CMER MARSH EXPANSION MONITORING

Year 1 – 2019 Monitoring Report

Prepared for
Marin Audubon Society

January 2020

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GLOSSARY OF ACRONYMS

BCDC – Bay Conservation and Development Commission

CDFW – California Department of Fish and Wildlife

CIR – Color Infrared

EL – Elevation

ESA – Environmental Science Associates

HOA – Homeowners' Association

MAS – Marin Audubon Society

MHHW – Mean Higher High Water

MLLW – Mean Lower Low Water

NDVI – Normalized Difference Vegetation Index

OBIA – Object Based Image Analysis

PWA – Philip Williams and Associates

RGB – True Color

RTK-GPS – Real-Time Kinematic GPS

TWN – The Watershed Nursery

STA – Survey Stationing Along Profile

USACE – U.S. Army Corps of Engineers

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CORTE MADERA ECOLOGICAL RESERVE MARSH EXPANSION MONITORING

Year 1 – 2019 Monitoring Report

1. Introduction

The Corte Madera Ecological Reserve (CMER) Marsh Expansion Project site is located in east Marin County at the end of Industrial Way, north of San Clemente Creek and south of Corte Madera Creek in Corte Madera, California (**Figure 1**). The 6.2-acre project area is adjacent to a large and ecologically important tidal marsh to the south known as the Corte Madera Ecological Reserve (Reserve) and is co-owned by both the Marin Audubon Society (MAS) as well as the California Department of Fish and Wildlife (CDFW). MAS owns a majority 5.2 acres of the site, and CDFW owns the remaining 1 acre (Siegel Environmental, 2017).

Between the 1940s and 1970s the project site was gradually filled with construction debris and sold to a private land developer. Additional fill from Lake County was placed in 1984 prior to anticipated development. After 20 years of working to acquire the property, MAS successfully purchased the it in 2015 with the intention of restoring the parcel back to tidal marsh habitat. Between October 2017 and February 2018, construction was completed in order to restore tidal marsh habitat, connect existing channels, and provide high tide refugia for species such as the endangered California Ridgeway's Rail. The restored site can now be seen in **Figure 2**. Two main excavated channels run through the site, connecting the Corte Madera Flood Control Channel to the south of the project site to a smaller tidal channel to the north of the project area (a former MAS tidal restoration project completed in the 1980s). Just south of the CDFW parking lot, a small designed upland and transitional slope was constructed and subsequently planted with approximately 18,201 site-specific native plants, with the plantings completed in December 2018.

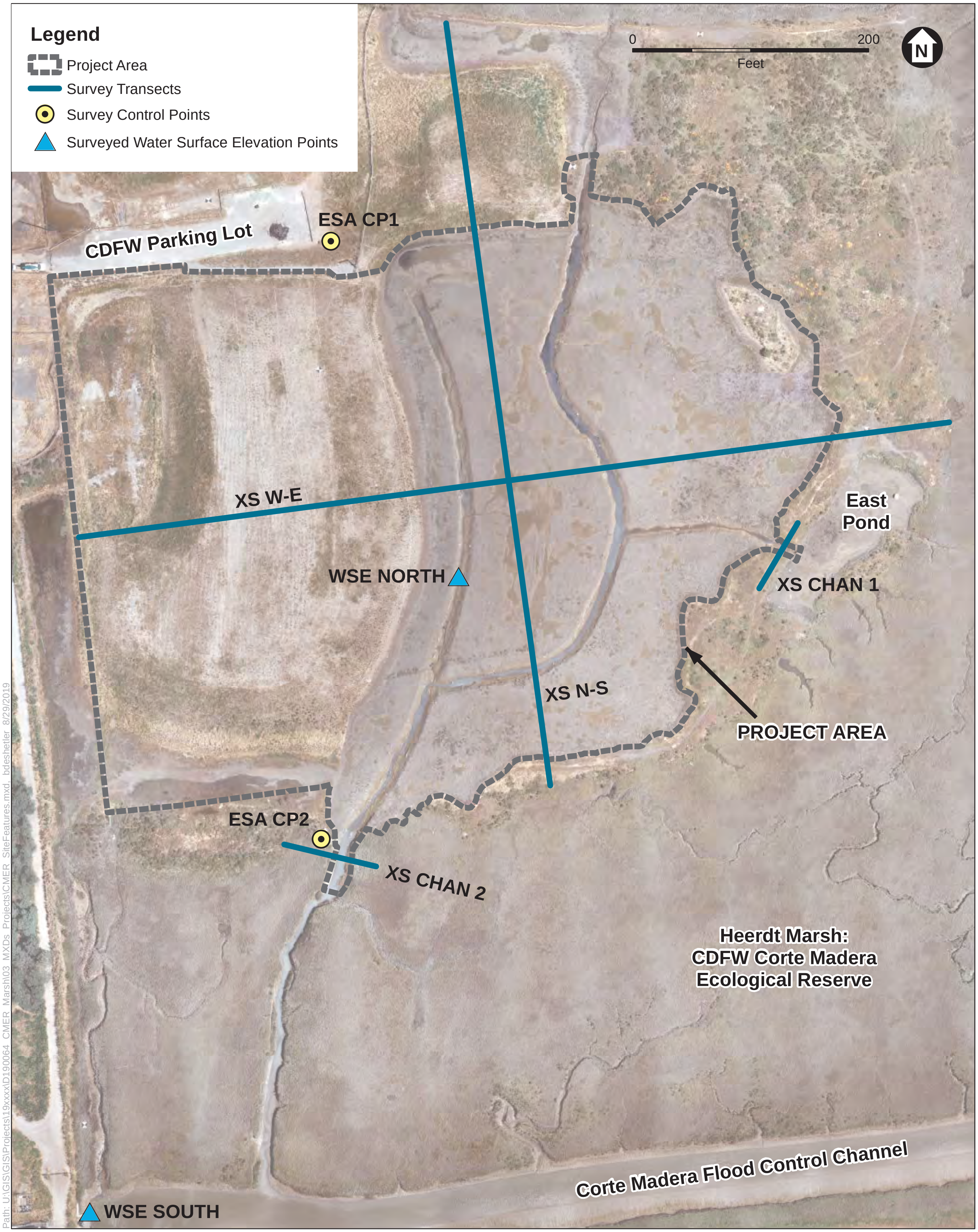
Project success criteria metrics were developed through permits and water quality certifications under the U.S. Army Corps of Engineers (USACE), Bay Conservation and Development Commission (BCDC) and San Francisco Bay Regional Water Quality Control Board (RWQCB). These criteria were largely developed from a pre-restoration monitoring plan (Monitoring Plan) written by Siegel Environmental in 2017. The criteria aim to track the development of the marsh towards target conditions (**Table 1-1**).

SOURCE: ESRI

CMER Marsh Expansion Monitoring. D190064.00

Figure 1
Project Vicinity

ESA



SOURCE: ESA (2019)

CMER Marsh Expansion Monitoring. D190064.00

Figure 2
Site Features

ESA

TABLE 1-1
PROJECT SUCCESS CRITERIA

Monitoring Parameter	Performance Expectations
Intertidal Marsh Elevations	Intertidal marsh elevations are restored to 0.5 feet below local mean high water, at conclusion of construction.
Tidal Marsh Sedimentation	Natural sedimentation deposits at least 0.5 feet of sediment within the tidal marsh restoration footprint, by Year 5.
Tidal Water Levels	Tidal water levels fill and drain the restoration area in alignment with tides in the adjacent tidal waterways, at conclusion of construction and going forward.
Native Tidal Marsh Vegetation	Native tidal marsh vegetation naturally colonizes and establishes within the restored tidal marsh to at least 50% cover, by Year 5.
Native Tidal Marsh Vegetation	Native transition zone and upland establishes within the restored transition zone to comprise at least 50% cover, by Year 5.

For this Year 1 monitoring report, geomorphic and hydrologic monitoring elements such as marsh elevations, marsh sedimentation, and tidal water levels was conducted by ESA. The vegetation monitoring elements were conducted through a partnership between The Watershed Nursery (TWN) and ESA. ESA conducted remote sensing techniques from aerial images and TWN conducted a series of vegetation transects and collected ground truthing points to verify the remote sensing accuracy. The TWN report was then incorporated into this Year 1 monitoring report in order to maintain one cohesive monitoring report. This monitoring report describes the methods and results of the 2019 monitoring activities at the CMER Marsh Expansion site and describes the project progress toward meeting stated performance targets for Year 1.

2. Methods

This section describes methodologies used to collect and analyze geomorphic, hydrologic, and vegetation establishment data for the 2019 (Year 1) monitoring year. **Table 2-1** outlines the schedule of monitoring elements for each monitoring year, as presented in the Monitoring Plan. The inundation task was conducted differently than the Monitoring Plan called for, with permission for the change in approach approved by the RWQCB prior to completing the work.

TABLE 2-1
CMER MARSH EXPANSION: SCHEDULE OF MONITORING ELEMENTS

Physical Processes Monitoring	
1. Topographic transects	Years 1, 5
2. Inundation surveys	Years 1, 3, 5
3. Erosion	Years 1, 3
Vegetation	
1. Aerial photographs	Years 1, 3, 5
2. Aerial photograph ground-truthing	Years 1, 3, 5
3. Vegetation Transects	Years 1, 3, 5
Fixed Ground Photo Monitoring	Years 1, 3, 5
Reporting	Years 1, 3, 5

2.1 Physical Processes Monitoring Methods

Physical processes monitoring during Year 1 includes topographic survey transects, inundation (water level) measurements, and erosion monitoring.

All topographic survey data was surveyed with Leica Viva GS08plus Real-Time Kinematic GPS (RTK-GPS) rover units receiving real-time corrections through the Leica SmartNet base station network. All horizontal data coordinates are provided in NAD83 State Plane Zone 3 feet (Epoch 2010.00), and vertical coordinates are provided in NAVD88 feet (Geoid 12b).

2.1.1 Topographic Survey Transects

ESA surveyed a total of four transects in order to evaluate marsh plain accretion and tidal channel development within the site (**Figure 2**). The two largest transects run perpendicular across the site end-to-end. Transect XS-WE runs west to east beginning at the western fence line and ending at the eastern site boundary. The transect crosses over an upland region of site plantings and across two tidal channels that extend into the restored marsh plain. Transect XS-NS runs north to south, beginning at the MAS restored tidal channel north of the site, and ending at the southern site boundary. Two shorter transects, XS-CHAN 1 and XS-CHAN 2 both aim to track development of the tidal channels near the project boundary. XS-CHAN 1 runs across the channel that drains into east pond area and XS-CHAN 2 runs across the entrance to the main tidal channel to the South.

ESA established two (2) project control points, ESA CP1 and ESA CP2, for future quality control efforts. They are located in the CDFW parking lot and adjacent to Cross-Section Channel 2, respectively. Coordinates are provided relative to the Leica SmartNet RTK GPS base station network.

TABLE 2-2
SURVEY CONTROL ESTABLISHED

CP #	Northing	Easting	Elevation	Description
ESA CP1	5981555.32	2170521.13	7.27	Rebar with cap
ESA CP2	5981547.24	2170014.47	7.62	Rebar with cap

Surveys were completed on-foot at low tide using an RTK-GPS rover attached to a traditional fixed-height survey rod. Special care was taken to survey all the developing channels that crossed the transects. Data was post-processed and quality control checked as per ESA protocol.

2.1.2 Inundation Monitoring

Water depth observations were performed with two RTK-GPS rover units simultaneously measuring water surface elevations both within the interior of the site and within the Corte Madera Flood Control Channel to the south of the site. Water surface elevations were measured three times and captured both during flood tide and during ebb tide.

2.1.3 Erosion Monitoring

Erosion monitoring was done in conjunction with topographic transect surveying. Special care was taken when surveying the tidal channels to capture signs of geomorphic erosion such as high tide marks and slump blocks. Photographs were also taken to document any signs of channel degradation.

2.2 Vegetation Monitoring Methods

The vegetation monitoring methods conducted during Year 1 include aerial photography, remote sensing mapping of marsh vegetation to identify percent cover and native vs non-native species, ground truth surveys guide classifications, and vegetation transects. Vegetation transects were only conducted in the transition/upland zone, while the remote sensing and aerial photography encompassed the entirety of the site.

The tidal portion of the project is expected to vegetate through natural recruitment. The transition/upland zone, however, has limited native propagule input and high non-native invasive pressure leading MAS to contract for the production of a final total of 18,201 site-specific plants; 3001 installed in January 2018 and 15,200 installed in December 2018 (The Watershed Nursery, 2019). **Table 2-3** and **Table 2-4** show the species, size and quantity of these plantings.

TABLE 2-3
MAS CORTE MADERA JANUARY 2018 INSTALLED CONTAINER PLANTS:

Species	Size	Qty
Achillea millefolium	D16	300
Ambrosia psilostachya	D16	125
Artemesia californica	D40	160
Baccharis pilularis	D40	160
Elymus triticoides	SC	711
Euthamia occidentalis	D16	125
Grindelia stricta	D40	50
Juncus patens	D16	300
Mimulus aurantiacus	D40	120
Stipa pulchra	SC	950
Totals		**3001**

TABLE 2-4
MAS CORTE MADERA DECEMBER 2018 INSTALLED CONTAINER PLANTS:

Species	Size	Qty
Achillea millefolium	D16	1500
Ambrosia psilostachya	D16	1450
Artemesia californica	D16	1000
Baccharis pilularis	D16	1200
Elymus triticoides	SC	3000
Euthamia occidentalis	D16	1450
Juncus patens	D16	2000
Stipa pulchra	SC	3600
Totals		**15200**

The vegetation transects surveyed by The Watershed Nursey (TWN) were conducted specifically to monitor these upland plantings.

2.2.1 Aerial Photography

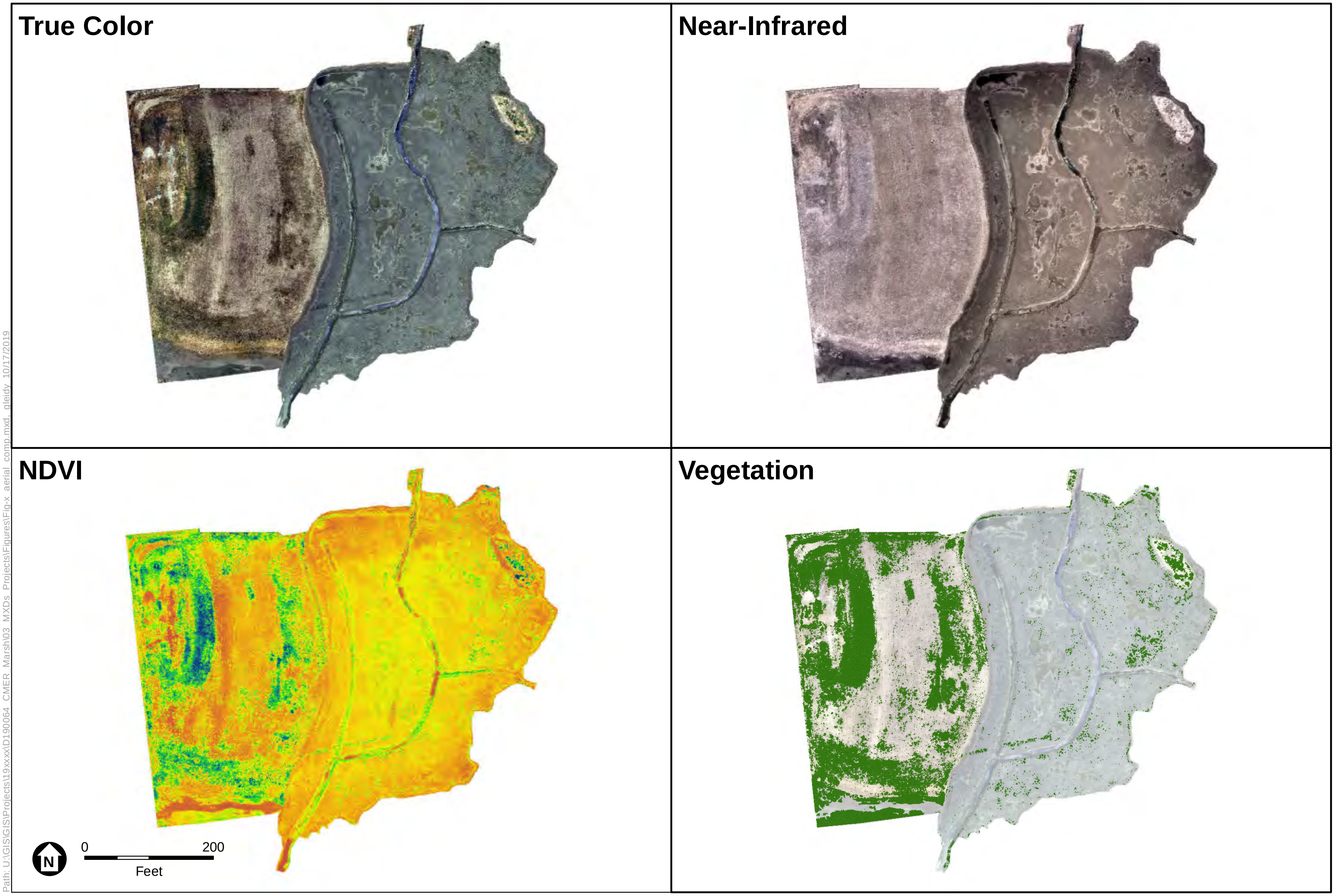
On June 20, 2019, a series of true color (RGB) and color infrared (CIR) aerial photographs (1.3 cm pixel resolution) of the CMER project site were taken between 11:30am and 12:30pm using a DJI Inspire 2 RGB camera as well as a Sentera Double 4K Sensor camera. Photographs were taken at low tide to capture exposed mudflat, tidal channels, and emergent vegetation. Year 1 photographs were taken at a tide height of approximately 1.1 feet MLLW and ortho-rectified to NAD83, California State Plane Zone 3, feet.

2.2.2 Vegetation Remote Mapping

Remote sensing was used to map the vegetated extent of the tidal and upland portions of the site. This was done to provide a holistic view of how vegetation succession is occurring within the restored site. The workflow for this analysis is shown in **Figure 3** and described below.

With the CIR imagery as input, an object based image analysis (OBIA) was performed using the open-sourced image-classification program Orfeo (v4.4) native to Quantum GIS (QGIS). CIR imagery is useful for mapping vegetation because the photosynthetic molecule chlorophyll reflects infrared wavelengths, creating a sharp visual signature. However, other photosynthetic organisms like cyanobacteria and algae also contain chlorophyll and can show similar signatures in CIR imagery. This is particularly true in tidal marsh sites where photosynthetic organisms are common in the expanses of mudflat, especially at low tides.

The first step in this process was to subdivide the imagery so that pixels with the same spectral signature were grouped together. This computationally-intensive process uses an algorithm to assign each pixel a numerical value based on the spectral signature of that pixel and the signature differential between pixels and their neighbors. This signature is based on the value of the infrared band contained within the imagery. A distance function is then used to spatially



SOURCE: ESA (2019)

CMER Marsh Expansion Monitoring. D190064.00

Figure 3
Remote Sensing Workflow

ESA

aggregate like-values (based on a set tolerance) into larger groupings (objects). These objects represent different land-cover types: open water, mudflat, dead/dormant vegetation, and active vegetation. Objects were then converted into an ESRI shapefile for classification. To classify each object into the landcover classes mentioned above, an NDVI map was generated from the CIR imagery. NDVI, or normalized difference vegetation index, is a metric commonly used to distinguish photosynthetically active objects from surrounding landcover classes. NDVI is derived from the relationship between visible and near-infrared light as reflected, or absorbed, by vegetation. Active vegetation absorbs most visible light that hits it, and reflects a large portion of infrared light. Whereas dormant, or sparse, vegetation reflects more visible light and less near-infrared light. Thus, by comparing the relationship between the absorbance of visible and infrared light it becomes easier to remotely distinguish between active vegetation and other landcover classes. The relationship between visible and infrared light, as reflected by the red and infrared bands of the CIR imagery, was used to develop an NDVI raster and map. Subsequently, the NDVI raster was used to classify each object into a landcover class.

To distinguish active vegetation from other land-cover types, an average NDVI value was extracted from the underlying NDVI raster for each object in the segmented shapefile. Once each object was assigned an NDVI value all objects without a signature suggesting the presence of active vegetation were screened from the dataset.

Figure 4, which captures a series of native plantings in the upland portion of the site, supports the use of a photosynthetically active signature as a positive indicator of native vegetation. As shown below, it is clear that the installed native vegetation displays a distinct, photosynthetically active signature, which is clearly delineated from the surrounding bare earth and dormant vegetation. It was therefore determined that this signature was the best metric for mapping the establishment and spread of the planted native vegetation within the site.

2.2.3 Vegetation Ground Surveys

In support of the aerial imagery analysis, ground-truthing was conducted by TWN in order to help characterize the plant community at three locations within the site (**Figure 5**). ESA provided TWN with both GPS coordinates and detailed aerial imagery for each of the three locations. On September 9th, 2019 TWN conducted a vegetation assessment of species present, native/non-native status, average species height and vigor, and relative percent cover within a 1m radius at each of the 3 points. Two of the points were selected at random from the upland portion of the site and one from the tidal area.

2.2.3 Vegetation Transects

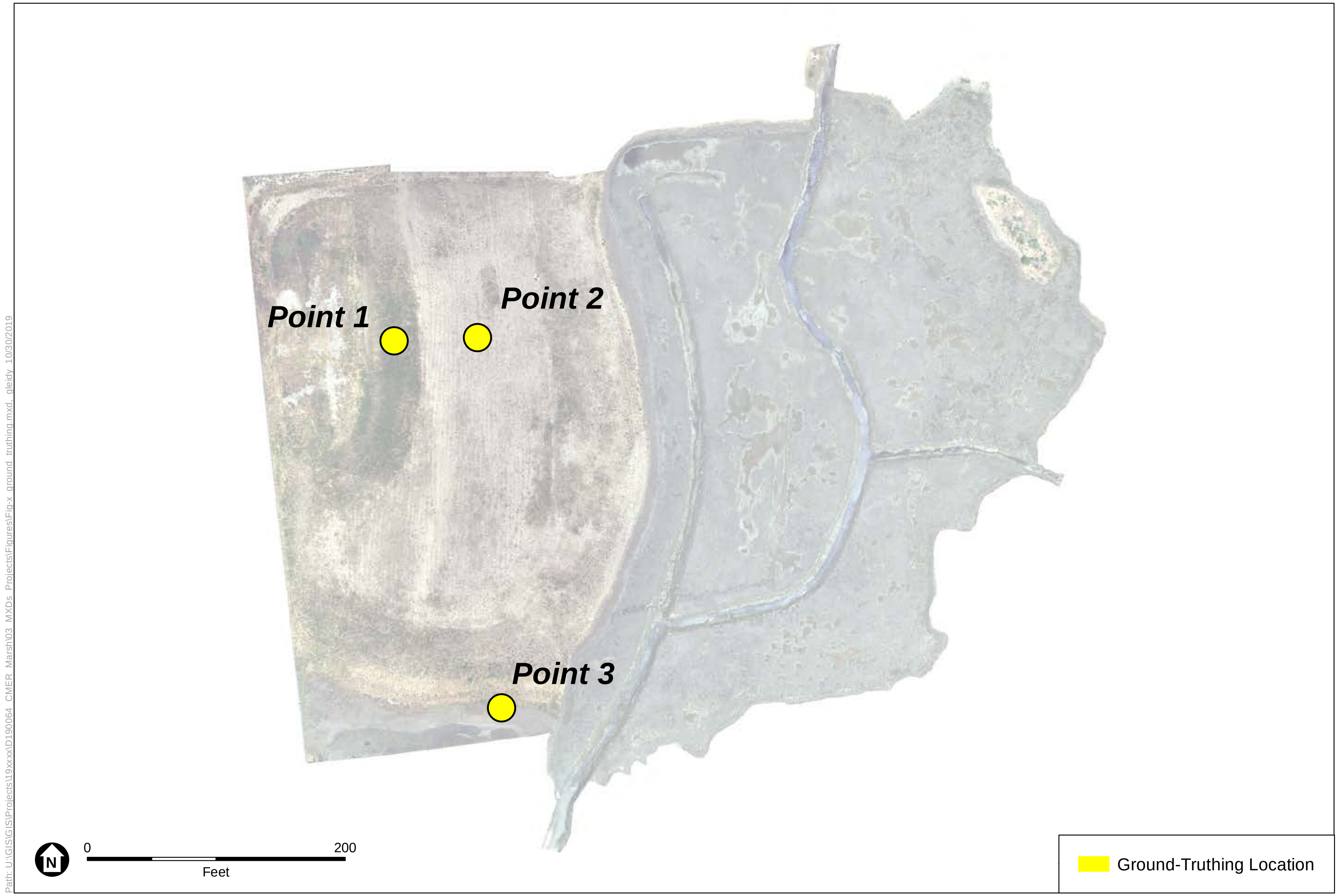
In July 2019 TWN conducted sampling along 8 randomly placed transects of 100’ length and recorded height and vigor of any installed native species within 3’ of transect line/ within. **Figure 6** shows the approximate locations of the 2019 transects. The total sampled area represents ~5% of the area of the restored transition and upland zones area of ~ 2.2 acres (The Watershed Nursery, 2019).

SOURCE: TWN (2019)

CMER Marsh Expansion Monitoring. D190064.00

Figure 4
Upland Native Plant Installations

ESA



SOURCE: ESA (2019)

CMER Marsh Expansion Monitoring. D190064.00

Figure 5
Ground-Truthing Locations

ESA

SOURCE: TWN (2019)

CMER Marsh Expansion Monitoring. D190064.00

ESA

Figure 6
Vegetation Transect
Approximate Locations

As noted in the initial TWN monitoring proposal, the Monitoring Plan outlines to record percent survival of planted material which would include monitoring all installed species which is not feasible with available resources and in light of there being no original planting plan to guide monitoring. The Monitoring Plan also includes language regarding "percent survival of naturally recruited vegetation" which would require mapping and on-going monitoring of natural recruits would also be unfeasible with available resources. Refuge islands and seasonal wetlands were not planted so attributes of these areas will be assessed through aerial imagery analysis. Due to these constraints no assessment of percent survival is included in the monitoring.

2.3 Photo Documentation Monitoring Methods

During Year 1 monitoring, ESA established three (3) photo benchmark locations (**Figure 7**). These photo benchmarks were established in specific locations to qualitatively monitor the development of constructed tidal channels, sedimentation, and vegetation establishment on the interior marsh plain. The photo benchmark locations were established from north to south with PBM 1 furthest to the north and PBM 3 furthest to the south. Both PBM 1 and 2 document the interior of the project site, while PBM 3 was established for reference just outside the project boundaries and to track the southern main channel development where it connects with the Corte Madera Flood Control Channel.

The photographic documentation technique used is based on the principals of re-photography, also known as repeat photography. This is a technique of landscape study where scenes are re-photographed at certain time intervals to determine the nature of long-term change.

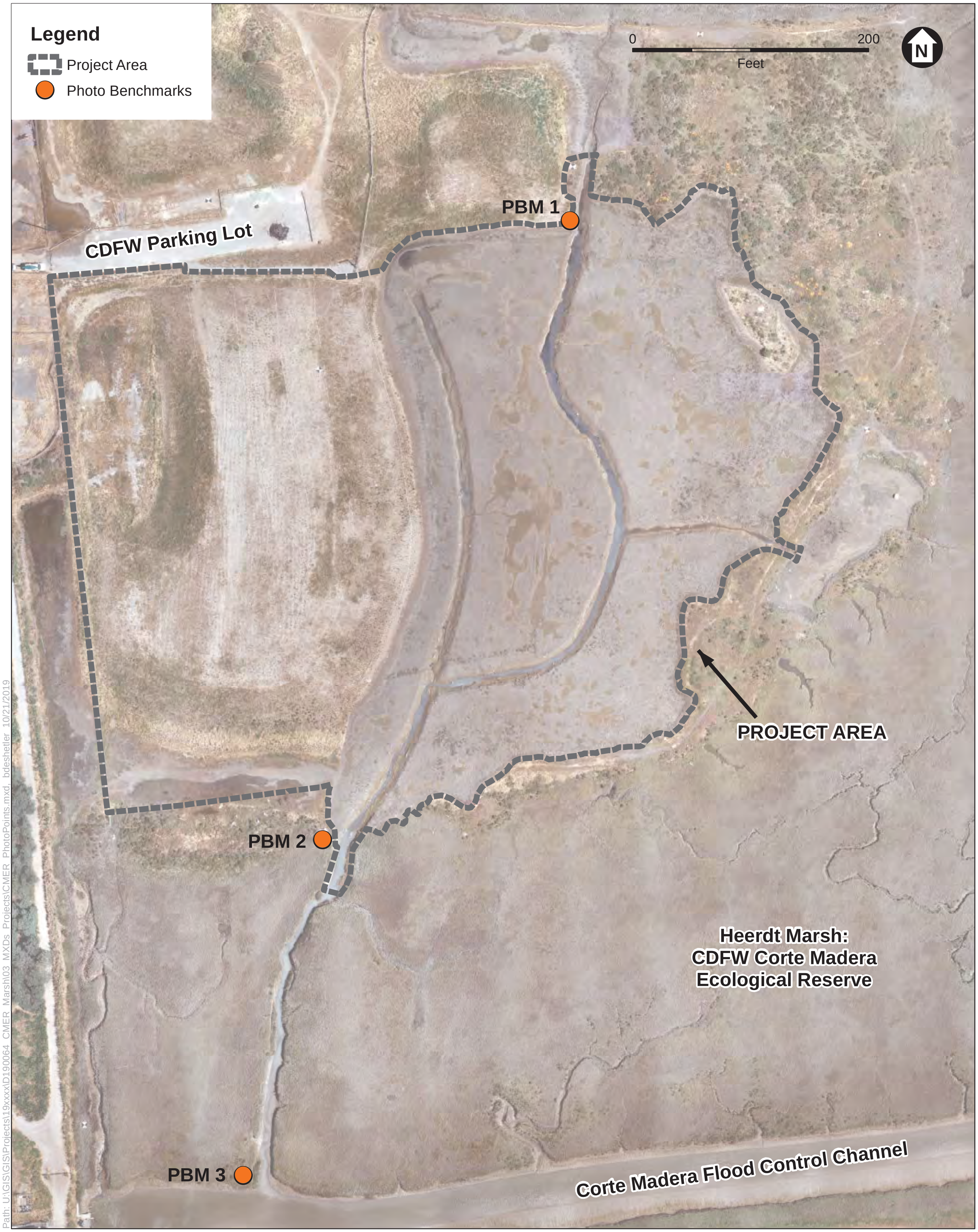
3. Results

3.1 Physical Processes Monitoring Results

The results of physical processes monitoring efforts can be found described below.

3.1.1 Topographic Transects

The marsh plain topography along transects XS-WE and XS-NS can be found in **Appendix A**. Transect XS-WE (**Appendix A-1**) runs west to east across the upland region and two tidal marsh channels and approximately 100 feet past the eastern site boundary. The transitional slope from the upland region down to the marsh plain can be seen sloping down at roughly a 9:1 slope, from approximately 15 ft NAVD down to 5 ft NAVD across 90 horizontal feet. Marsh plain begins at the eastern toe of that transitional slope at an elevation of approximately 5.3 ft NAVD. The two tidal channels are similar in depth with thalweg elevations of 2.6 and 2.4 ft NAVD from west to east, respectively. The eastern channel is approximately 10 feet wider than the western channel. The lowest part of the marsh plain along transect XS-WE is between the two tidal channels, which sits at an elevation of approximately 4.8 ft NAVD.



SOURCE: ESA (2019)

CMER Marsh Expansion Monitoring. D190064.00

Figure 7
Photo Points

ESA

Transect XS-NS (**Appendix A-2**) runs north to south beginning at the MAS restored tidal channel, crossing the pre-existing mounded high ground west of the 2015 PG&E Tidal Restoration, then crossing the graded and restored marsh plain, including one tidal marsh channel, and ending just beyond the southern project boundary. The transect extends 175 feet beyond the project boundary to the north and 22 feet in the south. The transitional slope from the high ground down to the restored marsh plain slopes down from approximately 12.4 ft NAVD down to 4.8 ft NAVD across 68 horizontal feet, roughly an 8.5:1 slope. The restored marsh plain begins at 4.8 ft NAVD at the eastern toe of that slope and remains relatively consistent in elevation until the tidal channel is reached. The tidal channel here is approximately 20 feet wide with a thalweg elevation of 2.2 ft NAVD. This makes the channel slightly deeper and narrower here than seen on the same stem in XS-WE.

XS-CHAN 1 (**Appendix A-3**) crosses the channel to the east pond. Year 1 surveys found the channel to be approximately 12 feet wide with a thalweg of 2.7 feet NAVD. The cross section location lies just outside the construction area of impact, and crosses through mature marsh on either side of the channel, thus the marsh plain elevations being higher in elevation then seen in XS-WE or XS-NS. XS-CHAN 2 (**Appendix A-4**) crosses the south connector channel, with a thalweg of 0.3 feet NAVD and a channel width of approximately 25 feet. A fallen slump block as a result of erosion of the adjacent marsh plain can be observed on the east bank, starting at a station distance of 60 feet along the distance axis of the profile.

As outlined in the Monitoring Plan, marsh plain elevations were to be excavated and graded to an elevation of 5.0 ft NAVD, or 0.5 feet below a local mean high water elevation of 5.5 ft NAVD. The survey data collected in Year 1 shows an average marsh plain elevation of 4.99 ft NAVD, narrowly satisfying the performance criteria located in Table 1-1. Average marsh plain elevation was calculated based on an average of all non-channel surveyed marsh plain elevations.

3.1.2 Inundation Monitoring

Water surface elevation data obtained for the Year 1 monitoring effort are presented in **Table 3-1**. Water surface elevations were measured simultaneously at WSE-North inboard of the site and at WSE-South in the Corte Madera Flood Control Channel three times on June 20, 2019. Measurements were taken at 1:09 p.m. and 2:13 p.m. Both measurements occurred during a rising (flood) tide, and the water surface elevations were identical at the inboard and outboard locations. A falling (ebb) tide measurement was surveyed on November 18, 2019, and like the flood tide measurements the water surface elevations surveyed were identical at both the inboard and outboard locations.

TABLE 3-1
WATER SURFACE ELEVATION MONITORING

			Water Surface Elevation (ft NAVD)	
Date	**Time**	**Tides**	**Inboard (WSE-North)**	**Outboard (WSE-South)**
6/20/2019	1:09 PM	Flood	3.2	3.2
	2:13 PM	Flood	4.3	4.3
11/18/2019	7:56 AM	Ebb	4.7	4.7

These inundation monitoring results indicate that both the filling and draining of the site are in alignment with tides in the adjacent tidal waterways, satisfying success criteria permit conditions presented in the Monitoring Plan.

3.1.3 Erosion Monitoring

Evidence of channel erosion was noted in XS-CHAN 1 and XS-CHAN 2 and can be seen in **Table 3-2**. Both channels have experienced scour and some scarping as they are beginning to widen in response to increased tidal prism within the site interior. The slump block located on the eastern bank of XS-CHAN 2, seen in Figure A-3 and formed as a result of channel widening, can also be seen in the table below.

TABLE 3-2
EROSION MONITORING PHOTOGRAPHS

 XS-CHAN 1 - Slope erosion and undercut banks, looking Southwest at south bank	 XS-CHAN 1 – bank erosion in areas of higher marsh plain, looking West
 XS-CHAN 2 – evidence of erosion near the high tide line below pickleweed on northwest bank of channel, looking West	 XS-CHAN 2 - fallen slump block on southeast bank of channel, looking South

3.2 Vegetation Monitoring Results

The results of vegetation monitoring, including both the remote sensing mapping as well as the ground surveys, can be found below.

3.2.1 Aerial Photography

Aerial images of the project site can be found in **Appendix B**. **Appendix B-1** presents true color (RGB) imagery and **Appendix B-2** shows color infrared (CIR) imagery.

3.2.2 Remote Sensing Mapping

Based on the methodologies described in section 2.2.2 of this report, the resulting vegetated extents, split by upland and tidal habitats, are shown below in **Table 3-3** and in **Figure 8**.

TABLE 3-3
CMER MAPPED VEGETATED EXTENT

Habitat	Acreage		Percent Cover
	Total	Vegetated	
Tidal	3.5	0.2	6.3
Upland	2.6	1.1	41.0

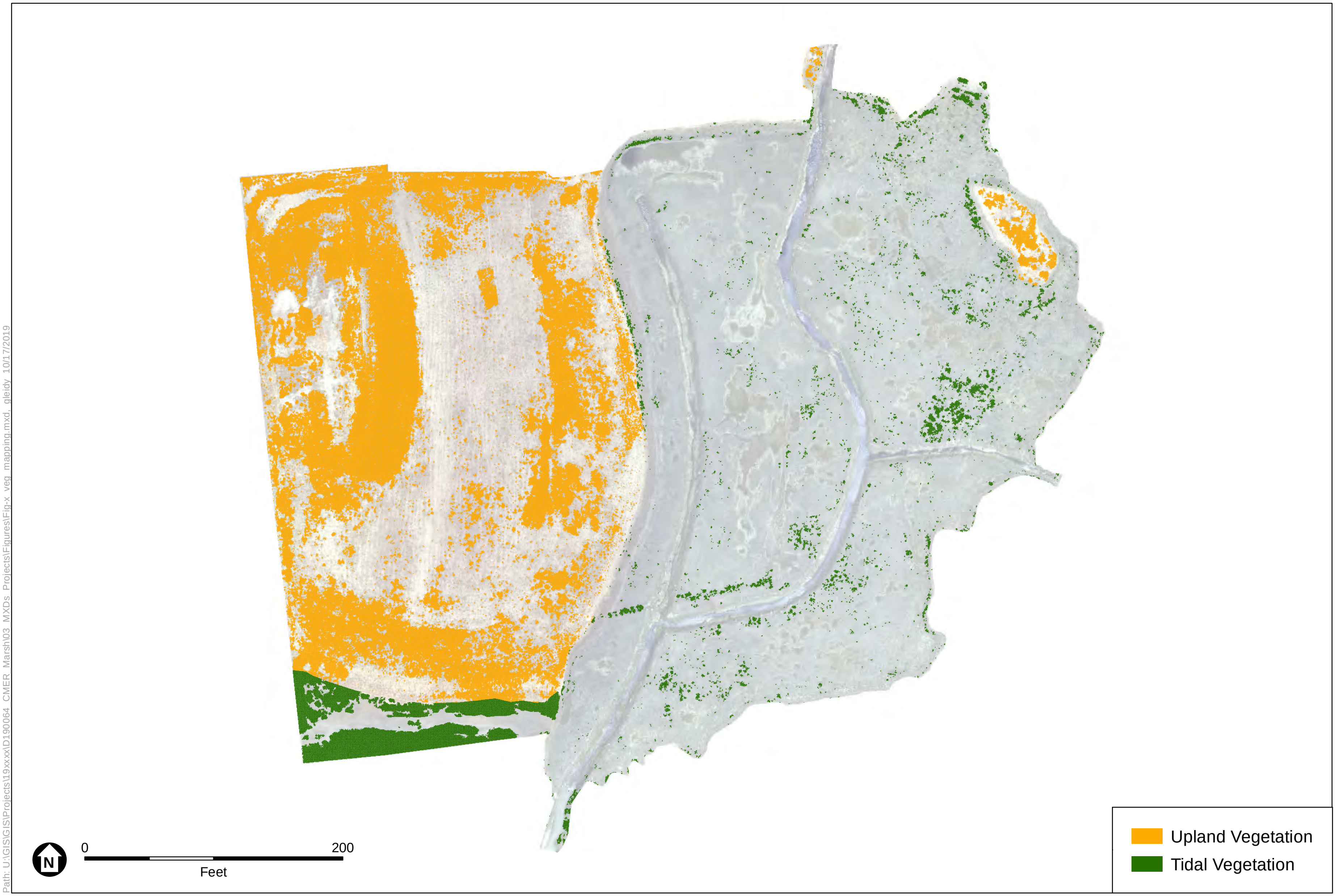
SOURCE: ESA 2019

Year 1 vegetation monitoring mapped a total of approximately 0.2 acres of native vegetation within the tidal portions of the site and 1.1 acres of native vegetation within the upland and transition areas. Overall, approximately 6.3 percent of the total tidal area was mapped as vegetated (primarily *Salicornia pacifica*) and approximately 41 percent of the upland and transition zone was covered by native vegetation.

Percent cover within the tidal portion of the site is well below the 50% benchmark for Year 5, but that is to be expected this early in the project timeline. Establishment of tidal vegetation is expected to be slower within tidal areas compared to upland portions, where 15,200 site-specific native plantings were installed in December 2018. As a result of the head-start provided by plantings, the upland portion of the project site is already quite close to achieving the 50% cover benchmark.

3.2.2 Vegetation Ground Surveys

The vegetation results from the ground-truthing conducted by TWN are shown in **Table 3-4**.



SOURCE: ESA (2019)

CMER Marsh Expansion Monitoring. D190064.00

Figure 8
Native Vegetation Extent
Monitoring Year 1 - 2019

ESA

TABLE 3-4
GROUND-TRUTHING VEGETATION MAPPING

Point #	Species	Relative Percent Cover (5-meter radius)	Average Height (cm)	Vigor	Native (N)/ Non-native (NN)
1	*Deinandra corymbosa*	~25%	80	Active	N
	Lotus corniculatus	~75%	30	Stressed	NN
	Achillea millefolium	<1%	25	Stable	N
	Rumex crispus	<1%	80	Stressed	NN
	Foeniculum vulgare	<1%	75	Stable	NN
2	*Salicornia pacifica*	~20%	20	Stable	N
	Limonium californicum	2%	20	Active	N
	Distichlis spicata	2%	20	Stable	N
	Frankenia salina	2%	15	Stable	N
	Polypogon monspeliensis	2%	10	Dead	NN
	Salsola soda	2%	20	Stable	NN
	Bare ground	~70%	NA		
3	*Ambrosia psilostachya*	1.5%	40	Active	N
	Achillea millefolium	1.5%	8	Stable	N
	Baccharis pilularis	1.5%	35	Stable	N
	Stipa pulchra	1.5%	5	Stable	N
	Lythium hyssopifolia	1.5%	5	Dead	NN
	Polypogon monspeliensis	1.5%	5	Dead	NN
	Lotus corniculatus	1.5%	5	Stable	NN
	Euthamia occidentalis	1.5%	90	Active	N
	Lysimachia arvensis	1.5%	5	Active	NN
	Rumex crispus	1.5%	5	Stable	NN
	Bare ground	~85%	NA		

SOURCE: The Watershed Nursery 2019

3.2.3 Vegetation Transects

TWN Vegetation Ecologist Diana Benner conducted transect monitoring of the Corte Madera site on July 19th and July 26th, 2019. An average GPS accuracy of 16.5 feet was observed during monitoring. Along each randomly placed transect height and vigor of species from installed species palette were recorded. It became clear during this monitoring event that the outplanted *Juncus patens* was a mixed lot of *J. patens* and *J. effusus*. These were grown from the same seed lot so were collected from the two species growing together at the same location in Marin county and not correctly separately during collection. Despite the *J. effuses* not being on original species list the species is not inappropriate and seems to be establishing well at the site.

The percent of plants of each species captured in the monitoring in the 8 transects compared to the total amount outplanted is shown in Table 1 and averaged 3.46% for all species. The count for the two Juncus species is merged for the percent captured calculation.

TABLE 3-5
PROPORTION OF OUTPLANTED MATERIAL CAPTURED IN TRANSECT MONITORING JULY 2019

Species	Count	Total # planted	% captured
Achillea millefolium	50	1500	3.33
Ambrosia psilostachya	80	1450	5.52
Artemisia californica	30	1000	3.00
Baccharis pilularis	64	1200	5.33
Elymus triticoides	70	3000	2.33
Euthamia occidentalis	93	1450	6.41
Juncus effusus	73	2000	3.65
Juncus patens	20		
Stipa pulchra	46	3600	1.28
Total	526	15200	3.46

The height and vigor averaged across the 8 transects for the installed species is given in Table 2. Vigor is assessed on a scale of 0 to 3 with 0 representing dead or missing material, 1= plant exhibiting signs of stress (may be from biotic or abiotic causes), 2= plant in stable state, 3= plant actively growing. Due to the varying phenology of the outplanted species it is expected that some species may be flowering at the time of monitoring while others may have already flowered and basically be in a summer ‘dormant’ state. This expected difference in phenology is accounted for in the vigor such that a plant in dormancy at expected timing is recorded as a ‘2’ stable, rather than ‘1’ stressed.

TABLE 3-6
AVERAGE HEIGHT AND VIGOR OF PLANTED MATERIAL JULY 2019

Species	Ave Height (cm) 2019	Ave Vigor 2019
Achillea millefolium	27	2.39
Ambrosia psilostachya	47	2.80
Artemisia californica	30	1.80
Baccharis pilularis	40	2.15
Elymus triticoides	81	2.45
Euthamia occidentalis	72	2.24
Juncus effusus	53	1.96
Juncus patens	32	2.49
Stipa pulchra	25	1.95

Overall the installed material appears to be establishing well. The only species for which dead/stressed individual plants were recorded was the California sagebrush (*Artemisia californica*). For all species average vigor was close to or above a stable ranking of 2.

The count recording for the purple needlegrass (*Stipa pulchra*) was probably negatively impacted overall by the timing of the monitoring as many individual plants had already flowered and dropped their inflorescences thus making their identification more challenging. TWN recommends shifting monitoring in Year 3 and Year 5 to earlier in the season to late June to facilitate capturing this earlier flowering and relatively low growing species.

Some of the marsh goldenrod (*Euthamia occidentalis*) were installed higher than ideal tidal elevation zone but still seemed to be establishing well on the site with all individuals recorded showing some sign of vegetative spread and most in bud. There was some evidence of insect infestation in this species in the form of tip leaves curled up around small caterpillars. This infestation may impact flowering and seed set this year but should not impair the establishment and vegetative spread of this species.

The majority of the recorded western ragweed (*Ambrosia psilostachya*) were exhibiting vegetative spread as well as beginning to flower. Many of the yarrow (*Achillea millefolium*) recorded had already flowered and set seed. The *Juncus patens* was further along in phenology cycle with more fully plants developing fruit whereas the *J. effuses* for the most part was still in a flowering phase.

MAS installed an irrigation system across the site and their efforts to water and control non-native species is clearly aiding the establishment of outplanted material. Many of the species were showing signs of vegetative spread in addition to flowering and seed set. The northeastern portion of site currently has more invasive pressure than the larger southern area. The main invasive species in this northeastern area are bristly oxtongue (*Helminthotheca echioides*) and Harding grass (*Phalaris aquatica*). Focused control of non-native invasive species in the initial years of establishment will be critical to ultimate successful establishment of outplanted species and achievement of the success criteria of at least 50% native cover by Year 5 (2023).

In addition to the outplanted material the site has well established populations of what keyed out to two annual tarweed species: coastal tarweed (*Deinandra corymbosa)* and common tarweed (*Centromadia pungens subsp. pungens)* which appear to have been present in the seed bank of the site (The Watershed Nursery, 2019). Photos of each different species can be found in **Appendix C**.

3.2.4 Maintenance Report

Per MAS president Barbara Salzman on 12/23/19, "Volunteer workdays are held monthly by MAS throughout the year. The volunteer work has focused on removing weeds, primarily Harding grass. Occasional work is done by volunteers between regularly scheduled days, including three additional volunteer days were held to remove bristly ox-tongue (one with volunteers from TWN). Plants were also irrigated five times during the summer and fall using the watering system Marin Audubon had installed."

3.3 Photo Documentation

Photo documentation plates from Year 1 monitoring are presented in **Appendix D** The restored marsh plain and excavated tidal channels are captured in PBM 1 and PBM 2. The majority of the restored marsh plain is exposed mudflat, lightly covered by emergent native pickleweed. Shallow depressions on the marsh plain hold water at low tide. The 2015 PG&E Tidal Restoration channel can be seen in PBM 1. The upland planted area is captured in PBM 1 and 2, with recent native plantings and irrigation infrastructure in place. The existing vegetated marsh plain of Heerdt Marsh is seen in PBM 2 and 3, with extensive pickleweed cover showing healthy vegetation establishment success at higher elevations. The Corte Madera Flood Control channel is shown in PBM 3, with banks currently vegetated with pickleweed. The location of WSE South can also be seen in the westward looking photo near the control structure.

4. Performance Expectations and Standards

Performance expectations were developed for several physical monitoring parameters in the Monitoring Plan for the restoration project (Siegel Environmental, 2017), including marsh plain elevations, tidal marsh sedimentation, tidal regime of the restored channels, and native tidal marsh vegetation. The progress of the restoration project on each of these parameters in 2019 is discussed in **Table 4-1** below.

TABLE 4-1
PHYSICAL MONITORING PERFORMANCE CRITERIA ASSESSMENT

Monitoring Parameter	Performance Expectations	Progress as of Year 1
Intertidal Marsh Elevations	Intertidal marsh elevations are restored to 0.5 feet below local mean high water, at conclusion of construction.	The average marsh elevation found in Year 1 monitoring is 4.99 ft NAVD. This performance criterion has been met.
Tidal Marsh Sedimentation	Natural sedimentation deposits at least 0.5 feet of sediment within the tidal marsh restoration footprint, by Year 5.	To be assessed in Year 5.
Tidal Water Levels	Tidal water levels fill and drain the restoration area in alignment with tides in the adjacent tidal waterways, at conclusion of construction and going forward.	Matching flood and ebb tide elevations suggest there is no tidal muting within the site. Based on these values, this performance criterion has been met.
Native Tidal Marsh Vegetation	Native tidal marsh vegetation naturally colonizes and establishes within the restored tidal marsh to at least 50% cover, by Year 5.	To be assessed in Year 5.

5. Conclusions/Recommendations

Overall the site is progressing well as of Year 1 monitoring. Topographic surveys show the site was constructed as intended, meeting performance expectations for intertidal marsh elevations. No tidal muting is occurring inside the site and tidal range is in line with expectations. It is still too early to determine any sedimentation trends within the marsh as well as determine marsh vegetation success, although the outlook for vegetation succession appears positive.

Since this is the first year of physical monitoring since construction, recommendations are limited for the geomorphic aspects of the site. The erosion seen in XS-CHAN 1 and XS-CHAN 2 should be monitored closely in the following survey, but channel erosion and widening is an expected response as the channels work towards achieving equilibrium. For vegetation monitoring, it is recommended to shift future surveys to earlier in the season (late June) to facilitate capture of flowering and relatively low growing species.

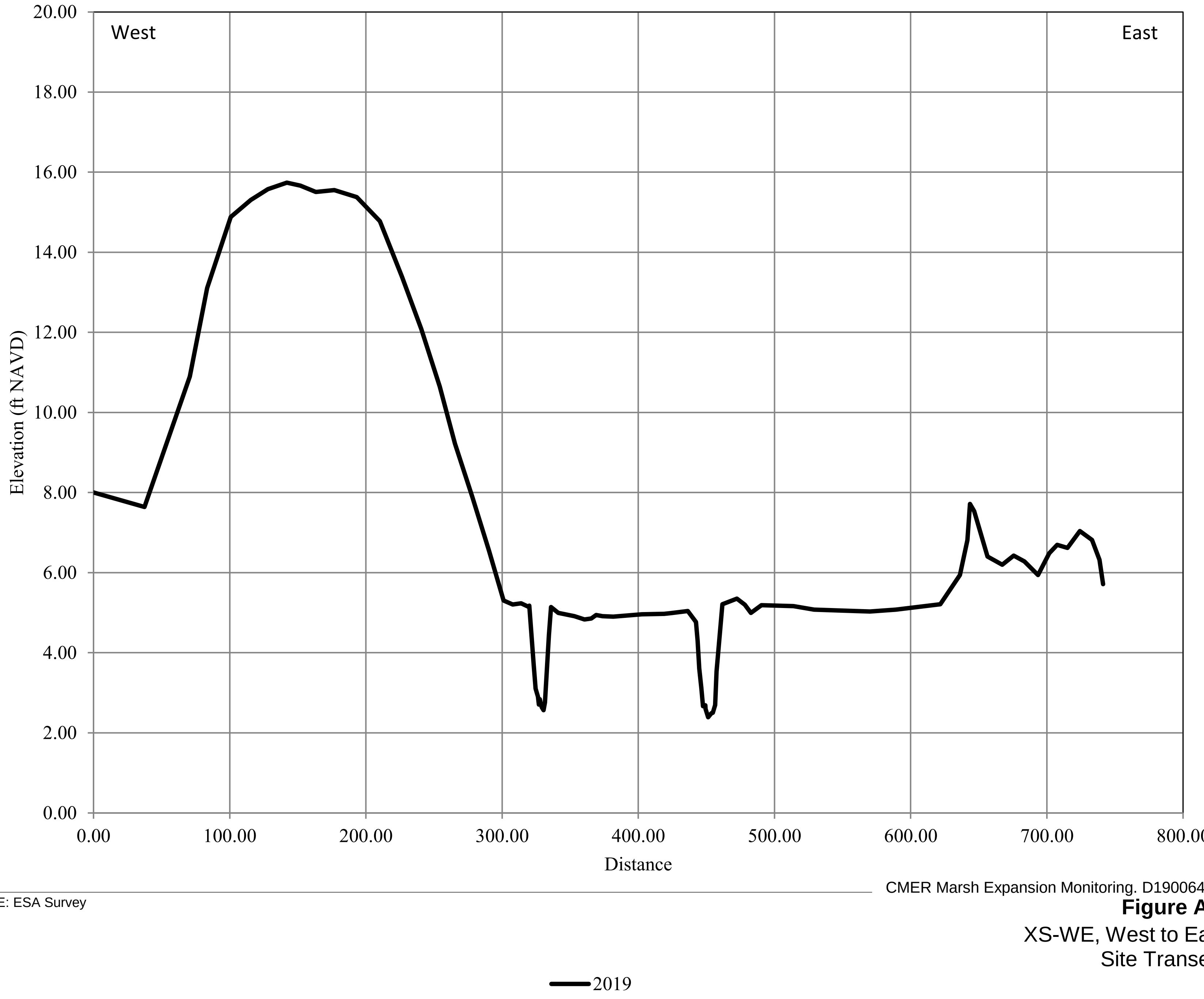
6. References

Siegel Environmental. 2017. *Corte Madera Ecological Reserve Expansion Project – Monitoring Plan*. Prepared for Marin Audubon Society.

The Watershed Nursery. 2019. *Marin Audubon Corte Madera Vegetation Transect Monitoring Report 2019, Year 1*. Prepared for Marin Audubon Society.

Appendix A.
Survey Profiles

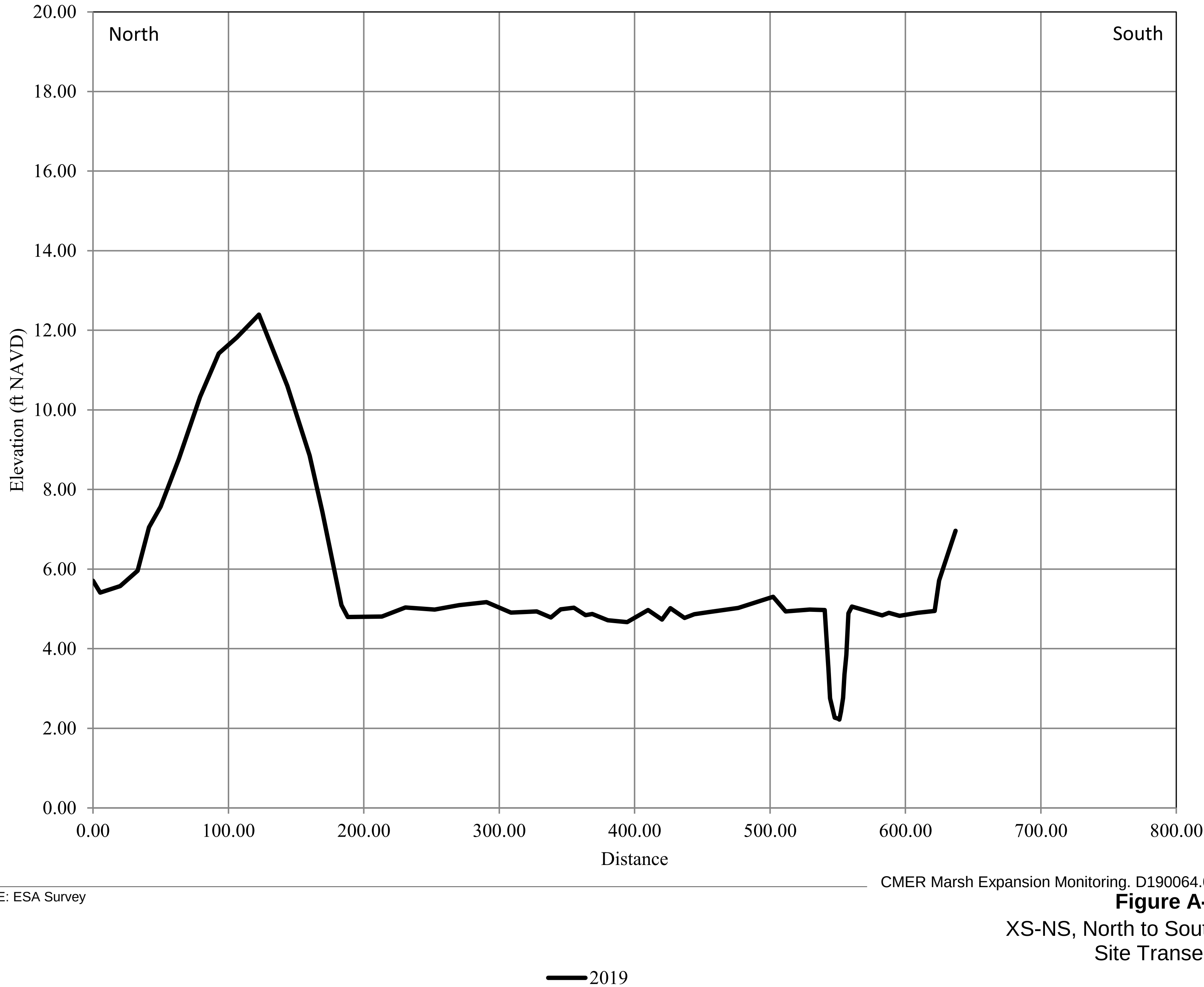
ESA



SOURCE: ESA Survey

CMER Marsh Expansion Monitoring. D190064.00

Figure A-1
XS-WE, West to East
Site Transect

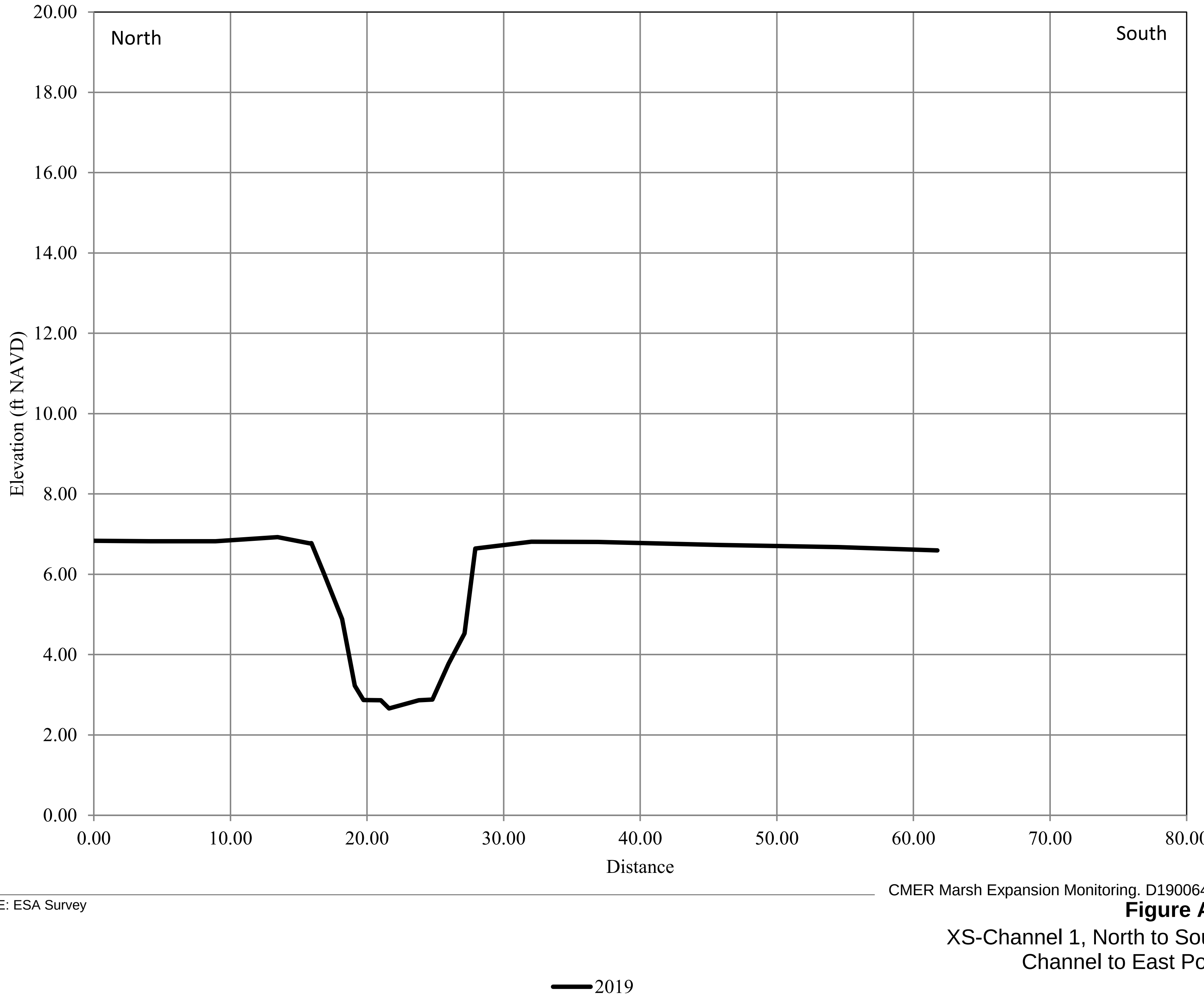


SOURCE: ESA Survey

CMER Marsh Expansion Monitoring. D190064.00

Figure A-2

XS-NS, North to South
Site Transect

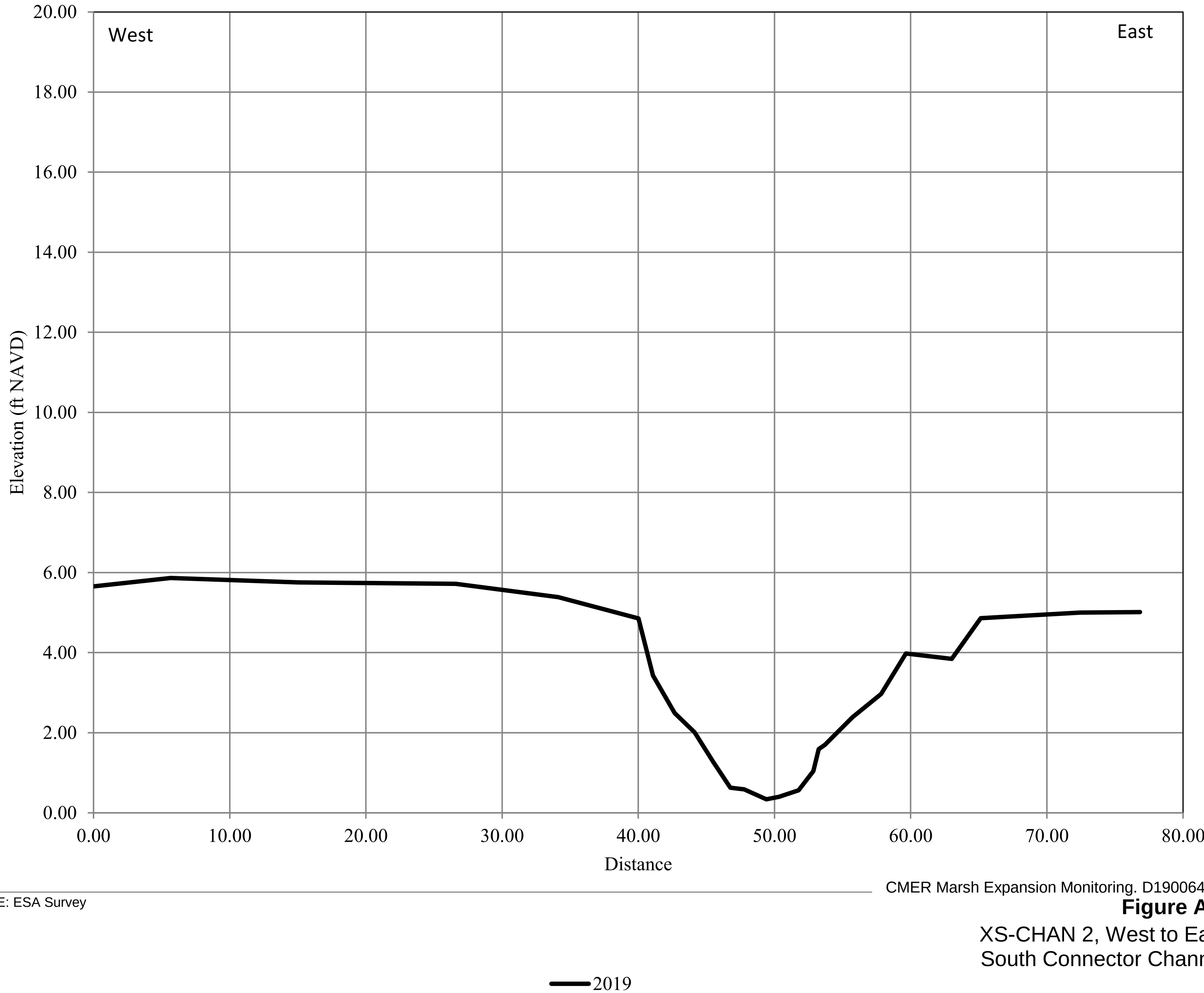


SOURCE: ESA Survey

CMER Marsh Expansion Monitoring. D190064.00

Figure A-3

XS-Channel 1, North to South
Channel to East Pond



SOURCE: ESA Survey

CMER Marsh Expansion Monitoring. D190064.00

Figure A-4

XS-CHAN 2, West to East
South Connector Channel

Appendix B.
Aerial Imagery

ESA

Image Date: 6/20/2019, 11:30am
Tide Level: 0.9 ft MLLW

SOURCE: ESA (2019)

Corte Madera Ecological Reserve Marsh Expansion Monitoring

Appendix B1
RGB Imagery
Monitoring Year 1 - 2019

ESA

Image Date: 6/20/2019, 11:55am
Tide Level: 1.1 ft MLLW

SOURCE: ESA (2019)

Corte Madera Ecological Reserve Marsh Expansion Monitoring

Appendix B2
NIR Imagery
Monitoring Year 1 - 2019

ESA

Appendix C.
The Watershed Nursery Photos

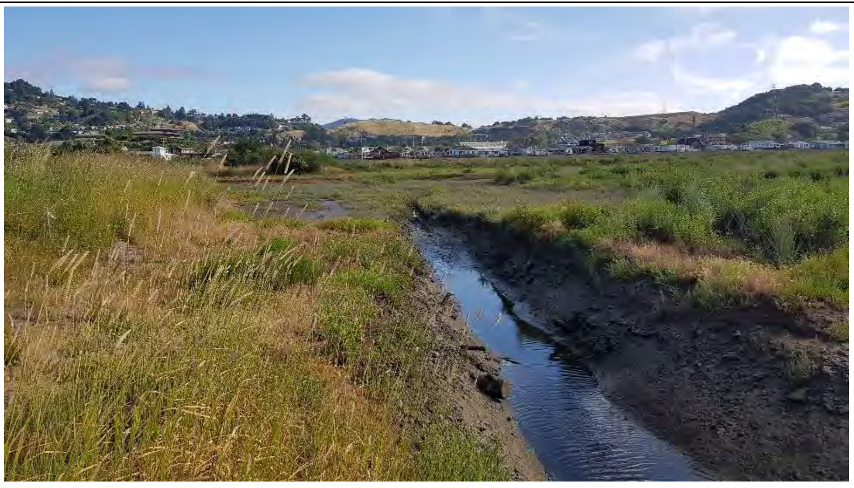
ESA

Transect 1	Transect 3	Transect 5
		
(37° 56’21.04, -122° 30’41.89”)	(37° 56’19.20, -122° 30’41.86”)	(37° 56’18.98, -122° 30’43.67”)
Sample Plant Species Photos		
		
Western ragweed (*Ambrosia psilostachya*)	Marsh goldenrod (*Euthamia occidentalis*)	Yarrow (*Achillea millefolium*)

Sample Plant Species Photos		
 California sagebrush (*Artemisia californica*) foreground, western ragweed behind	 Grey rush (*Juncus patens*)	 Common rush (*Juncus effuses*)
Sample Plant Species Photos		
	 Common tarweed (*Centromadia pungens subsp. pungens).*	

Appendix D.
Photo Documentation

ESA

PBM 1, Looking North	PBM 1, Looking East
 June 2019	 June 2019
PBM 1, Looking South	PBM 1, Looking West
 June 2019	 June 2019

PBM 2, Looking North	PBM 2, Looking East
 June 2019	 June 2019
PBM 2, Looking South	PBM 2, Looking West
 June 2019	 June 2019

PBM 3, Looking North	PBM 3, Looking East
 June 2019	 June 2019
PBM 3, Looking South	**PBM 3, Looking West**
 June 2019	 June 2019

Appendix E.
The Watershed Nursery Report

ESA

The Watershed Nursery
601-A Canal Blvd.
Richmond, Ca. 94804
(510) 234-2222 ph
(510) 234-2242 fx
www.thewatershednursery.com

Dec. 23, 2019

Marin Audubon Corte Madera Vegetation Transect Monitoring Report 2019, Year 1:

Project Description:
The purpose of the Corte Madera Ecological Reserve Expansion Project is to restore tidal marsh habitat and high tide refuge and sea level rise accommodation transition zone to benefit the endangered California Ridgeway's Rail and other resident and migratory species that depend on the tidal marsh. Project restoration activities including excavation, construction, and plant installation were conducted in 2018.

The tidal portion of the project is expected to vegetate through natural recruitment but for the transition/upland zone, with limited native propagule input and high non-native invasive pressure, MAS contracted for the production of a final total of 18,201 site-specific plants, 3001 installed in January 2018 and 15,200 installed in December 2018 (species lists below).

MAS Corte Madera January 2018 installed container plants:

Species	**Size**	**Qty**
Achillea millefolium	D16	300
Ambrosia psilostachya	D16	125
Artemesia californica	D40	160
Baccharis pilularis	D40	160
Elymus triticoides	SC	711
Euthamia occidentalis	D16	125
Grindelia stricta	D40	50
Juncus patens	D16	300
Mimulus aurantiacus	D40	120
Stipa pulchra	SC	950
Totals		3001

MAS Corte Madera December 2018 installed container plants:

Species	**Size**	**Qty**
Achillea millefolium	D16	1500
Ambrosia psilostachya	D16	1450
Artemisia californica	D16	1000
Baccharis pilularis	D16	1200
Elymus triticoides	SC	3000
Euthamia occidentalis	D16	1450
Juncus patens	D16	2000
Stipa pulchra	SC	3600
Total		15200

Project success criteria per Monitoring Plan, Corte Madera Ecological reserve Expansion Project dated Feb. 5, 2017 are:

1. Intertidal marsh elevations are restored to 0.5 feet below local mean highwater, at conclusion of construction.
2. Natural sedimentation deposits at least 0.5 feet of sediment within the tidal marsh restoration footprint, by Year 5.
3. Tidal water levels fill and drain the restoration area in alignment with tides in the adjacent tidal waterways, at conclusion of construction and going forward.
4. Native tidal marsh vegetation naturally colonizes and establishes within the restored tidal marsh to at least 50% cover, by year 5.
5. Native transition zone and upland establishes within the transition zone to comprise at least 50% cover, by Year 5.

Environmental Science Associates (ESA) will solely conduct monitoring relevant to success criteria 1-3. The Watershed Nursery (TWN) and ESA will conduct monitoring activities relevant to performance criteria 4-5.

To ascertain compliance with specified performance criteria in relation to vegetation the following monitoring has been outlined in the ‘Monitoring Plan Corte Madera Ecological reserve Expansion Project Final February 5, 2017’:

1. Aerial photography will be flown of the entire site conducted at construction completion and in years 1,3, and 5.
2. Ground truthing of aerial imagery in the field to document vegetation species composition, percent cover, attributes of condition (e.g., height), and percent survival of planted and naturally recruited vegetation in the restored tidal marsh, transition zone, refuge islands, and seasonal wetlands. Surveys will be timed appropriately to the target plant communities and conducted in years 1, 3, and 5.

Monitoring Methods:

Aerial Imagery Ground-Truthing:
For tidal marsh and upland/transition zone areas TWN coordinated with ESA to conduct ground truthing of aerial imagery. ESA provided TWN will specific points to navigate to with both gps coordinates and detailed aerial imagery. On September 9th, 2019 TWN conducted a vegetation assessment of species present, native/non-native status, average species height and vigor, and relative percent cover within a 1m radius relevee at each of the 3 points delineated. Ground-truthing data and photos intended to aid in informing imagery in regard to relative percent cover of native and non-native species within a particular imagery 'signal' were provided to ESA on Sept. 28th, 2019.

Establishment of Native Species within Transition and Upland Zones of Project:
In July 2019 TWN conducted sampling along 8 randomly placed transects of 100' length and recorded height and vigor of any installed native species within 3' of transect line/ within. The total sampled area represents ~5% of the area of the restored transition and upland zones area of ~ 2.2 acres.

As noted in the initial TWN monitoring proposal the 'Monitoring Plan Corte Madera Ecological reserve Expansion Project Final February 5, 2017' outlines to record percent survival of planted material which would include monitoring all installed species which is not feasible with available resources and in light of there being no original planting plan to guide monitoring. The monitoring plan also includes language regarding 'percent survival of naturally recruited vegetation' which would require mapping and on-going monitoring of natural recruits would also be unfeasible with available resources. Refuge islands and seasonal wetlands were not planted so attributes of these areas will be assessed through aerial imagery analysis. Due to these constraints no assessment of percent survival is included in the monitoring.

TWN will provide monitoring report including conclusions and recommendations to ESA for incorporation into the larger project site report.

Monitoring Results:

TWN Vegetation Ecologist Diana Benner conducted transect monitoring of the Corte Madera site on July 19th and 26th, 2019. The approximate location of transects is depicted in Figure 1. Accuracy of gps readings averaged 16.5'.

Figure 1: Approximate location of 2019 transects

Along each randomly placed transect height and vigor of species from installed species palette were recorded. It became clear during this monitoring event that the outplanted *Juncus patens* was a mixed lot of *J. patens* and *J. effusus*. These were grown from the same seed lot so were collected from the two species growing together at the same location in Marin county and not correctly separately during collection. Despite the *J. effuses* not being on original species list the species is not inappropriate and seems to be establishing well at the site.

The percent of plants of each species captured in the monitoring in the 8 transects compared to the total amount outplanted is shown in Table 1 and averaged 2.9% for all species. The count for the two Juncus species is merged for the percent captured calculation.

Table 1: Proportion of outplanted material captured in transect monitoring July 2019.

Species	**Count**	**Total # planted**	**% captured**
Achillea millefolium	50	1800	2.78
Ambrosia psilostachya	80	1575	5.08
Artemisia californica	30	1160	2.59
Baccharis pilularis	64	1360	4.71
Elymus triticoides	70	3711	1.89
Euthamia occidentalis	93	1575	5.90
Juncus effusus	73	2300	3.17
Juncus patens	20		
Mimulus aurantiacus	0	120	0.00
Stipa pulchra	46	4550	1.01
Total	526	18151	2.90

The height and vigor averaged across the 8 transects for the installed species is given in Table 2. Vigor is assessed on a scale of 0 to 3 with 0 representing dead or missing material, 1= plant exhibiting signs of stress (may be from biotic or abiotic causes), 2= plant in stable state, 3= plant actively growing. Due to the varying phenology of the outplanted species it is expected that some species may be flowering at the time of monitoring while others may have already flowered and basically be in a summer ‘dormant’ state. This expected difference in phenology is accounted for in the vigor such that a plant in dormancy at expected timing is recorded as a ‘2’ stable, rather than ‘1’ stressed.

Table 2: Average height and vigor of planted material July 2019.

Species	**Ave Height (cm) 2019**	**Ave Vigor 2019**
Achillea millefolium	27	2.4
Ambrosia psilostachya	47	2.8
Artemisia californica	30	1.8
Baccharis pilularis	40	2.2
Elymus triticoides	81	2.4
Euthamia occidentalis	72	2.2
Juncus effusus	53	2.0
Juncus patens	32	2.5
Mimus aurantiacus	0	0.0
Stipa pulchra	25	1.9

Conclusions/Recommendations:

Overall the installed material appears to be establishing well except for the *Mimulus aurantiacus* for which no individuals were observed. The only species for which dead/stressed individual plants were recorded was the California sagebrush (*Artemisia californica*). For all species besides the *Mimulus aurantiacus* the average vigor was close to or above a stable ranking of 2.

The count recording for the purple needlegrass (*Stipa pulchra*) was probably negatively impacted overall by the timing of the monitoring as many individual plants had already flowered and dropped their inflorescences thus making their identification more challenging. TWN recommends shifting monitoring in Year 3 and Year 5 to earlier in the season to late June to facilitate capturing this earlier flowering and relatively low growing species.

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MAS installed an irrigation system across the site and their efforts to water and control non-native species is clearly aiding the establishment of outplanted material. Many of the species were showing signs of vegetative spread in addition to flowering and seed set. The northeastern portion of site currently has more invasive pressure than the larger southern area. The main invasive species in this northeastern area are bristly oxtongue (*Helminthotheca echioides*) and Harding grass (*Phalaris aquatica*). Focused control of non-native invasive species in the initial years of establishment will be critical to ultimate successful establishment of outplanted species and achievement of the success criteria of at least 50% native cover by Year 5 (2023).

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Maintenance Report (per Barbara Salzman 12/23/19)

"Volunteer workdays are held monthly by MAS throughout the year. The volunteer work has focused on removing weeds, primarily Harding grass. Occasional work is done by volunteers between regularly scheduled days, including three additional volunteer days were held to remove bristly ox-tongue (one with volunteers from TWN). Plants were also irrigated five times during the summer and fall using the watering system Marin Audubon had installed."

Photos:

Sample Transect photos:

Transect 1 Transect 3 Transect 5
(37° 56’21.04, -122° 30’41.89”) (37° 56’19.20, -122° 30’41.86”) (37° 56’18.98, -122° 30’43.67”)

Species photos:

Western ragweed (*Ambrosia psilostachya*) Marsh goldenrod (*Euthamia occidentalis*)

Yarrow (*Achillea millefolium*)

California sagebrush (*Artemisia californica*) foreground, western ragweed behind.

Grey rush (*Juncus patens*)

Common rush (*Juncus effuses*)

Common tarweed (*Centromadia pungens subsp. pungens).*