State of Louisiana

Coastal Protection and Restoration Authority of Louisiana (CPRA)

2021 Operations, Maintenance, and Monitoring Report

for

Sabine Refuge Marsh Creation Cycles – 3, 4 & 5

State Project Number CS-28-3 and CS-28-4-5
Priority Project List 8

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Cameron Parish

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Preface

The Sabine Refuge Marsh Creation Project (CS-28) was originally an Army Corps of Engineer (USACE) sponsored project approved in 1999 as part of the Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) Project Priority List 8. The project was later broken into five cycles. In 2012 the CWPPRA Task Force transferred the Lead Federal Agency role to Fish and Wildlife Service (USFWS) for Cycles 4 & 5 and future cycles. The Sabine Refuge Marsh Creation Cycles 3 and Cycle 4 & 5 Projects (CS-28-3 & CS-28-4-5) were completed in September 2010 and March 2015, respectively. US Army Corps of Engineers (USACE) as federal sponsor for Cycle 3, U.S. Fish and Wildlife Service (USFWS) as the federal sponsor for Cycles 4 & 5, and the Coastal Protection and Restoration Authority (CPRA) as local sponsor are responsible for O&M and Monitoring activities through their respective twenty year project life. The 2021 OM&M Report format combines the Operations and Maintenance annual project inspection information with the Monitoring data and analyses for the project. This report includes monitoring data collected through December 2021, and annual Maintenance Inspections through October 5, 2021.

This report is intended to update USFWS and USACE on the latest land change, vegetation, and elevation change data. The 2021 report is the 6th report in a series of OM&M reports on the CS-28 Cycles. For more detailed analysis, see the previous OM&M reports (2005, 2007, 2011 and 2014) online at (http://lacoast.gov/new/Projects/Info.aspx?num=CS-28-1 or CS28-2, CS-28-3 or CS-28-4-5). Future reports are planned in 2025 and 2031, with a final OM&M report planned for 2034.

I. Introduction

The Sabine Refuge Marsh Creation project area is composed of 3,550 acres (1,437 ha) of wetlands located in the Calcasieu-Sabine Basin on the Chenier Plain west of Hwy 27 and Calcasieu Lake. The project area is within the Sabine National Wildlife Refuge and roughly bounded by Starks North Canal to the north and east, Back Ridge Canal to the south, and existing marsh to the west (Figure 1). Most land loss in the area occurred between 1956 and 1978 (United States Department of Agriculture [USDA] 1993) with the highest loss rate around 1965 (Dunbar et. al. 1990). The current land loss rate in the project area is approximately 0.5 square miles (1.3 km^2) per year (United States Army Corp of Engineers [USACE] 2000). Major causes for the land loss are vegetation death caused by hurricanes, oil and gas canals and the subsequent altered hydrology, and saltwater intrusion via large navigation canals acting as conduits for Gulf of Mexico water (USDA 1993). Saltwater from the Calcasieu Ship Channel (CSC) has been introduced from several sources including the GIWW through Alkali Ditch and the West Cove Canal via Back Ridge Canal (Miller 1997). More recently, land loss has been attributed to wind driven waves eroding marshes surrounding the large open water areas. Vegetation has shifted from intermediate sawgrass dominated marsh including *Cladium jamaicense* (sawgrass), *Schoenoplectus californicus* (giant bulrush), and *Phragmites australis* (Roseau cane), with some fresh marsh to more brackish species including *Spartina patens* (saltmeadow cordgrass), *Spartina alterniflora* (smooth cordgrass), and *Bolboschoenus robustus* (sturdy bulrush) since at least 1968 (Chabreck and Linscombe 1968, 1978, 1988). Most of the project is shallow open water with brackish marsh interspersed and on the surrounding edges.

The Sabine Refuge Marsh Creation Project (CS-28) is designed to create approximately 1,120 acres (450 ha) of emergent vegetated marsh and to nourish and protect existing broken marsh via five cycles of dredge spoil placement. The project also incorporated the construction of a permanent spoil disposal pipeline to be used in future marsh creation efforts.

Cycle 1 was constructed during the May 2001 USACE maintenance dredging event of the Calcasieu River by the Operations Division of the U.S. Army Corps of Engineers-New Orleans District. Approximately 834,416 cubic yards of sediment were dredged from the Calcasieu Ship Channel between miles 8.3 to 10.4 and placed in a the Cycle 1 containment area within the Sabine National Wildlife Refuge. Sediments were pumped to 4.0 to 4.4 ft MLG, creating approximately 227 acres of emergent marsh (Table 1). The marsh cell was planted with 36,000 *Spartina alterniflora* plants along the edges of the perimeter and the constructed canals. Plantings were completed but the interior of the marsh cell revegetated quickly on its own. Cycle 1 appeared to have vegetated from the soil seedbank and windborne seed sources so plantings were not recommended for future Cycles. Construction was completed in February 2002.

Cycle 2 marsh creation was constructed as a State Only project using State Surplus Funds during the July 2009 USACE maintenance dredging of the Calcasieu River Ship Channel. Approximately 1,190,812 cubic yards of sediment were dredged from the Calcasieu Ship Channel between miles 8.5 and 10.0 and placed in the Cycle 2 containment area, creating approximately 227 acres of emergent marsh (Table 1). Sediments were pumped to 4.0 to 4.5 ft MLG. A low level weir was utilized to create a nourishment area west of the cell of at least 100 acres. Construction was completed in April 2010. There is no monitoring of this cycle.

Cycle 2 Permanent Pipeline was constructed as a joint effort between the USACE and CPRA and completed in April 2010. The pipeline consists of approximately 19,000 ln ft of 29 in. ID permanent steel pipeline extending form the Calcasieu Lake on the East to the Cycle No. 1 cell on the West. The pipeline is buried in a designated 30ft easement with four above ground locations, the East End Riser, two booster pump locations, and the West End Riser. The permanent pipeline was used in the construction of the Sabine Refuge Marsh Creation Cycles 4 & 5 project.

Cycle 3 was constructed during the September 2006 USACE maintenance dredging event of the Calcasieu River. Approximately 828,767 cubic yards of sediment were dredged from the Calcasieu Ship Channel between miles 9 and 12 and placed into the Cycle 3 containment area. Sediments were pumped to 2.6 to 4.2 ft MLG, creating approximately 193 acres of emergent marsh (Table 1). Containment levees on the northwest side of the area were breached every 500 ft to allow for delta formation. Construction of the fill area was completed in March 2007; however, USACE records has the CWPPRA project life starting in September 2010.

Cycles 4 &5, 1A-North and 1A-South were constructed during the September 2014 USACE maintenance dredging of the Calcasieu River Ship Channel using the permanent pipeline installed in conjunction with the USACE sponsor. Just under 4,000,000 cubic yards of sediment were placed in four containment areas. Sediments were pumped to 3.5 to 4.0 ft MLG, creating approximately 230 acres of emergent marsh in Cycle 4, 232 acres in Cycle 5, 250 acres in Unit 1A-North, and 194 acres in Unit 1A-South (Table 1). Sediment for Unit 1A was pumped through a temporary pipeline through the West Cove Canal and around the Hog Island Gully Structure. The dredged material was contained by low elevation earthen dikes and low level earthen overflow weirs were constructed to assist in the dewatering of the marsh creation area and to create fringe marsh with the overflow. Construction was completed in March 2015.

CS-28 was initially conceived of as one big project with several phases or cycles. In reality it was constructed as four separate projects with different levels of monitoring. Cycle 1 was monitored with project specific vegetation stations from 2001 until 2009 when CRMS6301 was installed and continuous vegetation, elevation, hydrology, soils and land change monitoring began at that site. Cycle 2 was initiated with CWPPRA but became a state only funded project and has no project specific monitoring. Cycle 3 was constructed as a standalone project in 2007. Cycles 4, and 5 along with Units 1A North and South were constructed in one event in 2015. This report includes all available data from all five cycles constructed in the original CS-28 project area. The entire area including Cycles 1 and 2 is included in spatial analyses. All available project specific data are combined with CRMS data to assess project effectiveness.

This report is considered as a close-out report for Cycle 1, having reached the end of its 20-year life in February 2022. The other four cycles are currently active at various stages of the O&M phase of their 20-year project life. Cycle 2 Permanent Pipeline is inspected annually and will be reported separately in an O&M report.

A new phase of the CS-28 concept on Sabine Refuge is currently in design and has a new project ID. It is the CS-81 Sabine Refuge Marsh Creation Cycles 6 & 7 project which will continue the concept of beneficial use of dredged material using cost savings from a planned USACE maintenance dredging event of the Calcasieu Ship Channel.

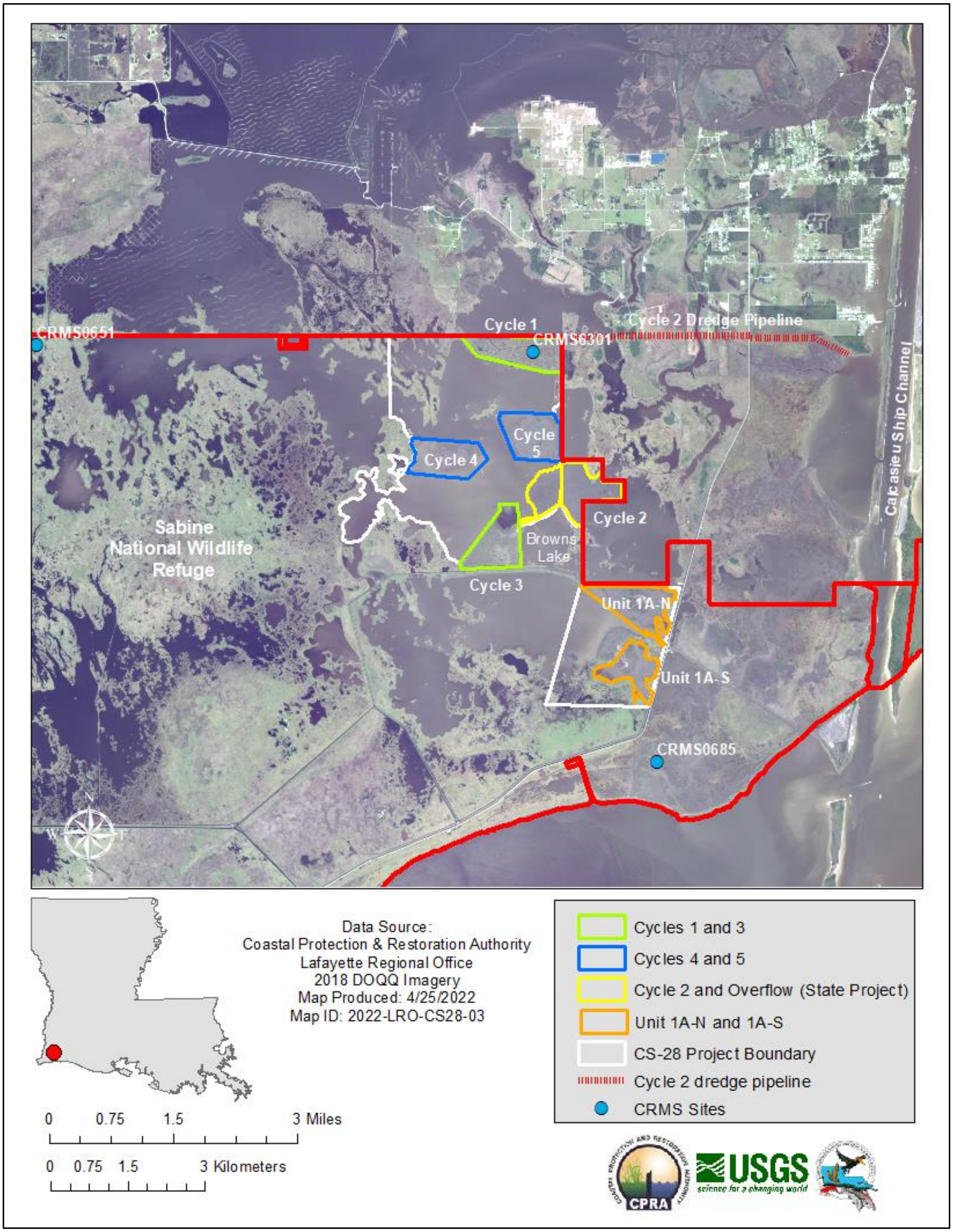


Figure 1: Sabine Refuge Marsh Creation (CS-28) project area boundary, deposition area boundaries, Sabine Nation Wildlife Refuge boundary, and reference CRMS site locations.

Table 1: Sabine Refuge Marsh Creation (CS-28) project area construction data by Cycle.

Cycle #	Date Complete	Planted	Dredge Quantity M	Disposal Area ac	Constructed Elevation MLG
Cycle 1	1/2001	Yes	~0.83 y^3	239	4.0-4.4
Cycle 2	5/2010	No	~1.19 y^3	189	4.0-4.5
Cycle 3	5/2007	No	~0.83 y^3	231	2.6-4.2
Cycle 4	1/2015	No	~0.91 y^3	227	3.5-4.0
Cycle 5	3/2015	No	~0.74 y^3	232	3.5-4.0
Unit 1A North	11/2014	No	~0.96 y^3	250	3.5-4.0
Unit 1A South	5/2015	No	~0.89 y^3	371	3.5-4.0

II. Maintenance Activity

a. Project Feature Inspection Procedures

The CS-28-2 Permanent Pipeline O&M activities will be addressed in a separate O&M report to be distributed to stakeholders. CS-28-4-5 Cycles 4 & 5 inspection information is provided below.

The purpose of the annual inspection of the Sabine Refuge Marsh Creation Cycle 4&5 Project (CS-28-4-5) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, CPRA shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs . The annual inspection report also contains a summary of maintenance events completed since construction of the project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix B. A summary of past operation and maintenance projects completed since completion are outlined in Section d. Maintenance History.

An inspection of the Sabine Refuge Marsh Creation Cycle 4 & 5 Project (CS-28-4-5) was held on October 5, 2021 under sunny skies and mild temperatures. The project site visit was performed in conjunction with an inspection to the Cycle 2 Permanent Pipeline. Also visited during the trip were the Cycle 1, 2, 3 and the USACE BUDMAT marsh creation areas. Jody White, Mark Mouledous and Glenn McNeese from CPRA Operations, Alice Kerl, Julio Vidal Salcedo and Terri Von Hoven from USACE, Chris Simon and Blake Boatwright from Simon and Delany, LLC, and Jett Berard, Pilot for Dauterive Airboat Service. An additional airboat captain was present for a total of three airboats on the trip. The inspection began at the Cycle 2 permanent pipeline and progressed to cycle 1, cycle 4, cycle 3, the BUDMAT unit, cycle 2 and ended at Cycle 5.

The field inspection included an inspection of all of the project features. Photographs were taken (see Appendix A).

b. Inspection Results

<u>Marsh Creation Cycle 4</u>

The emergent marsh platform has good vegetation coverage. However, the western and southern side of the cell has shallow open water that will be addressed with the forthcoming CS-81 Sabine Cycles 6 & 7 project. The containment dikes are sufficiently gapped where post-construction gapping was not required. (Photos: Appendix A, Photos 2 - 4)

<u>Marsh Creation Cycle 5</u>

The emergent marsh platform has thick stands of vegetation, more so than Cycle No. 4. The containment dikes are sufficiently gapped where post-construction gapping was not required. (Photos: Appendix A, Photos 5 - 6)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

No maintenance work is required at this time.

ii. Programmatic/ Routine Repairs

No O&M related maintenance work is required at this time for the marsh creation cycles. However, it is agreed by the project team that the additional fill material placed during the construction of the CS-81 Cycles 6 & 7 phase will dramatically benefit the performance of Cell No. 4.

The Cycle 2 – Permanent Pipeline maintenance activities will be provided in a separate report.

d. Maintenance History

<u>General Maintenance:</u> Below is a summary of completed maintenance projects and operation tasks performed since construction. The only exception is the Cycle 2 – Permanent Pipeline will be provided in a separate report.

Cycle No. 1 - February 2002 – Although trenasses were excavated prior to placement of fill material in Cycle no. 1, it did not produce the effect needed. A one year post construction maintenance event was performed using a marsh buggy to track over the trenasse alignment creating the desired tidal creek effect.

Cycles 4 & 5 - No Maintenance has been performed since construction. Budgeted maintenance for this project was for creation of additional gaps in the containment dike to allow tidal exchange within the marsh creation cells. It was determined that sufficient tidal exchange was occurring from exiting gap locations created during construction in Cycles 4 & 5. However, USFWS was interested in using budgeted O&M funds to construct tidal creeks for black rail habitat in Unit 1 A & Cycle 3. USFWS obtained approval from the USACE and CWPPRA to use CS-28-4-5 budget for CS-28-3. The work was bid in 2019 and bids exceeded the available budget. An additional incremental O&M budget increase was requested to facilitate a rebid. Due to COVID, a rebid was delayed. Furthermore, recent development of the CS-81 Cycles 6 & 7 design includes an unconfined fill technique deposited in the vicinity of Cycle 3 which could potentially infill shallow creeks during the future marsh creation construction activities. Further discussion would be needed to evaluate benefits of proceeding with tidal creek construction at this time.

e. Operation Activity

i. Operation Plan

There are no structure operations for this project. However to note, the project area water level and salinity is impacted by the CS-23 Sabine Water Control Structures project operations.

ii. Actual Operations

There are no structure operations for this project.

III. Monitoring Activity

CS-28 marsh creation areas are monitored with project specific vegetation stations and three CRMS sites (Figure 1). CRMS6301 is within the Cycle 1 marsh creation area and captures process in a marsh creation area 20 years post construction. CRMS0651 is a reference site in the marsh west of the project area and it captures conditions at pre-existing impounded marshes in Sabine NWR Unit 1. CRMS0685 is a reference station located in the marsh adjacent to West Cove outside of the structural protection provided by CS-23 and Hwy 27. Vegetation and marsh creation elevation data collected within CS-28 marsh creation areas were combined with complimentary CRMS data for this assessment. Additional data provided by CRMS including surface elevation change, soil characteristics, water elevation and salinity are also included in this report. Details on data collection methodology can be found in Folse et al. 2020.

a. Monitoring Goals

The Sabine Refuge Marsh Creation (CS-28) project is classified as a marsh creation project. Land loss is expected to slow with the addition of dredge filled containment cells to the project area. The project was originally divided into 5 cycles of marsh creation and has now been expanded to include additional disposal areas near the original project area.

The objectives of the Sabine Refuge Marsh Creation Project are:

1. Create new vegetated marsh and enhance and protect existing surrounding marsh.

The specific measurable goals established to evaluate the effectiveness of the project are:

1. Place dredge spoil slurry to a maximum height of 4.5 ft MLG to settle to a height of 2.5 ft MLG after five years, for each of five dredging cycles.
2. Create 214 acres (Cycle 1), 227 acres (Cycle 2), and 232 acres (Cycle 3) of emergent vegetated wetland, and approximately 460 total acres (93ha) of emergent vegetated wetland withing Cycles four and five.
3. Reduce the loss of existing surrounding marshes within the project area.

b. Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

Aerial Photography

Near-vertical color-infrared aerial photography (1:24,000 scale) was used to measure vegetated and non-vegetated areas for the project and reference areas. Aerial photography was collected in December 2002, 2009 and 2015. The original photography was checked for flight accuracy, color correctness, and clarity and was subsequently archived. Aerial photography was scanned, mosaicked, and georectified by USGS/NWRC personnel according to standard operating procedures for land:water analyses (Steyer et al. 1995, revised 2000). Land:water analyses in 2015 was measured using 1 meter resolution CIR (color-infrared) digital orthoimagery. Aerial photography will be captured again in 2025 and 2034.

Project scale land trends were calculated using Landsat Thematic Mapper (TM) data for 1984 – 2016. Linear regressions were calculated for the period of record. The variability in percent land data points around the slope illustrate the influence of various sources of environmental variance or classification error. Positive slopes indicate increasing percent land or historical land gain and negative slopes indicate decreasing percent land or historical land loss (Couvillion et al., 2017). The data provided by this tool are at a large spatial scale and are designed to show trends in land change, not exact acreages.

Elevation Survey

To document vertical elevation change within Cycles 3-5 and the Cycle 2 overflow area, transect lines were established and tied in to a known elevation datum by professional surveyors. These transect lines were surveyed in August 2013 for Cycle 3 and the Cycle 2 overflow area as well as in October 2018 for Cycles 3, 4 and5 and the Cycle 2 overflow area. Elevation and water level data from CRMS6301 were used to represent elevation within Cycle 1 and water level within the project area. Future replicable surveys are planned for 2025 and 2034.

Soil Surface Elevation Change

Soil surface elevation change was measured with rod surface elevation tables (RSET) at each CRMS site. These data were used to extract Cycle 1 elevation data for comparison to survey data and to describe trends in surface elevation change. The RSET was surveyed to a known elevation datum (ft, NAVD 88, Geoid 12a). Data was used to calculate elevation change rates at the project and reference sites.

Submergence Vulnerability Index

The Submergence Vulnerability Index (SVI) assesses the relationship between marsh elevation and water level on a wetland's vulnerability to submergence within 5 years. The SVI of a site is based on the 5-year projection of its surface elevation and water levels (based on at least 5 years of data). Surface elevation is projected using surface elevation change rates, and water levels are projected using eustatic sea-level rise rates. The position of the projected wetland relative to the distribution of projected water levels determines the SVI score. The SVI score ranges from 0-100, representing the frequency of flooding experienced by a site in relation to its vulnerability to submergence. A lower score represents a site more vulnerable to submergence, whereas a site with a higher score is considered less vulnerable to submergence.

Soil Properties

Soil cores were collected to describe major soil properties such as bulk density and percent organic matter. Three, 4” (10.16-cm) diameter cores were collected to a depth of 24 cm and divided into 6, 4-cm sections at each site. The soil was processed by the Department of Agronomy and Environmental Management at Louisiana State University. Soil cores were collected at the project and reference CRMS sites in 2006-2008 and in 2018.

Emergent Vegetation

Emergent vegetation was evaluated in the marsh creation areas, at CRMS6301 in the Cycle 1 marsh creation area, in the adjacent reference marsh, and at reference CRMS sites. Prior to CRMS monitoring seven reference stations were monitored in the existing marsh within the project area along with eight stations within the Cycle 1 marsh creation area) (Figure 2). Eight vegetation stations were established in Cycle 3 in 2008 and evaluated in 2010, 2012, 2018, and 2020. Eight sites each were also established in Cycles 4 and 5 in 2018 and evaluated in 2018 and 2020. Ten pre-established reference stations in the marshes in the northwest portion of the project area were used for project assessment. Each station consisted of two 2 m^2 plots and was evaluated using techniques described in Folse et al. (2020) to quantify precent cover and species composition.

Water level

Water elevation was measured at CRMS6301 within the project area and at reference sites in nearby marsh (CRMS0651) and adjacent to Calcasieu Lake (CRMS0685). in the Cycle 1 marsh creation area and at reference sites CRMS0651 and CRMS0685 (Figure 1). Water level was measured every hour with a continuous recorder installed at each CRMS site. The gauge was surveyed relative to a vertical datum, currently NAVD88 Geoid 12a. Water level data was used to document the elevation and variability in water levels and duration of inundation in project and reference areas. Marsh elevation used in flood depth analyses was determined from the 2018 elevation monitoring survey of the CS-28 project area.

Salinity

Salinity was recorded hourly from continuous recorders at CRMS6301 in the Cycle 1 marsh creation area, CRMS0651 in an interior marsh west of the project area, and CRMS0685 in a marsh site on the perimeter of Calcasieu Lake southeast of the project area (Figure 1).

Soil interstitial (porewater) salinity data were collected monthly from 10 and 30 cm depths at CRMS6301. Monthly porewater salinity data were utilized to compare differences between salinity and porewater salinity for years 2010-2021.

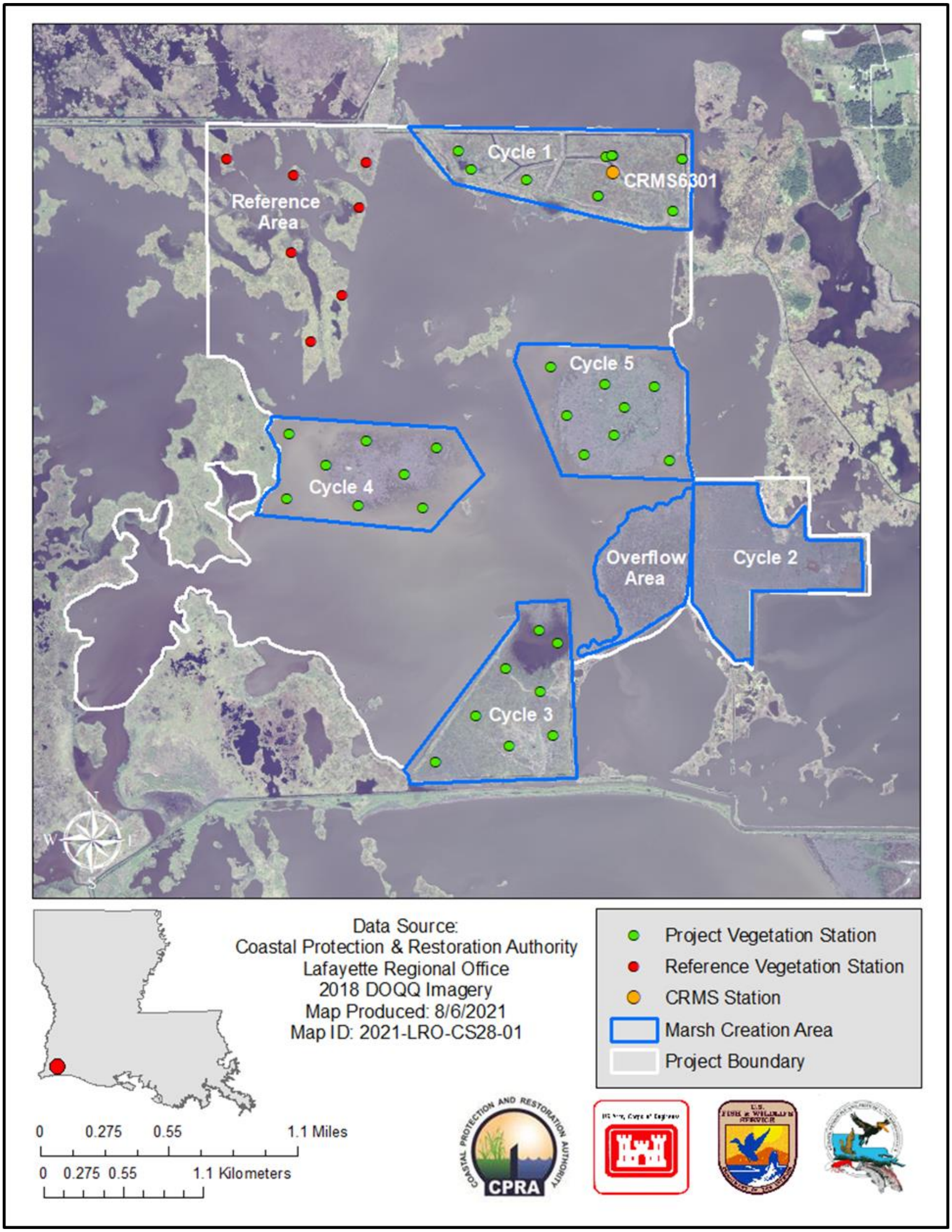


Figure 2: Sabine Refuge Marsh Creation (CS-28) project area boundary, deposition area boundaries, vegetation monitoring stations, and CRMS site.

c. Monitoring Results and Discussion

Aerial Photography

Aerial photography was collected in 2002, 2009, and 2015. During that timeframe, dredged material deposited into seven marsh creation areas became vegetated. Ponds filled in and vegetation expanded in all marsh creation areas.

Aerial photography collected one year post-construction of Cycle 1 (2002) showed unvegetated dredged material or mudflat in about 58% of the marsh (Figures 3-4). All other marsh creation areas were open water at that time. Between 2002 and 2009 in Cycle 1, 171 additional acres became vegetated, increasing the percent land to 77% (Figures 3, 5, and 6). By 2015, 94% of the Cycle 1 marsh creation area was vegetated wetland (Figures 3 and 7).

Aerial photography collected two years post-constructions of Cycle 3 (2009) show Cycle 3 percent land around 62% (Figures 3 and 5). Land in the Cycle 3 marsh creation area increased to 94% by 2015(Figures 3 and 7). Cycle 2 consisted of 77% percent land in 2015 (Figure 7).

Cycles 4-5 as well as Units 1A-N and 1A-S were constructed in January and March 2015. Aerial photography conducted in December of that year shows Cycle 4 consisting of 30% land, Cycle 5 consisting of 64% land, and Units 1A-N and 1A-S consisting of 87% and 74% land (Figures 3 and 7). Cycles 1 and 3 have filled in to at least 94% wetland over time as vegetation colonized and expanded within the marsh creation areas. Units 1A-N and 1A-S are expected to fill in and become vegetated similar to Cycles 1 and 3. It remains to be seen whether Cycles 4 and 5 will vegetate, however, in the next phase (CS-81 Cycles 6 & 7), additional material will be pumped into the open water of Cycle 4.

This dataset allows for an assessment of the relationship between marsh creation area age and percent land (Figure 8). With the exception of Cycle 4, all marsh creation areas were at least 50% land in the first year. The trend in the area is an increase of 2.5% land/yr. Marsh creation areas from this borrow source can be expected to vegetate relatively quickly if elevation is on target.

The general land change trend in the CS-28 project area prior to construction was slightly positive with an increase of 9 ac/yr (0.2%/yr) from 1984 to 2001 (Figure 9). From 1984 to present, the land gain rate has increased to 42.5 ac/yr (0.9%/yr). The increase reflects both created marsh area and any effect that the project may have had on slowing landloss in the pre-existing marsh in the project area. In order to assess whether the project has met its goal of reducing landloss in existing surrounding marshes, created marsh area quantified through spatial analysis was subtracted from project land acreage and the rate of change was assessed. Excluding created marsh area, the land change rate from 1984 to 2016 would be 17.8 ac/yr (0.4%/yr). The project does appear to have provided some protection to adjacent marshes though differences between pre and post construction, excluding created marsh, are slight and within the range of error for the estimates.

The project is achieving its goals of creating land through marsh creation. Surrounding marshes are still slowly gaining land as they were pre project so there is no clear impact of the project on slowing regional marsh loss yet. Those effects may become more evident in time.

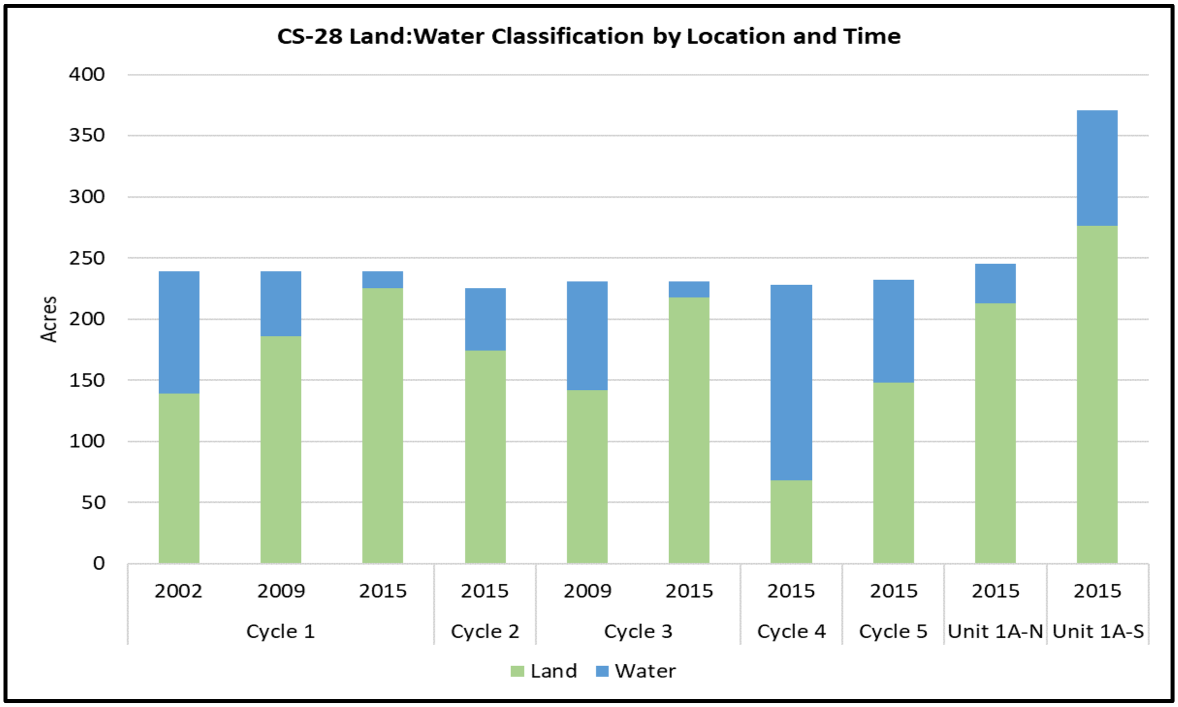


Figure 3. Acreages for land:water classifications from aerial photography collected in 2002, 2009 and 2015.

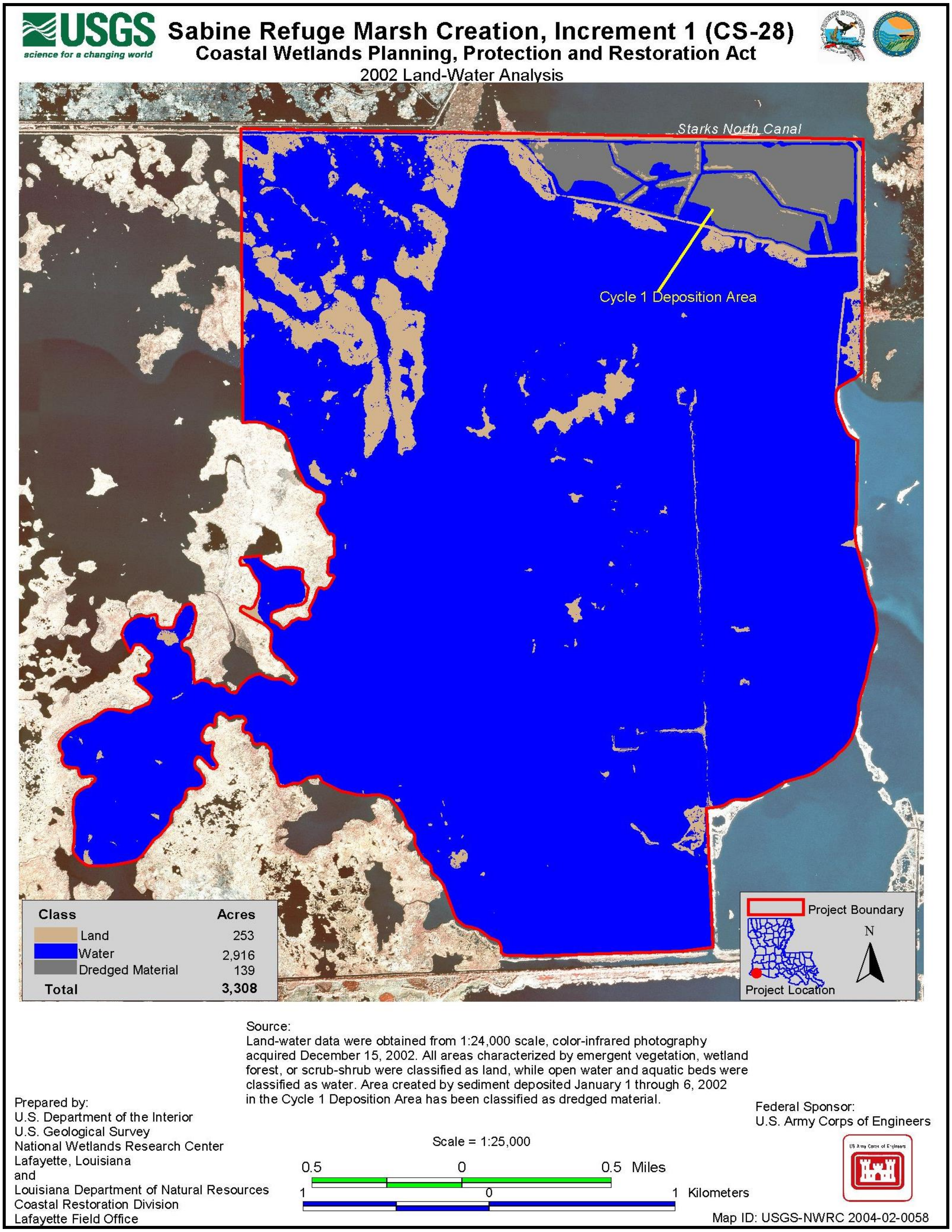


Figure 4. Land:Water classification from photography obtained in December 2002.

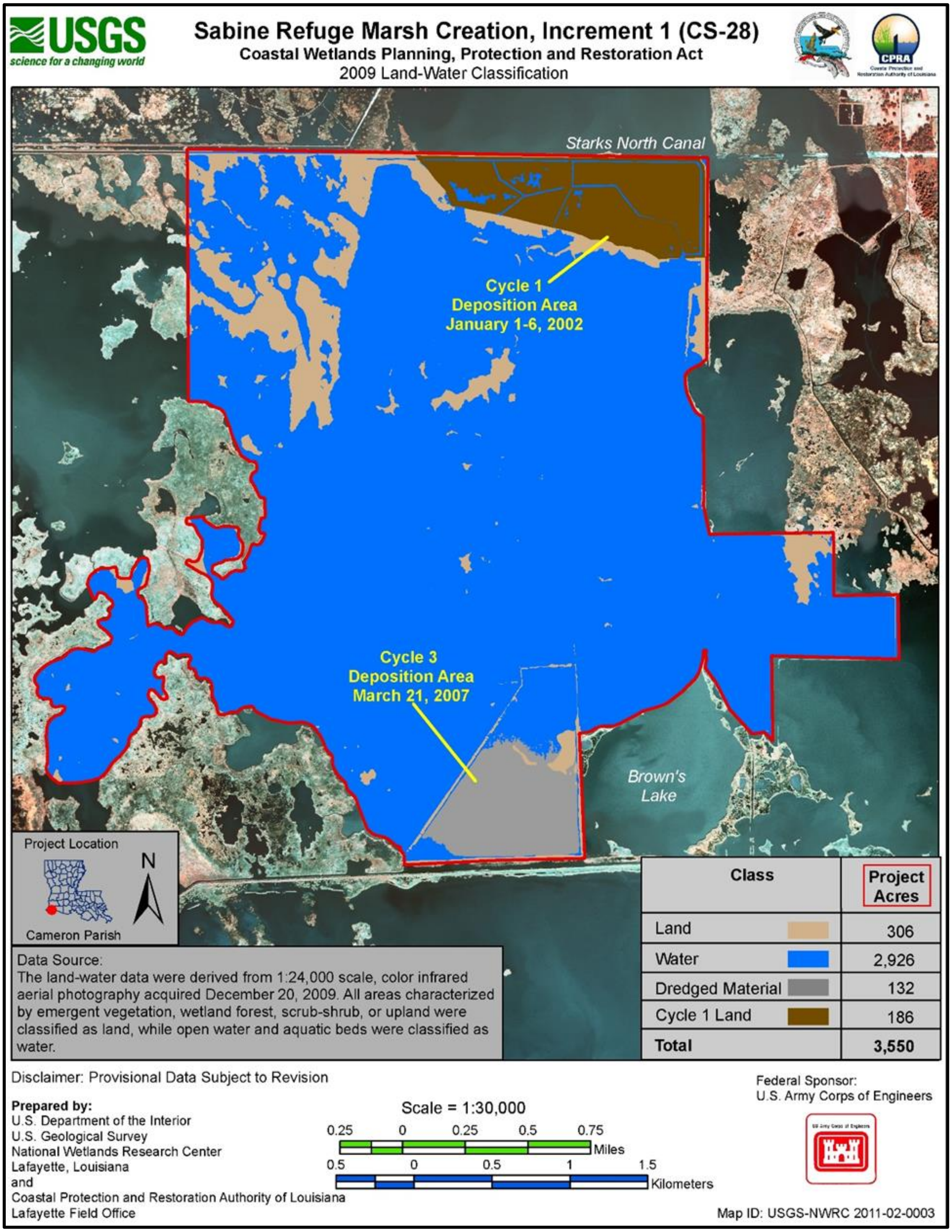


Figure 5. Land:Water classification from photography obtained in December 2009.

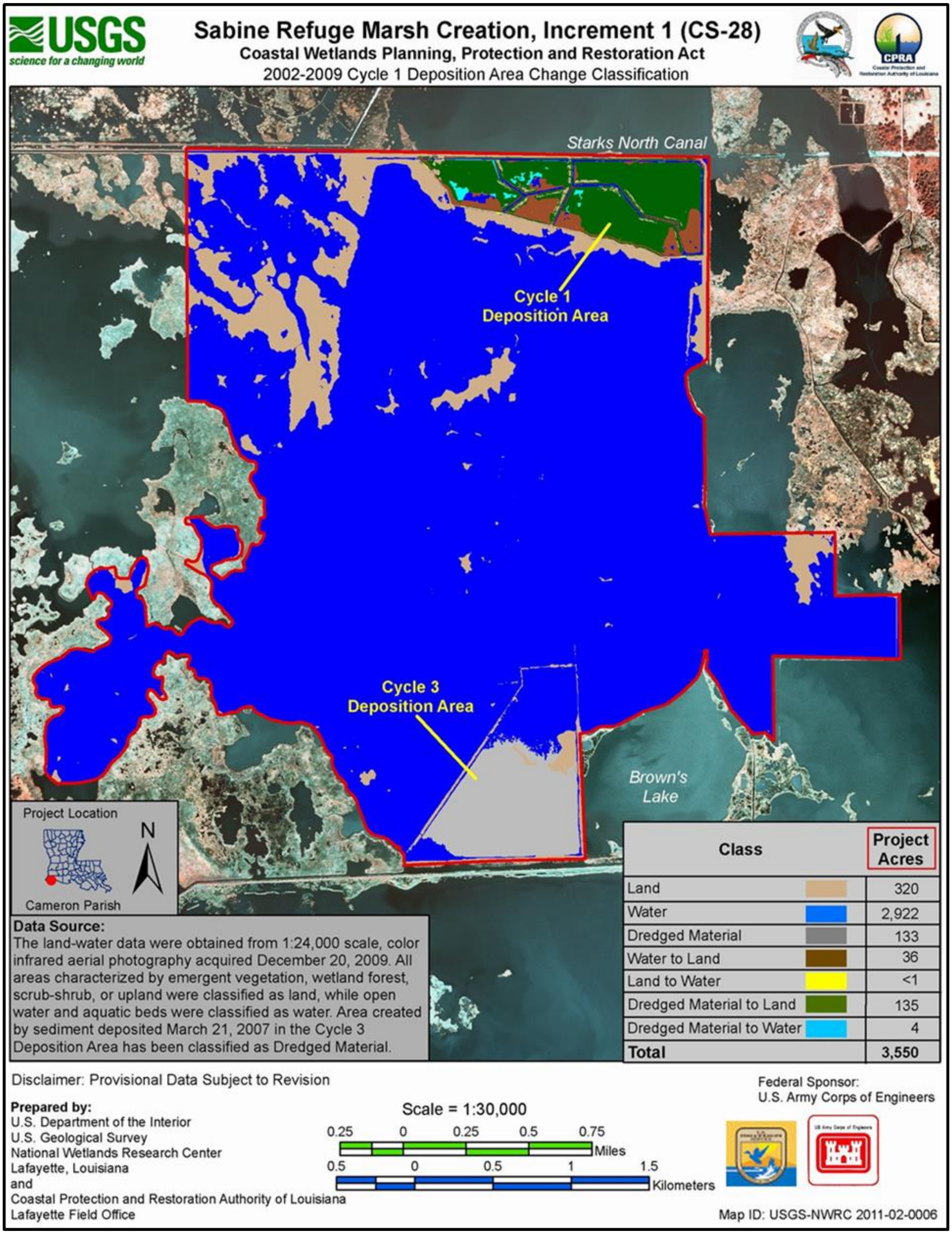


Figure 6. Cycle 1 Deposition Area Change classification from photography obtained in December 2002 and 2009.

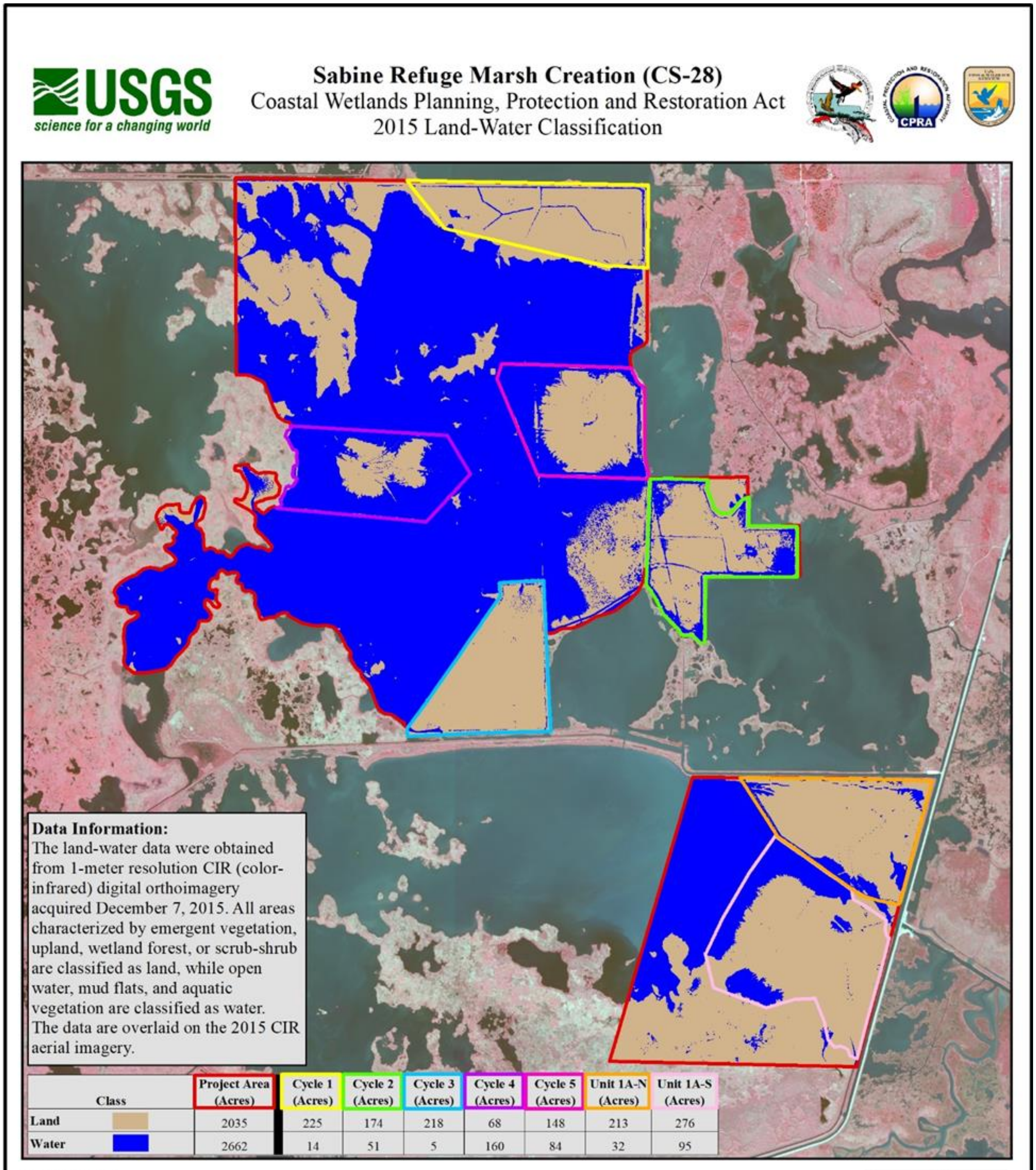


Figure 7. Land:Water classification from photography obtained in December 2015.

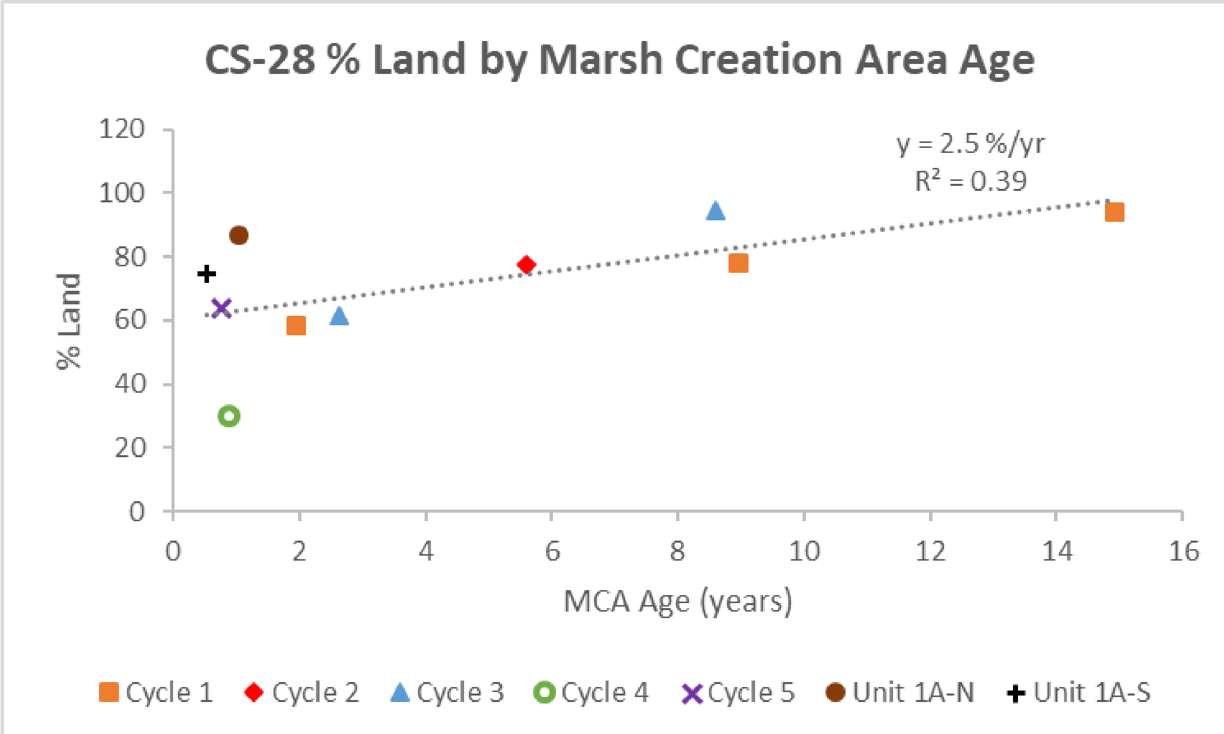


Figure 8. Percent land by marsh creation area age compiled from CS-28 Cycles 1-5, and 1A data presented in figures 4-7.

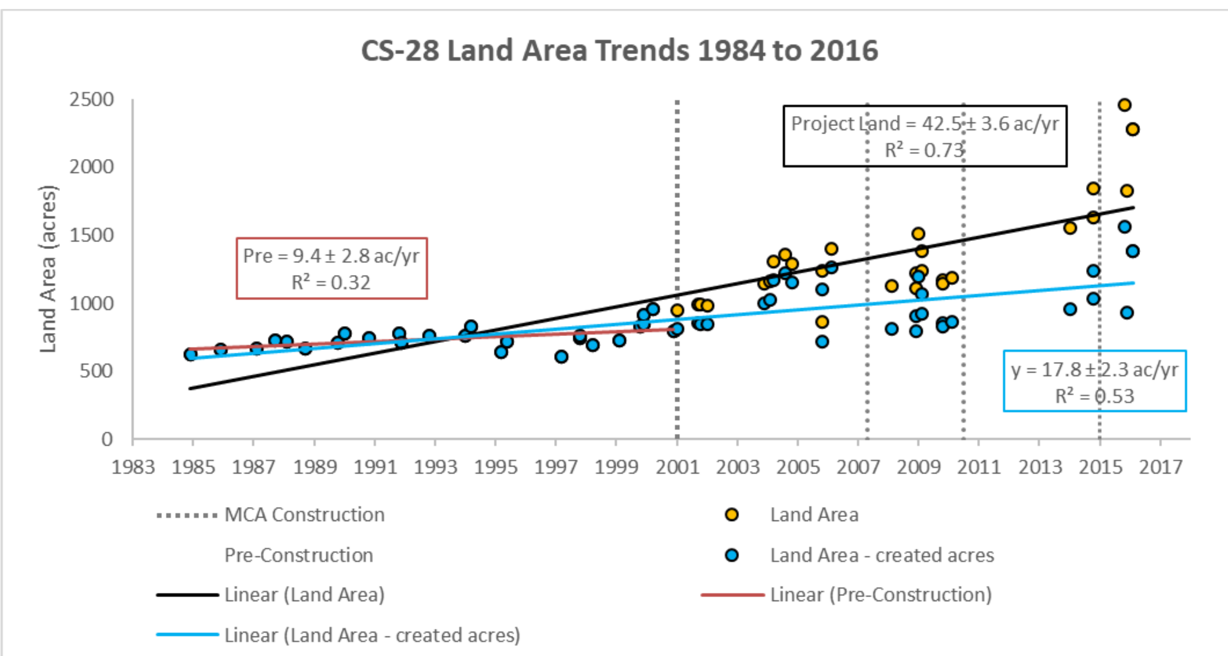


Figure 9: Land area trends in acres for the CS-28 project area for years 1984 to 2016. The blue line depicts the land area trend prior to the construction of CS-28. The green line depicts the land area trend for the post-construction time period. The red line depicts the post-construction land area trend with the CS-28 project acreage removed.

Elevation

Marsh creation elevation data are available from post construction monitoring surveys conducted in 2013 and 2018 and water and marsh elevation data are available from CRMS sites. The goal of the project is a settled marsh elevation of 2.5 ft MLG (0.29 ft NAVD88 (Geoid 12A)) after 5 years. Cycle 3 was pumped to between 2.6 and 4.2 ft MLG (1.1 to 2.7 ft NAVD88 (Geoid12A)) and was measured to be between -2.03 and 0.80 ft NAVD 88 (Geoid 12A) in the 2013 survey at year 6. The Cycle 3 area is below the target elevation in the northern 3 of 9 transects surveyed in 2013 with 76% of the marsh creation area below the target elevation (Figure 9). Low elevations are found in the shallow open water areas in the northern end of the marsh creation area. In 2018 (year 11 post construction) elevation was surveyed to be between -1.90 and 2.43 ft NAVD 88 (Geoid 12A) with 14% of the marsh creation area below the target elevation (Figure 10). Mean transect elevation increase between 2013 and 2018 was +0.48' (Figure 11). Over that same time frame, water elevation went up 0.2'. Flooding would explain some of the elevation gain. The influence of hydrology and vegetation will be explored in this report.

Cycles 4 and 5 were pumped to between 3.5 and 4.0 ft MLG (2.0 to 2.7 ft NAVD88 (Geoid 12A)). Cycle 4 was measured to be between -0.56 and 1.85 ft NAVD88 (Geoid 12A) in the 2018 survey at year 3 with 17% of the marsh creation area below the target elevation. Cycle 5 was measured to be between -0.66 and 2.66 ft NAVD 88 (Geoid 12A) with 4% of the marsh creation area below the target elevation (Figure 10). Elevations are expected to increase as areas become vegetated.

Elevation change data are available from CRMS sites. Elevation within Cycle 1 has increased steadily from 2010 through 2021, with 2020 (post hurricanes) showing the only negative elevation change (Figure 12). The elevation gain between 2018 and early 2020 is notable at CRMS6301. The trend was seen in the marsh creation area but not at nearby reference sites (Figure 12). There was a drought in the spring of 2018 that was observed to stimulate vegetative production and produce elevation gain at some CRMS sites in the region including CRMS6301. This process may explain some of the elevation gain in Cycle 3 between 2013 and 2018.

Of the CRMS sites utilized for this report, surface elevation trajectories are highest at CRMS6301 (3.6 cm/yr), are stable adjacent to the lake at CRMS0685 (0.14 cm/yr) and are negative in the marsh at CRMS0651 (-0.29 cm/yr). The Submergence Vulnerability Index (SVI) provides information on elevations relative to water levels and helps interpret these rates. SVI scores for CRMS6301 in Cycle 1 and CRMS0685 near the lake are high (>90) indicating that the sites are high in the tidal frame (Figures 13a and b). Current elevation change rates should prevent submergence over the next five years at current trajectories. CRMS0651 is losing elevation and becoming more submerged (Figure 13c).

Soil samples were collected in 2008, 2014 (CRMS6301 only) and in 2018. Percent organic matter (%OM) has been lowest in the created marsh with % OM at the surface approaching 25% at year 17 (Figure 14a). CRMS0685, which sees mineral sediment deposition from Calcasieu Lake, has similar %OM at the surface though it is more organic than the created marsh beyond 12 cm deep indicating a more developed root zone (Figure 14b). CRMS0651 is much more organic at the surface (>50% OM) than the other two sites and becomes less organic with depth with <25% OM beyond 16 cm.

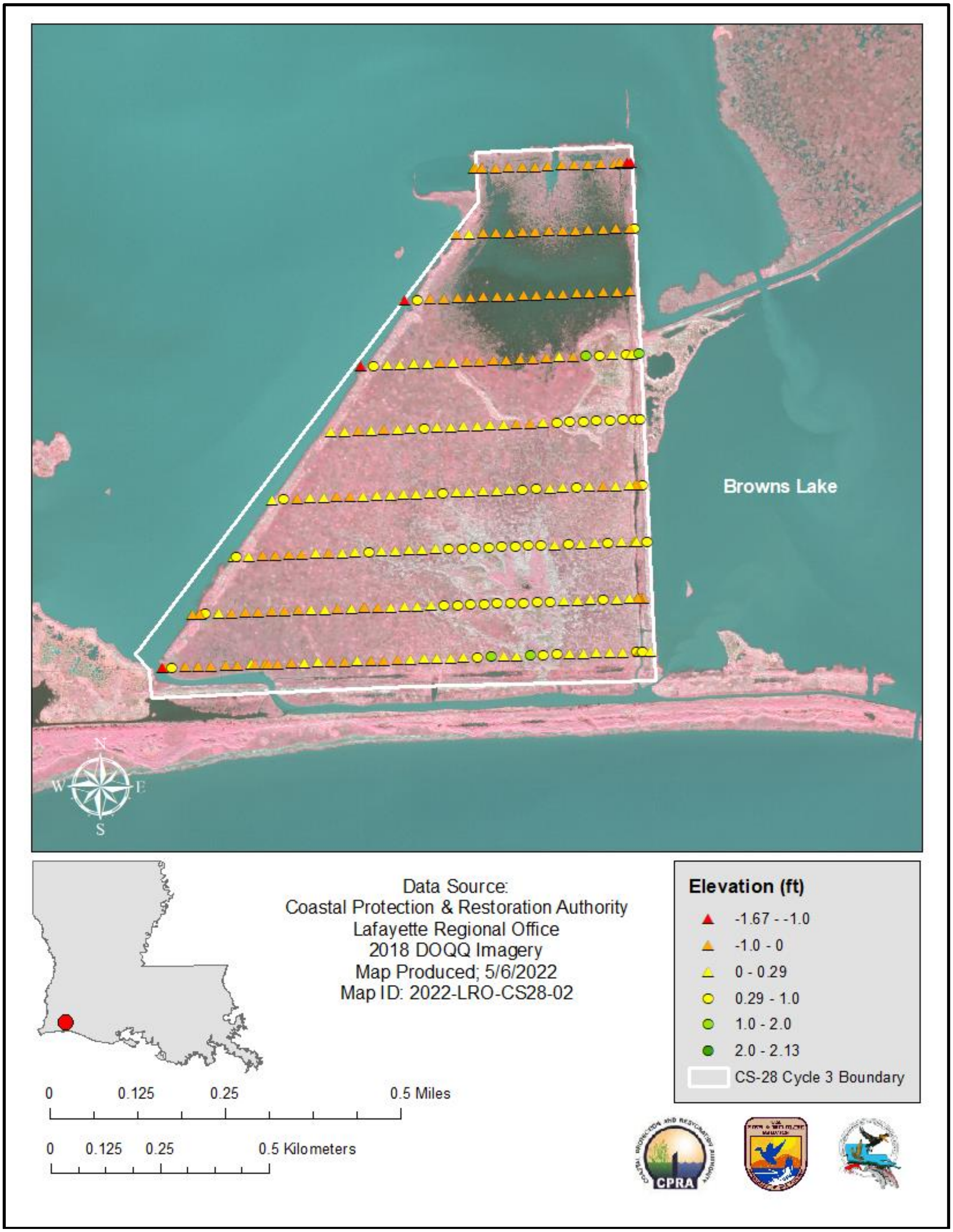


Figure 9. Survey transect elevations and project area boundary of the Cycle 3 containment area in 2013.

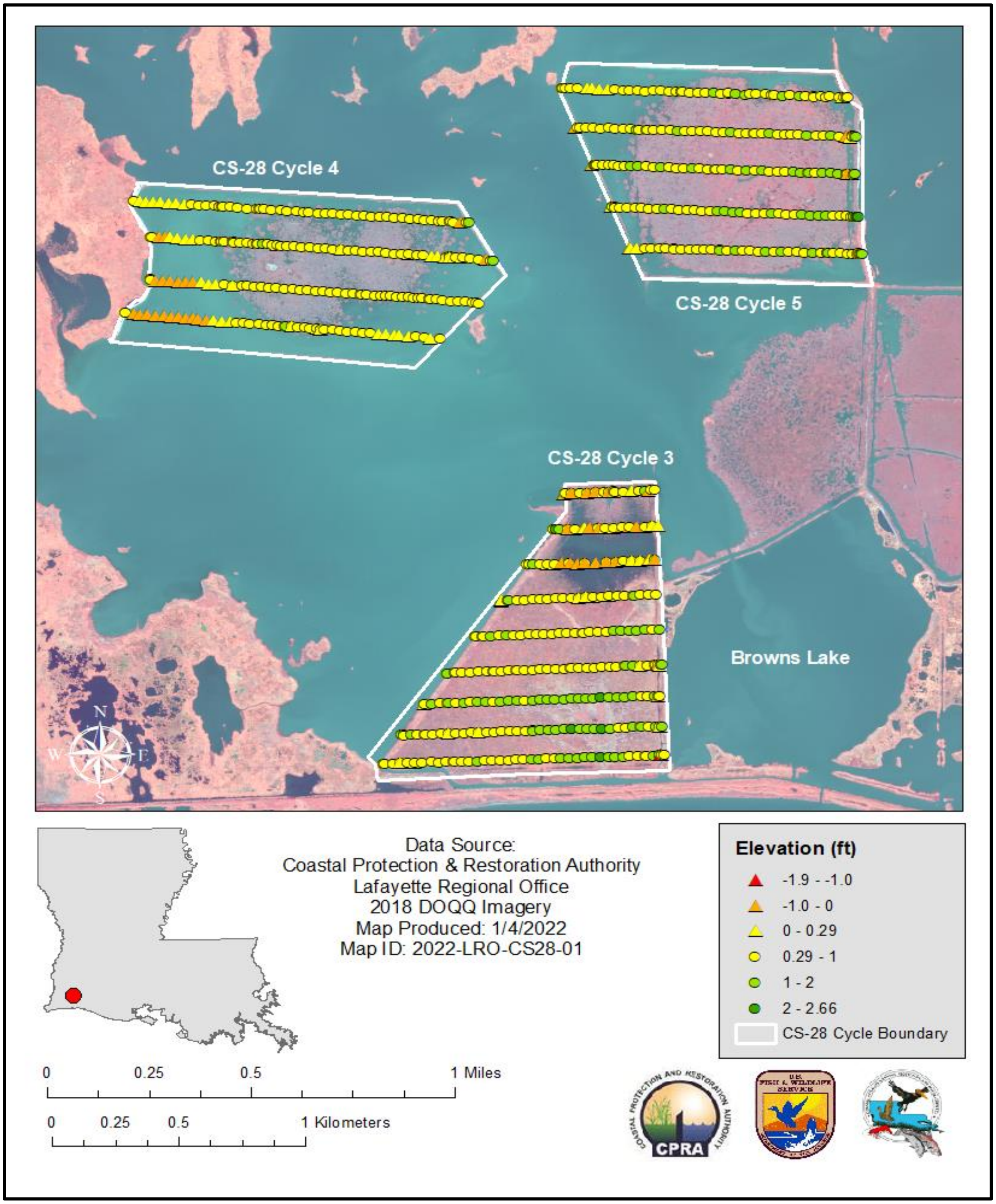


Figure 10. Survey transect elevations and project area boundary of the Cycle 3, 4 and 5 containment areas in 2018.

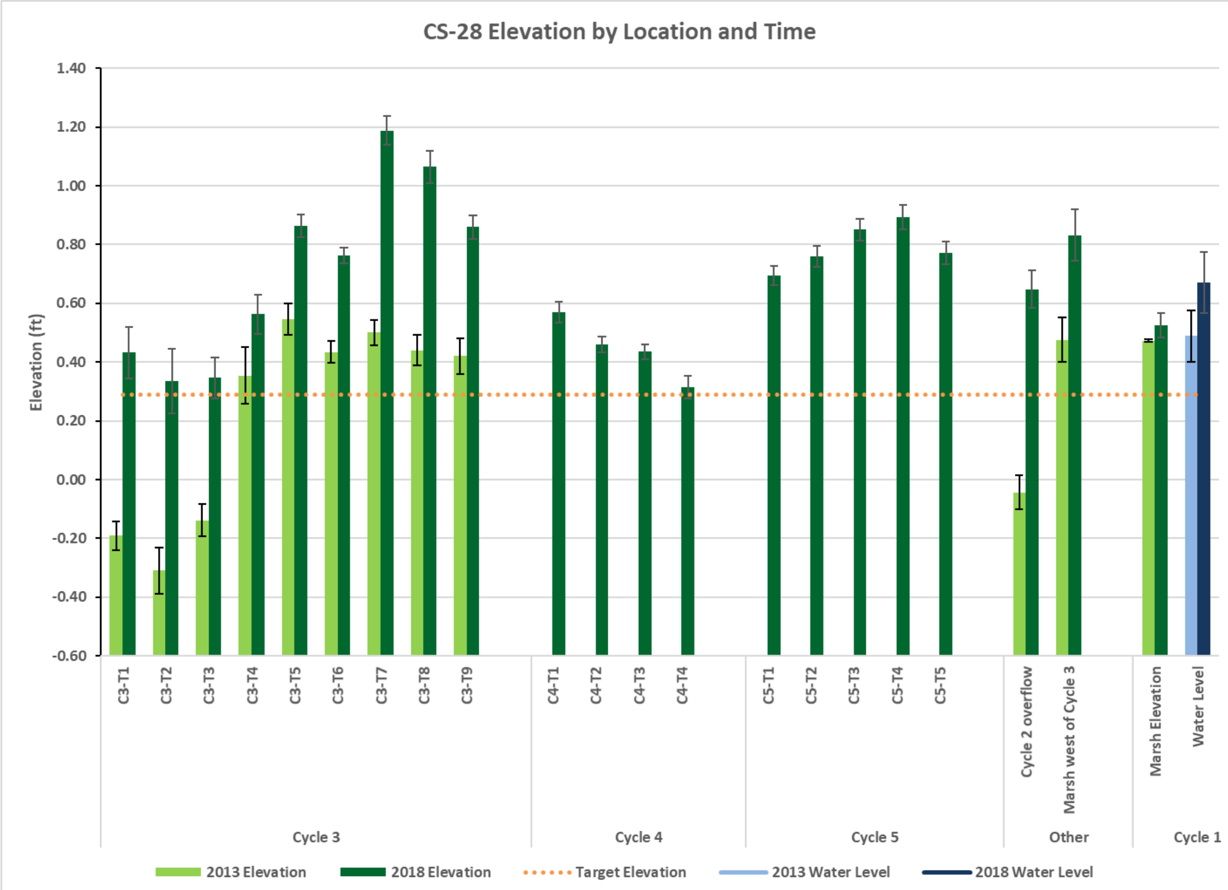


Figure 11. Survey elevation data and target elevation from 2013 and 2018 for Cycles 1, 3, 4 and 5 containment areas and Cycle 2 overflow. Mean water elevation was recorded at CRMS6301 in the Cycle 1 containment area.

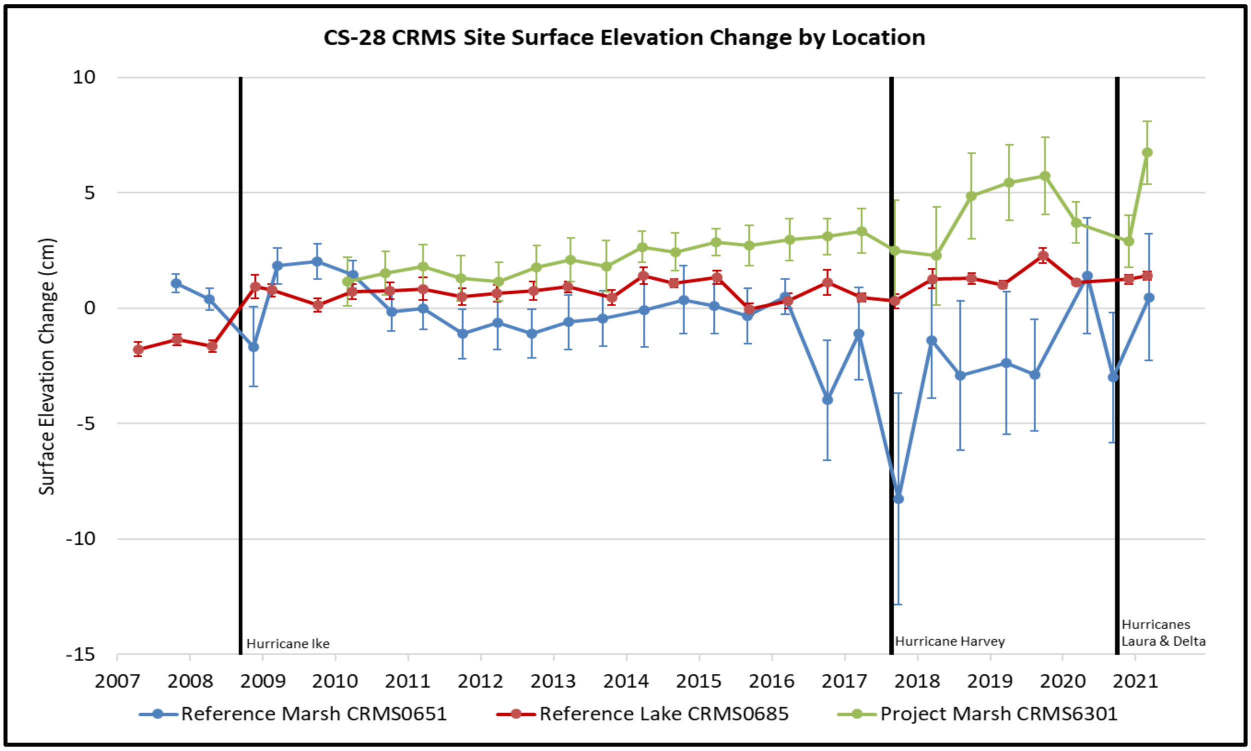
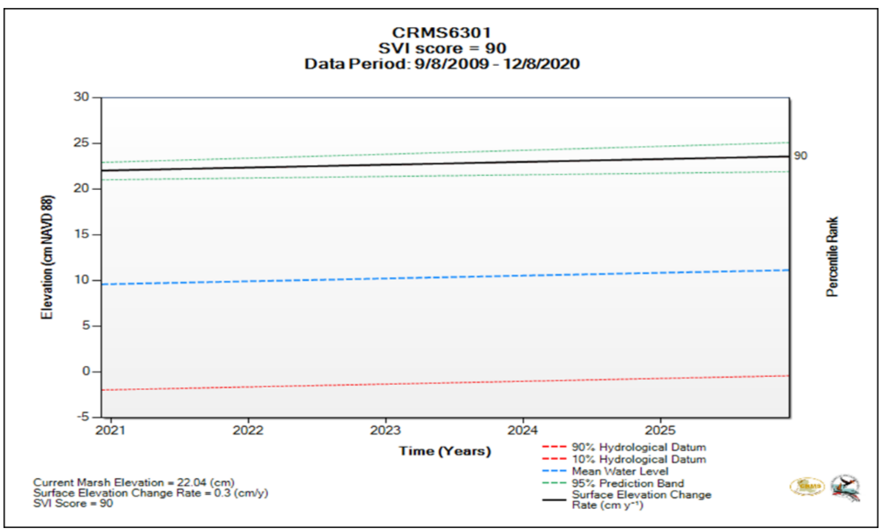
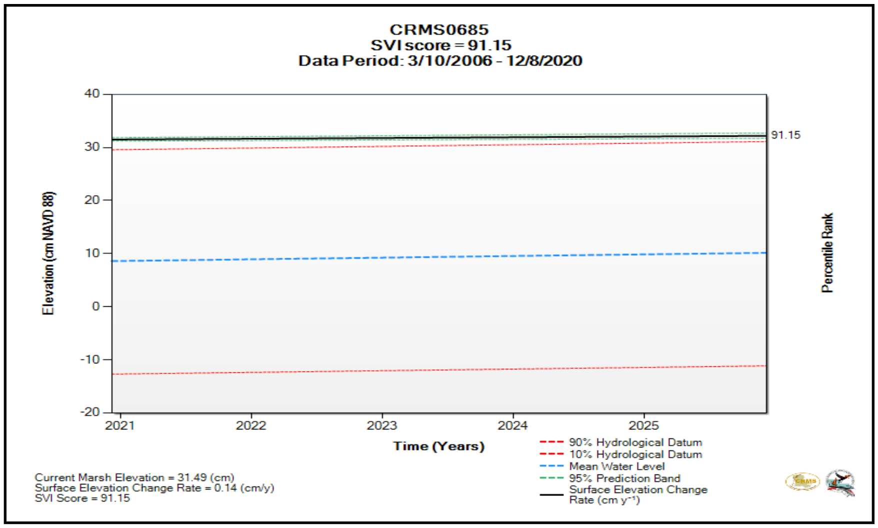
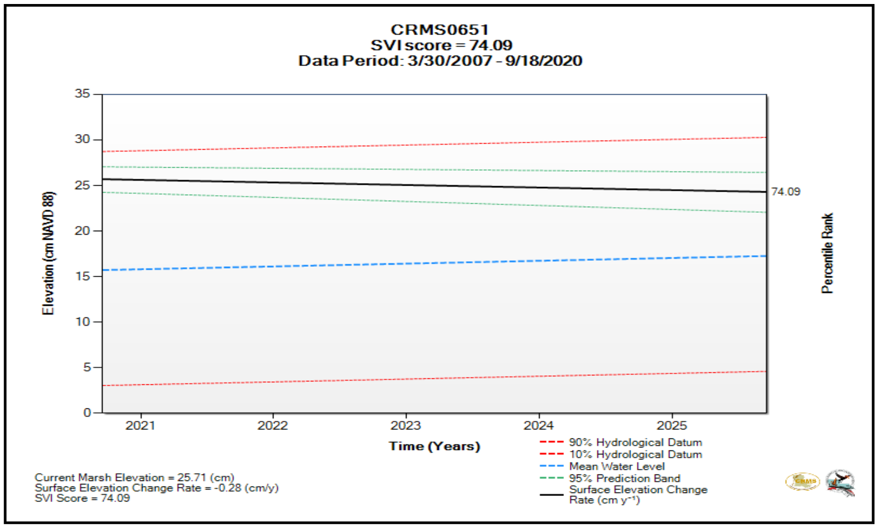


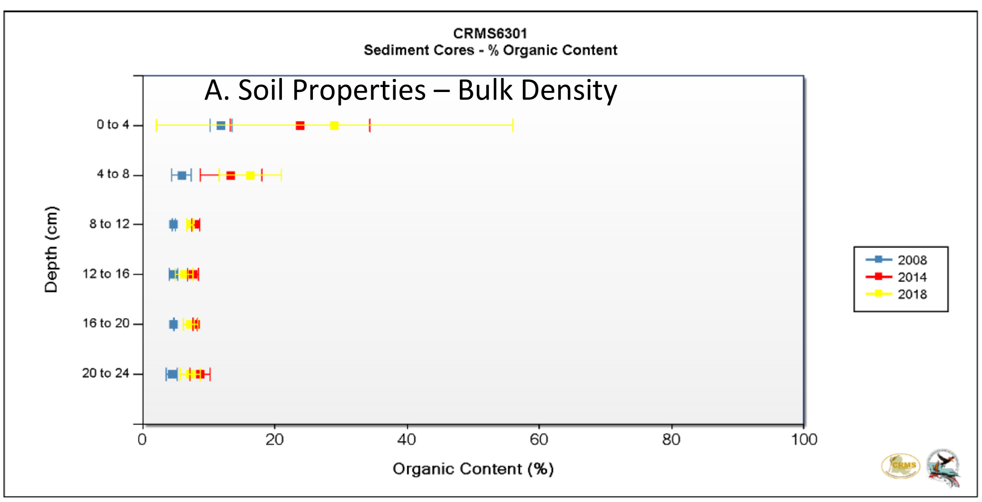
Figure 12. Yearly means and standard errors of surface elevation change collected in the project and reference locations from 2010-2021.







Figures 13a, b and c . Submergence Vulnerability Index 2020.



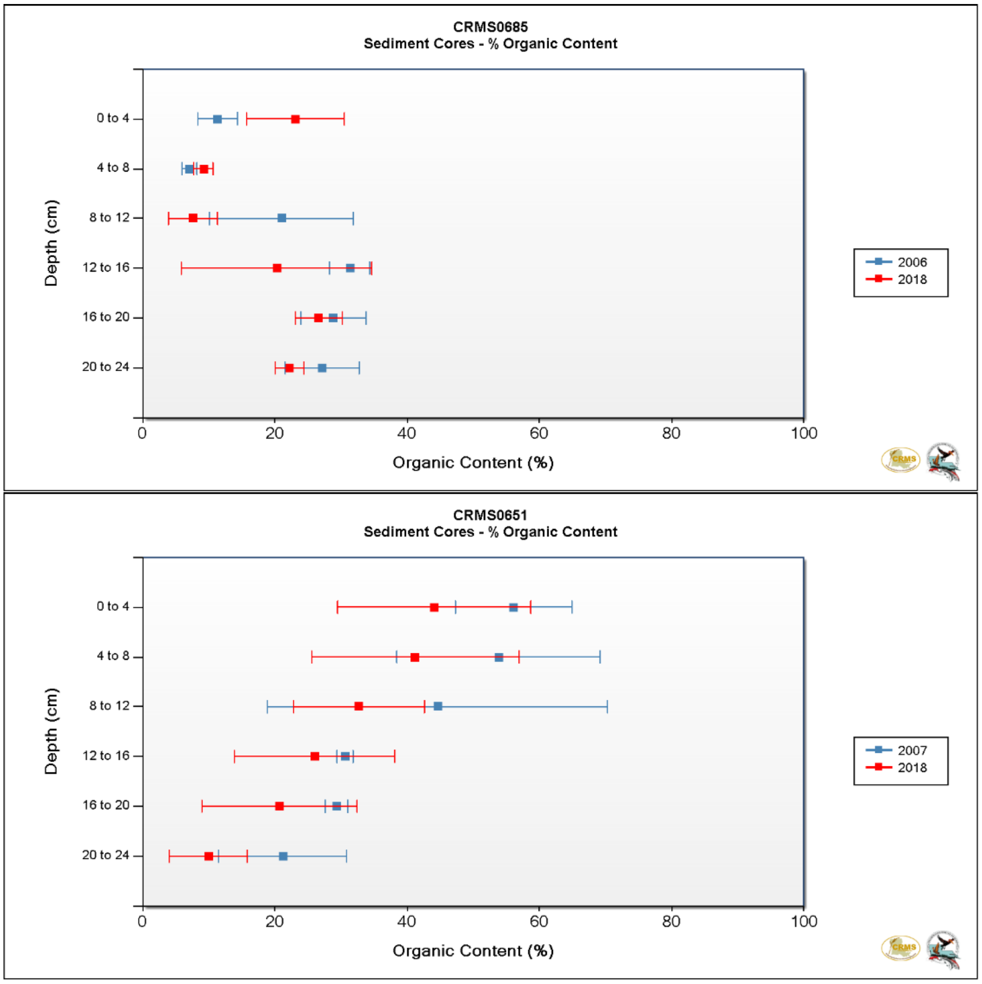


Figure 14 a, b and c: Soil % organic matter (at CRMS sites within the project and reference areas for 2006-2008, 2014 and 2018. Mean ± SE

Emergent Vegetation

Vegetation data from the CRMS sites reveal that all three sites have different dominant species. CRMS6301 is mostly *Distichlis spicata* and *Spartina alterniflora* while CRMS0685 is a *Spartina patens/Spartina alterniflora* mix (Figures 15a and b). CRMS0651 in the marsh east of the project area has shifted from *Spartina patens* to fresher species like *Typha latifolia* (Figure 15c). Though the Cycle 1 area is now over 20 years old, it has not begun to approximate the community in the pre-existing marsh, (intermediate to brackish vegetation), rather continuing to support a salt marsh vegetation community. All three sites lost cover between the 2019 and 2020 vegetation data collection campaigns. CRMS 2020 data was collected before Hurricane Laura (June and July 2020) so the loss in cover in 2020 at all three sites is not related to the 2020 hurricanes. Despite storms, vegetation at CRMS6301 and CRMS0685 recovered between 2020 and 2021 while CRMS0651 saw additional loss. Previous analyses of sites in this region have shown persistent flooding associated with vegetation loss (McGinnis et. al 2019).

Within the marsh creation areas, vegetation cover increased as vegetation colonized and expanded (Figure 16). Vegetation was impacted by hurricanes in 2005, 2008, 2017 and 2020 and recovered after each storm. 2020 vegetation data from Cycles 3, 4, 5 and the reference stations were collected after Hurricane Laura (October 2020). Each of the marsh creation areas lost cover between 2018 and 2020 with Cycle 3 and the Reference area losing the most. Within the marsh creation areas, vegetation is expected to recover and continue to expand. The reference stations are on the pre-existing land within the project area. Those have remained stable according to land change data (Figure 9) so those should also recover.

The Cycle 4 marsh creation area has both the lowest elevation and the lowest cover (Figures 11 and 16). All of the other marsh creation areas monitored, including Cycle 5 which was created in the same year, had at least 50% vegetative cover by Year 3 and Cycle 4 only had 25% (Figure 17). Hurricane Rita (2005) killed the vegetation in Cycle 1 at year 5 and it had recovered by Year 6. Both Cycle 4 and Cycle 5 lost a similar amount of vegetative cover between 2020 and 2021 which reduced Cycle 4 down to 20% cover. Cycle 3 had about the same amount of cover at Year 4 as Cycle 3 but Cycle 3 saw vegetation expansion between Years 4 and 6 while Cycle 5 did not see a similar increase (Figure 17). Cycle 3 vegetation expansion occurred during the 2011 drought which exposed mudflats in lower areas within the marsh creation area. Those conditions have not been repeated in recent years. It remains to be seen whether Cycles 4 and 5 see the same vegetation expansion that Cycles 1 and 3 did. Future Cycles should be built higher to account for current sea level.

These vegetation data allow for an assessment of early succession in marsh creation areas. All CS-28 MCAs are colonized first by *Spartina alterniflora* and salt tolerant succulents like *Salicornia depressa* and *Batis maritima* (Figure 18; Batis included in the "Other" class). After a few years, more salt tolerant grasses and sedges emerge including *Distichlis spicata* and *Shoenoplectus robustus*. *Spartina patens*, which is one of the most commonly found species in the reference marsh has not become established in the Cycle 1 marsh creation area after 20 years. *Distichlis spicata*, which is a salt tolerant grass, is co-dominant in both the Reference area and the Cycle 1 marsh creation area but otherwise, the vegetation communities remain distinctly different from one another.

These marsh creation areas tend to vegetate quickly from seeds in Calcasieu Ship Channel (CSC) sediments or windblown sources. Cycle 1 was planted along the edge but was observed to vegetate naturally so future marsh creation cycles were not planted and all became vegetated within the first few years. Our previous recommendation has been that marsh created with CSC sediments do not need to be planted but Cycles 4 and 5 may require planting if they do not self-vegetate.

The CS-28 project area is meeting the goal of creating emergent vegetated wetland where elevations are not too low. Future vegetation surveys will provide insight as to how the marsh creation areas recover from hurricane impacts and how that recovery compares to nearby natural marshes.

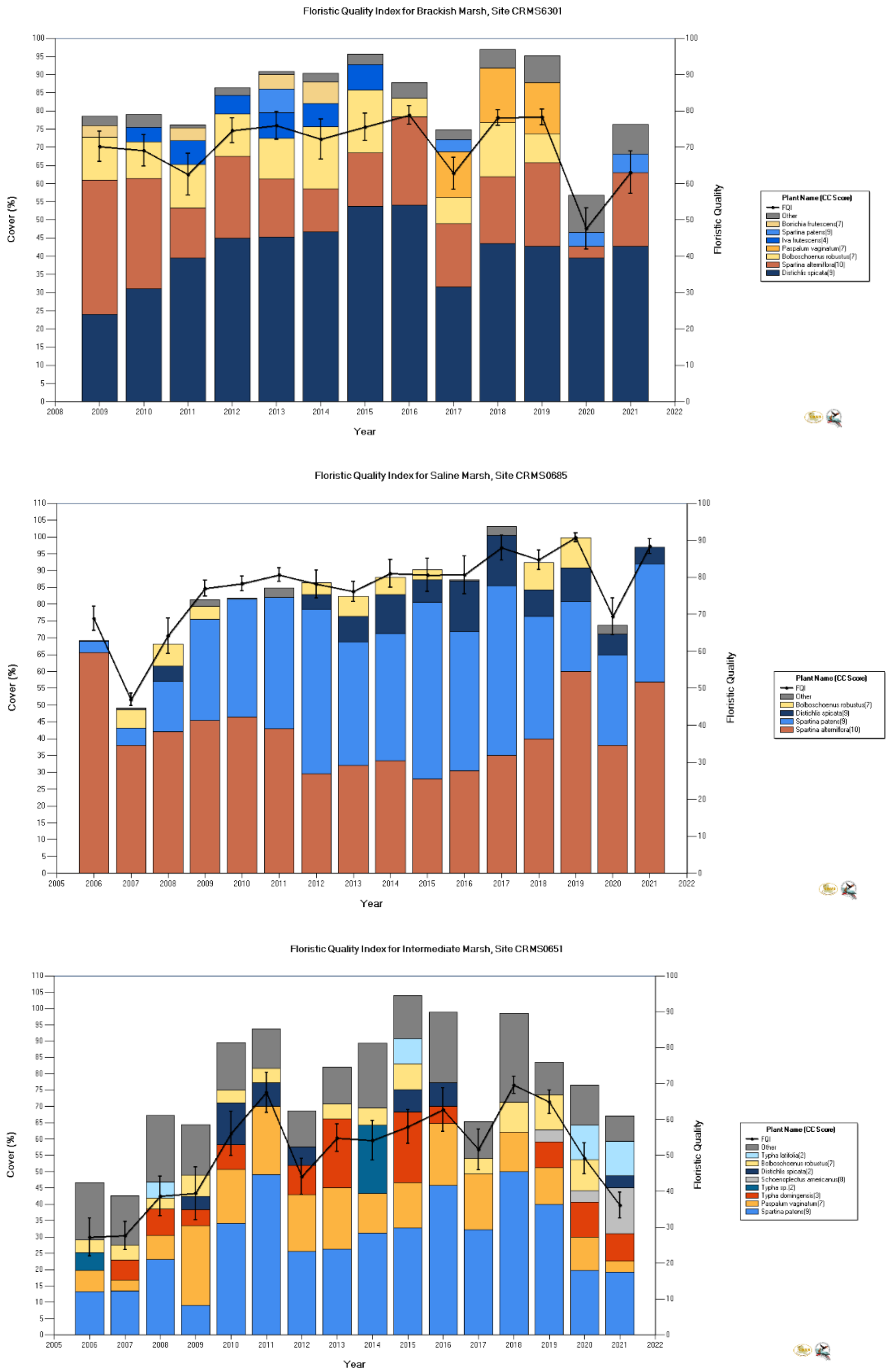


Figure 15 a, b and c. CRMS Floristic Quality Index charts from Cycle 1 (CRMS6301), near West Cove (CRMS0685), and in the marsh west of the project (CRMS0651).

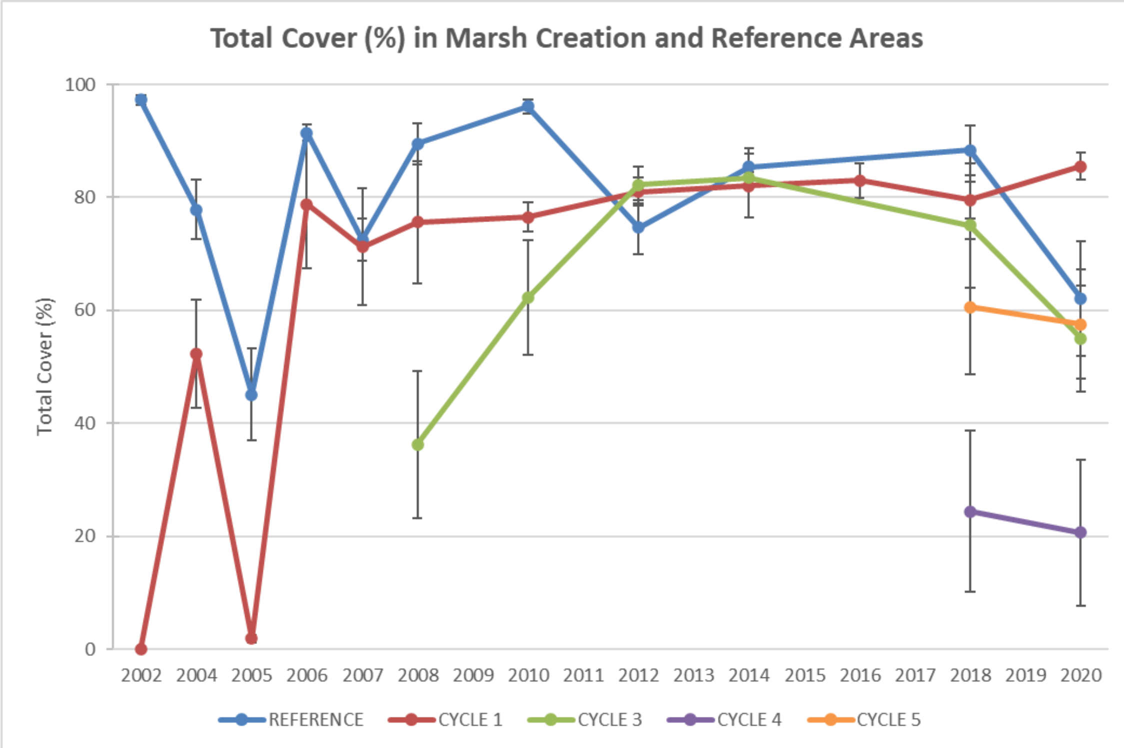


Figure 16. Total percent cover of emergent vegetation by year within CS-28 marsh creation areas and the reference area. Mean ± SE.

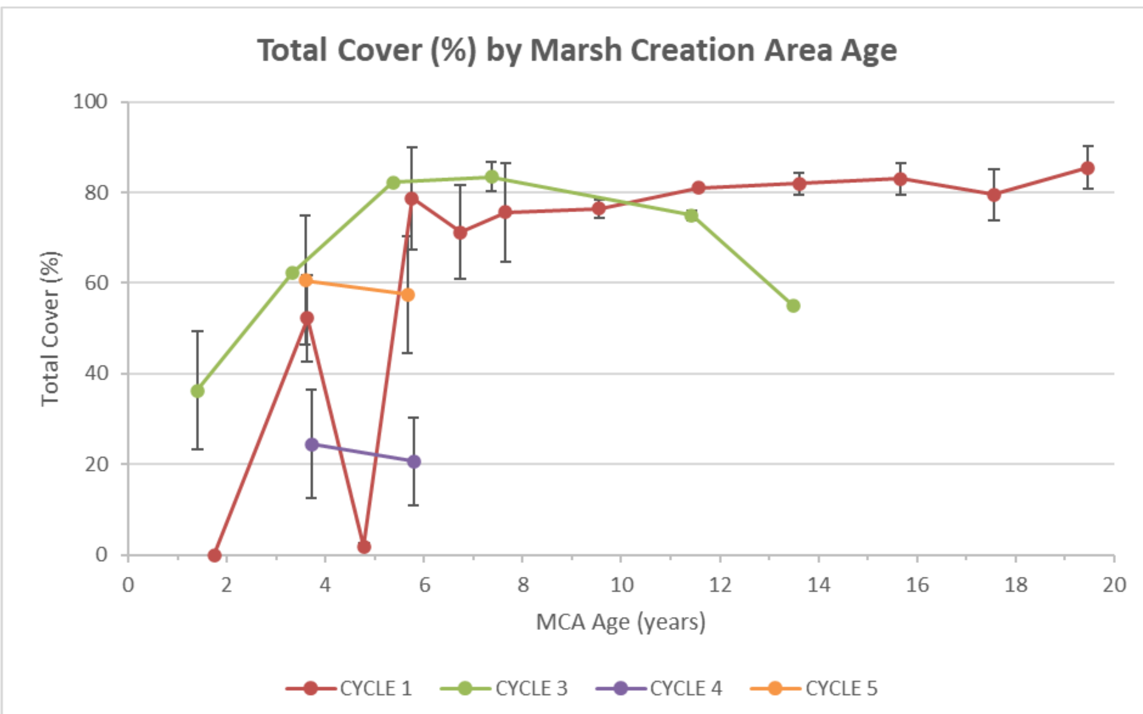


Figure 17. Total percent cover of emergent vegetation by marsh creation area age. Mean ± SE.

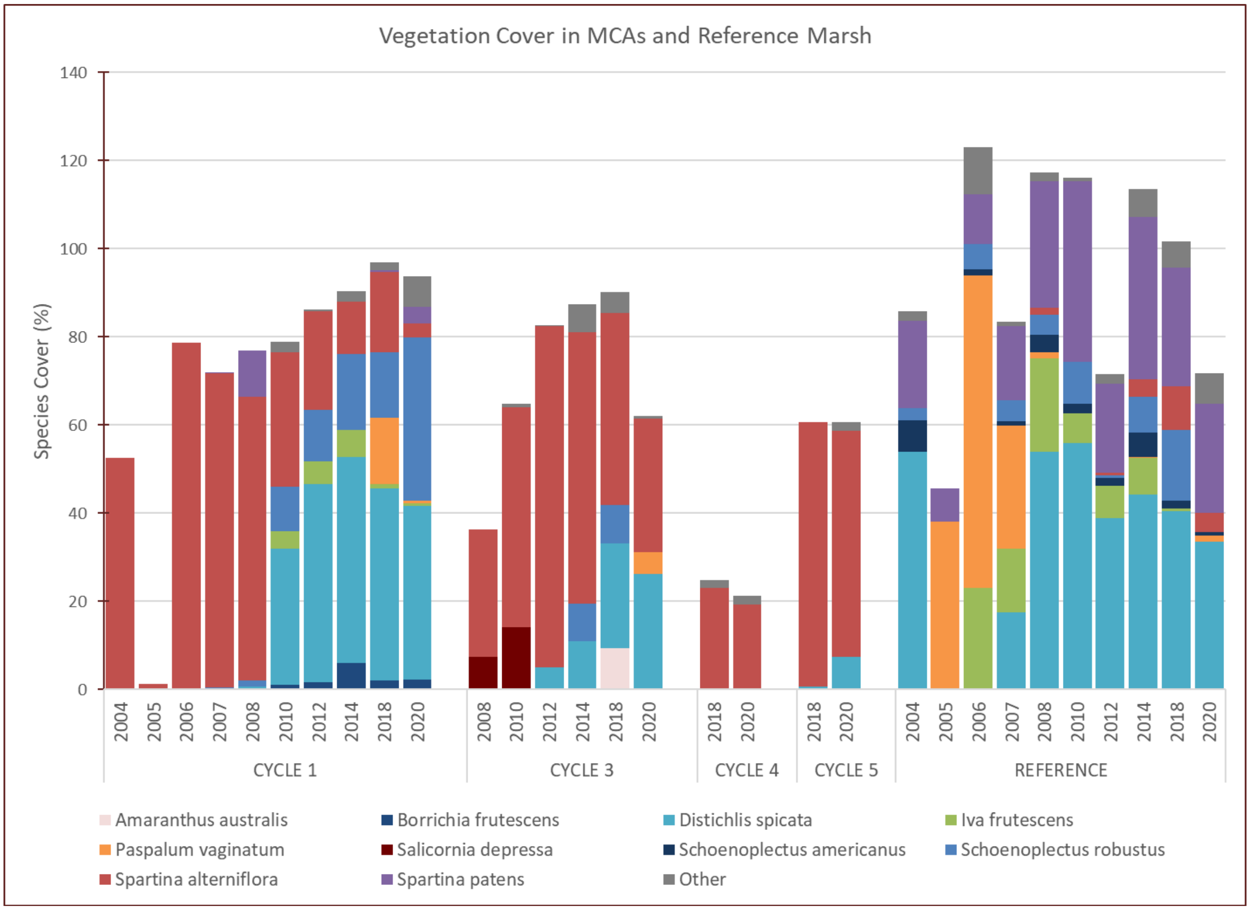


Figure 18. Percent cover of individual vegetation species by years within CS-28 cycles 3, 4, 5 and reference area.

Water Level

Water level data were collected hourly at each of the CRMS sites utilized. Annual mean water elevations were calculated from CRMS hourly data from 2006-2021. Water levels have been increasing within the project area as well as the reference areas since 2015 (Figure 19) with water levels remaining higher than marsh elevations during this time (Figure 20). Water elevation within the project marsh was lower than the reference areas until 2018 which is surprising since CRMS0685 is adjacent to West Cove and drains tidally each day. In looking at the data and the location of the CRMS6301 hydro station which is in the northernmost tidal creek that was excavated in Cycle 1, it looks like the station was isolated in an area that dewatered more easily prior to 2018. The CS-28 marsh creation areas dried out during the 2011 drought which contributed to vegetation expansion in Cycle 3 (Figure 16). Since 2018, CRMS6301 water level has been at or above CRMS0685 water level indicating that the Cycle 1 tidal creeks are no longer hydrologically isolated at these current elevated sea levels.

When compared to the interior reference marsh, water elevation within the project area remained lower than the reference marsh. During the 2011 drought, water elevation in the project marsh decreased more than the reference marsh. But during flood events, such as Hurricane Harvey in 2017, the project marsh and reference marsh both experienced an increase in water elevation (Figures 19 and 20). The project area is impounded and has limited drainage to Calcasieu Lake, which can cause high levels and extended durations of flooding during flood conditions. The reference marsh also experienced high levels of flooding because it is located further in the interior of the basin than the project marsh, also reducing draining potential.

When compared to the marsh site on the perimeter of Calcasieu Lake, water elevation within the project area remained lower than the reference lake site as well. During the 2011 drought, water elevations in the project area decreased nearly twice as much as the reference lake site (Figures 19 and 20). The reference marsh on the perimeter of the lake experienced minimal impact to water elevation and flood depth from drought conditions and hurricanes because it does not see the effects of marsh impoundment and is able to drain to the lake.

Marsh creation is designed to build a wetland to an elevation best suited for vegetative growth and production, taking into consideration hydrology and sea level rise. The CS-28 settled elevation goal of 2.5 ft MLG (0.29 ft NAVD88 (Geoid 12A) is below the mean annual water level within the project area in all years except the drought year of 2011, causing flood conditions for extended periods of time. Future marsh creation areas should be created at an elevation higher than the current project goal in order to account for rising water levels. When examining the water level range within the marsh creation area, in comparison to the target settled elevation, the marsh platform would remain nearly permanently inundated in recent years (Figure 21). The target elevation should possibly be as much as a foot higher than currently to enable vegetation to colonize before the elevation settles, but also to maintain productivity after settling, and enable expansion during lower water periods. Sea level rise should also be taken into consideration but based on elevation surveys of Cycle 3 in 2013 and 2018 (Figure 11), established vegetation is capable of adjusting to rising water levels by increasing below ground vegetative productivity and increasing marsh elevation.

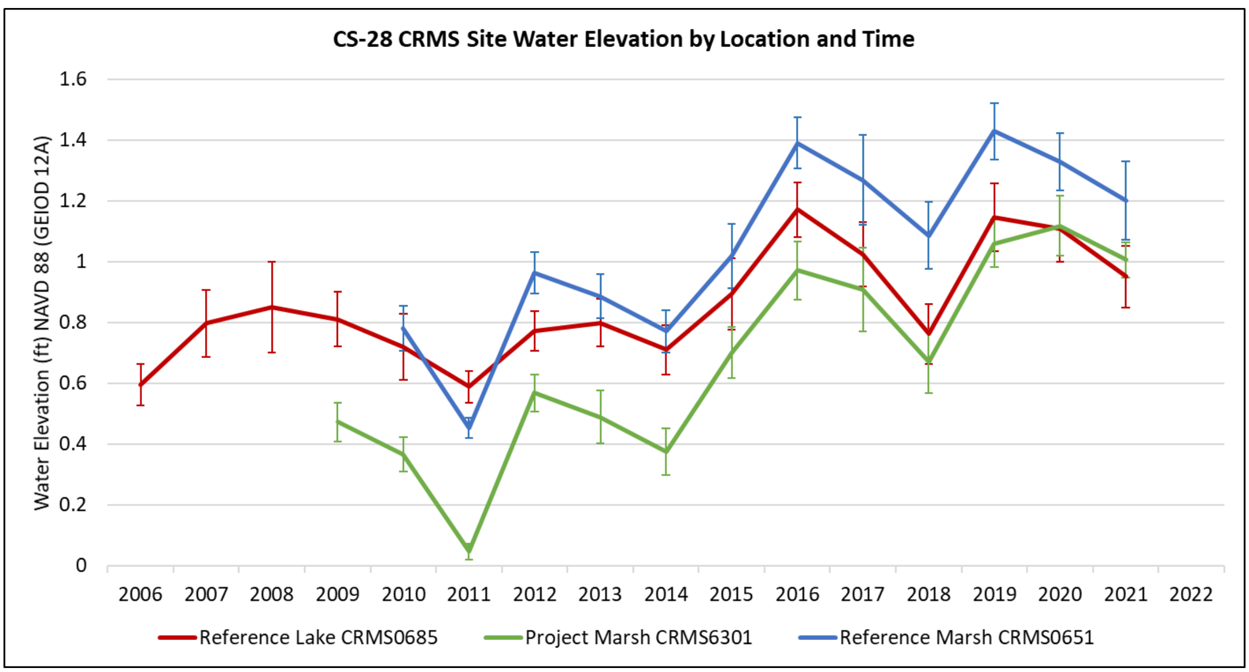


Figure 19. Annual means of surface water elevation collected in the project area, reference lake, and reference marsh CRMS sites from 2010-2021. Mean ± SE.

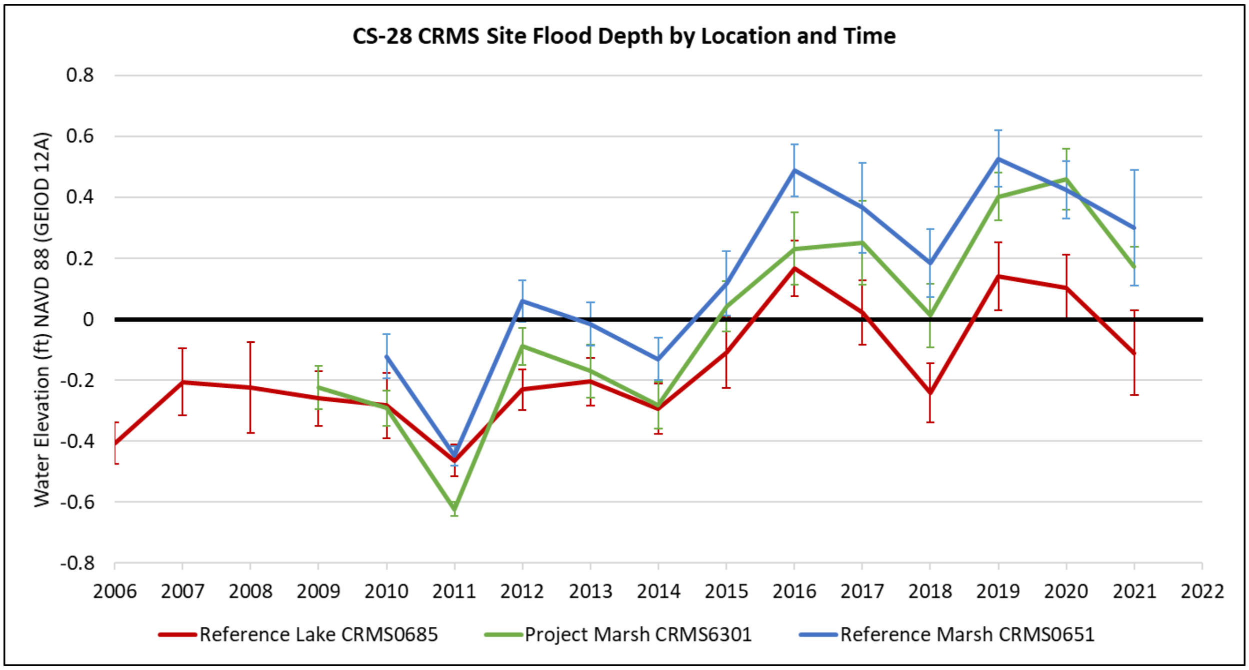


Figure 20. Annual means of water depth collected in the project area, reference lake, and reference marsh CRMS sites from 2010-2021. Mean ± SE.

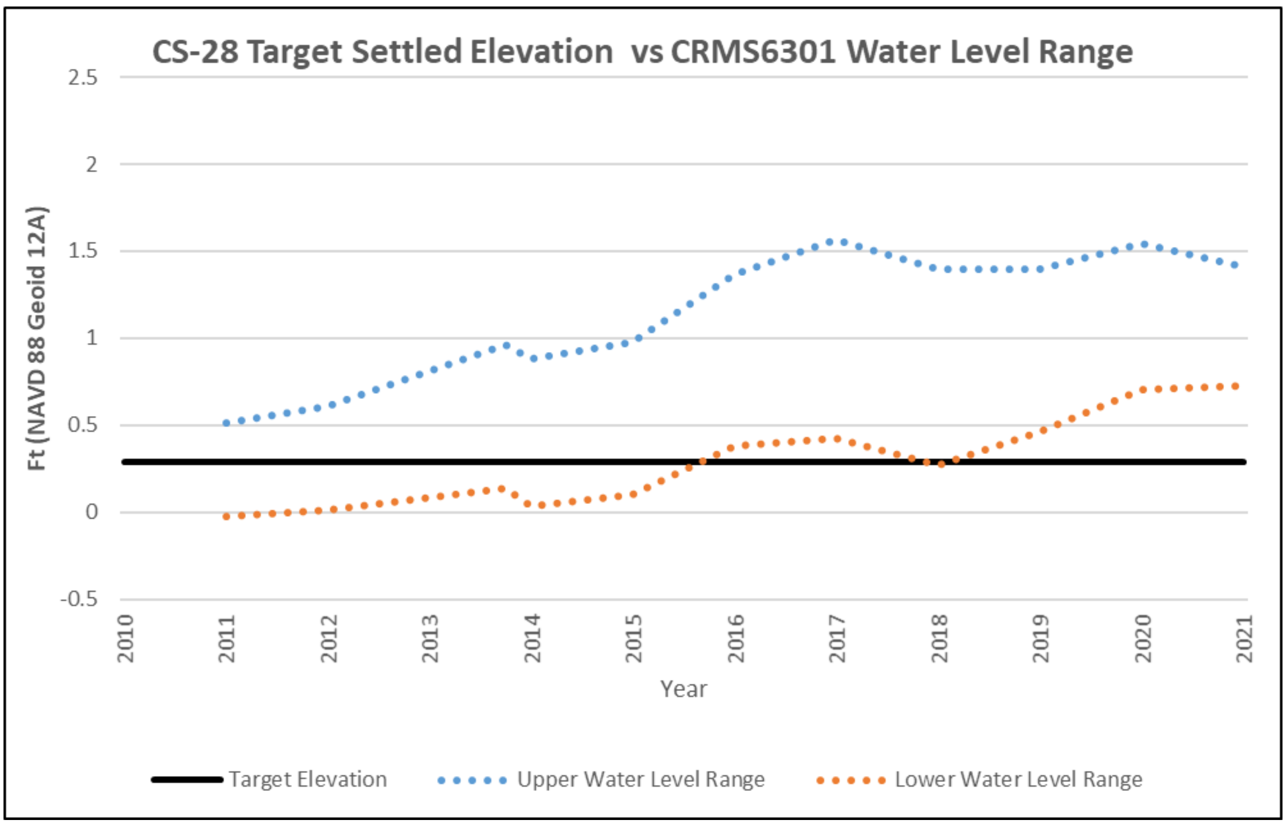


Figure 21. Annual water level range collected in the Cycle 1 marsh creation cycle plotted against the target settled elevation goal for the CS-28 marsh creation areas.

Salinity

Salinity data were collected at each of the CRMS sites utilized.

Monthly water surface salinity was calculated from CRMS hourly data from 2006-2021. Salinity was highest during the 2011 drought and has decreased since (Figure 22). There was another, much shorter drought in 2018 that did not have the same effect as the 2010/2011 drought. CRMS0685 has consistently had the highest salinities as it is directly connected to the Gulf of Mexico. The project area salinities are higher than those found in the marsh to the east of the project area. This consistent decrease in salinity can, in part, be attributed to the effects of the CS-23 Sabine control structures, which became operational in 2013, and ponding due to drainage limitations caused by sea level rise.

When comparing surface water salinity and porewater salinity within the Cycle 1 containment area, both surface water and porewater salinity rose sharply in response to drought conditions in 2011. Porewater salinity reduced to a range similar to pre-drought conditions by 2013 but remained more saline than surface water for approximately 7 years until 2018 (Figure 23). The 2018 drought again caused a slight increase in porewater salinity but freshened up early in 2019.

The CS-23 water control structures were constructed to discharge excess water and reduce saltwater intrusion into the interior marshes from the Calcasieu Ship Channel and Gulf of Mexico. The CSC is periodically above 15 ppt but can reach 20-25 ppt on a monthly average. Lower salinity ranges, within the CS-28 project area, than the bordering CSC indicate that the CS-23 control structures are successfully maintaining separation between the CSC and the CS-28 project area and maintaining salinity levels to support intermediate to brackish marsh within the project area.

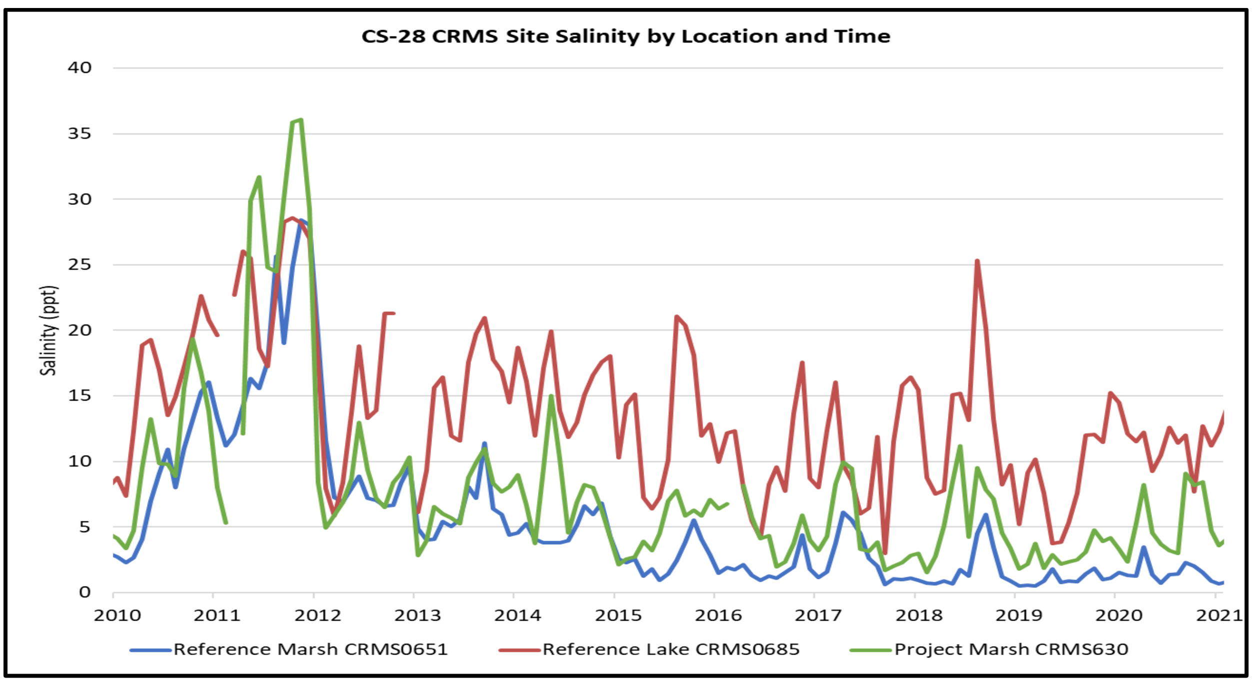


Figure 22. Monthly means of surface water salinity collected in the project and reference area locations from 2010-2021.

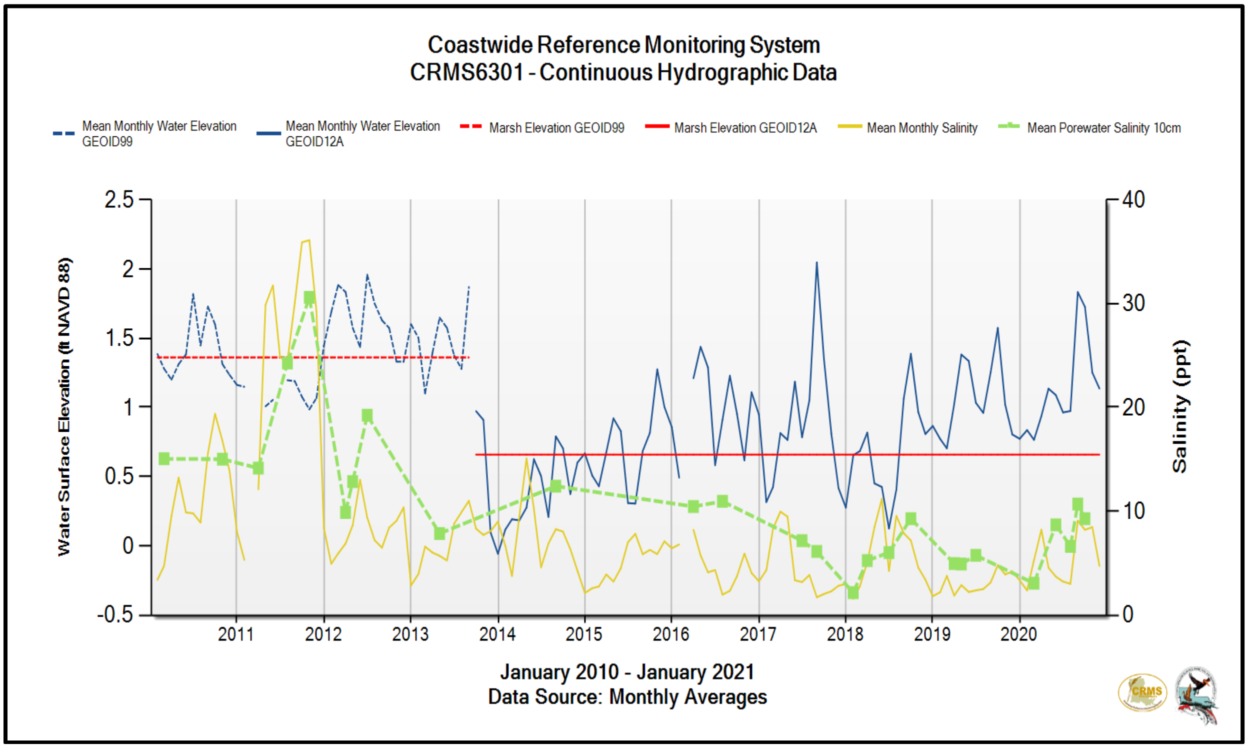


Figure 23. Monthly means of surface water elevation, marsh elevation, salinity, and porewater salinity collected in the project location (CRMS 6301) from 2010-2021.

IV. Discussion

The CS-28 marsh creation projects have successfully constructed new marsh where there was open water and have provided some limited protection to adjacent marshes though they have not caused land expansion outside of the marsh creation cells. Sea level has gone up over the project's timeframe which has resulted in more persistent flooding and lower salinities in general (Figures 19 and 22). More recent marsh creation areas (Cycles 4 and 5) have not vegetated as quickly as previously constructed cells built at the same elevation (Figure 17). This difference is most likely related to higher water levels within the project area.

One surprising yet encouraging finding from this data is that elevation appears to have risen significantly (>0.5') within the Cycle 3 marsh creation area without the addition of dredged sediments (Figure 11). Elevation gain at this rate is typically only seen at sites in the active deltas and at rapidly eroding sites. The process responsible for elevation gain in this case would have to be related to vegetative processes like root formation and expansion. Given sea level projections, it is encouraging to see these areas keep up with sea level rise. However, Cycle 3 was vegetated before the high water began and it saw the greatest expansion in vegetation after the 2011 drought when water was the lowest and the low area of the marsh creation area filled in (Figure 16). Water has not been as low as it was in 2011 since, though it was lower during the growing season in 2018 (Figure 19). If a drawdown is required to stimulate the kind of vegetative growth that caused elevation gain between 2013 and 2018, newer marsh creation areas (Cycles 4, 5, 1A and 1B) may not have the same opportunity due to current sea level.

Given current water elevations, future cycles should be constructed as much as a foot higher than they were in 2015 or water management strategies in the area need to be improved to allow for vegetation expansion.

V. Conclusions

a. Project Effectiveness

The project has been successful in meeting its goals of creating contained marsh and protecting adjacent existing marsh. The vegetation within these areas is expanding and contributing to marsh elevation. However, more recently constructed cycles are not vegetating as quickly as earlier created marshes due to persistent flooding in recent years.

b. Recommended Improvements

Higher elevation targets for future marsh creation areas are recommended to account for the effects of rising sea level and increased flooding conditions on the marsh creation areas.

c. Lessons Learned

Dredge containment cells near the Browns Lake area, within the Sabine National Wildlife Refuge will vegetate without the addition of vegetative plantings. It is not necessary to pre-dig crevasses for tidal ingress and egress. Rather, the track hoe/marsh buggy can be driven over the area where tidal channels are desired approximately one-three years after pumping to create channels. Pre-digging crevasses is costly and can interfere with the placement of the dredged material.

Vegetation in created marshes will expand and will help maintain elevation. A drawdown or period of low water that exposes the marsh surface may be necessary to stimulate elevation gain.

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Appendix A

Photographs

Photo No. 1, Cycle No. 1, Northeast corner of cell at pipeline riser

Photo No. 2, Cycle No. 4, Southern Containment Dike, Looking Southwest

Photo No. 3, Cycle No. 4, Vegetation where Established on north end

Photo No. 4, Interior of Marsh Creation Cycle No. 4, South East End


Photo No. 5, Marsh Interior West Side of Cycle No. 5, well established vegetation


Photo No. 6, Marsh Creation Cycle No. 5 – West side containment dike

APPENDIX B
(Three Year Budget Projection)

SABINE REFUGE MARSH CREATION CYCLE 4&5/ CS-28-4&5 / PPL 8

Three-Year Operations & Maintenance Budgets 07/01/2022 - 06/30/2025

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Jody White	*Jody White*	*USFWS*	*Jody White*

	2022/2023 (-8)	**2023/2024 (-9)**	**2024/2025 (-10)**
Maintenance Inspection	$ 7,943.00	$ 8,181.00	$ 8,426.00
Structure Operation			
State Administration	$1,000.00	$ 1,000.00	$ 5,000.00
Federal Administration	$1,000.00	$ 1,000.00	$ 1,500.00
Maintenance/Rehabilitation			

22/23 Description:

	2022/2023 (-8)
E&D	
Construction	
Construction Oversight	
Sub Total - Maint. And Rehab.	$ -

23/24 Description

	2023/2024 (-9)
E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

24/25 Description: Tidal Creeks

	2024/2025 (-10)
E&D	
Construction	$ 130,000.00
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ 130,000.00

	2022/2023 (-8)	**2023/2024 (-9)**	**2024/2025 (-10)**
Total O&M Budgets	**$ 9,943.00**	**$ 10,181.00**	**$ 144,926.00**

O &M Budget (3 yr Total)	**$ 165,050.00**
Unexpended O & M Budget	**$ 165,264.00**
Remaining O & M Budget (Projected)	**$ 214.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

SABINE REFUGE MARSH CREATION CYCLES 4 & 5 PROJECT
CS-28-4-5 / C.140028.8 / PPL NO. 8/ 2022-2023

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$7,943.00	**$7,943.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract & Minor Maitenance	LUMP	0	$0.00	**$0.00**
Other	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
State Admin.	LUMP	1	$1,000.00	$1,000.00
FEDERAL SPONSOR Admin.	LUMP	1	$1,000.00	$1,000.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$2,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Bathymetry/ Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
Bank Paving	7184	1.9	0	$85.00	$0.00
Rip Rap - Structures (LUMP)	0	0.0	0	$0.00	$0.00
Crushed Stone - Breaches	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$9.00	$0.00
Navigation Aid		EACH	0	$0.00	$0.00
Signage		LUMP	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)		SQ FT	0	$0.00	$0.00
Batter Piles (each or lump sum)		LN FT	0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	0	$0.00	$0.00
Contingency (25%)		LUMP	0	$0.00	$0.00
General Structure Maintenance		LUMP	0	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: $9,943.00

OPERATION AND MAINTENANCE BUDGET WORKSHEET

SABINE REFUGE MARSH CREATION CYCLES 4 & 5 PROJECT
CS-28-4-5 / C.140028.8 / PPL NO. 8/ 2023-2024

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$7,965.85	**$7,965.85**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract & Minor Maitenance	LUMP	0	$0.00	**$0.00**
Other	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

State Admin.	LUMP	1	$1,000.00	$1,000.00
FEDERAL SPONSOR Admin.	LUMP	1	$1,000.00	$1,000.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
Construciton Admin & Oversight		0	$0.00	$0.00
			TOTAL ADMINISTRATION COSTS:	**$2,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:

Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Bathymetry / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:

Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
Bank Paving	7184	1.9	0	$85.00	$0.00
Rip Rap - Structures (LUMP)	0	0.0	0	$0.00	$0.00
Crushed Stone - Breaches	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$9.00	$0.00
Navigation Aid		EACH	0	$0.00	$0.00
Signage		LUMP	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)		SQ FT	0	$0.00	$0.00
Batter Piles (each or lump sum)		LN FT	0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	0	$0.00	$0.00
Contingency (25%)		LUMP	0	$0.00	$0.00
General Structure Maintenance		LUMP	0	$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: $9,965.85

OPERATION AND MAINTENANCE BUDGET WORKSHEET

SABINE REFUGE MARSH CREATION CYCLES 4 & 5 PROJECT

CS-28-4-5 / C.140028.8 / PPL NO. 8/ 2024-2025

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$8,205.00	**$8,205.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract & Minor Maitenance	LUMP	0	$0.00	**$0.00**
Other	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
State Admin.	LUMP	1	$5,000.00	$5,000.00
FEDERAL SPONSOR Admin.	LUMP	1	$1,000.00	$1,000.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
Construction Admin and Oversight	LUMP	0	$0.00	$0.00
			TOTAL ADMINISTRATION COSTS:	**$6,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Bathymetry/ Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION: Tidal Creek Excavation

Rip Rap	LIN FT	TON / FT	QTY	UNIT PRICE	
Bank Paving	7184	1.9	0	$85.00	$0.00
Rip Rap - Structures (LUMP)	0	0.0	0	$0.00	$0.00
Crushed Stone - Breaches	0	0.0	0	$0.00	$0.00

DESCRIPTION	UNIT	QTY	UNIT PRICE	ESTIMATED TOTAL
Filter Cloth / Geogrid Fabric	SQ YD	0	$9.00	$0.00
Navigation Aid	EACH	0	$0.00	$0.00
Signage	LUMP	0	$0.00	$0.00
General Excavation / Fill	CU YD	9,823	$5.50	$54,026.50
Dredging	CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)	SQ FT	0	$0.00	$0.00
Batter Piles (each or lump sum)	LN FT	0	$0.00	$0.00
Timber Members (each or lump sum)		0	$0.00	$0.00
Hardware	LUMP	0	$0.00	$0.00
Materials	LUMP	0	$0.00	$0.00
Mob / Demob	LUMP	1	$45,000.00	$45,000.00
Contingency (25%)	LUMP	0	$0.00	$0.00
General Structure Maintenance	LUMP	0	$0.00	$0.00
Tidal Creek Excavation			$0.00	$0.00
Survey - 2 man crew - 4 days	LUMP	1	$20,000.00	$20,000.00
Contingency (10%)			10%	$11,902.65
			TOTAL CONSTRUCTION COSTS:	**$130,929.15**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: $145,134.15