North Campus Open Space Restoration Project

First Year Monitoring Report (2018)

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1. Introduction

The North Campus Open Space (NCOS) Restoration Project comprises 100 acres of a 136-acre site located northwest of the main UC Santa Barbara (UCSB) campus and bordered by UCSB's Coal Oil Point Reserve to the South, the City of Goleta's Ellwood Open Space Preserve to the West, and residential housing to the North and East. The project is restoring 40 acres of estuarine and palustrine wetlands that were historically part of Devereux Slough and were filled in the mid-1960s to create the Ocean Meadows golf course. Funded by federal, state and local agencies, the project's goals include flood reduction, wetland and upland habitat restoration, support for threatened and endangered species, public access and the provision of educational opportunities. Ancillary benefits of the project include carbon sequestration, preservation of local genotypes, protection of adjacent ecological values and infrastructure through a design that integrates sea level rise considerations.

The NCOS project began in February 2017 with the removal of most of the exotic trees on the former Ocean Meadows golf course. The grading and movement of soil on the site occurred from April to October 2017. This was followed by the construction of a multi-use trail, two bridges, and a boardwalk and culvert crossing that were completed in June 2018. Restoration planting of parts of the saltmarsh and the peripheral scrubland-grassland began in September 2017, and about one-third of the area of perennial grassland (the eastern portion) was drill-seeded with *Stipa pulchra* in October 2017. Restoration planting is expected to be completed by the year 2020, and most of the components of monitoring will continue through the year 2022. Figure 1 contains a map displaying the habitats/vegetation communities being restored, the as-built elevation contour lines (one-foot interval), and the trails, bridges and crossings.

This report describes the monitoring program, methods and protocols for the NCOS Project at the University of California, Santa Barbara. The report also includes a summary of the data collected for the first year of monitoring (September 2017 to October 2018) as an example of the types of data that are collected and the progress of the restoration project and monitoring program during the first year. The monitoring efforts described herein includes:

- landscape photo monitoring
- vegetation
- wildlife
- wetland topography, hydrology, and water quality
- sediment accretion and carbon sequestration
- public use

The as-built topography and some aspects of the hydrology are described in a separate report, portions of which are included in section 4 of this report. Data and related information about the project are being posted on the EcoAtlas website, and monitoring reports and associated data will also be posted and available through eScholarship and the CCBER website.

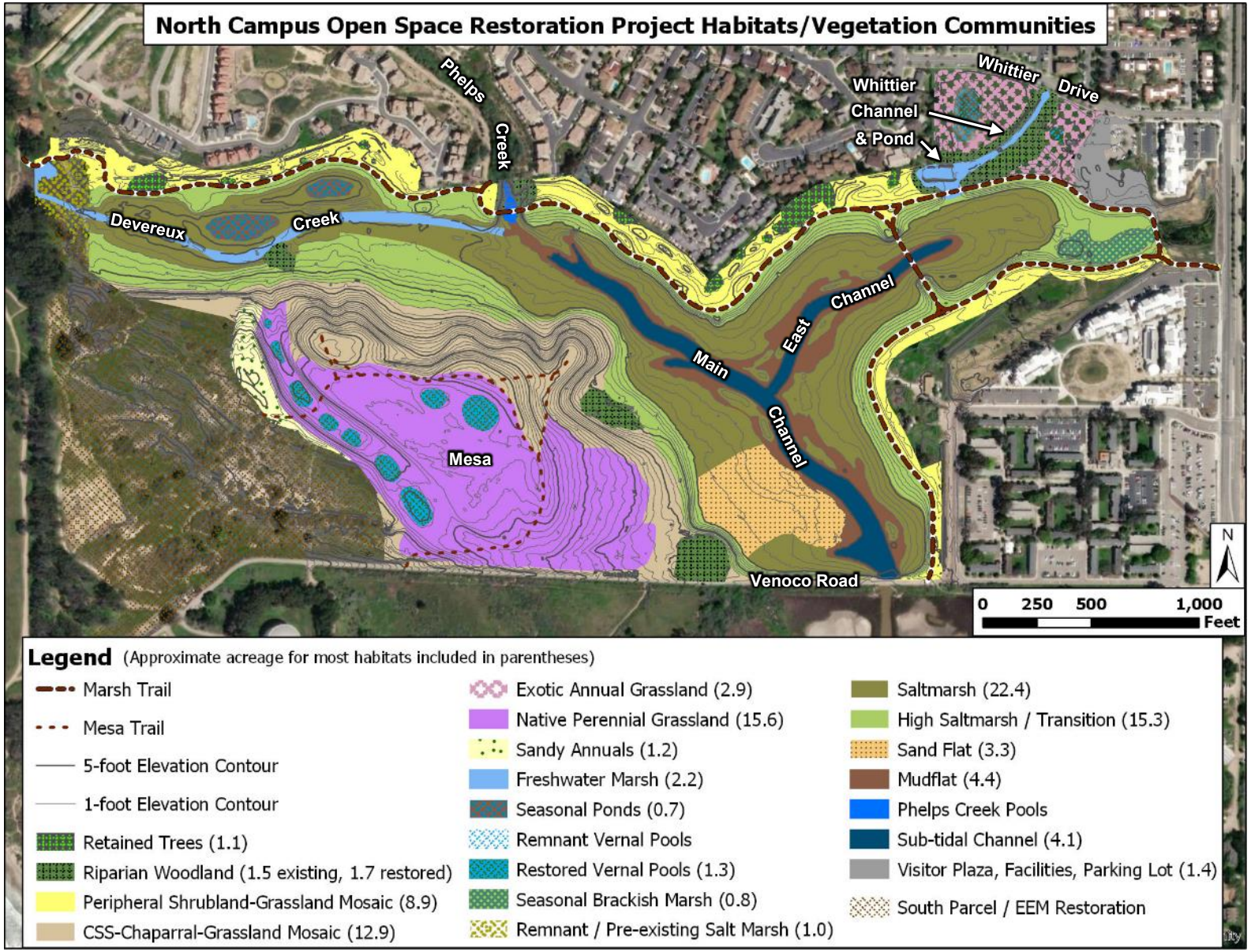


Figure 1. Map of the habitats/vegetation communities being restored at NCOS.

2. Landscape Photo Monitoring

Photo monitoring is the primary method for assessing landscape change over time. The photo monitoring of NCOS began in December 2016, prior to the start of the project, and is being conducted on a quarterly basis for at least the first two years of the project, then biannually for up to five years. One to six photographs are taken at 43 photo points distributed across the site, depending on what is required to capture all aspects of the site that are visible from each point (see Figure 2 for a map of the photo monitoring points). Photo point numbers with the letters ‘a’, ‘b’ and ‘c’ are where photos are taken of the same general area but from different views or angles. Photo point numbers with only a letter ‘b’ were relocated after the first or second round of photo monitoring in order to improve overall coverage of the project site.

Each photo is labeled with the photo point number, direction (N, SE, W, etc.), and the date the photo was taken. Appendix 1 contains a subset of photos from a selection of points (the points outlined in yellow on the map in Appendix 1), taken in October 2017, at the completion of the grading of the project site, and one year later in October 2018. The complete set of photos will be made available through the CCBER website.

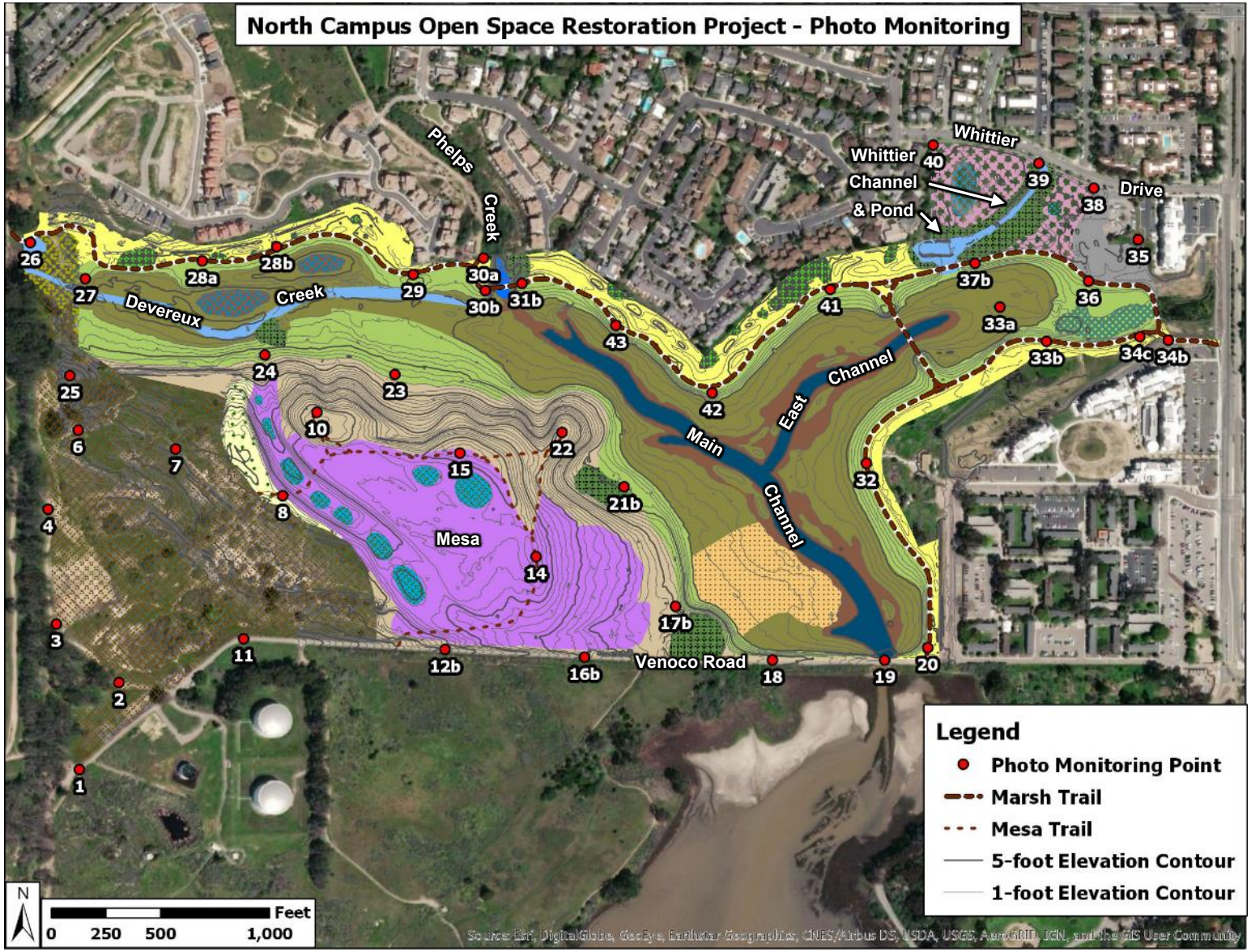


Figure 2. Map of the NCOS restoration project showing locations of photo monitoring points. See Figure 1 for a map and legend of the habitat/vegetation communities, and Appendix 1 for samples of photos.

3. Vegetation

The vegetation monitoring plan is outlined in Table 1, followed by descriptions of each method. The goal of this monitoring effort is to capture absolute and relative cover on the project site by species and by native/non-native category. Trees are monitored individually, low growing vegetation and wetlands are monitored with transects and quadrats (T&Q), and taller vegetation is monitored with point-intercept transects (PIT)

Table 1. Vegetation Monitoring Plan for the habitat/vegetation communities at NCOS. See Figure 1 for a map of the habitat/plant communities.

Habitat / Vegetation Community	Acres	Method	Survey Month	Number of Transects / Quadrats
Coastal Sage Scrub-Chaparral-Grassland Mosaic	12.9	PIT, Individual Trees	June/July	7 / 70
Perennial Grassland (primarily *Stipa pulchra*)	15.6	T&Q	July	8 / 80
Peripheral Scrubland-Grassland Mosaic	8.9	T&Q	June	7 / 70
Riparian Woodland - Existing	1.5	PIT	June/July	2
Riparian Woodland - Restored	1.7	PIT, Individual Trees	June/July	2 transects, ~ 140 trees
Saltmarsh – Remnant	1.0	T&Q	August	2 / 20
Saltmarsh at 6-8 and 8-10 feet in elevation, and Transitional/High Elevation Saltmarsh at 10-15 and 15-18 feet in elevation	37.7	T&Q	August	21 / 210
Sand Flat (Snowy Plover Habitat)	3.3	T&Q	September (post-plover breeding season)	2 / 20
Sandy Annuals	1.2	T&Q	June	1 /10
Seasonal Ponds: Existing Brackish Marsh & New Freshwater Pond	1.5	T&Q	July/August	2 / 20
Vernal Pools - Restored	1.3	T&Q	June	8 pools, 1 lengthwise transect with a minimum of 5 quadrats per pool, every other meter as necessary.

Vegetation Monitoring Methods

T&Q: Transect with Quadrats - Permanent transects that are typically 30 meters long with a one-square-meter quadrat placed every three meters, alternating between the left and right side of the transect tape. The length of transects and number of quadrats across vernal pools and seasonal ponds depend on the overall shape and extent of these habitats. Daubenmire cover classes are used to estimate the cover of each species in the quadrat. Also recorded are the percent of the quadrat that contains only bare ground, thatch, or other cover types such as erosion control netting, black plastic for weed control, mulch and/or algae.

PIT: Point-Intercept Transects – Along a 30-meter transect, the species that cross a point at every meter are recorded. This method is used for vegetation communities with larger growth forms, such as Coastal Sage Scrub (CSS), Chaparral, and Riparian Woodland. Vegetation is grouped into two, or when necessary, three height classes: above two meters (canopy), below two meters (sub-canopy) and less than 0.5 meter (ground cover). The point is represented by a two-meter tall, half-inch diameter wood dowel. A laser pointer is attached to the top of the dowel for extending the point through the canopy. When no vegetation crosses the point in the sub-canopy, other cover such as bare ground or thatch is recorded.

Individual Trees – All trees planted in the Restored Riparian Woodland and the CSS-Chaparral-Grassland Mosaic habitats are monitored annually by measuring the height and diameter at breast height (DBH) in inches, and assessing tree vigor using a rating scale of 1 to 4, where 1 = high vigor with new growth; 2= medium vigor with some stunting, yellowing, or less vigorous growth; 3= poor, appearing nearly dead or dying; and 4 = dead.

At the start of each monitoring season, all surveyors are trained and calibrated on cover estimation and species identification as part of the QA/QC program. Transect and quadrat data are recorded using the ESRI Survey123 app on tablets, and photographs of each transect are taken from the starting point.

Transect locations were established by generating a randomly-placed starting point using GIS. Points were kept a minimum of 60 meters apart and 10 meters from the edge of the habitat/plant community. A 90-square-meter grid was used to divide the larger habitats (Peripheral Mosaic, Perennial Grassland, CSS Mosaic, Saltmarsh, and the Sand Flat) into similarly sized sections, each separated by a 10-meter buffer, and the randomly-placed transect starting points were generated within these sections. This helped provide a more spatially-balanced distribution of monitoring transects in these larger habitats/plant communities. In addition, we stratified the Saltmarsh and Transitional/High Elevation Saltmarsh each into two elevation bands (6-8 and 8-10 feet for Saltmarsh; 10-15 and 15-18 feet for Transitional/High Elevation Saltmarsh) in order to more closely assess the differences that may occur in species composition and coverage with changes in elevation. The Transitional/High Elevation Saltmarsh in the 15-18 foot elevation band occurs where the water table is higher in the western arm of the wetland, on the south side of Devereux Creek (Figure 3).

In the field, the locations of some of the starting points were adjusted slightly if they landed on irrigation infrastructure, soil accretion or carbon sequestration monitoring plots, or other features

where disturbance should be avoided. The direction or bearing of transects was determined by a combination of factors: the distance of the starting point from the edge or boundary with adjacent habitats; the width of the habitat area around the point (if 30 meters or less, then the transect direction would be limited to run approximately parallel to the edges of the area); and if the transect would cross any features where disturbance should be avoided (e.g. sediment accretion or carbon sequestration monitoring plots). The start and end points of all transects are marked in the field with a labeled tag attached to a one-inch diameter PVC tube placed over rebar and protruding about one foot above-ground. A map of the vegetation monitoring transects is provided below in Figure 3.

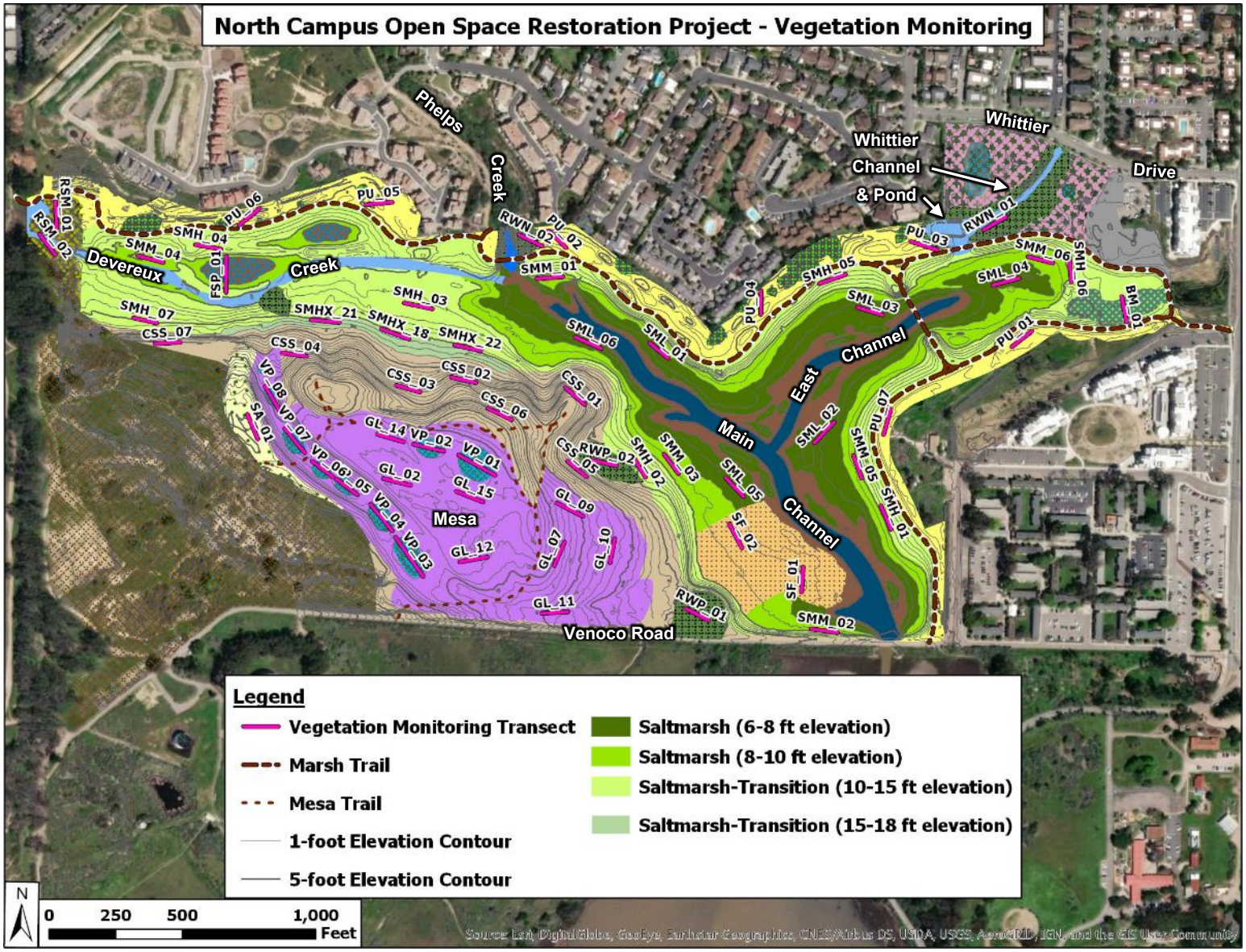


Figure 3. Map of the vegetation monitoring transects at NCOS, including the elevation bands for the Saltmarsh and Transitional/High Elevation Saltmarsh. See Figure 1 for a map and legend of the habitat/vegetation communities.

Year 1 Data

Over the first year of the project (September 2017 – October 2018), more than 150,000 native plants were installed across 40 acres, covering 75 percent of the Peripheral Scrubland-Grassland Mosaic and the Saltmarsh habitats. In December 2017, an inoculum containing seeds and dormant invertebrates from existing and adjacent vernal pools was spread in the eight vernal pools created on the Mesa area of NCOS (see Figure 1 for the locations of the vernal pools). In addition, throughout the winter and spring of 2018, grasses such as *Hordeum brachyantherum* ssp. *brachyantherum* and *Stipa pulchra* were planted along the margins and between the vernal pools. Approximately 25 percent (3.5 acres) of the Perennial Grassland habitat was drill seeded with *Stipa pulchra* in October 2017, and the remaining area was drill seeded in October 2018. More than 100 tree saplings were installed in the Restored Riparian Woodland along the Whittier Channel in the northeastern area of NCOS, and while no planting occurred in the other target habitats, a small number of native plants sprouted in many areas of the project site.

Bare ground was the dominant cover type recorded in nearly all monitoring transects, though not in the three remnant/pre-existing habitats (Remnant Saltmarsh, Brackish Marsh and Existing Riparian Woodland). A small amount of thatch resulting from a project-related application of sterile wheat hydromulch was recorded in a few transects, and other cover types such as erosion control netting, mulch and weed control plastic were recorded mainly in the Peripheral Scrubland-Grassland Mosaic and the Restored Vernal Pools. Figures of the vegetation monitoring data are included in Appendix 2 of this report.

Native vegetation cover of the Peripheral Scrubland-Grassland habitat averaged 11 percent overall, with 24 percent on average along the eastern portion. Non-native vegetation cover in this habitat averaged 14 percent overall and was mostly prevalent in the northwest (Figure A2.1). A total of 16 native species and 32 non-native species were recorded in this habitat (Figure A2.2).

Native vegetation cover in the Saltmarsh and Transitional/High Elevation Saltmarsh habitats averaged more than 15 percent overall in each of the three lower elevation bands, with greater coverage generally in the east, southeast, and southwest areas (Figures A2.3 to A2.5). Native cover was 50 percent in the north-central, low-elevation (6-8 feet) Saltmarsh, where we were able to plant earlier due to on-going construction in other areas (Figure A2.3). At the time of monitoring, no restoration planting had been conducted in the 15-18 foot elevation band of the Transitional/High Elevation Saltmarsh, resulting in only a few individual native plants being recorded and a greater coverage of non-natives than in the other Saltmarsh areas (Figures A2.6 and A2.8). In contrast, the small Remnant Saltmarsh area at the western end of NCOS has nearly 90 percent native vegetation cover (Figure A2.7). This area serves as a reference for the rest of the NCOS Saltmarsh. Native and non-native species diversity were lowest in the low elevation (6-8 feet) Saltmarsh and Remnant Saltmarsh, and increased in the mid-elevation (8-10 feet) and Transitional/High Elevation Saltmarsh (10-15 feet elevation, Figure A2.9).

The average native cover in the Perennial Grassland area that was drill seeded with *Stipa pulchra* in October 2017 is just over five percent, with slightly greater non-native coverage (Figure A2.10). The remaining two-thirds of the Grassland habitat had not yet been planted at the time of monitoring, and therefore had very low native coverage (Figure A2.11).

Bare ground and erosion control were the dominant cover types recorded in all vernal pools in the first year of monitoring. Native plant species cover was greatest in pools 3 and 4, and averaged over four percent overall (Figure A2.12). An average of eight native species were recorded in each pool, with an overall total of 17 different species recorded (Figure A2.13). The four most prevalent species encountered were *Eleocharis macrostachya*, *Hordeum brachyantherum* ssp. *brachyantherum*, *Baccharis pilularis,* and *Eryngium vaseyi.*

Since no planting occurred during the first year in the Brackish Marsh, Seasonal Pond, Sandy Annuals and Sand Flat habitats, the cover of these areas is primarily bare ground, except in the existing Brackish Marsh where native species cover dominated (Figures A2.14 and A2.15).

Restoration planting had not begun in the CSS-Chaparral-Grassland Mosaic community at the time of the point-intercept transect monitoring. Therefore, no canopy data were recorded, and only non-native and other, non-vegetative coverage (*e.g.* bare ground, mulch) were recorded for the sub-canopy (Figure A2.16). These results will serve as a baseline dataset for this habitat.

In the Restored Riparian Woodlands, though more than 100 tree saplings were planted along the Whittier Channel (Figure 4) before monitoring occurred, only one of these trees was recorded in the canopy of one transect (Figure A2.17). Table 2 below lists the number of each tree species planted and the mean height, DBH and vigor rating as of September 2018.

Table 2. Year 1 (2018) monitoring data for trees planted in the Restored Riparian Woodland along the Whittier Channel at the North Campus Open Space Restoration Project. See Figure 4 for a map of the locations where trees were planted.

Tree Species	Number Planted	Mean Height (inches)	Mean DBH (inches)	Mean Vigor Rating (1 to 4)
Arroyo Willow	5	95	0.4	1
Coast Live Oak	32	50	0.1	1
Fremont Cottonwood	12	96	0.5	2
Narrowleaf Willow	38	88	0.3	1
White Alder	8	120	1.2	1
California Sycamore	7	71	0.3	1
Overall	**102**	**79**	**0.4**	**1**

The two Remnant Riparian Woodlands exhibited quite different levels of native cover in both the canopy and sub-canopy (Figure A2.17 and A2.18), largely due to a clearing in one of the areas where the monitoring transect was established. We expect the native coverage in the clearing to increase as well as in the other riparian areas as restoration planting and weed control efforts continue.

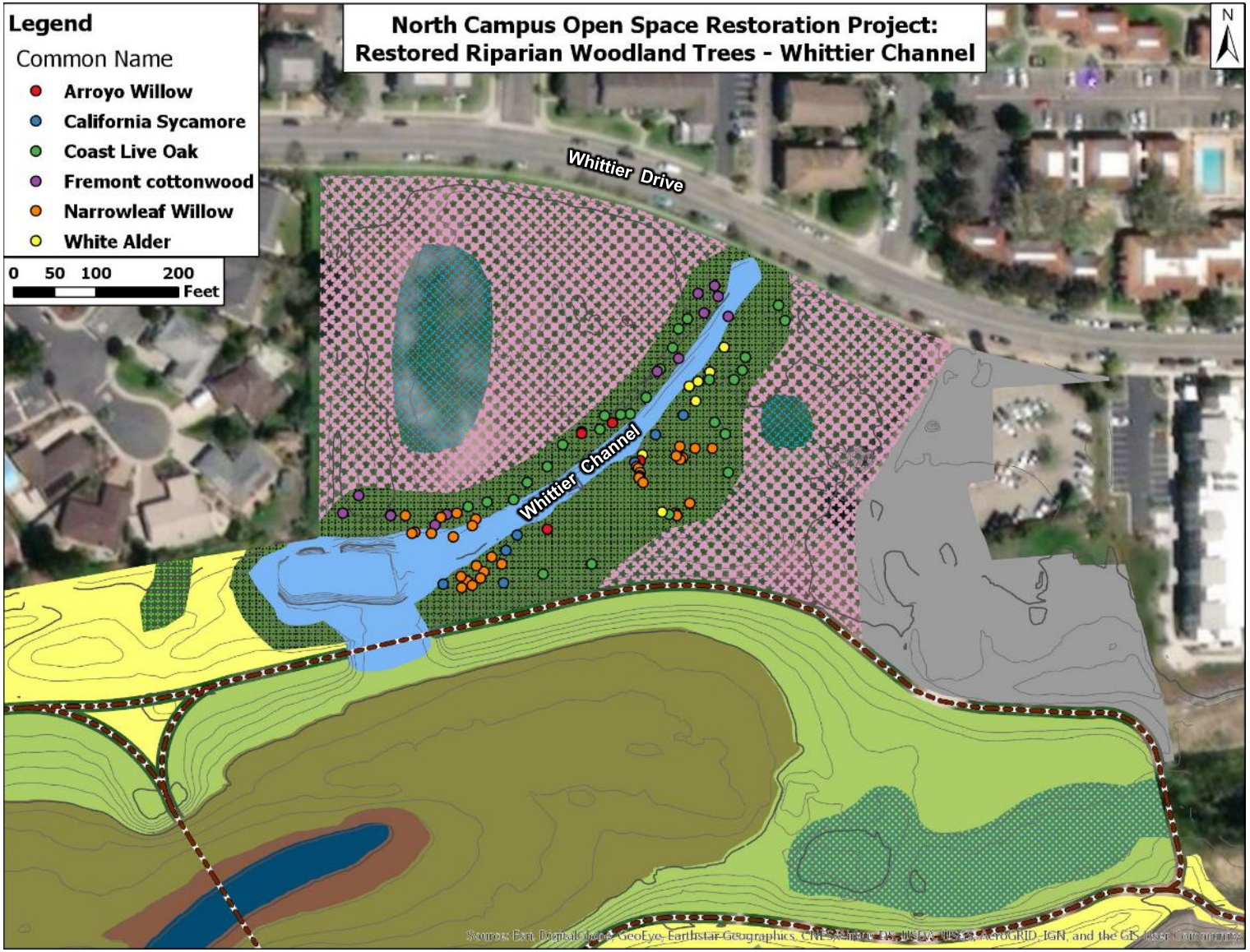


Figure 4. Map of the Whittier Channel Restored Riparian Woodland at NCOS showing the locations of six native tree species planted during the first year of the restoration project. See Table 2 for Year 1 (2018) monitoring data for these trees.

4. Wildlife

Wildlife monitoring efforts include monthly bird surveys; annual targeted surveys for three special status species: the Tidewater Goby (federally endangered), the California Red-legged Frog (federally threatened), and the Western Pond Turtle (federal protection status under review; California Species of Special Concern); and studies of terrestrial and aquatic arthropods.

Birds Surveys: Monthly bird surveys at the project site began in September 2017. The surveys are conducted in the morning, beginning within one hour of sunrise, and are typically 2.5 hours in duration. Beginning at the Venoco Road bridge near the southeast corner of NCOS, two teams of observers walk eastern and western routes around the site, typically meeting at the end of the survey near the trail bridge over Phelps Creek, along the northern side of the site (see Figure 5). At least one expert birder takes part in each survey, helping to verify species identification and counts. Using binoculars and a GIS app (ESRI Collector) on a tablet, each team records every species of bird seen or heard on site, including birds flying between habitats or structures on or adjacent to the site. The ESRI Collector app also automatically records the route walked by each of the two teams. Each observation recorded in ESRI Collector includes a minimum of the following information: the location and substrate/habitat of the observation, bird species (common name), and count (number of individuals of the species for the observation). Additional information that may be recorded for observations includes: the sex (male, female, or juvenile); noted evidence of breeding activity, and any other notes about the observation such as unusual or notable behavior and descriptions to help with uncertain identification of birds. Observations of birds seen previously during the survey in a different habitat, or that may have been observed by both teams are recorded as “Repeat Observations”. The weather conditions (temperature, wind speed and direction, cloud cover and precipitation) are recorded at the beginning and end of the survey. After the survey is completed, the total count of each species observed is reviewed and revised if needed by the expert birder and each team leader.

A total of 110 species from twelve guilds were observed over the first year of surveys (September 2017 through August 2018). A map of all observations by guild for the first year of surveys, and the typical survey route, is provided in Figure 5, followed by a pie chart summarizing the data by guild (Figure 6). Appendix 3 contains a complete list of species observed, grouped by guild. The data from the first year of surveys is also available online in an interactive ArcGIS map (http://arcg.is/19Semu) and via the CCBER website (https://www.ccber.ucsb.edu/ncos).

Special Status Species Surveys: Pre-construction surveys for Red-legged Frog, Tidewater Goby and Western Pond Turtle were conducted in 2016 and 2017, and the first post-construction survey was conducted in August 2018. No Red-legged Frogs or Tidewater Gobies were observed in those surveys. At least one Western Pond Turtle was observed near Phelps Creek prior to construction. Subsequent surveys for these three species will be conducted at least once per year for the next three to five years, after which an assessment will be made on whether further surveys will be needed. A Technical Memorandum on the results of the 2018 survey is provided in Appendix 4 of this report.

Arthropod Surveys: A survey of arthropods, using four sampling methods, was conducted in the spring and summer of 2016 as a pre-restoration “snapshot” of arthropod diversity and abundance in

the six dominant vegetation communities. The results of this project are being compiled and have led to multiple subsequent and ongoing student research projects. A similar, post-restoration survey may be conducted after plants become better established across the site. In the meantime, post-construction monitoring of aquatic arthropods began in the spring of 2018 through a collaboration with the Santa Barbara Audubon Society and the Coal Oil Point Reserve Nature Center. Samples of benthic and surface water arthropods are being collected monthly along with water quality data (dissolved oxygen, temperature, and salinity) from up to five locations in the main channels and creeks of NCOS, as well as one of the ponds in the western arm and two of the vernal pools on the mesa (Figure 7). Preliminary results of this monitoring have found 22 taxa dominated by five types (Copepod, Corixidae, Ostracod, Cladocera, and Chironomid larvae), with some variation by season and wetland type that may be at least partly explained by variation in salinity and dissolved oxygen.

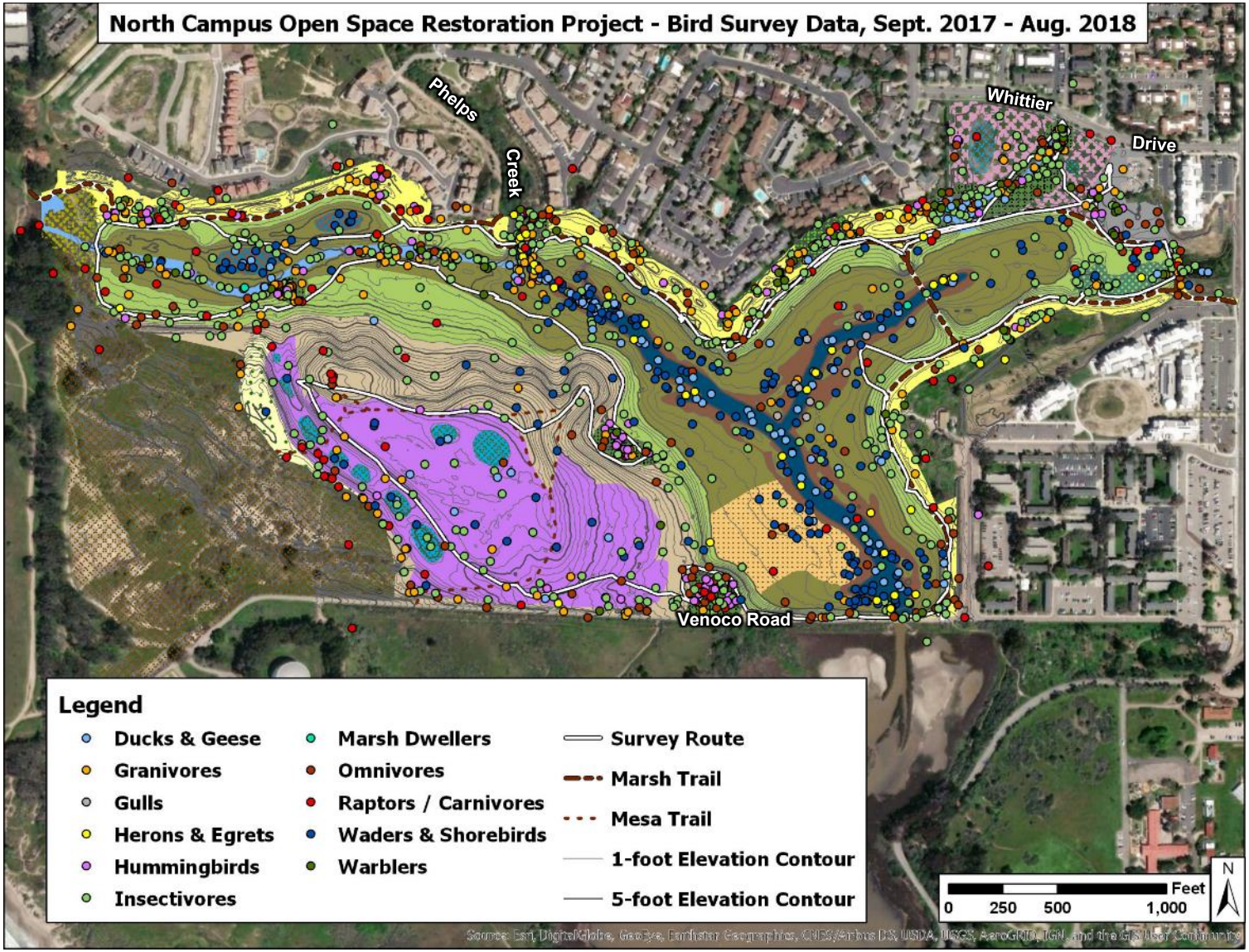


Figure 5. Map of observations grouped by guild from monthly bird surveys conducted at NCOS from September 2017 through August 2018. The typical survey route is indicated by the white line. See Figure 1 for a map and legend of habitats/vegetation communities. An online, interactive version of this map is available here: http://arcg.is/19Semu

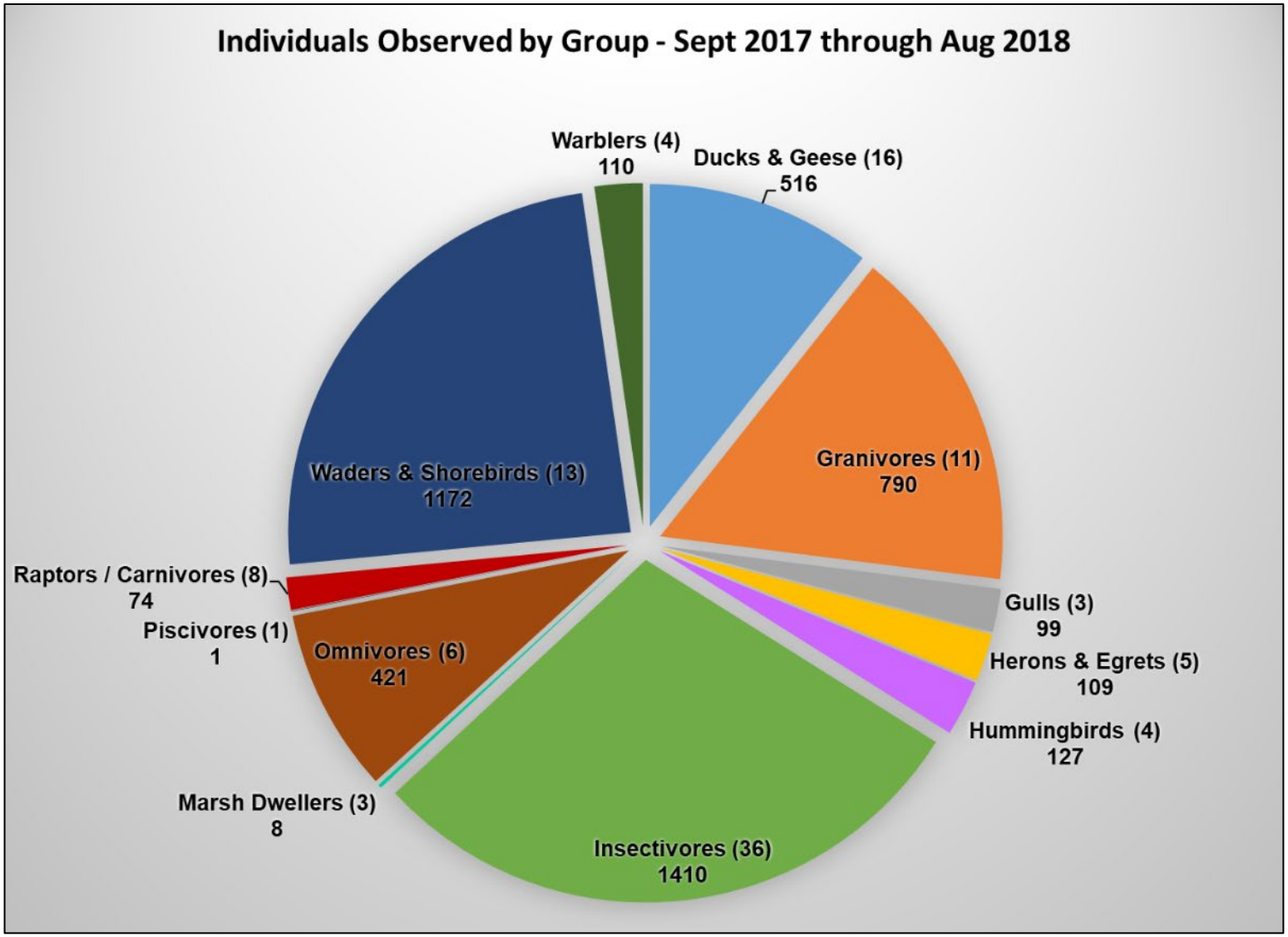


Figure 6. Pie chart showing the proportion of bird observations by guild for monthly surveys from September 2017 through August 2018 at the North Campus Open Space. The numbers in parentheses next to each guild name are the number of species observed in that guild, and the numbers below the guild name are the total individuals counted across all surveys. Appendix 3 contains a list of all species observed, grouped by guild.

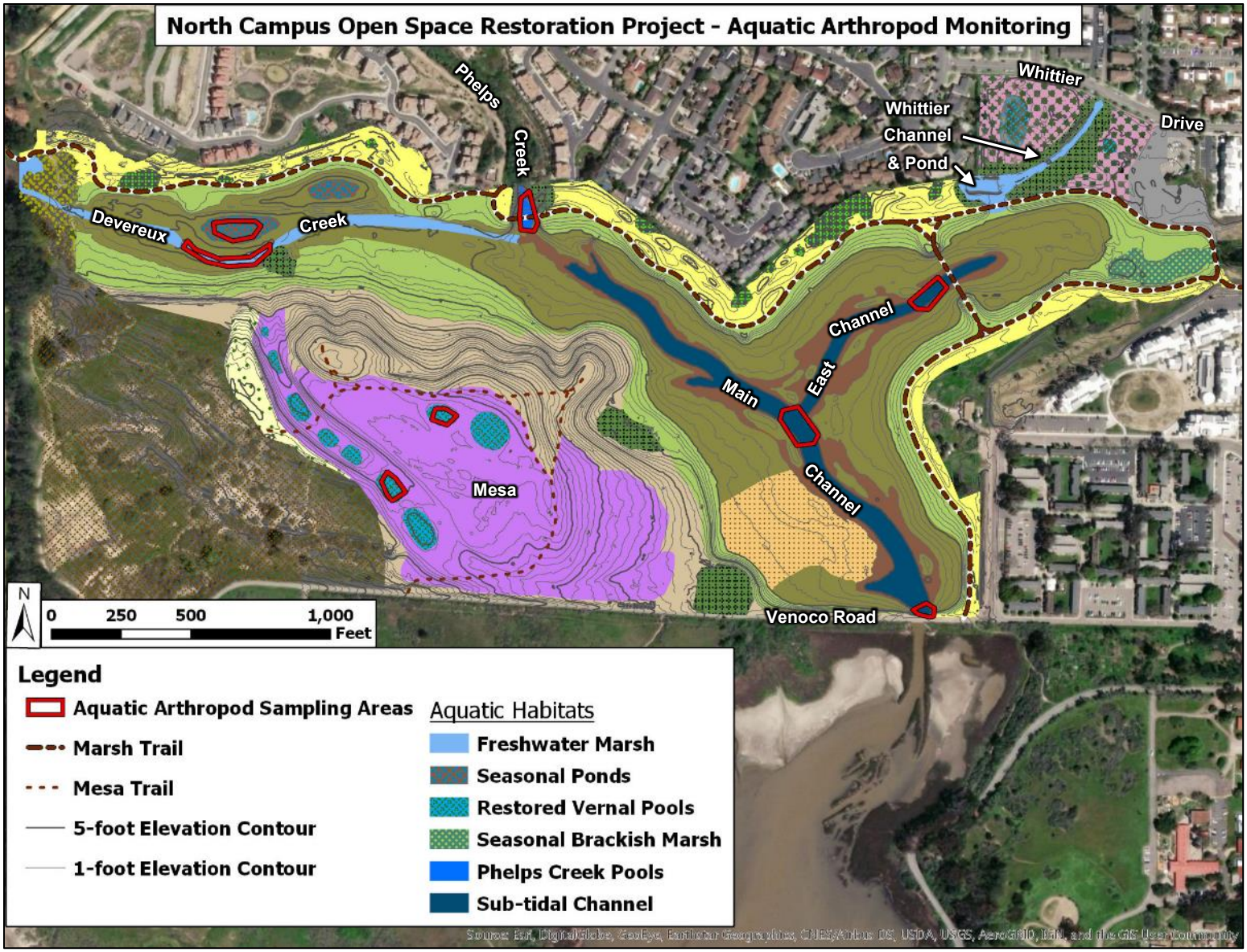


Figure 7. Map of the aquatic arthropod monitoring locations and aquatic habitats at NCOS. See Figure 1 for a map and legend of all habitats/vegetation communities.

5. Wetland Topography, Hydrology and Water Quality

Topography

Transects for measuring and monitoring the topography of the restored estuarine wetland channels were established and measured in November 2017, one month after the completion of grading. Fourteen transects in total were measured with a high-accuracy (within 5 centimeters (2 inches)), real-time kinematic (RTK) GPS unit. Seven of the transects are complete cross-sections that span the Main Channel (four transects), the East Channel (one), immediately downstream of the bridge over Phelps Creek (one), and immediately downstream of Venoco Bridge (one), with transect endpoints falling within the 10-foot elevation contour line (Figure 8). The other seven transects were measured across the width of the subtidal portion (below 5.5 feet in elevation) of the Main and East channels (four and three transects, respectively) (Figure 8). The elevation (in North American Vertical Datum 1988 - NAVD88) was measured at 6-foot intervals along the transect tape, except in the subtidal portion where elevation was measured at 3-foot intervals. Elevation profile charts of four of the complete cross-section transects (one of the East Channel and three of the Main Channel) are provided in Figures 9 and 10. The lowest elevation recorded in the seven subtidal transects and in the subtidal portions of the complete cross-sections of the Main and East channels are used together for an overall baseline thalweg elevation measurement (Table 3). The subtidal elevations of these transects demonstrate that the channel bathymetry was constructed as per plan specifications. These baseline transects will be re-surveyed in 2019 and 2021.

Table 3. Lowest elevations of the East and Main channel complete cross-section and subtidal transects. Together, these provide a baseline thalweg elevation of the as-built grading of the NCOS restoration project. See Figure 8 for a map showing the location of each transect.

Transect Label (upstream to downstream)	Lowest Elevation (feet NAVD88)
East Thal-1	3.87
East CS	3.82
East Thal-2	3.67
East Thal-3	3.39
Main CS-1	5.45
Main CS-2	4.04
Main Thal-1	3.71
Main Thal-2	3.78
Main CS-3	3.78
Main Thal-3	3.62
Main CS-4	3.56
Main Thal-4	3.24

Note: CS = Cross-section, Thal = subtidal transect for Thalweg measurement

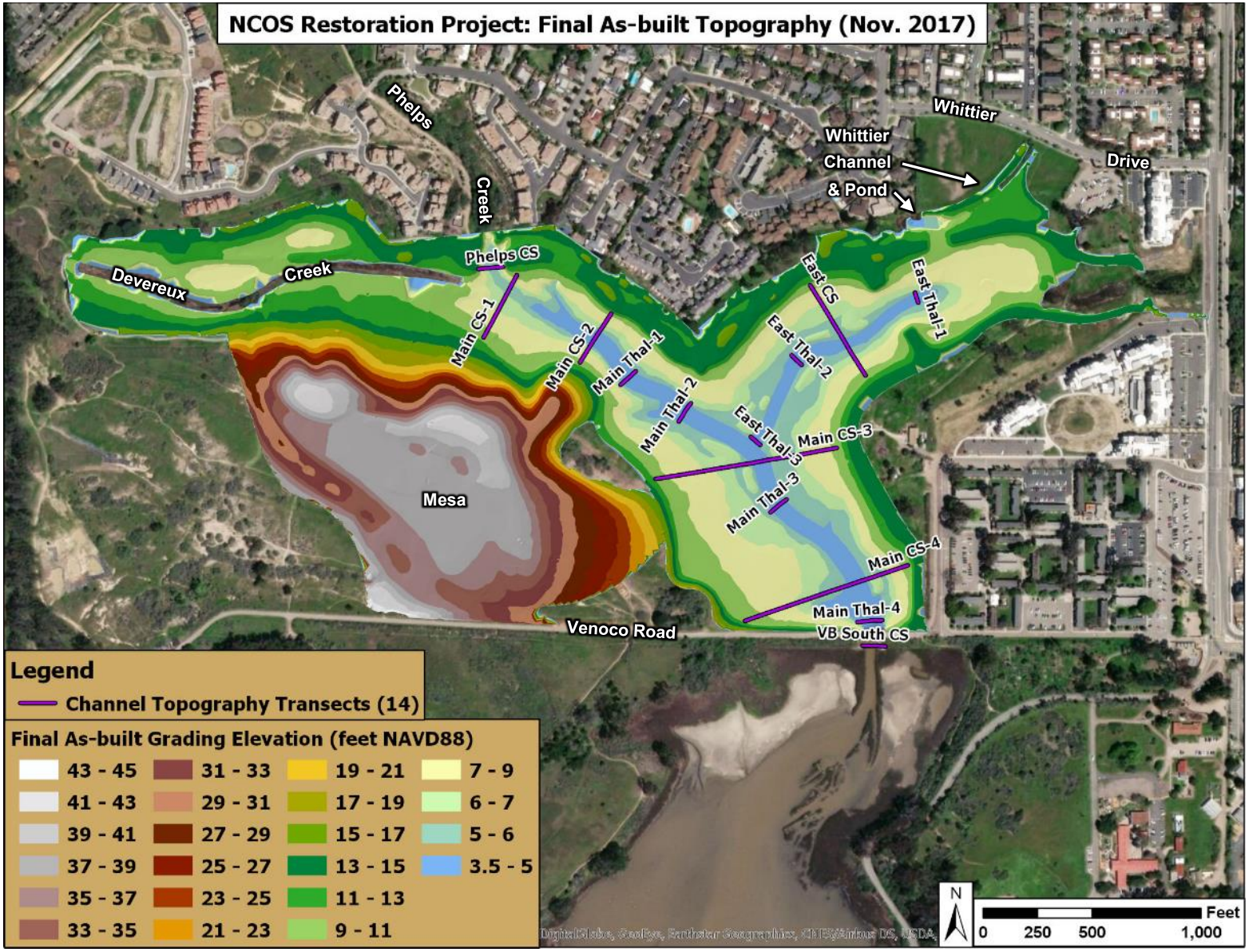


Figure 8. Map showing the 14 baseline topography cross-section (CS) and subtidal (Thal) transects across the restored wetland, overlaid on the as-built grading elevation of the NCOS Restoration Project.

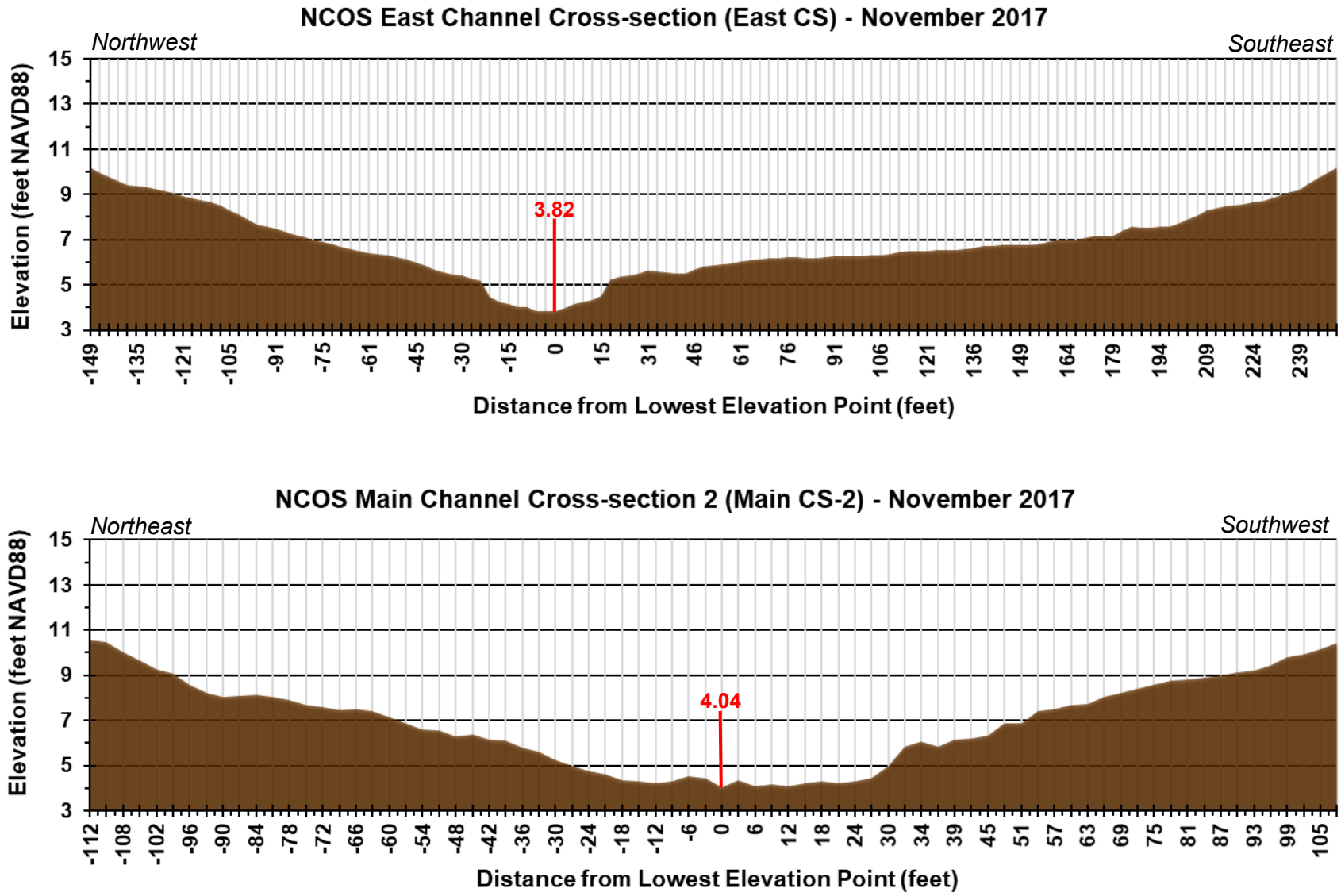
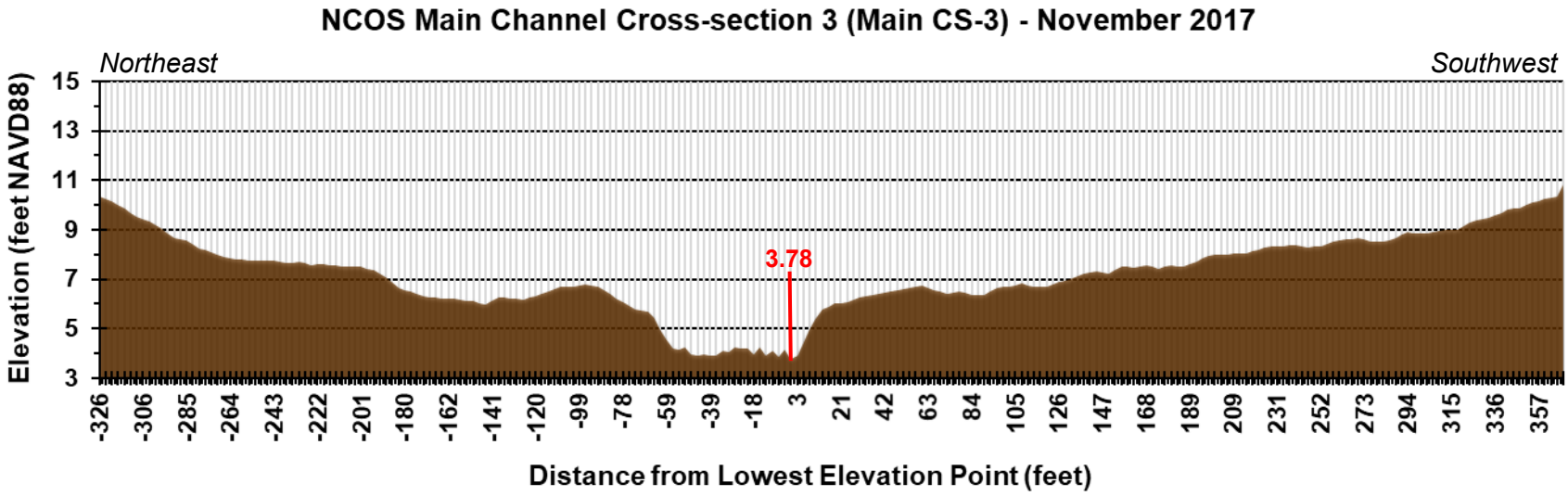


Figure 9. Profiles of as-built elevation cross-section transects in the East Channel (East CS) and the upper portion of the Main Channel (Main CS) of NCOS. The lowest elevation recorded is indicated in red. See Figure 8 for a map of the transects.



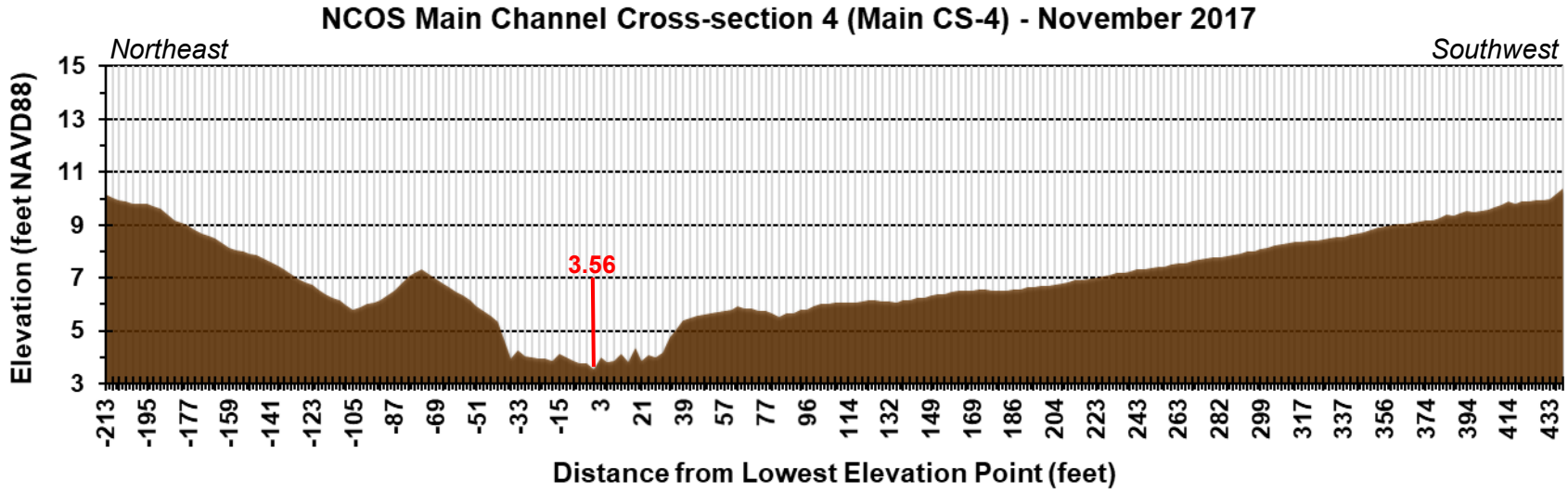


Figure 10. Profiles of as-built elevation cross-section transects in the middle and lower portions of the Main Channel (Main CS) of NCOS. The lowest elevation recorded is indicated in red. See Figure 8 for a map of the transects.

Hydrology

The three primary elements of hydrology that are monitored at NCOS are surface water level, surface flow, and groundwater level. Surface water levels are monitored continuously using pressure transducer loggers deployed at eight locations: within the three primary tributaries that drain into the upper arms of Devereux Slough, at three locations in the slough, and at two of the larger ponds on NCOS. One of the loggers is a YSI EXO1 sonde, and all others are Solinst Leveloggers. Table 4 lists the locations and elevations of the loggers, and Figure 11 contains a map showing the locations of the loggers and other hydrology and water quality monitoring sites. All loggers record the water level every 15 minutes. The YSI sonde automatically compensates for barometric pressure, while the data recorded on the Solinst loggers are compensated using barometric pressure data recorded with a "Barologger" deployed on site. Water surface elevation data will be used to document and understand the performance of the system under wet and dry conditions in order to improve our understanding of breaching and tidal patterns as well as evaporation and low flows. The data will also be valuable for documenting changes associated with sea level rise over the longer term.

Table 4. Deployment location and elevation (in feet NAVD88) of pressure transducer loggers (YSI EXO1 and Solinst Leveloggers) recording water level every 15 minutes in Devereux Slough and the North Campus Open Space.

Deployment Location	Logger Elevation (ft. NAVD88)
Devereux Slough Pier (YSI)	1.18
East Channel Bridge	3.96
Phelps Creek - Marymount Bridge	9.99
Venoco Bridge - north side	2.84
Devereux Creek	8.41
Western Seasonal Pond	6.20
Whittier Pond	5.04
Whittier Stormdrain	10.41

Prior to the NCOS restoration project, half of the wetland's potential water-holding capacity was supplanted by soil that was deposited to create the golf course. This caused water levels to rise rapidly to flood levels at the interface between the incoming creeks and the former wetland. Before the restoration of NCOS began, water levels recorded in Phelps and Devereux Creeks would rise by at least three feet immediately following rainfall amounts above 0.3 inches per hour, as was recorded in January 2017 (Figure 12). In March 2018, five months after the completion of the grading of the restoration project, the amount of water level rise has decreased by a foot or more in both creeks following similar rain events (Figure 13). See Figure 14 for a map showing the location of the water level loggers.

In the winter of 2016-17, it took six inches of rain to cause Devereux Slough to breach the sand bar (on 1/9/17) and connect the system to the ocean. Following the completion of the grading in October 2017, the slough did not breach until rainfall totals reached 7.8 inches on 3/22/18, reflecting an increased water holding capacity of the system. This increased capacity is also reflected in the hypsometric curve in Figure 15. The sand bar at the mouth of the slough usually holds the water in the system up to about 9.5 feet elevation. The blue line in Figure 15 shows the

capacity of the system before the project, when the mouth would breach after holding about 200 acre-feet of water. The orange line shows the post-project capacity of the system, indicating it will hold closer to 350 acre-feet before it breaches. The conclusion is that the hydrology of the as-built, restored system at NCOS closely follows the modeled predictions, and provides increased wetland capacity, habitat diversity and flood protection.

Since the completion of grading, surface water flow, in cubic feet per second (cfs), has been surveyed at two sites: Phelps Creek under Marymount Bridge on 1/9/2018 (6.7 cfs at 2.8 ft. depth), and Devereux Creek near Coronado Drive on 3/21/2018 (11.78 cfs at 2.9 ft. depth). Flow surveys were conducted during or within an hour of a sustained period of moderate to heavy rainfall (i.e. greater than 0.3 inches over a one- to two-hour period), using a Marsh-McBirney Model 2000 flow meter attached to a metric wading rod. Flow measurements will continue to be collected as opportunities arise in order to correlate flow rates to water levels.

Groundwater level and salinity is regularly monitored in eight piezometers, or index wells, on NCOS, and occasionally in another five wells that have been installed in the greater project area since 2011 (Figure 11). Four of the wells on NCOS were re-installed in the same locations as before the restoration project (wells 14, 15, 17 and 19). The water level and salinity in eight of the wells are monitored weekly once the rain season starts through the spring, and the frequency is reduced to bi-weekly in the summer and fall. The height of the water in the well is determined from the distance on a measuring tape (to 1/16 of an inch) where a wet-erase marker line is washed off by the well water. This measurement is compared with the overall depth and the known elevation of the well in order to determine the elevation of the groundwater (in feet NAVD88). The salinity (parts per thousand [ppt]) is measured by collecting a small sample in a vial attached to the measuring tape and applying the sample to a refractometer. This monitoring will expand our understanding of the underlying hydrology and salinity, and their relationship to plant survivorship and growth.

A comparison of the pre-restoration (2016) and post-restoration (2018) data for wells 14, 15, 17 and 19 suggests that the groundwater elevation near the east side of NCOS may have lowered by about two feet, and it may have risen by two to three feet in the western area of the site that is south of Devereux Creek (see Table 5 and compare wells 19 and 14 in Figures 16 and 17). This could be due to similar changes in the ground surface elevation from the grading of the site. Groundwater salinity doesn't appear to have changed (Table 5), except that salinity along the eastern side (well 19) is high (at or above 100 ppt) more often than before restoration (compare Figures 18 and 19). These trends will be assessed further with data collected over the next few years. The 2018 data for seven of the regularly monitored wells are presented in Figures 20 and 21.

Table 5. Average groundwater table elevation (in feet NAVD88) and salinity (parts per thousand) at four index wells at NCOS in 2016 and 2018.

Well Number	Avg. 2016 Elevation (ft.)	Avg. 2018 Elevation (ft.)	Avg. 2016 Salinity (ppt)	Avg. 2018 Salinity (ppt)
14	10.1	12.6	4	2
15	7.2	8.1	26	38
17	9.7	9.0	7	6
19	7.1	5.0	74	93

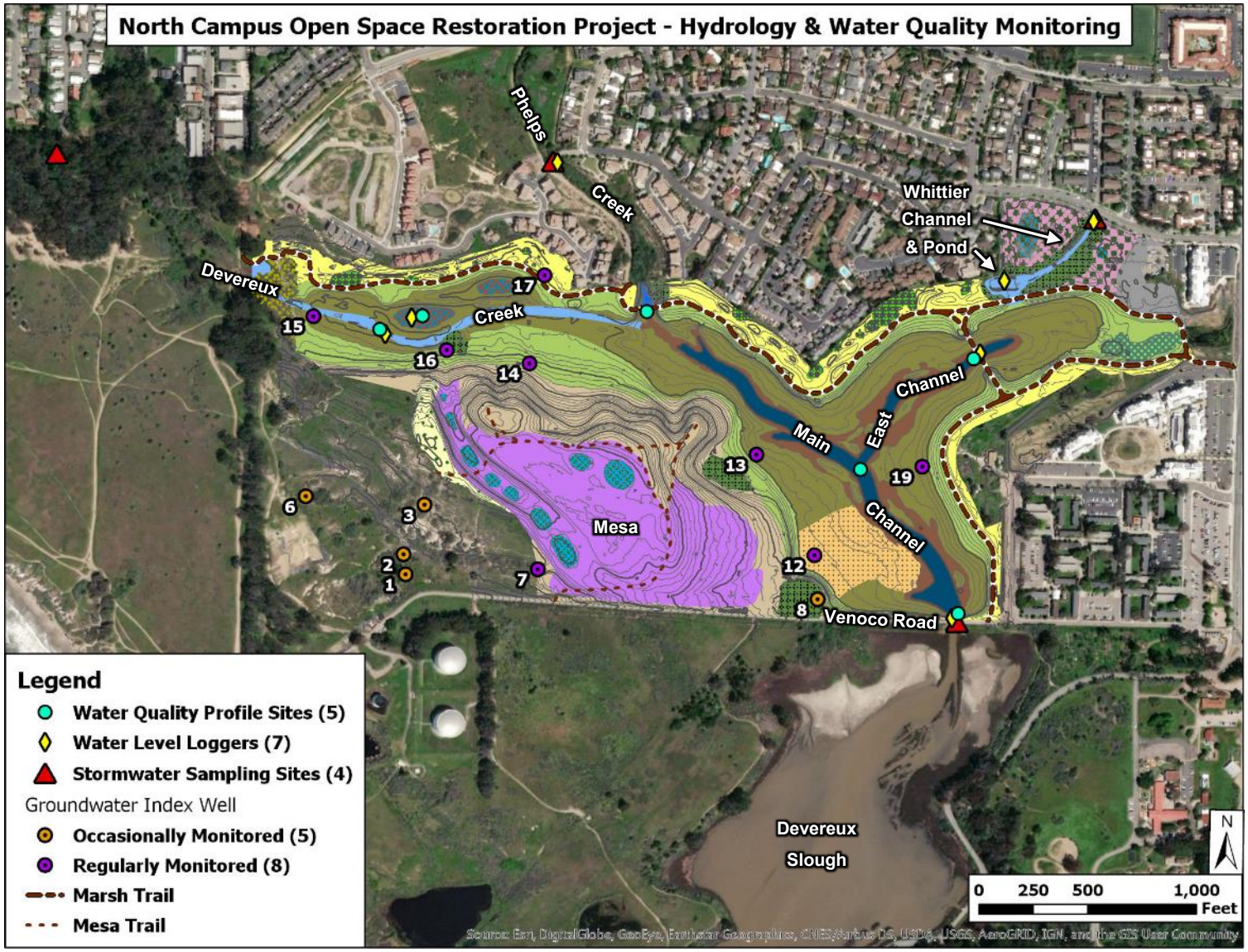


Figure 11. Map of NCOS showing hydrology and water quality monitoring sites, with groundwater index well numbers labeled. The hydrology and water quality monitoring site in the lower Devereux Slough is not shown on the map. See Figure 1 for a legend of the habitat/vegetation communities.

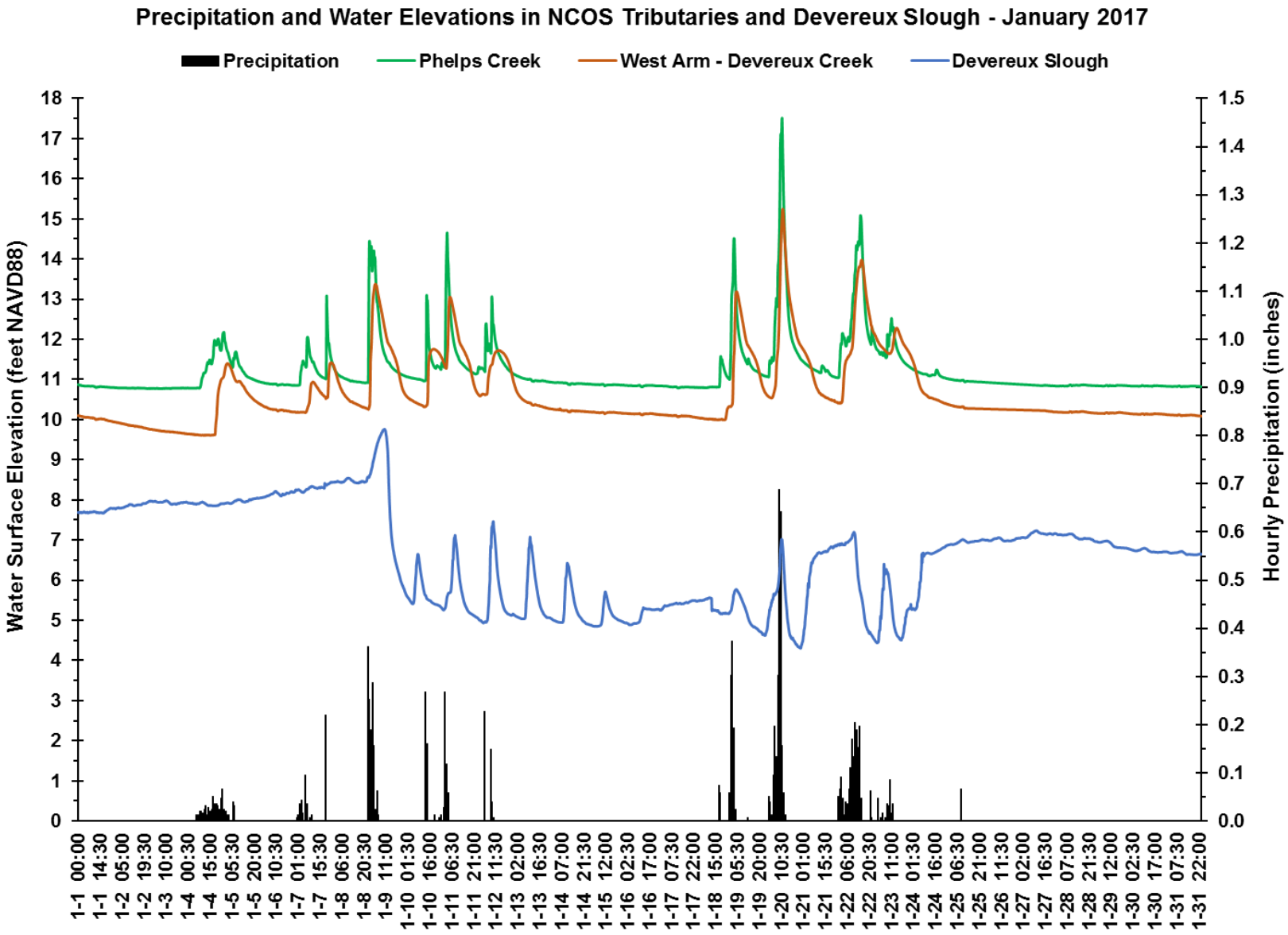


Figure 12. Pre-grading NCOS water surface elevations and precipitation, January 2017.

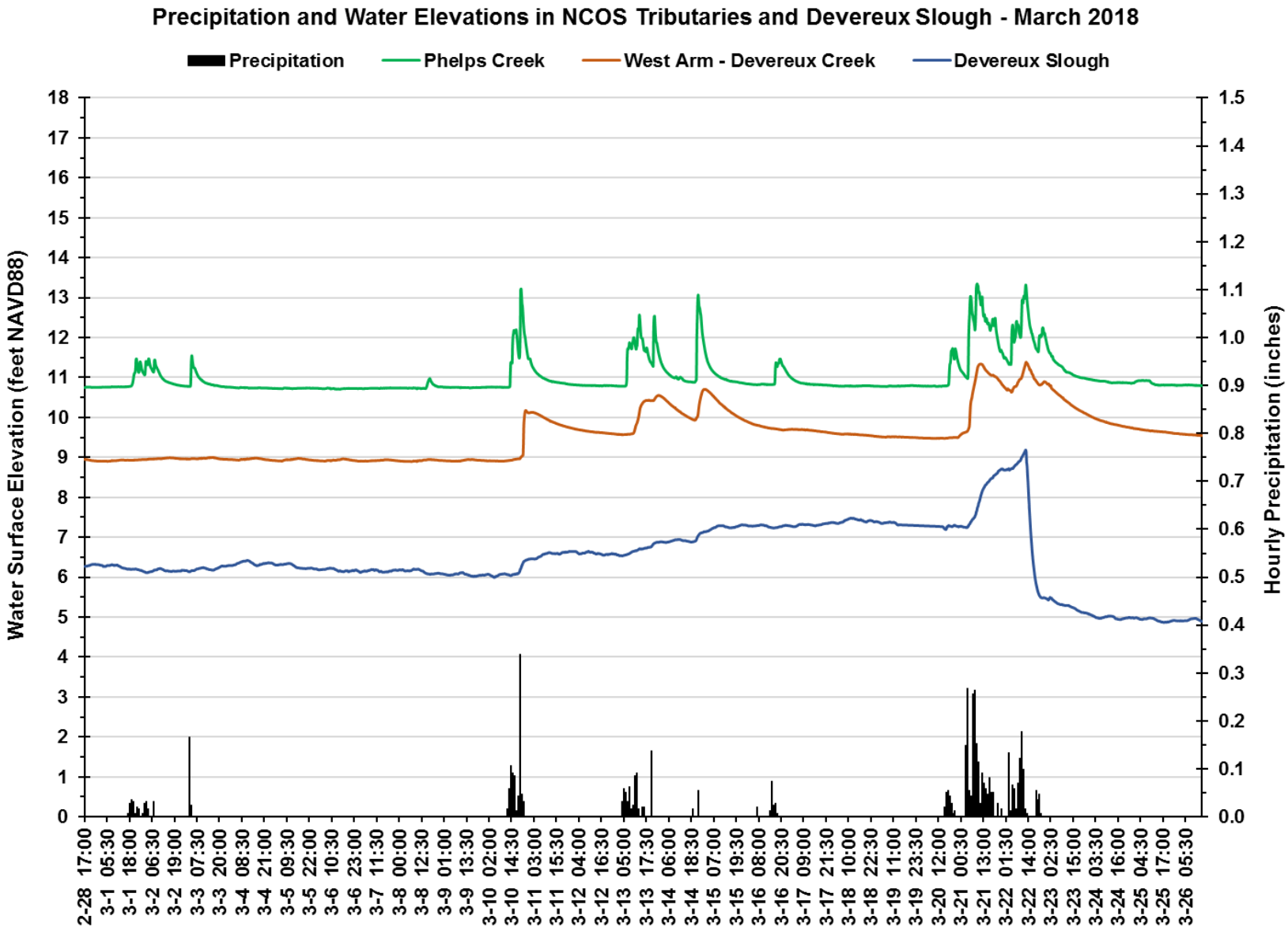


Figure 13. Post-grading NCOS water surface elevations and precipitation, March 2018.

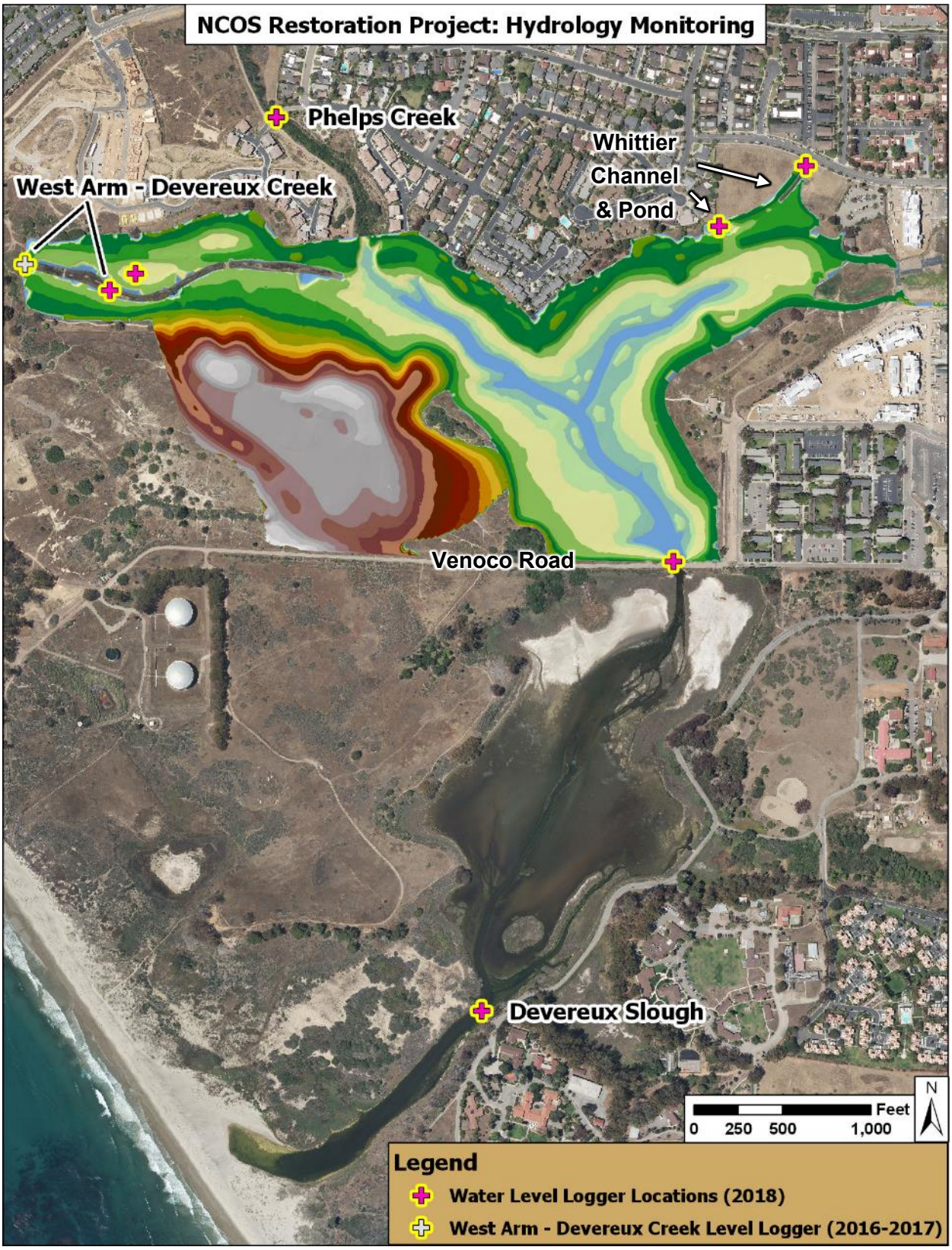


Figure 14. Map of the location of water level loggers for monitoring hydrology of the NCOS restoration site and lower Devereux Slough before (2016-2017) and after completion of the grading phase of the project.

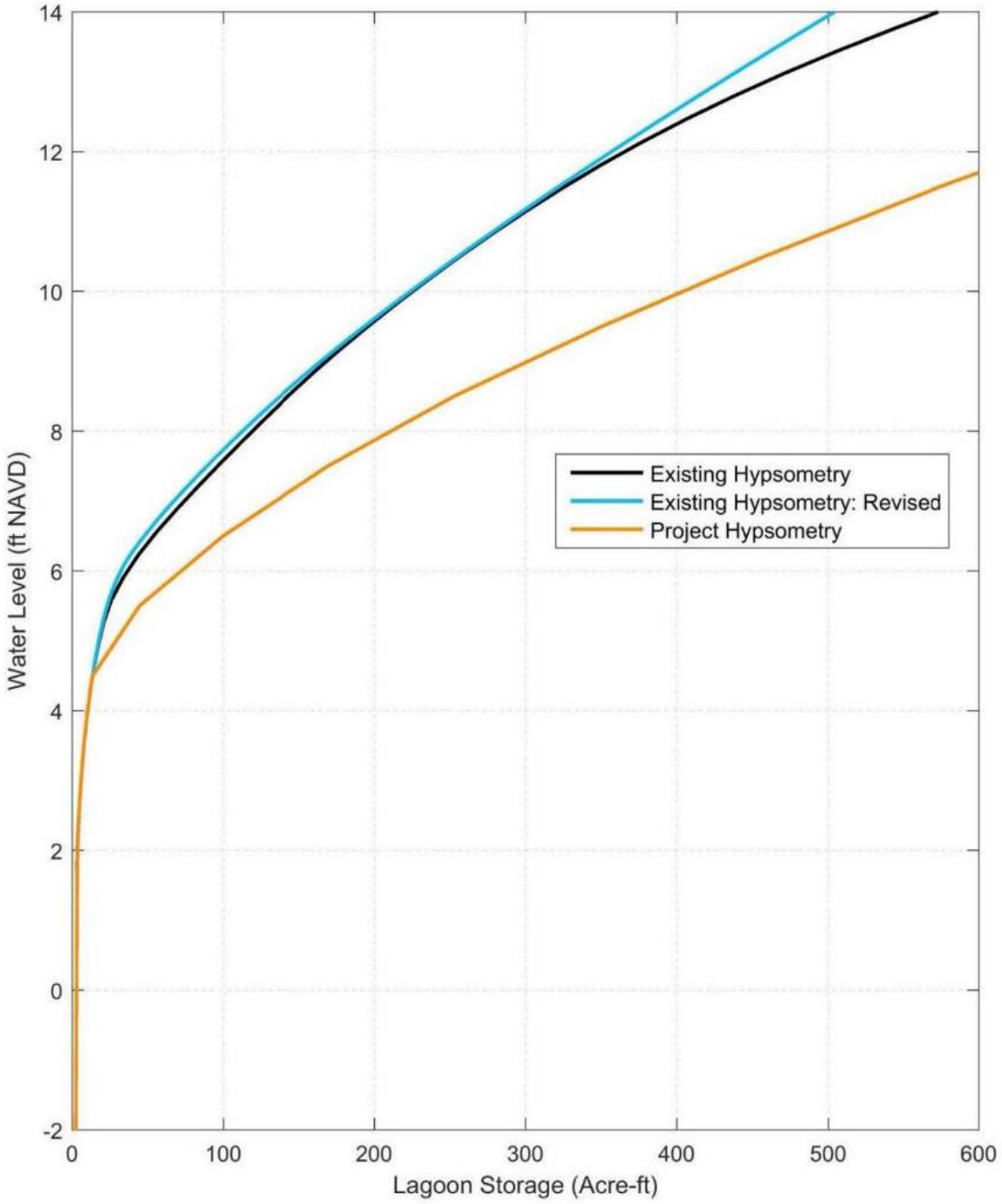


Figure 15. Comparison of pre- and post-grading water stage-storage curves for Devereux Slough (Lagoon). Notice the lower post-project water levels at equivalent water storage levels (orange line). Pre-grading hypsometry is from Rich (2013). Revised pre-grading hypsometry is based on an ESA and Stantec survey. Post-grading hypsometry is based on the ESA grading plan for NCOS.

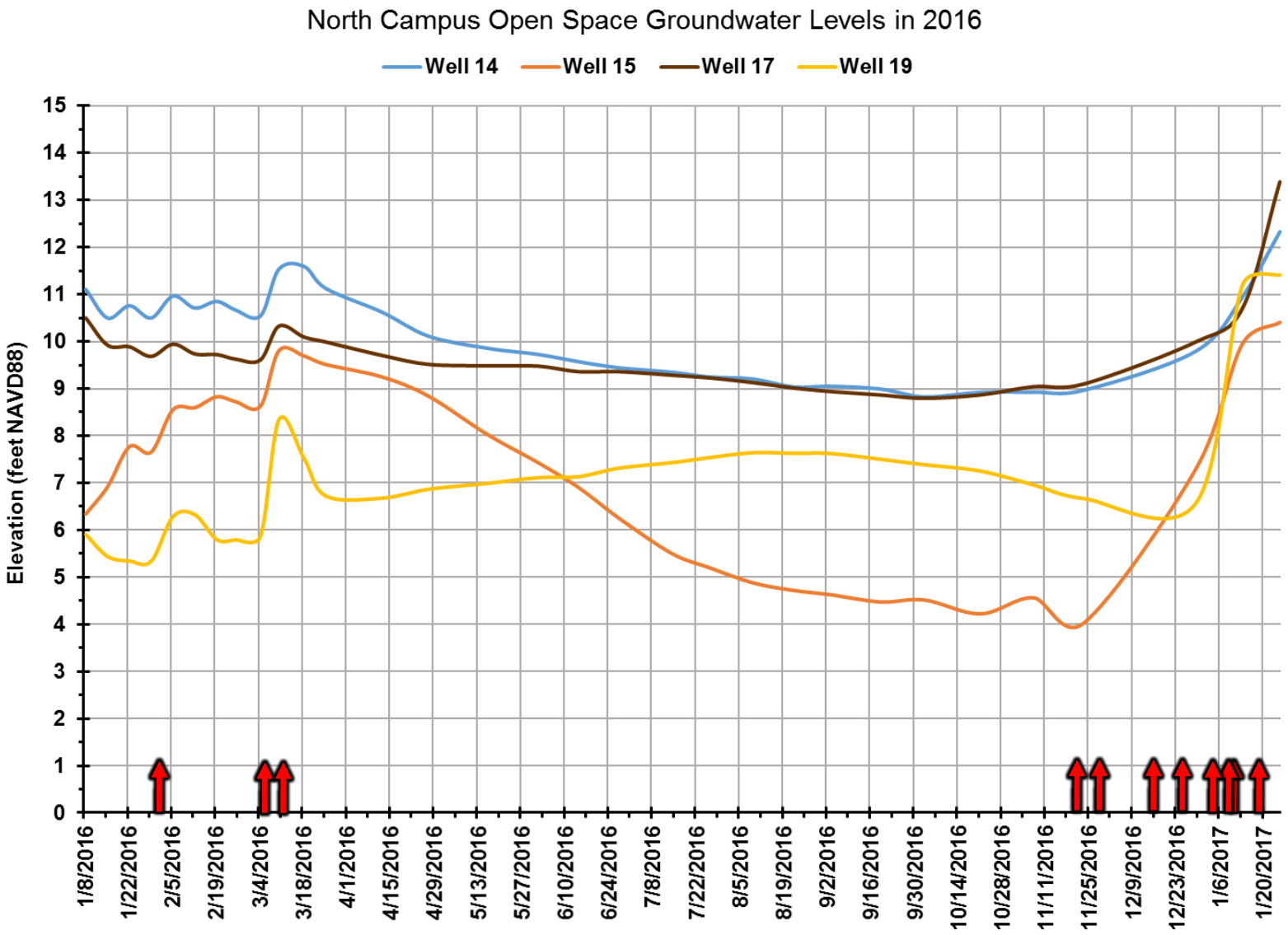


Figure 16. Groundwater elevation level (in feet NAVD88) measured in four index wells on North Campus Open Space in 2016, one year prior to the beginning of restoration. The red arrows represent rainfall amounts of 0.5 inches or greater in one day.

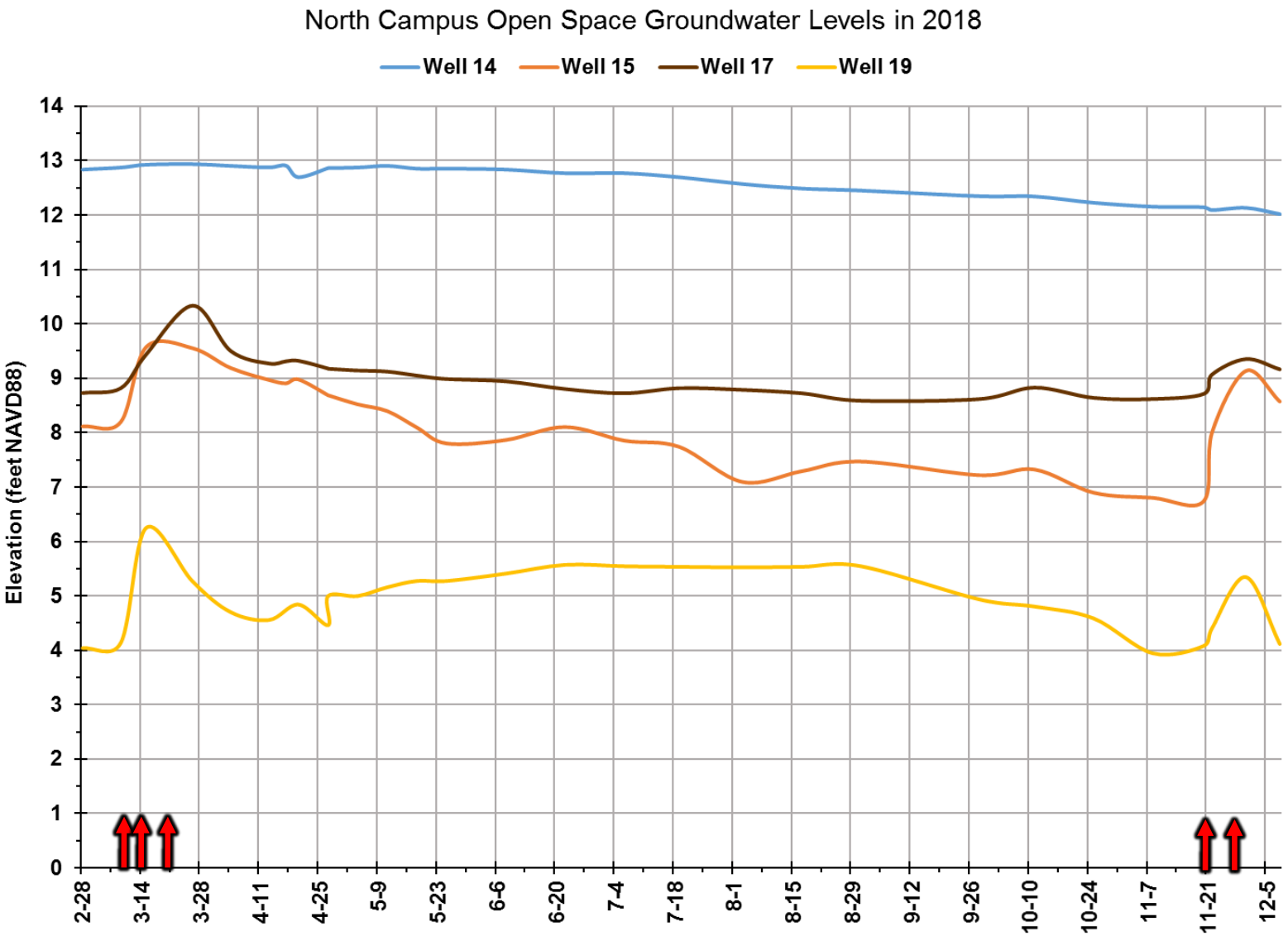


Figure 17. Groundwater elevation level (in feet NAVD88) measured in four index wells on North Campus Open Space in 2018, the first year following the completion of the grading phase of restoration. The red arrows represent rainfall amounts of 0.5 inches or greater in one day.

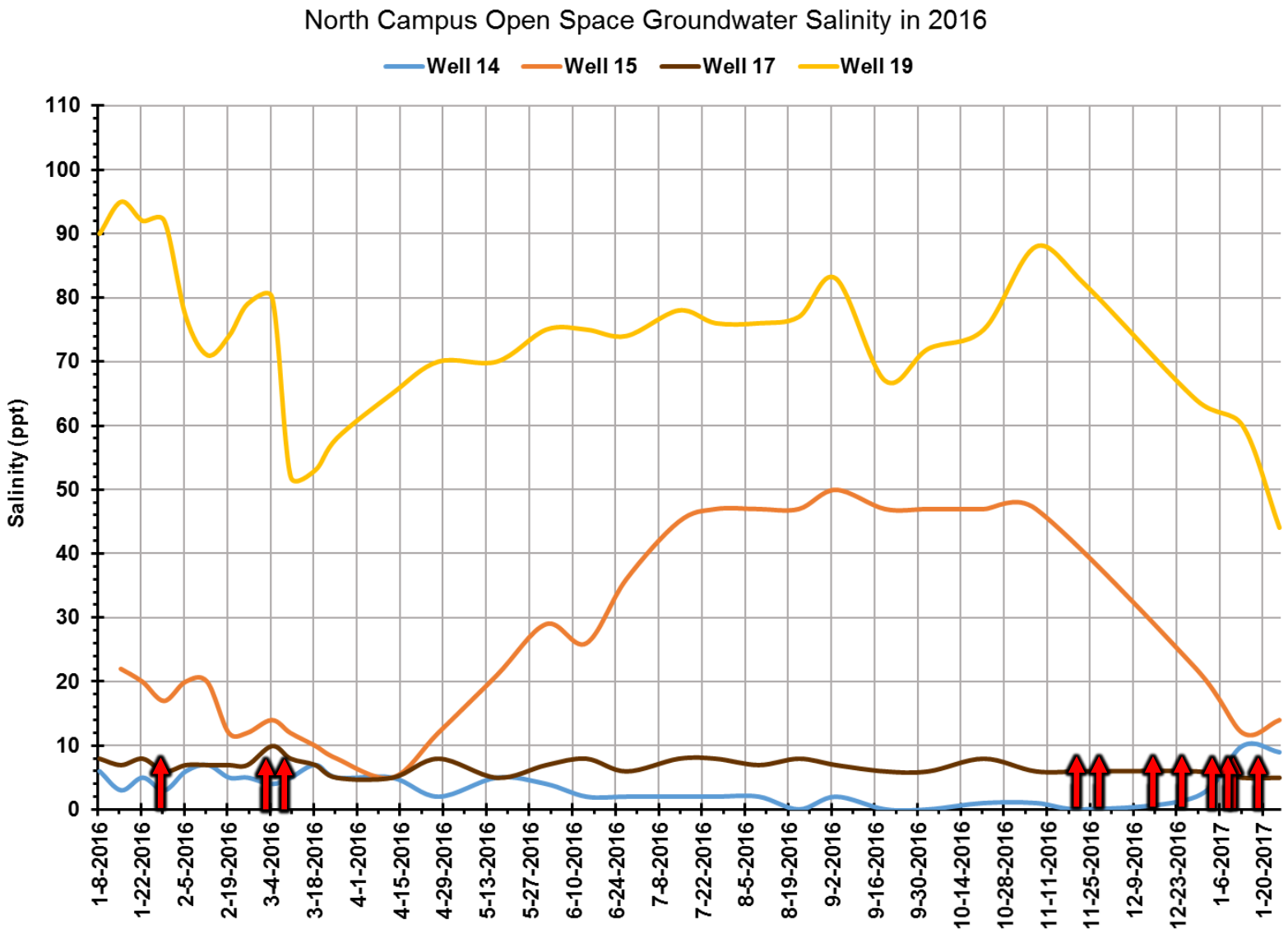


Figure 18. Groundwater salinity (in parts per thousand) measured in four index wells on North Campus Open Space in 2016, one year prior to the beginning of restoration. The red arrows represent rainfall amounts of 0.5 inches or greater in one day.

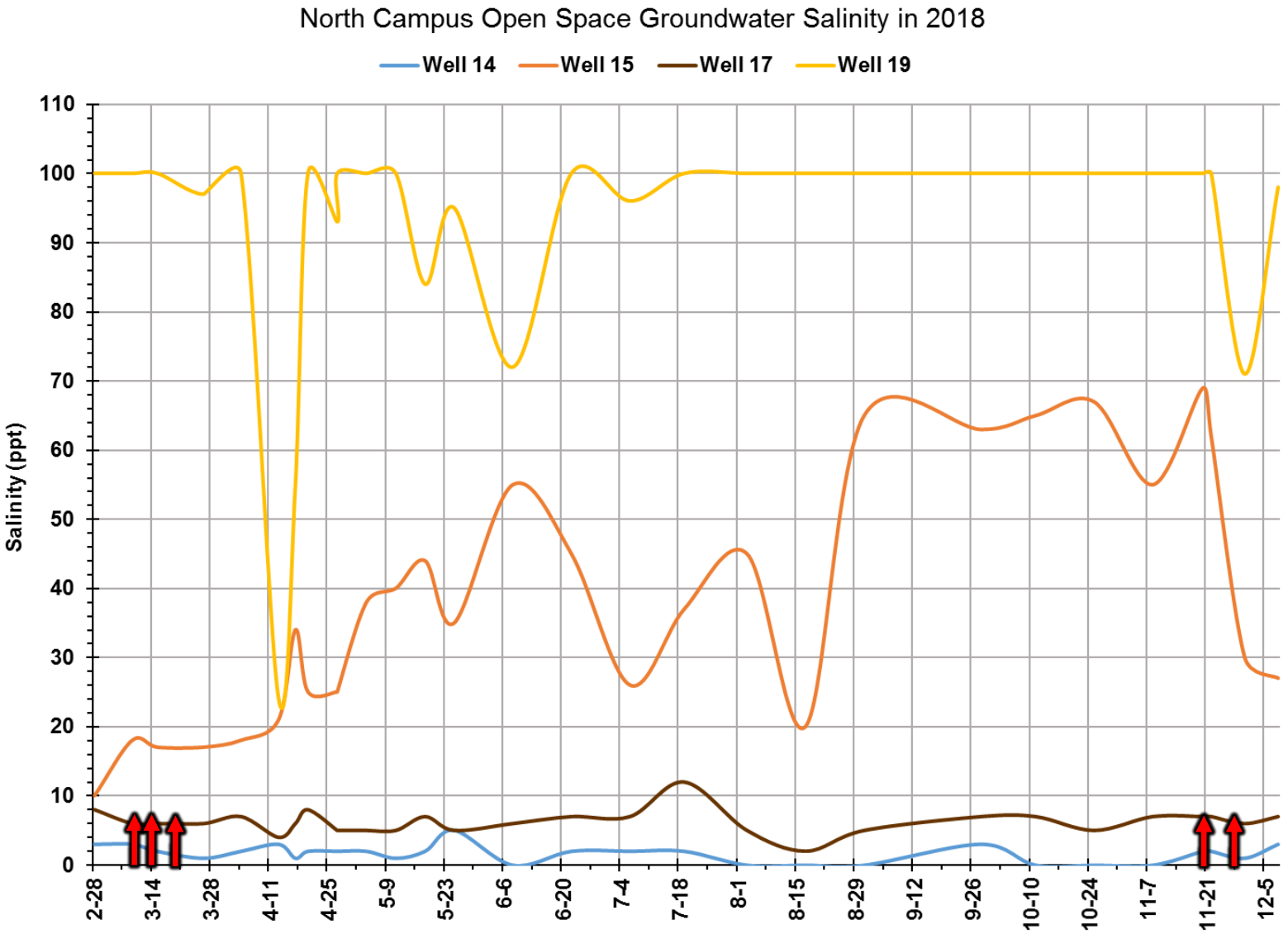


Figure 19. Groundwater salinity (in parts per thousand - ppt) measured in four index wells on North Campus Open Space in 2018, the first year following the completion of the grading phase of restoration. The red arrows represent rainfall amounts 0.5 inches or greater in one day.

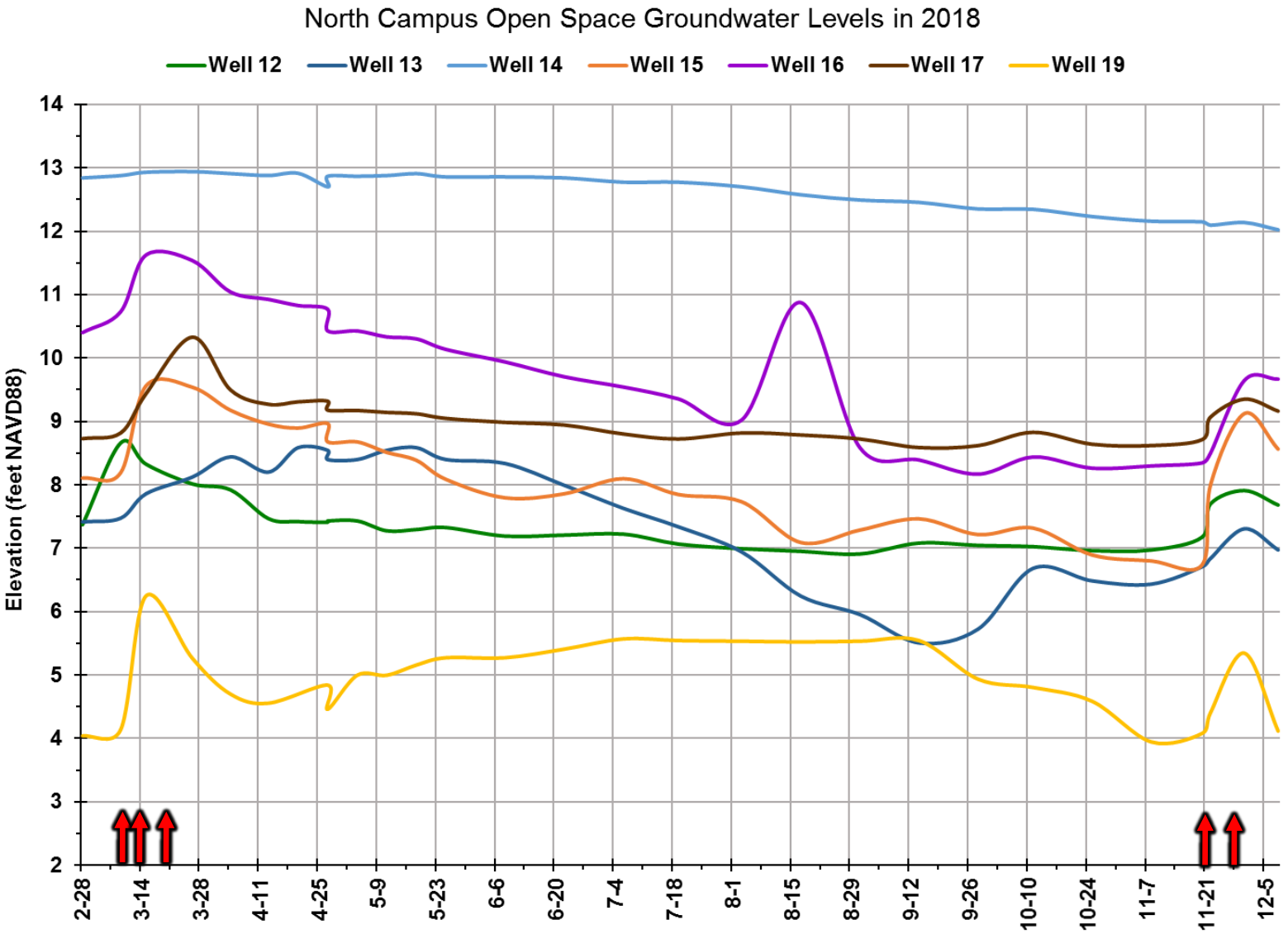


Figure 20. Groundwater elevation level (in feet NAVD88) measured in seven index wells on North Campus Open Space in 2018, the first year following the completion of the grading phase of restoration. The red arrows represent rainfall amounts of 0.5 inches or greater in one day.

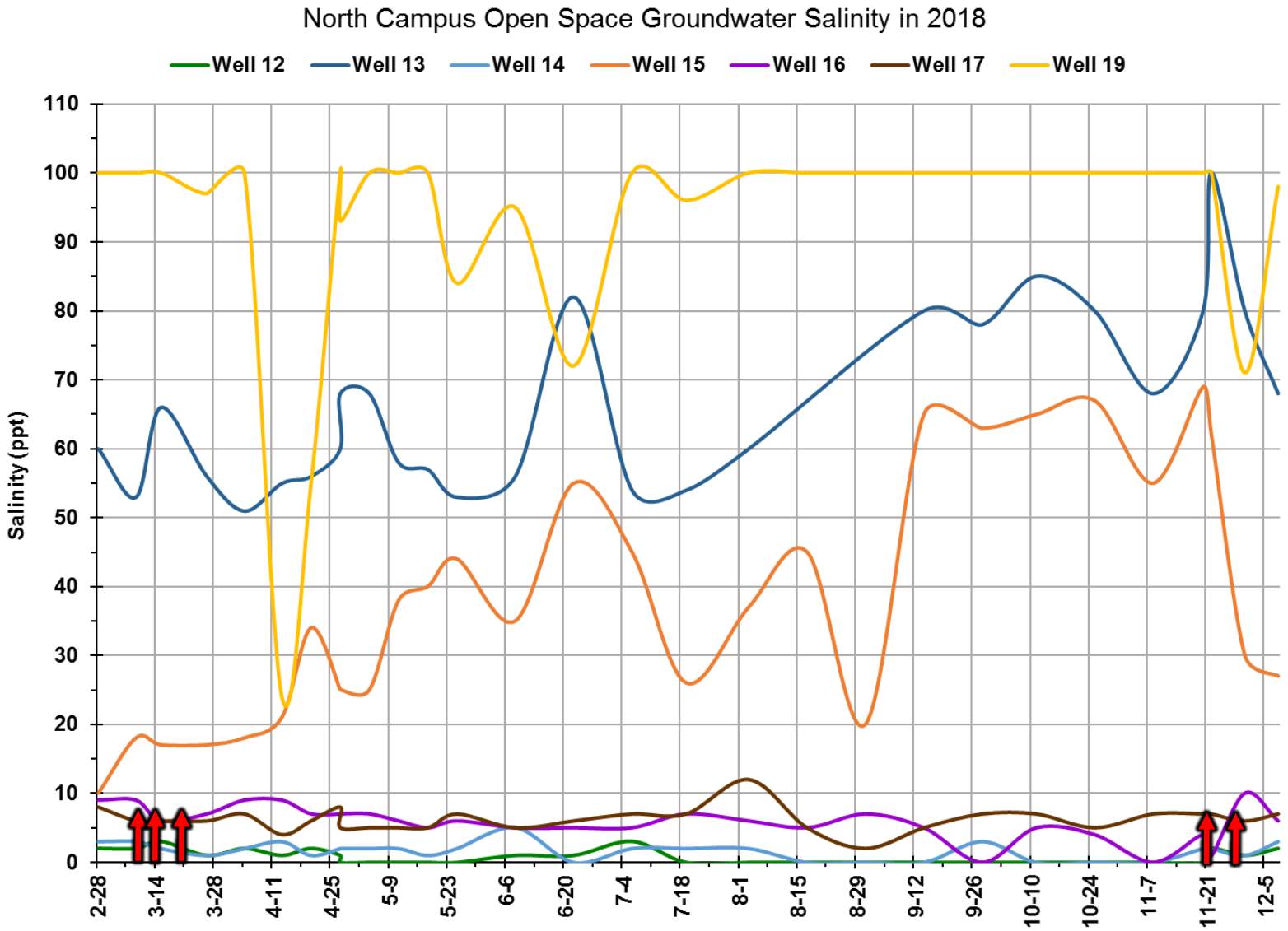


Figure 21. Groundwater salinity (in parts per thousand) measured in seven index wells on North Campus Open Space in 2018, the first year following the completion of the grading phase of restoration. The red arrows represent rainfall amounts of 0.5 inches or greater in one day.

The water levels in eight vernal pools created on the NCOS mesa are monitored on a weekly basis starting when the pools begin to hold water after the first rains of the wet season until the pools become dry (see Figure 1 for the locations of the vernal pools). Water levels in the pools are measured to the nearest quarter-inch by reading an 18-inch metal ruler installed at the deepest area of each pool. Monitoring of the NCOS vernal pools in 2018 began after the last significant rainfall in March, which filled the pools to a depth of 10 to 18 inches. Seven of the eight pools held water for eight to nine weeks, becoming dry by mid to late May.

Water Quality

Two types of water quality monitoring are conducted at NCOS: 1) continuous, year-round monitoring of dissolved oxygen, salinity and temperature; and 2) periodic collection and analysis of stormwater samples for nutrients and suspended solids.

Continuous Monitoring: Dissolved oxygen (mg/L and percent saturation), conductivity/salinity (µS/cm and ppt) and temperature (ºC) are recorded every 15 minutes with a YSI EXO1 sonde deployed at the "pier" in the deepest part of the main channel of the lower Devereux Slough. Salinity and temperature are also recorded every 15 minutes by Solinst Leveloggers deployed on the north side of Venoco Bridge and, as of November 2018, on the center support of the new trail bridge across the restored northeast arm (East Channel) of the slough (see Figure 11). These data will be collected continuously through 2024 under current funding conditions.

Additional data on dissolved oxygen, salinity and temperature are collected regularly throughout the year using a portable YSI Pro2030 sensor at up to five locations (see the turquoise circles in the map in Figure 11). Data are recorded at the surface and at each foot of depth at each site in order to understand the vertical and seasonal changes in these parameters throughout the water column. These data are primarily collected and analyzed by students on a weekly basis during winter and spring, and on a bi-weekly basis during summer and fall.

The data collected in 2018 with these methods show a general trend of salinity increasing with depth and increasing overall in late summer and fall as the water level declines due to evaporation, particularly in the lower portions of the slough. Dissolved oxygen concentrations tend to decrease by depth, most notably in deeper areas of the lower slough. It is anticipated that a more detailed analysis of these trends will be conducted after another year of data collection.

Stormwater Monitoring: Grab samples of stormwater runoff were collected at four locations (see the red triangles in Figure 11) during two major storms in January and March 2018 for the analysis of dissolved inorganic nutrients (Nitrogen, Orthophosphate, and Ammonia), total suspended solids, and oil and grease concentrations. Results of these analyses indicate that Nitrogen and Phosphate levels in stormwater entering NCOS may at times be above the EPA threshold limits for poor water quality (>1 mg/L for Nitrogen and >0.1 mg/L for Phosphate). Concentrations of these nutrients tend to decrease downstream, as suggested by the lower concentrations detected at the Venoco Bridge sampling site. Ammonia and Oil and Grease concentrations in the samples collected were below levels of concern. The concentration of suspended solids increased downstream, with the greatest concentration detected at Venoco Bridge. Sampling and analysis of stormwater will be conducted as funding allows in order to continue tracking and understanding the nature of inputs from urban

runoff, with a focus on nutrients and suspended solids. Beginning with the winter rain season of 2019, ISCO samplers installed at the Phelps Creek, Whittier Stormdrain outfall and Venoco Bridge locations will be used to collect samples at regular intervals throughout a storm, which will allow for more detailed analysis of the volume of nutrients and suspended solids that enter the wetland system.

6. Sediment Accretion and Carbon Sequestration

Long-term monitoring and research projects related to the rates of sediment accretion and carbon sequestration in the restored saltmarsh and perennial grassland were initiated in 2018, and an assessment of the contribution of the restoration project to carbon emissions and sequestration is in progress.

To study sediment accretion rates in the restored saltmarsh areas of NCOS and in the existing saltmarsh of the lower Devereux Slough, 2500 cm^2 (2.7 ft^2) plots with a 1-cm (0.4-inch) thick layer of feldspar were established at four elevations (6.5, 7.0, 7.5, and 8.0 feet) at six locations in NCOS and five in the lower slough (for a total of 50 plots). In addition, three control plots were established in two areas of NCOS that were not disturbed as part of the restoration project (Figure 22). Baseline soil cores/profiles were collected near each of the six sets of feldspar plots in NCOS. The feldspar plots in the lower slough were established near locations where soil cores were collected in 2015. The soil cores from the lower slough have been analyzed for the presence of Cesium-137 and Lead isotopes in 2-cm (0.8-inch) slices to a depth of 45-cm (1.5 feet), in order to determine the date and percent carbon of each slice, and to integrate accretion rates with carbon sequestration rates. Soil cores will be extracted from the feldspar plots at five and ten years following project inception to assess accretion and sequestration rates based on the depth of soil above the white feldspar marker. These data are being supplemented with gas exchange measurements taken from the ground surface soil shortly after grading, and on the same soil in 2019, one year after the establishment of saltmarsh plants.

Soil carbon sequestration processes of the native perennial grassland are being assessed in three 50-by-200 foot experimental plots established on the upland mesa of NCOS, where the soil excavated for the wetland was deposited (Figure 22). These plots are divided into eight sub-plots with different combinations of biochar and compost incorporated into the top 18 inches of the soil in two layers (at the surface and below 12 inches). The growth of two grass species in each plot is being monitored, and the analysis of several baseline characteristics of the soil (***e.g.*** percent moisture, salinity/electrical conductivity, carbon content) is in process.

7. Public Use

An opportunity and a challenge with any restoration project in an open space area is to balance public use and educational benefits with impacts to plants and wildlife (***e.g.*** arising from off-trail and off-leash dog use). CCBER is tracking the beneficial uses of NCOS by documenting volunteers, undergraduate student restoration workers and research interns, community tours, and K-12 school visits to the site. Starting in 2019, public use of the trail system will be documented through targeted observational surveys conducted over a one-month period on an annual or as-needed basis,

depending on whether issues are observed. Observations will be stratified by three time-of-day periods (morning, mid-day, late afternoon). The following data will be recorded: age group (child, college student, adult, senior), with or without dog, dog on or off leash, with or without bicycle, site entry location and direction of travel, and determination of primary activity (*e.g.* exercise, dog walking, leisure). These data will be used to assess the potential impacts to other site restoration goals and to determine if more education, fencing or enforcement is required to preserve the natural functions of the site.

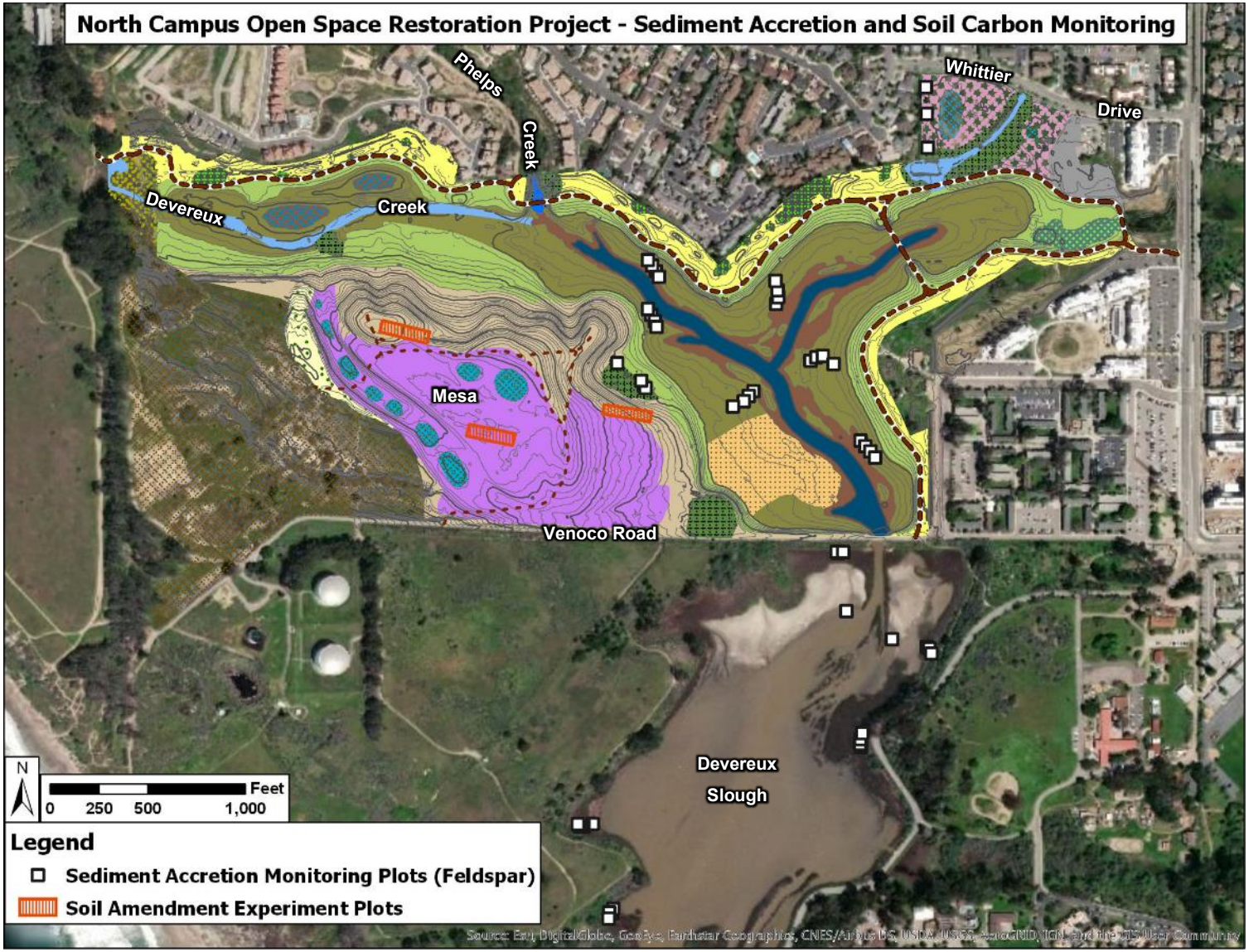
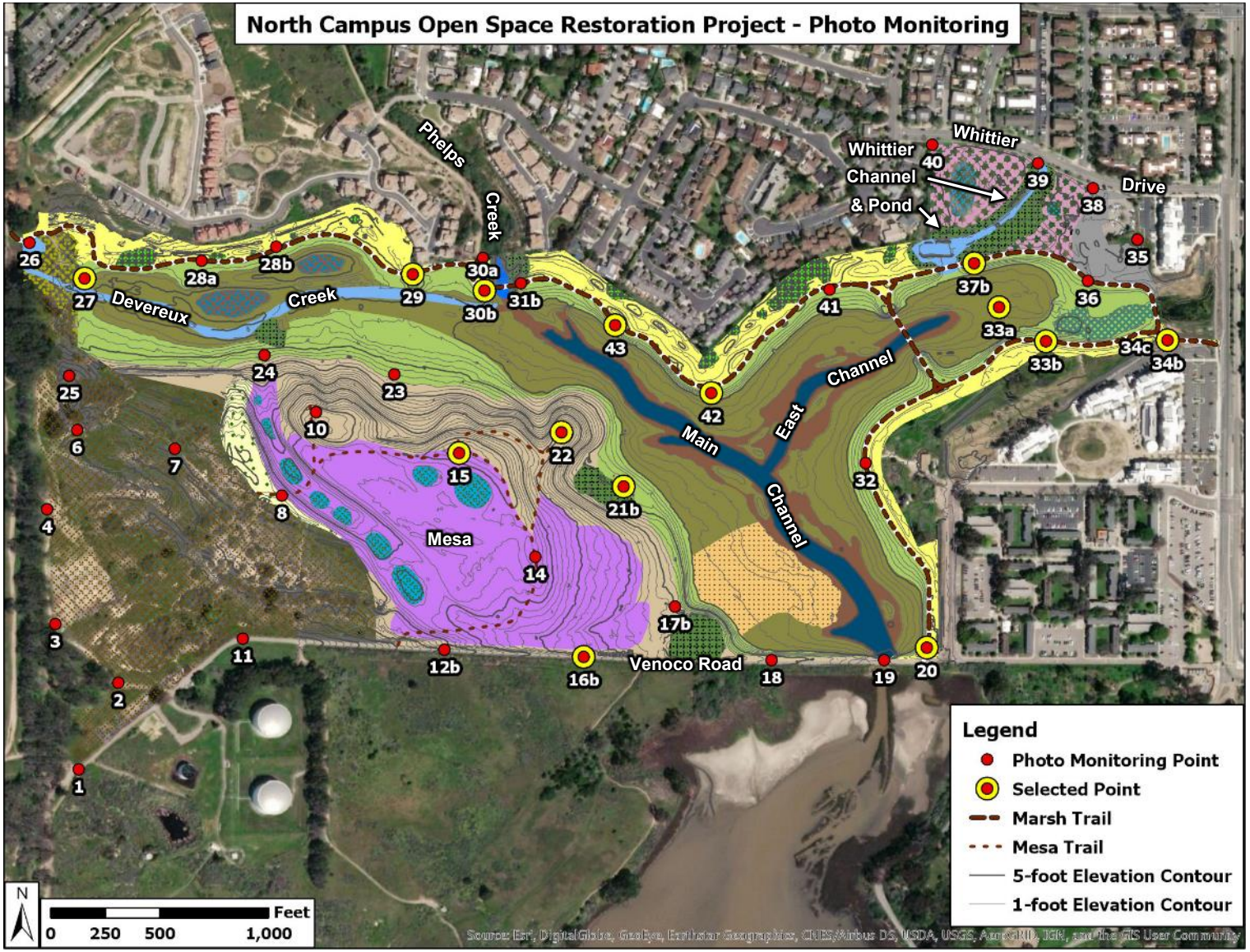


Figure 22. Map of the feldspar plots for monitoring sediment accretion in the saltmarsh areas of NCOS and Devereux Slough, and the upland experimental carbon sequestration plots on the NCOS mesa. See Figure 1 for a map and legend of all habitats/vegetation communities.

Appendix 1 – Landscape Monitoring Photos



Map of the NCOS restoration project showing locations of photo monitoring points. Some of the photos taken in October 2017 and October 2018 at the points outlined in yellow are presented in this appendix of the First Year Monitoring Report. See Figure 1 for a map and legend of the habitat/vegetation communities.

Photo point 15-SE – looking southeast from the Mesa trail, across the eastern-most vernal pool.

Baseline photo – post-grading, October 10, 2017.

Photo point 15-SE – looking southeast from the Mesa trail, across the eastern-most vernal pool.

Year 1 photo – October 16, 2018.

Photo point 16b-N – looking north from Venoco Road, across the drill-seeded grassland area.

Baseline photo – post-grading, October 10, 2017.

Photo point 16b-N – looking north from Venoco Road, across the drill-seeded grassland area.

Year 1 photo – October 16, 2018. Note the grass seedlings in the background and recent drill seeding in foreground.

Photo point 20-NW – looking northwest from the southeast corner of the NCOS project site.

Baseline photo – post-grading, October 10, 2017.

Photo point 20-NW – looking northwest from the southeast corner of the NCOS project site.

Year 1 photo – October 16, 2018.

Photo point 21b-N – looking north from north side of central remnant riparian woodland.

Baseline photo – post-grading, October 10, 2017.

Photo point 21b-N – looking north from north side of central remnant riparian woodland.

Year 1 photo – October 16, 2018.

Photo point 22-NE – looking northeast from the central overlook on the Mesa.

Baseline photo – post-grading, October 10, 2017.

Photo point 22-NE – looking northeast from the central overlook on the Mesa.

Year 1 photo – October 16, 2018.

Photo point 22-NW – looking northwest from the central overlook on the Mesa.

Baseline photo – post-grading, October 10, 2017.

Photo point 22-NW – looking northwest from the central overlook on the Mesa.

Year 1 photo – October 16, 2018.

Photo point 27-E – looking east from near the northwest corner of NCOS.

Baseline photo – post-grading, October 10, 2017.

Photo point 27-E – looking east from near the northwest corner of NCOS.

Year 1 photo – October 15, 2018. Note the western end of the completed Marsh trail and the habitat protection fence.

Photo point 29-W – looking west from the west side of the Phelps Creek Bridge.

Baseline photo – post-grading, October 10, 2017.

Photo point 29-W – looking west from the west side of the Phelps Creek Bridge.

Year 1 photo – October 15, 2018. Note completed Marsh trail and seasonal pond (dry).

Photo point 30b-E – looking east from the west end of Phelps Creek Bridge.

Baseline photo – post-grading, October 10, 2017.

Photo point 30b-E – looking east from the west end of Phelps Creek Bridge.

Year 1 photo – October 15, 2018.

Photo point 30b-NE – looking northeast from the west end of Phelps Creek Bridge.

Baseline photo – post-grading, October 10, 2017.

Photo point 30b-NE – looking northeast from the west end of Phelps Creek Bridge.

Year 1 photo – October 15, 2018.

Photo point 33a-NW – looking northwest from upper end of restored northeastern arm of slough.

Baseline photo – post-grading, October 10, 2017.

Photo point 33a-NW – looking northwest from upper end of restored northeastern arm of slough.

Year 1 photo – October 15, 2018.

Photo point 33a-SW – looking southwest from upper end of restored northeastern arm of slough.

Baseline photo – post-grading, October 10, 2017.

Photo point 33a-SW – looking southwest from upper end of restored eastern arm of slough.

Year 1 photo – October 15, 2018.

Photo point 33b-W – looking west from trail along south side of northeast arm of NCOS project site.

Baseline photo – post-grading, October 24, 2017.

Photo point 33b-W – looking west from trail along south side of northeast arm of NCOS project site.

Year 1 photo – October 15, 2018. Note both the east arm bridge and Whittier crossing.

Photo point 34b-N – looking north from the trail at the eastern end of the NCOS project site.

Baseline photo – post-grading, October 24, 2017.

Photo point 34b-N – looking north from the trail at the eastern end of the NCOS project site.

Year 1 photo – October 15, 2018. Note completion of culvert crossing and trail.

Photo point 37b-E – looking east from trail at eastern end of Whittier Crossing.

Baseline photo – post-grading, October 10, 2017.

Photo point 37b-E – looking east from trail at eastern end of Whittier Crossing.

Year 1 photo – October 15, 2018.

Photo point 37b-S – looking south from trail at eastern end of Whittier Crossing.

Baseline photo – post-grading, October 10, 2017.

Photo point 37b-S – looking south from trail at eastern end of Whittier Crossing.

Year 1 photo – October 15, 2018.

Photo point 37b-SW – looking southwest from trail at eastern end of Whittier Crossing.

Baseline photo – post-grading, October 10, 2017.

Photo point 37b-SW – looking southwest from trail at eastern end of Whittier Crossing.

Year 1 photo – October 15, 2018.

Photo point 42-NE – looking northeast from trail overlook point along north side of NCOS project site.

Baseline photo – post-grading, October 10, 2017.

Photo point 42-NE – looking northeast from trail overlook point along north side of NCOS project site.

Year 1 photo – October 15, 2018.

Photo point 42-SE – looking southeast from trail overlook point along north side of NCOS project site.

Baseline photo – post-grading, October 10, 2017.

Photo point 42-SE – looking southeast from trail overlook point along north side of NCOS project site.

Year 1 photo – October 15, 2018.

Photo point 43-NE – looking northeast from trail along north-central side of NCOS project site

Baseline photo – post-grading, October 10, 2017.

Photo point 43-NE – looking northeast from trail along north-central side of NCOS project site

Year 1 photo – October 15, 2018.

Photo point 43-SW – looking southwest from trail along north-central side of NCOS project site.

Baseline photo – post-grading, October 10, 2017.

Photo point 43-SW – looking southwest from trail along north-central side of NCOS project site.

Year 1 photo – October 15, 2018.

Appendix 2 – Vegetation Monitoring Data

List of Figures

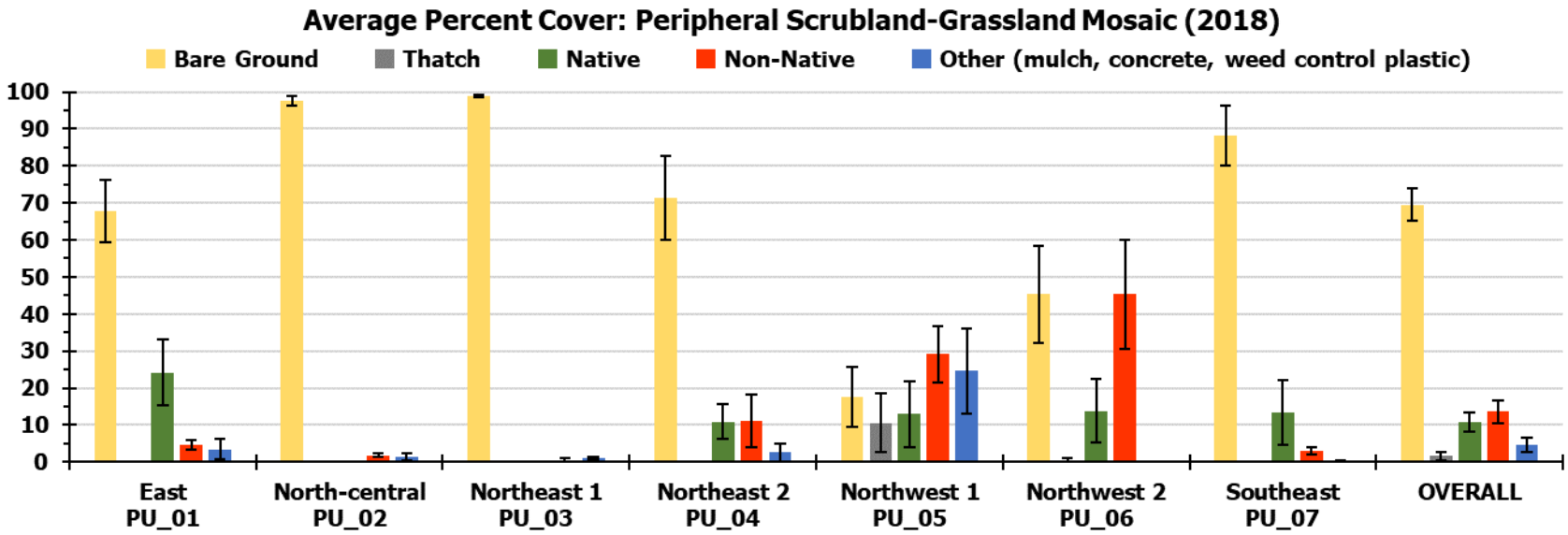


Figure A2.1. Average percent cover (y-axis), with standard error, of native and non-native vegetation, bare ground, thatch and other, uncategorized types recorded in 2018 at seven quadrat monitoring transects (x-axis) in the Peripheral Scrubland-Grassland Mosaic habitat of the North Campus Open Space Restoration Project.

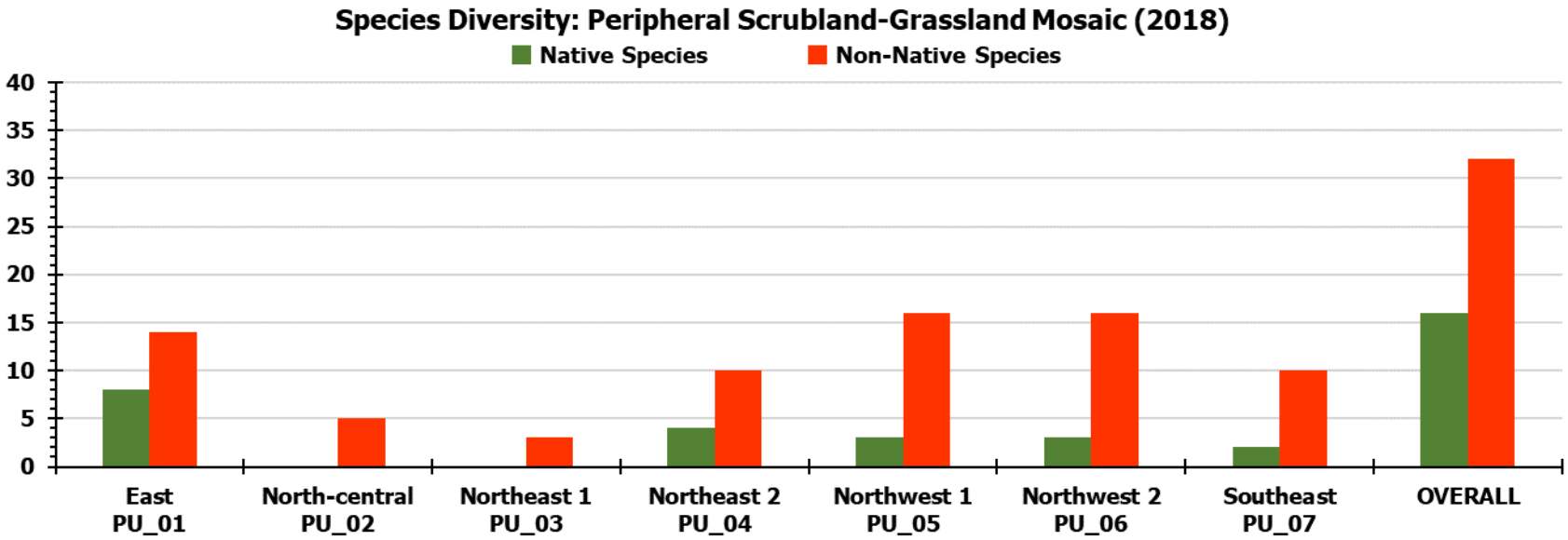


Figure A2.2. Number of native and non-native plant species (y-axis) recorded in 2018 along seven quadrat monitoring transects (x-axis) in the Peripheral Scrubland-Grassland Mosaic habitat of the North Campus Open Space Restoration Project.

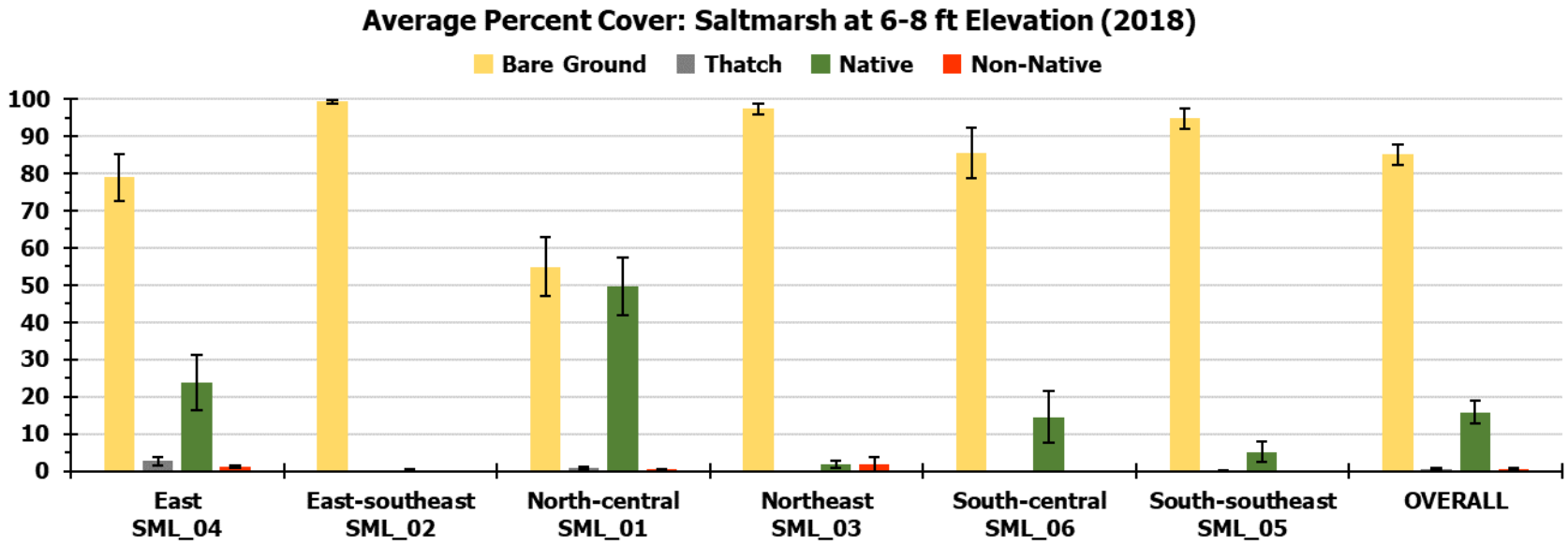


Figure A2.3. Average percent cover (y-axis), with standard error, of native and non-native vegetation, bare ground and thatch recorded in 2018 at six quadrat monitoring transects (x-axis) in the low-elevation (6-8 ft) Saltmarsh (SML) habitat of the North Campus Open Space Restoration Project.

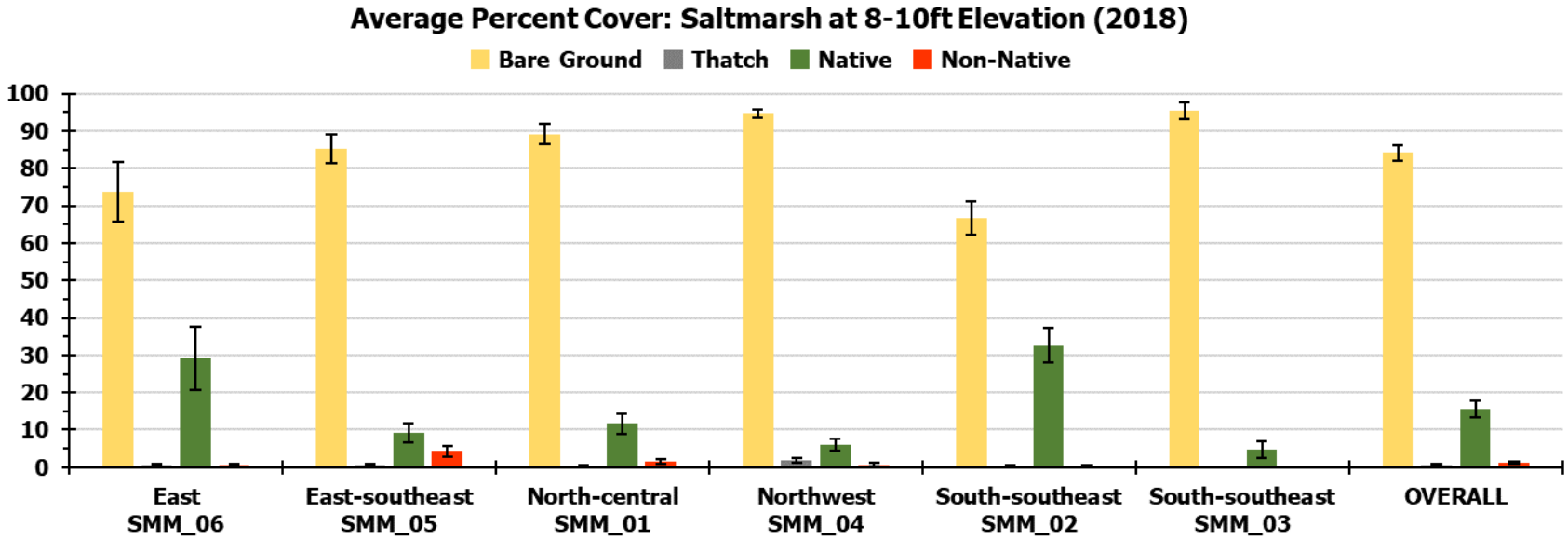


Figure A2.4. Average percent cover (y-axis), with standard error, of native and non-native vegetation, bare ground and thatch recorded in 2018 at six quadrat monitoring transects (x-axis) in the mid-elevation (8-10 ft) Saltmarsh (SMM) habitat of the North Campus Open Space Restoration Project.

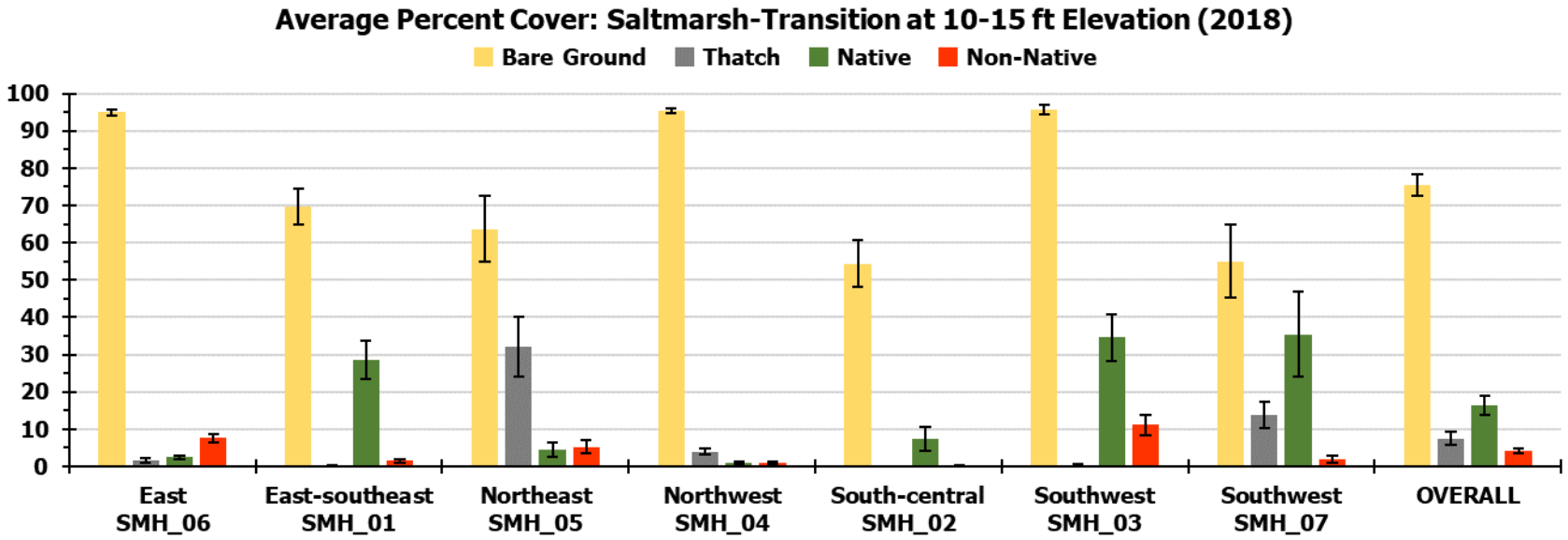


Figure A2.5. Average percent cover (y-axis), with standard error, of native and non-native vegetation, bare ground and thatch recorded in 2018 at seven quadrat monitoring transects (x-axis) in the high-elevation (10-15 ft) Saltmarsh-Transition (SMH) habitat of the North Campus Open Space Restoration Project.

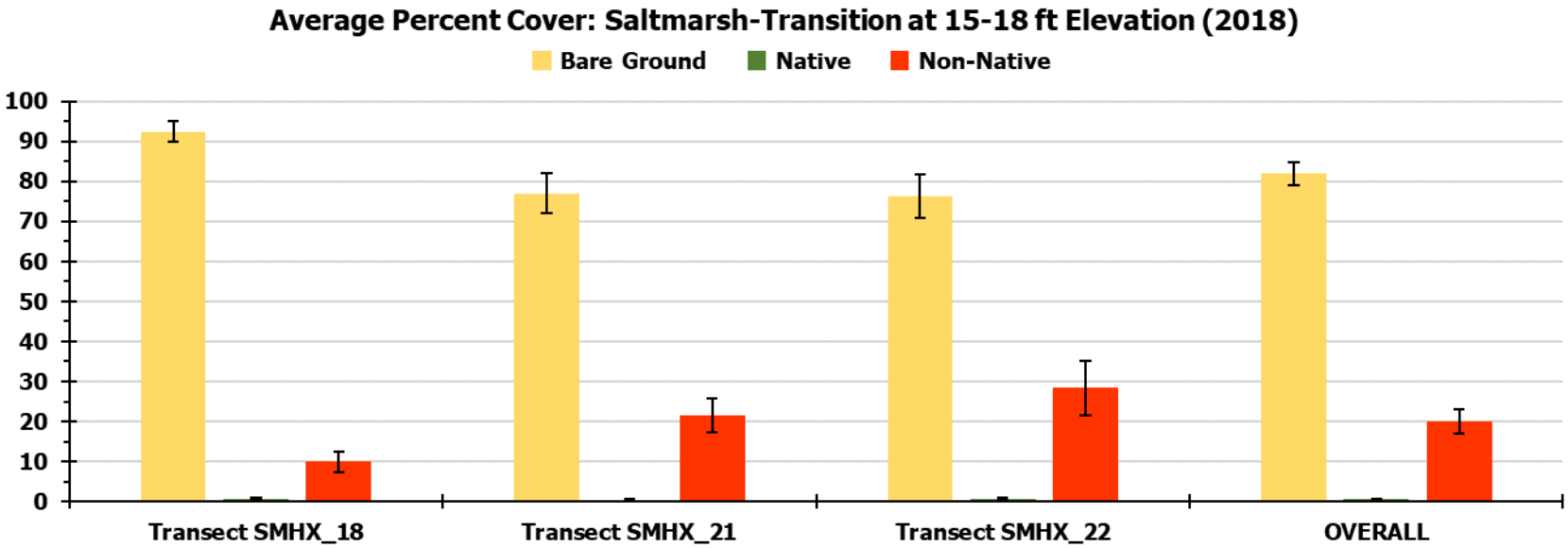


Figure A2.6. Average percent cover (y-axis), with standard error, of native and non-native vegetation, and bare ground recorded in 2018 at three quadrat monitoring transects (x-axis) in the extra-high-elevation (15-18 ft) Saltmarsh-Transition (SMHX) habitat of the North Campus Open Space Restoration Project.

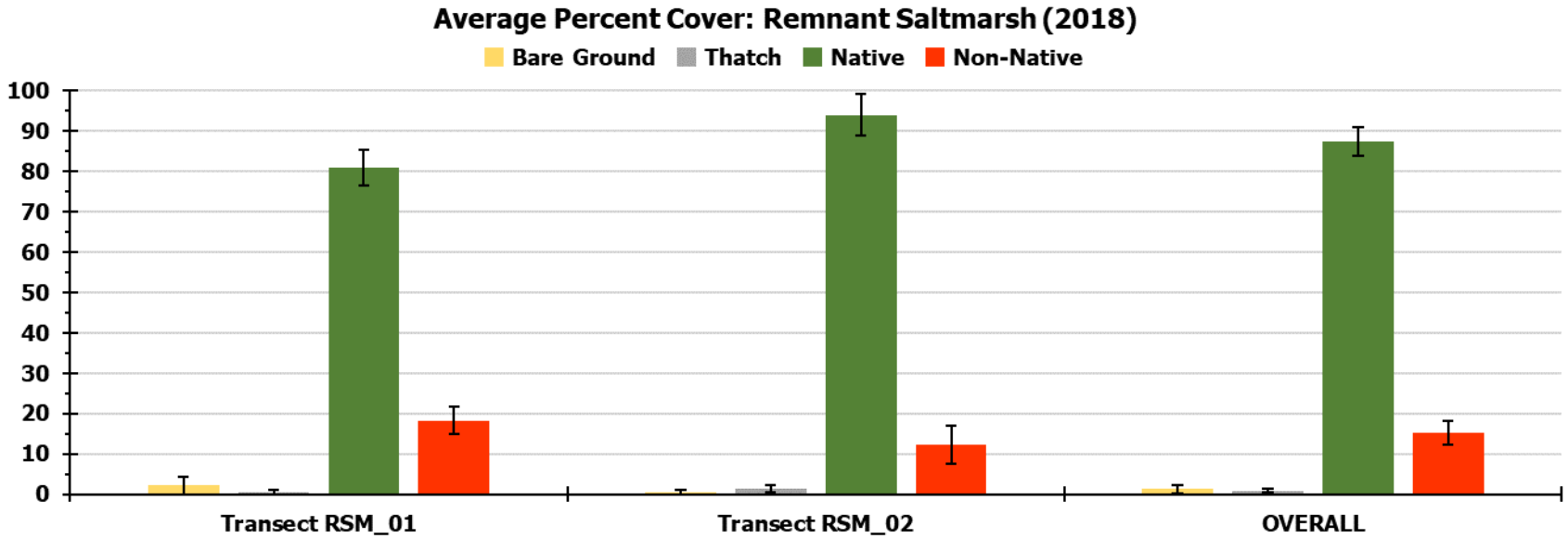


Figure A2.7. Average percent cover (y-axis), with standard error, of native and non-native vegetation, bare ground and thatch recorded in 2018 at two quadrat monitoring transects (x-axis) in the Remnant Saltmarsh (RSM) habitat of the North Campus Open Space Restoration Project.

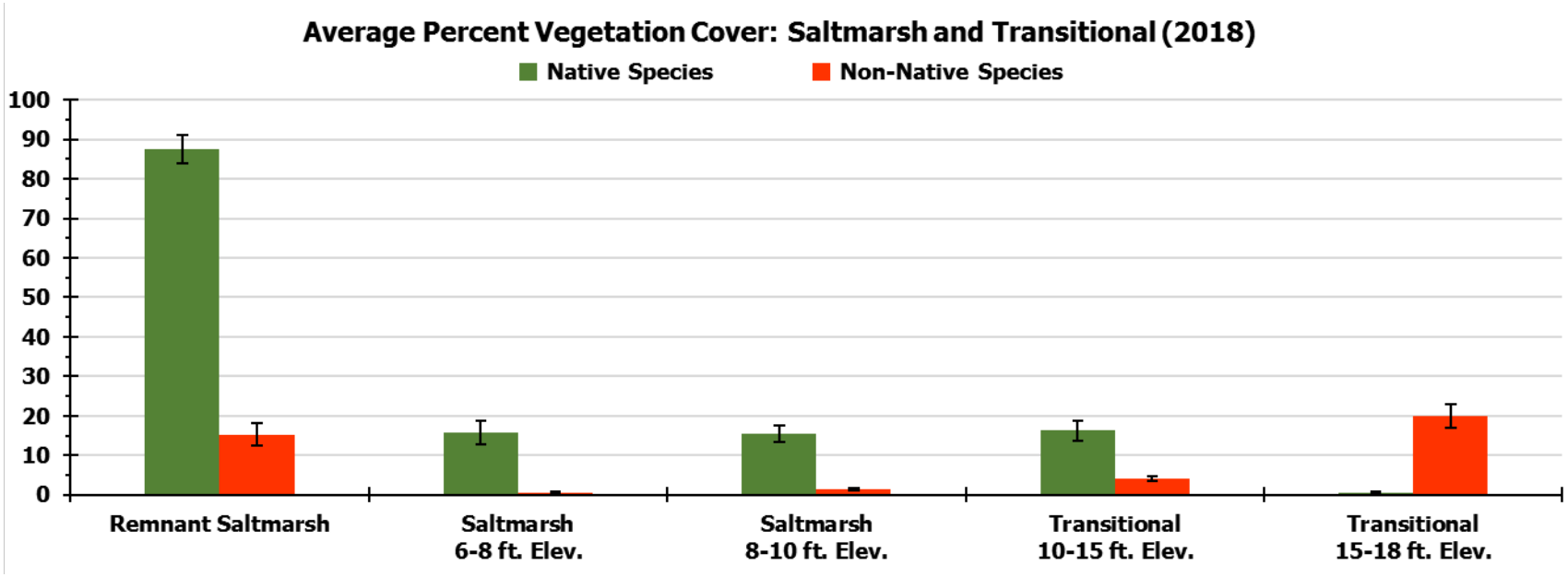


Figure A2.8. Overall average percent cover (y-axis), with standard error, of native and non-native vegetation recorded in 2018 at the five saltmarsh habitats (x-axis) of the North Campus Open Space Restoration Project.

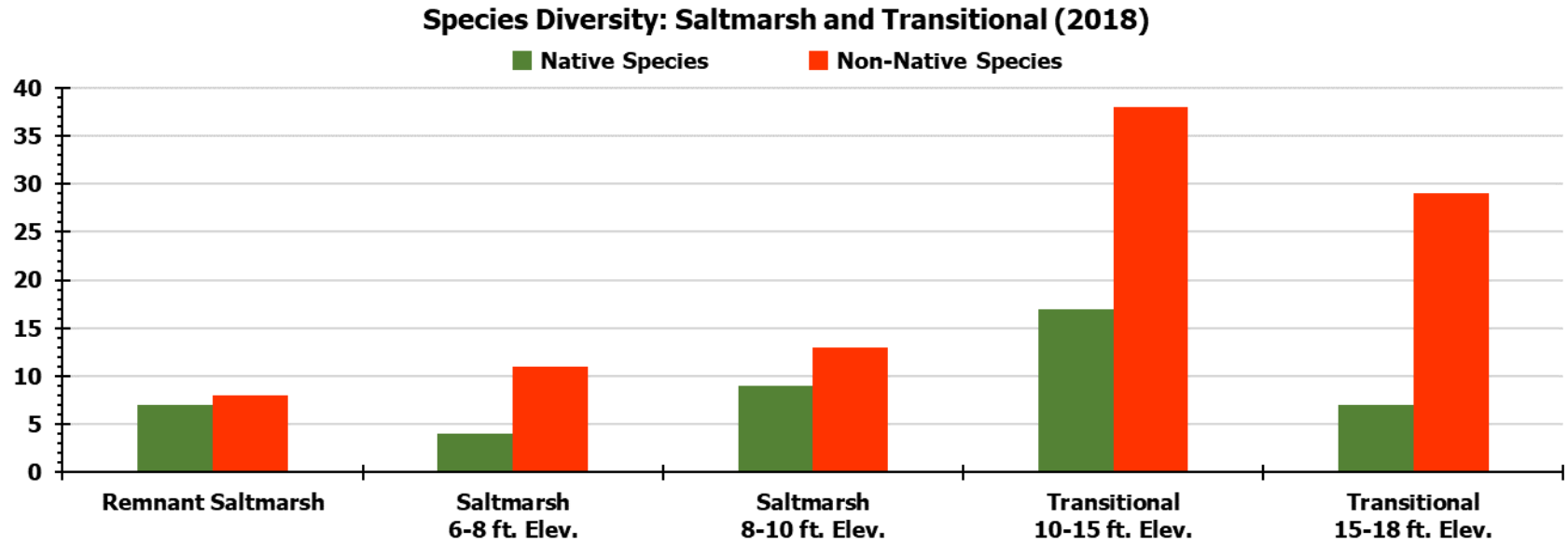


Figure A2.9. Number of native and non-native plant species (y-axis) recorded in 2018 along 22 quadrat monitoring transects in the five saltmarsh habitats (x-axis) of the North Campus Open Space Restoration Project.

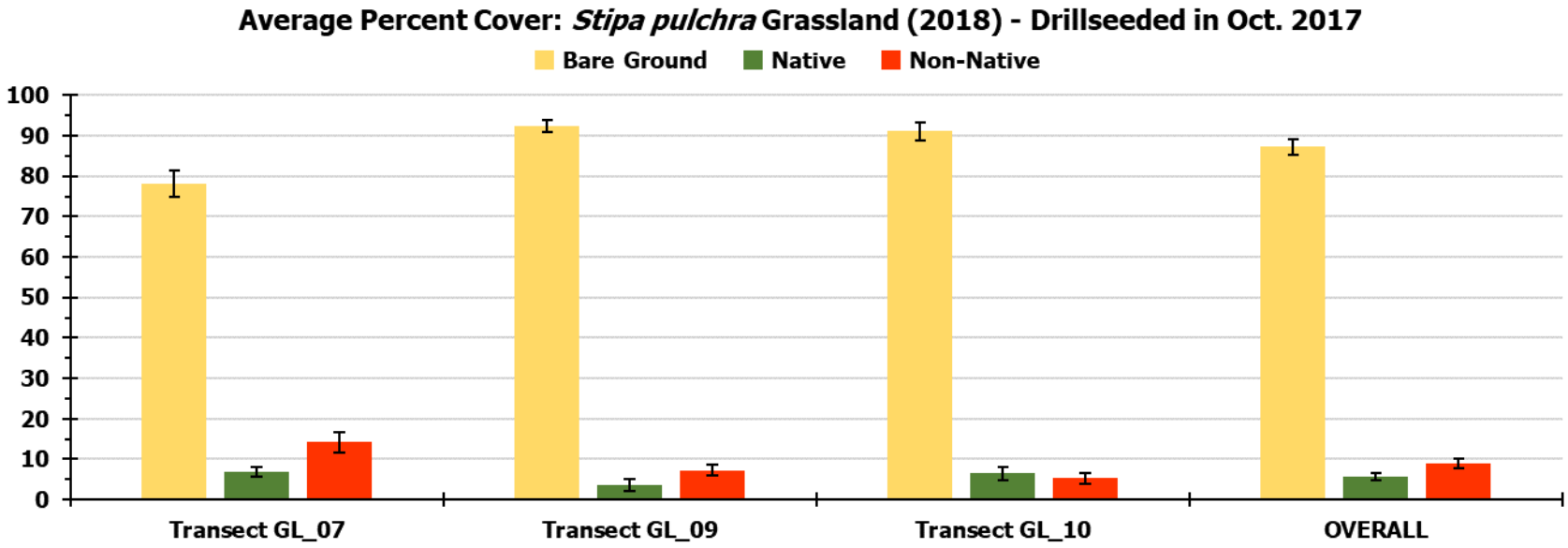


Figure A2.10. Average percent cover (y-axis), with standard error, of native and non-native vegetation, and bare ground recorded in 2018 at three quadrat monitoring transects (x-axis) in the Perennial (*Stipa pulchra*) Grassland (GL) planted in October 2017 at the North Campus Open Space Restoration Project.

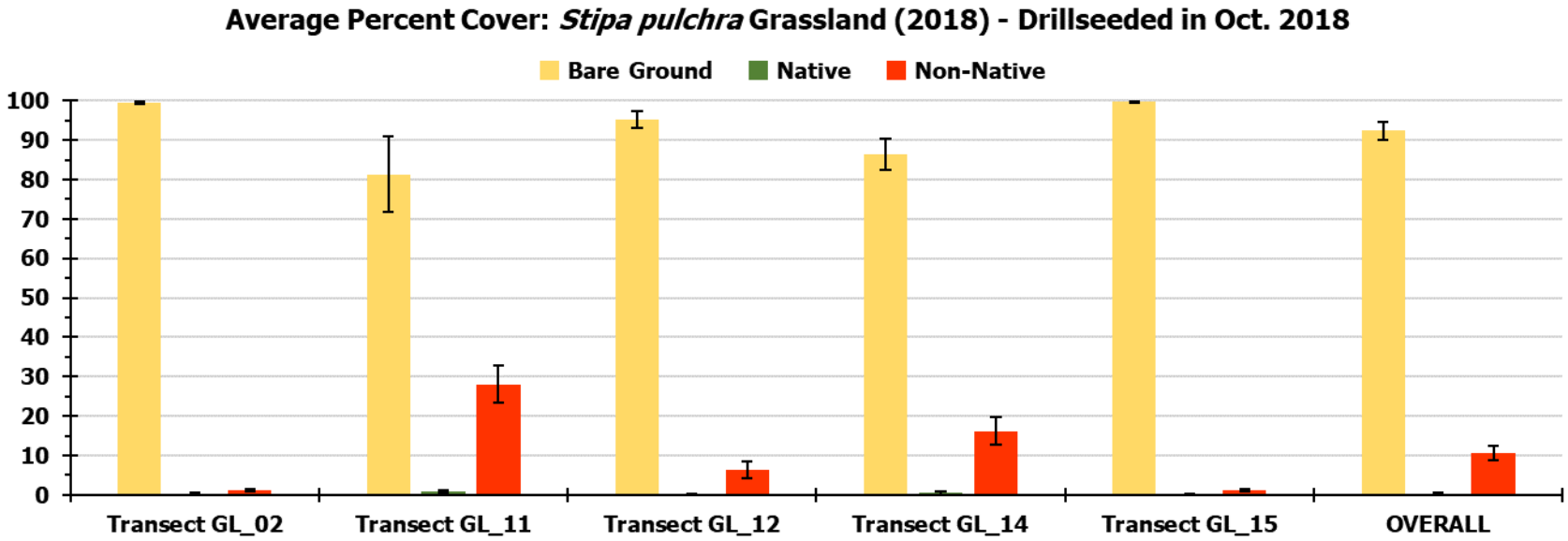


Figure A2.11. Average percent cover (y-axis), with standard error, of native and non-native vegetation, and bare ground recorded in 2018 at five quadrat monitoring transects (x-axis) in the Perennial (Stipa pulchra) Grassland (GL) planted in October 2018 at the North Campus Open Space Restoration Project.

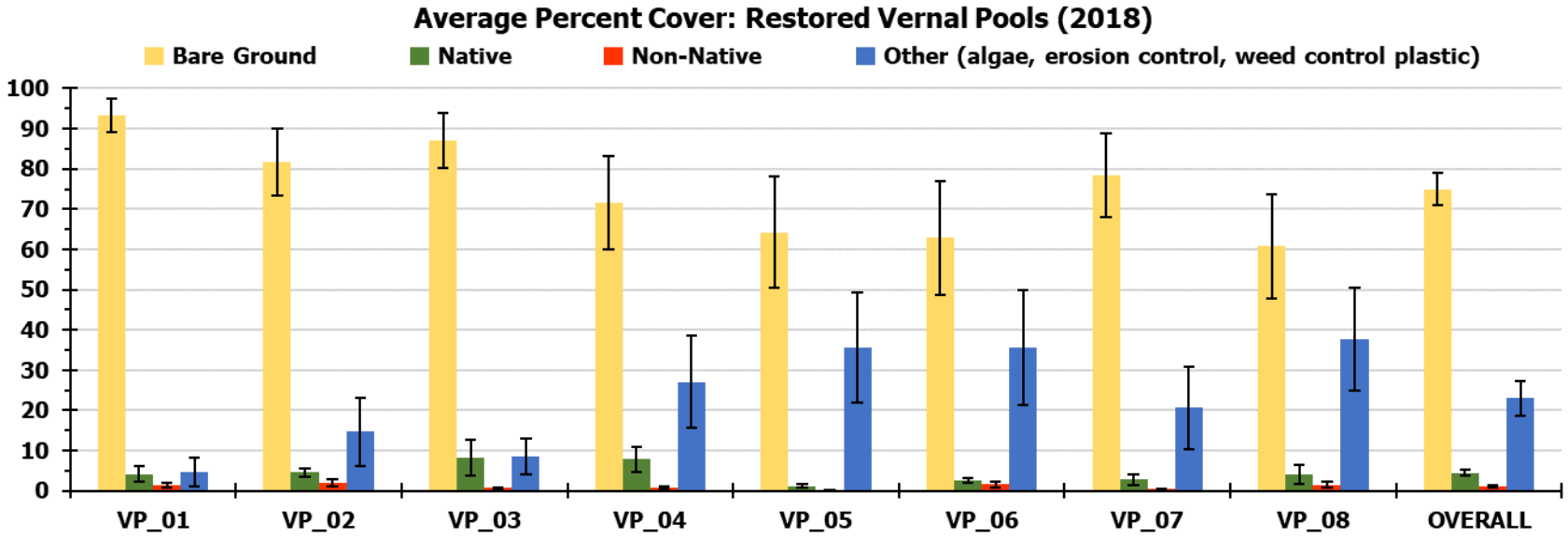


Figure A2.12. Average percent cover (y-axis), with standard error, of native and non-native vegetation, bare ground and other, uncategorized types recorded in 2018 at quadrat monitoring transects (x-axis) across the eight restored Vernal Pools (VP) at the North Campus Open Space Restoration Project.

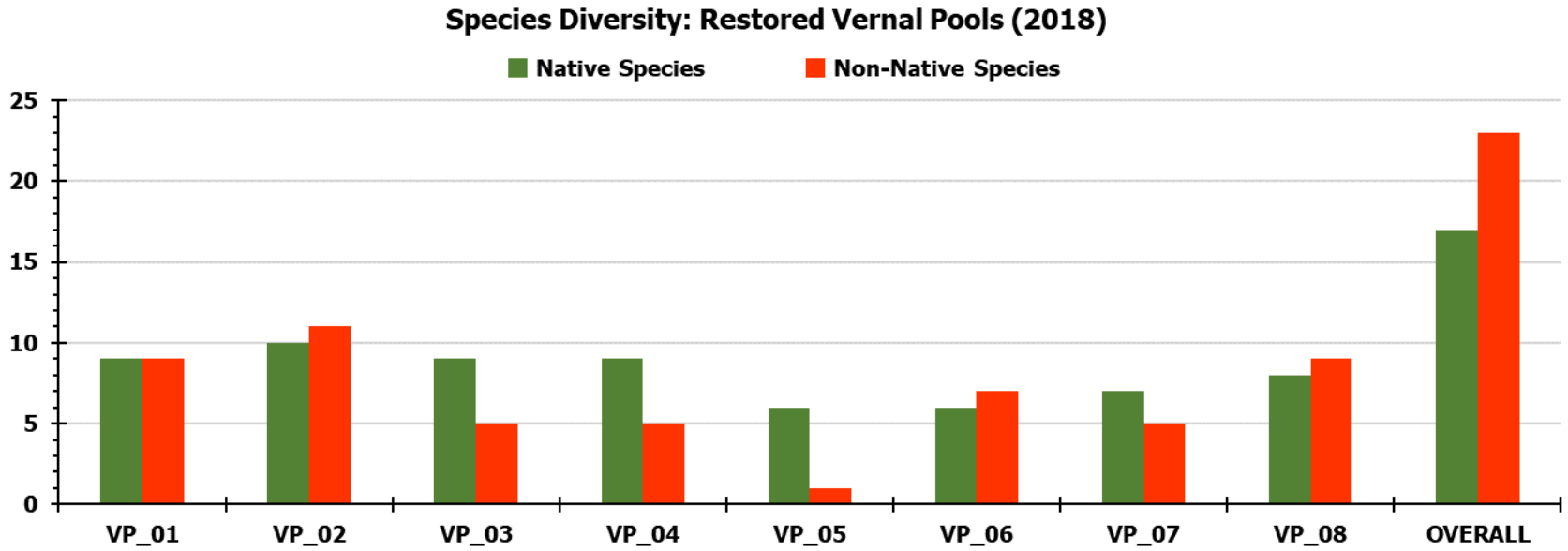
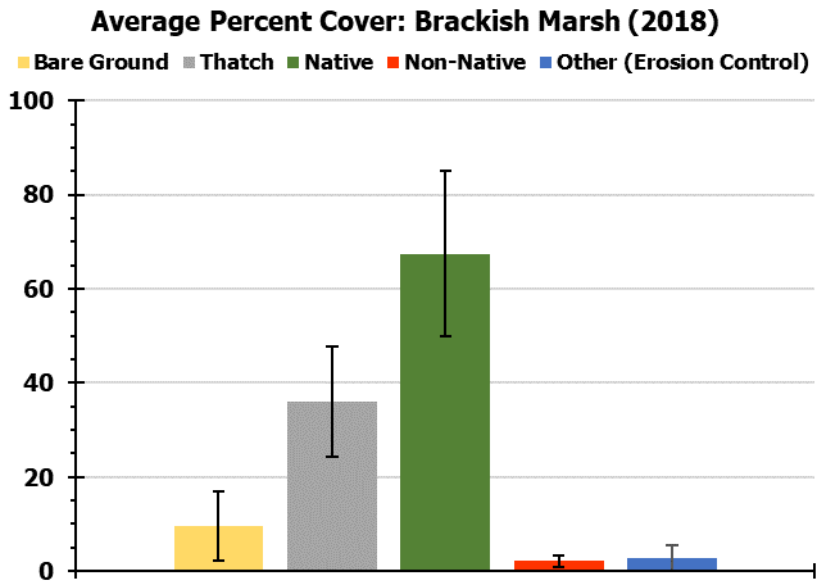


Figure A2.13. Number of native and non-native plant species (y-axis) recorded in 2018 along a quadrat monitoring transect across each of the eight vernal pools (x-axis) created on the Mesa of the North Campus Open Space Restoration Project.



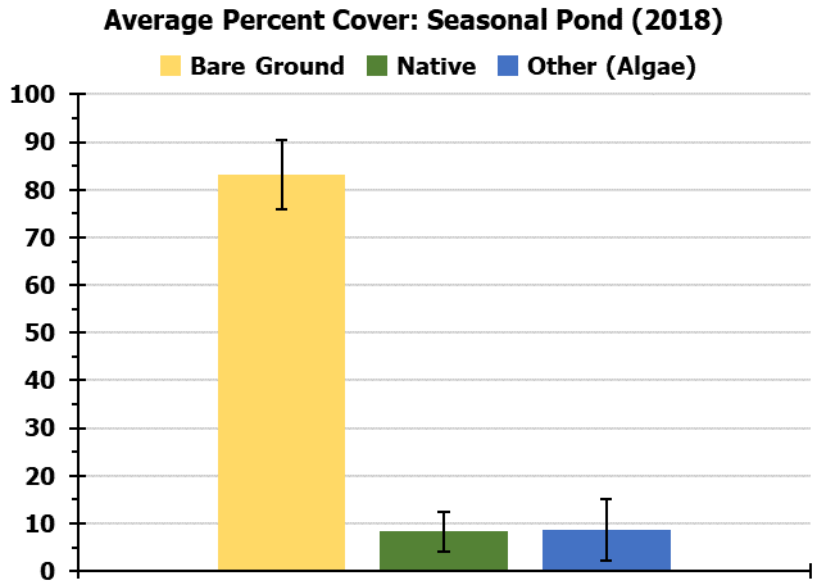
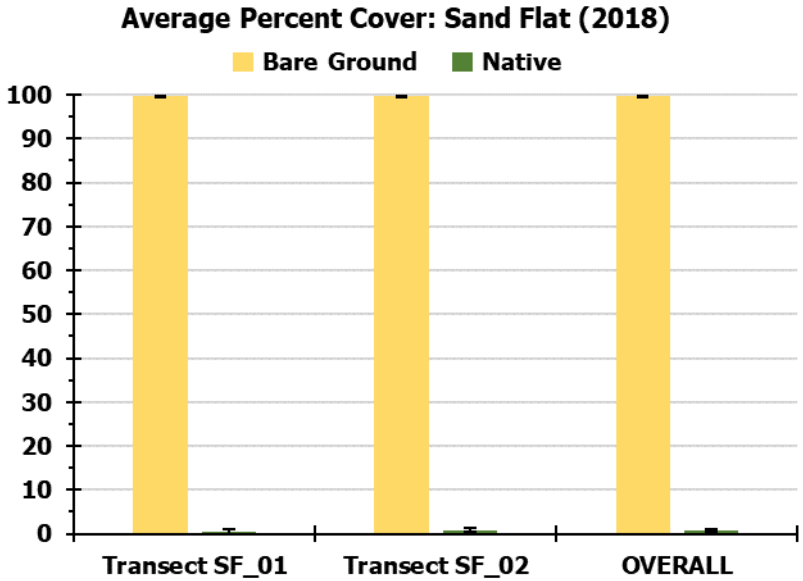


Figure A2.14. Average percent cover (y-axis), with standard error, of native and non-native vegetation, bare ground, thatch and other, uncategorized types recorded in 2018 at quadrat monitoring transects (x-axis) across the Brackish Marsh and Seasonal Pond habitats at the North Campus Open Space Restoration Project.



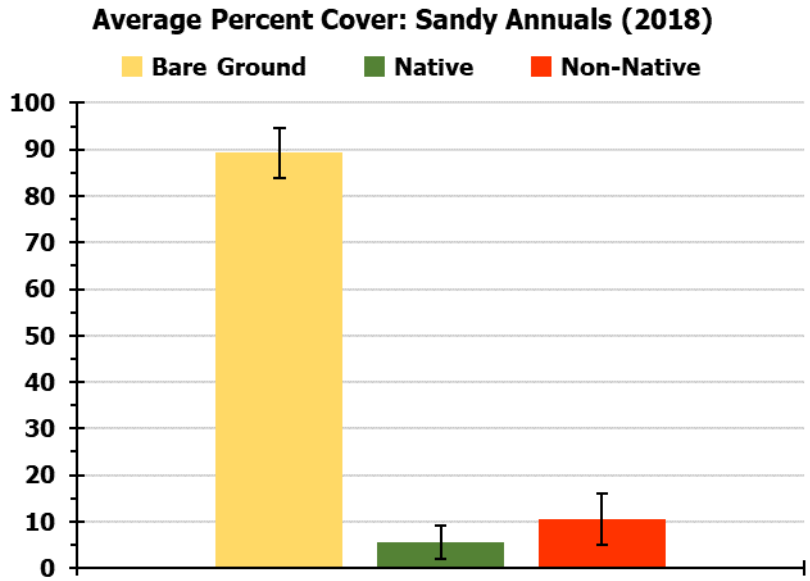


Figure A2.15. Average percent cover (y-axis), with standard error, of native and non-native vegetation and bare ground recorded in 2018 at quadrat monitoring transects (x-axis) in the Sand Flat and Sandy Annuals habitats at the North Campus Open Space Restoration Project.

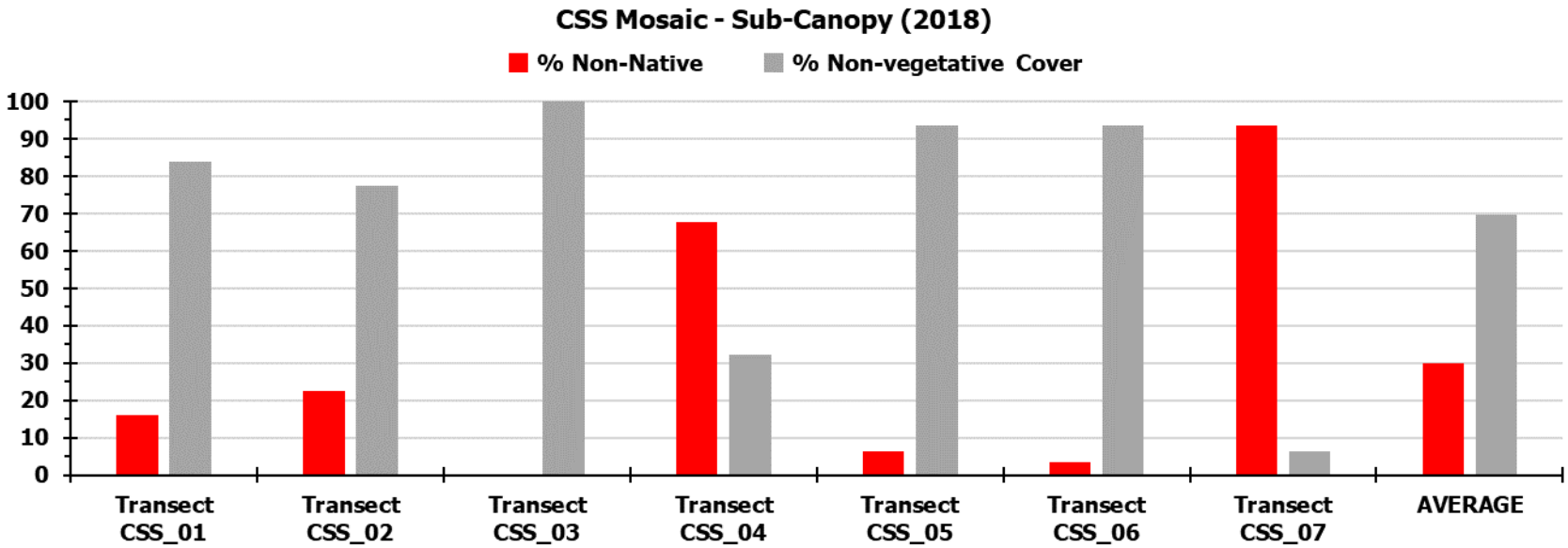


Figure A2.16. Average percent cover (y-axis) of non-native vegetation and other, non-vegetative types recorded in 2018 along point-intercept transects (x-axis) in the Coastal Sage Scrub (CSS) Mosaic habitat at the North Campus Open Space Restoration Project.

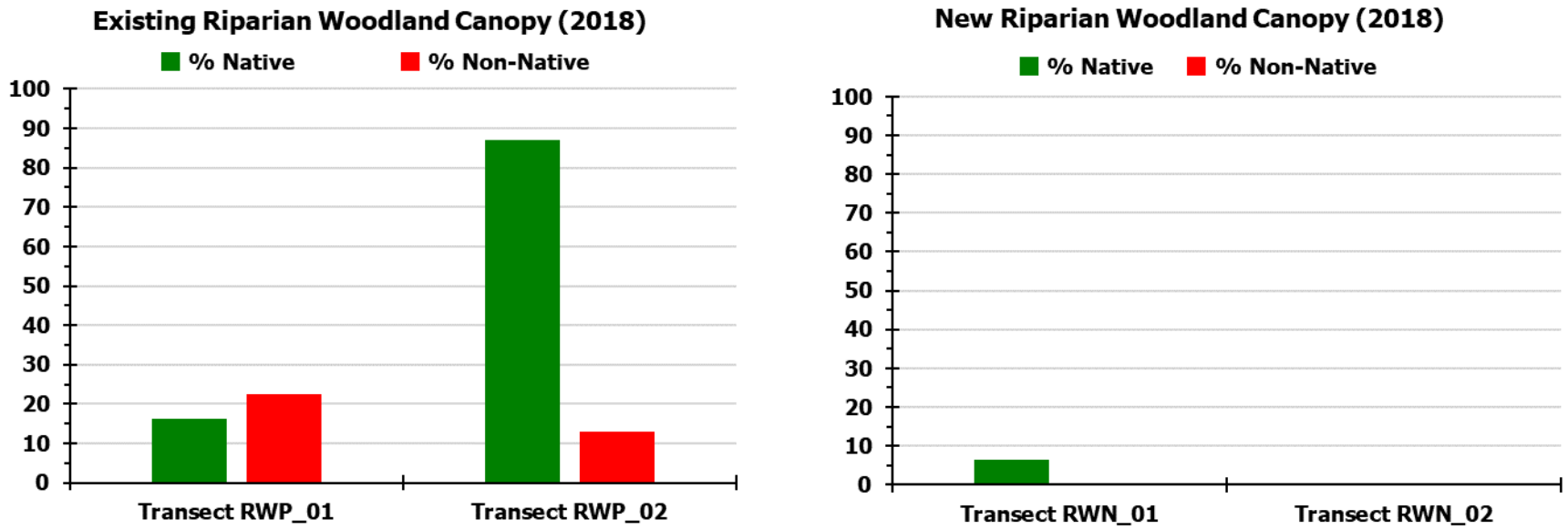
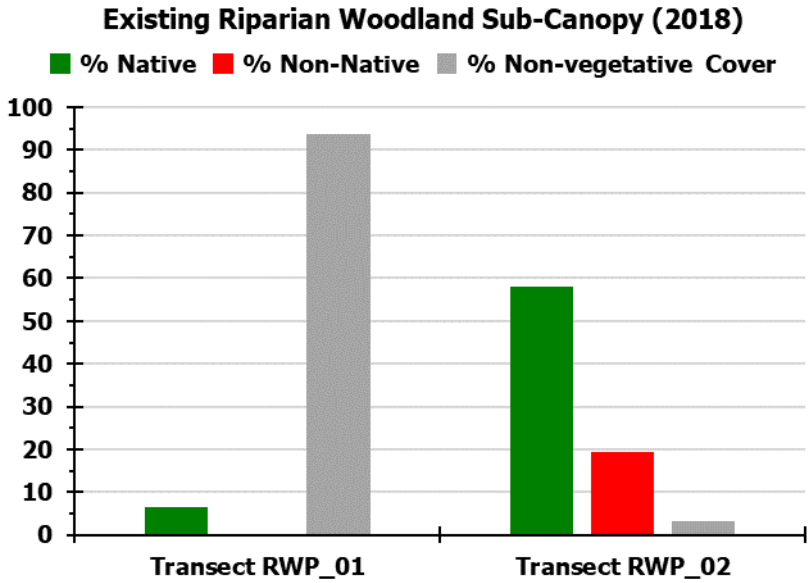


Figure A2.17. Average percent cover (y-axis) of native and non-native canopy (above 2 meters) vegetation recorded in 2018 along point-intercept transects (x-axis) in the Existing and Restored Riparian Woodland habitats at the North Campus Open Space Restoration Project.



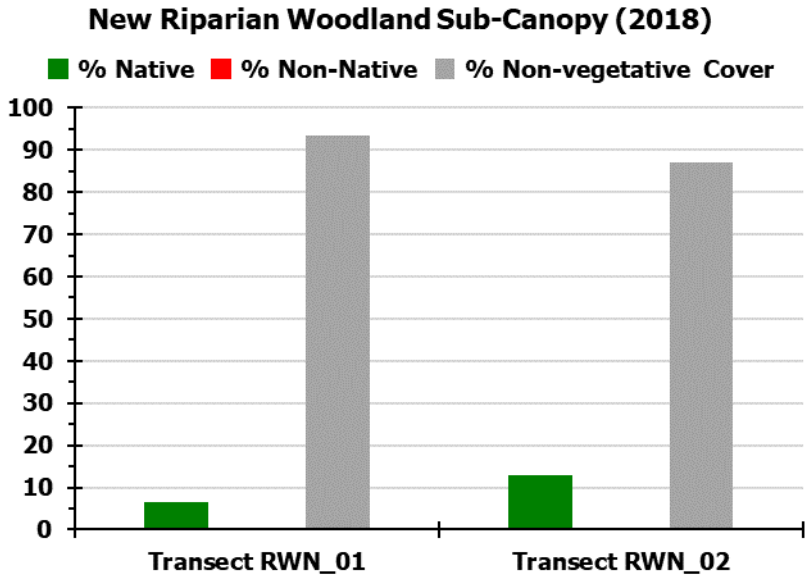


Figure A2.18. Average percent cover (y-axis) of native and non-native sub-canopy (below 2 meters) vegetation and other, non-vegetative types recorded in 2018 along point-intercept transects (x-axis) in the Existing and Restored Riparian Woodland habitats at the North Campus Open Space Restoration Project.

Appendix 3 – Bird Survey Species List

Complete list of species observed, including the total number of times each species was observed and the total number of individuals of each species observed throughout the first year (September 2017 through August 2018) of monthly bird surveys at the North Campus Open Space Restoration Project. The species are listed in alphabetical order by common name and grouped by guild.

Guild & Species	Total Count of Individuals	Total Count of Observations
Ducks & Geese	**516**	**102**
Aleutian Cackling Goose	15	5
American Coot	6	5
American Wigeon	7	3
Blue-winged Teal	1	1
Bufflehead	2	2
Canada Goose	166	16
Cinnamon Teal	24	7
Eared Grebe	3	2
Gadwall	19	7
Greater White-fronted Goose	56	7
Hooded Merganser	1	1
Mallard	193	35
Northern Pintail	3	2
Northern Shoveler	9	3
Redhead	1	1
Ruddy Duck	10	5
Granivores	**790**	**174**
Blue Grosbeak	1	1
Brown-headed Cowbird	1	1
Dark-eyed Junco	1	1
Eurasian Collared Dove	13	8
Goldfinch spp.	1	1
House Finch	229	72
Lark Sparrow	8	2
Lesser Goldfinch	22	13
Mourning Dove	94	23
Rock Pigeon (Feral Pigeon)	282	29
Scaly-breasted Munia	138	23
Gulls	**99**	**13**
California Gull	12	2
Ring-billed Gull	36	3
Western Gull	51	8
Herons & Egrets	**109**	**33**
Black-crowned Night Heron	4	2
Great Blue Heron	16	14

Guild & Species	Total Count of Individuals	Total Count of Observations
Great Egret	43	6
Green Heron	7	7
Snowy Egret	39	4
Hummingbirds	**127**	**93**
Allen's Hummingbird	7	5
Anna's Hummingbird	112	81
Hummingbird spp.	5	5
Rufous Hummingbird	3	2
Insectivores	**1410**	**428**
Acorn Woodpecker	4	2
American Pipit	171	23
Barn Swallow	10	6
Belding’s Savannah Sparrow	14	8
Bewick's Wren	14	13
Black Phoebe	72	65
Blue-gray Gnatcatcher	8	7
Bullock's Oriole	1	1
Bushtit	60	9
California Thrasher	2	2
Cassin's Kingbird	18	11
Cliff Swallow	347	26
Downy Woodpecker	2	2
European Starling	20	6
Fox Sparrow	1	1
Golden-crowned Sparrow	2	1
Great-tailed Grackle	2	1
Hairy Woodpecker	2	2
Hooded Oriole	6	4
House Wren	4	4
Northern Rough-winged Swallow	21	10
Pacific-slope Flycatcher	1	1
Phoebe spp.	1	1
Red-winged Blackbird	32	12
Rock Wren	2	2
Ruby-crowned Kinglet	5	5
Savannah Sparrow	3	1
Say's Phoebe	46	42
Song Sparrow	104	69
Tree Swallow	11	4
Vaux's Swift	2	1
Western Bluebird	53	28
Western Kingbird	1	1
Western Meadowlark	216	19

Guild & Species	Total Count of Individuals	Total Count of Observations
Western Wood Pewee	1	1
White-crowned Sparrow	151	37
Marsh Dwellers	**8**	**5**
Sora	2	2
White-faced Ibis	1	1
Wilson's Snipe	5	2
Omnivores	**421**	**152**
American Crow	251	53
California Towhee	112	77
House Sparrow	48	14
Northern Mockingbird	8	6
Sparrow spp.	1	1
Spotted Towhee	1	1
Piscivores	**1**	**1**
Double-crested Cormorant	1	1
Raptors / Carnivores	**74**	**64**
American Kestrel	6	5
Cooper's Hawk	11	11
Loggerhead Shrike	9	9
Red-shouldered Hawk	10	8
Red-tailed Hawk	18	17
Turkey Vulture	9	7
Unidentified Hawk	2	1
White-tailed Kite	9	6
Waders & Shorebirds	**1172**	**221**
Black-necked Stilt	10	5
Dunlin	1	1
Greater Yellowlegs	21	17
Killdeer	454	93
Least Sandpiper	169	45
Long-billed Curlew	2	2
Red-necked Phalarope	4	2
Sandpipers	40	1
Semipalmated Plover	352	16
Spotted Sandpiper	1	1
Western Sandpiper	116	36
Western Snowy Plover	1	1
Willet	1	1
Warblers	**110**	**56**
Common Yellowthroat	19	16
Orange-crowned Warbler	4	3
Yellow Warbler	1	1
Yellow-rumped Warbler	86	36

Appendix 4 – Devereux Slough and UCSB North Campus Open Space Post-Construction Aquatic Species Survey Report

Technical Memorandum

Date 4 February 2019

To: Lisa Stratton, UCSB

From: Rosemary Thompson

RE: **Devereux Slough and UCSB North Campus Open Space Post-Construction Aquatic Species Survey Report**

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1 Introduction

The Cheadle Center for Biodiversity and Ecological Restoration (CCBER) at The University of California, Santa Barbara (UCSB) is in the process of restoring the former Ocean Meadows Golf Course to native upland and wetland/marsh habitats in Santa Barbara County. This area is called the North Campus Open Space (NCOS) and includes the downstream end of Devereux Creek from the west, Phelps Creek from the north, and stormwater inflows from the northeast that converge and drain into Devereux Slough (Figure 1). Prior to restoration, Devereux Creek flowed into Devereux Slough at a weir on the north side of Venoco Access Road. The weir has been removed, and grading has restored portions of the upper channels of Devereux Slough, allowing tidal influence upstream to near the Phelps Creek confluence and the eastern channel. Preconstruction surveys of Devereux Creek and Phelps Creek by Rosemary Thompson and CCBER staff in 2016, and a post-construction survey in the Fall of 2017 found no tidewater gobies to be present. Post-construction surveys for southwestern pond turtles, California red-legged frogs, tidewater gobies, and other aquatic species were conducted by Rosemary Thompson (federal permit TE-815144-9, state permit SC-002731) on 8, 9, and 23 August 2018 in Devereux Slough, the restored channels, and lower Phelps Creek with assistance from CCBER staff (Lisa Stratton, Beau Tindall, and Darwin Richardson). The methods used and results of the surveys are described below.

2 Methods

California red-legged frog. A night survey for California red-legged frog was conducted on 8 August in areas of open water on NCOS. This included Phelps Pond, Devereux Creek at the confluence of Phelps Creek, and Red Pond (Figure 1). The survey was conducted from 8:30 to 9:05 PM using flashlights (Maglite 3D cell) to look for eyeshine. Air temperature was approximately 66ºF. All of the open water and adjacent banks were scanned with the flashlights. A day survey with binoculars was conducted in combination with the southwestern pond turtle survey on 9 August (see below).

Southwestern pond turtle. A visual survey of open waters on NCOS was conducted from 9:30 to 11:00 AM on 9 August using binoculars. The weather was sunny with a light breeze. Areas surveyed were Phelps Pond, Phelps Creek confluence with Devereux Creek, Phelps Creek (from access points on the bank), Red Pond, and the restored estuarine East Channel near the bridge (Figure 1). The biologists carefully approached the habitat and scanned the water surface and banks while standing still.

Tidewater goby and other fish. Sampling sites were selected in the field based on access, water depth, and least amounts of aquatic vegetation (primarily *Ruppia*). Three locations in Devereux Slough were seined (Figure 2). Three locations in the restored channels were also seined, one near Venoco Road, one in the East Channel, and one in the Main Channel (Figure 2). A minnow seine 3 meters (m) long by 1 m high with 3 mm mesh was used for the sampling. Seine hauls varied in length depending on how much the *Ruppia* and filamentous green algae

clogged the net. The length of the seine hauls varied from about 6 m to 11 m. The seine was pulled parallel to shore and then swept into the shoreline, lifted, and placed on the shore. Fish captured were identified and counted. The native fish were then returned to the water. Water Depth ranged from approximately 0.3 to 0.6 m. Phelps Creek was sampled using dip nets with 3 mm or smaller mesh. Many sweeps were made wherever open water occurred with minimal obstructions. Organisms captured were identified and released.

Water quality. Water quality parameters (dissolved oxygen in mg/l and salinity in ppt) were measured with a YSI Pro 2030 at four locations. Due to high salinity at the confluence of the East and Main channels and near Venoco Bridge, dissolved oxygen was measured in percent saturation.

3 Results and Discussion

3.1 Results

California red-legged frog. No California red-legged frogs were observed (day or night) at any of the locations surveyed.

Southwestern pond turtle. No southwestern pond turtles were observed at any of the locations surveyed.

Fish. Table 1 summarizes the fish and crayfish captured. All fish captured are native to the area, except the silversides that have been introduced in California and appear to be spreading, and mosquitofish. The crayfish are also not native. The killifish ranged from approximately 25 to 75 millimeters (mm) in total length. The longjaw mudsuckers were approximately 50 to 150 mm in length. No tidewater gobies were captured.

Water Quality. Water quality measured at the sample sites is presented in Table 2. All of the fish species collected can tolerate a wide range of salinities.

Table 1 Fish Captured on 23 August 2018

Site	Common Name	Scientific Name	Number	Method
PC	Mosquitofish	*Gambusia affinis*	47	Dipnet
	Red swamp crayfish	*Procambarus clarkii*	52	
PC mouth	Mosquitofish	*Gambusia affinis*	29	dipnet
	Red swamp crayfisn	*Procambarus clarkii*	4	
DS-L	California killifish	*Fundulus parvipinnis*	76	seine
	Longjaw mudsucker	*Gillichthys mirabilis*	33	
	Mississippi silversides	*Menidia audens*	45*	
	Topsmelt	*Atherinops affinis*	5*	
DS-M	California killifish	*Fundulus parvipinnis*	51	seine
	Longjaw mudsucker	*Gillichthys mirabilis*	7	
	Mississippi silversides	*Menidia audens*	8*	
	Topsmelt	*Atherinops affinis*	0	
DS-U	California killifish	*Fundulus parvipinnis*	127	seine
	Longjaw mudsucker	*Gillichthys mirabilis*	5	
	Mississippi silversides	*Menidia audens*	1	
MC-L	California killifish	*Fundulus parvipinnis*	2	seine
	Longjaw mudsucker	*Gillichthys mirabilis*	10	

Site	Common Name	Scientific Name	Number	Method
MC	Mosquitofish	*Gambusia affinis*	5	seine
EC	California killifish	*Fundulus parvipinnis*	4	seine
	Longjaw mudsucker	*Gillichthys mirabilis*	13	
	Mosquitofish	*Gambusia affinis*	1	
	Mississippi silversides	*Menidia audens*	6	
*A few of the silversides may have been topsmelt				
PC = Phelps Creek DS = Devereux Slough; L= lower, M = middle, U = upper MC = Main Channel; L = lower; EC = East Channel				

Table 2 Water Quality at Fish Sample Sites

Site	Salinity (ppt)	Dissolved Oxygen (mg/l)
PC	3	11-12
MC*	89	118% saturation
EC	61	5.3
MC-L	84	68.6% saturation

Dissolved oxygen % saturation was measured where salinity was too high for meter to read mg/l
*At confluence of East and Main channels

3.2 Discussion

California red-legged frog and southwestern pond turtle. Most of the aquatic habitat associated with the restored estuarine channels on NCOS currently has limited emergent vegetation and the banks are also sparsely vegetated. However, both emergent and bank vegetation is becoming established by natural colonization (primarily emergent species) and planting of native species on the banks and adjacent uplands. As this vegetation develops, it will provide cover for the California red-legged frog. However, high salinity in the estuarine habitat (up to 65 ppt) may limit suitability for California red-legged frogs. Rocks along the shore at the mouth of Phelps Creek will provide pond turtle basking sites as will algal mats that develop in the summer.

Habitat in Phelps Creek is suitable for California red-legged frog, with abundant cover. This dense cover makes it difficult to conduct a good day or night visual survey for this species. The creek also provides suitable habitat for the southwestern pond turtle, although the area is well shaded with reduced availability of good basking sites. Subsequent to the August survey, the pond turtle has been observed in the Phelps Pond area at NCOS.

Fish. No tidewater gobies were captured in Phelps Creek, although this species has been reported in that creek in the past. Tidewater gobies remaining upstream or any in Devereux Slough could expand into NCOS aquatic habitats in the future. Although no tidewater gobies were captured in Devereux Slough, it is possible that some are still present in very low abundance. Only a small proportion of the Slough was sampled so a few could have been present in areas not sampled. Continued sampling several times a year will help to determine if any are present.

The fish species collected in Devereux Slough are now present in the restored estuarine channels on NCOS. Removal of the weir at the Venoco Road crossing has allowed them access to upstream areas. Abundance of these species is expected to fluctuate over time in response to changes in habitat conditions and may stabilize as the restored area reaches a dynamic equilibrium

The non-native red swamp crayfish is well established in Phelps Creek. Its spread into the restored channels will likely be limited by its intolerance to high salinity.

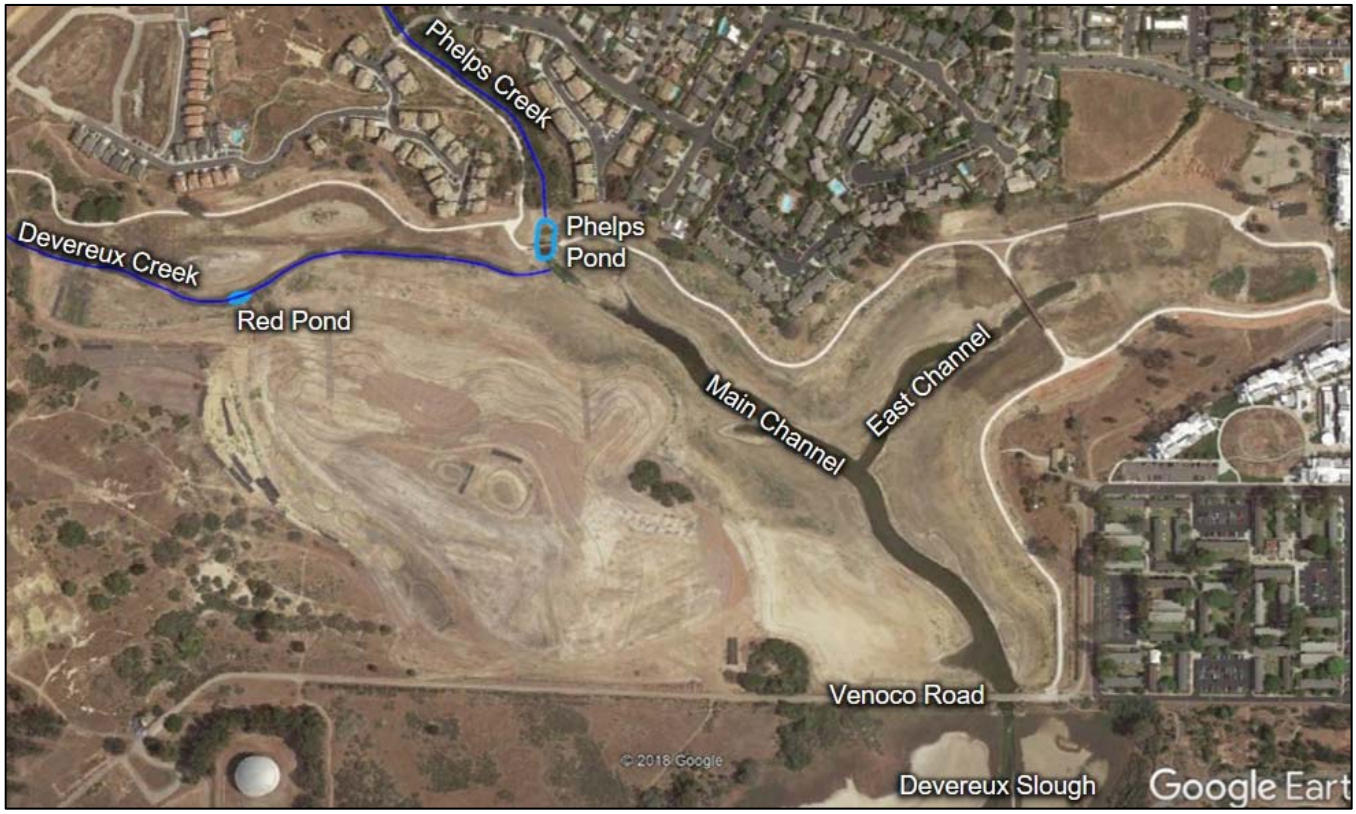

Figure 1 Creeks, channels, and ponds on NCOS.

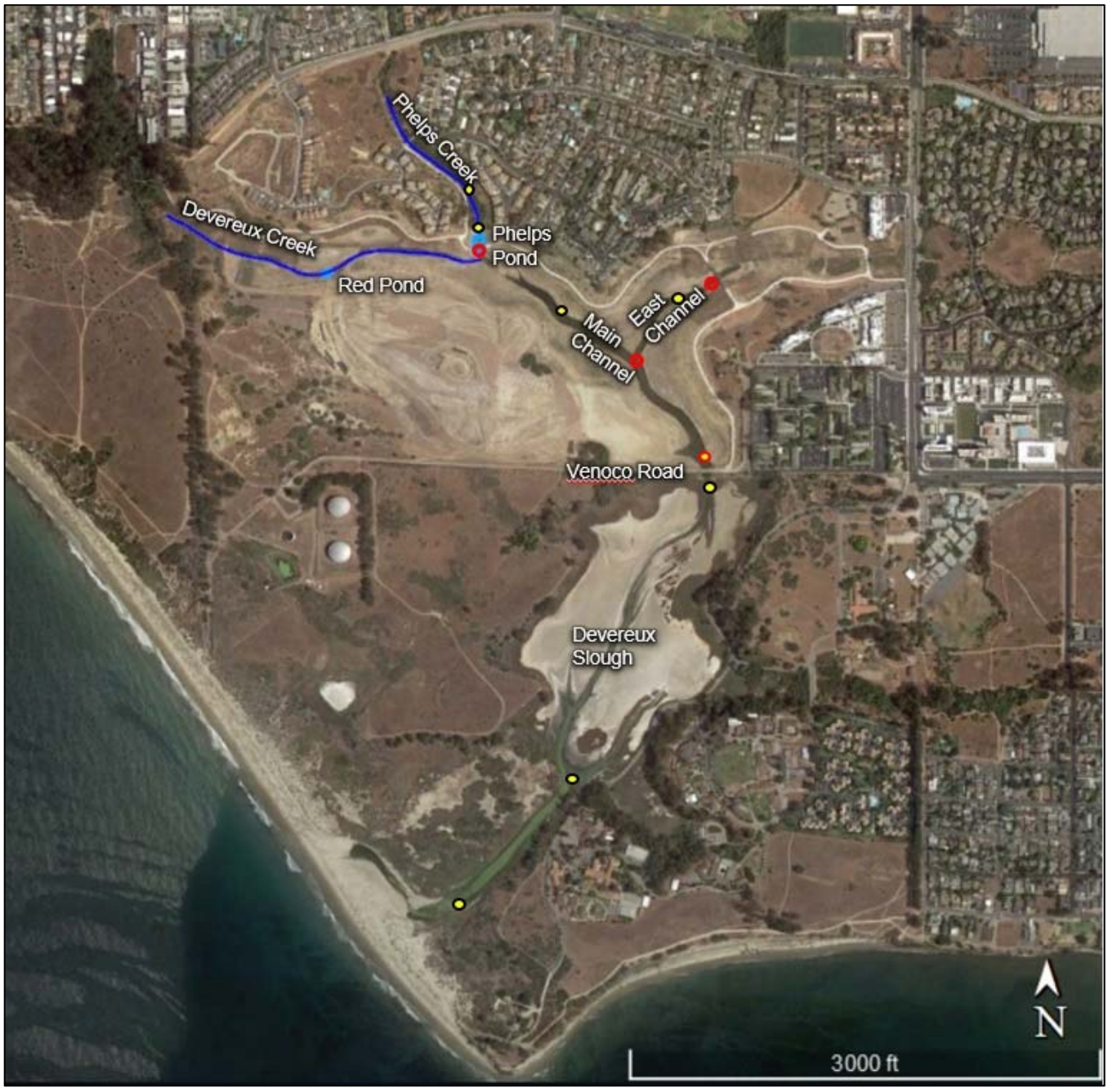

Figure 2 Fish sample locations (yellow circles) and water quality sample locations (circles with red outline).