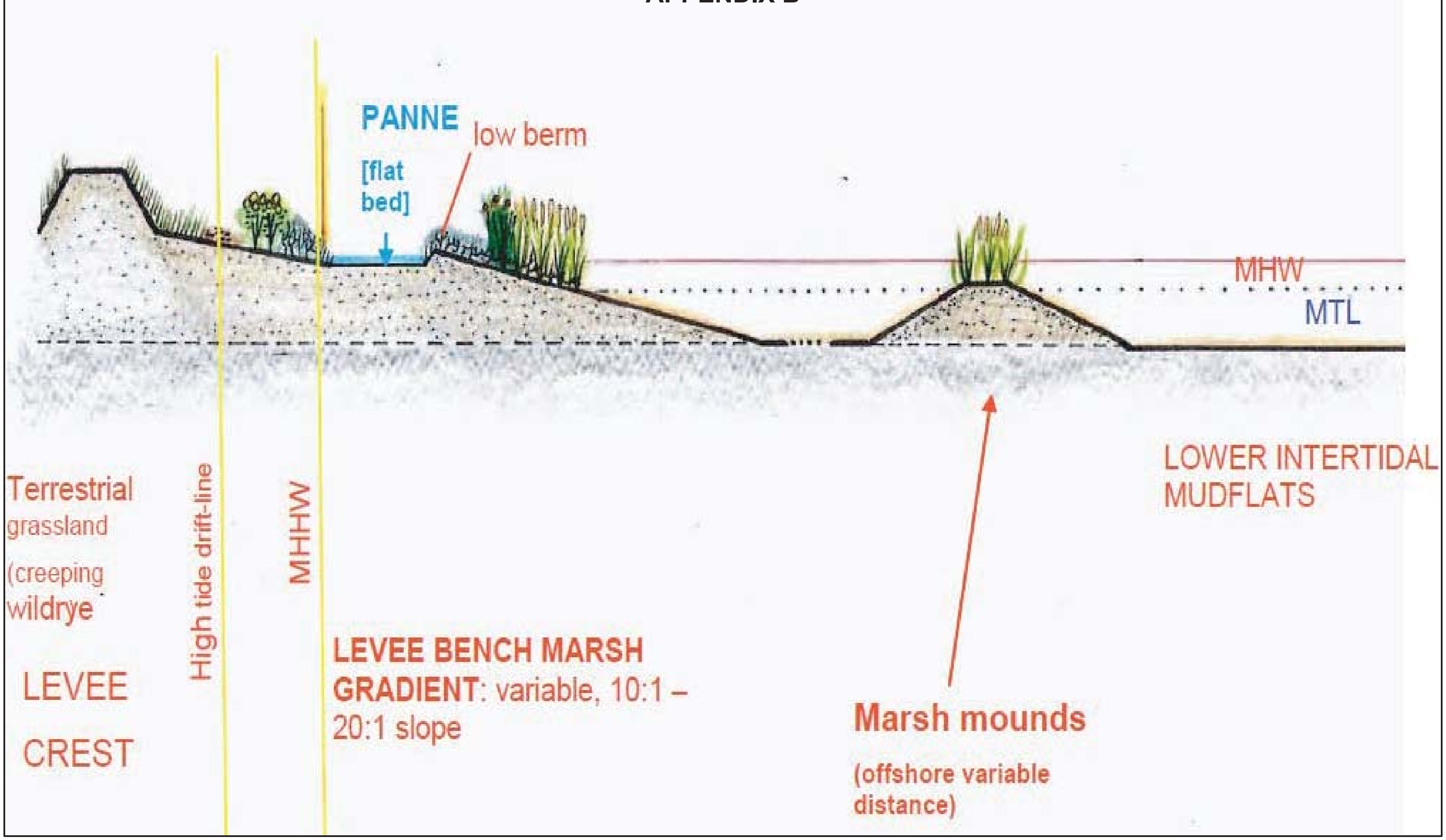


Figure 1. Habitat Levee with gently sloping bayward edge (habitat slope) extending toward the water and intended to support transition zone and upland plant species. Eventually, it will serve as high tide refugia. Drawing by Peter Baye.

Figure 2. Overview of levee areas seeded with native species and oat hay crop in October 2015. Aerial photo date: August 2016.

Figure 3. Overview of levee planting areas in 2016/17. Oat hay planted in October 2016. Hemizonia seeded in October 2016. Elymus rhizomes planted November2015-April 2016. Aerial photo date: August 2016.

Appendix C. Sears Point Photo Monitoring
Feb 2013 – June 2016

Contents:

Notes:

- Photo points 1-8 were established in spring 2013 on February 2, March 29, and May 3 prior to major construction. Varying dates are a result of poor image quality needing to be retaken or additional photo points being added to fill gaps.
- Photo points 9-11 were established June 2014 to fill additional gaps in coverage which became apparent as the project progressed.
- Photo points 12-14 were established in June 2016 to capture views from the new levee that were not available prior to its completion and flooding of the site.
- Flooded conditions in December 2014 photos are the result of storms, not tidal inundation. All water is freshwater. Much of it had to be pumped from the site in order to resume work the following spring/summer.
- The October 2015 photos were taken immediately before the levee breach.
- The June 2016 photos were taken eight months after the breach and the return of the tides.

SEARS POINT PHOTO MONITORING POINTS

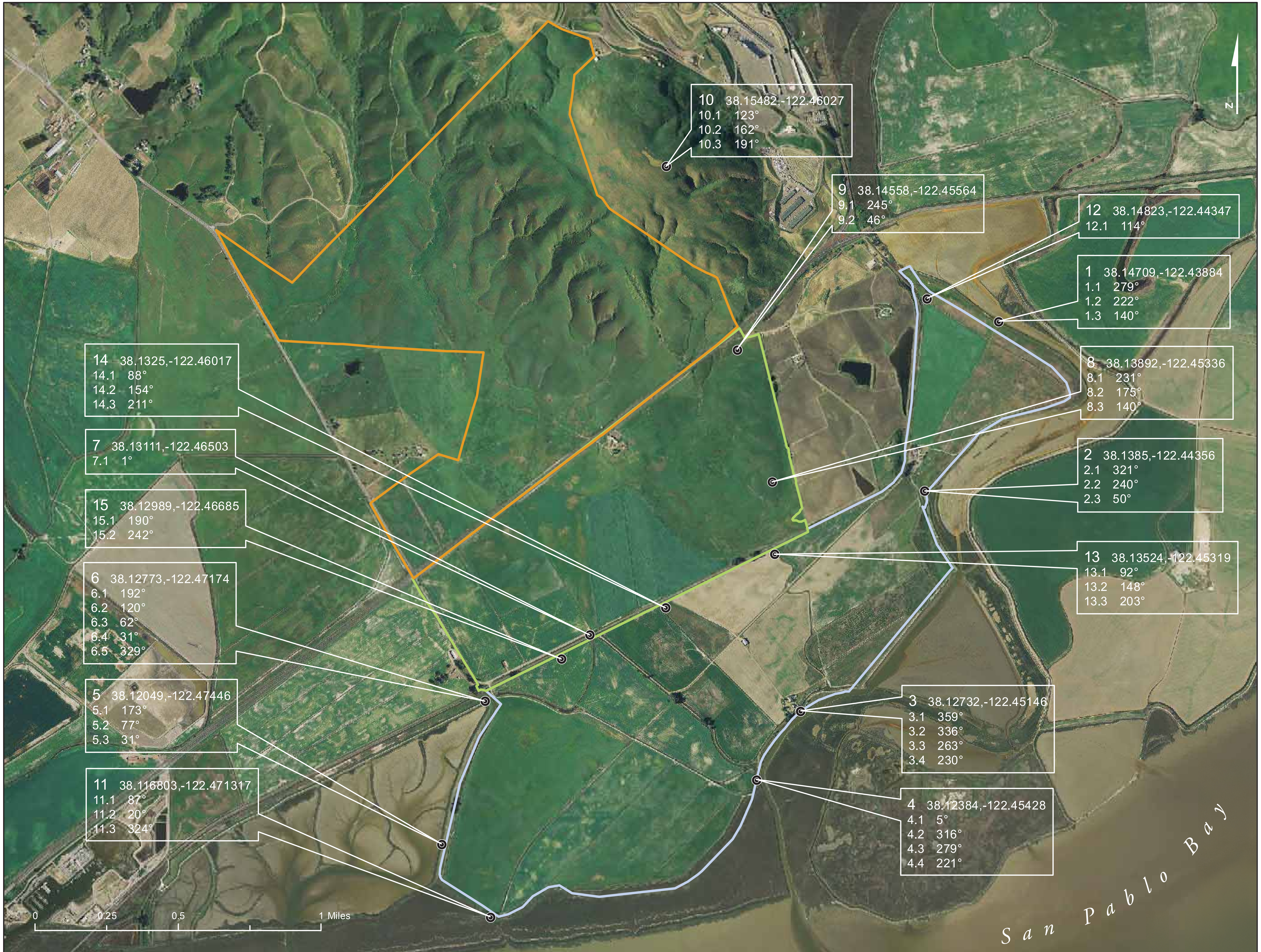
Photo #	Original Photo Date	Photo Point Description	Photo Point Location	Photo Bearing	Photo Description, Purpose, and Intent
1.1	2/13/2013	Crest of old levee near northeast corner of property	N 38.14709 W 122.43884	279	View WNW overlooking ag field to vineyard and Cougar Mountain to show where eastern end of new levee and marsh mounds will be constructed
1.2	2/13/2013	Crest of old levee near northeast corner of property	N 38.14709 W 122.43884	222	View WSW across ag field toward hunt club and eucalyptus trees to show that both these features are removed and that marshmounds and tidal channels have been constructed
1.3	2/13/2013	Crest of old levee near northeast corner of property	N 38.14709 W 122.43884	140	View ESE across ag field with Tubbs Island radio towers and Mt Diablo visible in background to show marsh mound and tidal channel construction
2.1	2/13/2013	Crest of old levee at pinch point of property	N 38.13850 W 122. 44356	321	View NW to show hunt club and eucalyptus trees to be removed and soil remediation area.
2.2	2/13/2013	Crest of old levee at pinch point of property	N 38.13850 W 122. 44356	240	View W across ag fields toward Dickson barns and home site to show future tidal channels and marsh mounds and removal of structures
2.3	12/31/2014	Crest of old levee at pinch point of property	N 38.13850 W 122. 44356	50	View E over graded levee with Tolay Creek on right of photo.
3.1	2/13/2013	Crest of levee behind Dickson farm buildings	N 38.12732 W 122.45146	359	View N of pumps and buildings that will be removed. Cougar Mountain in distance
3.2	2/13/2013	Crest of levee behind Dickson farm buildings	N 38.12732 W 122.45146	316	View NW of Dickson buildings to be removed
3.3	2/13/2013	Crest of levee behind Dickson farm buildings	N 38.12732 W 122.45146	263	View W of Dickson buildings and power poles to be removed. Mt Burdell in background
3.4	5/3/2013	Crest of levee behind Dickson farm buildings	N 38.12732 W 122.45146	230	View along levee crest toward planned breach 2 with power poles scheduled for removal
4.1	5/3/2013	Crest of levee just west of planned breach two	N 38.12384 W 122.45428	5	Alternate view along levee crest toward planned breach 2 with poles to be removed
4.2	2/13/2013	Crest of levee just west of planned breach two	N 38.12384 W 122.45428	316	View NW over ag fields and existing drainage ditch where new tidal channels and marsh mounds will be constructed
4.3	2/13/2013	Crest of levee just west of planned breach two	N 38.12384 W 122.45428	272	View W over ag fields where new tidal channels and marsh mounds will be constructed. Mt Burdell in distance.
4.4	2/13/2013	Crest of levee just west of planned breach two	N 38.12384 W 122.45428	221	View SW over fields toward Sonoma Baylands where new tidal channels and marsh mounds will be constructed
5.1	5/3/2013	south end of levee dividing Sears Point from Sonoma Baylands	N 38.12049 W 122.47446	173	View S of future Breach 1
5.2	5/3/2013	south end of levee dividing Sears Point from Sonoma Baylands	N 38.12049 W 122.47446	77	View NE over ag fields where new tidal channels and marsh mounds will be constructed
5.3	5/3/2013	south end of levee dividing Sears Point from Sonoma Baylands	N 38.12049 W 122.47446	31	View NE along levee and fields where new tidal channels and marsh mounds will be constructed
6.1	2/13/2013	Sonoma Baylands levee where it will join Sears Point levee	N 38.12773 W 122.47174	192	View S with Sonoma Baylands marsh in foreground and Sears Point in background intended to show proximity of restored sites
6.2	2/13/2013	Sonoma Baylands levee where it will join Sears Point levee	N 38.12773 W 122.47174	120	View SE over ag fields where new tidal channels and marsh mounds will be constructed. Mt Diablo in distance
6.3	2/13/2013	Sonoma Baylands levee where it will join Sears Point levee	N 38.12773 W 122.47174	62	View ENE where new levee will be built
6.4	2/13/2013	Sonoma Baylands levee where it will join Sears Point levee	N 38.12773 W 122.47174	31	View NE toward Cougar Mountain across fields north of RR with barn where new levee will be built
6.5	2/13/2013	Sonoma Baylands levee where it will join Sears Point levee	N 38.12773 W 122.47174	329	View NW across RR track toward eucalyptus that will be removed
7.1	5/3/2013	North of railroad crossing on Reclamation Road	N 38.13111 W 122.46503	1	View N toward Cougar Mountain. New road will be in foreground
8.1	3/29/2013	Hilltop located north of railroad track looking over future tidal area	N 38.13892 W 122.45336	206	View toward Mt. Tam and San Pablo Bay with future tidal restoration area in mid-ground
8.2	3/29/2013	Hilltop located north of railroad track looking over future tidal area	N 38.13892 W 122.45336	175	View toward San Francisco and San Pablo Bay with Dickson Ranch buildings and future tidal area in mid-ground
8.3	3/29/2013	Hilltop located north of railroad track looking over future tidal area	N 38.13892 W 122.45336	140	View toward Mt. Diablo and San Pablo Bay with vineyard in foreground and future tidal area in mid-ground
9.1	5/21/2014	Riparian enhancement area just south of Hwy 37	N38.14558 W122.45564	245	Inside riparian exclosure looking downstream at riparian plantings
9.2	5/21/2014	Riparian enhancement area just south of Hwy 37	N38.14558 W122.45564	46	Inside riparian exclosure looking into headcutting tributary with willow wall.
10.1	5/21/2014	Top of Cougar Mountain overlooking project site (need raceway permission for access)	N38.15482 W122.46027	123	View ESE toward the head of Tolay Creek (tidal portion) and the eastern portion of the tidal restoration area.
10.2	5/21/2014	Top of Cougar Mountain overlooking project site (need raceway permission for access)	N38.15482 W122.46027	162	View SE of middle portion of tidal restoration area with riparian enhancement area and stormwater pond 2 visible in mid-ground of photo
10.3	5/21/2014	Top of Cougar Mountain overlooking project site (need raceway permission for access)	N38.15482 W122.46027	191	View SW over Refuge headquarters, stormwater pond 1 and western portion of tidal restoration area. Mt Tam in background.
11.1	6/6/2014	On old levee just west of planned Breach 1	N38.11680 W122.47131	87	View toward Breach 1 on levee
11.2	6/6/2014	On old levee just west of planned Breach 1	N38.11680 W122.47131	20	View NNE toward Cougar Mountain where channel will be built
11.3	6/6/2014	On old levee just west of planned Breach 1	N38.11680 W122.47131	324	View NW with Sears Point levee in foregrand and Sonoma Baylands divider levee in background
12.1	6/7/2016	Top of new levee near northeastern end overlooking restoration area and marsh panne.	N38.14823 W122.44347	114	View SE over marsh panne, habitat levee slope, and restoration area.
13.1	6/7/2016	On top of levee at Pump 2 outlet	N38.13524 W122.45319	92	View E of habitat levee slope and restoration area. Low tide during original photo shows exposed mudflat
13.2	6/7/2016	On top of levee at Pump 2 outlet	N38.13524 W122.45319	148	View ESE over pump 2 outlet and restoration area. Low tide during original photo shows exposed mudflat
13.3	6/7/2016	On top of levee at Pump 2 outlet	N38.13524 W122.45319	203	View SW over habitat levee and restoration area. Low tide during original photo shows exposed mudflat
14.1	6/7/2016	On top of levee	N38.13250 W122.46017	88	View E over levee habitat slope and restoration area. Low tide during original photo
14.2	6/7/2016	On top of levee	N38.13250 W122.46017	154	View SE over levee habitat slope and restoration area. Low tide during original photo
14.3	6/7/2016	On top of levee	N38.13250 W122.46017	211	View SW over levee habitat slope and restoration area. Low tide during original photo
15.1	6/7/2016	On top of levee	N38.12989 W122.46685	190	View SW over levee habitat slope and restoration area. Marsh panne in forground is full. Low tide during original photo
15.2	6/7/2016	On top of levee	N38.12989 W122.46685	242	View W along Bay Trail showing both sides of levee. Vegetation on either side of levee is stubble following hay harvest.

Sears Point Photo Monitoring

Photo Monitoring Points

Sears Point Restoration Zones

- Tidal
- Upland
- Seasonal Wetland



Aerial Imagery:
Digital Globe 2009, SCAOSD
Sears Point Restoration Zones:
Sonoma Land Trust GIS
Photo Monitoring Points:
Sonoma Land Trust 2016
Map Created 7/8/2016 V.1

SONOMA LAND TRUST

Photo Point 1, Photo 1.1

N 38.14709, W 122.43884

Bearing 279°

Photo Point Description: Crest of historic levee near northeast corner of property

Photo Description: View W overlooking ag field to Paradise Vineyard and Cougar Mountain showing where eastern end of new levee and marsh mounds will be constructed

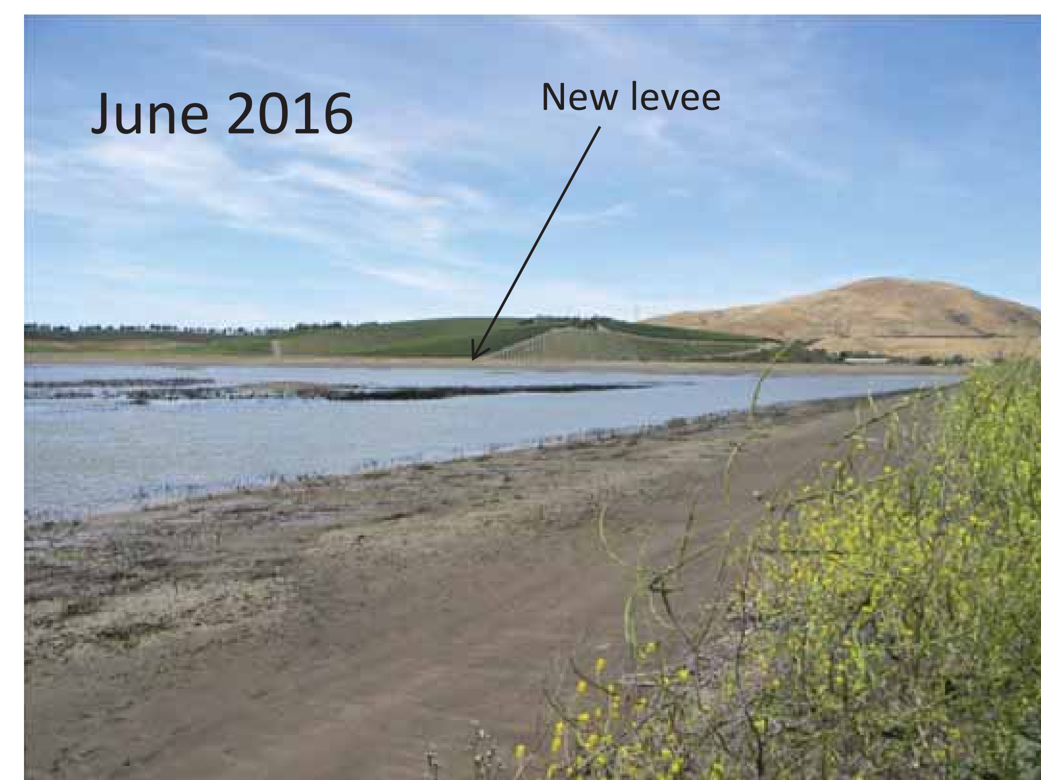


Photo Point 1, Photo 1.2

N 38.14709, W 122.43884

Bearing 222°

Photo Point Description: Crest of historic levee near northeast corner of property

Photo Description: View WSW across ag field toward hunt club and eucalyptus trees to show that both these features are removed and that marsh mounds and tidal channels have been constructed

Photo Point 1, Photo 1.3

N 38.14709, W 122.43884

Bearing 140°

Photo Point Description: Crest of old levee near northeast corner of property

Photo Description: View ESE across ag field with Tubbs Island radio towers and Mt Diablo visible in background to show marsh mound and tidal channel construction

Photo Point 2, Photo 2.1

N 38.13850, W 122. 44356

Bearing 321°

Photo Point Description: Crest of historic levee at pinch point of property

Photo Description: View NW to show hunt club and eucalyptus trees to be removed and soil remediation area


February, 2013


May, 2014

December, 2014


October, 2015


June, 2016

Photo Point 2, Photo 2.2

N 38.13850, W 122. 44356

Bearing 240°

Photo Point Description: Crest of old levee at pinch point of property

Photo Description: View W across ag fields toward Dickson barns and home site to show future tidal channels and marsh mounds and removal of structures

Photo Point 2, Photo 2.3

N 38.13850, W 122. 44356

Bearing 50°

Photo Point Description: Crest of old levee at pinch point of property

Photo Description: View E over graded levee with Tolay Creek on right of photo

Photo Point 3, Photo 3.1

N 38.12732, W 122.45146

Bearing 359°

Photo Point Description: Crest of historic levee behind Dickson farm buildings

Photo Description: View N of pumps and buildings to be removed. Cougar Mountain in distance.

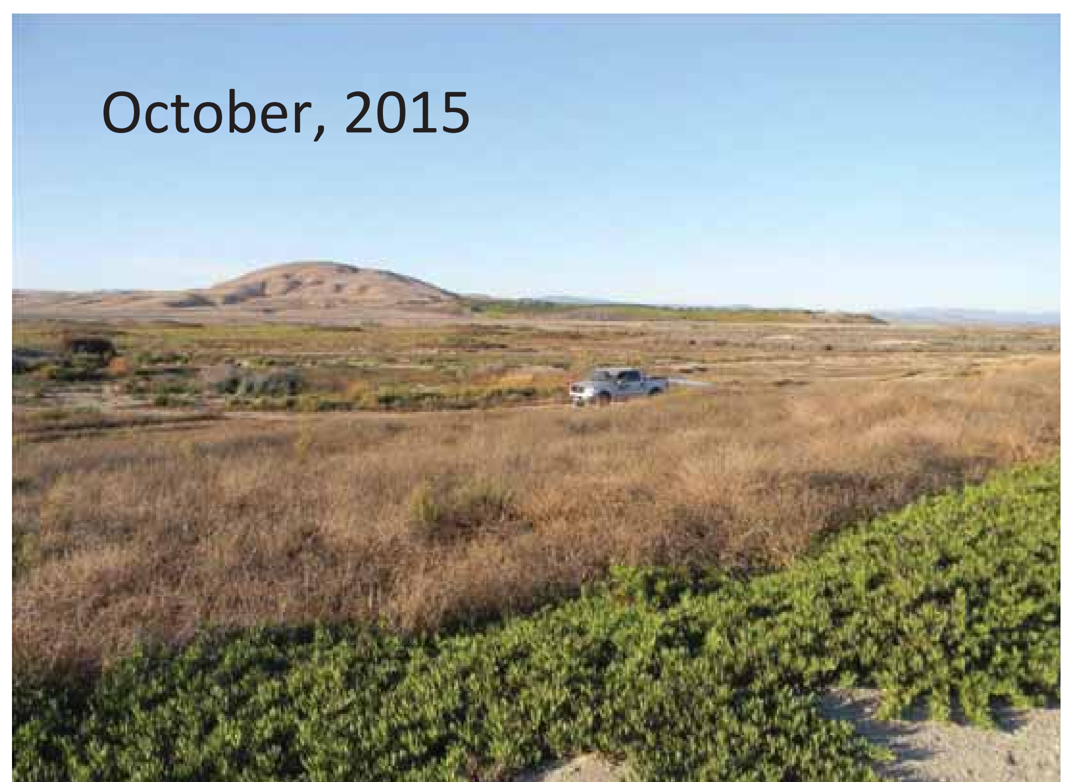


Photo Point 3, Photo 3.2

N 38.12732, W 122.45146

Bearing 316°

Photo Point Description: Crest of historic levee behind Dickson farm buildings

Photo Description: View NW of Dickson buildings to be removed.

February, 2013

May, 2014

December, 2014

October, 2015

June, 2016

Photo Point 3, Photo 3.3

N 38.12732, W 122.45146

Bearing 263°

Photo Point Description: Crest of historic levee behind Dickson farm buildings

Photo Description: View W of Dickson buildings and power poles to be removed. Mt Burdell in background

February, 2013

May, 2014

December, 2014

October, 2015

June, 2016

Photo Point 3, Photo 3.4

N 38.12732, W 122.45146

Bearing 230°

Photo Point Description: Crest of historic levee behind Dickson farm buildings

Photo Description: View along levee crest toward planned breach 2 with power poles scheduled for removal

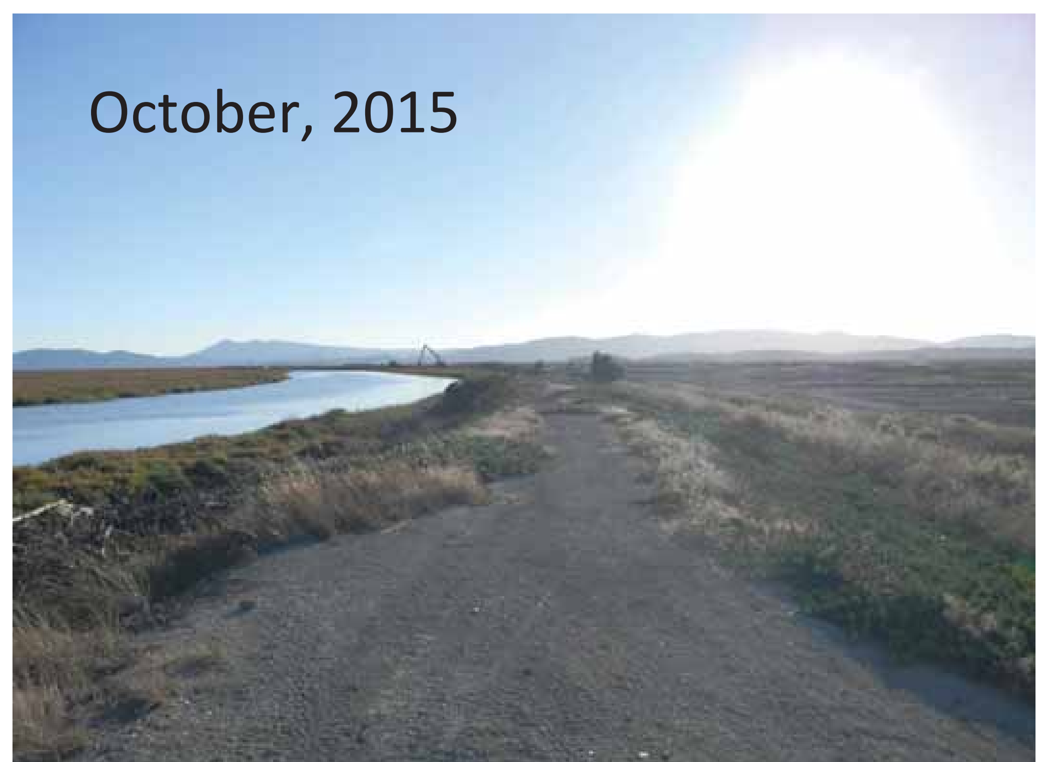


Photo Point 4, Photo 4.1

N 38.12384, W 122.45428
Bearing 5°

Photo Point Description: Crest of historic levee just west of planned breach two

Photo Description: Alternate view along levee crest toward planned breach 2 with poles to be removed

Photo Point 4, Photo 4.2

N 38.12384, W 122.45428
Bearing 316°

Photo Point Description: Crest of historic levee behind Dickson farm buildings

Photo Description: View NW over ag fields and existing drainage ditch where new tidal channels and marsh mounds will be constructed

Photo Point 4, Photo 4.3

N 38.12384, W 122.45428

Bearing 272°

Photo Point Description: Crest of historic levee behind Dickson farm buildings

Photo Description: View W over ag fields where new tidal channels and marsh mounds will be constructed. Mt Burdell in distance.


February, 2013


May, 2014

December, 2014


October, 2015


June, 2016

Photo Point 4, Photo 4.4

N 38.12384, W 122.45428

Bearing 221°

Photo Point Description: Crest of historic levee behind Dickson farm buildings

Photo Description: View SW over fields toward Sonoma Baylands where new tidal channels and marsh mounds will be constructed

February, 2013

May, 2014

December, 2014

October, 2015

June, 2016

Photo Point 5, Photo 5.1

N 38.12049, W 122.47446

Bearing 173°

Photo Point Description: south end of levee dividing Sears Point from Sonoma Baylands

Photo Description: View S of future Breach 1

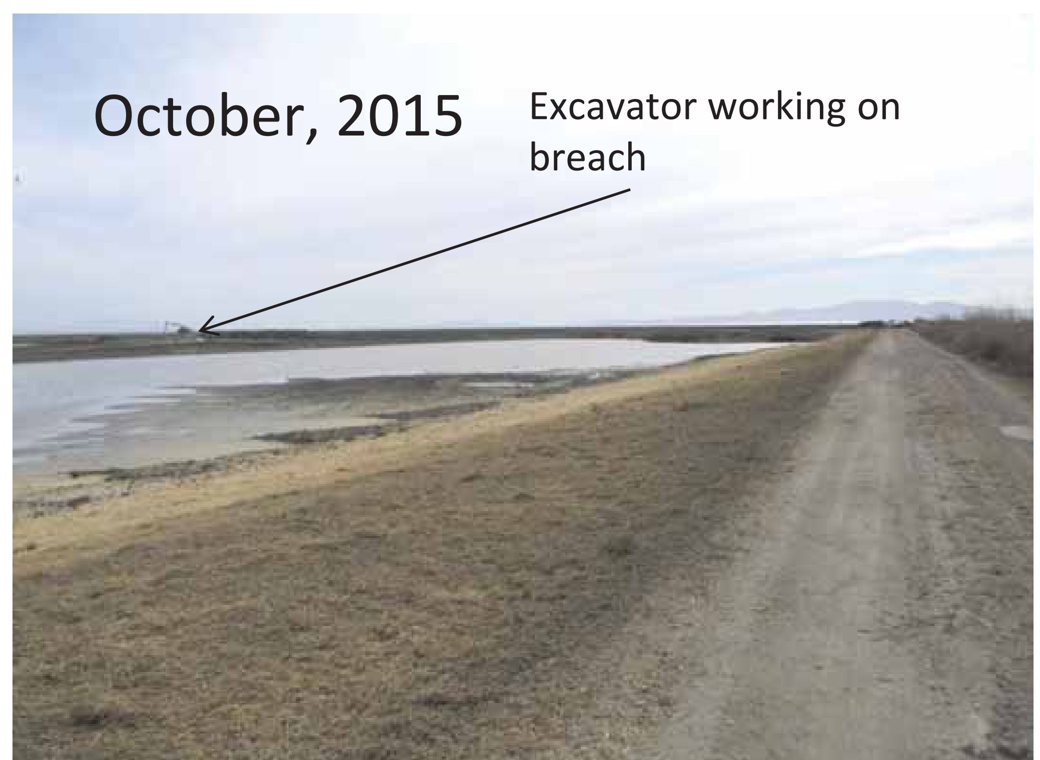


Photo Point 5, Photo 5.2

N 38.12049, W 122.47446

Bearing 77°

Photo Point Description: south end of levee dividing Sears Point from Sonoma Baylands

Photo Description: View NE over ag fields where new tidal channels and marsh mounds will be constructed

Photo Point 5, Photo 5.3

N 38.12049, W 122.47446

Bearing 31°

Photo Point Description: south end of levee dividing Sears Point from Sonoma Baylands

Photo Description: View NE along levee and fields where new tidal channels and marsh mounds will be constructed

Photo Point 6, Photo 6.1

N 38.12773, W 122.47174

Bearing 192°

Photo Point Description: Sonoma Baylands levee where it will join Sears Point levee

Photo Description: View S with Sonoma Baylands marsh in foreground and Sears Point in background intended to show proximity of restored sites. Sonoma Baylands was restored in 1995.

Photo Point 6, Photo 6.2

N 38.12773, W 122.47174

Bearing 120°

Photo Point Description: Sonoma Baylands levee where it will join Sears Point levee

Photo Description: View SE over ag fields where new tidal channels and marsh mounds will be constructed. Mt Diablo in distance


February, 2013


May, 2014


December, 2014


October, 2015


June, 2016

Photo Point 6, Photo 6.3

N 38.12773, W 122.47174

Bearing 62°

Photo Point Description: Sonoma Baylands levee where it will join Sears Point levee

Photo Description: View ENE where new levee and Bay Trail will be built

Photo Point 6, Photo 6.4

N 38.12773, W 122.47174

Bearing 31°

Photo Point Description: Sonoma Baylands levee where it will join Sears Point levee

Photo Description: View NE toward Cougar Mountain across fields north of RR with barn where new levee will be built

Photo Point 6, Photo 6.5

N 38.12773, W 122.47174

Bearing 329°

Photo Point Description: Sonoma Baylands levee where it will join Sears Point levee

Photo Description: View NW across RR track toward eucalyptus that will be removed

Photo Point 7, Photo 7.1

N 38.13111, W 122.46503
Bearing 1°

Photo Point Description: North of railroad crossing on Reclamation Road

Photo Description: View N toward Cougar Mountain. New road and stormwater pump will be in foreground

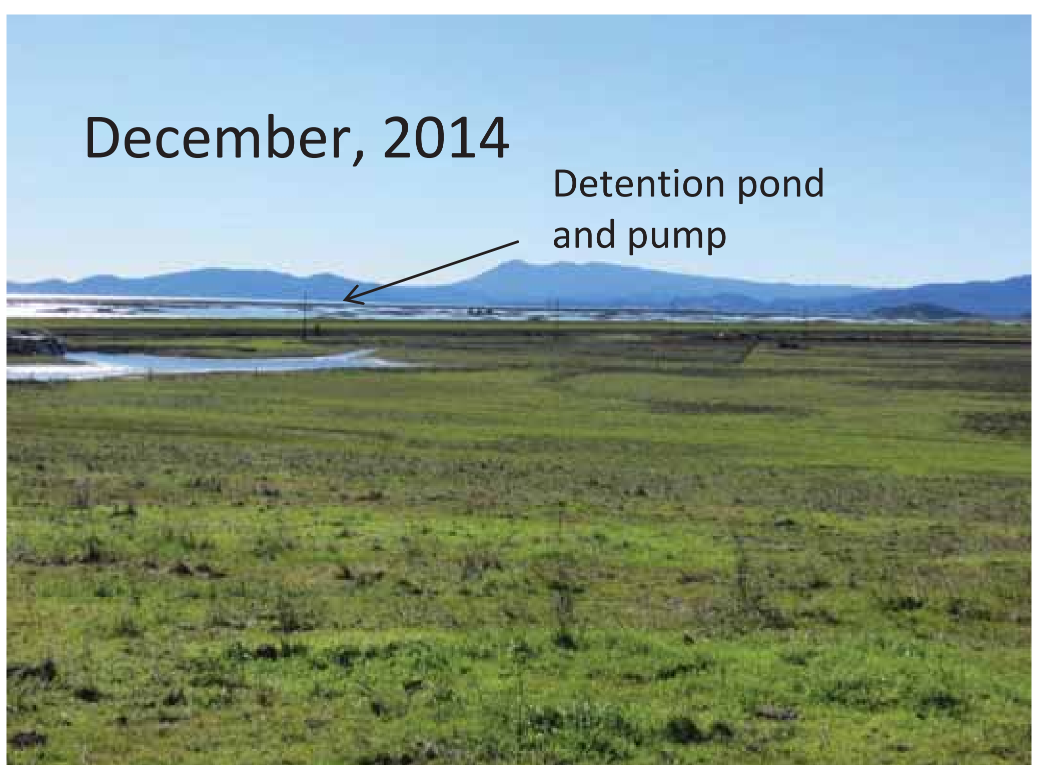
Photo Point 8, Photo 8.1

N 38.13892, W 122.45336

Bearing 206°

Photo Point Description: Hilltop located north of railroad track looking over future tidal area.

Photo Description: View toward Mt. Tam and San Pablo Bay with future tidal restoration area in mid-ground. Note detention pond for stormwater pump built in foreground



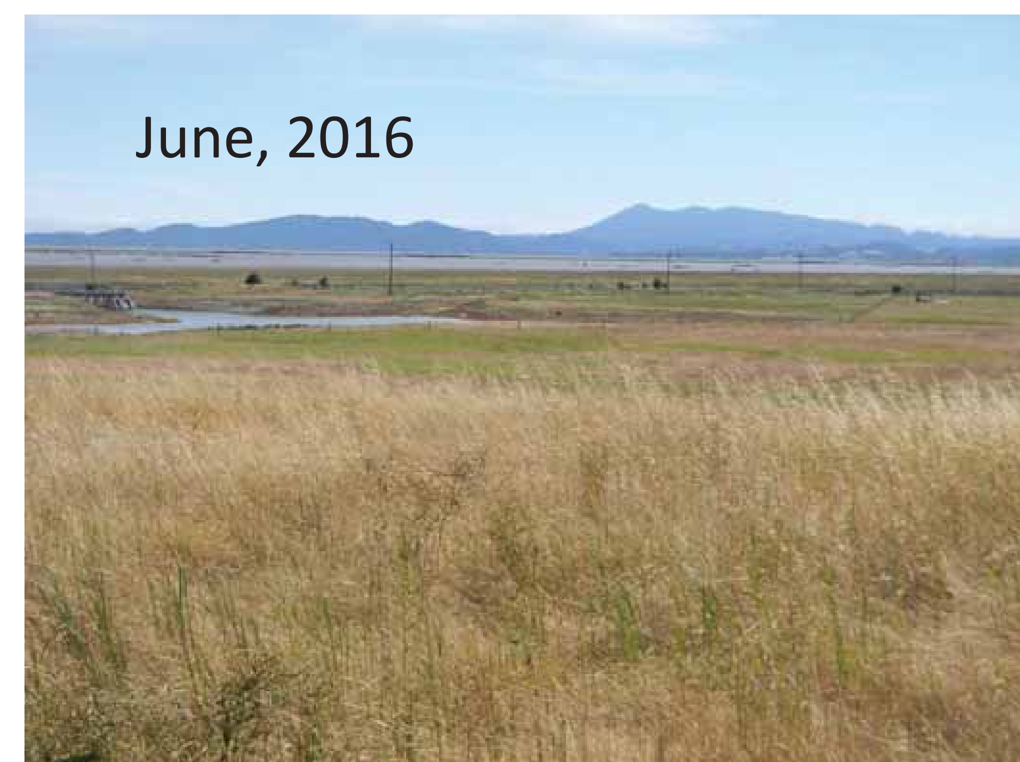


Photo Point 8, Photo 8.2

N 38.13892, W 122.45336

Bearing 175°

Photo Point Description: Hilltop located north of railroad track looking over future tidal area.

Photo Description: View toward San Francisco and San Pablo Bay with Dickson Ranch buildings and future tidal area in mid-ground. Note detention pond for stormwater pump built in foreground

Photo Point 8, Photo 8.3

N 38.13892, W 122.45336

Bearing 140°

Photo Point Description: Hilltop located north of railroad track looking over future tidal area

Photo Description: View toward Mt. Diablo and San Pablo Bay with vineyard in foreground and future tidal area in mid-ground

Photo Point 9, Photo 9.1

N38.14558, W122.45564

Bearing 245°

Photo Point Description: Riparian enhancement area just south of Hwy 37
Photo Description: Inside riparian exclosure looking downstream at riparian plantings

Photo point not yet established

Photo not taken

Photo Point 9, Photo 9.2

N 38.13892, W 122.45336

Bearing 46°

Photo Point Description: Hilltop located north of railroad track looking over future tidal area

Photo Description: Inside riparian exclosure looking into headcutting tributary with willow wall.

Photo point not yet established

Photo not taken

Photo Point 10, Photo 10.1

N38.15482, W122.46027
Bearing 123°

Photo Point Description: Top of Cougar Mountain overlooking project site

Photo Description: View ESE toward the head of Tolay Creek (tidal portion) and the eastern portion of the tidal restoration area.

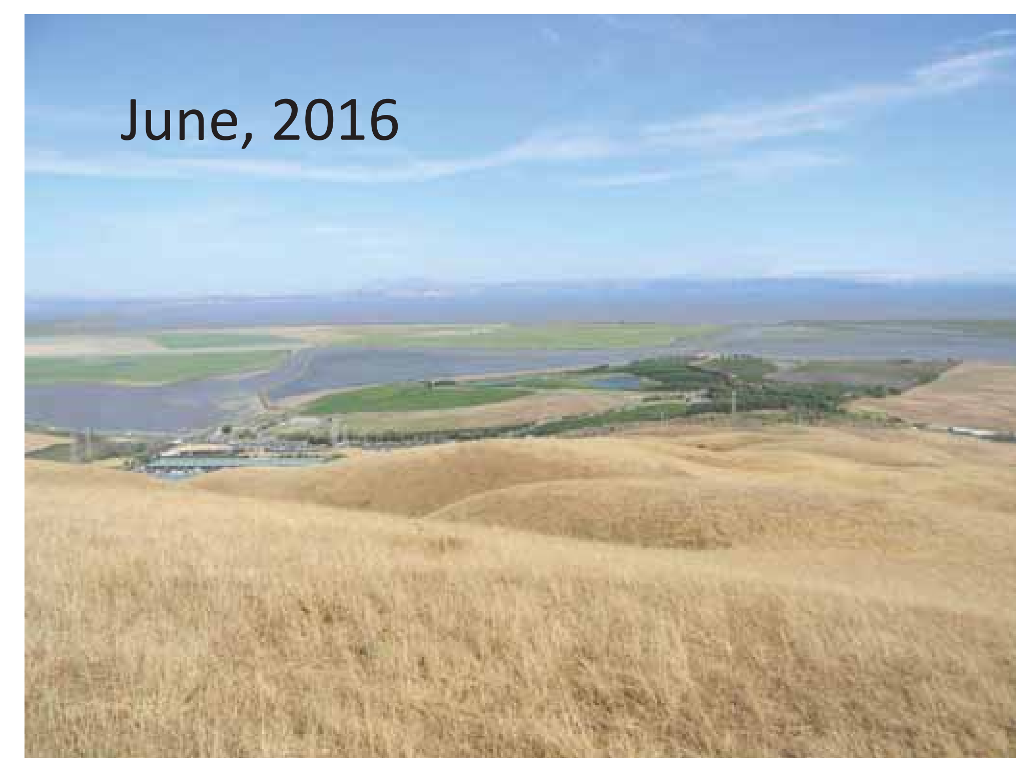


Photo Point 10, Photo 10.2

N38.15482, W122.46027

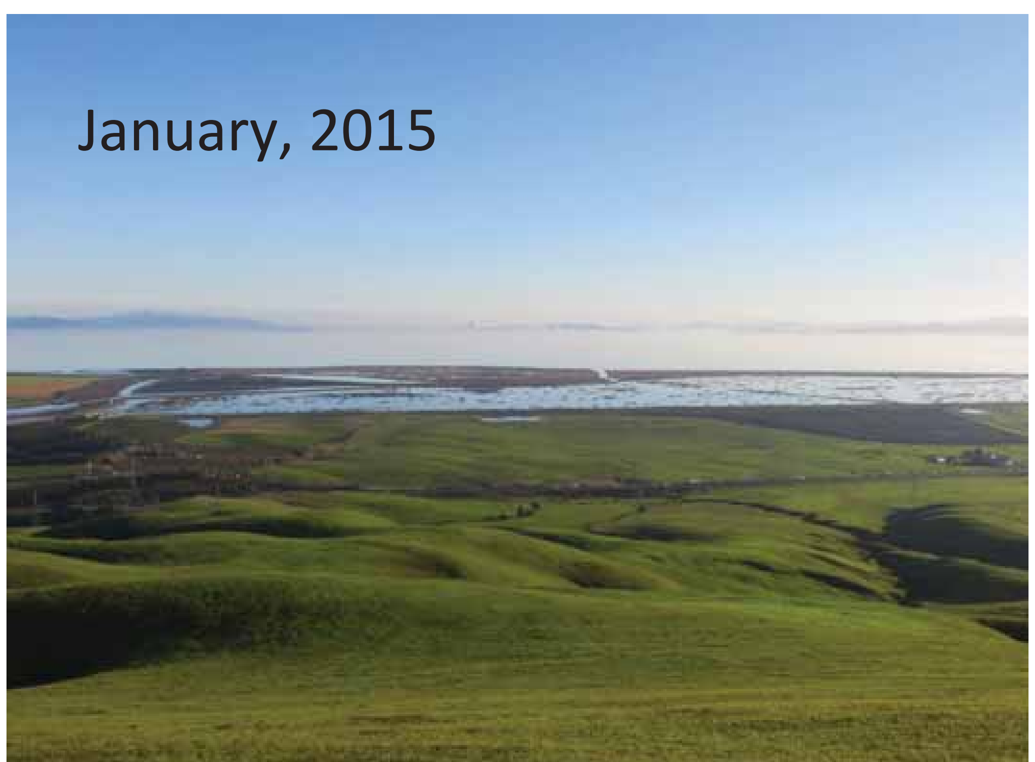
Bearing 162°

Photo Point Description: Top of Cougar Mountain overlooking project site

Photo Description: View SE of middle portion of tidal restoration area with riparian enhancement area and stormwater pond 2 visible in mid-ground of photo

Photo point not yet established


May, 2014


January, 2015


October, 2015

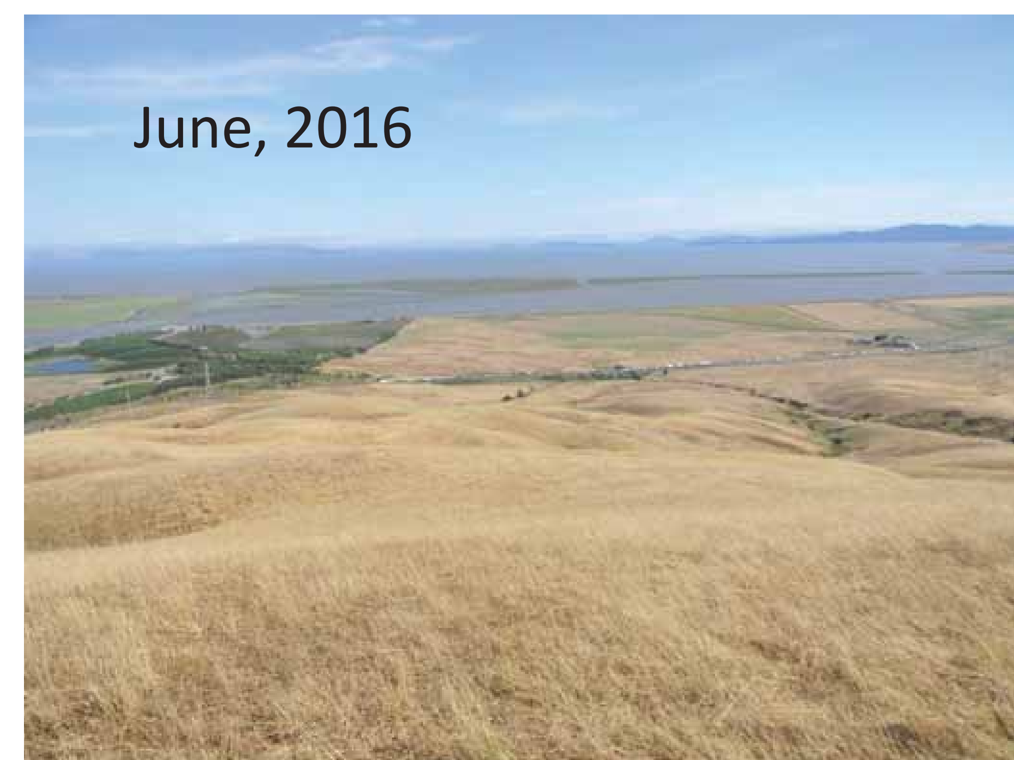

June, 2016

Photo Point 10, Photo 10.3

N38.15482, W122.46027

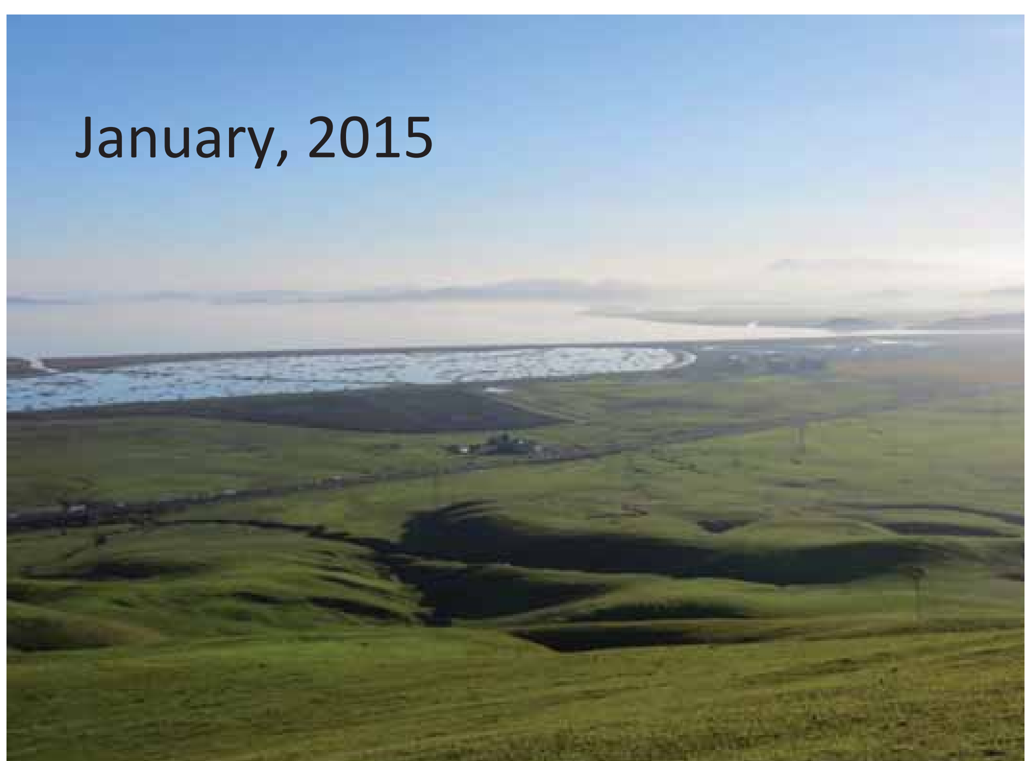
Bearing 191°

Photo Point Description: Top of Cougar Mountain overlooking project site

Photo Description: View SW over Refuge headquarters, stormwater pond 1 and western portion of tidal restoration area. Mt Tam in background.

Photo point not yet established


May, 2014


January, 2015


October, 2015


June, 2016

Photo Point 11, Photo 11.1

N38.11680, W122.47131

Bearing 87°

Photo Point Description: On old levee just west of planned Breach 1

Photo Description: View toward Breach 1 on levee

Photo point not yet established

June, 2014

December, 2014

October, 2015

June, 2016

Photo Point 11, Photo 11.2

N38.11680, W122.47131

Bearing 20°

Photo Point Description: On old levee just west of planned Breach 1

Photo Description: View NNE toward Cougar Mountain where channel will be built

Photo point not yet established

June, 2014

December, 2014

October, 2015

June, 2016

Photo Point 11, Photo 11.3

N38.11680, W122.47131
Bearing 324°

Photo Point Description: On old levee just west of planned Breach 1

Photo Description: View NW with Sears Point levee in foreground and Sonoma Baylands separator levee in background

Photo point not yet established

Photo Point 12, Photo 12.1

N38.14823, W122.44347

Bearing 114°

Photo Point Description: Top of new levee near northeastern end overlooking restoration area and marsh panne.

Photo Description: View SE over marsh panne, habitat levee slope, and restoration area.

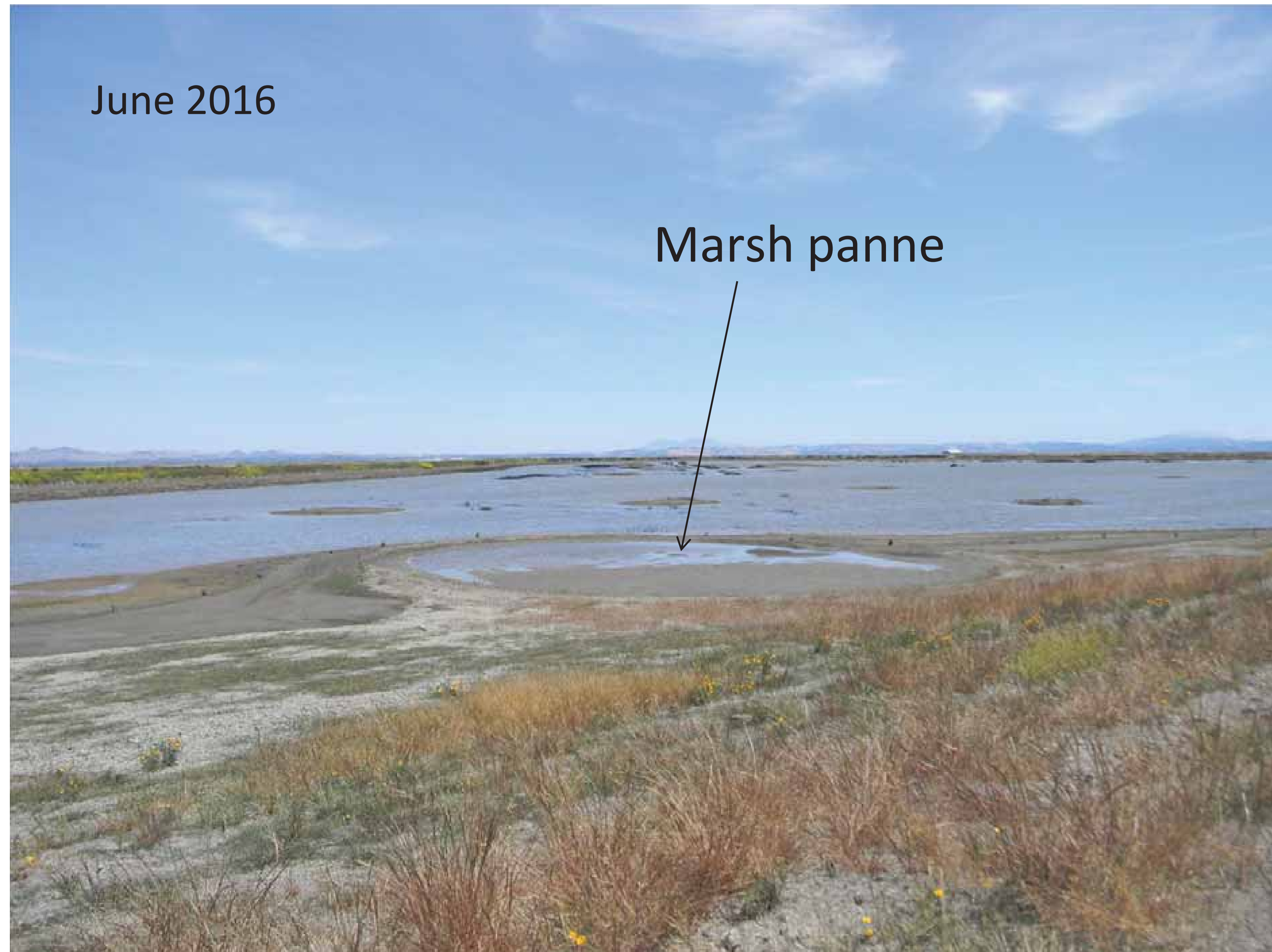


Photo point first established June 2016

Photo Point 13, Photo 13.1

N38.135244, W122.45319

Bearing 92°

Photo Point Description: Top of new levee near northeastern end overlooking restoration area and marsh panne.

Photo Description: View E of habitat levee slope and restoration area. Low tide during original photo shows exposed mudflat

Photo point first established June 2016

Photo Point 13, Photo 13.2

N38.135244, W122.45319

Bearing 148°

Photo Point Description: Top of new levee near northeastern end overlooking restoration area and marsh panne.

Photo Description: View ESE over pump 2 outlet and restoration area. Low tide during original photo shows exposed mudflat

Photo point first established June 2016

Photo Point 13, Photo 13.3

N38.135244, W122.45319
Bearing 203°

Photo Point Description: Top of new levee near northeastern end overlooking restoration area and marsh panne.

Photo Description: View SW over habitat levee and restoration area. Low tide during original photo shows exposed mudflat

Photo point first established June 2016

Photo Point 14, Photo 14.1

N38.13250, W122.46017

Bearing 88°

Photo Point Description: On top of levee

Photo Description: View E over levee habitat slope and restoration area. Low tide during original photo shows exposed mudflat area

Photo point first established June 2016

Photo Point 14, Photo 14.2

N38.13250, W122.46017

Bearing 154°

Photo Point Description: On top of levee

Photo Description: View SE over levee habitat slope and restoration area. Low tide during original photo shows exposed mudflat area

Photo point first established June 2016

Photo Point 14, Photo 14.3

N38.13250, W122.46017

Bearing 211°

Photo Point Description: On top of levee

Photo Description: View SW over levee habitat slope and restoration area. Low tide during original photo shows exposed mudflat area

Photo point first established June 2016

Photo Point 15, Photo 15.1

N38.12989, W122.46685

Bearing 190°

Photo Point Description: On top of levee

Photo Description: View SW over levee habitat slope and restoration area. Marsh Panne in foreground full. Low tide during original photo shows exposed mudflat area

.

Photo point first established June 2016

Photo Point 15, Photo 15.2

N38.12989, W122.46685
Bearing 190°

Photo Point Description: On top of levee

Photo Description: View W over levee habitat slope and restoration area. Levee top in photo center. Vegetation on either side of levee is stubble following hay harvest.

Photo point first established June 2016

APPENDIX D

Sears Point Wetland Restoration
Condition Bathymetric Survey

Field Data Collection Procedures

February 2017

Prepared For:
Siegel Environmental LLC
San Rafael, CA 94901

Prepared By:
CLE Engineering
10 Commercial Blvd., Suite 100
Novato, CA 94949

APPENDIX D

Services provided pursuant to this agreement are intended solely for the use by Siegel Environmental LLC.

No other person or entity shall be entitled to rely on the services, opinions, recommendations, plans or specifications provided pursuant to this agreement without the express written consent of CLE Engineering.

TABLE OF CONTENTS

List of Acronyms

Abbreviation	Definition
AOC	Area of Concern
CORS	Continually Operating Reference Station
DEM	Digital Elevation Model
HARN	High Accuracy Reference Network
LiDAR	Light Detection and Ranging
IHO	International Hydrographic Organization
MBES	Multibeam Echo Sounder System
MLLW	Mean Lower Low Water
MRU	Motion Reference Unit
NAD83	North American Datum
NAVD88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
NGS PID	National Geodetic Survey – Point Identification
NGVD29	National Geodetic Vertical Datum of 1929
OPUS	Online Positioning User Service
PPK	Post-Process Kinematic
RTK-GPS	Real-Time Kinematic GPS
SAV	Sub-Aquatic Vegetation
TIN	Triangulated Irregular Network
SSS	Sidescan Sonar
SBP	Sub-Bottom Profiler
USBL	Ultra-Short Baseline
USGS	United States Geological Survey
USACOE	United States Army Corps of Engineers
WSE	Water Surface Elevation

1. INTRODUCTION

1.1 PURPOSE AND SCOPE

CLE Engineering (Novato, CA) was contracted by Siegel Environmental (San Rafael, CA) to collect condition bathymetric survey data (USACOE Class 1 Standards) along seven elevation monitoring transects within the Sears Point Wetland Restoration Project located in southern Sonoma County, CA (Figure 1).

Singlebeam sonar-based survey data were collected along seven survey transects throughout the restoration site. The resultant survey data represent baseline elevations and will be resurveyed throughout the project monitoring period in order to track elevation changes as the marsh plain develops. This document outlines survey equipment, procedures and results of the initial monitoring effort.

1.2 DESCRIPTION OF SURVEY AREA

The 960-acre restoration site was breached in October 2015 after ten years of planning. Natural sedimentation is expected to raise the marsh plain to an elevation that will sustain tidal and subtidal habitats. The elevation surveys are part of a monitoring program designed to track the natural sedimentation, and in some areas, erosion, over the course of the evolution of the site.

2. METHODS

2.1 SURVEY CONTROL

The CLE field team tied into a control point network that was established by Ducks Unlimited (DU) and supplied to CLE by Siegel Environmental (Figure 2). CLE utilized a *Leica Geosystems System 1200* GPS base station established over DU point PT#52 with a tie-in to PT#50. The base station was programmed to collect high frequency satellite observations for processing by the National Geodetic Survey (NGS) computers in order to check the integrity of the point.

2.1.1 Datums

Table 1 outlines survey datums and coordinate systems.

Table 1 – Project Datums and Coordinate Systems

Horizontal Datum	Epoch	H. Coordinate System	Vertical Datum	GEOID Model	Units
NAD 83	2010.00	NAD 83 Ca State Plane Zone 2	NAVD 88	Geoid 12a	US Survey Ft.

APPENDIX D

Background Image: Google 2014

cle

Sears Point Wetland Restoration – 2017 Baseline Elevation Surveys
Location Map

February 2017	**Figure 1**

APPENDIX D

CONTROL POINT SUMMARY TABLE			
Point#	Northing	Easting	Elevation (ft, NAVD88)
1	1813251.37	6428487.450	14.26
2	1813355.380	6428340.690	21.69
50	1808564.204	6425499.161	0.2
51	1805479.605	6425124.222	1.46
52	1810619.999	6429166.493	-0.27
53	1811942.595	6432016.712	8.52
54	1816182.367	6433909.419	10.45
55	1814428.429	6436930.110	-1.01
56	1808403.505	6429100.802	-0.86
57	1805565.182	6429430.584	1.15

Horizontal Datum is NAD83, California Zone 2, US Survey feet.

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

SEARS POINT WETLAND RESTORATION PROJECT
SURVEY CONTROL POINT
SUMMARY MAP

Background Image: Google 2014

cle

Sears Point Wetland Restoration – 2017 Baseline Elevation Surveys
DU Survey Control Point Location Map

February 2017

Figure 2

2.2 SINGLEBEAM SONAR SURVEY SYSTEM

The hydrographic surveys utilized Class 1 methods and accuracies as outlined in the Army Corps of Engineers' January 2002 *Hydrographic Surveying Manual* (EM 1110-2-1003).

In order to take advantage of a high-water window at the site, the survey team utilized two shallow-water survey vessels outfitted with specially designed shoal-water sonars in order to collect singlebeam data throughout the site. Each survey system consisted of a survey-grade sonar unit, RTK-GPS rover for position, WSE data collection and vessel heave. Each survey skiff was also outfitted with a sound velocity probe, heading sensor and *Intel*-based data acquisition computer.

2.2.1 Survey Vessels

The survey crew utilized two 14 Ft. Lowe Jon Boats, each powered by a 10-horsepower jet-drive outboard specifically constructed for shallow water surveys. Each vessel was equipped with a 1,500-watt generator and acquisition computer weather housings.

2.2.2 Singlebeam Echo Sounder

Bathymetric data were collected using an *Ohmex SonarMite* survey-grade fathometer with a 4°, 200-kHz transducer. The *SonarMite* is engineered to collect sonar data in depths as shoal as ~ 1.0 Ft. The transducer was mounted on the port side of each vessel utilizing an over-the-side mount and placed with a 0.60 Ft. draft (see Appendix A for equipment specifications).

2.2.3 Positioning Equipment

Position data were measured and recorded utilizing a *Leica System 1200* RTK-GPS rover mounted directly above the fathometer sonar transducer. The RTK-GPS base station was located over the aforementioned control point established on the levee.

The rover was programmed to output position data at a rate of 20 Hertz directly to the survey acquisition program. The survey acquisition program was programmed to stop logging if the GPS mode was anything other than fixed.

2.2.4 Tides and Motion Compensation

The most common problem in accurately measuring the seafloor with any sonar-based system is the calculation of the tidal elevation offset. Commonly a tide staff or electronic gauge is deployed in one location near the survey site and is used to calculate the tides, or other types of water surface elevation changes (wind wave setup, reservoir draw-down etc.) for the entire survey area. However, it is widely understood that non-linear tidal phenomena, such as phase lags and tidal gradients can drastically influence the water surface elevation (WSE) spatially throughout the survey area and therefore the use of a single point measurement is often unreliable.

To avoid these potential WSE errors which can translate into significant departures from the true bottom depth, the survey crew utilized geodetic GPS with RTK baseline processing that is integrated within the survey data acquisition system on each vessel. The motion and Geoid 12a compensated positions and orthometric elevations of the RTK-GPS data stream are tagged with each sonar ping. In effect, the RTK-GPS mounted on the hydrographic survey vessel acts as a roving tide gauge collecting the most accurate tidal measurements throughout the survey area.

2.2.4.1 Motion Compensation

The fast update rate programmed into the GPS rover is necessary in order to utilize the GPS-generated ellipsoid heights time series for heave compensation. As the survey vessel is heaving upward or squatting downward (either due to undulations in the water surface or vessel squat resulting from the forward motion of the vessel through the water), the vertical change in the GPS antenna will be reflected in the height of the antenna above (or below) the reference ellipsoid. Post-processing computes an RTK heave correction for each sonar ping.

2.2.5 <u>Vessel Heading</u>

Each survey vessel utilized a *Hemisphere VS 111* heading and roll sensor. This heading reference unit is comprised of two differential GPS antennas mounted 1.5 meters apart, and an inertial-based roll sensor unit mounted in-line with the sonar transducer. The *VS 111* is accurate to 0.25 degrees.

2.2.6 <u>Speed of Sound Measurements</u>

Fathometers calculate water depth by using algorithms based on the speed of sound through the water column. The survey crew utilized an *Odom Digibar Pro* speed of sound probe to measure sound velocity multiple times during each survey day.

Mounted near the end of the sound velocity probe is a high frequency "sing-around" transducer and its associated reflector. This precisely spaced pair is used to measure the velocity of sound in water by transmitting and receiving a signal across their known separation distance. Speed of sound tables were loaded into the fathometers at the beginning of each survey day. Additional sound velocity casts were collected at the beginning of each ebb and flood.

The on-board data streams were collected utilizing a *Panasonic Toughbook* running *Hypack Max* (Version 2015) survey planning, data collection and reduction software.

The 4-person field crew for each survey included Mr. James Kulpa (ACSM Certified Hydrographer #288 - CLE), Mike Campagnone (Hydrographer – CLE), Kyle Berger (Hydrographic Technician – CLE) and Skylar Hurley (Hydrographic Technician – CLE).

3. RESULTS AND QUALITY ASSURANCE / QUALITY CONTROL

3.1 DATA COLLECTION TIME PERIODS

Table 2 outlines survey dates and associated survey activities.

Table 2 – Survey Diary

Date	Survey Activities	Notes
2/9/2017	Reconnoiter survey areas, verify DU control	Crew realizes Boston Whaler has too much draft, MOB both skiffs
2/10/2017	Survey	No wind, calm water surface conditions

3.2 RTK-GPS TIDES CALIBRATION

To check the accuracy of the *Hypack*-derived tidal elevation, a temporary tide staff was established at the boat ramp and surveyed into the project control network. The WSE was then checked against the *Hypack* reported values before and after each survey day for each vessel.

Table 3 – RTK Tide Calibration Results

Date	WSE As measured from tide staff	Time	Jet Boat *Hypack* Tides	Jon Boat *Hypack* Tides	Notes
2/10/17	6.55	13:30	6.50	6.52	Pre-survey cal
2/10/17	4.43	15:36	4.40	4.40	Post-survey cal

3.3 FATHOMETER BARCHECK CALIBRATIONS

There are two standard procedures used to check the accuracy of a survey fathometer whether it be a multibeam or singlebeam transducer; 1) speed of sound profiles and 2) fathometer barcheck calibrations. Fathometers calculate water depth by using algorithms based on the speed of sound through the water column. Depth-integrated sound velocity measurements were taken two times each survey day throughout the survey footprint. Sound velocity profiles were measured and recorded utilizing an *Odom Digi-Bar Pro* speed of sound probe. The sound velocity profile was then programmed directly into *Hypack*.

The second protocol is a barcheck calibration which is performed on the fathometer and consists of lowering a 36-inch diameter, weighted steel plate below the fathometer transducer and recording the actual depth of the disc (via markings on a cable) and the fathometer nadir output (output was corrected for the transducer depth offset). Table 4 shows the results of the barcheck calibrations which were measured within 0.10 Ft or less for each checked depth.

Table 4 – Barcheck Results

Date	Bar Depth	Jet Boat Fathometer Read	Jon Boat Fathometer Read	Notes
2/10/2017	2.60	2.60	2.59	Pre-survey cal
2/10/2017	3.00	3.00	3.02	Pre-survey cal
2/10/2017	5.50	5.50	5.48	Post-survey cal
2/10/2017	3.50	3.50	3.52	Post-survey cal

3.4 RTK-GPS CHECK SHOTS

In order to check the accuracy of the *Leica System 1200* RTK-GPS, and provide for a "blunder check", the *Leica* rover was checked into two of the DU survey control points. In addition, DU Points PT#50 and PT#52 was checked against the NGS Online Position User Service (OPUS - https://www.ngs.noaa.gov/OPUS/) results. The surveys were held to the OPUS result for PT#50. Figure 2 shows the location of the DU control points (map provided to CLE by Siegel).

Seven hours of static GPS data was uploaded to OPUS for processing Table 5 outlines the result of the check-in shots.

Table 5 – RTK-GPS Check-in Results

Mark	DU Reported		Reported Elevation NAVD (Ft.)	CLE Check-in Survey Results *based on OPUS results		Surveyed Elevation NAVD (Ft.)
	Northing (US ft.)	Easting (US ft.)		Northing (US ft.)	Easting (US ft.)	
PT# 50	1,808,564.204	6,425,499.161	0.20	1,808,565.5864	6,425,498.2084	0.29
PT# 52	1,810,619.999	6,429,166.493	-0.27	1,810,621.382	6,4291,65.555	-0.39

3.5 SURVEY COVERAGE

Both survey crews collected data along a total of 274 planned survey lines covering more than 78 miles of total distance. Figure 3 shows survey coverage throughout the north, central and southern lobes, as well as top of bank coverage within the main interior channel. Table 6 lists the survey bounding coordinates.

Table 6 – Bounding Coordinates

West Longitude	-122.474089
East Longitude	-122.437407
North Latitude	+38.147110
South Latitude	+38.118413

3.6 SOUNDING REDUCTION

In order to reduce each raw bathymetric survey line into an XYZ dataset, the survey line was imported into the *Single Beam Editor* in *Hypac*k (Version 2013). The *Single Beam Editor* enables all of the survey variables and ancillary data sets (tides, heave, pitch and roll values and sensor offsets) to be reviewed and applied to each survey line.

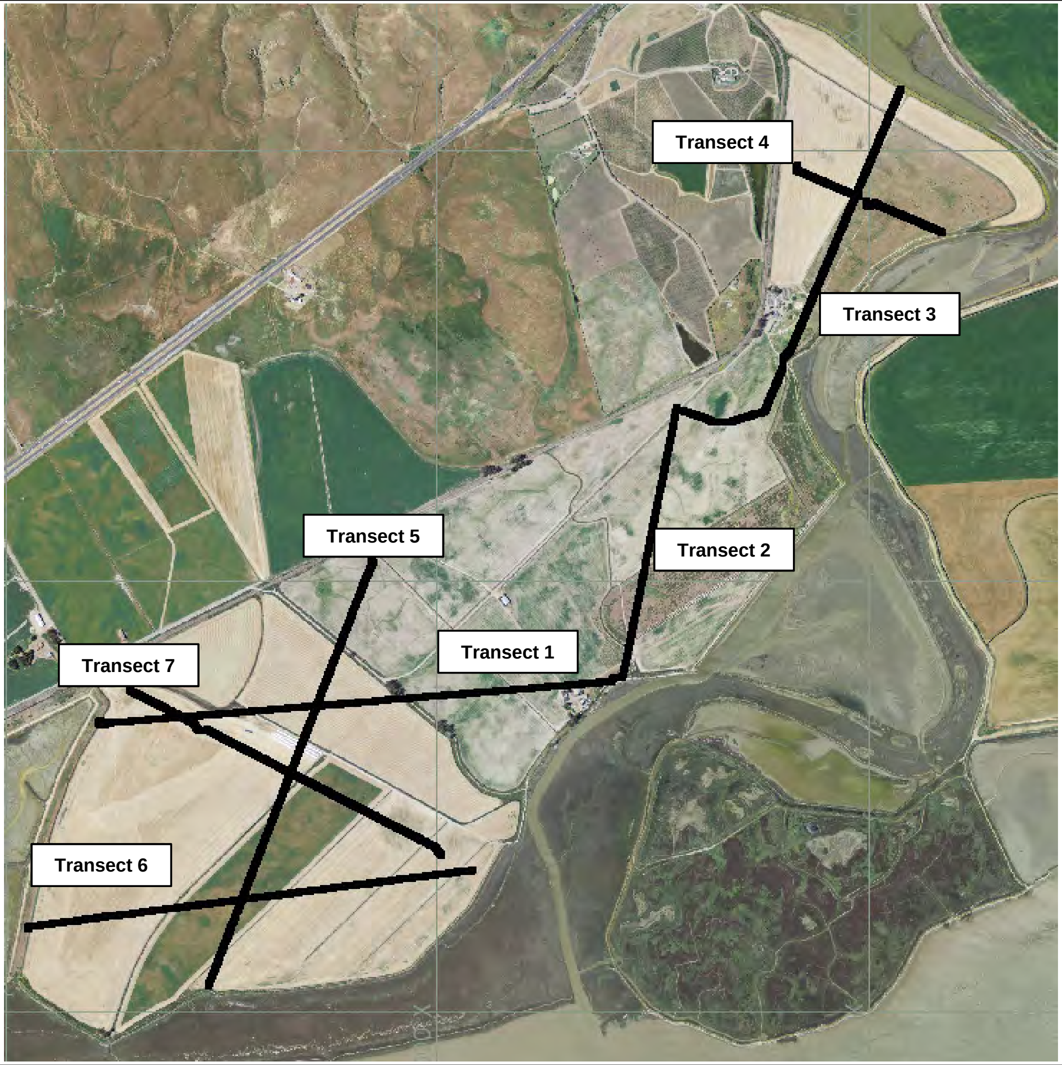
The next step is extracting the *Hypack*-derived RTK-tidal time series from the raw log files, and compared against tides measured by the NOAA gage located just south of the breach on the Stinson Beach seawall in the lagoon. Hypack-derived tides are also compared to water surface elevation points that were periodically measured and recoded by the RTK-GPS topographic rover.

Each survey line is then imported and reviewed in detail and erroneous bathymetric points (spikes and other outliers) are deleted or interpolated into the survey line. RTK-GPS position and elevation quality values are also reviewed during this step. Once each line has been reviewed and edited, all of the lines for each survey day are then exported into a *Hypack Edited* file. The edited file is then reviewed in the *Hypack Shell* for position and elevation quality. Where survey lines intersect (cross lines), a review of the overlapping soundings from each line is analyzed using the *Cross Check Statistics* program in *Hypack*.

Once the *Edited Hypack* file has passed the final review, the data is then filtered using the *Sounding Selection* algorithm in *Hypack* in order to reduce the soundings to one point at three foot intervals along each survey transect. After sounding selection, the resultant dataset is then exported to an XYZ text file.

The text file is then brought into *AutoCAD Civil 3D* (Version 2014) for final review. Transects were cut and imported into Excel for graphing. The elevation transects are in Appendix B.

APPENDIX D



Background Image: Google 2014

cle

Sears Point Wetland Restoration – 2017 Baseline Elevation Surveys
Baseline Transect Locations

February 2017

Figure 3

4. REFERENCES

U.S. Army Corps of Engineers. 2002. *Hydrographic Survey Manual*, Engineering and Design Manual No. EM-1110-2-1003, Washington D.C.

Appendix A
Equipment Specifications

Leica GPS1200+
Technical specifications and system features

GPS1200+ receivers	GX1230+ GNSS/ ATX1230+ GNSS	GX1220+ GNSS	GX1230+	GX1220+	GX1210+
GNSS technology	SmartTrack+	SmartTrack+	SmartTrack	SmartTrack	SmartTrack
Type	Triple frequency	Triple frequency	Dual frequency	Dual frequency	Single frequency
Channels	120 channels L1/L2/L5 GPS L1/L2 GLONASS E1/E5a/ E5b/ Alt-BOC Galileo Compass[1] 4 SBAS	120 channels L1/L2/L5 GPS L1/L2 GLONASS E1/E5a/ E5b/ Alt-BOC Galileo Compass[1] 4 SBAS (with DGPS option)	16 L1 + 16 L2 GPS 4 SBAS	16 L1 + 16 L2 GPS 4 SBAS (with DGPS option)	16 L1 GPS 4 SBAS (with DGPS option)
Upgrade to GX1230+ GNSS	-	Yes	Yes	Yes	Yes
RTK	SmartCheck+	No	SmartCheck	No	No
Status indicators	3 LED indicators for GX1200+: power, tracking, memory				

GPS1200+ receivers	GX1230+ (GNSS)/ GX1220+ (GNSS)	GX1210+	ATX1230+ GNSS
Ports	1 power port, 3 serial ports, 1 controller port, 1 antenna port		1 power/controller port, *Bluetooth®* Wireless-Technology port
Supply voltage, Consumption	Nominal 12 VDC 4.6 W receiver + controller + antenna		Nominal 12 VDC 1.8 W
Event input and PPS	Optional: 1 PPS output port 2 event input ports	Optional: 1 PPS output port 2 event input ports	
Standard antenna Built-in groundplane	SmartTrack+ AX1203+ GNSS Built-in groundplane	SmartTrack AX1201 Built-in groundplane	SmartTrack+ ATX1230+ GNSS Built-in groundplane

The following apply to all receivers except where stated.

Power supply	Two Li-Ion 4.4 Ah/7.4 V plug into receiver. One Li-Ion 2.2 Ah/7.4 V plugs into ATX1230+ GNSS and RX1250.
Plug-in Li-Ion batteries Same for GNSS and TPS	Power receiver + controller + SmartTrack antenna for about 17 hours (for data logging). Power receiver + controller + SmartTrack antenna + low power radio modem or phone for about 11 hours (for RTK/DGPS). Power SmartAntenna + RX1250 controller for about 6 hours (for RTK/DGPS)
External power	External power input 10.5 V to 28 V.
Weights	Receiver 1.20 kg. Controller 0.48 kg (RX1210) and 0.75 kg (RX1250). SmartTrack antenna 0.44 kg. SmartAntenna 1.12 kg. Plug-in Li-Ion battery 0.11 kg (2.2 Ah) and 0.2 kg (4.4 Ah) Carbon fiber pole with SmartTrack antenna and RX1210 controller: 1.80 kg. All on pole: carbon fiber pole with SmartAntenna, RX1250 controller and plug-in batteries: 2.74 kg.

Temperature ISO9022 MIL-STD-810F	Operation: Receiver Antennas Controllers Controller RX1250c	−40° C to +65° C −40° C to +70° C −30° C to +65° C −30° C to +50° C
	Storage: Receiver Antennas Controllers Controller RX1250c	−40° C to +80° C −55° C to +85° C −40° C to +80° C −40° C to +80° C
Humidity ISO9022, MIL-STD-810F	Receiver, antennas and controllers Up to 100 % humidity.	
Protection against water, dust and sand IP67, MIL-STD-810F	Receiver, antennas and controllers: Waterpoof to 1 m temporary submersion. Dust tight	
Shock/drop onto hard surface	Receiver: withstands 1 m drop onto hard surface. Antennas: withstand 1.5 m drop onto hard surface.	
Topple over on pole	Receiver, antennas and controllers: withstand fall if pole topples over.	
Vibrations ISO9022 MIL-STD-810F	Receiver, antennas and controllers: withstand vibrations on large construction machines. No loss of lock.	

[1] The Compass signal is not finalized, although, test signals have been tracked with GPS1200+ receivers in a test environment. As changes in the signal structure may still occur, Leica Geosystems cannot guarantee full Compass compatibility.

APPENDIX D

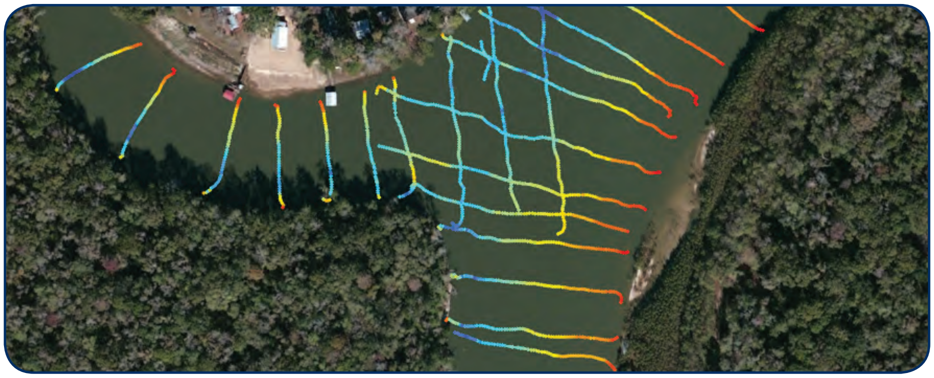
SmartTrack+ **Advanced GNSS measurement technology**	Time needed to acquire all satellites after switching on: typically about 50 seconds. Re-acquisition of satellites after loss of lock (e.g. passing through tunnel): typically within 1 second.
	Very high sensitivity: acquires more than 99 % of all possible observations above 10 degrees elevation. Very low noise. Robust tracking. Tracks weak signals to low elevations and in adverse conditions. Multipath mitigation. Jamming resistant.
	Measurement precision: Carrier phase on L1: 0.2 mm rms. On L2: 0.2 mm rms. Code (pseudorange) on L1 and L2: 20 mm rms.
SmartCheck+ **Advanced, long range RTK technology**	Initialization typically 8 seconds. Position update rate selectable up to 20 Hz. Latency < 0.03 secs. Range 40 km or more in favorable conditions. Self checking.
Accuracies	Kinematic Horizontal: 10 mm + 1 ppm Vertical: 20 mm + 1 ppm Static (ISO 17123-8) Horizontal: 5 mm + 0.5 ppm Vertical: 10 mm + 0.5 ppm
	Reliability: 99.99 % for baselines up to 40 km.
	Formats supported for transmission and reception: Leica proprietary (Leica, Leica 4G), CMR, CMR+, RTCM V2.1/2.2/2.3/3.0/3.1.
Reference station networks	RTK rover fully compatible with Leica's Spider i-MAX & MAX formats, VRS and Area Correction (FKP) reference station networks.
DGPS GX1230+ (GNSS), ATX1230+ GNSS,	DGPS, includes support of MSAS, WAAS, EGNOS and GAGAN. RTCM V2.1/2.2/2.3/3.0/3.1. formats supported for transmission and reception.
GX1220+ (GNSS) – standard GX1210+ – optional	Baseline rms: typically 25 cm rms with suitable reference station.
Position update rate and latency	Applies to RTK, DGPS and navigation positions. Update rate selectable from 0.05 sec (20 Hz) to 1 sec. Latency less than 0.03 secs.
NMEA output	NMEA 0183 V3.00 and Leica proprietary.
Post-processing with Leica Geo Office software **All GPS1200+ receivers**	Horizontal: 10 mm + 1 ppm, kinematic Vertical: 20 mm + 1 ppm, kinematic
	Horizontal: 5 mm + 0.5 ppm, static Vertical: 10 mm + 0.5 ppm, static
	For long lines with long observations Horizontal: 3 mm + 0.5 ppm, static Vertical: 6 mm + 0.5 ppm, static
Notes on performance and on accuracies	Figures quoted are for normal to favorable conditions. Performance and accuracies can vary depending on number of satellites, satellite geometry, observation time, ephemeris, ionosphere, multipath etc.

Controllers	High contrast, 1/4 VGA display with colour option (RX1250)
RX1210/RX1250	Touch screen, 11 lines x 32 characters.
	Windows CE 5.0 on RX1250.
	Full alphanumeric QWERTY keypad. Function keys and user definable keys. Illumination for screen and keys.
	Can also be used with TPS1200+ for alphanumeric input and extensive coding.
Operation with controller Same for GNSS and TPS	Via keypad and/or via touch screen. Graphical operating concept. Function keys and user definable keys. All information displayed.
Displayed information	All information displayed: status, tracking, data logging, database, RTK, DGPS, navigation, survey, stakeout, quality, timer, power, geographical, cartesian, grid coordinates etc.
Graphical display of survey Same for GNSS and TPS	Graphical display (plan) of survey. Zooming. Can access surveyed points directly via touch screen.
Stakeout display Same for GNSS and TPS	Graphical with zoom. Digital, polar and orthometric. Accuracy: 10 mm + 1 ppm at 20 Hz (0.05 sec) update rate. No degradation with high update rates.
Operation without controller GX1200+ only	Automatic on switching on. LED status indicators. For reference stations and static measurements.
Data logging Same cards used for GNSS and TPS	On CompactFlash cards: 256 MB and 1 GB Optional internal receiver memory: 256 MB.
Capacity	64 MB sufficient for (30 % less for GPS/GLONASS): About 500 hours L1 + L2 data logging at 15 sec rate. About 2 000 hours L1 + L2 data logging at 60 sec rate. About 90 000 RTK points with codes.
Data management Same for GNSS and TPS	User definable job management. Point identifiers, coordinates, codes, attributes etc.
	Search, filter and display routines. Multi point averaging. Five types of coding systems cover all requirements.
Coordinate systems Same for GNSS and TPS	Ellipsoids, projections, geoidal models, coordinate, transformations, transformation parameters, country specific coordinate systems. Fully support of RTCM 3.1 coordinate system transfer.
Application programs Same for GNSS and TPS	Standard: Full range of COGO functions. Hidden point.
	Optional: RoadRunner, Reference Line, DTM Stakeout, Reference Plane, Area Division and X-Section Survey, DXF Export, LandXML Export and Volume Calculations
Programmable Same for GNSS and TPS	User programmable in GeoC++. Users can write and upload programs for their own special requirements and applications.
Communication **Data links**	One or two of the following devices can be connected: Radio modem, GSM, GPRS, CDMA. Different frequencies and/or formats can be received and transmitted. Time slicing is supported.

Seafloor™

datasheet

SonarMite MILSpec™



multibeam survey image

benefits

- rugged, field-proven survey grade echo sounder
- Bluetooth technology integrated with Windows Pocket PC devices
- proven “Smart” transducer design with QA output
- easily integrates with other modern software and GPS technology

about

The SonarMite MILSpec™ echo sounder is the result of nearly two years’ research and development to further extend the boundaries of shallow water hydrographic survey equipment. The introduction by Ohmex in 1997 of the SonarLite, the world’s first truly portable echo sounder system has been a hard act to follow and it remains the portable instrument of choice in many survey companies around the world. The release of the SonarMite MILSPec instrument marks the next stage introducing a series of equipment designed around the WinSTRUMENT concept using the latest portable computer integrated with new measurement technologies.

specifications

frequency	200 KHz
beam width	4 degrees
ping rate	6 Hz
depth accuracy	1cm / 0.1% of depth
output formats	NMEA, ASCII
range	0.3m–75m
I/O	serial, Bluetooth
environmental	IP-65
power	rechargeable 12v battery

options

- data collection software
- heave, pitch and roll measurements
- sound velocimeter
- portable mounting bracket
- rugged shipping case
- extended warranty

SonarMite MILSpec echo sounder with cable

Seafloor Systems, Incorporated
3941 Park Drive, Suite 20-218 · El Dorado Hills, CA 95762 · USA
(530) 677–1019 · info@seafloorsystems.com · www.seafloorsystems.com

Rev 07/13/2015

Hemisphere GPS

VS101 and VS111 GPS Compass

Professional Heading and Positioning Receiver

Precise applications demand the heading and positioning performance of the VS101™ and VS111™ GPS compass. Ideal for professional machine control and navigation applications, the VS101/111 delivers reliable accuracy at significantly less cost than competitors' products or traditional methods. The Crescent® Vector™ II technology brings a series of new features to the VS101/111 including heave, pitch and roll output, and more robust performance.

The VS101/111 receiver, with its display and user interface, can be conveniently installed near the operator. The two antennas are mounted separately and with a user-determined separation to meet the desired accuracy.

Powered by Crescent

The VS101 uses SBAS (WAAS, EGNOS, MSAS, etc.) for differential GPS positioning. The VS111 includes both SBAS and radio beacon differential GPS positioning options.

Key VS101 and VS111 GPS Compass Advantages

- Affordable solution delivers 2D GPS heading accuracy better than 0.1 degree rms
- Differential positioning accuracy of less than 60 cm, 95% of the time
- Integrated gyro and tilt sensors deliver fast start-up times and provide heading updates during temporary loss of GPS
- Fast heading and positioning output rates up to 20 Hz
- SBAS compatible (WAAS, EGNOS, MSAS etc.), integrated beacon (VS111 only), and optional external differential input
- COAST™ technology maintains differentially-corrected positioning for 40 minutes or more after loss of differential signal
- The status lights and menu system make the VS101 series easy to monitor and configure

Hemisphere GPS

VS101 and VS111 GPS Compass

GPS Sensor Specifications

Receiver Type:	L1, C/A code, with carrier phase smoothing
Channels:	Two 12-channel, parallel tracking (Two 10-channel when tracking SBAS)
SBAS Tracking:	2-channel, parallel tracking
Update Rate:	Standard 10 Hz, optional 20 Hz (position and heading)
Horizontal Accuracy:	< 0.02 m 95% confidence (RTK[1,4]) < 0.6 m 95% confidence (DGPS[1]) < 2.5 m 95% confidence (autonomous, no SA[2])
Heading Accuracy:	< 0.30° rms @ 0.5 m antenna separation < 0.15° rms @ 1.0 m antenna separation < 0.10° rms @ 2.0 m antenna separation
Pitch / Roll Accuracy:	< 1° rms
Heave Accuracy:	30 cm
Timing (1PPS) Accuracy:	50 ns
Rate of Turn:	90°/s maximum
Cold Start:	< 60 s typical (no almanac or RTC)
Warm Start:	< 20 s typical (almanac or RTC)
Hot Start:	< 1 s typical (almanac, RTC and position)
Heading Fix:	< 10 s typical (valid position)
Antenna Input Impedance:	50 Ω
Maximum Speed:	1,850 kph (999 kts)
Maximum Altitude:	18,288 m (60,000 ft)

Beacon Sensor Specifications (VS111 version)

Channels:	2-channel, parallel tracking
Frequency Range:	283.5 to 325 kHz
Operating Modes:	Manual, automatic and database
Compliance:	IEC 61108-4 beacon standard

Communications

Serial ports:	2 full-duplex RS-232
Baud Rates:	4800 - 115200
Correction I/O Protocol:	RTCM SC-104, L-Dif™[3], RTK[3]
Data I/O Protocol:	NMEA 0183, Crescent binary[3], L-Dif[3], RTK[3]
Timing Output:	1PPS (HCMOS, active high, rising edge sync, 10 kΩ, 10 pF load)
Event Marker Input:	HCMOS, active low, falling edge sync, 10 kΩ

Environmental

Operating Temperature:	-30°C to +70°C (-22°F to +158°F)
Storage Temperature:	-40°C to +85°C (-40°F to +185°F)
Humidity:	95% non-condensing
Shock and Vibration:	EP 455
EMC:	FCC Part 15, Subpart B, CISPR22, CE

Power

Input Voltage:	9 to 36 VDC
Power Consumption:	4.1 W nominal
Current Consumption:	340 mA @ 12 VDC nominal
Power Isolation:	Isolated power supply
Antenna Voltage:	5 VDC nominal
Antenna Short Circuit Protection:	Yes
Antenna Gain Input Range:	10 to 40 dB
Antenna Input Impedance:	50 Ω

Mechanical

Dimensions:	18.9 L x 11.4 W x 7.1 H (cm) 7.4 L x 4.5 W x 2.8 H (in)
Weight:	0.86 kg (1.9 lb)
Status Indication:	Power, primary GPS lock, secondary GPS lock, DGPS lock, and heading lock
Power Switch:	Miniature push-button
Power Connector:	2-pin, micro-Conxall
Data Connectors:	DB9-female (x2)
Antenna Connectors:	TNC-female (x2)

Aiding Devices

Gyro:	Provides smooth heading, fast heading reacquisition and reliable < 1° heading for periods up to 3 minutes when loss of GPS has occurred
Tilt Sensors:	Assists in fast start-up of heading solution

Authorized Distributor:

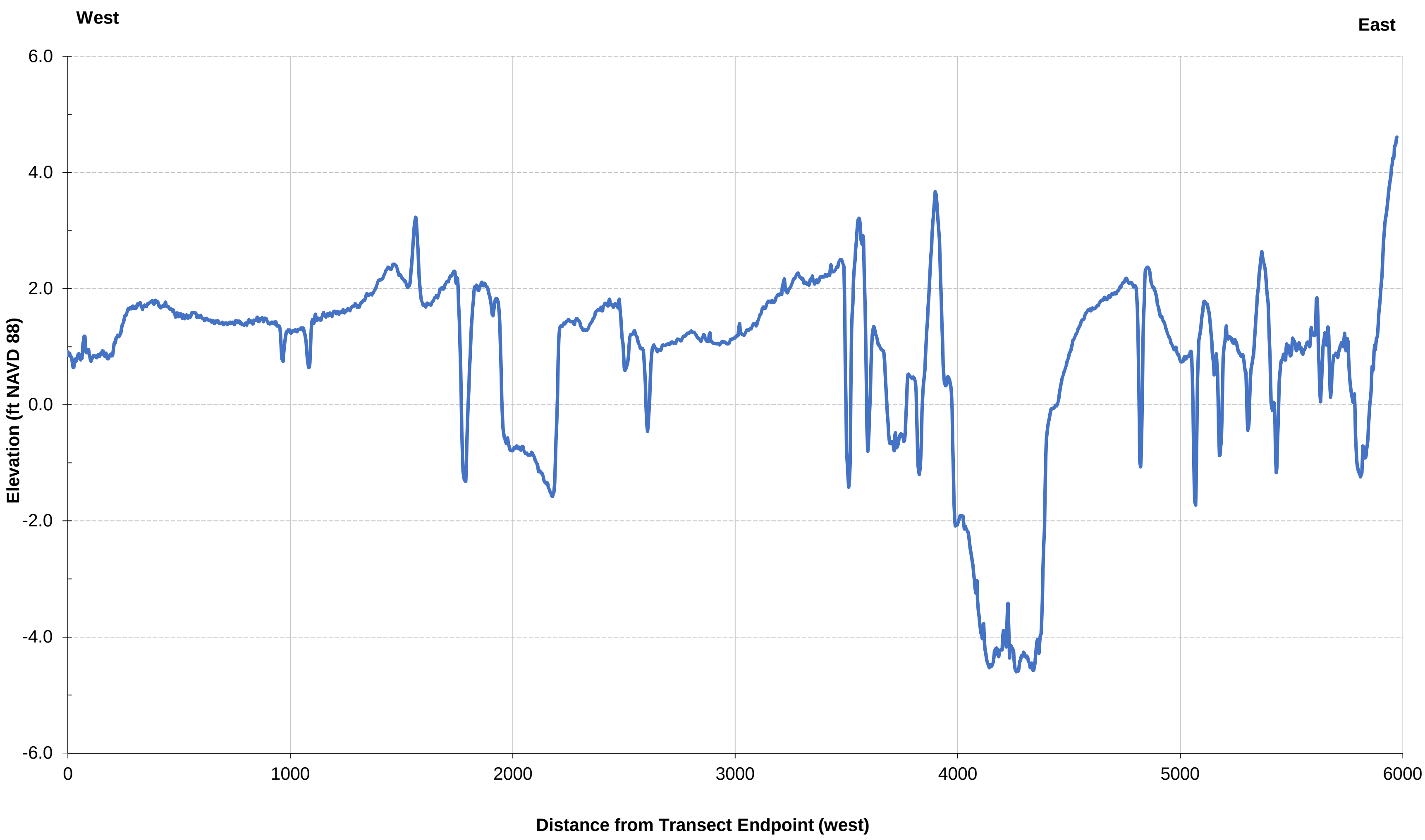
1 Depends on multipath environment, antenna selection, number of satellites in view, satellite geometry, baseline length (for local services), and ionospheric activity
2 Depends on multipath environment, number of satellites in view, and satellite geometry
3 Hemisphere GPS proprietary
4 Up to 5 km baseline length

HEMISPHERE GPS
4110 - 9th Street S.E.
Calgary, AB T2G 3C4
Canada

Phone: 403.259.3311
Fax: 403.259.8866
precision@hemispheregps.com
www.hemispheregps.com

Appendix B
Elevation Transect Graphs

APPENDIX D



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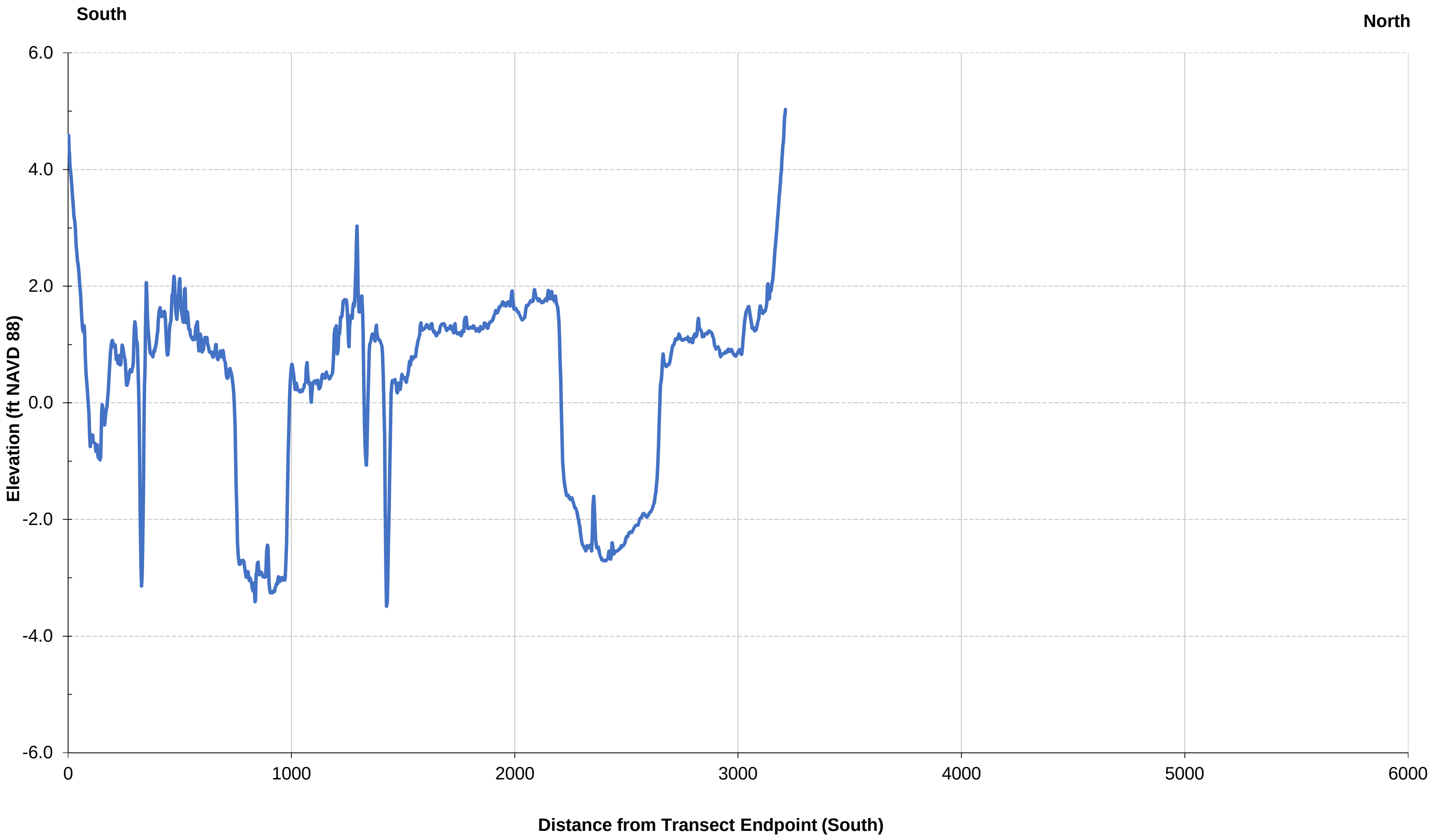
Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 1

APPENDIX D



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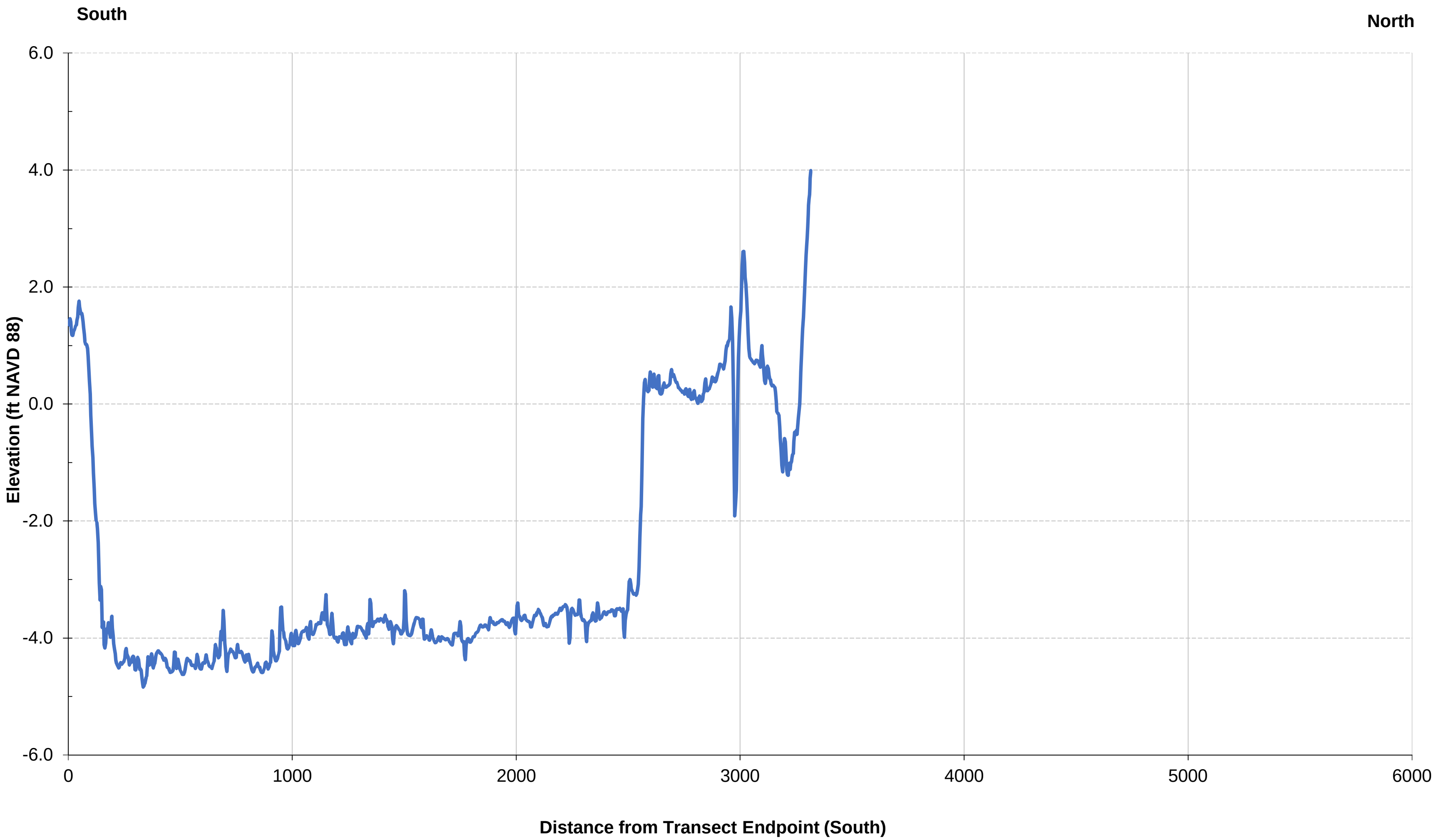
Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 2

APPENDIX D



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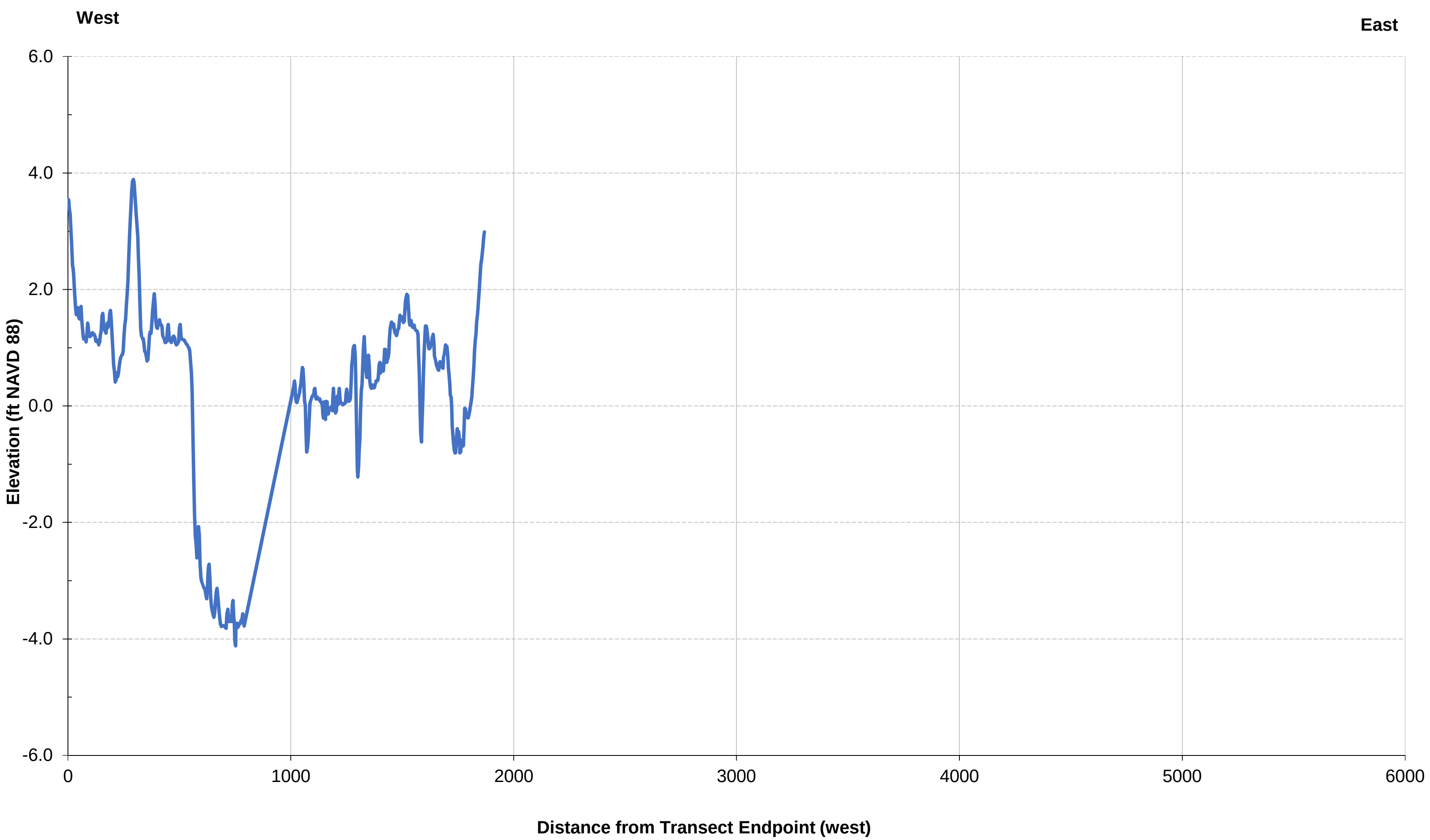
Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 3

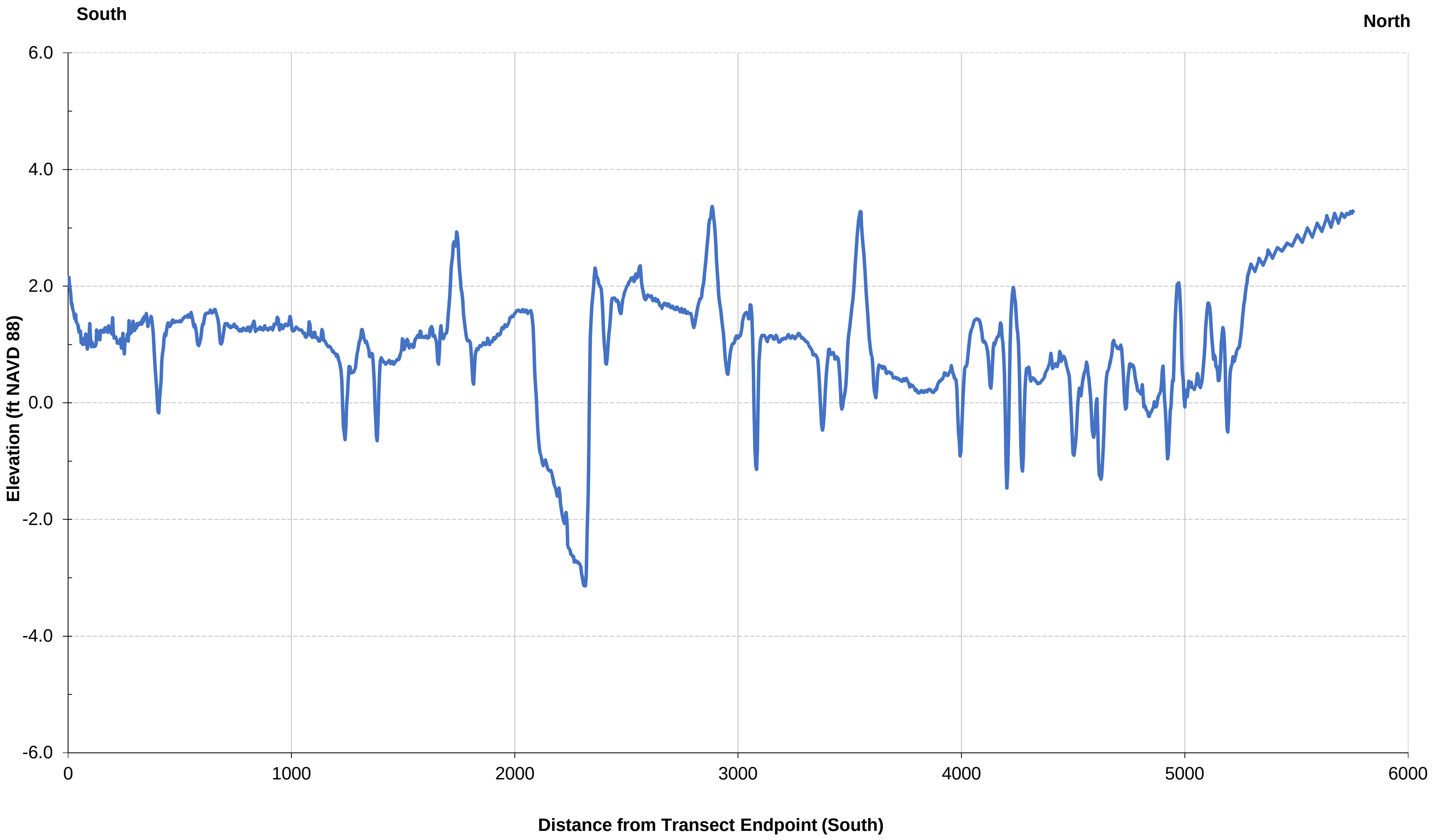
APPENDIX D



Sears Point Wetland Restoration

Elevation Transects Establishment - February 2017
Transect 4

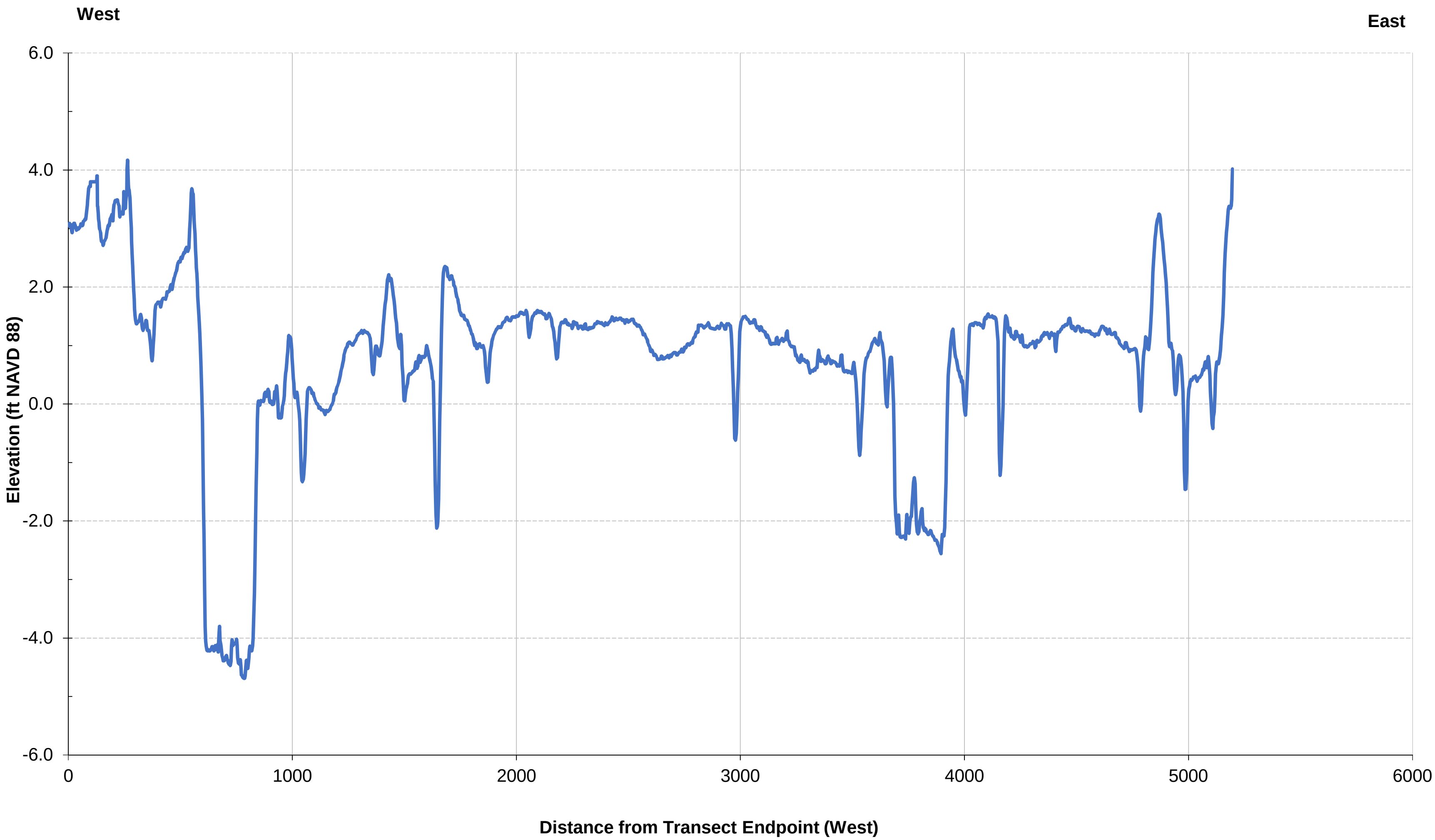
APPENDIX D



Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 5

APPENDIX D



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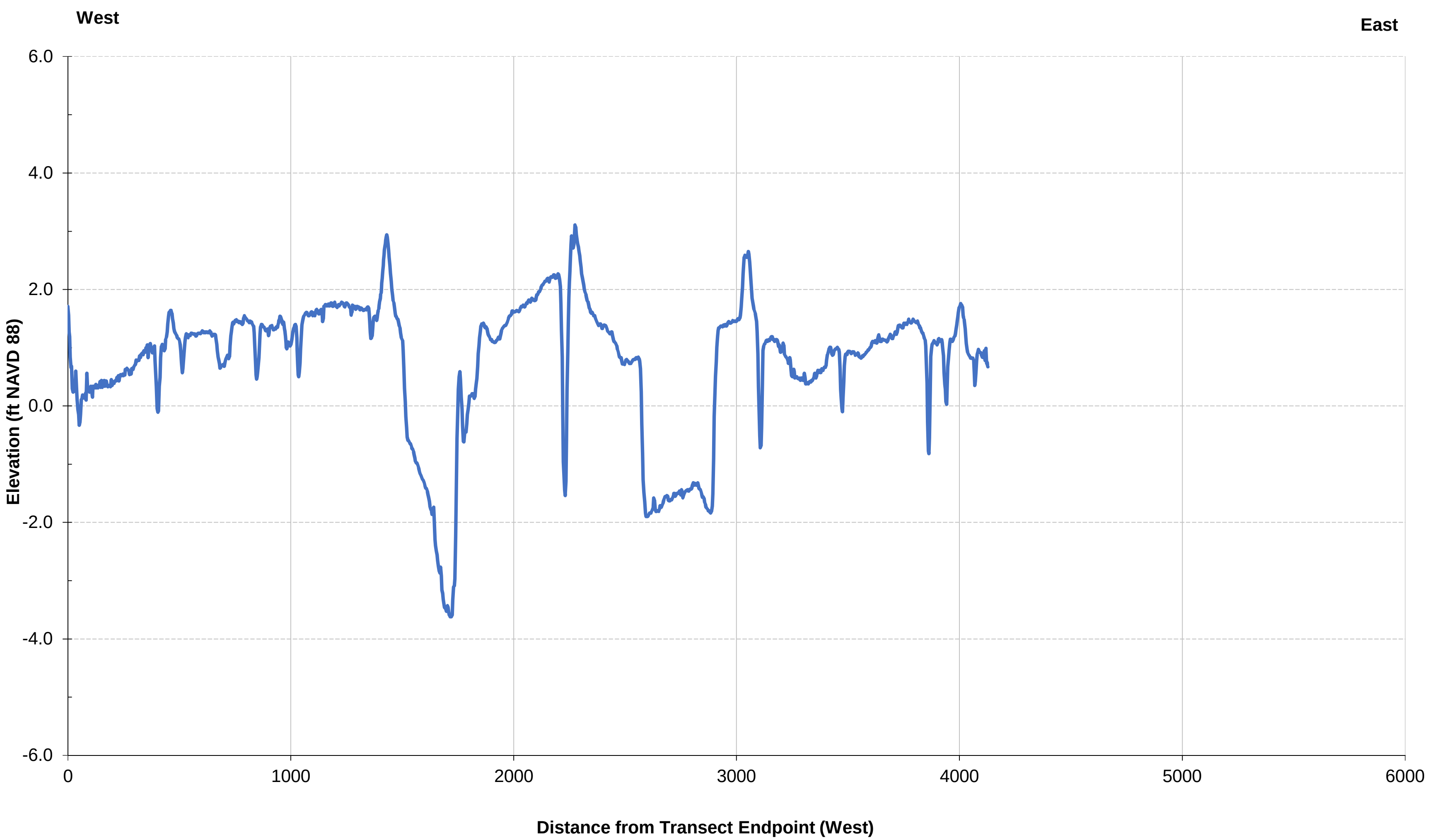
Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 6

APPENDIX D



Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 7

Fig. 1. Julian Meisler (SLT), Peter Baye, and Meg Marriott (USFWS) discussing use of *Elymus triticoides* rhizomes for upper T-zone planting (October 25, 2016)

Fig. 2. Julian Meisler (SLT) and Anna Deck (SF Bay NERR) on clay pan scoured by wind-wave action. The *E. triticoides* plantings did not survive wind-wave disturbance (March 8, 2017)

Fig. 3. Anna Deck and Margo Buchbinder on experimental mound observing planting of *Spartina foliosa*, a sediment pin (in the middle of the mound), and a Canada goose exclosure to protect *Spartina* planting from goose grazing (March 16, 2017)

Fig. 4. Vegetation sampling on constructed panne. Note zoned vegetation patterns (April 11, 2017)

Fig. 5. *Salicornia pacifica* establishing in coarse deposits onto clay pan and especially in wind-protected area on the lee side of the drift log. (April 28, 2017)

Fig. 6. *Salicornia pacifica* in coarse sediments overlying clay pan with associates such as *Atriplex prostrata* and *Cotula coronopifolia*. West end of northern levee. (April 28, 2017)

Fig. 7 Buildup of sediments and vegetation establishment on the lee side of the constructed pannes (April 28, 2017)

Fig. 8. Levee scour between high tide wrack and low tide zone (April 29, 2017)
Photo by Stuart Siegel

Fig. 9. Constructed panne with pool evaporated. Note ring of *Cotula coronopifolia* in middle zone above pool and what appears to be *Spartina foliosa* along the northern edge of the pool. (May 7, 2017)

Fig. 10. Northeastern intertidal zone where wind-wave activity is dampened. Note extensive stand of *Salicornia pacifica* as well as *Atriplex prostrata*, *Polygonum aviculare*, *Lythrum hysoppifolia* and occasional *Jaumea carnosa*, *Frankenia salina*, and *Grindelia stricta* var. *angustifolia* (May 7, 2017).

Fig. 11 Alkali bulrush (*Bolboschoenus maritimus*) spontaneously establishing at base of mound in the low intertidal zone (May 9, 2017) Photo by Peter Baye.

Fig. 12. *Spartina foliosa* establishing at lower intertidal zone along the T-zone levee (May 9, 2017) Photo by Peter Baye.

Fig. 13. Mud flat shoaling on and around eroded mound. Rapid accretion of sediments around eroded mounds and side-cast ridges is developing a low intertidal plain that should present significant heterogeneity that promotes future marsh plant diversity (April 28, 2017)

Fig. 14. View over an constructed panne showing deeper water to the right (dark band) and evolving mudflat shoals to the left punctuated by eroding mounds (April 28, 2017)

March 30, 2017

Sears Point Restoration Area Fish Sampling Plan – Spring 2017

The overall goal of this study is to understand the species assemblage and habitat use in the tidal marsh of the Sears Point Restoration Project Area.

Seasonal sampling will be conducted over 5 days between May 7 and 11, 2017. Field days during this time period will encompass the range of tides and will allow for access to all of the habitats found in the restoration area. We propose conducting surveys (eight transects and eight stationary) at 16 locations throughout the restored area (see attached figure). The transects and stationary sampling locations have been selected to encompass each of the following key habitat types:

- rootwads,
- marsh mounds,
- sidecast ridges,
- low marsh with submerged vegetation, and
- slough channels).

Data analysis for each survey location will correspond with these specific habitat features. Each of the transect sites will be replicated throughout the five day sampling period in order to allow for direct comparison of repeated transects.

Transect Surveys

Eight transects of approximately 500 meters in length have been chosen to represent the key habitat types found at the Sears Point restoration area (see figure). At each transect site, the ARIS camera will be deployed first to identify and characterize fishes within each transect. An otter trawl (12' mouth, equipped with 1/4" delta mesh) survey will be conducted immediately following each ARIS transect along identical alignments. During the trawl survey, the ARIS camera will be pointed at the net and will collect fish behavior data throughout the entire transect. The paired ARIS-Trawl survey design will allow us to better understand the efficiency of the trawl, behavioral avoidance, and inform fish ID from ARIS images of captured species

Trawl surveys will be replicated three times between May 9 and May 11. All eight transects will be sampled on each day in order to facilitate comparisons between habitat types.

Stationary Surveys

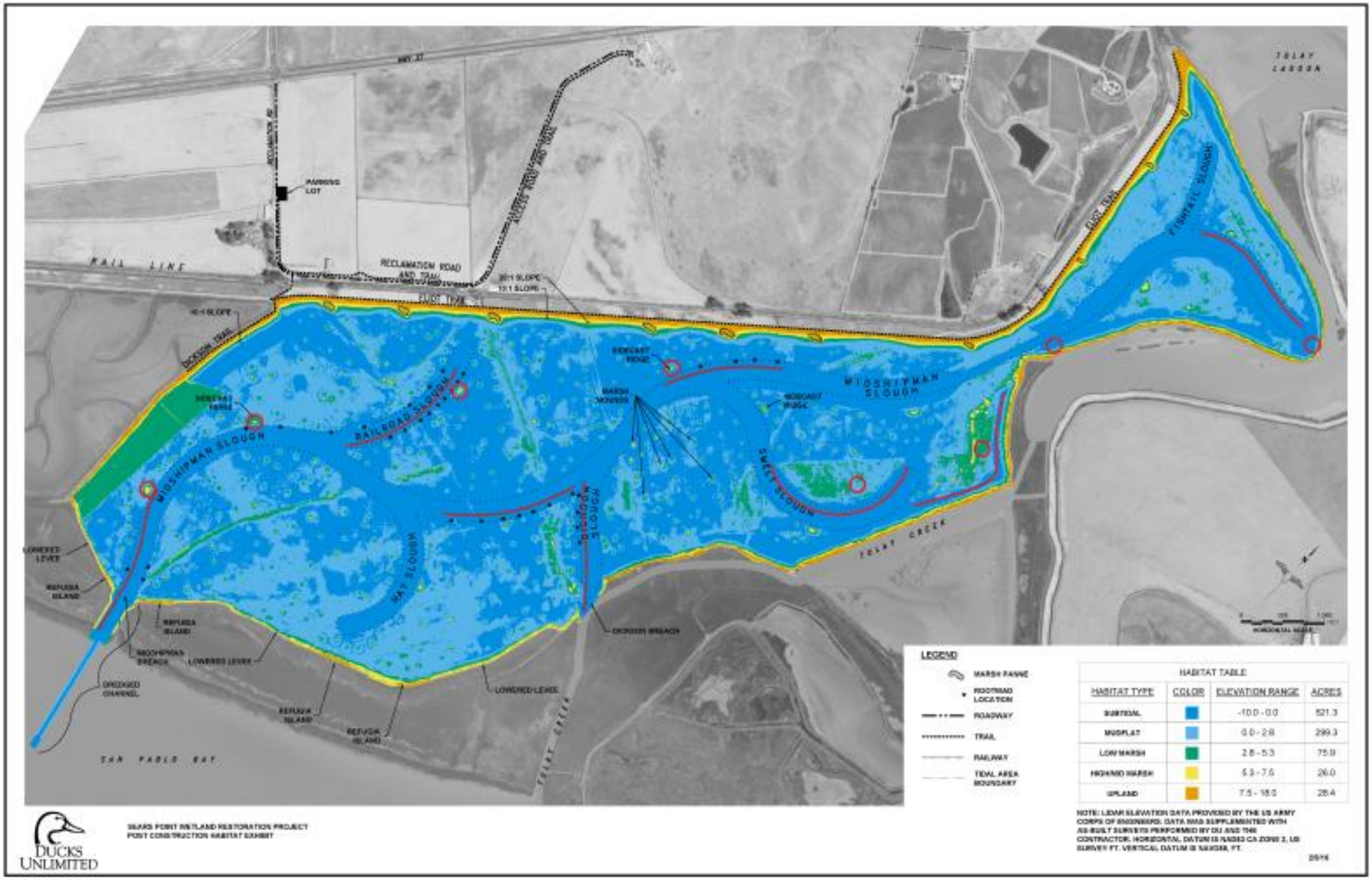
Eight stationary sampling locations have also been chosen throughout the restoration area that represent each of the key habitats listed above (see figure). At each stationary sampling location, the ARIS camera will be deployed with a stationary mount for a fixed amount of time (e.g., 30 minutes). Seining will be conducted using a 75' seine (1/4" delta mesh) at the same location immediately following the ARIS sampling and the ARIS camera will continue to operate throughout the seining effort. However, we will use smaller two-person seines (15' to 25' in length) in the *low marsh with submerged vegetation* habitat. The use of this gear type will facilitate collecting fish within the submerged vegetation, to understand the extent to which fish are using submerged vegetation as cover. The use of the ARIS camera throughout the seining effort will allow us to better understand the efficiency of the seining effort, behavioral avoidance, and inform fish ID from ARIS images of captured species.

Stationary surveys will be replicated twice between May 7 and May 8. All eight survey locations will be sampled on each day in order to facilitate comparisons between habitat types.

Sample Processing

All fish and crustaceans collected from each trawl and seine sample will be identified, counted and measured (mm). If a sample contains over 30 individuals of a single species, length measurements will be collected from a representative subsample of 30 individuals. Upon collection of a sensitive fish species (delta smelt, longfin smelt and salmonids), those individuals will be sorted and placed in individual, water-filled tubs, immediately processed, and released in the same location from where they were collected. The remainder of the catch will then be processed. A photo log of all sensitive fish species, along with a representative number of individuals of other species, will be maintained.

Map of the Sears Point Restoration Area with transect survey locations indicated by red lines and stationary survey locations indicated by red circles.



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June 24, 2017

Appendix G. Bird Monitoring Results

Mr. Julian Meisler
Sonoma Land Trust
Santa Rosa, CA

Subject: Summary of Avian Survey Findings For Initial Six Surveys (Among Eight) For Year One Citizen Science Point Count Survey At The Sears Point Restoration Area

1. Background

Following the restoration of tidal action to Sears Point, Sonoma Land Trust (SLT) hired me as a consultant to develop and initially lead a citizen science bird monitoring program at the Sears Point Restoration Area (SPRA). The purpose of the program is to track avian use of the site over time as habitat develops and changes. This report summarizes the six citizen science bird monitoring surveys completed December 2016 - April 2017. Two additional surveys will occur in August 2017 to complete year one. Year number two will begin in November, 2017 when eight surveys will again occur for 2017-2018 (i.e., two surveys per season equals eight per year) and so on for each succeeding year, thereby ensuring an ongoing annual census will occur to document the progressive avifauna richness and abundance in the SPRA.

2. Protocol

All surveys followed the protocol detailed in the attached Citizen Science Bird Monitoring Program. The protocol was taught to the volunteer avian survey monitors during two educational classroom training slide shows sessions and two follow-up practice field sessions prior to the first survey in November 2016.

During surveys, citizen scientist monitors divided into small groups ranging from 2-7 members each. Each group had a designated leader. The leader was granted this role because I deemed him or her to possess high level bird identification experience and, thus, able to ensure accurate avian identification for the entire group. A second group member was designated to complete the data form as the "recorder" of avian sightings based on the verbal instruction of the leader and other monitors.

Using binoculars and a spotting scope, monitors counted shorebird, duck, raptor, and rail species within a 0.1-mile survey radius at each of the twelve stations. Each station was surveyed for 10 minutes. Songbird order members were not included in Year1 but may be added in Year two because songbird use of the transitional and upland habitat on the levee will be useful to track.

The survey date schedule for 2016-2017 appears below and includes a four-hour time allowance for each survey that was scheduled to coincide with moderate low and high tides at the SPRA site (via saltwatertides.org), meaning a low tide survey time was deemed to occur below a reading of two feet and a high tide survey time as above five feet.

Autumn Survey = #1 Survey: 11/18/16, Moderate High Tide: 1-5 pm survey time range (3:45 pm high tide was 6.7', so moderate high tide occurred during the start of the 1-5 survey time range)

Autumn Survey = #2 Survey: 11/21/17, Moderate Low Tide: 1-5 pm (2:27 pm low tide was 1.9', so moderate low tide occurred at the start of this survey time range)

Winter Survey = #3 Survey: 1/13/17: Moderate High Tide, 11 am - 3 pm
(1:30 pm high was 7.5' at 8:15 am, so moderate high tide occurred at the start of this survey time range)

Winter Survey = #4 Survey: 1/16/17: Moderate Low Tide, noon pm - 4 pm
(10:58 am low was 1.9', so moderate low tide occurred at the start of this survey time range)

Spring Survey = #5 Survey: 4/19/17: Moderate Low Tide, 1 pm - 5 pm
(3:24 pm low tide was 0.4', so moderate low tide occurred at the start of this survey time range)

Spring Survey = #6 Survey: 4/24/17: Moderate High Tide, 10 am - 2 pm
(12:57 pm high tide was 5.7', so moderate high tide occurred at the start of this survey time range)

Upcoming Summer Survey = #7 Survey: 8/15/17 10 AM - 2 PM, Moderate High Tide;
high tide of 4.6' will occur at 8:52 am

Upcoming Summer Survey = #8 Survey: 8/21/17 10 AM - 2 PM, Moderate Low Tide;
Low of -0.6 will occur at 8:36 am

3. Summary of Findings

A summary of surveys 1-6 is attached. Based on this collective assessment, several trends emerge:

1) Given the survey observations were limited to identifying duck, shorebird, and rail family members, in addition to raptor order members, survey observations on the data forms yielded avian presence in the following habitat types at the SPRA site: a) Wetland (WET); b) Tidal Mudflat (MUD); c) Upland Levee (LEV); d) Beach (BEA); e) Rocky Shoreline (ROCK); f) Open Water (OPEN); and g) Marsh Panne (MAR).

2) Avian guilds most commonly represented with the greatest abundance during the six surveys:

Duck Family Members

a) Diving duck guild species: Greater Scaup and Canvasback were the two most commonly seen diving duck members in this guild. Significantly, the documented presence of these two species within the SPRA site suggests it provides important non-breeding season foraging habitat for these two visiting, non-breeding duck species. The importance of these sightings is illuminated by studies that show large portions of these two species' entire populations depend on the San Francisco Bay and tributaries in the North Bay (including the SPRA site) for "over-wintering" (i.e., non-breeding season) foraging habitat, with more than half the entire population of Greater Scaup present in the San Francisco Bay during the non-breeding season, according to California Department of Fish and Wildlife (CDFW) studies conducted in the North Bay and bay-wide in recent years (See: http://www.southbayrestoration.org/Fact%20Sheets/FS4.html)

In addition, similar CDFW studies indicate large portions of Canvasback on the West Coast of the USA depend on the type of open water habitat present in the restored SPRA site.

Collectively, for the 12 point count stations totals tabulated among the six surveys, stations #1-#10 hosted the greatest richness and abundance of diving duck guild species.

b) Puddle/Dabbling duck guild species: American Wigeon and, in far lesser abundance, Gadwall, were the two most commonly seen puddle/dabbling duck members noted in this guild. Gadwall is already a likely nesting species in the SPRA within pickleweed and other vegetation areas adjacent to the edges of the SPRA site. In the future, the expansion of the created "islands" with ongoing soil deposition may also likely serve as nesting refugia sites that will eventually be above water at both high and low tides.

c) Stiff-tailed duck guild species: Ruddy Duck, which is in its own distinct guild as the only stiff-tailed duck member on the West Coast, was one of the top five duck family members detected during the surveys. As a Sonoma County nester, it is provided ideal foraging habitat based on the open water present within the site and, in addition, its presence is likely to remain at robust levels with current and future nesting habitat accommodated via the creation of the "islands" as part of the site's restoration design.

Shorebird Family Members

Among approximately 19 species of shorebird family members typically seen annually in the San Francisco Bay Area, 13 were seen at the SPRA site during the surveys.

The most abundant were Least Sandpiper, Western Sandpiper and Dunlin, as each of these species was seen at 11 of the 12 point count stations.

The largest numbers of Least Sandpiper were noted at stations #4-#5 and #7-#10 — with each of these six stations yielding more than 100 total Least Sandpiper individuals for all six surveys. Only station #11 among the 12 points was devoid of any Least Sandpiper for all six surveys.

The largest numbers of Western Sandpiper were noted at stations #1-#2 and

#7-#11 — with monitors at each of these six stations observing a total of more than 100 Western Sandpiper individuals at both #1 and #9 for all six surveys. Only station #3 among the 12 points was devoid of any Western Sandpiper for all six surveys.

The largest numbers of Dunlin were noted at station #1, #6-#8, and #12 — with monitors at each of these six stations observing a high of 568 individuals at point count station #8. Point #12 yielded 202 Dunlin individuals and 190 were seen throughout all six surveys at #1.

Only stations #2 and #10 were devoid of Dunlin for all six surveys.

Far fewer numbers of total individuals for all six surveys were recorded for the following shorebird family members (from the most abundant to the least abundant) Marbled Godwit, Black-bellied Plover, Willet, Greater Yellowlegs, Long-billed Curlew, Short-billed Dowitcher, Killdeer, Whimbrel, Long-billed Dowitcher, and Lesser Yellowlegs.

For the 10 aforementioned shorebird family members, the largest numbers were typically seen at stations #4-#5 and #7-#10. These stations at low tide provided mudflat and shallow water habitat suitable for several species to successfully forage.

Stilt/Avocet Family Members

Although American Avocet was the lone representative noted in this family during the surveys, its presence was limited to occurring within only four of the 12 point count stations (stations #9-#12). This result is interesting, based on the habitat structure (i.e., geomorphology) present at these four points, as the varying tide cycles provide periodic suitable water level to aid the American Avocets' foraging ability as they exploit food resources. For example, the majority of American Avocet observed during the six surveys was primarily limited to one survey (November 18, 2016) when a moderate high tide created an ideal mudflat/water depth regime by which 186 American Avocet individuals were counted at point count station #11 and 50 at station #9. During the two spring surveys in April, 2017, no nesting and/or newborn American Avocet were detected. Black-necked Stilt was absent from all 12 stations during all six surveys.

Raptor Order Members

Raptor species richness and abundance was low for the six surveys. Four raptor order members were observed by monitors, with all of them considered "common" and expected both in the region and at the SPRA site: Turkey Vulture, White-tailed Kite, American Kestrel, and Red-tailed Hawk.

Significantly, the upland areas of the SPRA, including low tide periods, provide habitat for rodent order members and snake species as prey base for the latter three aforementioned raptors species. Turkey Vulture, likewise, capitalizes on the carrion present from deceased food web members present in the SPRA site.

Rail Family Members

Rail family member richness and abundance was low for the six surveys, with only American Coot observed by monitors. It potentially nests within the SPRA site and nearby it, but during the surveys was only seen foraging, typically in groups.

Absence of other typical rail family members in the region's more heavily vegetated freshwater and brackish marsh habitats — Virginia Rail, Sora, and Common Gallinule — (including brackish marsh habitat adjacent to the SPRA site) was not surprising. That's because the SPRA site currently is devoid of emergent vegetation that provides suitable shelter, foraging, and nesting conditions for these common species.present in the study area where the point count stations occurred and based on the survey protocol guidelines.

Likewise, listed species such as Ridgway's Rail and California Black Rail that are locally present in nearby suitable salt marsh and brackish marsh habitat were also not present on the surveys nor would they be expected based on the early successional vegetation expression at the SPRA site.

4. Conclusions

Based on the results of the six surveys, and assessing them in relation to the habitat conditions present at the point count stations, the following conclusions apply:

a) The SPRA site provides important foraging (i.e., stopover/"wayside" habitat) and breeding opportunities for several shorebird and duck family member species.

Given that several recent studies indicate San Francisco Bay bayside habitat types matching those found at the SPRA site offer important resting and foraging sites for coastal wintering shorebird family and duck family populations, it is not surprising that the avian observation results during the six surveys support the conclusions of these studies.

As evidence, the large numbers of aforementioned Western and Least Sandpiper individuals noted by monitors at several of the 12 point count stations, along with impressive abundance of Dunlin individuals, vouch for the importance of the SPRA site as a winter refugium for these three common shorebird family members. As a result, it's significant to note how the newly-created mudflat and other habitats introduced at the SPRA site have already successfully attracted these three "keystone" shorebird family members, as well as the other shorebird family members mentioned above (i.e., at least 12 other common shorebird family members are annual visitors to the SPRA).

Related, the importance of the SPRA to host a federally threatened subspecies in plover family member — the Western Snowy Plover — may be more likely in the near future as mudflat habitat on the site expands and serves as over-wintering foraging habitat for this threatened subspecies. Although the subspecies of this Snowy Plover is typically more common in sand substrate, such as coastal areas of California where it also nests, sporadic reports of its presence exist for San Francisco Bay shoreline areas within Sonoma County (within which the SPRA exists) and sometimes include mudflat areas similar to those currently present within the SPRA.

Consequently, as deposition infill mudflat habitat progresses over time in the SPRA, I would expect more observations of Western Snowy Plover to occur. In particular, the outer fringes of the SPRA adjacent to North Bay mudflats are the most likely spots where Western Snowy Plover may likely occur in low numbers during the non-breeding season.

Likewise, large expanses of open water at the SPRA site attracted several duck species during the surveys conducted to date. Although the SPRA site does not yet host large breeding populatons of duck family members, several foraging species were seen during the surveys, given they benefit from the presence of the SPRA site as suitable non-breeding, "over-wintering" habitat, including Canvasback and Greater Scaup. These two species in particular should be considered signficant sightings because the majority of their entire West Coast populations as a species spend the non-breeding season in the San Francisco Bay and its adjoining habitats such as the SPRA site.

Studies conducted by the California Department of Fish and Wildlife (CDFW) have shown, for example, that deep water habitat adjacent to the San Francisco Bay (including those represented at the SPRA site) provides essential refugium to sustain current and future populations of Canvasback and Greater Scaup, as well as other duck populations that utilize the Pacific Flyway, within which the SPRA parcel resides.

Northern Pintail, for example, is another annual non-breeding season resident at the SPRA site that utilizes the site based on its geography within the Pacific Flyway corridor. This common puddle/dabbling duck species can be seen in large numbers throughout the North Bay and, consequently, it's not surprising that bird monitors during the surveys observed it at several point count stations.

Of note, as time progresses, it's likely the SPRA site's shallow and deep water areas will continue to attract these duck species and additonal diving and puddle/dabbling duck species (as well as other waterfowl species, including heron family members — Snowy and Great Egret, as well as Great-Blue Heron — that were merely seen in low numbers during the six survey) — in addition to greater abundance of them during the non-breeding season.

Moreover, note the deep open water introduced at the SPRA site offers suitable resting and foraging habitat conditions to attract grebe family members such as the Western and Eared Grebe individuals that monitors also observed in low numbers during the surveys.

Equally significant, duck family members that breed in the region were seen by monitors in impressive, robust numbers during the surveys, including the aforementioned Ruddy Duck.

Fewer numbers of Gadwall and Mallard were noticed during the survey, but they are also resident, year-round waterfowl species that breed in the region and, most likely, in upland habitat adjacent to or within the SPRA site. Consequently, it's plausible to state that the SPRA site is already serves as a nesting area by at least three breeding species of ducks: the Ruddy Duck, Gadwall and Mallard. Their numbers will likely increase in future years within the SPRA site as more upland habitat develops via soil deposition.

b) The SPRA site provides valuable, multiple habitat types for resting and foraging bird species that utilize it within the Pacific Flyway migration corridor that also serves as valuable stopover/"wayside" habitat.

Given the SPRA site occurs within and adjacent to the San Francisco Bay — one of the West Coast's most important coastal non-breeding season and migratory habitats for shorebird and duck family populations — it is important to note how the six surveys to date provide evidence that the SPRA site hosts several important habitat types to sustain "over-wintering" populations and breeding populations in these two bird families. These habitats include wetlands (brackish and saltwater marsh); tidal mudflat; open water, and marsh panne.

Discussion in the previous section is also in part applicable to this section. Consider how studies by the CDFW indicate significant numbers of Canvasback, Bufflehead, Greater and Lesser Scaup, Canvasback, and Bufflehead appear during the non-breeding season in the San Francisco Bay/Delta region within which the SPRA site occurs. The initial three of these four species were detected in good numbers during the six surveys. Canvasback and Greater Scaup are especially noteworthy sightings within the SPRA site, given large portions of their entire species' populations also utilize open water habitat in other portions of San Francisco Bay during the non-breeding season.

The newly-created habitat types within the SPRA provide over-wintering bird species an oasis of suitable habitat refugium buffer zone. Equally important, based on recent drought conditions that pervaded the North Bay region from approximately 2011-2016, sites such as the SPRA's habitats provide essential refugium to sustain shorebird and duck family member populations that are forced to retreat and find available suitable foraging and breeding habitat when challenged due to the absence of moderate to deep open water open habitat during drought periods, such ~2011-2016.

Beyond its role as a resting and foraging site along the Pacific Flyway corridor, as previously noted, the SPRA site contains several created raised "islands" that promise to soon serve as suitable habitat for potential colonization by breeding populations of Gadwall and Mallard that occur in the area year-round. The Cinnamon Teal is another common duck species in the region I believe will potentially soon begin nesting within the SPRA site's upland areas, including the "islands" as they succeed botanically and become more expansive via soil deposition and colonized with rhizomatic expansion of emergent vegetation (e.g., bull rush species, cordgrass, gum plant, and pickleweed, among other pioneer plant species). In turn, as swaths of emergent vegetation expand at the SPRA site, the following additional avian species should be expected to begin nesting within the SPRA site: Pied-billed Grebe, Common Gallinule, and American Coot (with all three of these species potentially already nesting successfully adjacent to the SPRA site).

Likewise, this same kind of upland habitat either within the SPRA site or bordering it will likely attract rising breeding populations of two non-native goose family members: Canada Goose and Mute Swan. The confirmation of these two invasive goose family members as nesters at the SPRA site could cause several negative impacts. Consider how their presence would result in food resource competition and nesting site "carrying capacity" impediments upon aforementioned native avifauna species ability to optimally utilize the SPRA site for resting, foraging, and breeding. time,

Related, these same upland "island" areas separated by water from the mainland in the SPRA, provide essential safety habitat to ensure ongoing presence of shorebird and duck family members within the SPRA, given these bird species depend on these removed "island" areas to avoid predation from mammals such as racoons, gray fox, coyote, river otter, snakes, non-native rat species, and feral cats.

Equally significant, upland habitat within the SPRA site and adjacent areas provide shelter for shorebird and duck family members, thereby helping these species hide from predators. These same habitats also serve as shelter for several species of "over-wintering" and resident duck and shorebird family members (in addition to raptor order members) when extreme wind and stormy weather conditions pervade the region, including the SPRA site.

c) **The SPRA site's 2016-2017 avian surveys provide important data that will be shared with the CADC to help the Sonoma Land Trust and the wider scientific avian community understand short- and long-term avian breeding and migration patterns.**

After review by the Sonoma Land Trust staff, the data from the surveys will be submitted to the CADC. This database hosts several ongoing West Coast avian survey databases. Collectively, these surveys help researchers analyze avian species population levels and trends. Migration trends and insights may also be aided by adding the SPRA annual survey results. Ensuing, optional management techniques may then be considered, based on new, cumulative avian data submittals.

Ultimately, as the annual surveys are added to the CADC, insights into the value of habitat preservation and restoration could be positive results noticed and implemented at the SPRA site — and, in so doing, highlight the Sonoma Land Trust's success as the initator of restoring the SPRA site.

Lastly, the representation of the SPRA site's avian survey data shows promise as a valuable asset to the CADC and, likewise, to the local San Francisco Bay and, in addition, West Coast avian scientific community.

CITIZEN SCIENCE

BIRD MONITORING PROGRAM

SEARS POINT TIDAL RESTORATION AREA

VOLUNTEER MANUAL

SONOMA LAND TRUST

... to protect the land forever

Point-count Survey Method for Surveying the Sears Point Restoration Area (SPRA)

Please review this survey method, survey map, and data sheet before conducting a survey. This protocol was adapted from The Pacific Flyway Shorebird Survey (www.prbo.org/pfss) and Migratory Shorebird Project (www.migratoryshorebirdproject.org). The usefulness of data collected as part of these surveys requires that all observers follow the protocol outlined here.

CONTENTS

1. BACKGROUND

The San Francisco Bay Estuary is the largest estuary on the West Coast of North and South America. More than one million resident waterfowl and shorebirds depend on its varied habitats while at least a million more migrate to or through it. While significant, these bird numbers are reduced from historic times when the expanse of tidal marsh was far greater. Approximately ninety 90 percent of the Bay's marshes were lost between 1850 and 1960, and thus many birds dependent on the marshes for foraging and breeding, like the threatened California Black Rail and endangered Ridgway's Rail, have suffered severe population declines.

Over the last few decades, however, interest in marsh restoration has taken root. This movement began small, with Bay projects rarely exceeding a few hundred acres at best, but has recently included multiple projects nearing or exceeding 1,000 and even 10,000 acres. Such large projects require intense planning and permitting and carry price tags in the tens of millions of dollars. Understandably, only large government agencies are able to see through the long timelines required.

Unfortunately, the timeframe to get this work done is relatively short. A new report, *The Baylands and Climate Change,* prepared by over 200 scientists and government officials, urges a redoubling of restoration efforts in advance of rising seas, more severe storms, and, in the case of San Francisco Bay, a declining sediment supply that is the building block of new marshes. Ramping up restoration will require that private organizations step up their efforts in conserving and restoring the bay.

Some groups have already begun. Sonoma Land Trust (SLT), a small, non-governmental organization working to conserve the lands and waters of Sonoma County, California, has been invested in northwestern San Francisco Bay shoreline conservation and restoration since the mid-1980s. It has protected more than 7,000 acres of diked baylands (reclaimed tidal wetlands) and uplands directly adjacent to the Bay.

One of SLT's greatest conservation achievements began in 2003, when a plan to build a Las Vegas-style casino on the shoreline lit a fire under the conservation community. Not only would such a development permanently alter the region's rural character, it stood in the face of every major conservation plan for the Bay. The proposed site was entirely within the historic Bay margin — the area once part of the Bay but reclaimed for agriculture, industry, and other development. SLT and partners, such as the San Francisco Bay Joint Venture, worked to convince the project proponents, a local Native American tribe, that this proposal would be at odds with conservation initiatives. The efforts were rewarded not only with the tribe relinquishing its right to purchase the site but it also donated its purchase option valued at $4.2 million.

Over the next two years, SLT raised a total of $20 million to buy the property and, conveniently, the one next door. Collectively the 2,327-acre site is known as Sears Point. Unique among nearly all shoreline conservation properties, Sears Point extends deep into the adjacent uplands reaching elevations of nearly 400 feet. Some nine miles of riparian corridors traverse its grasslands, willow groves, and broad plains of seasonal wetlands to connect upland to Bay.

The purchase set in motion a ten-year effort to plan, permit, and fundraise for a large-scale restoration known as the Sears Point Restoration Project. The nearly 1,000-acre portion slated for tidal wetland restoration housed farm buildings, hay fields, and an upland game bird hunting club. The plan was to remove all the human built structures, create some new and innovative natural features to hasten the evolution of the new marsh, and then to breach the century-old levee to bring back the tides. SLT hired some of the best minds in the Bay to design a project that incorporated lessons learned from previous projects and anticipated sea level rise. Five years into the process, SLT partnered with Ducks Unlimited (DU) to bring its experience and expertise to the project.

Closely following the original design, SLT and DU built a new 2.5-mile levee, whose gentle slopes would not only serve a necessary flood protection role, but also provide high tide refugia for marsh wildlife during extreme tides and storm surges. The levee was built with soil dug on site during the excavation of six miles of new channels. Over 500 "marsh mounds" were built within the site to break up wind waves that might prevent tidally borne sediment from settling out of the incoming Bay waters—sediment that will be needed to raise the site more than six feet to reach marsh plain elevation, the elevation at which vegetation grows. These were but a few of the construction activities leading up to October 25, 2015, when the historic levee was finally breached.

Birders flocked to the site and emails to SLT looked like this: "There are huge numbers of shorebirds, including stilts, avocets, curlews, etc., etc. The same goes for gulls. The wintering ducks have not arrived but there were a few Mallards, pintails and shovelers. There were also egrets, herons, cormorants, lots of Killdeer and pipits. A few raptors were also around. In short, this is going to be a wonderful place for shorebirds, waterfowl and waders."

In the weeks that followed, the ducks arrived. And in years, the marsh will begin to emerge, giving home to rails and other marsh-dependent wildlife—all resulting from the work of a single small land trust. Nationwide more than 1,700 land trusts like SLT have protected 37 million acres—an area roughly the size of all the New England states combined. The cumulative effect of this work is tremendous. The Sears Point Restoration Project is but one example of what local organizations can do to meet global challenges.

2. PURPOSE

This survey is designed to obtain data on annual variation, long-term trends, and habitat associations of shorebird, duck, raptor, and rail use of the agricultural, tidal, and wetland landscapes in the North Bay within the Pacific Coast of the Americas. These data will be submitted and combined annually with comparable data from other sites across the Pacific Flyway to assess spatial and temporal patterns of avian abundance at multiple spatial scales from the SPRA within the Flyway.

3. SURVEY DESIGN

Each survey among eight per year (two each season) will employ a fixed-radius point count method at 12 pre-determined survey stations within the Sears Point Restoration Area (SPRA). For each survey, observers will be assigned one or more numbered survey stations by Sonoma Land Trust (SLT). Observers will walk to each survey station, which will have a permanent marker (please see your map for stations numbers 1-12). Survey locations will be located equidistant from each other along the trail system within the SPRA. At each survey location, observers will count all shorebirds, ducks, and rails within a 0.1 mile (528 feet or 160 meters) radius and record survey area characteristics on a datasheet. Surveys will be scheduled to occur when low tides are below two feet and high tides are above five feet. Survey dates and times will be established by SLT and, in turn, shared with you. Hard copies of completed datasheets will be shared with the United States Fish and Wildlife Service (USFWS).

IMPORTANT THINGS TO REMEMBER

Inclement Weather: Surveys should not be conducted in weather with strong winds (>24 mph), heavy fog (<600 feet visibility), or steady rain.

Observers: Under most conditions, surveys should be conducted by one lead observer along with helpers to assist identification. Having multiple lead observers counting simultaneously may bias results. We recommend working in small groups where one person counts birds (Lead Observer) while a second person records data (Data Recorder), and others, if present, help gather other data, including identification of bird species. The observers (people counting) and data recorders should be listed on the data sheet and will be entered into the California Avian Data Center (CADC) by one of the volunteer citizen scientist monitors.

Pre-survey Scouting: We encourage you to visit one or more of your assigned point count stations prior to the survey to familiarize yourself with the surrounding environment and to assess potential obstructions and conditions.

Survey Distance Calibration: Observers should calibrate their distance estimation prior to conducting surveys. The point count circle radius (0.1 mile) can easily be estimated by stopping at a utility pole or other obvious landmark within the SPRA, then driving 0.1 mile looking back at the starting landmark. Do this several times to get a sense of what 0.1 miles looks like in the field. You can then test yourself by predicting where 0.1 miles should be in front of you, then drive to that point and see if it was 0.1 mile. With practice, you will get used to estimating the 0.1 mile count semi-circle radius.

4. SURVEY METHOD AND DATA COLLECTION

Data should be recorded on a separate datasheet for each of the 12 points as indicated on the survey map. At each point, indicate on the datasheet the station number, the date (mm/dd/yyyy) and the observer(s) (e.g., the names of the lead observer, Data Recorder on the datasheet, and any other observers.)

Proceed along the point-count route to each assigned survey location as indicated on your map of the SPRA. Begin each count of each survey area along the route by noting the point count station number and starting time on the datasheet (24-hr clock; e.g., 3PM = 1500). Then, count and identify to species all shorebird, duck, raptor, and rail species within the 0.1-mile survey area for 10 minutes. This includes birds that enter or leave the survey area during the count. For a bird to be considered "using" the survey area, it needs to be on the ground within the defined survey area for at least part of the time it takes to do the survey. Thus, shorebirds that fly over, but do not land in, the survey area should NOT be counted. Keep track of bird movements and do not double-count birds if they leave and then re-enter the survey area or if they fly from one side of the road to the other. Sightings may be documented by sight or sound, or both.

In addition, record the number and species of raptors that are in, perched adjacent to, or foraging over the survey area. Record species observed in the appropriate column of the datasheet. The total number of each species observed during the count of each survey area should be entered into the count column.

Conduct each survey from the pre-defined survey location along the point-count route (see your map). It is critical to the validity of the analyses that the survey occur at the same location for each survey.

As noted above, there is a 10-minute time limit for counting birds at each point count station. Utilize a watch or digital device to ensure the 10-minute duration is accurate. Once all birds at a point count station have been recorded, the count is considered complete. At this point, note the End Time on the datasheet and thereafter NO additional birds should be recorded for that point.

COUNTING METHOD

It usually will be possible to make exact counts of small groups of birds (<50 individuals), but estimation may be needed for larger flocks. However, it may not be possible to identify a few or, sometimes, even large numbers of birds because of poor lighting, quick or distant views, similarity of species, or other factors. Try to count or estimate numbers by whatever technique works best as listed here in order of preference:

1. Identify species and their abundance (e.g., 148 Western Sandpipers, 153 Dunlin, 308 Least Sandpipers) for each point count station
2. Estimate the proportion of species in the flock and use the proportions and total flock size to calculate the total of each species (e.g., 600 birds: 25% Western, 25% Dunlin, 50% Least = 150 Western, 150 Dunlin, and 300 Least). Note: only do this calculation if you are confident the proportions are accurate. Please use a mixed-species code if necessary (see next bullet).
3. Estimate size of flock and species present (e.g., 600 birds, composed of Western Sandpipers, Least Sandpipers and Dunlin). Please see the species list provided at the end of the protocol for commonly recorded species.

Following bird observations fill out the remainder of the datasheet completely, including Site Conditions before proceeding to the next point count station. Please fill out a datasheet completely even if no birds were detected. This will help us determine the total effort expended during each survey, and knowing that zero birds were observed are important data for determining the conditions that influence bird use. Move promptly from one station to the next do ensure data is collected during comparable tide levels.

SURVEY AREA CHARACTERISTICS

To understand what habitats birds use and why, this protocol includes the collection of weather and habitat characteristics for each survey area. Please record weather conditions (Wind, Cloud, Precipitation) and site characteristics (habitat cover type) for each survey area using the following codes:

WEATHER

1. **Wind**

CODE	CATEGORY	DESCRIPTION
0	*Calm*	smoke rises vertically (<1 mph)
1	*Light air*	smoke drifts (1 – 3 mph)
2	*Light breeze*	felt on face, leaves rustle (4 – 7 mph)
3	*Gentle breeze*	leaves and small twigs in constant motion (8 – 12 mph)
4	*Moderate breeze*	dust, leaves, and loose paper rise up; small branches move (13 – 18 mph)
5	*Fresh breeze*	small trees sway (19 – 24 mph)
6	*Strong breeze**	large branches in motion (25 – 30 mph)

**Surveys should not be conducted in weather with strong winds (>24 mph)*

2. Cloud: Enter numeric percentage (0 – 100) indicating the amount of the sky covered by clouds.

3. Precipitation

CODE	CATEGORY
0	*None*
1	*light intermittent; mist, sprinkle of rain*
2	*Fog*
3	*Drizzle*
4	*rain**

**Do not conduct surveys in heavy rain, or heavy fog (<600 feet visibility), but if the survey is conducted despite rain please record 4*

4. **Cover type** (Type): *Document the cover type(s) that best describes the dominant characteristic(s) of the survey area. Record the <u>one or two</u> cover types that each compose <u>at least 40%</u> of the survey area.*

CODE	CATEGORY	DESCRIPTION
1	*Tidal Marsh (MAR)*	open fresh water with pickleweed, cordgrass, bullrush, or other emergents
2	*Tidal Mud Flat (MUD)*	areas of mud, sand or gravel (generally lacking vegetation) alternately exposed and inundated by tides. If flats are covered at the time of the survey, the area should be considered Open Water (see protocol)
3	Upland levee *(LEV)*	including the trail from which you conduct a point survey
4	*Beach (BEA)*	sandy shoreline; sand can be coarse or fine grain and composed of multiple substrate.
5	*Rocky Shoreline (ROCK)*	includes riprap, i.e., embankments lined with rocks or chunks of concrete to limit erosion
6	Open Water *(OPEN)*	open water within a tidal system. Includes waters over subtidal areas, water covering tidal flats at time of survey, and the ocean.
7	*Tidal panne (PAN)*	a wetland that is located adjacent to levees; retaining depression that may host vegetation and is usually dry/upland.

3. WHAT TO TAKE INTO THE FIELD

- □ Survey Area map, Protocol, Datasheets
- □ Pencils or Permanent Ink Pen
- □ Binoculars
- □ Scope and Tripod
- □ Compass
- □ Watch
- □ Smart Phone
- □ Sunscreen
- □ Water
- □ Field guide
- □ Apps
- □ Clipboard

DATA ENTRY

Via the direction of Sonoma Land Trust, data will be entered after the surveys into the appropriate project in the California Avian Data Center (CADC).

4. SPECIES LIST

The following list contains the primary species of shorebirds, including mixed flocks, and diurnal raptors that may be seen in or around shallow-water habitats along the North Bay.

SHOREBIRDS:

Black-bellied Plover (BBPL)
American Golden-Plover (AMGP)
Pacific Golden-Plover (PAGP)
Snowy Plover (SNPL)
Semipalmated Plover (SEPL)
Killdeer (KILL)
Mountain Plover (MOPL)
Black Oystercatcher (BLOY)
Black-necked Stilt (BNST)
American Avocet (AMAV)
Spotted Sandpiper (SPSA)
Solitary Sandpiper (SOSA)
Wandering Tattler (WATA)
Greater Yellowlegs (GRYE)
Lesser Yellowlegs (LEYE)
Willet (WILL)
Whimbrel (WHIM)
Long-billed Curlew (LBCU)
Whimbrel/Curlew (XNUM)
Marbled Godwit (MAGO)
Ruddy Turnstone (RUTU)
Black Turnstone (BLTU)
Surfbird (SURF)
Red Knot (REKN)
Sanderling (SAND)
Semipalmated Sandpiper (SESA)
Western Sandpiper (WESA)
Least Sandpiper (LESA)
Baird's Sandpiper (BASA)
Pectoral Sandpiper (PESA)
Rock Sandpiper (ROSA)
Dunlin (DUNL)
S.B. Dowitcher (SBDO)
L.B. Dowitcher (LBDO)
Wilson’s Snipe (WISN)
Wilson's Phalarope (WIPH)
Red-necked Phalarope (RNPH)
Red Phalarope (REPH)

DIURNAL RAPTORS:

Turkey Vulture (TUVU)
Osprey (OSPR)
White-tailed Kite (WTKI)
Bald Eagle (BAEA)
Northern Harrier (NOHA)
Sharp-shinned Hawk (SSHA)
Cooper's Hawk (COHA)
Sharp-shinned/Cooper’s (XSCH)
Red-shouldered Hawk (RSHA)
Swainson's Hawk (SWHA)
Red-tailed Hawk (RTHA)
Ferruginous Hawk (FEHA)
Rough-legged Hawk (RLHA)
Golden Eagle (GOEA)
American Kestrel (AMKE)
Merlin (MERL)
Peregrine Falcon (PEFA)
Prairie Falcon (PRFA)

DUCKS:

Gadwall (GADW)
Cinnamon Teal (CITE)
Green-winged Teal (GWTE)
Blue-winged Teal (BWTE)
Canvasback (CANV)
Redhead (REDH)
Ring-necked Duck (RNDU)
Greater Scaup (GRSC)
Lesser Scaup (LESC)
Surf Scoter (SUSC)
Black Scoter (BLSC)
WhiTe-winged Scoter (WWSC)
Common Goldeneye (COGO)
Barrow’s Goldeneye (BOGO)
Bufflehead (BUFF)
Hooded Merganser (HOME)
Common Merganser (COME)
R.N. Merganser (RNME)
Ruddy Duck (RUDU)

5. FIELD GUIDES

Some groups of birds such as shorebirds and raptors require training, study, and practice to ensure correct identifications. Therefore, SLT recommends that you bring a bird identification field guide to a survey. Excellent Apps for Android and iOS may also be useful and complementary to a field guide.

Title
The Sibley Field Guide to the Birds of Western North America by David Allen Sibley
Field guide to the Birds of North America /Western America National Geographic (6th edition, with the 7th edition appearing in 2017)
Kaufman Field Guide to Birds of North America
Peterson Field Guide to birds of Western North America
Shorebirds of North America by Dennis Paulson
The Shorebird Guide by Michael O'Brien, Richard Crossley, Kevin Karlson

APPs

Application name	Price	Platforms	Details
Sibley eGuide to the Birds of North America	$19.99	iOS, Android, Kindle Fire, Windows, and Blackberry	Covers 810 species and features all of the drawings, range maps, and explanatory text found in the Sibley Guide to Birds. Taking advantage of the digital format it includes more than 2,000 recordings of songs and calls, a compare species function, and a smartsearch tool that allows you to filter species by color, shape, and your current location.

Audubon Bird Guide	Free	iOS, Android, Kindle Fire, HP, and Nook	Covers 810 species using photos instead of drawings, includes range maps that also cover Central and South America, has a good selection of audio recordings including alternate calls and regional variations, and slightly more descriptive text including habitat, range, and nesting information. Similar species and browse by family or shape tools are useful for identifying unknown birds, and includes a find birds with eBird function to find nearby reports of specific species.

APPENDIX G

Site	Latitude	Longitude
CS 1	38.124271	-122.473316
CS 2	38.127142	-122.471652
CS 3	38.129156	-122.4692
CS 4	38.130566	-122.465625
CS 5	38.131991	-122.462059
CS 6	38.133443	-122.458511
CS 7	38.134792	-122.454898
CS 8	38.13616	-122.451297
CS 9	38.137529	-122.447696
CS 10	38.139545	-122.444742
CS 11	38.142648	-122.444106
CS 12	38.145795	-122.443817

BIRD SURVEY DATA FORM Sears Point Restoration Area			
Lead Survey Observer; Other Observers		Data Recorder	
Date		Tide: Low or High	
Start Time		End Time	
Station #		Cover Type (see back)	
WEATHER (see legend on back)			
Est. Temp. (°F)		Wind	
Precipitation		Cloud Cover (0-100%)	
SPECIES (refer to species list for codes)			

Legend

Date: (mm/dd/yyyy)	**Time:** 24-hr clock; e.g. 3PM = 1500

Cover Type:	Tidal Marsh (MAR)	Tidal Mud Flat (MUD)	Upland Levee (LEV)	Beach (BEA)	Rocky Shoreline (ROCK)	Open Water (OPEN)	Tidal Panne (PAN)
Code:	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Wind:	Calm	Light air	Light Breeze	Gentle Breze	Moderate Breeze	Fresh Breeze	Strong Breeze
Code:	**0**	**1**	**2**	**3**	**4**	**5**	**6**

Precipitation	None	Sprinkle	Fog	Drizzle	Rain
Code:	**0**	**1**	**2**	**3**	**4**

SPECIES cont.							