Appendix F:
CPRA 95% Design Report

Reggio Marsh Creation Project
(BS-0043)

Coastal Wetland Planning, Protection and Restoration Act PPL 30

95% Design Report

October 2023

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Executive Summary

The Reggio Marsh Creation project area is in Region Two (2) of the Breton Sound Basin in St. Bernard Parish, Louisiana. The community of Reggio, LA is located approximately twenty-one (21) miles southeast of New Orleans, in St. Bernard Parish. The Reggio Marsh Creation project area is bounded on the north by an existing tidal levee, on the south by the Reggio Canal, and on the west by the Reggio community, and will serve as an important buffer to protect this coastal community from storm surge. St. Bernard Parish may incur some of the highest wetland loss as a percentage of total parish land area over the next fifty (50) years of any coastal parish (CPRA, 2017). With no further coastal protection or restoration actions, the parish could lose an additional two hundred thirty-seven (237) square miles, or seventy-two percent (72%) of the parish land area over the next fifty (50) years (CPRA, 2017). In this area, coastal wetland loss can be attributed to both anthropogenic and natural factors, such as drilling and dredging for oil and gas, flooding marshes from sea-level rise, storm-driven erosion from Hurricanes Katrina (2005), Rita (2005), Isaac (2012) and Ida (2021), and subsidence. The Coastal Protection and Restoration Authority (CPRA) and the 2017 Coastal Master Plan (CMP) utilize two (2) primary marsh restoration techniques to help offset marshland loss in the Breton Sound Basin. These marsh restoration techniques include river diversions and marsh creation projects.

The goal of this project is to restore marsh habitat east of the community of Reggio by creating and nourishing an area to be tidal marshes during the twenty (20) year project life. Another goal of this project at Phase 0 was to decrease salt-water intrusion in the area west of Reggio by plugging two canals along the west shore of Bayou Terre aux Boeufs. However, these project features were removed after further analysis and coordination with the CWPPRA community and stakeholders post-30% Design. The project will aid in stopping wetland loss and buffering future storm surge events for the long-term protection of the community of Reggio.

The project will create and nourish approximately five hundred and nineteen (519) acres of intermediate marsh by hydraulically dredging sediment from Lake Lery. Marsh creation projects involve raising the marsh elevation with dredged sediment so that the marsh can support healthy marsh vegetation for the twenty (20) year project design life. The Marsh Creation Borrow Area is located approximately seven (7) miles southwest of the project footprint within Lake Lery, and will be connected to the project footprint via a temporary sediment delivery pipeline.

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List of Acronyms

ACRE	Applied Coastal Research and Engineering
ADCP	Accoustic Doppler Current Profiler
APE	Area of Potential Effect
BA	Borrow Area
BS	Breton Sound
BTAB	Bayou Terre aux Boeufs
CIAP	Coastal Impact Assistance Program
CMFE	Constructed Marsh Fill Elevation
CMP	Coastal Master Plan
CPC	Colonial Pipeline Company
CPRA	Coastal Protection and Restoration Authority
CPT	Cone Penetration Test
CRMS	Coastwide Reference Monitoring System
CSD	Cutterhead Suction Dredge
CSI	Chustz Surveying Inc.
CTD	Conductivity, Temperature, and Depth
CWPPRA	Coastal Wetlands Planning, Protection and Restoration Act
CY	Cubic Yard
DPC	Dredge Pipeline Corridor
EAC	Equipment Access Corridor
ECD	Earthen Containment Dike
EM	Existing Marsh
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
ESLR	Eustatic Sea Level Rise
ESRI	Environmental Systems Research Institute
FT	Foot
GER	Geotechnical Engineering Report
GIS	Geographic Information System
HDPE	High Density Polyethylene
HPGT	High Point Gas Transmission
HTRW	Hazardous, Toxic, and Radioactive Waste
IDIQ	Indefinite Delivery/Indefinite Quantity
ITD	Internal Training Dike
LDFW	Louisiana Department of Wildlife and Fisheries
LF	Linear Foot
LI	Liquidity Index
LiDAR	Light Detection and Ranging
LL	Liquid Limit
LS	Lump Sum
MC	Marsh Creation
MCA	Marsh Creation Area
MCBA	Marsh Creation Borrow Area
MCDG	Marsh Creation Design Guidelines
MCY	Million Cubic Yards
MHW	Mean High Water
ML	Mudline

MLW	Mean Low Water
MTL	Mean Tide Level
NAD83	North American Horizontal Datum of 1983
NAVD88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NPMS	National Pipeline Mapping System
NRHP	National Register of Historic Places
OPUS	Online Positioning User Services
PI	Plasticity Index
PL	Plastic Limit
PPL	Project Priority List
PSDDF	Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill
RSLR	Relative Sea Level Rise
RTK	Real-time Kinematic
SF	Square Foot
SHPO	State Historic Preservation Office
SLR	Sea Level Rise
SONRIS	Strategic Online Natural Resources Information System
TBS	T. Baker Smith, LLC
TIN	Triangulated Irregular Network
TY	Target Year
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USGS	United States Geological Survey

1.0 INTRODUCTION

The Reggio Marsh Creation project is in the Breton Sound (BS) Basin shown in **Figure 1**. In 2021, the Louisiana Coastal Wetlands Planning, Protection and Restoration Task Force designated BS-0043 as part of the 30th Priority Project List (PPL30). The U.S. Environmental Protection Agency (EPA) will serve as the lead federal sponsor with funding approved through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) of 1990. The Louisiana Coastal Protection and Restoration Authority (CPRA) is serving as the local sponsor and will provide engineering and design services.

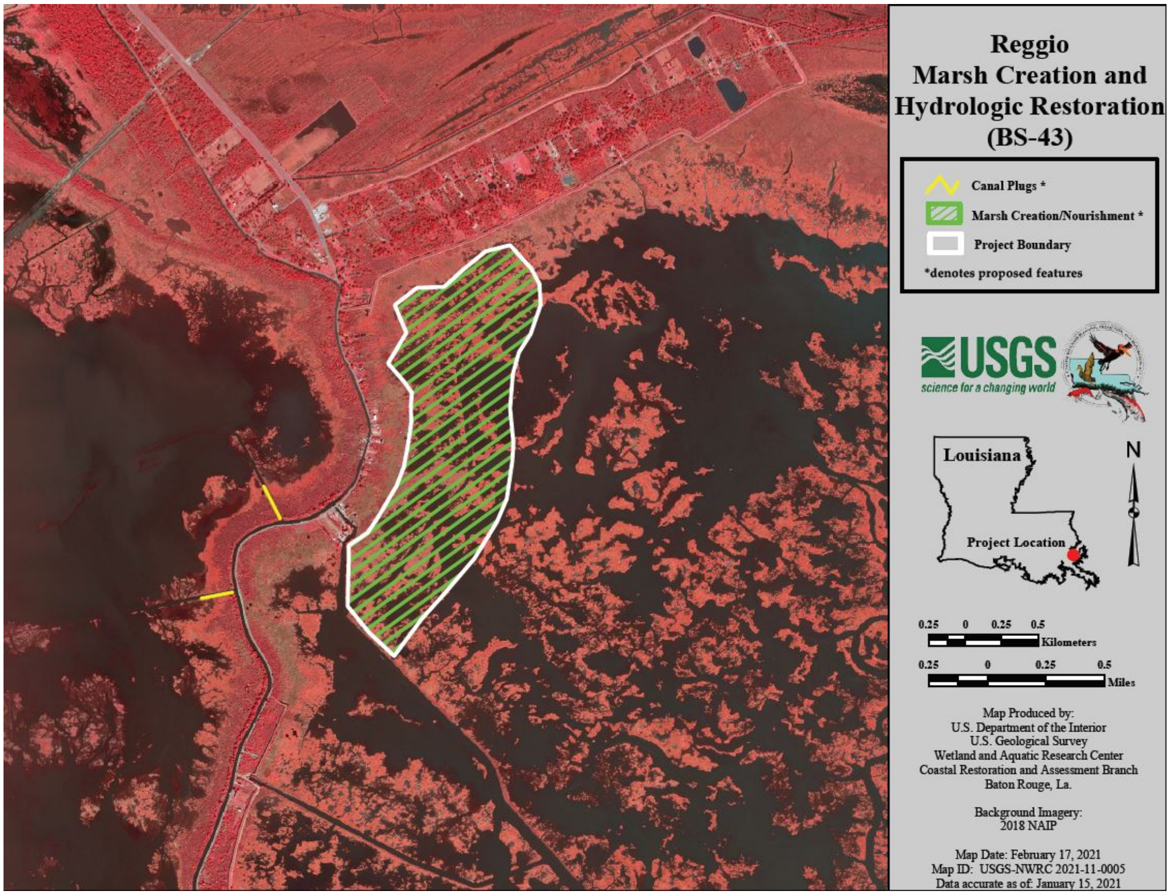


Figure 1: CWPPRA Phase 0 Project Area (CWPPRA 2020).

1.1 Work Performed

The EPA is serving as the federal project sponsor in addition to providing environmental compliance and coordination for cultural resources. The CPRA is both serving as the local project sponsor and providing the professional engineering and drafting services for the proposed project, and the development of the project bidding documents. To complete these technical tasks, several consulting services were utilized from the approved CPRA Indefinite Delivery/Indefinite Quantity (IDIQ) Contracts. The project's consulting team included Chustz Surveying Inc. (Chustz), Fugro USA Land, Inc. (Fugro), Eustis Engineering, LLC (Eustis), T. Baker Smith, LLC (TBS), C.H. Fenstermaker and Associates, LLC (Fenstermaker), TerraSond, and Coastal Environments Inc. (CEI).

1.1.1 Surveying Services

Chustz performed the topographic and bathymetric surveys and gauge readings for the Marsh Creation Areas (MCAs) and Dredge Pipeline Corridor (DPC), and consolidated all of the survey data for the survey report. Fugro was contracted by Chustz to provide magnetometer and cultural resource surveys within the MCAs and along the entire DPC. Fugro hired archaeologist Jason Burns to help with the cultural resource surveys (Chustz, 2022).

The proposed Marsh Creation Borrow Area (MCBA) was surveyed in 2021 as part of the BS-0041 North Delacroix Marsh Creation project survey. TerraSond assisted Fenstermaker in the bathymetry and magnetometer surveys and cultural resources investigation of the proposed MCBA. The cultural resource investigation of the proposed MCBA was conducted with the help of a marine archaeologist from CEI, contracted by TerraSond (C.H. Fenstermaker, 2021).

1.1.2 Geotechnical Services

Eustis performed geotechnical exploration and engineering services for the project, including the analysis of project features. TBS provided surveying services for Eustis to gather elevations and magnetometer data at the proposed boring locations in the proposed MCBA, MCAs, and the two canals along Bayou Terre aux Boeufs (BTAB) that were proposed to be plugged.

1.1.3 Land Rights Services

The CPRA Project Management Division was tasked with leading the required land rights services while the CPRA Planning and Research was tasked with environmental services. Land Management Services, LLC provided land rights services, including researching ownership information in the tax assessment records, preparing a tax assessment report, and chain of title report. Land Management Services, LLC is currently conducting title research in the project area.

1.1.4 Environmental Services

The National Environmental Policy Act (NEPA) requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions (EPA, 2023). Using the NEPA process, agencies evaluate the environmental effects of their proposed actions. The Environmental Protection Agency (EPA) utilized the tool NEPAssist to research the project area, along with a one-half (0.5) mile buffer around the project area. NEPAssist is a tool that facilitates the environmental review process and project planning in relation to environmental consideration. This web-based application draws environmental data from EPA GIS databases to provide immediate screening of environmental assessment indicators for a specific area of interest (EPA, 2023). Through their research, along with the cultural resources investigation findings for this project, EPA concluded that the Hazardous, Toxic, and Radioactive Waste Investigation (HTRW) was not necessary for BS-0043. EPA came to this conclusion based on the Phase 1 Environmental Site Assessment conducted for the BS-0041 project at Delacroix and the results from the cultural resources investigation from the Reggio project area.

1.2 Project Area History

The project area is located within the Breton Sound Basin, which is a remnant of the Mississippi River delta lobe and the abandoned St. Bernard Delta (Saucier, 1994) (Error! Reference source not found.). The principal hydrologic features of the Breton Sound Basin include the Mississippi River and its natural levee ridges, the flood protection levee, abandoned delta distributaries, Lake Lery, Grand Lake, other interior lakes, and the freshwater diversions at Caernarvon, White Ditch, Bohemia, and Bayou Lamoque. The barrier islands, which make up the Breton National Wildlife Refuge, are far offshore and thus provide minimal protection to the project area.

St. Bernard Parish was named after Don Bernardo de Galvez, who became the governor of Spanish Louisiana in 1777. Galvez realized a need to populate the area below New Orleans to secure it from English encroachment. Several families were brought from the Canary Islands to settle in four areas around New Orleans, including Terre aux Boeufs in St. Bernard, and were provided with housing, farming equipment, animals, rations, and financial assistance (Fugro, 2022).

Initially known as *La Concepcion*, the St. Bernard Post was established in 1780 along BTAB. In 1788 a Spanish census listed 661 people living in the settlement at BTAB including the Isleños from the Canary Islands and descendants of the earlier Acadian settlers. Groups in the region occupied simple palmetto huts and survived by fishing, hunting, and trapping. Trading or selling of pelts, oysters, and fish to New Orleans traders and merchants were early industries in the area (Fugro, 2022).

The Mississippi deltaic plain formed over the last 10,000 years as the Mississippi River flowed towards the Gulf of Mexico, depositing sediment and nutrients to coastal marshes. BTAB and La Loutre were once the primary channels of the Mississippi River during the formation of the St. Bernard Delta between 5,500 to 1,100 years ago (Saucier, 1994). The natural levee of BTAB is the highest natural landform in the project area. Since the construction of flood control levees along the Mississippi River in the 1930's to reduce floodwaters on urban areas in the Mississippi floodplain, the Mississippi River no longer provides a significant freshwater source and sediment to this region. Coastal marshland growth in the Breton Sound Basin generally ceased, resulting in a slow marsh vegetation retreat.

The loss of coastal marsh in the project area has increased dramatically over the last several decades due to a combination of anthropogenic and natural processes. These factors include hydrologic modifications of the Basin, storm-driven erosion, subsidence, and sea-level rise. Canals that were once used for access to the extraction locations are still prevalent, such as Howard's Ditch and Reggio Canal. Today, all gas wells within the project area are listed as plugged and abandoned. A map displaying these features within the project area is shown in **Figure 2** (SONRIS, 2023).

By the 1990's, the marsh in the project area was severely degrading with open water taking the place of marsh grass by 1998. Land loss in the project area became even more apparent following Hurricanes Katrina, Isaac, and Ida's passage in 2005, 2012, and 2021 respectively. Inundation of high saline water from surrounding saline waterbodies, and wind-induced scour from Hurricane Katrina, Isaac, and Ida increased land loss within the project area. The damaging effects of Hurricane Katrina are shown in aerial photography taken in 2004 and 2005 (**Figure 3** and **Figure 4**) (Google Earth, 2023).

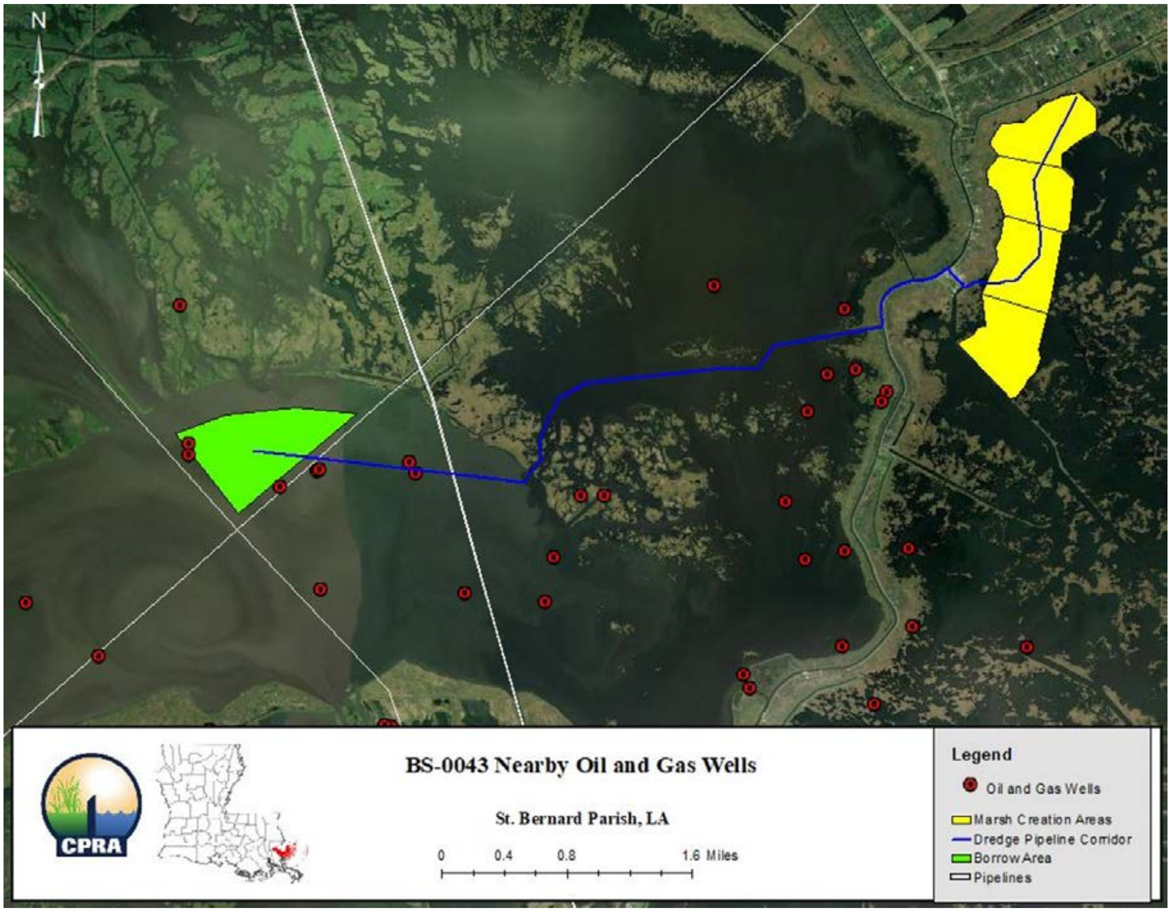


Figure 2: Map of project area showing the location of oil and gas wells (SONRIS)

Figure 3: Google Earth imagery of Reggio, LA (2004)

Figure 4: Google Earth imagery of Reggio, LA (2005)

1.3 Project Goals

At Phase 0, and as stated on the CWPPRA PPL 30 Project Fact Sheet, the primary goals of BS-0043 were to create two hundred eighty-seven (287) acres and nourish one hundred ninety-three (193) acres (four hundred eighty-four (484) acres total) of marsh in one (1) fully confined marsh fill area by hydraulically dredging material from Lake Lery. The project also investigated the effectiveness of plugging two (2) canals on the west bank of BTAB (**Figure 1**), in an effort to reduce salt-water intrusion to the west of Reggio, LA.

Throughout the Phase I process, adjustments were made to the configuration of the MCA to avoid deeper areas, which could cause stability issues for the Earthen Containment Dikes

(ECDs), and existing oil and gas infrastructure. The total acreage of the marsh creation and nourishment areas has changed from four hundred eighty-four (484) acres to five hundred nineteen (519) acres. Additionally, the locations and design of the proposed canal closures were investigated heavily throughout Phase I, including a twelve-week data collection effort. This effort was to support the creation of a hydrodynamic computer model to assess the efficacy of reducing salinity west of BTAB with Canal Plugs. All project features are discussed in further detail in Section 6.0 **Project Design**.

The project goals for the Reggio Marsh Creation project are to:

- Restore marsh habitat via marsh creation and nourishment, ensuring tidal influence on the constructed marsh platform as early as possible and for as long as possible during the twenty (20) year project life, taking into consideration elevations and ecological performance of existing marsh habitats.
- Create and nourish marsh east of the community Reggio, LA in St. Bernard Parish using sediment dredged from Lake Lery.
- Investigate the effectiveness of plugging two canals along the west bank of BTAB in reducing salt-water intrusion into the area west of BTAB.

1.4 Existing Project Area Features

Reggio is situated on the east bank of the BTAB ridge bounded by an existing tidal levee to the north, broken marsh to the east, Reggio Canal to the south, and Highway 300 (Hwy. 300) on the west. Two canals extend from the west bank of BTAB and connect making up Howard's Ditch. These two canals were proposed to be plugged in Phase 0 as the hydrologic restoration feature of BS-0043, as shown in **Figure 1**. There is an existing tidal creek that runs north to south through the marsh fill area, from MCA-1 to Reggio Canal at the southern border of MCA-4, called Schooner Canal. One aspect that is crucial to the construction of this project is the bridge along Hwy. 300 at the intersection of BTAB and Reggio Canal. The DPC and Equipment Access Corridor (EAC) will both pass under this bridge in order to reach the marsh fill area.

1.5 Breton Sound Marsh Creation Projects

To date, two (2) marsh creation projects have been constructed using Lake Lery as a sediment borrow source. These two (2) projects are South Lake Lery Shoreline and Marsh Creation (BS-0016) and Lake Lery Marsh Creation (BS-0017 Phase I). The most relevant existing marsh creation project is BS-0017 due to the borrow source material's proximity. BS-0017 Phase I completed construction in 2015. This project, sponsored by the Coastal Impact Assistance Program (CIAP) and St. Bernard Parish, dredged roughly half a million cubic yards of sediment from Lake Lery to create approximately seventy (70) acres of marsh. Also included in St. Bernard Parish's Priority Coastal Projects is the Phase II component of marsh creation for Lake Lery. This project intends to restore thirty-nine (39) acres of marsh near the western natural levee of BTAB and continue restoring wetland from the northern extent of the Phase I project. Sediment borrow material will be dredged from a similar location to that of the Phase I project. The Lake Lery Marsh Creation Phase I (completed) and Phase II projects, along with several other Breton Sound projects currently in Phase I or pending construction, are shown in **Figure 5** and shown in **Table 1**.

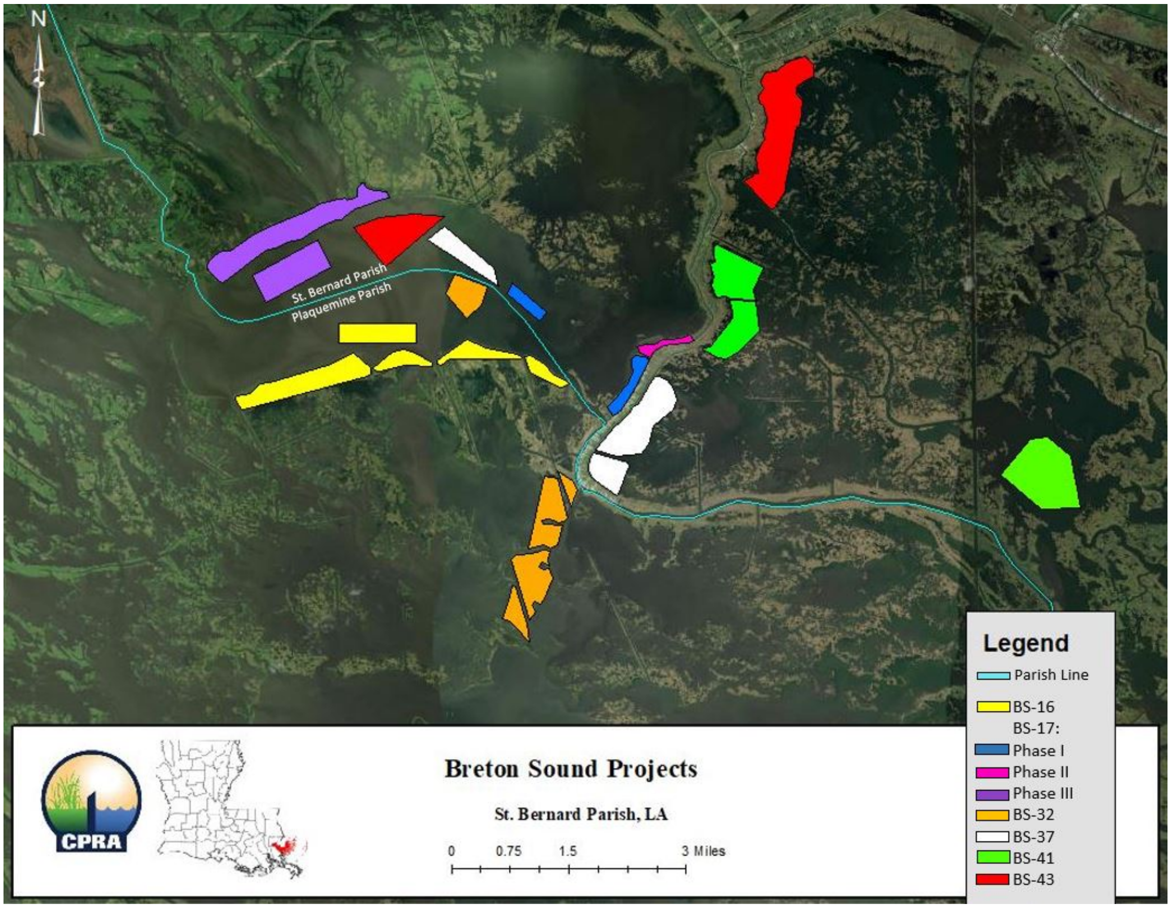


Figure 5: Map of the Marsh Restoration Projects and Borrow Areas in the Breton Sound Basin

Table 1: Restoration Projects in the Breton Sound Basin

Project ID	Project Name	Status	Funding Source	Borrow Source
BS-0016	South Lake Lery Shoreline and Marsh Restoration	Constructed	CWPPRA	Lake Lery
BS-0017	Lake Lery MC Phase 1	Constructed	CIAP	Lake Lery
BS-0032	Mid-Breton Land Bridge MC and Terracing	Awarded Phase II Construction Funding	CWPPRA	Lake Lery
BS-0037	East Delacroix MC and Terracing Project	Awarded Phase II Construction Funding	CWPPRA	Lake Lery
BS-0041	North Delacroix MC and Terracing	Phase I E&D Funding	CWPPRA	Lake Amedee
TBD	Lake Lery MC and Rim Restoration Project (Phase 3)	E&D	CIAP	Lake Lery

1.6 Land Ownership

A land rights investigation was conducted by CPRA's Land Rights Division following the CWPPRA Standard Operating Procedure (SOP) and implemented as per the Marsh Creation Design Guidelines Version 1.0 (MCDG 1.0 Section 3.4). Land Management Services, LLC has completed the tax assessment for this project and is currently working on the title research.

The project area contains fifty-five (55) privately owned parcels of land, consisting of approximately thirty-nine (39) undivided landowners and sixteen (16) corporations (**Figure 6**). The borrow area in Lake Lery is claimed by the Office of State Lands. The primary landowner within the project area is Delacroix Corporation.

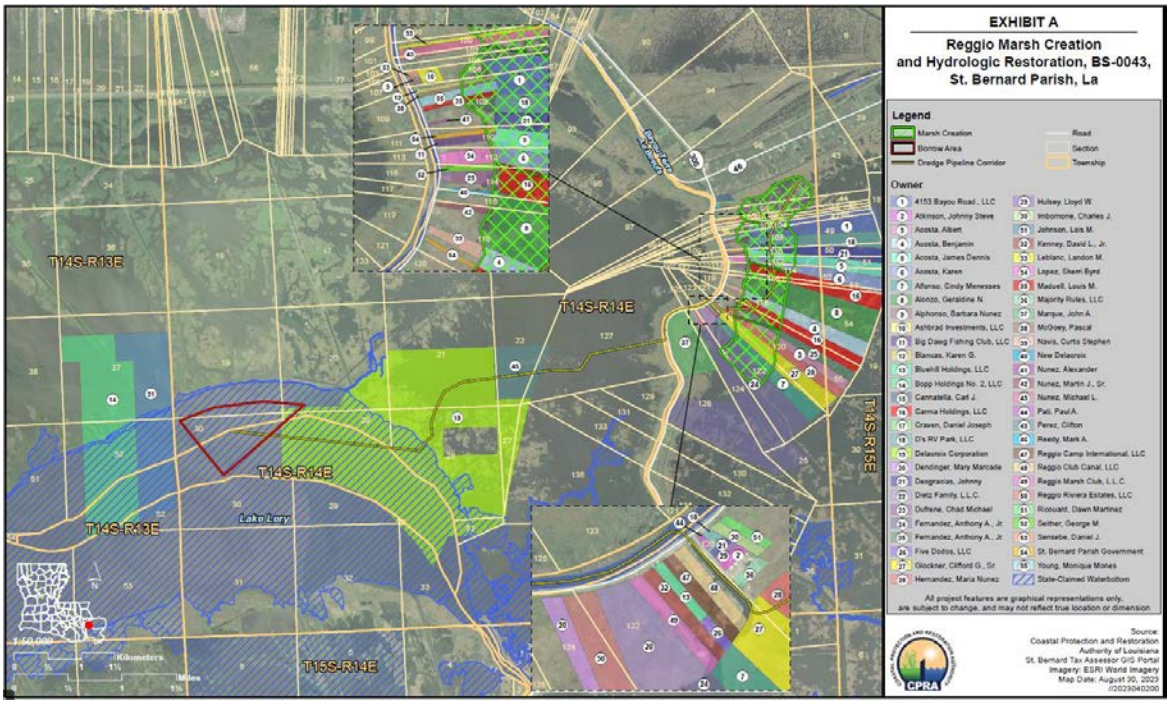


Figure 6: Land Ownership Map

1.7 Cultural Resources Assessment

Cultural resources assessments were conducted for the MCAs and the DPC separately from the proposed MCBA. After the initial cultural resources investigation, it was determined that no additional cultural resources assessment surveys would be necessary for the DPC, MCAs, or the proposed MCBA.

1.7.1 Marsh Creation Area and Dredge Pipeline Corridor

Fugro was contracted by Chustz to provide magnetometer and cultural resource surveying services for the DPC and MCAs. To collect the Cultural Resource survey a land magnetometer, sub-bottom profiler, and side-scan sonar system were used to collect data over the project areas. Based on research and analysis of the magnetometer data, Fugro also performed a probing investigation to determine depth of cover of pipelines. Field work commenced on March 3, 2022, and the data collection was completed on March 14, 2022. The probing effort was later completed on August 2, 2022. Findings and recommendations are contained in *BS-0043 Magnetometer and Cultural Resources Survey* (Chustz, 2022) and located in **Appendix D**. Upon completion of the survey, Fugro concluded that no submerged cultural resources were identified within the remote sensing data, and no further work is recommended for this particular action.

Chustz also performed an investigation and remote sensing survey of the DPC connecting the Marsh Creation Borrow Area (MCBA) to the MCAs. The corridor exits Lake Lery on the east side and connects to Howard's Ditch. The corridor follows the southern canal of Howard's Ditch to BTAB, and tracks up the Bayou to Reggio Canal. The corridor follows Reggio Canal to Schooner Canal, which connects to the southwestern border of MCA-3.

Data Analysis identified 528 magnetic anomalies, 32 side-scan sonar contacts, and one (1) sub-bottom paleo channel. The majority of the anomalies and contacts represent woody debris/trees/stumps, fishing gear, ferrous debris, pipelines and other man-made objects. No submerged cultural resources were identified within the remote sensing data and no further work is recommended for this particular action.

1.7.2 Borrow Area

As part of the original BS-0041 survey of the proposed MCBA performed by Fenstermaker, a Registered Professional Archeologist (RPA) was present for the efforts in accordance with LR 20:410 of April 1994. Fenstermaker was contracted by TerraSond to perform the cultural resources survey for the proposed MCBA, along with a marine archaeologist from CEI (**Appendix D**). The survey effort commenced on June 15, 2021 and concluded on July 12, 2021. The survey pattern consisted of one hundred (100) ft. spaced parallel primary track lines running from southeast to northwest direction; along which bathymetry, magnetic, sonar, and sub-bottom profile data was collected. The survey revealed twelve (12) side-scan sonar contacts and six (6) magnetic anomalies within the MCBA, however none of them were recommended for avoidance or investigation based on historical archaeological potential.

The EPA consulted with the State Historic Preservation Office (SHPO) regarding the BS-0043 MCAs, borrow, and dredge pipeline Area of Potential Effect (APEs). Copies of the letters sent to the EPA by the SHPO can be found in **Appendix A**. After a review of the provided surveys, the EPA was issued letters stating that the SHPO concurred with the assessments that no archeological properties were listed in or eligible for listing in the National Register of Historic Places (NRHP) for either survey. No further work is recommended.

1.8 Oyster Lease Assessment

The State of Louisiana leases water bottoms to oyster harvesters for the production and harvesting of oysters. There are approximately 400,000 acres of state water bottoms currently under lease statewide. A review of the Louisiana Department of Wildlife and Fisheries (LDWF) oyster lease database revealed that no oyster leases or oyster seed grounds are present near the Marsh Creation Areas, access and Pipeline Corridors, or Borrow Area (**Figure 7**).

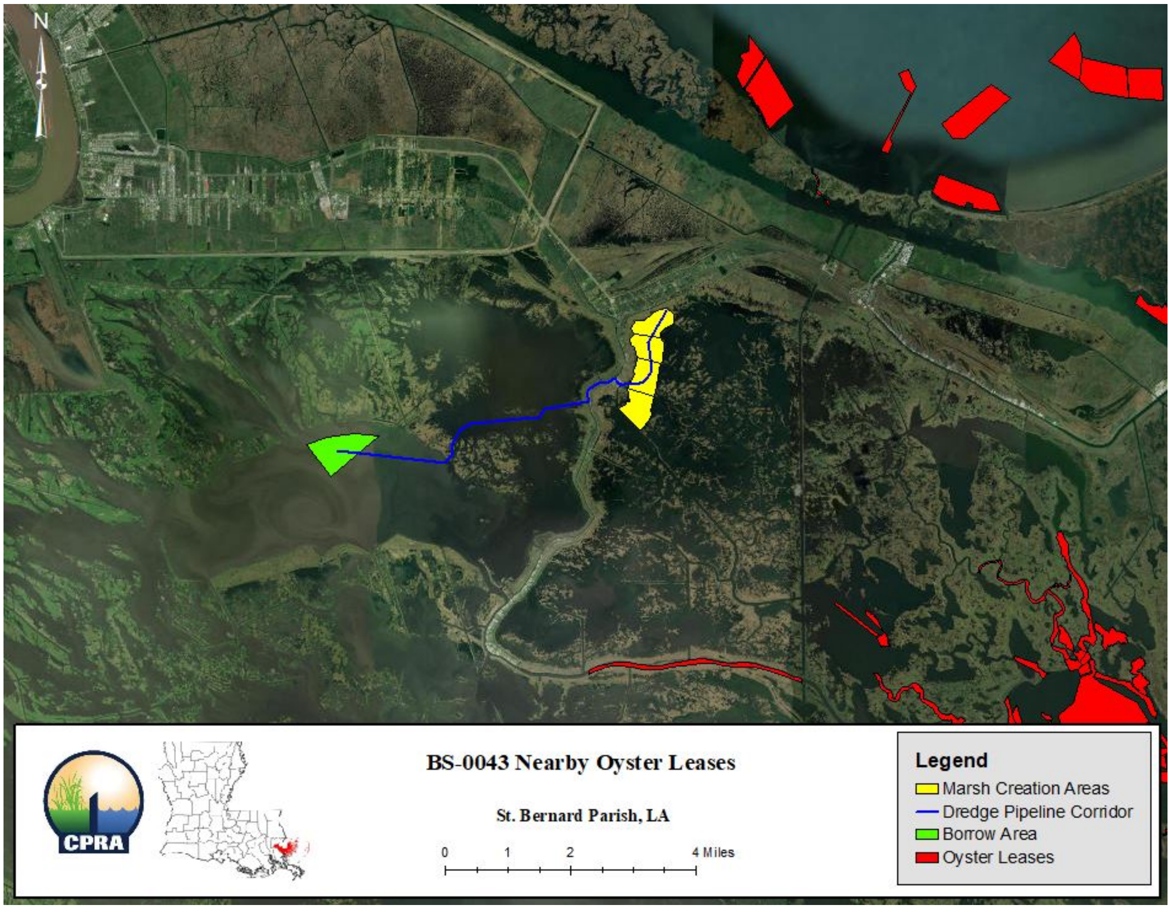


Figure 7: BS-43 Project Area and Nearby Oyster Leases (SONRIS).

2.0 HYDROLOGIC CONDITIONS

2.1 Sea Level Rise

To properly design the Reggio Marsh Creation Project and ensure it performs according to the objectives of the twenty (20) year project life, specific natural processes such as eustatic (global) sea-level rise (ESLR) and subsidence must be assessed. ESLR refers to a global change in water level. The value associated with ESLR is based on a global average rate of water level increase that considers several variables including ocean heat uptake and thermal expansion, loss of glaciers, and runoff from thawing permafrost. The CPRA Planning Division provided forecasted sea-level rise rates consistent with the 2017 Master Plan. These rates range from 0.5 to 1.98 meters of sea-level rise by 2100 and are bracketed in various scenarios to account for uncertainty. The CPRA Planning Division recommends using the one (1.0) meter (intermediate) scenario to design marsh creation projects (Demarco et al. 2012), which is what was used for the BS-0043 project design. This accounts for nearly six (6) inches of sea-level rise over the twenty (20) year project design life. Details of these calculations are provided in the 95% Design Calculations Package (**Apppendix H**).

2.2 Subsidence

Subsidence differs from ESLR in that it is measured locally. Subsidence is defined as the rate of local vertical land movement down or in a negative direction. Natural causes of subsidence include plate tectonics and Holocene sediment compaction. Anthropogenic causes of subsidence include drilling and removal of subsurface fluids. For the BS-0043 project area, the expected subsidence rates in the region were determined using information from a study performed by Applied Coastal Research and Engineering (ACRE) and guidance literature produced by CPRA's Planning and Research Division. The current model being used to draft the 2023 State Coastal Master Plan (CMP) estimates subsidence around the project area ranges from three (3) to five (5) mm/yr. According to these sources, the BS-0043 project area experiences an approximate subsidence rate of 3.9 mm per year (0.15 inches/yr) (ACRE, 2019) (CPRA, 2023). This equates to a decrease in the project area mudline elevation of 3.07 inches (0.256 ft.) over the twenty (20) year project design life.

2.3 Tidal Conditions

The tidal datum is a standard elevation defined by a certain phase of the tide and issued to measure local water levels and establish design criteria. Typically, the primary objective for computing the tidal datum is to establish the optimal marsh elevation range that maximizes the duration that the restored marsh will be at an intertidal elevation throughout the twenty (20) year project life. A tidal datum is referenced to a fixed-point known as a benchmark and is typically expressed in terms of mean high water (MHW), mean low water (MLW), and mean tidal levels (MTL) over the observed period. MHW is the average of all the high-water elevations observed over one tidal epoch. MLW is the average of all the low water elevations observed over one tidal epoch. MTL is the average of the MHW and MLW for that period. The Coastwide Reference Monitoring System (CRMS) monitoring station

CRMS 4355, located at 29°83'89.56" N and 89°82'29.75" W, was selected as the control station because of its proximity to the project area as shown in **Appendix B** and **Figure 8**.

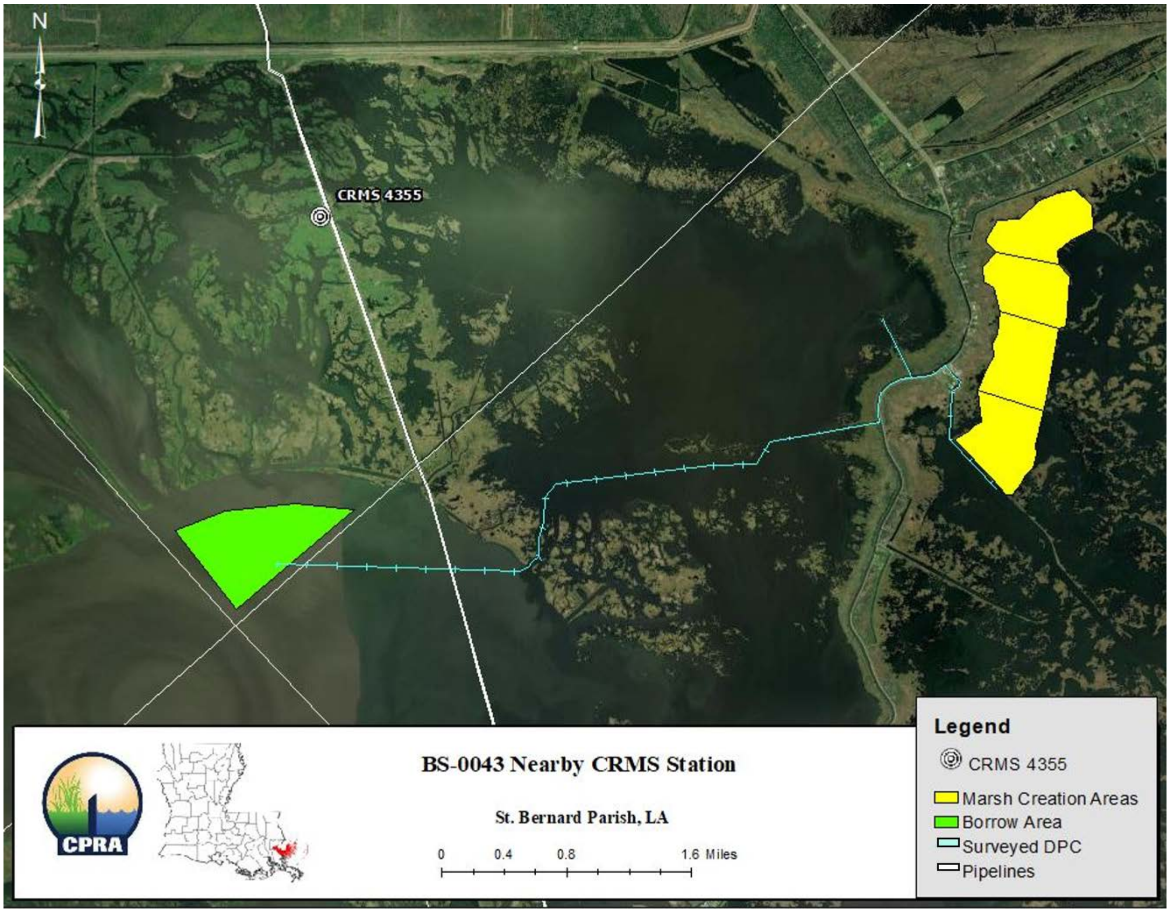


Figure 8: Tidal Gage Locations (CRMS, 2022)

Hourly hydrographic data was collected from CRMS 4355 for the period of record from June 27, 2017 to June 27, 2022; five (5) years as per CPRA's Marsh Creation Design Guidelines 1.0 (MCDG 1.0): Appendix D: *Marsh Inundation Methodology*. Recent high water and named tropical storm events are tabulated in **Table 2** and storm surge signatures from CRMS 4355 can be seen in **Figure 9**.

Table 2: Recent Tropical Storm Events in Reggio, LA

Tropical System	Landfall Date	Recorded Water Surface Elevations (ft. NAVD88)
Hurricane Nate	Wednesday October 4, 2017	3.62
Hurricane Michael	Saturday October 6, 2018	4.16
Hurricane Barry	Saturday July 13, 2019	4.13
Tropical Storm Cristobal	Sunday June 7, 2020	4.27
Hurricane Laura	Thursday August 27, 2020	3.69
Tropical Storm Beta	Monday September 21, 2020	4.90
Hurricane Delta	Friday October 9, 2020	3.04
Hurricane Zeta	Wednesday October 28, 2020	3.42
2021 High Water Event	May 17-18, 2021	4.31
Tropical Storm Claudette	Saturday June 19, 2021	3.21
Hurricane Ida	Sunday August 29, 2021	4.91

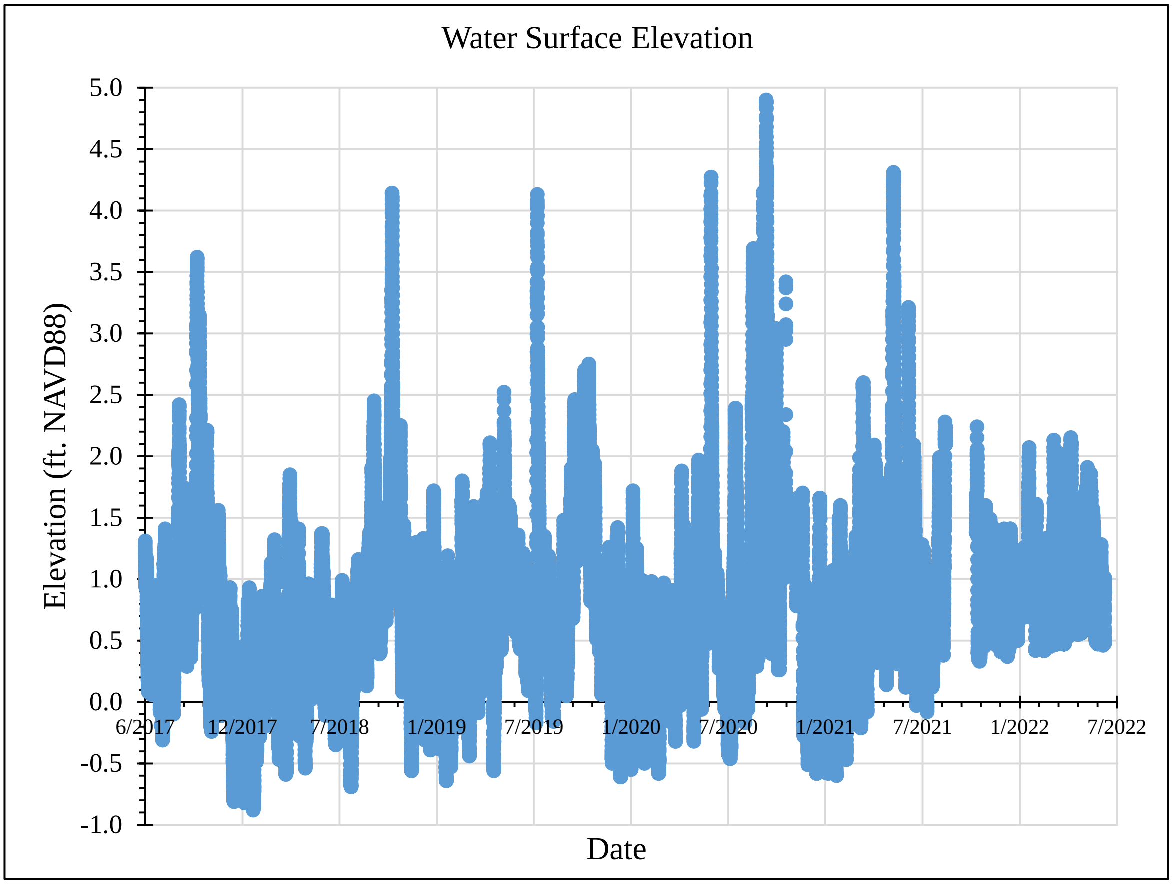


Figure 9: CRMS 4355 Water Surface Elevations Observations from June 2017 – June 2022 (CRMS, 2022)

The results of the tidal datum determination for the BS-0043 project area are as follows:

- MHW = +0.96 ft., NAVD88 (GEOID12B)
- MLW = +0.56 ft., NAVD88 (GEOID12B)
- MTL = +0.76 ft., NAVD88 (GEOID12B)

The mean high water (MHW) elevation at CRMS 4355 during the past five (5) years was +0.96 ft. NAVD88, and the mean low water (MLW) elevation was +0.56 ft. NAVD88. This equates to a mean range in the tide of 0.40 ft.

2.4 Percent Inundation Determination

The vertical positioning of marsh platforms and the frequency with which the marsh floods strongly influence plant communities and marsh health (Visser et. al 2003, Mitsch and Gosselink, 1986). Historically, the tidal range between MHW and MLW has been the accepted range for healthy marsh. However, this approach only takes into account the tidal influences on the water levels, whereas in many areas, non-tidal influences such as meteorological events, river discharges, and management regimes often have a large impact on the water levels found in that region. In order to account for tidal and non-tidal influences, an additional water level determination method, the Percent Inundation Method, was used to determine the marsh elevation range corresponding to an appropriate inundation and established marsh vegetation (as per MCDG 1.0, Appendix D). Percent inundation refers to the percentage of the year a certain elevation of land would be flooded. Therefore, using percent inundation rather than tidal range as a proxy for marsh health can give a more accurate representation of the water levels found in the area.

To determine percent inundation, the percentiles were calculated based on data gathered from the CRMS 4355 station for a five (5) year period from June 27, 2017 to June 27, 2022. **Table 3** and **Figure 10** presents the percent inundation results with ESLR applied for the duration of the project life for a Target Year (TY) 0 (2025) and TY20 (2045). For design analysis of the Marsh Creation Areas (MCAs) over the twenty (20) year project life, the subsidence rate was applied to the settlement curves of marsh fill elevations, while ESLR was applied to the tidal datum and the inundation range. **Figure 10** shows the impact of ESLR on MHW and MLW, as well as on the most productive inundation range (ten percent (10%) to ninety percent (90%)) for intermediate marsh vegetation.

Existing salinity levels in the project area average 1-2 ppt, with peaks of 4-5 ppt regularly occur during the winter. CRMS4355 had a 5-year average salinity of 1.76 ppt. The project team determined that the marsh type that would ensure the long-term success of the BS-0043 Marsh Creation Project is intermediate. Intermediate marshes typically range in salinity levels from 0.5 – 5.0 ppt. Intermediate marshes are most productive when flooded between 10% and 90% of the time (Snedden and Swensen, 2012). Productivity of the marsh vegetation is based on salinity and vertical position of the marsh in relation to water levels (Snedden and Swenson, 2012).

Table 3: Percent Inundation Elevations with ESLR

% Inundated	Survey Year (2022) Marsh Elevation (ft. NAVD88 Geoid 12B)	TY0 (2025) Marsh Elevation (ft. NAVD88 Geoid 12B)	TY20 (2045) TY20 Marsh Elevation (ft.)
1%	+2.981	+3.051	+3.586
10%	+1.550	+1.619	+2.155
20%	+1.210	+1.279	+1.815
30%	+1.010	+1.079	+1.615
40%	+0.850	+0.919	+1.455
50%	+0.700	+0.769	+1.305
60%	+0.560	+0.629	+1.165
65%	+0.500	+0.569	+1.105
70%	+0.430	+0.499	+1.035
80%	+0.250	+0.319	+0.855
90%	-0.010	+0.059	+0.595

*Highlighted rows represent the optimal inundation range for intermediate marsh.

The ninety percent (90%) inundation level is the elevation at which the marsh will be inundated ninety percent (90%) of the time based on the CRMS 4355 water level data. The ninety percent (90%) inundation level is a lower marsh elevation than the ten percent (10%) inundation level, which is the elevation that the marsh will be inundated less frequently at only ten percent (10%) of the time.

For analysis and design of the MCAs over the twenty (20) year project life, the subsidence rates presented in this report will be applied to the existing mudline elevation within the project area, and ESLR will be applied to the tidal datum and optimum inundation range. This calculation process is documented in detail in **Appendix H**.

Throughout the 95% design phase, TY0 was adjusted from 2027 to 2025 in order to represent the earliest possible year for start of construction for this project. This adjustment to TY0, and subsequently TY20, resulted in a slight decrease to the values listed in **Table 3** from the 30% design phase to the 95% design phase.

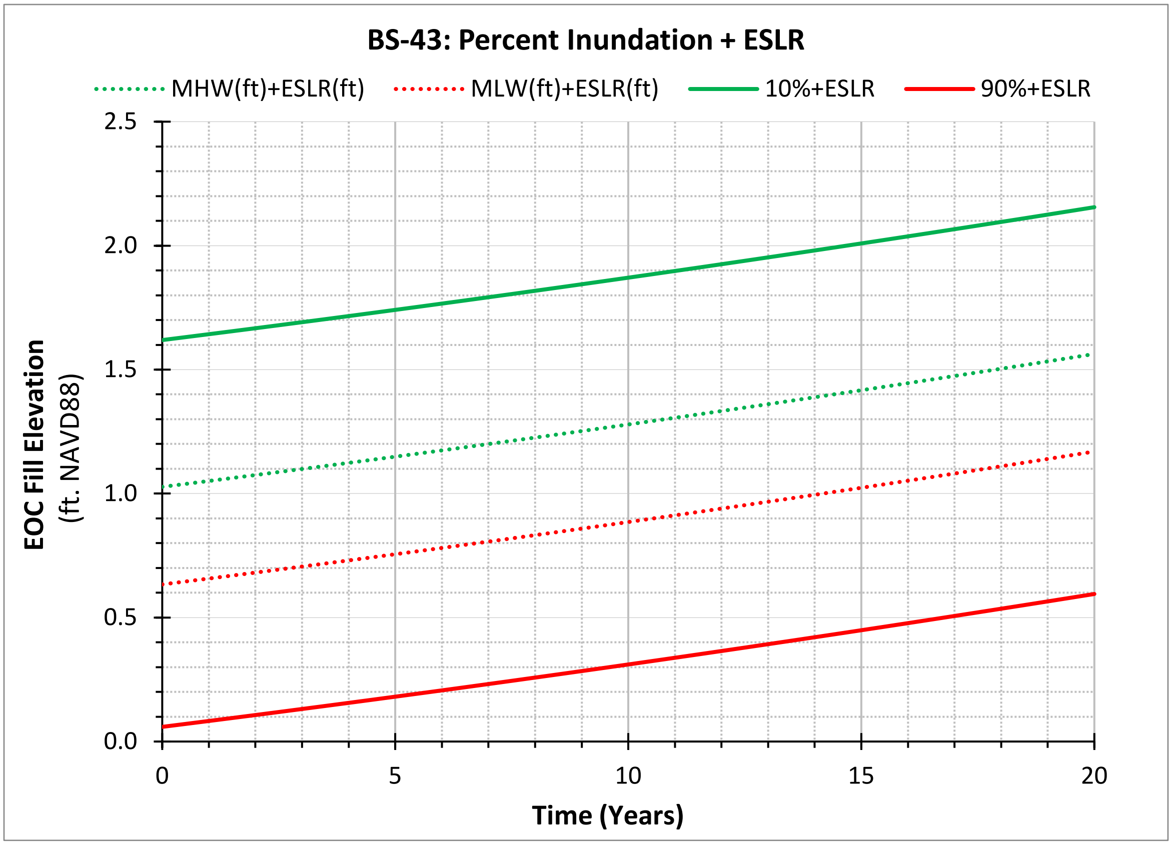


Figure 10: Tidal Datum and Percent Inundation over Project Life

3.0 SURVEYS

Chustz Surveying Inc. (Chustz) performed the design survey for BS-0043 per CPRA Survey Standards from March 3, 2022 – April 28, 2022. Chustz performed the topographic and bathymetric surveys within the Marsh Creation Areas (MCAs) and Dredge Pipeline Corridor (DPC). Fugro was contracted by Chustz to provide magnetometer, geophysical, and cultural resource surveying services within the MCAs and DPC. Fugro also performed a probing investigation to determine depth of cover of pipelines for the project. Fugro field work commenced on March 3, 2022 and was completed on March 24, 2022, and the probing effort was later completed on August 2, 2022. Topographic, bathymetric, and magnetometer survey methods were used as applicable to obtain all transects and were consistent with CPRA's MCDG 1.0: Appendix A: *A Contractor's Guide to the Standards of Practice*.

A 2-man survey crew from Fenstermaker and one (1) team member from TerraSond performed the single-beam bathymetric surveys, magnetometer survey, side-scan sonar and sub-bottom sonar surveys within the Lake Lery Marsh Creation Borrow Area (MCBA) for the BS-0041 project. TerraSond was a sub-contractor to Fenstermaker, and assisted Fenstermaker with sub-bottom profile surveys and Cultural Resource Investigations. TerraSond sub-contracted a marine archaeologist who was onboard reviewing the survey data in real-time. Bathymetric surveys included a single-beam fathometer, side-sonar, sub-bottom profiler, and marine magnetometer. Bathymetric surveys in the proposed MCBA commenced on June 15, 2021 and finished on June 17, 2021 (C.H. Fenstermaker, 2021).

Survey data collected for design and analysis include the following:

- Topographic, bathymetric, and magnetometer surveys of the MCAs.
- Bathymetric, magnetometer, and geophysical surveys of the Lake Lery MCBA and the DPC (Bayou Terre aux Boeufs (BTAB), Howard's Ditch, and Reggio Canal).

3.1 Survey Datum

The horizontal datum is State Plane Louisiana South (NAD1983) and vertical datum is NAVD 1988 GEOID 12B.

3.2 Horizontal and Vertical Control

The horizontal and vertical control for the topographic surveys was constrained to primary monument PO-30-SM-02 (CRMS4355) and secondary monument "Reggio 2." The locations of the primary and secondary monuments are shown in **Figure 11**. The field survey was accomplished utilizing real-time kinematic (RTK) surveying procedures and checked using the National Geodetic Survey (NGS) Online Positioning User Services (OPUS). The datasheet for the survey monument is provided in **Appendix B**.

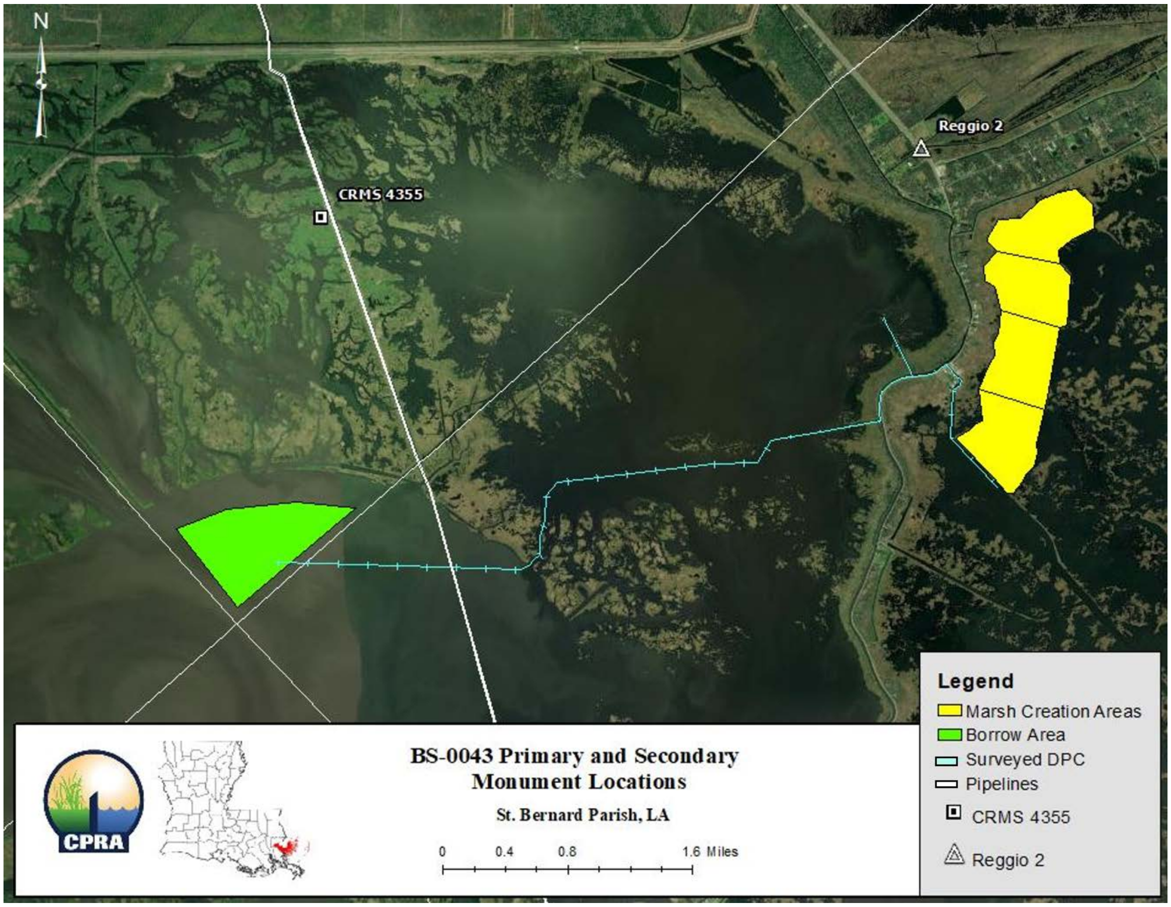


Figure 11: Primary and Secondary Monument Locations (CRMS, 2022)

3.3 Marsh Creation Area Survey

3.3.1 Bathymetry/Topographic Survey

Chustz began surveying the MCAs on March 3, 2022. Survey transects were spaced every five hundred (500) ft. as shown in **Figure 12**. Transects were taken across open water areas, broken marsh, existing spoil banks, and the existing tidal levee north of the MCAs. Position, elevation, and water depths were recorded every twenty-five (25) ft. along each transect or where elevation changes were greater than one-half (0.5) ft.

The topographic portions of the survey were merged with the bathymetric portions at the land/water interface and were separated by no more than fifty (50) ft. Side shots were taken as necessary to pick up variations in topographic features (highs and lows) such as meandering channels, broken marsh areas, or any other existing infrastructure such as pipelines, wellheads, duck blinds, and warning signs, which may affect project design implementation. The use of a fixed height aluminum rod with a six (6) inch diameter metal plate at the base of the rod was used to prevent the rod from sinking when topographic data was collected. The fill area had a minimum elevation of -3.27 ft. NAVD88 and maximum elevation of +3.70 ft. NAVD88, with an average mudline elevation of -0.25 ft. NAVD88.

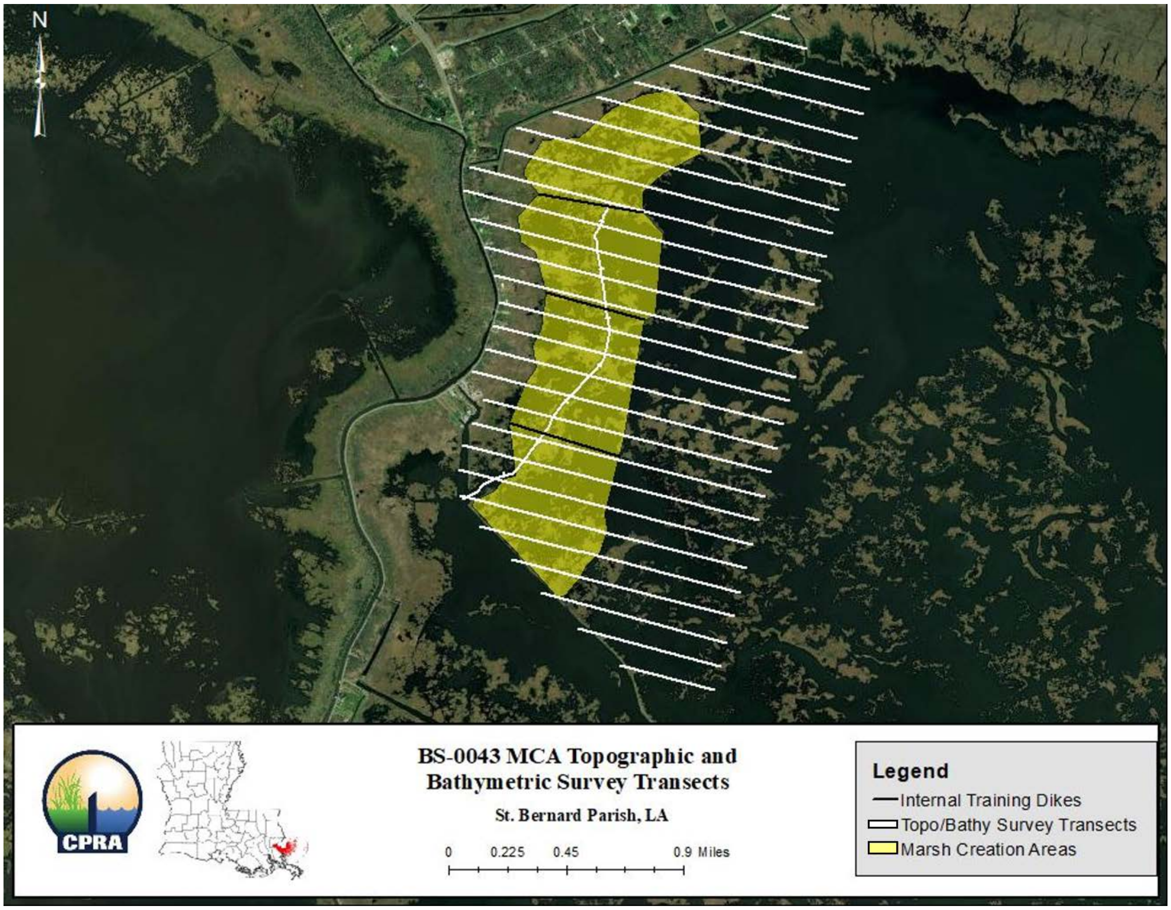


Figure 12: MCA Topographic & Bathymetric Survey Transects.

3.3.2 Magnetometer Survey and Pipeline Probing Investigation

A magnetometer survey was taken along transects that made up a 500' x 500' grid across the MCAs, that included the bathymetric and topographic transects, to locate any pipelines or other infrastructure (**Figure 13**). The magnetometer survey detected a total of sixty (60) magnetic anomalies within the MCAs.

These anomalies ranged in amplitude from five (5) to two hundred fifty-one (251) gammas, and in duration from nine (9) to one hundred sixty-eight (168) feet. No indications of existing infrastructure were observed in the magnetometer data collected in the MCAs. Therefore, no pipeline probing was conducted within the MCAs. All available data from within the MCAs is summarized in the survey reports provided in **Appendix D**.

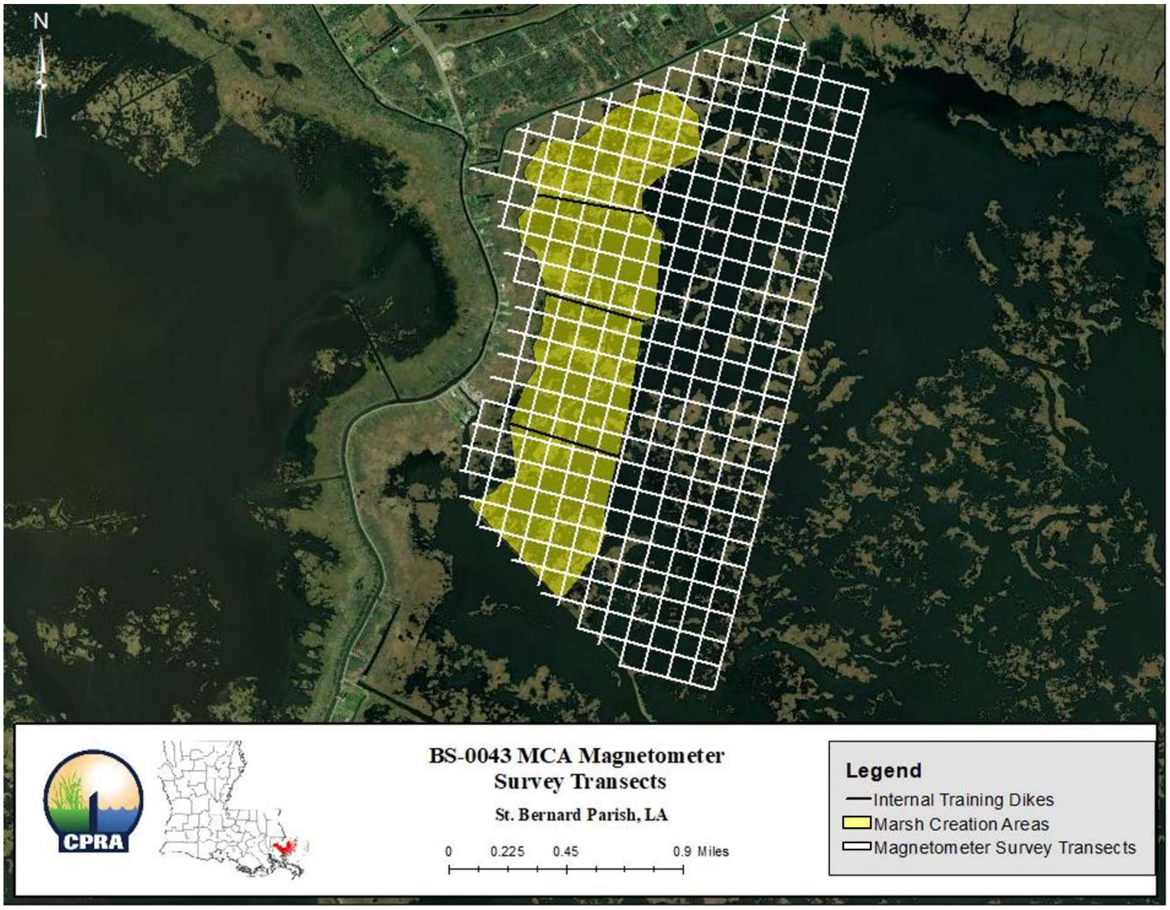


Figure 13: Marsh Creation Area Magnetometer Survey Transects

3.4 Borrow Area Survey

3.4.1 Bathymetric Survey

From June 15, 2021 to July 12, 2021 Fenstermaker commenced single-beam bathymetric surveys within the proposed MCBA for the BS-0041 project. The bathymetric survey track lines for the BS-0041 project can be seen in **Figure 14**. Bathymetric survey methods consistent with the CPRA MCDG 1.0: Appendix A (*A Contractor's Guide to the Standards of Practice*) were used to obtain all transects. Survey transects of the proposed MCBA were spaced every one hundred (100) feet, as required for cultural resources surveys, oriented from southwest to northeast. Position, elevation, and water depth were recorded every fifty (50) feet along each transect or where elevation changes were greater than one-half (0.5) feet. The bottom elevation data obtained from these surveys was used for creating water depth maps for construction equipment access and determining available sediment borrow quantities. The water bottom elevation in the MCBA ranges between -4 ft. to -6 ft. NAVD88.

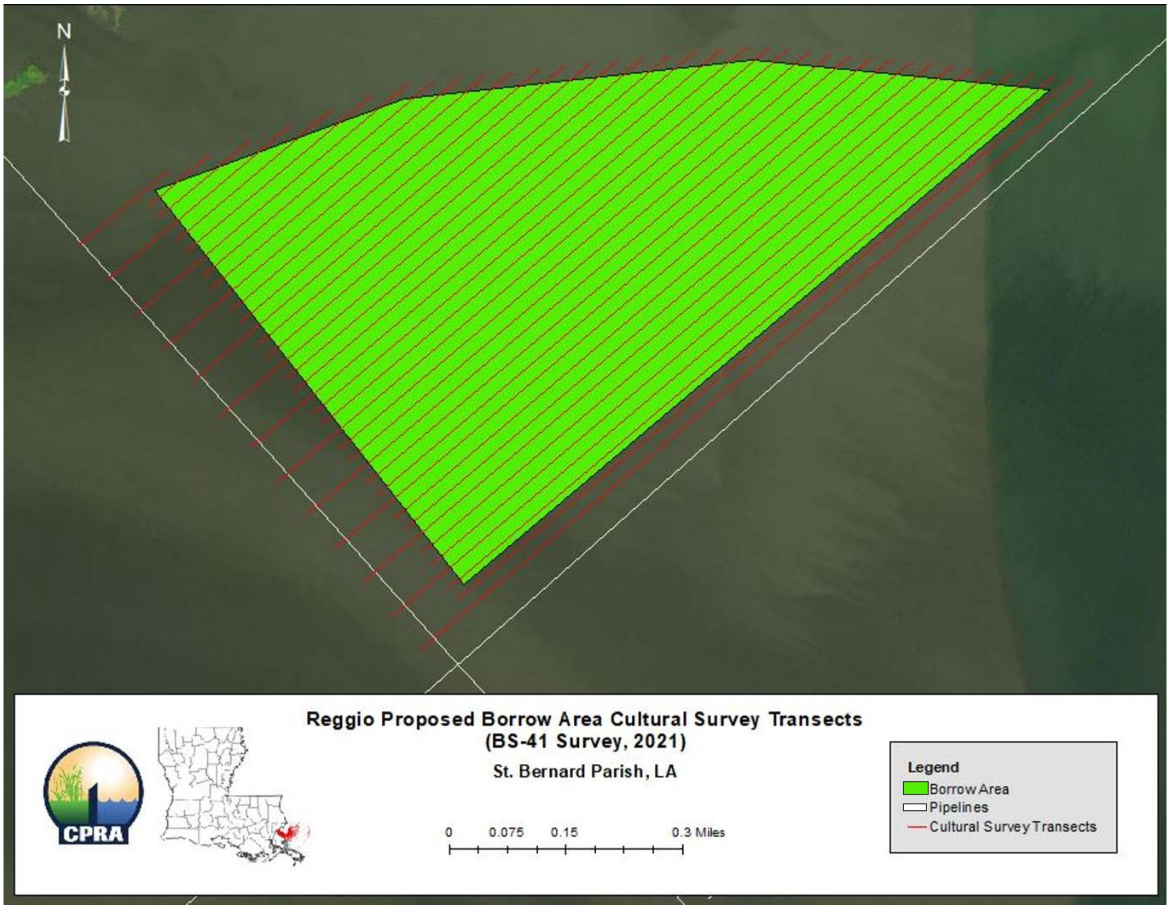


Figure 14: BS-0041 Lake Lery Borrow Area Bathymetric Survey Transects (C.H. Fenstermaker, 2021)

3.4.2 Magnetometer Survey, Geophysical Survey, and Pipeline Probing Investigation

In addition to a single-beam bathymetric survey, a marine magnetometer, side-scan sonar, and sub-bottom profile surveys were performed along the same transects as the MCBA bathymetric survey as a part of the 2021 marine cultural survey of Lake Lery for the BS-0041 project. The G-882 marine magnetometer detected one hundred twenty-nine (129) magnetic anomalies in the MCBA. One hundred fourteen (114) unidentified magnetic anomalies could not be correlated to known features within the borrow area. These unknown magnetic anomalies have amplitudes ranging from forty-five (45) to 1,155 gammas and durations ranging between twenty (20) to two hundred sixty-three (263) feet (**Appendix D**). Most of the unidentified magnetic anomalies recorded were interpreted as small, unknown debris. There were twelve (12) side-scan sonar hits, of which ten (10) were of negligible size. The other two (2) side-scan sonar hits were of unknown origin. TerraSond recommended that the two (2) sonar contacts be avoided by a distance of one hundred (100) feet on an archaeological and hazard basis until it can be assessed through direct physical examination. There are three (3) additional anomalies identified in the proposed MCBA that were determined to be plugged and abandoned wellheads, and will require a two hundred fifty (250) foot "no dredge" buffer zone around each wellhead. Overall, the survey area is heavily occupied by active and inactive crab pots, as observed during the field survey and during office interpretation

(C.H. Fenstermaker, 2021). All significant magnetic and side-scan sonar targets with their associated avoidance areas are summarized in **Table 4** and **Figure 15**, and as shown on the 95% Design Drawings (**Appendix G**).

Table 4: Summary of Significant Magnetic & Sonar Targets in the Borrow Area

Name	**Well Serial Number**	**Mag Hit Number**	**Status**	**Northing** (NAD83)	**Easting** (NAD83)	**Avoidance Radius** (ft.)
AMAX Petroleum Corp	148554	248 (BS-0041)	Dry and Plugged	478,961.73	3,754,994.59	250
ARKLA Exploration Company	151314	256 (BS-0041)	Dry and Plugged	479,206.21	3,755,169.02	250
Inactive Operator	185209	304 (BS-0041)	Dry and Plugged	477,952.16	3,758,174.09	250
139-ba	n/a	SSS 0103	n/a	479,510.70	3,759,895.62	100
136-ba	n/a	SSS 0114	n/a	477,769.39	3,757,789.45	100
135-ba	n/a	SSS 0121	n/a	477,336.77	3,757,288.33	100
145-ba	n/a	SSS 0124	n/a	477,260.84	3,756,883.21	100
159-ba	n/a	SSS 0140	n/a	480,013.03	3,759,827.63	100
169-ba	n/a	SSS 0143	n/a	479,249.97	3,758,463.51	100
198-ba	n/a	SSS 0160	n/a	479,802.74	3,758,179.78	100
315-ba	n/a	SSS 0167	n/a	479,852.13	3,758,399.67	100
205-ba	n/a	SSS 0173	n/a	479,595.36	3,757,795.17	100
241-ba	n/a	SSS 0225	n/a	479,308.85	3,755,895.50	100
240-ba	n/a	SSS 0226	n/a	479,359.68	3,755,944.19	100
247-ba	n/a	SSS 0235	n/a	479,107.91	3,755,369.84	100

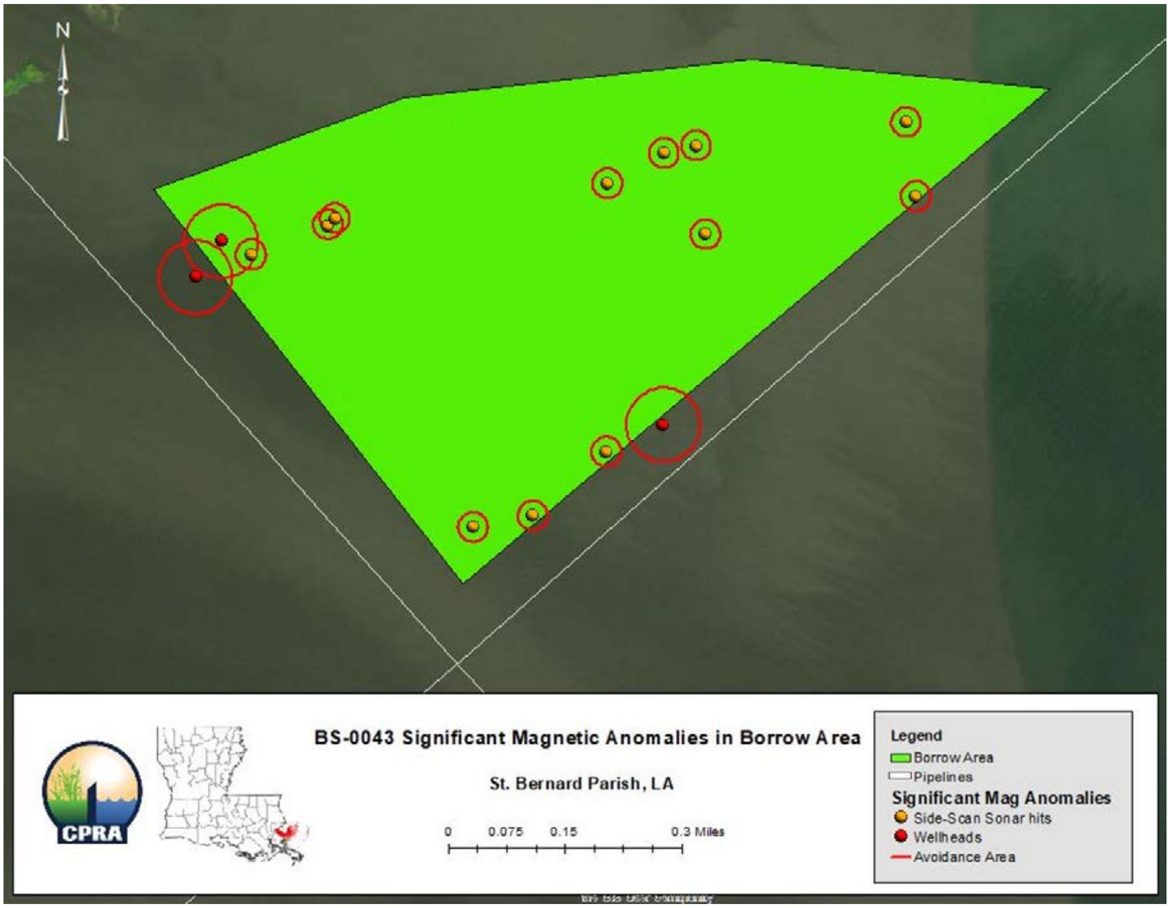


Figure 15: Lake Lery Borrow Area Infrastructure

3.5 Dredge Pipeline Corridor and Equipment Access Routes

3.5.1 Geophysical Survey

The proposed Dredge Pipeline Corridor (DPC) would run through Lake Lery, Howard's Ditch, BTAB, and Reggio Canal. The proposed DPC route was surveyed for construction feasibility as shown in **Figure 16**. The DPC and equipment access surveys consisted of side-scan sonar, magnetometer, single-beam bathymetry, and RTK GPS data collection along one (1) centerline transect with 1,000-ft spaced cross-sections with position and elevation data collected continuously every five (5) feet. All wellheads and significant magnetic anomalies along the DPC are summarized in **Table 5**. The average water depth, when measured from MLW, in Lake Lery along the DPC is five (5) ft. The average water depth in the southern Howard's Ditch canal (along the DPC) is 4.17 feet. The average water depth of BTAB (along the DPC) is 5.66 feet and the average water depth in Reggio Canal is 3.14 ft.

Table 5: Summary of Significant Magnetic Anomalies along the DPC

Name	Well Serial Number	Mag Hit Number	Status	Location	Northing (NAD83)	Easting (NAD83)	Avoidance Radius (ft.)
TIPCO	185210	144 (Anomaly0568)	Dry and Plugged	Lake Lery	3,762,846	478,330	250
Republic Mineral Corp	191951	395 (BS-0037)	Dry and Plugged	Lake Lery	3,762,460	478,705.9	250
Inactive Operator	183760	2 (Anomaly0603)	Dry and Plugged	Lake Lery	3,759,695.49	478,705.9	250
Republic Mineral Corp	190794	53-BA (BS-0041)	Dry and Plugged	Lake Lery	3,759,651.62	478,285.88	250
Collapsed Bridge	N/A	336 (Anomaly0310)	N/A	BTAB	3,780,179.34	484,768.95	N/A
UID	N/A	113 (Anomaly0558)	N/A	Howard's Ditch	3,769,919.84	481,384.19	100

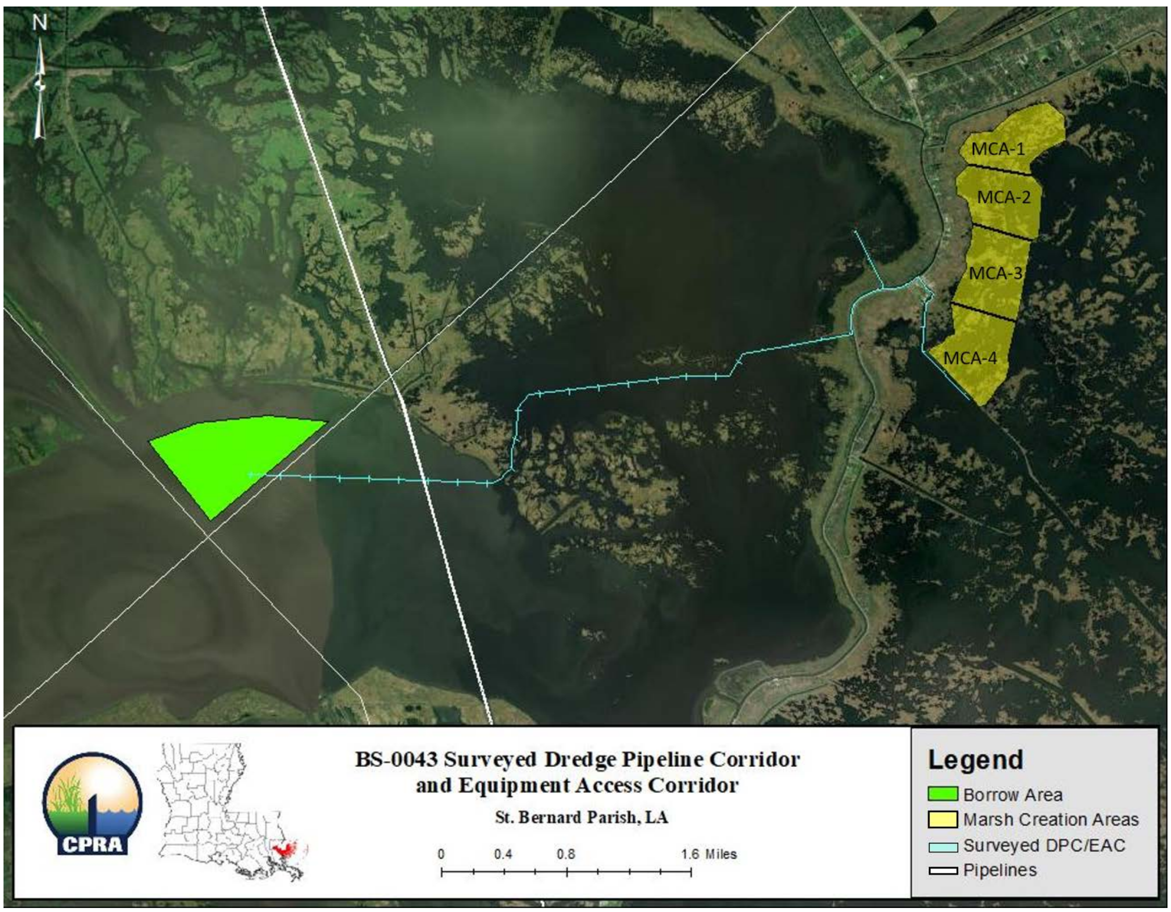


Figure 16: Surveyed Dredge Pipeline Corridor

3.5.2 Pipeline Probing Investigation

A probing investigation was conducted on August 2, 2022 by Fugro to identify subsurface utilities along the DPC and determine the depth of cover and depth of water for any submerged pipelines. The probing was in an effort to provide as close to a Quality Level – B Utilities Survey (as defined by the American Society of Civil Engineers, CI/ASCE 38-02) as possible without actual exposure of the located sub-surface infrastructure. Fugro used a spud barge to execute this task, and collected a total of five (5) probing data points. Two (2) possible pipelines were probed along the DPC within Lake Lery. According to the National Pipeline Mapping System (NPMS) the pipeline probing points align with one (1) Colonial pipeline just outside the east side of the MCBA, and one (1) High Point Gas Transmission pipeline on the east side of Lake Lery (**Table 6**). According to the NPMS, there are two (2) additional pipelines that intersect the DPC in Lake Lery. Both additional pipelines run along the east side of Lake Lery and are coupled with the probed High Point Gas Transmission pipeline. One (1) of the pipelines also belongs to High Point Gas Transmission, and the other additional pipeline belongs to Targa Resources, splitting the two High Point Gas Transmission Pipelines. All four (4) possible pipelines are shown in **Table 6**. All four (4) of these pipelines cross the proposed DPC in Lake Lery, as shown in **Figure 17**. Dredging activity will be offset by a minimum of two hundred fifty (250) ft. from all pipelines near the MCBA. Dredge pipe installed within the DPC will be required to float over all four (4) pipelines in Lake Lery, as shown in the 95% Design Drawings. Coordination with the four (4) pipeline owners and operators will continue as the project design progresses.

Table 6: Summary of Pipelines Probed Near the Borrow Area

Pipeline Operator Name (System Name)	**Object ID/ OPID**	**Depth of Cover** (ft.)	**Size** (in.)	**Product**	**Status**	**Probed**
Colonial Pipeline Company (CPC)	60107/ 2552	6.5’	Unknown	Liquid (non-HVL Product)	Active	Yes
High Point Gas Transmission, LLC (HPGT)	45934/ 38902	Unknown	26"	Natural Gas	Active	No
Targa Resources Operating, LLC (Cayenne)	45499/ 32296	Unknown	20"	Liquid Natural Gas	Active	No
High Point Gas Transmission, LLC (HPGT)	64718/ 38902	4’	20"	Natural Gas	Active	Yes

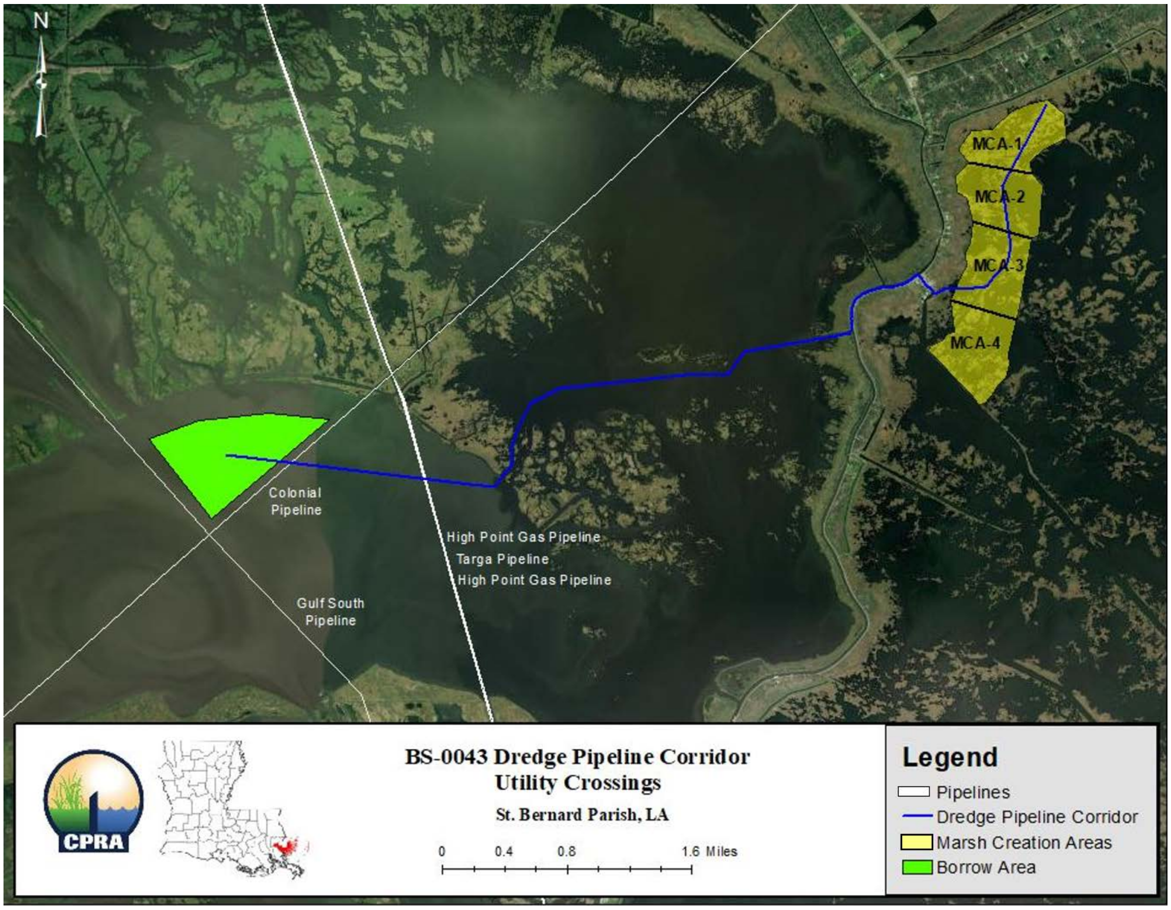


Figure 17: The Dredge Pipeline Corridor crossing over one (1) Colonial Pipeline, two (2) High Point Gas Transmission Pipelines, and one (1) Targa pipeline.

3.6 Howard's Ditch Survey

The two (2) canals that were proposed to be plugged on the west bank of BTAB make up a canal system called Howard's Ditch. Both canals were surveyed for construction feasibility to potentially be plugged at the BTAB intersection. The survey consisted of single-beam bathymetry, side-scan sonar, and RTK GPS data collection along one (1) centerline transect with 1,000-ft spaced cross-sections with position and elevation data collected continuously every five (5) ft. All side-scan sonar hits within Howard's Ditch are summarized in **Table 7**. The southern canal has an average water depth of 4.17 feet and the northern canal has an average water depth of 5.7 feet.

Table 7: Side-Scan Sonar Hits in Howard's Ditch

SSS Contact	Northing (NAVD88)	Easting (NAVD88)	Size	Description	Location
27	3,778,971.65	486,051.64	21.15' x 1.49'	Tree Detritus	North Canal
29	3,779,133.27	485,666.74	22.52' x 0.65'	Tree Detritus/ Possible Pipeline Segment	North Canal

3.7 Project Feature Survey Analysis

The topographic and bathymetric survey data provided by Chustz was imported into Esri's ArcMap for site analysis. Triangulated Irregular Network (TIN) surface models and histograms were generated with the merged bathymetric and topographic survey data to create maps for analysis of the fill area (Esri, 2021).

3.7.1 Marsh Creation Area

The average elevation of the entire fill area footprint is -0.25 ft. with a maximum elevation of 3.70 ft. and a deepest point of -3.27 ft. Based on survey data, the existing mudline becomes deeper moving eastward away from the Reggio community. The entire fill area has an Earthen Containment Dike (ECD) layout delineated to avoid building the dikes on areas with an existing mudline below -2.5 ft. to facilitate ECD construction with in-situ materials. The results of the survey analysis for each MCA is shown in **Table 8** and in the Triangular Irregular Network (TIN) surface created in **Figure 18**. The mudline elevation analysis for each MCA is also displayed as histograms in **Figure 19**, **Figure 20**, **Figure 21**, and **Figure 22**.

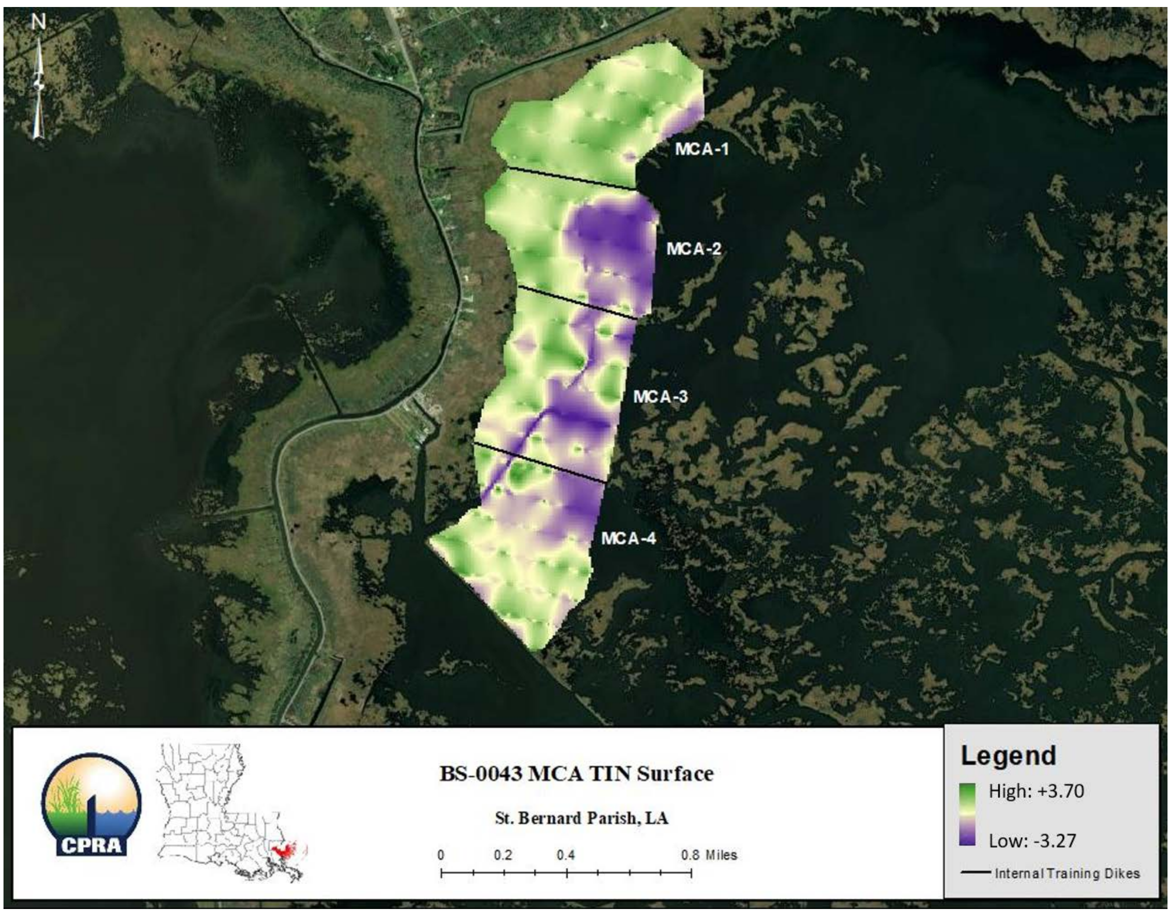


Figure 18: Marsh Creation Area TIN Surface

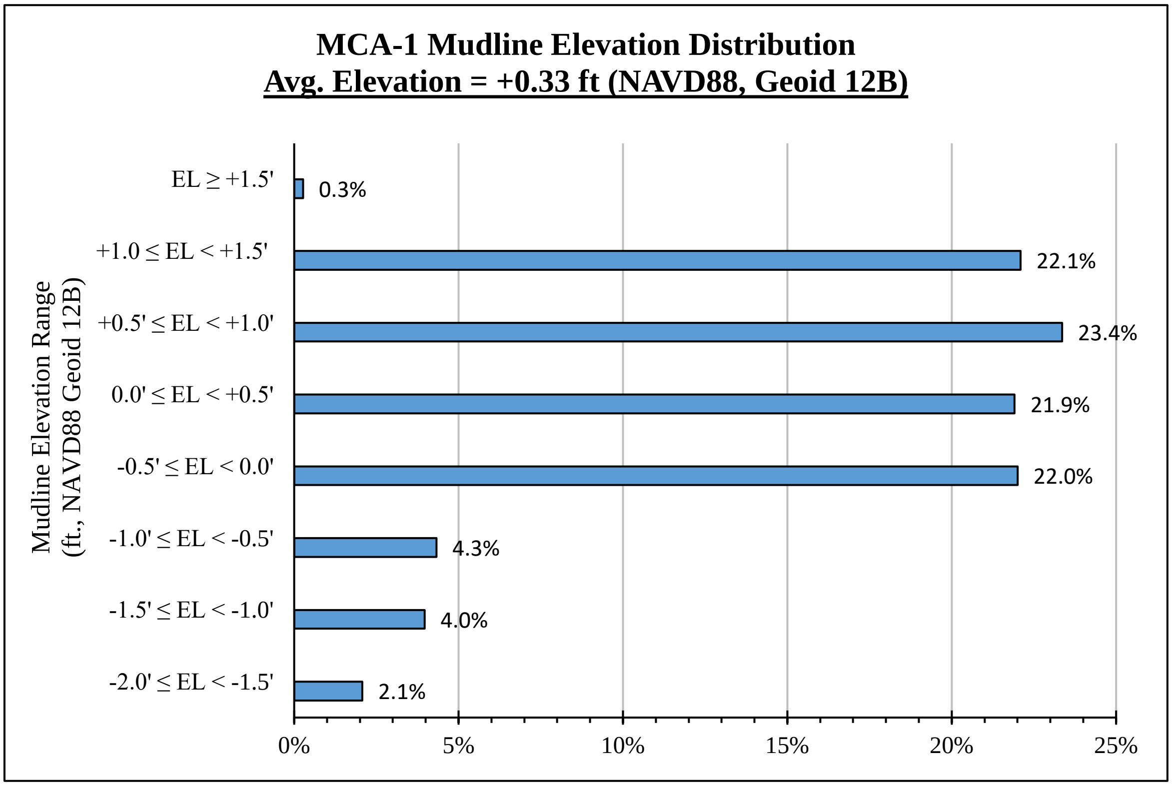


Figure **19**: MCA-1 Existing Mudline Elevation Distribution

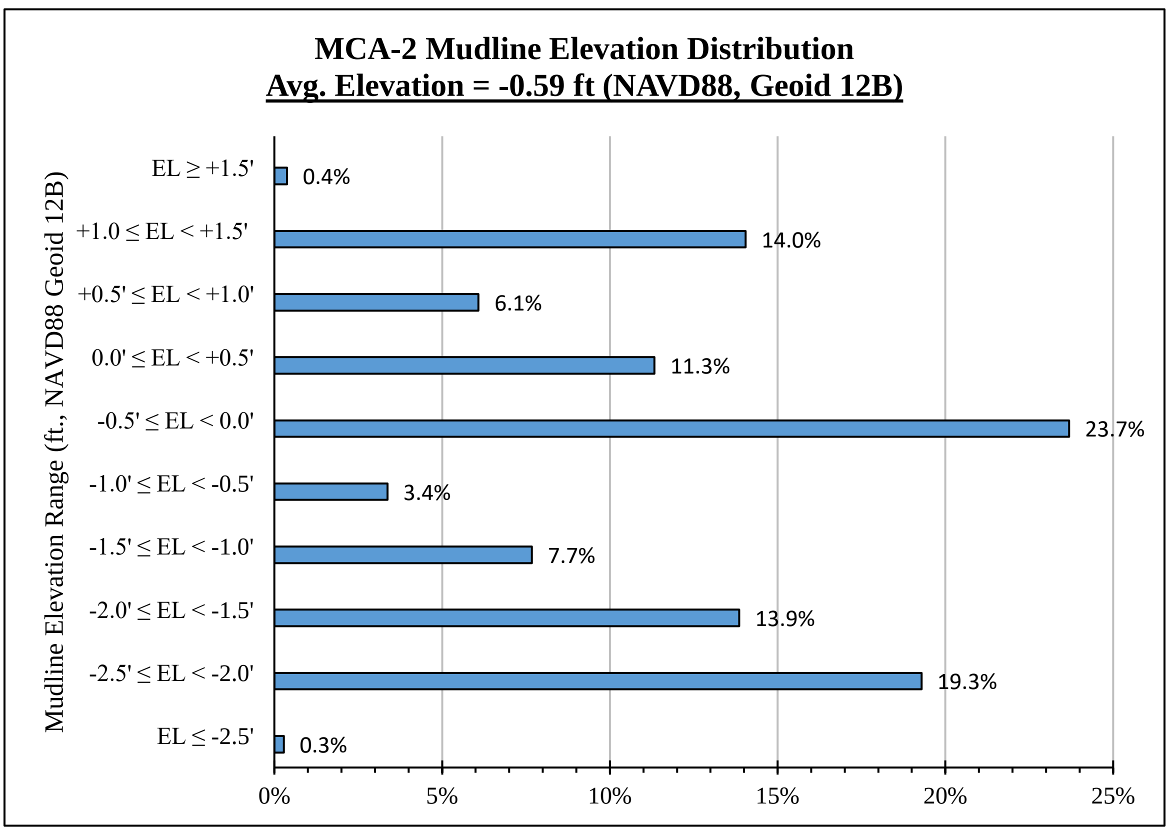


Figure 20: MCA-2 Existing Mudline Elevation Distribution

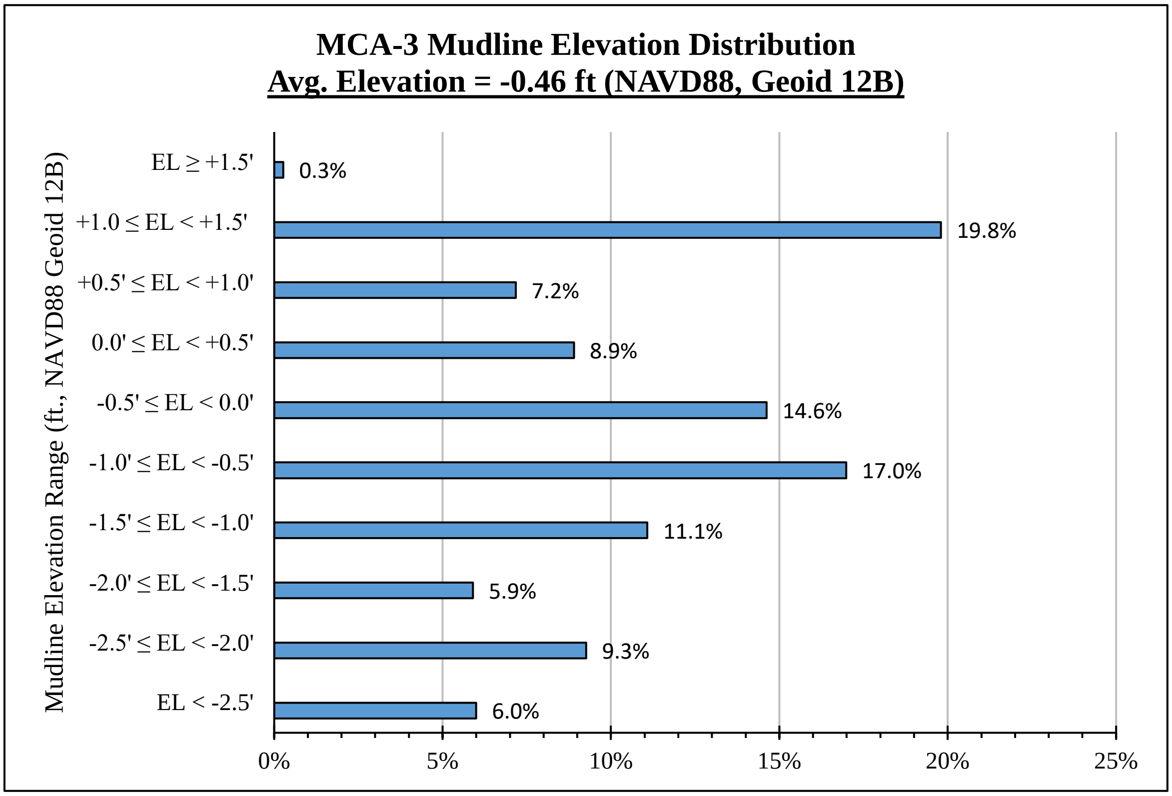


Figure 21: MCA-3 Existing Mudline Elevation Distribution

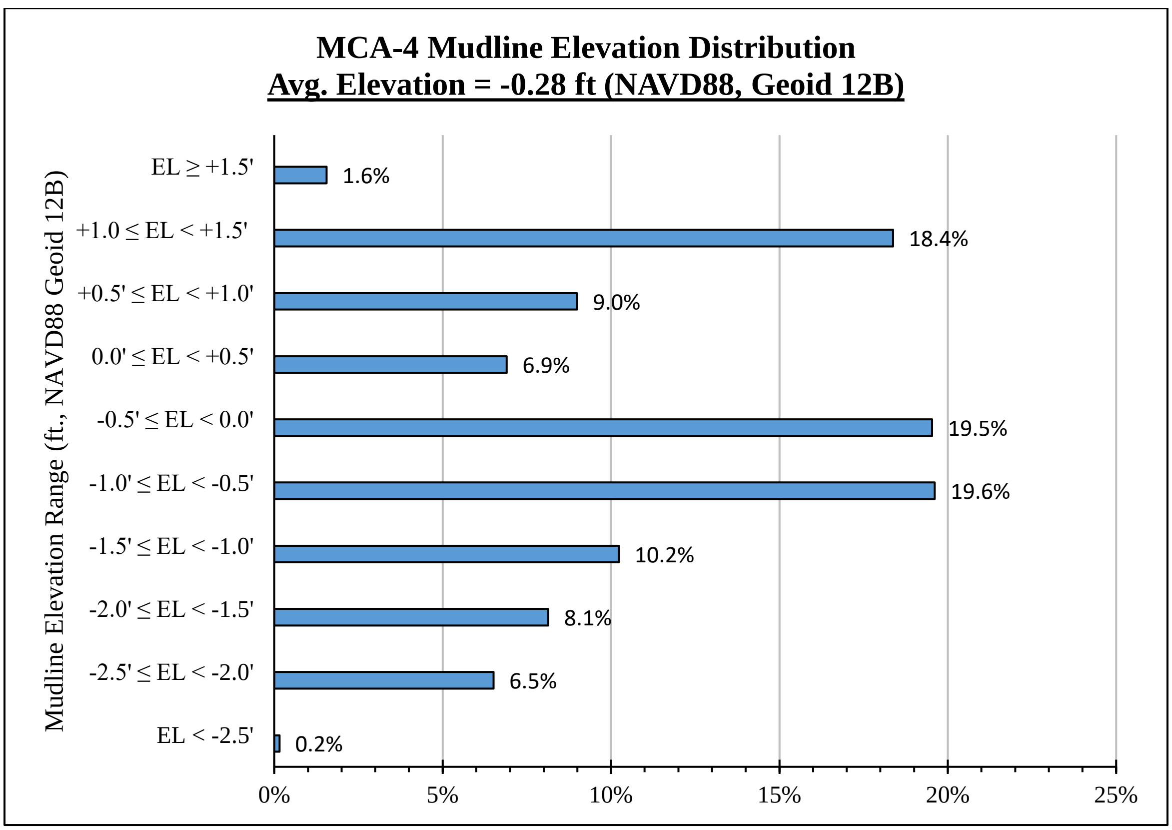


Figure 22: MCA-4 Existing Mudline Elevation Distribution

The surface created in ArcMap shown in **Figure 18** and the histograms presented in **Figure 19**, **Figure 20**, **Figure 21**, and **Figure 22** reveal that two hundred ninety-seven (297) acres, or fifty-seven percent (57.3%), of the total MCA footprint is below an elevation of 0.0 ft. NAVD88 (**Table 9**). This survey analysis performed within the fill area helped select the baseline mudline elevations used in modeling marsh fill settlement. The representative mudlines that were used for geotechnical analysis for each MCA and the entire fill area (**Section 6.1.1**) are displayed in **Table 8**, along with the changes to each MCA since 30% design phase.

Table 8: Summary of Mudline (ML) Distribution for each MCA and entire fill area

Feature	30% Design		95% Design	
	Area (acres)	**Representative Mudline** (ft. NAVD88)	**Area** (acres)	**Representative Mudline** (ft. NAVD88)
MCA-1	141	-1.00	123	-0.50
MCA-2	134	-1.75	123	-1.75
MCA-3	204	-1.50	136	-1.50
MCA-4	N/A	N/A	137	-1.00
Entire Fill Area:	**479**		**519**	

Table 9: Mudline elevation distribution for each MCA

Feature	Area (acres)	Average Mudline (ft. NAVD88)	Representative Mudline (ft. NAVD88)	Mudline Distribution (%)		
				Below -2.0 ft.	**Below -1.0 ft.**	**Above 0 ft.**
MCA-1	123	+0.33	-0.50	0.0	6.0	67.6
MCA-2	123	-0.59	-1.75	19.6	41.1	31.8
MCA-3	136	-0.46	-1.50	15.3	32.2	36.1
MCA-4	137	-0.28	-1.00	6.7	25.0	35.8
Entire Fill Area:	**519**	**-0.25**		**10.1**	**25.1**	**42.7**

Adding a third ITD in the marsh fill area during the 95% design phase changed the fill area layout from three (3) MCA's to four (4) MCA's. This reconfiguration caused changes to the representative mudlines for MCA-1 from the 30% design phase. The shift of ITD-1 caused MCA-1 to have a shallower mudline elevation distribution, which caused the representative mudline for MCA-1 to increase from -1.0 ft. NAVD88 to -0.5 ft. NAVD88 (**Table 8**).

3.7.2 Existing Marsh Elevation Survey

Chustz surveyed three (3) existing marsh locations within the MCAs between March 3 and March 9, 2022. These surveys were conducted to determine the dominant species of vegetation and to help determine an average existing marsh platform elevation for the project area. RTK surveys were taken at thirty-six (36) locations within each selected site, separated by twenty (20) feet. Elevations were recorded on a data logger at the top of the marsh root mass and top of the mudline adjacent to the root mass. Marsh elevation survey locations are shown in **Figure 23**. Based on observations from site visits, the project area's dominant marsh is marsh hay cordgrass (*Spartina patens*). The results from the existing marsh elevation survey are shown in **Table 10**.

According to this survey, the average existing marsh elevation in the project area is approximately +1.26 ft. NAVD88. With current water surface elevations, the marsh surface is estimated to be inundated about twenty percent (20%) of the time at an elevation of +1.26 ft. At this elevation, the existing marsh is expected to be inundated about sixty-one percent (61%) of the time at TY20 water levels, which falls within the optimum inundation range for intermediate marsh (10% - 90%).

Table 10: Average Existing Marsh Results

Survey	**Location**	**Average Top of Mudline Elevation** (ft. NAVD88)
EM-1	MCA-1	+1.04
EM-2	MCA-3	+1.34
EM-3	MCA-4	+1.39
	Average:	**+1.26**

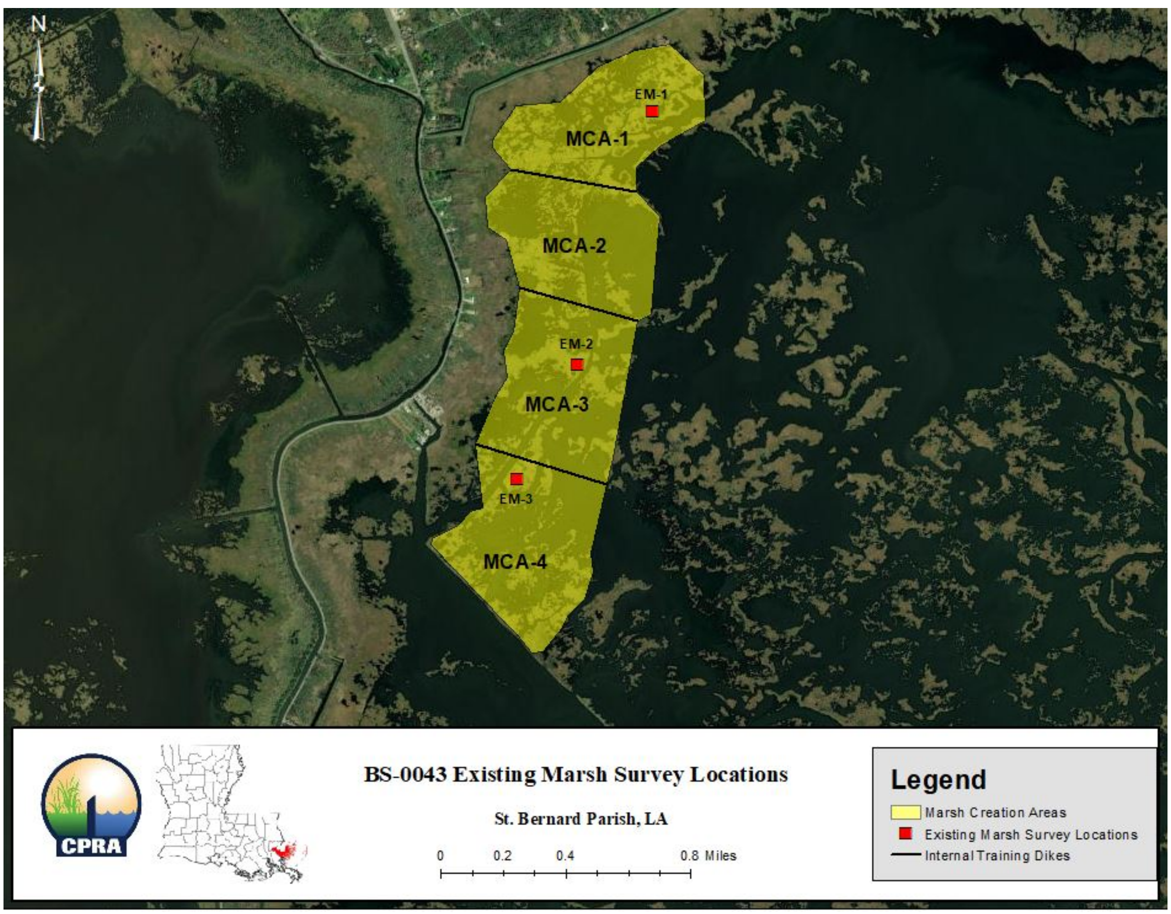


Figure 23: Existing Marsh Elevation Survey Locations

4.0 GEOTECHNICAL INVESTIGATION

Eustis Engineering was tasked to explore and evaluate the subsurface soil conditions and guide the geotechnical aspects of the design and construction of BS-0043. Field explorations began on May 14, 2022 and lasted until May 18, 2022. Prior to Eustis field explorations, TBS performed magnetometer surveys at each boring and CPT location to ensure no pipelines or obstructions existed at the proposed geotechnical exploration points. Eustis was tasked with the following data collection efforts:

- Collect four (4) undisturbed soil borings in the Marsh Creation Borrow Area (MCBA).
- Collect one (1) undisturbed soil boring at each of the two (2) proposed canal plug locations along Bayou Terre aux Boeufs (BTAB).
- Collect five (5) soil borings in the marsh fill area.
- Perform five (5) Cone Penetrometer Tests (CPTs) soundings in the marsh fill area
- Perform laboratory classification and strength testing to determine soil characteristics.
- Perform one (1) composite low-pressure consolidation tests.
- Perform one (2) column-settling test on the selected composite sample.

In addition to data collection, Eustis was also tasked to perform the following geotechnical analyses:

- Slope stability analysis of the proposed Earthen Containment Dikes (ECDs).
- Total settlement estimates of the proposed ECDs and Marsh Creation Areas (MCAs).

The geotechnical data collection and geotechnical engineering report can be found in **Appendix E** and **Appendix F**, respectively.

4.1 Existing Geotechnical Data Review

Before conducting the field subsurface investigation, a search of any historical data on the area was conducted. This included looking at prior subsurface investigations that occurred in the area as well as reviewing historical geological maps. This review found three (3) geotechnical engineering reports from previous subsurface investigations. These three (3) projects and the work performed are summarized in **Table 11**. All three of these projects' geotechnical subsurface investigations were conducted with guidance provided by the CPRA's Project Engineer and as per the MCDG1.0, Appendix B, *Geotechnical Standards*.

Table 11: Summary of Previous Subsurface Investigations Performed in Lake Lery

Project	Performed Geotechnical Work	Work Performed	Soil Characteristics	Location
BS-16: Lake Lery Marsh Creation	GeoEngineers	3 soil borings	Very soft peat and/or organic clay in top 15 feet	West Lake Lery
BS-32: Mid-Breton Land Bridge	Fugro	8 soil borings	Soft clays and peats to depths of 5 feet. Milder and stiffer clays from 5 to 15 feet below mudline.	South Lake Lery
BS-37: East Delacroix Marsh Creation and Terracing	Eustis Engineering	12 soil borings	General stratigraphy of alternating stratum of extremely soft to soft dark gray and brown humus/organic clay, and extremely soft to soft gray clay.	East Lake Lery

(GeoEngineers, 2010; Fugro, 2019; Eustis, 2020)

Surface geology maps published by the Louisiana Geological Survey reveal that the project area is underlain by the deposits of the St. Bernard delta lobe of the Mississippi River. These deposits are composed of cyclically interbedded interdistributary peat and clay, natural levee silt and clay, distributary sand, delta front sand, and prodelta mud and clay.

4.2 Marsh Creation Area Geotechnical Subsurface Investigation

Five (5) subsurface borings were taken in the MCAs by Eustis to depths of thirty (30) feet below the existing mud line. The soil borings were performed using airboat-mounted equipment provided by Eustis. The mud line ranged from elevations of -2.87 feet to +3.05 feet NAVD88. Samples were collected with a piston sampler in Shelby tubes continuously in the upper twenty (20) feet of the soil and then at intervals of five (5) feet or changes in stratum, thereafter, using a 3-in. diameter thin wall Shelby tube sampler in accordance with ASTM D1587 (Eustis, 2023). All samples were then classified, stored, and transported to the laboratory. Laboratory tests included soil strength, moisture content, organic content, grain size analysis, specific gravity, consolidation with rebound, and Atterberg limits. A summary of the geotechnical subsurface investigation is shown in **Table 12** and **Table 13**.

The general stratigraphy for the project area borings comprised of extremely soft to soft gray and brown humus, peat, and organic clay to approximate depths of 3 to 15 feet below the mudline. These organic clays were underlain by extremely soft to soft gray clay with interbedded strata of loose gray sand to boring termination depths of twenty (20) feet below the mudline (Eustis, 2022). Soil conditions were also evaluated in the MCAs by performing five (5) cone penetration tests (CPTs) using an airboat-mounted rig at depths ranging from thirty-five to forty (35 - 40) feet below the existing mud line. A map of the geotechnical sampling layout in the project area is shown in **Figure 24** and are presented in **Table 12** and **Table 13**. All CPT data and soil boring logs can be found in the Geotechnical Investigations Data Report, provided in **Appendix E**.

4.3 Proposed Canal Plug Geotechnical Subsurface Investigation

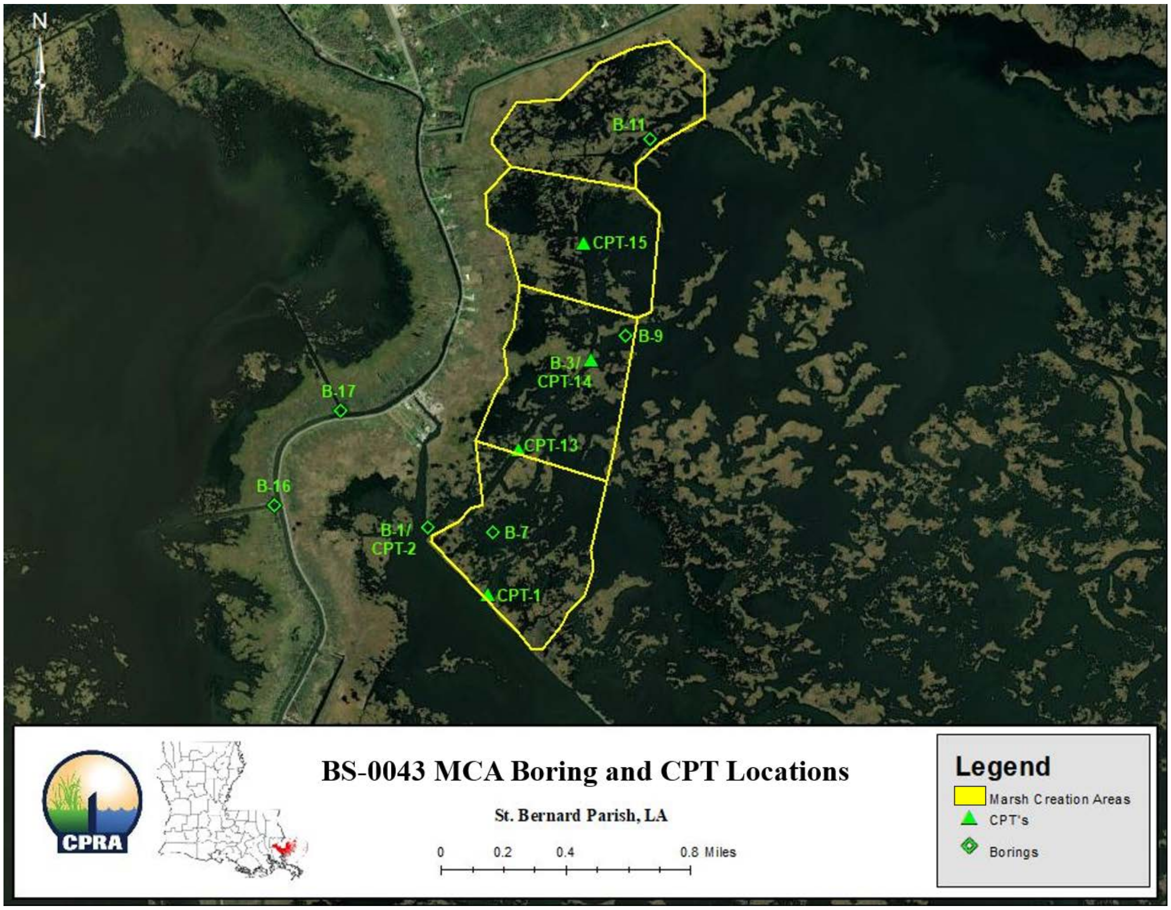
Soil conditions were evaluated at each proposed Canal Plug location by collecting one (1) soil boring at each location within Howard's Ditch to a depth of sixty (60) feet below the mudline (**Table 12**). Boring B-16 was collected in the southern canal (Canal Plug A), and B-17 was collected in the northern canal (Canal Plug B). B-16 and B-17 exhibited alternating stratum of very soft to soft gray clay to depths of 39 and 33 feet below the mudline. These clays were underlain by medium dense gray clayey sand and loose gray fine sand with silt and few clay layers to a depth of 43 feet for B-16, and a depth of 53 feet in B-17. Beneath these materials, we encountered very soft gray clay to boring termination depth of 60 feet in B-16 and very dense silty sand in B-17.

Table 12 : Subsurface Investigation Plan: Soil Boring Locations

Boring ID	**Easting** (NAD83)	**Northing** (NAD83)	**Water Depth** (ft.)	**Ground Elevation** (ft.)	**Boring Termination Elevation** (ft.)	**Location**
B-1	3,781,048.29	482,797.43	4.7'	-3.7	-43.7	MCA-3
B-3	3,783,783.37	485,679.03	2.5'	-1.5	-41.5	MCA-2
B-7	3,782,153.44	482,701.53	3.1'	-2.1	-42.1	MCA-3
B-9	3,784,401.17	486,038.14	3.8'	-2.8	-42.8	MCA-2
B-11	3,784,822.97	489,349.51	3.2'	-2.2	-42.2	MCA-1
B-16	3,778,442.43	483,185.95	6.0'	-7.9	-67.9	Canal Plug A
B-17	3,779,583.46	484,774.54	13.5'	-14.0	-74.0	Canal Plug B

Table 13: Subsurface Investigation Plan: CPT Locations

Boring ID	**Easting** (NAD83)	**Northing** (NAD83)	**Water Depth** (ft.)	**Ground Elevation** (ft.)	**CPT Termination Depth Elevation** (ft.)
CPT-1	3,782,077.14	481,654.88	2.9'	-1.9	-42.5
CPT-2	3,781,048.29	482,797.43	4.7'	-3.7	-44.8
CPT-13	3,782,551.60	484,115.30	3.9'	-2.9	-43.4
CPT-14	3,783,783.37	485,679.03	2.5'	-1.5	-37.4
CPT-15	3,783,685.43	487,600.17	3.3'	-2.3	-42.8



*IDs: B = MCA boring, CPT = MCA cone penetrometer test

Figure 24: Boring and CPT Locations in the MCA and Proposed Canal Plug Locations

4.4 Borrow Area Geotechnical Subsurface Investigation

Soil conditions were evaluated in the MCBA by advancing four (4) cores to twenty (20) feet below the existing mud line (**Table 14**). Locations of the samples are shown in **Figure 25**. Index properties observed during drilling and laboratory test results are located on the boring logs in the Geotechnical Investigations Data Report, provided in **Appendix E**. The four (4) borings indicate a general stratigraphy of an alternating stratum of extremely soft to soft dark gray, gray, and brown humus/organic clay, and extremely soft to soft gray clay. Some interbedded strata of loose gray and brown sand was also encountered in some of the borrow borings. Pockets of shells and shell fragments were also encountered in all four borings in the MCBA (Eustis, 2022). The proposed fifteen (15) foot cut depth in the borrow area extends from about -5.0 feet NAVD88 to -20.0 feet NAVD88.

Table 14: Borrow Area Subsurface Investigation Plan: Soil Boring Locations

Description	**Easting** (NAD83)	**Northing** (NAD83)	**Water Depth** (ft.)	**Ground Elevation** (ft.)	**Boring Termination Elevation** (ft.)
BA-1	3,756,815.10	477,856.13	6.7'	-5.7	-25.7
BA-2	3,755,826.60	479,268.63	5.9'	-4.9	-24.9
BA-3	3,757,973.78	479,458.40	6.1'	-5.1	-25.1
BA-4	3,759,638.92	479,923.80	4.9'	-3.9	-23.9

Figure **25: Borrow Area Soil Boring Locations**

5.0 NUMERICAL MODELING

5.1 Introduction

During the Phase 0 analysis, the EPA proposed two (2) canals along the west shore of Bayou Terre aux Boeufs (BTAB) to be plugged in order to reduce seasonal saltwater intrusion into the area west of BTAB, as shown in **Figure 1**. The benefits of the potential hydrologic restoration feature were investigated by CPRA through a modeling effort conducted by Baird.

5.2 Background

In order to determine the feasibility of the Canal Plugs, both canals were surveyed for bathymetry data and soil borings were collected at the proposed plug locations to analyze the in-situ soil properties, as stated in **Section 3.6** and **Section 4.3**. In order to determine the efficacy of the proposed Canal Plugs, a numerical modeling effort of the project area was conducted by Baird.

Baird has been supporting the hydrological design of the Mid-Breton Sediment Diversion Project (BS-0030), having developed a comprehensive modeling system consisting of six (6) modeling components. The modeling domain covers the project area for BS-0043, and was developed using Delft3D to simulate hydrodynamics, salinity, sediment transport, delta development, and vegetation change in the entire middle Breton Basin (Baird, 2022). The driving forces that were included in the model were river inflow, outfalls, tide, wind, sea-level rise, and seasonal variation of sea-levels in the Gulf of Mexico. The model has been calibrated with the CRMS data and the USACE flow data around Lake Lery (USACE, 1987). This model was intended to be used for BS-0043, however after testing the model for this application, it was determined that there was insufficient model resolution at the Reggio project site to obtain accurate results. Baird was able to make use of previously collected data for the project area, but a new model domain and grid was created for BS-0043 (Baird, 2023).

5.3 Numerical Model Boundaries

The model domain was selected to align with existing CRMS stations in the project area in order to be used for model boundary conditions (**Table 15**). The model grid for BS-0043 consists of 1306 x 1220 cells, with a resolution of 7 m x 7 m at the project site. The southeast boundary aligns with CRMS 0146, the northwest boundary aligns with CRMS 4355, and the domain extends southwest to CRMS 0115, as shown in **Figure 26** and **Table 15** (Baird, 2023). All points between the CRMS Stations used interpolated values between the two closest CRMS stations. The coordinates of the model boundaries are displayed in **Table 16**.

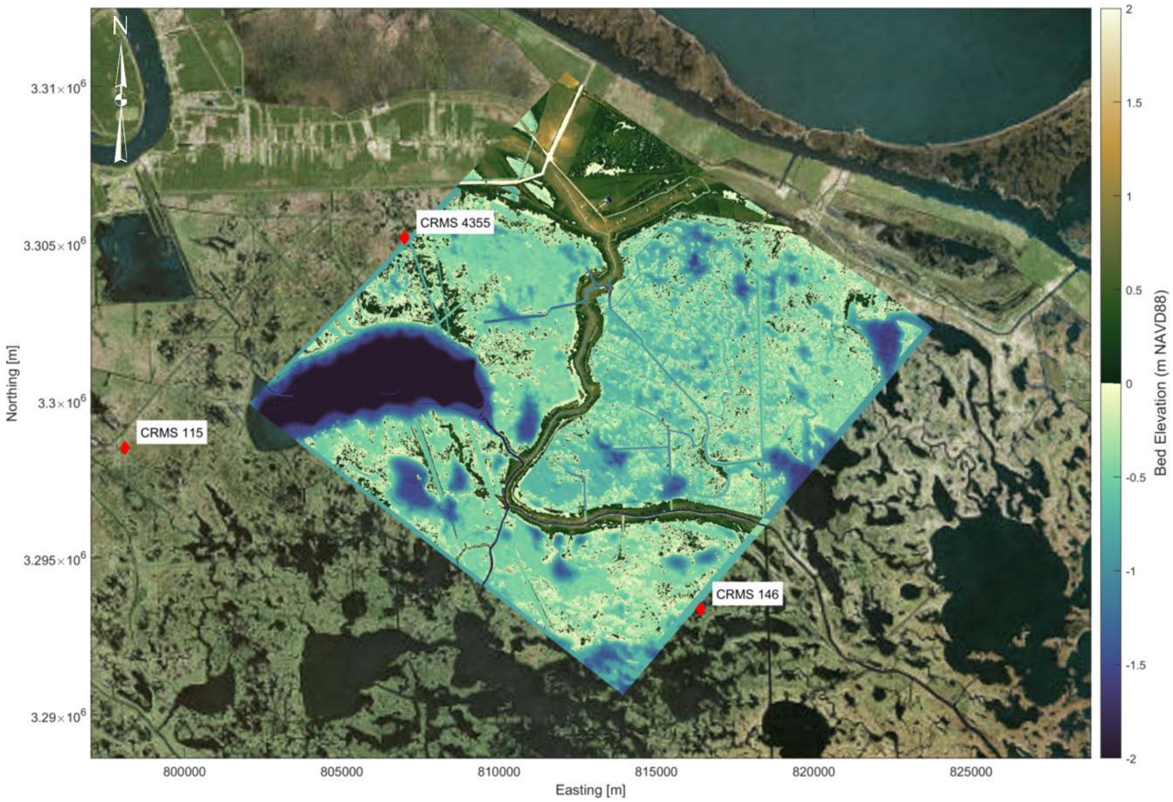


Figure 26: Updated model domain used by Baird for BS-0043 (Baird, 2023).

Table 15: Model Boundary Data Sources

Model Boundary	Start of Boundary	End of Boundary
Northwest	CRMS 0115	CRMS 4355
Southwest	CRMS 0146	CRMS 0115
Southeast	CRMS 0146	CRMS 0146

Table 16: Model Domain Boundaries

Model Boundary	Easting (NAD83)	Northing (NAD83)
North Corner	507,978.23	3,777,027.12
East Corner	479,951.97	3,814,522.27
South Corner	442,274.41	3,781,465.08
West Corner	473,640.38	3,742,877.75

5.4 Existing Data Compilation

Baird was responsible for collecting the data required for the model development. The bathymetry for the model domain includes data collected for the Mid Breton project and 2011 LiDAR data extracted from a CPRA model grid. For more detailed bathymetry near the project site, CPRA provided survey data of the two Howard's Ditch canals, BTAB, and the marsh area to the east of Reggio. The survey was completed by Chustz in March and April of 2022 for BS-0043, as shown in **Figure 27**. The survey data was incorporated into Baird's datasets and used to create the model bathymetry.

In order to collect hydrological and salinity data, Baird used five (5) horizontal Acoustic Doppler Current Profiler (ADCP) sensors and five (5) Conductivity, Temperature, and Depth (CTD) sensors located within BTAB, Howard's Creek, and Reggio Canal (**Figure 28**). The sensors collected existing data over a twelve (12) week span from July – September in 2022. The bathymetry data and data collected from the sensors was used to understand the local hydrologic conditions of the project area and recreate existing model conditions in order to determine if the Canal Plugs would be beneficial. The data collected includes, but is not limited to:

- Topographic and bathymetric data;
- Water levels, discharges, and salinity;
- Local meteorological information, including wind; and
- Any structure layout and designs relating to this project.

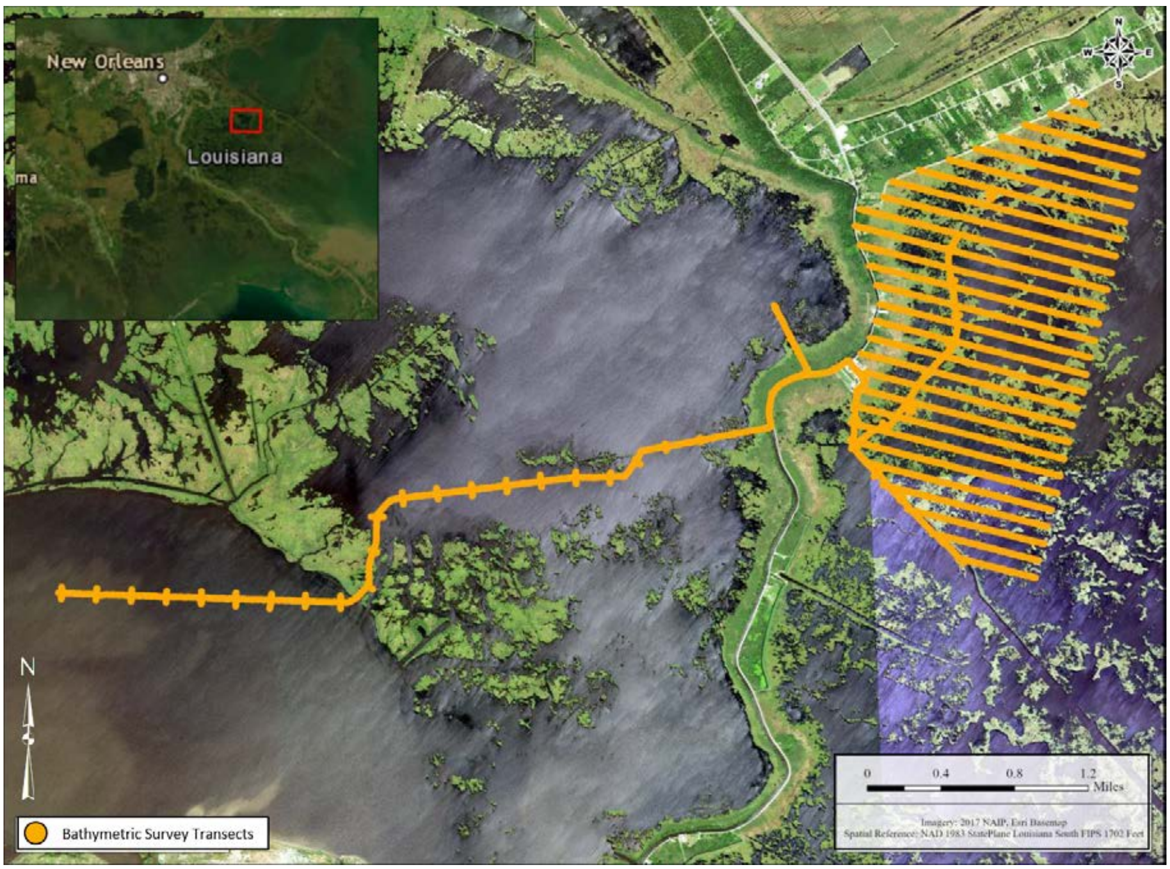


Figure 27: Map of survey data obtained by Chustz for BS-0043 that was used by Baird for the modeling effort.

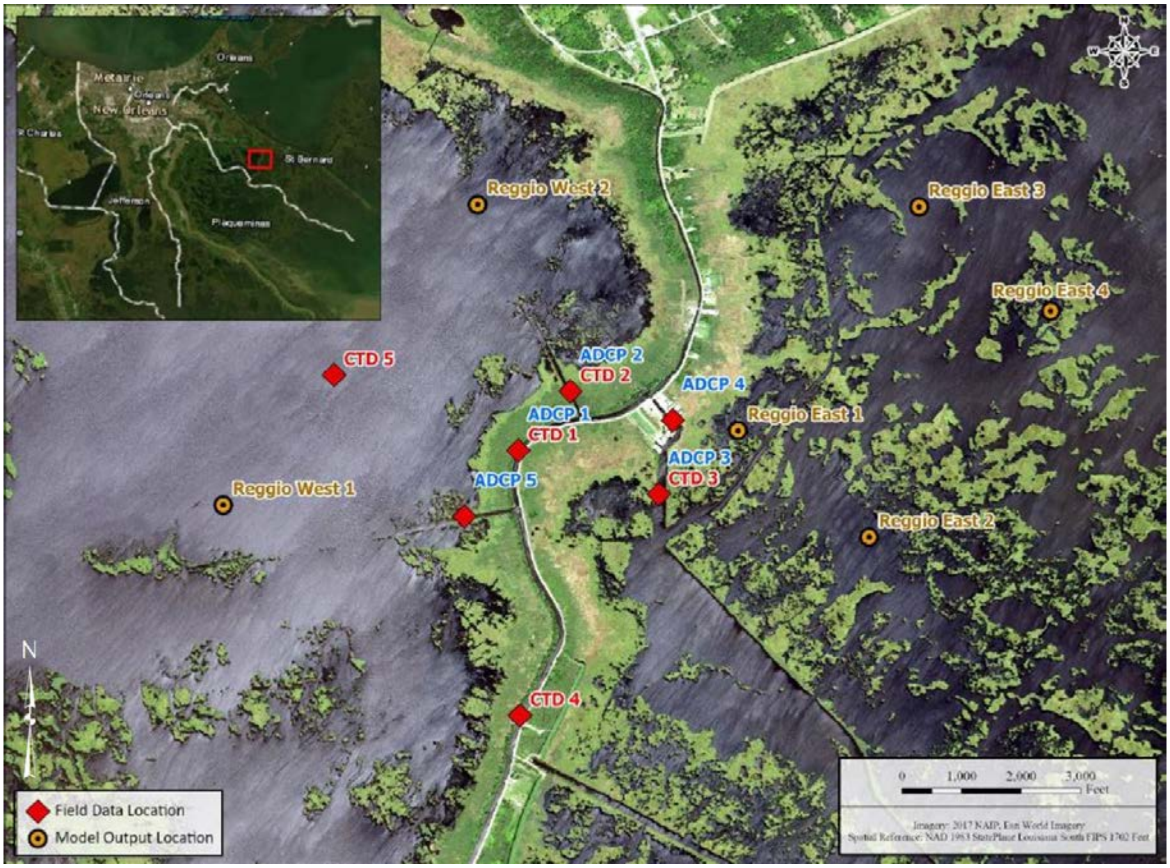


Figure 28: Map of horizontal ADCP and CTD sensor locations and model output locations (Baird, 2022).

5.5 Model Validation

5.5.1 Field Data

A model validation was completed by comparing model results to the measured field data collected by the ADCP and CTD sensors. For the model validation period, an adjustment was made for the data used at the northwest boundary. Instead of using data from both CRMS0115 and CRMS4355 stations, as shown in **Table 15**, only data from CRMS0115 was used for the salinity input. This is because the salinity at CRMS4355 during the model validation period is likely inaccurate (Baird, 2023). The salinity data from CRMS4355 is three to five (3-5) times higher than the salinity data collected from CRMS0115. This difference in salinity is attributed to the Caernarvon diversion, which diverts freshwater from the Mississippi River into Breton Sound. CRMS 0115 is under the influence of this fresh water diversion outflow; while CRMS 4355 receives very little flow, even under high diversion flows. Another caveat for salinity modeling is that there is no long-term data set (CRMS) on the east side of BTAB, so there is very little knowledge of variation and changes over time. The only salinity data collected in the region was the CTD sensors described above. While this presents some limitation, there is no resolution to this issue as years of data collection is not feasible under this project scope.

Baird also selected model output locations for validation and design simulation. These locations match the locations of all the ADCP and CTD sensors used, along with additional points to evaluate changes farther from the project site in the marsh areas both east and west of Reggio.

5.5.2 Validation Results

The model validation simulation time was 2 weeks, from July 1 to July 14, 2022. The water level, salinity, and velocity were compared between the measured data and the model data at the nearest grid cell to the respective measured data locations. The results of the model validation show a strong, positive linear relationship between the model and measured data, indicating a good validation (Baird, 2023). The model accurately predicts the water level (**Figure 29**) and slightly under-predicts the salinity by approximately 0.5 to 1 ppt. at all CTD locations (**Figure 30**). The salinity in the model is not as high as the measured values because the boundary inputs of salinity are slightly less than the measured values. This is dictated by the measured CRMS data used for the boundary inputs. However, the difference in salinity is mostly less than 1 ppt., which is within the accuracy threshold for this model application.

The depth-averaged speed has more scatter between modeled and measured results, indicating a weaker correlation (**Figure 31**). A weaker correlation is expected for depth-averaged speed for a few reasons. First, the model result is depth-averaged because it is a 2-dimensional model, whereas the ADCP measurement is at one depth of the water column, so it is not a direct comparison. Secondly, ADCP measurements have inherent scatter due to flow variability such as eddies, turbulence and other features, which would not be represented accurately in the model. Overall, the modeled flow speed is accurate at ADCP 1, 4 and 5. At ADCP 2 and 3 the model is slightly under-predicting the flow speed. This is likely due to the width of the canal at these locations being different in reality compared to the model, where a wider canal in the model would lead to slightly lower flow speeds (Baird, 2023). The results for all five (5) ADCP depth-averaged velocities are shown in **Figure 31**.

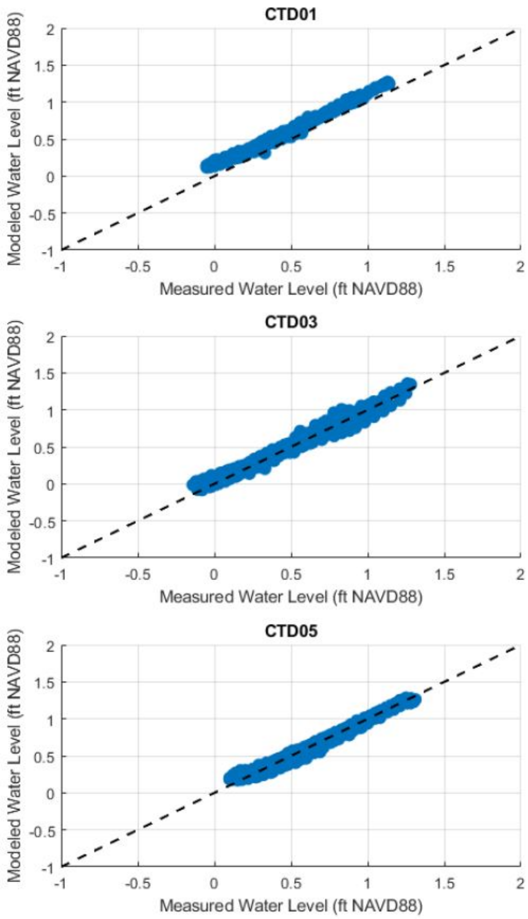


Figure 29: Model vs measured water level for the five (5) CTD locations during the two-week model validation simulation

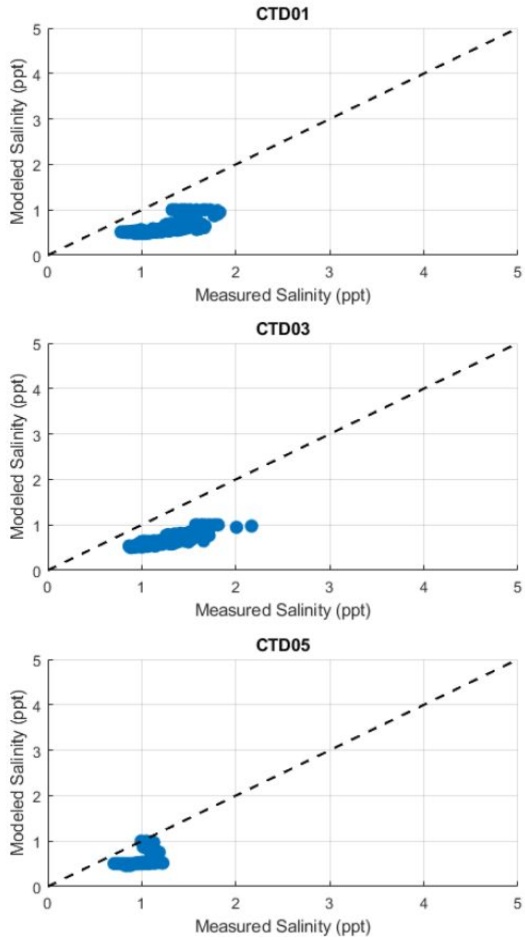


Figure 30: Model vs. measured salinity from the five (5) CTD locations during the two-week model validation simulation

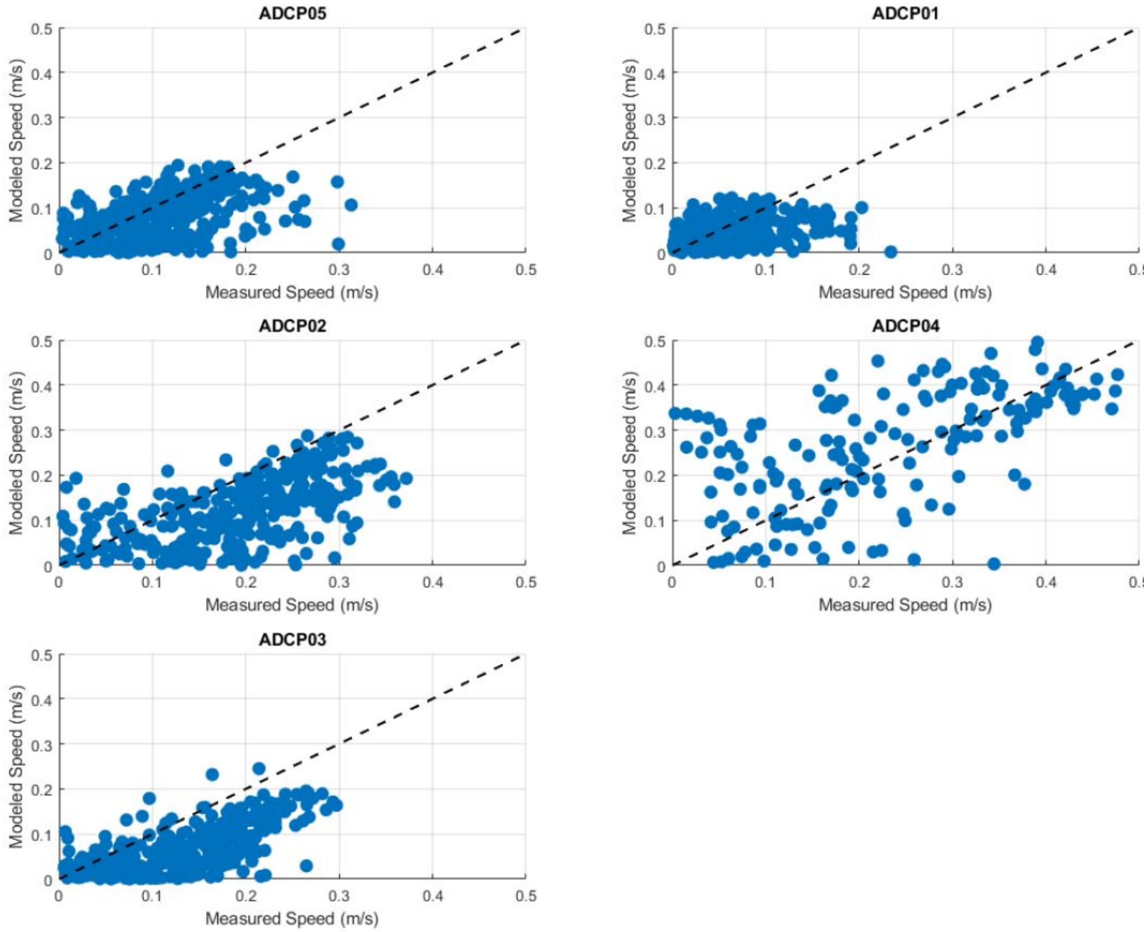


Figure 31: Model depth averaged speed vs. measured speed at the five (5) ADCP locations during the two-week model validation simulation

5.6 Model Results and Analysis

The methodology for determining the impact of plugging the canals included first running the model under the existing conditions (no plugged canals), and then running the model during the same time period with modified bathymetry representing the plugged canals (Baird, 2023). Note that all findings presented here are based on a one-month model simulation, and do not encompass all conditions that the project site is exposed to, or extreme storm conditions. Maximum and average values are only for the one-month period that the model simulated.

The goal of plugging the canals was to reduce the salinity in the marsh area to the west of Reggio by blocking the flow of high saline water coming from the southeast. Therefore, a time-period with high saline water and strong easterly winds was selected so that the impact from plugging the canals could be easily assessed. This was determined by analyzing historical water levels, salinity, and wind at the project site. October 2017 was chosen due to the combination of high salinity and water levels, as well as high wind speeds ranging in direction from northwest through to east.

To evaluate the impact of the Canal Plugs on the local hydrodynamics, Baird first modeled the existing conditions to have a comparable baseline dataset for the results of the production runs. Secondly, Baird modeled three design conditions representing independent and simultaneous closure of the canals linking Howard's Ditch and BTAB.

5.6.1 Salinity

Plugging the canals did not have a significant impact to the salinity of the project area. The largest observable difference in average salinity when compared to the existing conditions occurred within each canal when both canals were plugged (**Table 18**). Plugging the north canal reduces the peak salinity in the north canal by 1.4 ppt (-25%), while plugging the south canal reduces the peak salinity in the south canal by 1.9 ppt (-35%). The largest observable change in peak salinity occurs at the mouth of Reggio Canal by MCA-4, where salinity increased by 1.51 ppt (+50%) when both canals were plugged (**Table 17**). Results for changes in peak and average salinities at each model output location are shown in **Table 17** and **Table 18**.

Table 17: Peak salinity levels (ppt) under design conditions at each model output location (Baird, 2023)

Design Condition	Howards Ditch	North Canal	BTAB between Canals	South Canal	BTAB south of Canals	Reggio Canal	Mouth of Reggio Canal	RE1	RE2	RE3	RE4	RW1	RW2
Existing	3.37	5.62	5.63	5.46	5.27	5.63	5.61	5.63	5.72	5.64	5.64	3.47	4.49
Both Plugged	2.92	4.40	5.25	3.40	5.14	5.61	5.63	5.66	5.73	5.68	5.68	3.49	3.21
% Difference	-13%	-22%	-7%	-38%	-2%	0%	0%	0%	0%	+1%	+1%	+1%	-29%
North Plugged	3.73	4.20	5.63	5.49	5.33	5.63	5.62	5.64	5.72	5.65	5.65	3.44	3.61
% Difference	+11%	-25%	0%	+1%	+1%	0%	0%	0%	0%	0%	0%	-1%	-20%
South Plugged	3.20	5.58	5.45	3.53	5.12	5.63	5.62	5.64	5.72	5.65	5.65	3.51	4.71
% Difference	-5%	-1%	-3%	-35%	-3%	0%	0%	0%	0%	0%	0%	+1%	+5%

Table 18: Average salinity levels (ppt) under design conditions at each model output location (Baird, 2023)

Design Condition	Howards Ditch	North Canal	BTAB between Canals	South Canal	BTAB south of Canals	Reggio Canal	Mouth of Reggio Canal	RE1	RE2	RE3	RE4	RW1	RW2
Existing	1.94	2.90	2.76	2.48	3.03	3.01	3.06	3.37	3.70	4.30	4.31	1.68	2.41
Both Plugged	1.65	1.83	3.72	1.68	3.14	4.32	4.57	4.65	4.79	4.82	4.83	1.60	1.73
% Difference	-15%	-37%	35%	-32%	+4%	+43%	+50%	+38%	+29%	+12%	+12%	-5%	-28%
North Plugged	1.99	2.29	2.78	2.58	3.10	3.02	3.15	3.45	3.84	4.38	4.39	1.70	2.17
% Difference	3%	-21%	+1%	+4%	+2%	0%	+3%	+2%	+4%	+2%	+2%	+1%	-10%
South Plugged	1.80	2.86	3.01	1.81	3.04	3.08	3.17	3.47	3.82	4.38	4.39	1.64	2.41
% Difference	-7%	-1%	+9%	-27%	0%	+2%	+4%	+3%	+3%	+2%	+2%	-2%	0%

It is important to note that increasing the salinity, even on the east side of BTAB, is not favorable for this area. While percent change in salinity on either side can appear significant, the actual maximum decrease in average salinity is 1.1 ppt, which does not carry any ecological significance to the region. While the maximum increase in average salinity is 1.3 ppt. The salinities reported for existing and modeled conditions all fall into the intermediate marsh range, as stated in **Section 2.4**. The water east of BTAB was more saline than the water on the west side, which causes the plugs to prevent freshwater from moving eastward (Baird, 2023). The plugs did not have an impact on salinity on the west side of BTAB, except in the canals themselves; and again, the salinity changes in the canals were not ecologically significant. The goal of the hydrologic restoration feature of this project was to decrease the seasonal increase of salinity to the area west of BTAB. The modeling revealed that plugging both canals did not result in any ecologically significant changes to the regional salinity regime during the period modeled.

5.7 Summary

When both canals are plugged, the blockage of higher saline flow from southeast through the canals to the northwest causes a general reduction in the peak and average salinity in Howard's Ditch, and increases the salinity in the marsh area east of Reggio. When only one canal is plugged, the magnitude of change in salinity from the existing conditions is smaller compared to when both canals are plugged; however, the salinity increases in the open canal and nearby area. Modeled changes in average salinity to the area west of BTAB with both canals plugged were minimal (-0.58 ppt on average), and remain within the intermediate marsh salinity range. Modeled changes in peak salinity to the area west of BTAB with both canals plugged were also minimal (-1.0 ppt on average), and remain within the intermediate marsh salinity range. The differences in salinity do not pose any significant ecological changes from existing baseline salinity conditions.

The original goals of the Canal Plugs was to influence salinity exchange across BTAB. Modeling results indicate that the plugs will not convey any ecologically significant alterations to the regional salinity regime. Therefore, the BS-0043 project team recommended eliminating these features and not proceeding with the full design of the canal plug structures. This modeling effort was optimized for regional qualitative trends, with regards to salinity, and is not recommended to be used for design purposes. Additional data collection and modeling would be required to properly design the canal plugs. Since the project team decided to remove the canal plug features, no additional modeling was performed for the BS-0043 project.

6.0 PROJECT DESIGN

This project proposes to create and nourish five hundred nineteen (519) acres of marsh by hydraulically dredging material from Lake Lery into four (4) Marsh Creation Areas as shown in **Figure 16**, and the 95% Design Drawings (**Appendix G**). The proposed fully confined fill area will utilize in-situ material to construct Earthen Containment Dikes around the perimeter to contain the hydraulically dredged marsh fill. To achieve the project goals, three (3) Internal Training Dikes are proposed within the fill area to help retain the dredge material during construction. The dredged slurry will need to be placed to a constructed fill elevation above the selected intermediate marsh inundation range so that the marsh platform will settle into the optimum inundation range over the twenty (20) year design life. The project design is broken up into the following sections: Marsh Creation Areas (MCAs), Earthen Containment Dikes (ECDs) and Internal Training Dikes (ITDs), Marsh Creation Borrow Area (MCBA), and Dredge Pipeline Corridor (DPC).

6.1 Marsh Creation Area Design

Marsh fill settlement analysis was performed to determine the Constructed Marsh Fill Elevation (CMFE) for each MCA and the total volume of marsh fill material needed for construction. The final elevation of the constructed marsh platform (at year twenty (20)) is governed by two forms of settlement: (1) the settlement of the underlying soils in the MCAs caused by the loading exerted by the placement of dredged fill material, and (2) the self-weight consolidation of the dredged material. Additionally, the natural process of subsidence plays a role in determining the final settled twenty-year (20) elevation of the MCAs as mentioned previously in **Section 2.2**. Data from traditional consolidation testing was used to estimate the settlement of the underlying soils of the MCAs and data from column settling tests and low-pressure consolidation tests were used to estimate the magnitude and time-rate of settlement of the slurry.

6.1.1 Preparation for Marsh Creation Area Settlement Analysis

To perform the marsh fill settlement analysis, parameters such as sea-level rise, subsidence, target marsh creation surface elevations, existing mudline elevations, fill volumes, and dredge fill placement rates are required. CPRA provided these parameters to Eustis to perform the total settlement analysis, as shown in the Geotechnical Engineering Report (**Appendix F**). Marsh fill and foundation settlement analysis were modeled for each MCA independently due to differences in bathymetry. The representative mudlines for each MCA are shown in **Table 8**, **Table 9**, and again below in **Table 19**. These mudlines represent the prevailing existing mudline elevations throughout the MCAs.

Table 19: MCA Representative Mudlines

Marsh Creation Area	Representative Mudline (ft. NAVD88)
MCA-1	-0.50
MCA-2	-1.75
MCA-3	-1.50
MCA-4	-1.00

6.1.2 Foundation Settlement

Settlement analysis of the foundation soils within the MCA's was modeled using the United States Army Corpse of Engineering (USACE) Primary consolidation, Secondary compression, and Desiccation of Dredge Fill (PSDDF) modeling software. These analyses assumed fill placement occurs in uniform layers throughout the MCA's, and used a dredge fill placement rate corresponding to approximately 10,000 CY of in-situ borrow material dredged per day. The filling plan modeled by Eustis is shown for each MCA in **Table 20**. The design water level for the fill area was set to the target year twenty (TY20) 90% inundation elevation of +0.635 ft. NAVD88. The TY20 for BS-0043 has since changed from 2047 to 2045, changing the TY20 90% inundation elevation to +0.595 ft. NAVD88. The filling plan performed by Eustis was conducted assuming a marsh fill area composed of three (3) MCA's using two (2) ITD's. The marsh fill area layout has also been altered since this analysis by the addition of a third ITD, creating a fourth (4th) MCA.

Table 20: Filling Plan from Eustis

Area	**Mudline** (ft. NAVD88)	**Lifts**	**Time Between Lifts** (days)	**Total Fill Time** (days)
MCA-1	-1.00	12	5	55
MCA-2	-1.75	16	5	75
MCA-3	-1.50	21	5	100

The near-surface soils of the MCAs are predominantly organic clays/peat/hummus underlain primarily by soft and fine-grained clays. This weak foundation material will experience significant initial consolidation due to dredged material placement, followed by continuing settlement over long periods of time at a diminishing rate (Eustis, 2023).

Foundation settlement was measured at the time of each lift during construction and at selected times throughout the twenty (20) year project design. The summary of foundation settlement for each MCA is displayed in **Table 21**. The total foundation settlement for each MCA, along with the previously mentioned subsidence estimate of 3.07 inches (0.256 ft.) of fill, will be added together to the target twenty (20) year surface elevation to be used in volume calculations as shown in **Appendix H** (Calculations Package). The foundation settlement analysis conducted by Eustis was performed assuming a marsh fill area composed of three (3) MCA's using two (2) ITD's. The marsh fill area layout has since been altered by the addition of a third ITD, creating four (4) MCA's instead of three (3) MCA's from the 30% design phase. This change in MCA subareas did not alter the uniform +2.0 ft. NAVD88 CMFE across all MCAs.

Table 21: MCA Foundation Settlement throughout Project Life

Foundation Settlement (ft.)			
Time (days)	**MCA-1**	**MCA-2**	**MCA-3**
60	0.492		
80	0.495	0.650	
105	0.498	0.655	0.648
110	0.499	0.656	0.649
115	0.499	0.657	0.650
120	0.500	0.658	0.651
420	0.528	0.695	0.688
790	0.551	0.724	0.717
1,885	0.592	0.779	0.771
3,710	0.634	0.834	0.826
5,530	0.661	0.870	0.862
7,300	0.678	0.893	0.884

A summary of the foundation settlement analysis conducted by Eustis Engineering is provided in **Appendix F** (Geotechnical Engineering Report).

6.1.3 Self-Weight Settlement

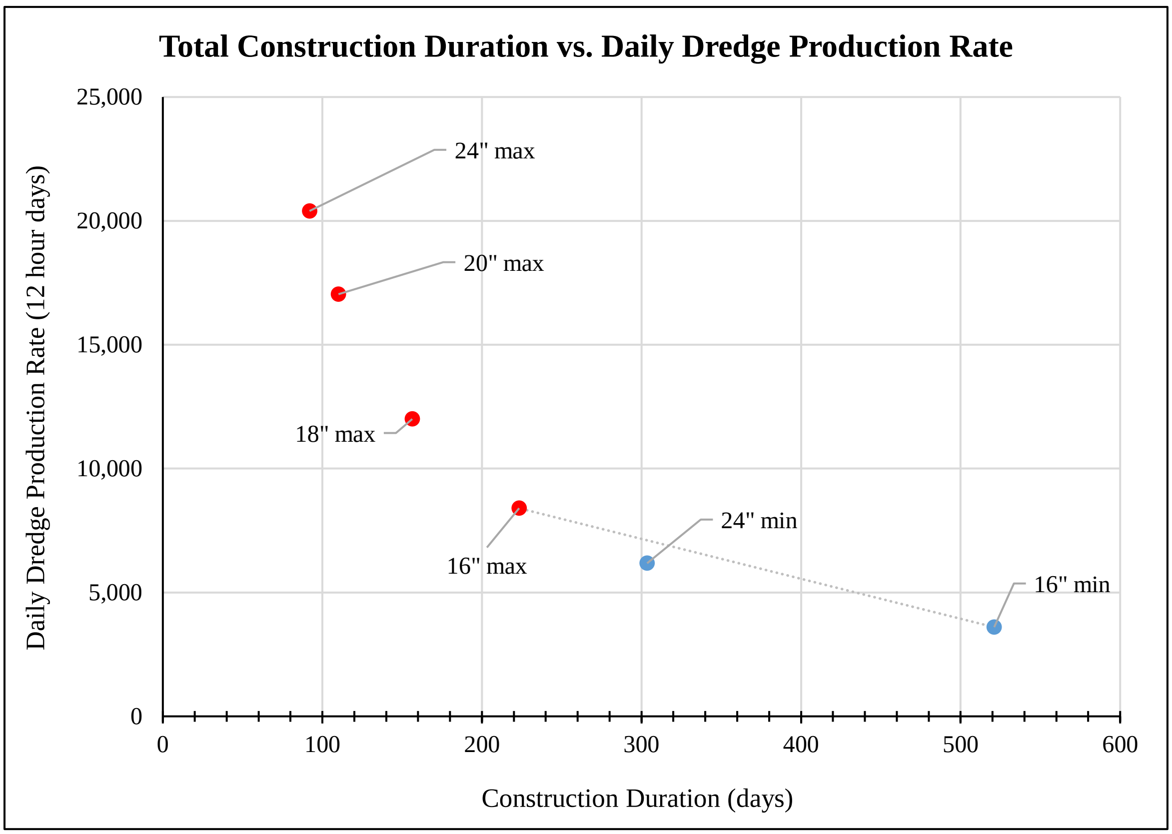
The other settlement required for marsh creation settlement analysis is self-weight settlement. A column settling test was performed by Eustis to understand the settling processes and properties of the dredged slurry, by the test method specified in the USACE Engineering Manual No. 1110-2-5027. Additionally, low-stress consolidation tests were also performed to analyze the self-weight consolidation of the dredged material (EM 1110-2-5027) after sedimentation (USACE, 2015). Column settling tests provide an insight into the sedimentation behavior of the marsh fill when placed within the fill area, while low-stress consolidation tests are used to measure the consolidation properties of the dredged material under increasing low-magnitude loading conditions. Together, the results of these tests are used to determine an initial void ratio of the dredged material, e_{00}, taken as the point when the slurry translates from zone settling to compression settling. The initial void ratio and the consolidation properties determined in these tests are used to estimate the magnitude and time-rate settlement of the dredged material using the PSDDF program developed by Dr. Timothy D. Stark. For the pilot-scale settling column tests the composite sample was mixed to initial concentrations of 152.9 g/L and 150.1 g/L, based on target concentrations of 150 g/L (Eustis, 2023). Results from the BS-0043 pilot-scale settling test are shown in **Appendix F** (Geotechnical Engineering Report). These tests were performed to gather necessary data inputs for PSDDF settlement runs.

6.1.4 Assumed Filling Sequence for PSDDF

In order to model fill placement in PSDDF, a hydraulic fill placement lift schedule must be determined. The dredge production rate determines the lift schedule, which can vary widely depending on dredge size and contractor means and methods. Based on the water depths in Lake Lery and the minimum draft required for cutter suction dredges, mobilization of a sixteen (16) to twenty-four (24) inch Cutterhead Suction Dredge

(CSD) is anticipated because there will be no access dredging allowed in Lake Lery. The required cut volume is discussed in **Section 6.1.6** and ranges of hydraulic dredge production rates from a collection of various hydraulic dredge data sheets are plotted in **Figure 32**. Based on **Figure 32**, the CSD construction duration for the total required cut volume of this project could vary from ninety-two to five hundred twenty-one (92-521) days depending on what size dredge mobilizes to the MCBA. It is impractical and cost inefficient for a contractor to pump at the minimum daily dredge production rates presented in **Figure 32**.

Eustis used three (3) assumed filling durations in PSDDF, a different duration for each MCA due to varying existing mudlines. Self-weight and foundation settlement during construction are included in the assumed filling schedules (Eustis, 2023). Eustis modeled all material lifts in PSDDF with an initial void ratio equal to 8.80. The initial void ratio of 8.80 corresponds to a concentration of placed dredged slurry at around one hundred fifty (150) g/L. To capture post-construction marsh fill settlement, each filling sequence was modeled with an additional thirty (30) days, six (6) months, one (1) year, two (2) years, five (5) years, ten (10) years, fifteen (15) years, and twenty (20) years after fill placement to determine future fill heights after dredge fill placement ceases (Eustis, 2023).



*Assumes cutter suction dredge is operational for twelve (12) hours per day

Figure 32: Total CSD Construction Duration (2.008 MCY) vs. Daily Dredge Production Rate

6.1.5 Constructed Marsh Fill Elevation

The next step in the settlement analysis involved determining an appropriate CMFE. One element of the design is to maximize the time that the marsh platform has an elevation within the selected intermediate marsh inundation range (ten to ninety percent (10% - 90%) inundated). To determine the CMFE that would yield the most productive marsh at the end of the twenty (20) year project life, water levels in the project area, eustatic sea-level rise (ESLR), subsidence rates, and foundation settlement estimates for the project area were determined. Accretion rates within the Breton Sound Basin were also investigated; however, they were not used for the CMFE determination to remain conservative. For design application, subsidence and foundation settlement estimates were applied to the marsh fill elevation (settlement curves), while ESLR was applied to the tidal datum and the optimal inundation range (Eustis, 2023). The ideal final marsh platform would settle into the optimal intermediate marsh range (ten to ninety percent (10% - 90%) inundated) shortly after construction and would remain there for the duration of the twenty (20) year project life. This analysis was also conducted under the assumption of using two (2) ITD's to create three (3) MCA's. The marsh fill layout has since been altered to use three (3) ITD's in order to create four (4) MCA's of similar size.

As mentioned previously, Eustis provided construction marsh fill settlement recommendations for various filling sequences for the MCAs that would maximize the amount of time that the marsh platform would remain within the ten to ninety percent (10% to 90%) inundation range. Eustis modeled the CMFE of the marsh creation fill equal to +1.85 ft. for MCA-1, +2.10 ft. for MCA-2, and +2.00 ft. for MCA-3 at the end of dredge fill placement, with the goal of achieving an elevation of +0.635 NAVD88 (90% inundation level) at TY20 (2047). The TY0 and TY20 for BS-0043 have since changed from 2027 and 2047, to 2025 and 2045. This change results in a new TY20 90% inundation elevation of +0.595 ft. NAVD88. The actual elevation at the end of dredge fill placement will depend on contractor equipment size, means and methods of fill placement, dewatering operations, as well as the initial concentration of dredged material (Eustis, 2023). Results of all three (3) filling scenarios modeled in PSDDF are presented in **Figure 33**.

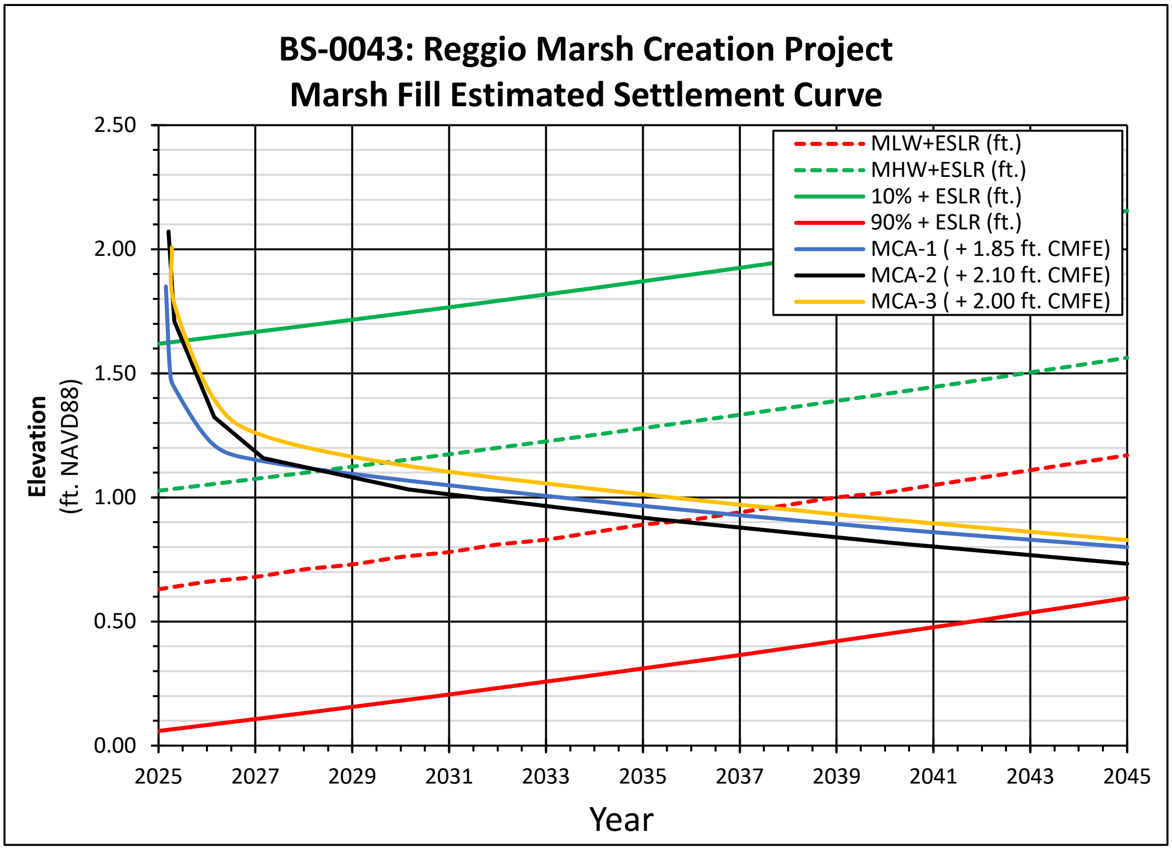


Figure 33: Marsh Fill Estimated Total Settlement Curve (Eustis, 2023)

These recommended CMFEs should provide a cost and material efficient marsh platform that will maximize time spent within the optimum inundation range for the duration of the project life. Based on the marsh fill settlement analysis and recommendations provided by Eustis, a CMFE of +2.0 ft. NAVD88 with an upper tolerance of one-half (0.5) feet has been selected for all MCAs. Cross-sections for all four (4) MCAs are shown in **Figure 34**, **Figure 35**, **Figure 36**, and **Figure 37**. During construction, the CMFE may be adjusted based on field observations, actual daily dredge production rates, and monitoring data. The observational approach to design typically involves geotechnical monitoring of the soil behavior during the early phases of construction to verify design parameters and predict responses to inform subsequent construction (Samtani and Nowatzki, 2006).

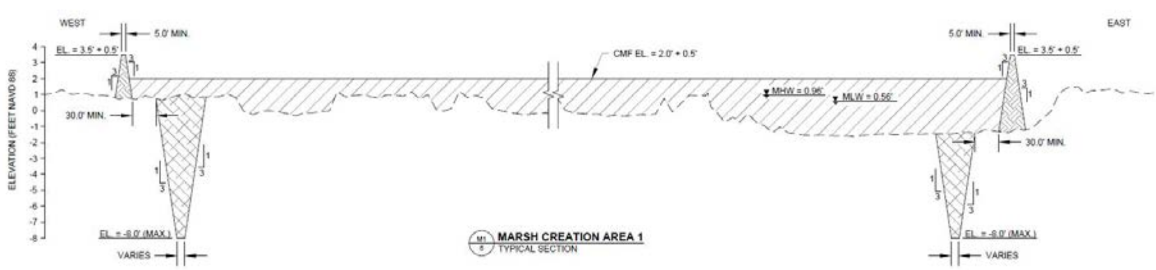


Figure 34: Typical marsh fill section for MCA-1

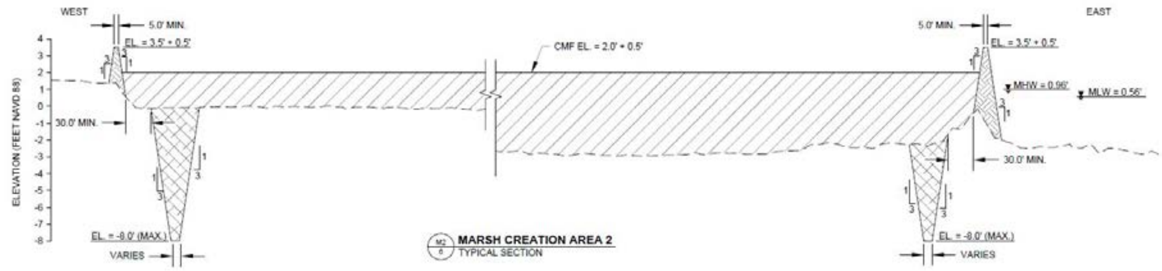


Figure 35: Typical marsh fill section for MCA-2

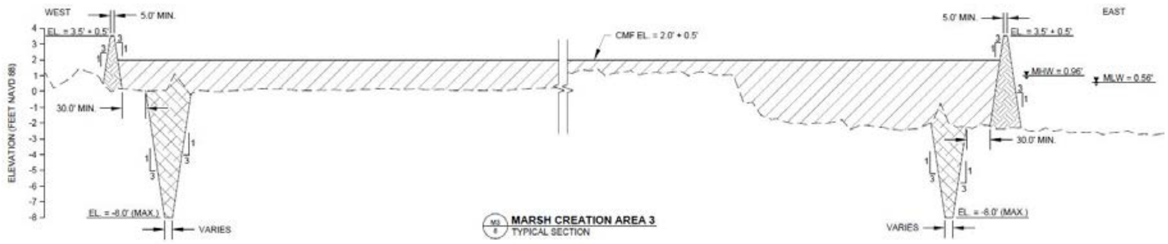


Figure 36: Typical marsh fill section for MCA-3

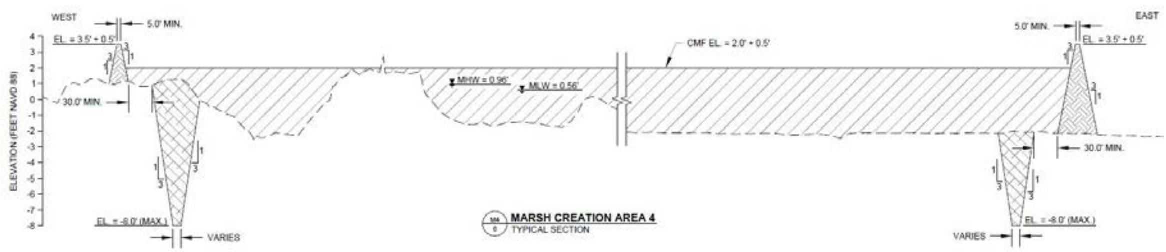


Figure 37: Typical marsh fill section for MCA-4

6.1.6 Marsh Fill Quantities

After determining the magnitude of foundation settlement, subsidence, and the twenty (20) year settled marsh platform elevation, the total volume of each MCA was calculated using ArcGIS ArcMap 2017 software. The software creates a 3-Dimensional surface based on three-dimensional coordinate data from design survey data. This surface is known as the base triangular irregular network (TIN) (**Figure 18**). The base TIN surface from the 2022 survey data and a flat TIN comparison surface for all four (4) MCAs was created by ArcMap. The flat TIN comparison surfaces represent the target year twenty (TY20) marsh elevation from the settlement curve for each MCA, with the addition of estimated foundation settlement for each MCA, and subsidence, as shown in **Appendix F** (Geotechnical Engineering Report) and **Table 22**. ArcMap then uses the XYZ differences of each surface to calculate the fill volume of each MCA.

Table 22: MCA Volume Calculation

Area	TY20 Marsh Elevation from Settlement Curve (ft. NAVD88)	Foundation Settlement (ft.)	Subsidence (ft.)	Elevation used for Volume Calculations (ft. NAVD88)
MCA-1	+0.80	0.678	0.256	+1.734
MCA-2	+0.73	0.893	0.256	+1.879
MCA-3	+0.83	0.884	0.256	+1.970
MCA-4	+0.83	0.884	0.256	+1.970

The cut-to-fill ratio for marsh fill was estimated twenty (20) years after dredging using the following equation from EM1110-2-5025:

$$V_f = V_i\left\{\left(\frac{e_o - e_i}{1 + e_i}\right) + 1\right\}$$

Where,

V_f = volume of fine-grained dredged material after placement, yd^3
V_i = volume of fine-grained sediments from borrow area, yd^3
e_i = average in-situ void ratio of the borrow area
e_o = void ratio after twenty (20) years.

Based on vibracore sampling in the MCBA, the initial in-situ void ratio in the top ten (10) feet of the MCBA is 3.27. At twenty (20) years, the void ratio throughout the marsh fill will decrease towards the initial in-situ void ratio of the MCBA. Based on the PSDDF output data, the average void ratio in the fill area at twenty (20) years is 3.90. The calculated cut-to-fill ratio using the equation shown above is 1.15. Based on observations from previously constructed inland borrow marsh creation projects, CPRA chose a cut-to-fill ratio for design and for the hydraulic dredging bid quantity of 1.1.

Since the containment borrow pits must also be refilled, the volume required to build the ECD and ITDs, including a cut-to-fill ratio of 1.5, is added to the volume required to fill each MCA. Finally, the cut-to-fill ratio of 1.1 for this project is applied, resulting in a final estimate of volume required to be cut from the MCBA for each MCA. A summary of the estimated marsh fill and cut volume calculations are shown in the **Table 23**.

Table 23: Summary of MCA Acreages and Volumes

MCA	CMFE (ft. NAVD88)	Area (acres)	Cut to Fill	Fill Volume* (CY)	Cut Volume (CY)
MCA-1	+2.0 (+ 0.50)	123	1.1:1	285,272	313,800
MCA-2	+2.0 (+ 0.50)	123	1.1:1	486,178	534,796
MCA-3	+2.0 (+ 0.50)	136	1.1:1	540,213	594,233
MCA-4	+2.0 (+ 0.50)	137	1.1:1	514,653	566,118
	Subtotal:	**519**		**1,826,316**	**2,008,947**

*Volume calculations shown in this table include ECD and ITD borrow quantities (**Table 27)**

6.2 Earthen Containment Dike and Internal Training Dike Design

The primary design parameter associated with the ECD design is the crown elevation. The ECD crown elevation governs the maximum elevation of marsh fill material that can be constructed with single lift construction methodology. Several factors associated with the equipment type, means of methods of the contractor, and the existing conditions of the project site drive the selection of the design crown elevation of containment dikes on marsh creation projects. These factors include, but are not limited to, the dredge production rate (dredge size), the concentration of slurry (or specific gravity of the slurry), fill placement area, volume of solids required to achieve the target twenty (20) year elevation, and the capacity of the fill area (**Table 24**).

Table 24: Dredge Parameter Assumptions

Pipe Diameter (in.)	Average Velocity (ft./sec)	Average Solids Production (CY/hour)
18	16	500 – 1,000

Marsh fill settlement calculations in PSDDF and the MCDG were used to guide the decision for determining the appropriate containment dike crown elevation required to contain the total volume of solids to achieve the target twenty (20) year elevation for this project. Based on the minimum one (1.0) ft. of freeboard requirements outlined in the MCDG, it is recommended that the minimum crown elevation for the ECD to contain dredged slurry for all four (4) MCAs is +3.5 ft. NAVD88 (Eustis, 2023) (**Table 25**).

Table 25: ECD Crest Height Analysis

Area	CMFE (ft. NAVD88)	Freeboard (ft.)	Minimum Crest Height (ft. NAVD88)
MCA-1	+2.0 (+ 0.5 ft.)	1.0	+3.50
MCA-2			
MCA-3			
MCA-4			

6.2.1 Earthen Containment Dike Stability

The minimum ECD crest elevation of +3.50 ft. NAVD88, along with three (3) horizontal to one (1) vertical (3H: 1V) side slopes, and a thirty (30) foot berm width, was selected for the ECD stability analyses (Eustis, 2023). The following slope stability scenarios were run in Slope/W:

Stability runs included evaluating:

Case A-1) Global failure of the containment dike, no marsh fill placed.

Case A-2) Failure of the borrow channel, no marsh fill place, with construction equipment modeled (Vertical load surcharge = 260 PCF);

Case B-1) Failure of the containment dike with no marsh fill

Case B-2) Failure of the containment dike after placement of marsh fill (no freeboard)

ECD templates were analyzed to meet a minimum factor of safety of 1.2 as recommended in MCDG 1.0. Based on the results conducted by Eustis, the ECDs can be safely constructed to a +3.50 ft. NAVD88 crest dike height elevation with side slopes of 3H:1V. A summary of the stability analysis results conducted at the -2.50 ft. NAVD88 elevation is presented in **Table 26**. This elevation was selected to remain conservative and ensure the deepest areas along the ECD alignment can be constructed with in-situ material.

Table 26: ECD Slope Stability Results

Condition	**Mudline Elevation** (ft. NAVD88)	**Crest Elevation** (ft. NAVD88)	**Borrow Pit Offset** (ft.)	**Berm Side Slope**	**Factor of Safety** (min = 1.2)
Borrow Excavation Global (Case A-1)	-2.50	+ 3.50	30	3H:1V	1.63
Borrow Excavation Local (Case A-2)	-2.50	+ 3.50	30	3H:1V	1.29
Filled to CMFE (Case B-1)	-2.50	+ 3.50	30	3H:1V	1.26
ECD Local Stability (Case C-1)	-2.50	+ 3.50	30	3H:1V	1.27

6.2.2 Earthen Containment Dike Settlement

Consolidation settlement of the foundation soils beneath the +3.50 feet (NAVD88) ECDs were computed by Eustis in Settle3 assuming instantaneous loading. Instantaneous loading of the ECD foundation will yield more conservative estimates of settlement. Eustis estimated an approximate nine (9) to twelve (12) inches of vertical downward movement during construction due to displacement of the soft surficial materials. The lateral displacing, or mud waving, that occurs during ECD construction will occur quickly and may increase the quantity required to reach the design construction elevation. This increase in quantity from settlement and lateral displacement is accounted for in the cut-to-fill ratio for ECDs (Eustis, 2023). This settlement during construction will also be mitigated with regular maintenance of the ECDs during construction until acceptance of the marsh fill area. Post-construction settlement of the ECDs will not be a concern due to the planned post-construction gapping and degrading of the ECDs. Figures of the ECD settlement results can be found in Appendix IV of the Geotechnical Engineering Report (**Appendix F**).

6.2.3 Earthen Containment Dike and Internal Training Dike Quantities

An ECD crown elevation of +3.50 ft. NAVD88 Geoid 12B was used to calculate volumes to account for the construction tolerance. To account for losses, settlement, and ongoing maintenance of the ECD template during construction, a cut to fill ratio of 1.5 was applied to determine the volume of borrow required to construct and maintain the ECDs. The same process that was used to design the ECD was used to design the ITD's for the marsh fill area. The final ECD and ITD quantities are summarized in **Table 27**. A typical ECD section is shown in **Figure 38** and a typical ITD section for this project is shown in **Figure 39**. Typical sections marsh fill and containment dikes are also in the 95% Design Plans in **Appendix G**.

Table 27: Summary of ECD and ITD Quantities

Dike Section	**Total Length** (ft.)	**Cut to Fill**	**Side Slopes** (H:V)	**Dike Height** (ft.)	**Fill Volume** (CY)	**Cut Volume** (CY)
ECD	26,145	1.5:1	3:1	+ 3.5 (+ 0.50)	48,596	72,894
ITD-1	2,157	1.5:1	3:1	+ 3.0 (+ 0.50)	3,355	5,033
ITD-2	2,075	1.5:1	3:1	+ 3.0 (+ 0.50)	3,228	4,842
ITD-3	2,330	1.5:1	3:1	+ 3.0 (+ 0.50)	3,624	5,437
Total:	**32,707**				**58,803**	**88,206**

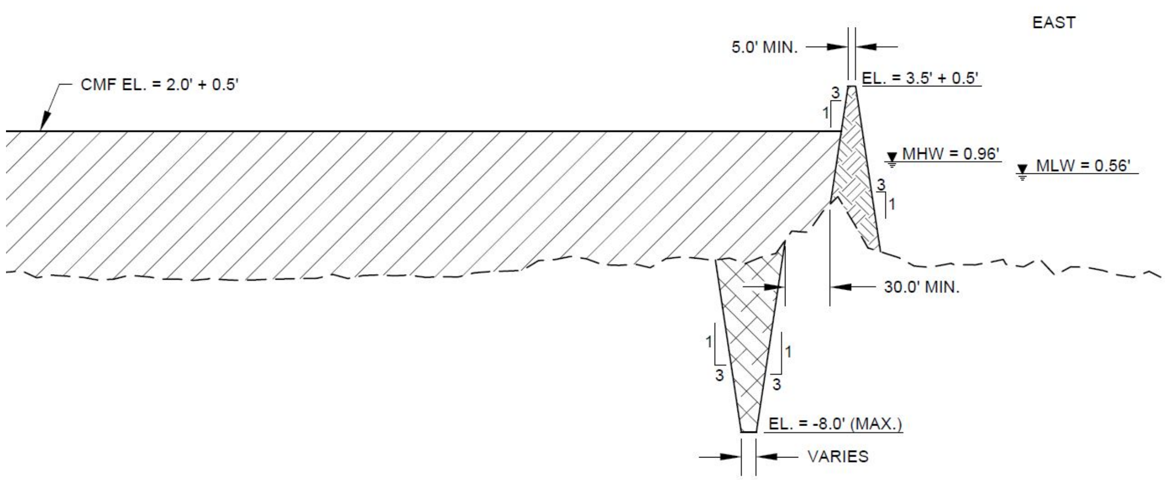


Figure 38: Typical Earthen Containment Dike Section for all four (4) MCAs

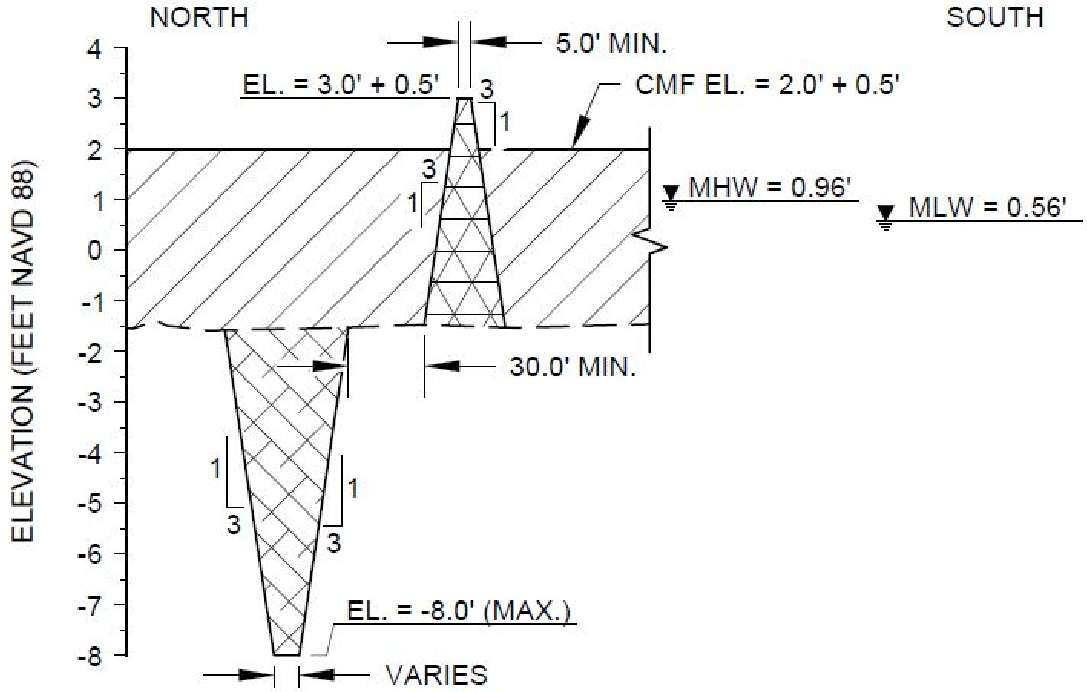


Figure 39: Typical Internal Training Dike Section for ITD-1, ITD-2, and ITD-3

6.3 Marsh Creation Borrow Area Design

The typical controlling factors in the MCBA design are the location, existing infrastructure, borrow soil properties, and quantities. It is preferred that the MCBA be located near the proposed MCAs to minimize the pumping distance of the dredged material and therefore minimize the dredging cost. The borrow area should be free of any existing oyster leases, critical habitat, culturally significant sites, and infrastructure, if possible.

The location of the proposed MCBA shown in **Figure 40** has evolved throughout the E&D process. This location was originally chosen for the BS-0041 North Delacroix Marsh Creation Project. The BS-0041 project team conducted a cultural resource investigation in the proposed MCBA in 2021, including magnetometer and bathymetry survey, as shown in **Figure 14**. The BS-0041 project team performed a cost-benefit analysis for various alternate dredge pipeline routes for the BS-0037, BS-0041, and BS-0043 projects. The alternative analysis considered pump distances from the Lake Lery MCBA to each proposed MCA. The alternative analysis concluded that the cost-benefit of relocating the BS-0041 Borrow to Lake Amedee would be increased for both the BS-0043 and BS-0041 projects, given the decrease in pump distances. The BS-0041 project team decided to borrow from Lake Amedee instead of Lake Lery, which left the proposed MCBA available for BS-0043.

The proposed MCBA footprint is two hundred thirty-seven (237) acres, and is shown in **Figure 40**. During the 30% E&D process, the identification of infrastructure and recommended offsets from nearby wellheads and pipelines required modifications to the proposed MCBA footprint. The edges of the MCBA were offset with a 100-foot buffer and designated as a no-dredge buffer zone, as shown in **Figure 41**. During the E&D process, three (3) wellheads were discovered within or near the proposed MCBA that need to be avoided. All three (3) wellheads are plugged and abandoned, but still require a 250-foot dredge avoidance radius, also shown in **Figure 41**. The side-scan sonar survey conducted as part of the cultural resource investigation in 2021 found thirteen (13) contact hits within the proposed MCBA, of which two (2) were deemed to be potentially significant. These two (2) areas require a 100-foot dredge avoidance radius for safety reasons, also shown in **Figure 41**. The resulting MCBA (**Figure 41**) is two hundred nine (209) acres.

The proposed MCBA was optimized further throughout the 95% design phase, emphasizing regional sediment management and quality of available sediment. The resulting MCBA will be subdivided into a primary borrow area and a secondary borrow area (**Figure 41**). The primary borrow area was selected based on preferable material in that area, although the material in the secondary borrow area is still useable for a marsh creation project in the future, if needed. The Contractor must exhaust the primary borrow area and request approval from the Engineer before dredging of the secondary borrow area can begin. During the 95% design phase, the dredge depth of cut was increased from ten (10) feet to fifteen (15) feet, further decreasing the required MCBA footprint and leaving more area for future project borrow areas.

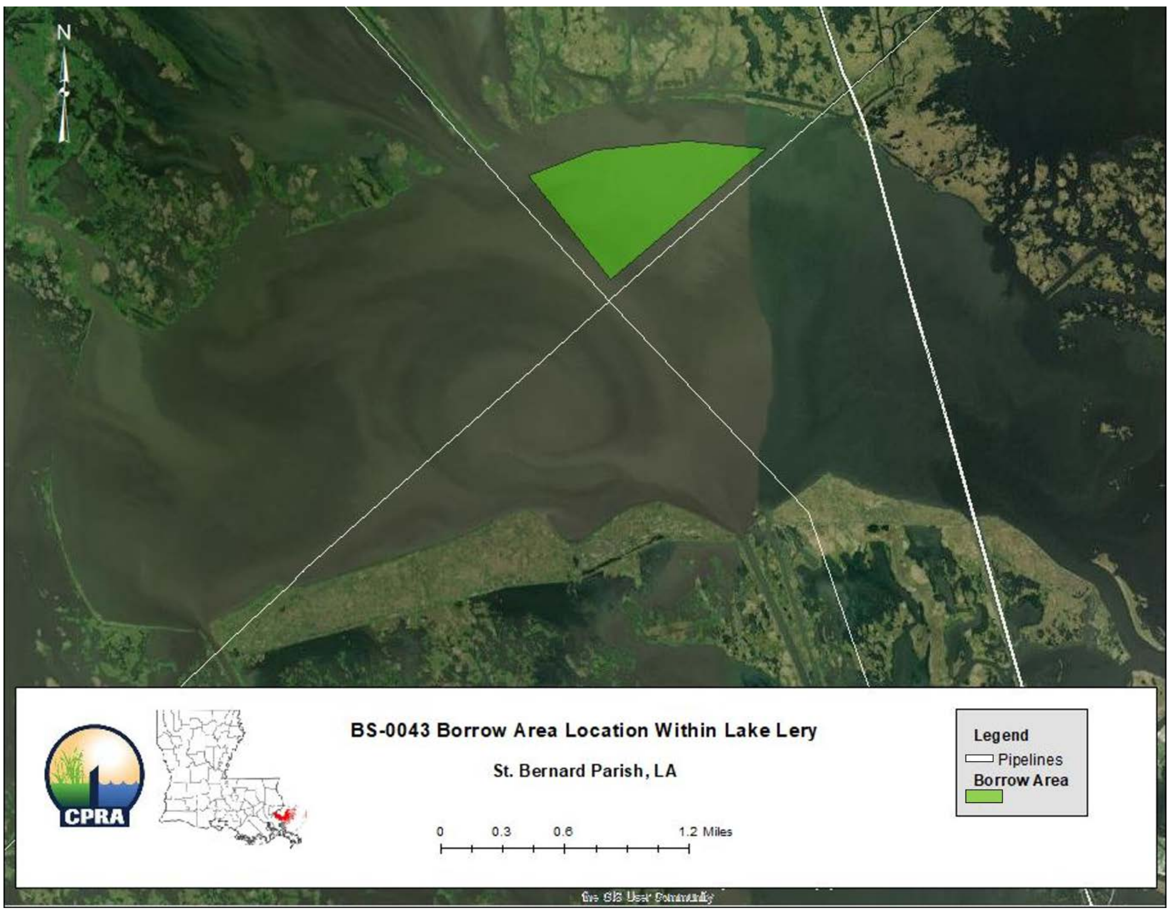


Figure 40: Proposed Marsh Creation Borrow Area Location within Lake Lery

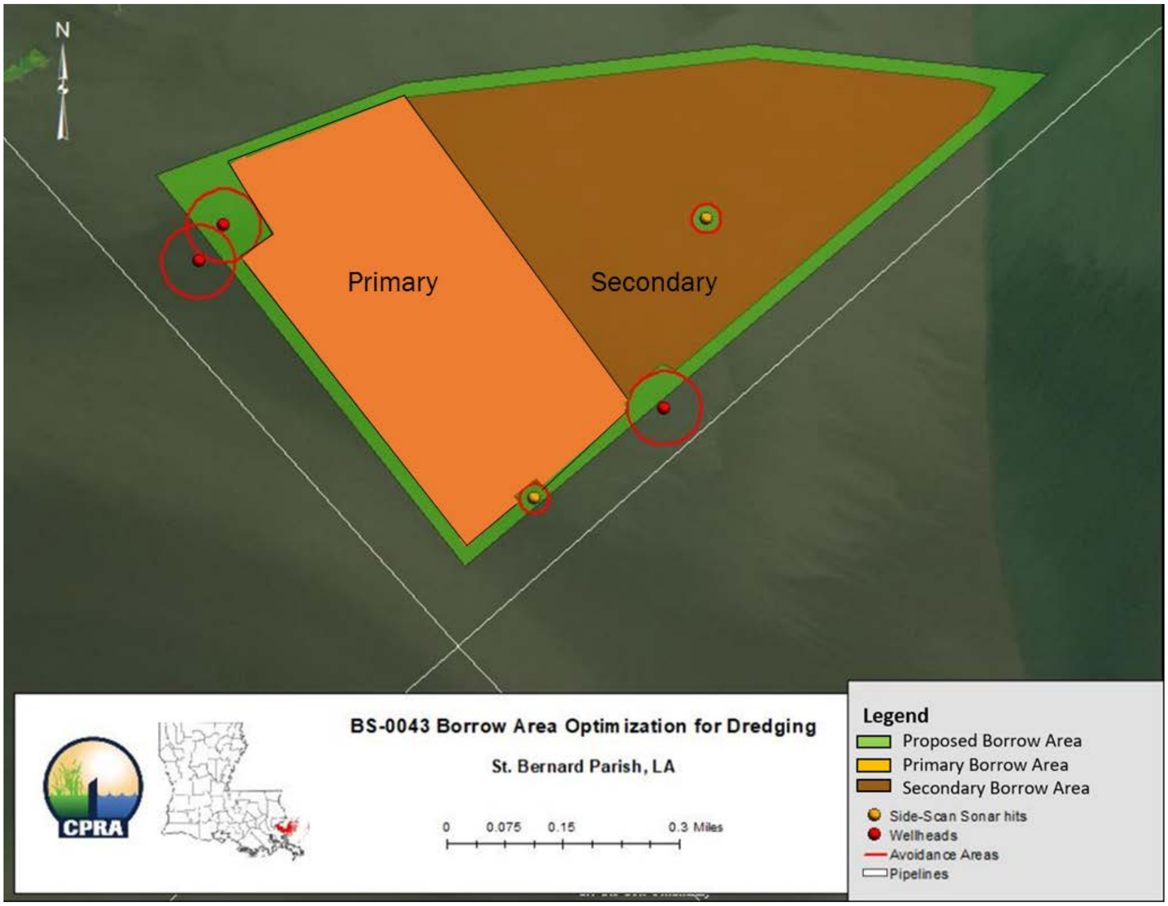


Figure 41: Borrow Area Design for Dredging

Of the eighty (80) soil boring samples (from four (4) borings) collected from the proposed MCBA, thirty-seven (37) were classified as organic clay, thirty-five (35) were classified as fat clay, six (6) were classified as inorganic/lean clay, and two (2) were classified as sand. Classification and engineering properties of all MCBA soil boring logs by depth is presented in **Figure 42**.

Visual classification and basic material characteristic testing was performed on selective representative soil samples from each soil boring to obtain Atterberg Limits, unit weight, moisture contents, organic testing, and particle size distributions (Eustis, 2023). These testing results provide useful insight to the geotechnical properties of the Lake Lery sediment, both to this project and future projects in the region.

The geotechnical behavior of clay material during the dredging process is particularly important for estimating the difficulty of transporting sediment. Dredging cohesive soils and hydraulically transporting via pipeline can be an inefficient process depending on the material's geotechnical properties. Data from index testing of the borrow materials, moisture content (w), and Atterberg Limits can be used to assess these properties. The results of the Atterberg Limits testing provide the liquid limit (LL), the plastic limit (PL), and thus the plasticity index (PI).

The liquidity index (LI) of a soil sample, as shown by the following formula, provides an assessment of the stress history of the in-situ materials and the viscosity of the material:

$$LI = \frac{w - PL}{LL - PL} = \frac{w - PL}{PI}$$

Soil boring samples where the moisture content is greater than the LL are likely to be under-consolidated soils and more prone to flowing like a fluid (Das and Sobhan, 2019). The top ten (10) feet of Lake Lery soil borings BA-2 and BA-3 mainly consist of organic clays (OH) (**Figure 42**) with low unit weight and water contents that exceed the LL. The average LI of BA-2 and BA-3 within the upper ten (10) feet is 1.96. This indicates that the material in the top ten (10) feet will behave more like a fluid than solid material. The opposite is true for soil borings BA-1 and BA-4, which have moisture contents less than the LL in the upper ten (10) feet of soil. Soil borings BA-1 and BA-4 consist of a mixture of organic clay (OH) and fat clay (CH) (**Figure 42**). The average LI in the upper ten (10) feet of soil borings BA-1 and BA-4 is 0.80.

BS-43 Borrow Area Borings

Elevation	BA-1	BA-2	BA-3	BA-4
-1	-	-	-	-
-2	-	-	-	-
-3	-	-	-	CH
-4	-	OH	OH	CH
-5	OH	OH	CL	CH
-6	OH	OH	OH	CH
-7	OH	OH	OH	CH
-8	OH	OH	OH	CH
-9	OH	OH	OH	CH
-10	CH	OH	OH	OH
-11	CH	OH	OH	OH
-12	CH	OH	OH	OH
-13	CH	OH	OH	OH
-14	CH	OH	OH	SP
-15	CH	OH	CH	OH
-16	CH	OH	CH	OH
-17	CH	CH	CL	OH
-18	CH	CH	CL	SP
-19	CH	CH	CH	CH
-20	CH	CH	CL	CH
-21	OH	CH	CH	OH
-22	CH	CH	CH	CL
-23	CH	CH	CL	-
-24	CH	-	-	-
-25	-	-	-	-

Legend	
OH	Organic Clay
CH	Fat Clay
CL	Lean Clay
SP	Poorly Graded Sand

Figure 42: Borrow Area Boring Log Classifications with Depth and Boring Locations within the Borrow Area

The center of the proposed MCBA is located approximately seven (6.95) miles from the furthest point in the fill area. ArcGIS ArcMap was used to calculate the volume of available material in the proposed MCBA. A dredge cut depth of ten (10) feet was analyzed for the

MCBA during the 30% design phase, which results in a total of 3,978,884 CY of available material. Using a dredge cut depth of fifteen (15) feet results in an increase of available material to 5,786,376 CY. The available volume of material within the proposed MCBA and the optimized MCBA, not including the no-dredge buffer zones, is shown in **Table 28**. **Table 29** shows a breakdown of available material in the primary borrow area and secondary borrow area using a fifteen (15) ft. cut depth. The difference in estimated area (acres) required to be dredged for this project using a ten (10) ft. dredge cut depth and a fifteen (15) ft. dredge cut depth is shown in **Table 30**. A typical section of the proposed MCBA is shown in **Figure 43** and in the 95% Design Drawings (**Appendix G**).

Table 28: Optimized MCBA Acreages and Available Volume

Borrow Area Design	**Area** (acres)	**Available Volume** (CY) **- 10 ft. Dredge Cut Depth**	**Available Volume** (CY) **– 15 ft. Dredge Cut Depth**
Total Area (excluding avoidance areas):	239	3,914,168	5,786,376
30% Design Borrow Area:	209	3,335,399	5,061,471

Table 29: Primary and Secondary Borrow Area volumes using a fifteen (15) ft. dredge cut depth

95% Design Borrow Area	**Size** (acres)		**Volume** (CY)	
	Limit of Borrow	**Limit of Pay**	**Limit of Borrow**	**Limit of Pay**
Primary	111	99	2,688,085	2,388,663
Secondary	128	110	3,098,291	2,672,808
Total:	**239**	**209**	**5,786,376**	**5,061,471**

Table 30: Required size in borrow area using a ten (10) ft. dredge cut depth and fifteen (15) ft. dredge cut depth

Borrow Area	**Dredge Cut Depth** (ft.)	**Optimized Area Required** (acres)	**Optimized Area Remaining** (acres)	**Percent Used**	**Percent Remaining**
30% Design	10	167	41	80%	20%
95% Design	15	110	98	53%	47%

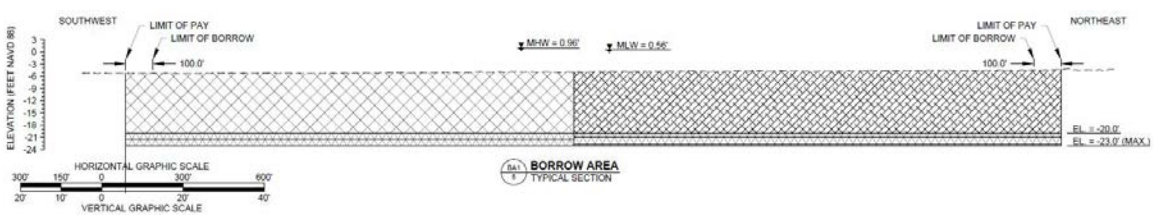


Figure 43: Typical section of the proposed MCBA

6.4 Dredge Pipeline Corridor Design

The optimum DPC to reach the MCAs is typically the shortest distance from the MCBA to the restoration area. The designated DPC analyzed for this project is shown in **Figure 44**. The DPC exits Lake Lery on the east side and travels north, then turns east towards Howard's Ditch. The DPC utilizes the southern canal of Howard's Ditch until it reaches Bayou Terre aux Boeufs (BTAB) where it then travels up-bayou. The DPC follows BTAB until it reaches Reggio Canal, where the DPC turns east and passes underneath a bridge to cross Hwy. 300. Once the dredge pipe passes underneath the Hwy. 300 bridge, the DPC follows Reggio Canal for approximately 750 feet until it crosses over existing marsh. Protective measures, such as timber mats, will be required for the approximate three hundred twenty (320) ft. distance the dredge pipeline will traverse across existing marsh, until it enters an existing water body connected to the western boundary of MCA-3. From there, it travels north through Schooner Canal until it reaches the farthest point of the fill area, the northern boundary of MCA-1. The total length of the DPC is approximately 36,690 linear feet, or 6.95 miles, as shown in **Figure 44** and **Table 31**.

Due to the long pumping distance from the proposed MCBA to the MCAs, booster pumps will be required for conveyance of dredged slurry from the MCBA to the MCAs. The proposed DPC will consist of mostly subline from the MCBA through BTAB, except where crossing the four (4) pipelines located in Lake Lery. As mentioned previously, water depths, when measured from MLW, in Lake Lery are generally four to six (4-6) ft. Water depths in the southern canal of Howard's Ditch are generally three to five (3-5) ft. The water depths along the centerline in BTAB is between three and four (3-4) feet until the intersection with the northern canal of Howard's Ditch. From there, the water depth in BTAB increases to an average of seven (7) feet. The DPC portion in Reggio Canal has an average water depth of six (6) ft.

There are three (3) proposed navigational crossings throughout the DPC that will be constructed by the Contractor in the Work Plan to provide safe, uninterrupted access to BTAB for boat traffic throughout construction. The first proposed navigation crossing occurs at the southern Howard's Ditch canal intersection with BTAB. The second navigation crossing will occur at the northern Howard's Ditch Canal where it intersects with BTAB. The third proposed navigation crossing will occur at the intersection of BTAB and Reggio Canal. The pre-construction depth of BTAB must be maintained at each navigation crossing location. All navigation crossings will be marked with warning signs per United States Coast Guard (USCG) standards, and the Contractor will be required to keep active and current notices to mariners, as required by the USCG, for the duration of dredging activities.

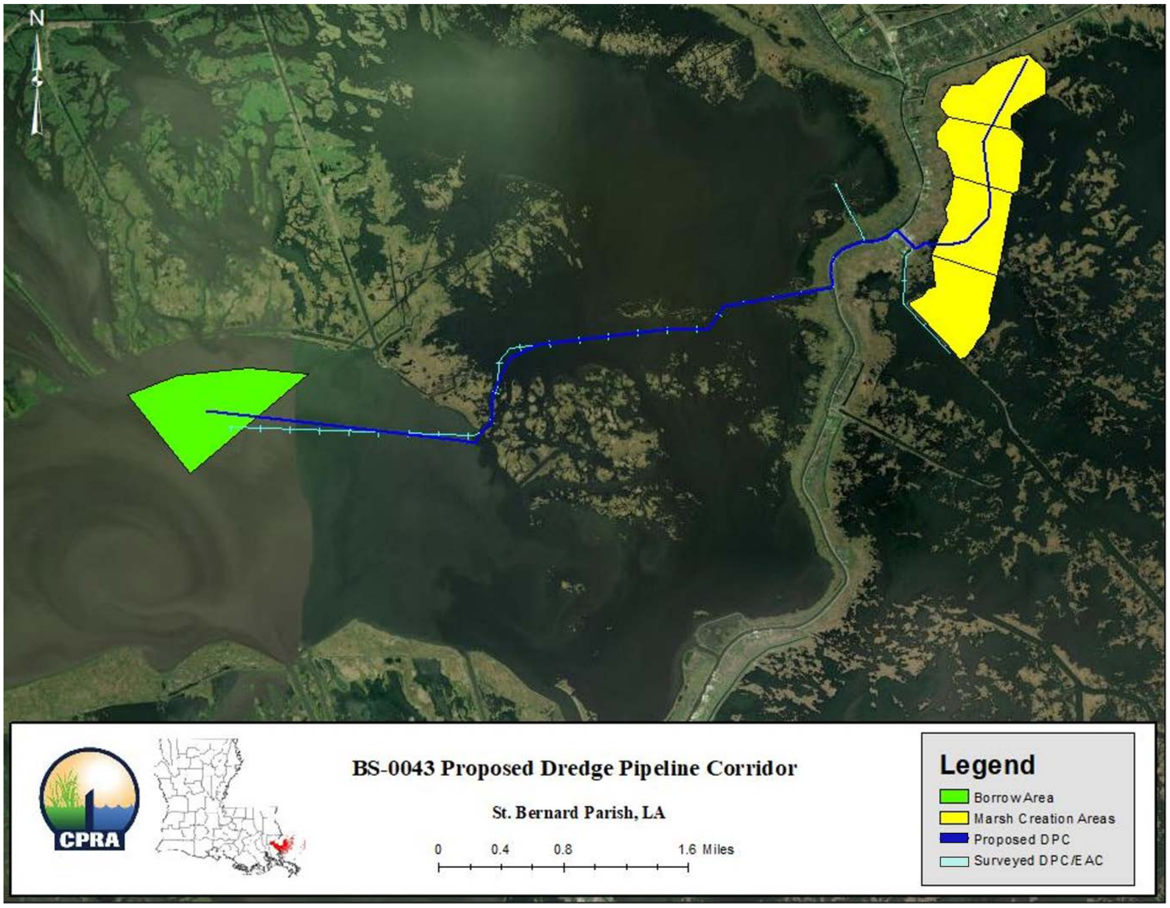


Figure 44: Proposed Dredge Pipeline Corridor

Immediately adjacent to navigation crossing #3, the dredge pipeline must pass under the Hwy. 300 bridge. The Project Team conducted initial coordination with DOTD District 2, the responsible DOTD District for the Hwy. 300 bridge, to determine the feasibility of crossing underneath the Hwy. 300 bridge with the dredge pipeline. The dredge pipeline will be placed and anchored on the existing mudline underneath the Hwy. 300 bridge, between support bents, without contacting the bridge or its support structure. Because the dredge pipeline and any associated equipment will not be attached to the bridge at any point during construction, it is anticipated that a standard DOTD Project Permit will be required to allow the dredge pipeline to temporarily cross underneath the bridge. From the initial coordination with DOTD District 2, it is not anticipated that the Hwy. 300 bridge crossing will require any additional or specialized permits aside from the standard DOTD Project Permit, which is required to cross/work on existing DOTD Right of Way. When Phase II funding is received for the BS-0043 project, CPRA will continue coordination with DOTD to finalize the dredge pipeline bridge crossing and apply for the Project Permit at that time.

While the dredge pipeline is in operation the southern canal of Howard's Ditch will be closed to navigation to prevent interruption with the dredge pipeline. To account for the navigation into and out of BTAB, the northern canal of Howard's Ditch will remain open to the public for recreational use. The proposed navigational crossings are shown in **Figure 45**, along with the southern Howard's Ditch canal that will be closed to navigation while the dredge pipeline is in operation. DPC types and distances from the proposed MCBA to each MCA are summarized in **Table 31**. Maps of all navigational crossings along with bathymetric data and cross sections are provided in the Plan Sets in **Appendix G**.

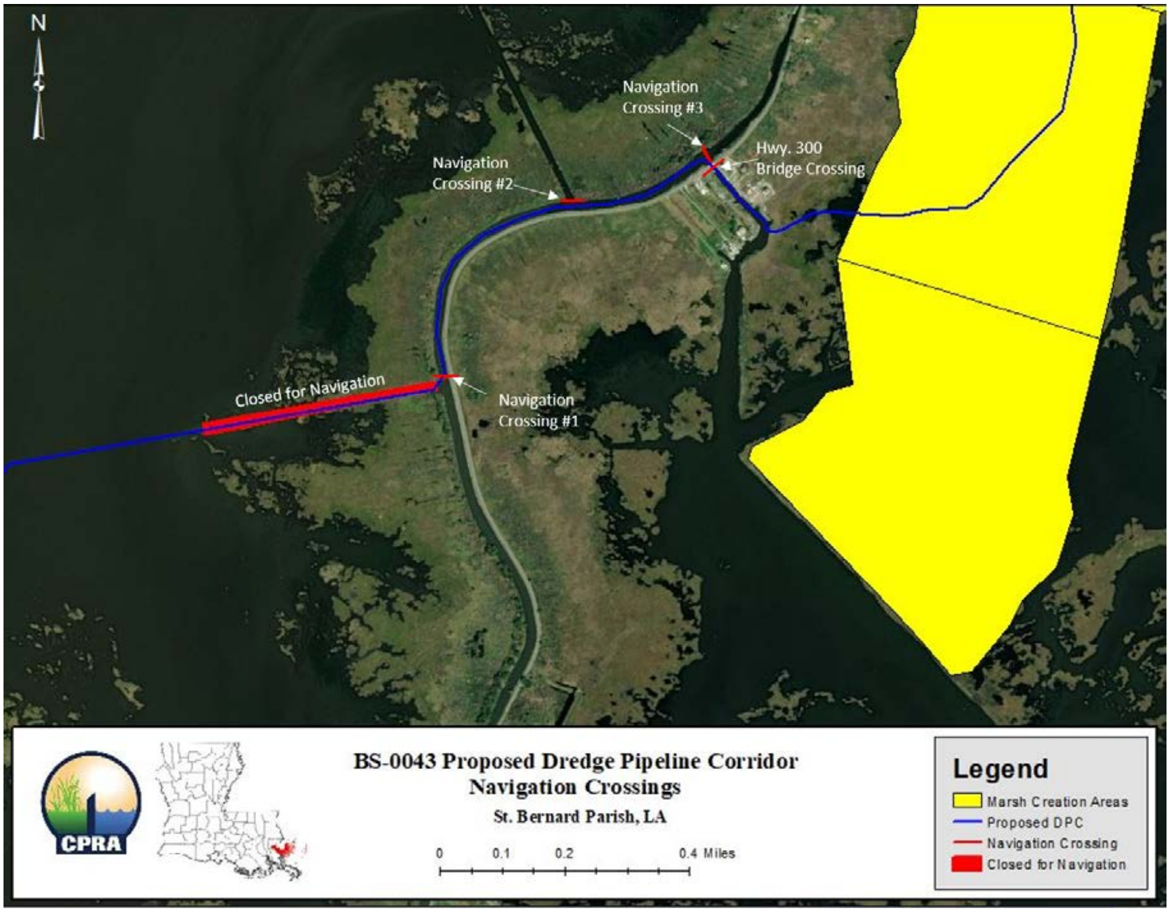


Figure **45**: Dredge Pipeline Corridor Proposed Navigation Crossings

Table 31: Dredge Pipeline Corridor Lengths

Type	LF	Miles
Distance from Center of BA to MCA-1 (Furthest Point)	36,690	6.95
Distance from Center of BA to MCA-2 (Furthest Point)	34,643	6.56
Distance from Center of BA to MCA-3 (Furthest Point)	31,888	6.00
Distance from Center of BA to MCA-4 (Furthest Point)	32,733	6.20
Average Pump Distance	33,989	6.43
Type	**LF**	**Miles**
Floated Pipeline	650	0.12
Submerged Pipeline	35,725	6.77
Existing Marsh Protective Measures	320	0.06

7.0 CONSTRUCTION

7.1 Equipment Mobilization

It is anticipated that the project will be constructed using an eighteen (18) to twenty-four (24) inch Cutterhead Suction Dredge (CSD) due to the shallow nature of Lake Lery, which has an average water depth of five (5) feet. For construction duration estimate purposes, an eighteen (18) inch CSD with an assumed production rate of 10,000 cubic yards per day was utilized, along with six (6) marsh buggies for initial ECD construction, with two (2) marsh buggies remaining for construction duration for ECD maintenance and dredge pipe outfall management. It is anticipated that given the nearly seven (6.95) mile pumping distance to reach the northern boundary of MCA-1, the Contractor will install a series of Booster Pumps throughout the DPC. To provide flexibility to the Contractor, the entire Equipment Access Corridor (EAC) and Dredge Pipeline Corridor (DPC) will be permitted for booster pump installation, excluding near existing infrastructure or the existing camps. Booster Pumps shall remain floating at all times. However, it will ultimately be up to the Contractor and the selected dredge equipment to propose the location(s) along the DPC to install booster pumps in the work plan and approved by the Engineer.

Soft terrain vehicles or marsh buggies will be required to construct containment dikes and manage the marsh fill throughout the fill area. Long and short reach amphibious marsh excavators can be barged in and offloaded within the equipment access corridor to reach to project site. Spill boxes, sections of High Density Polyethylene (HDPE) pipe, and steel pipe can be floated through the equipment access corridor to reach the project site.

7.2 Marsh Fill Placement

After the completion of Earthen Containment Dikes (ECDs), marsh fill can be delivered to the project area via the dredge pipeline. The contractor will be required as part of the Work Plan to provide the layout and schedule for dredged material placement into the Marsh Creation Areas (MCAs). Based on the estimated hydraulic dredge production rate, a dredging duration of at least two hundred six (206) days is expected. The quantity required for the fill area, as shown on the plans, must be placed and spread out uniformly in each MCA.

7.3 Duration

A construction duration estimate was developed assuming six (6) marsh buggies and an eighteen (18) inch hydraulic Cutterhead Suction Dredge (CSD) with a production rate of 10,000 CY/day, would be mobilized to the project area. The total construction duration, incorporating weather days, is approximately five hundred fifty-four (554) calendar days (**Table 32**). A breakdown of the construction duration are provided in **Table 32**.

Table 32: Construction Duration Estimate without Canal Plugs

Task	Duration (days)
Pre-Construction Survey and Mobilization (includes laying dredge pipe)	96
Containment Feature Construction (includes dress-up and survey)	105
Hydraulic Dredging (includes dredge wait time)	206
As-Built Survey	45
Demobilization (includes pick up dredge pipe)	28
Weather Days	74
Total (no task overlap)	**554**

7.4 Construction Cost Estimate

An Engineer's Estimate of Probable Construction Cost was prepared for this project using recent project bid data, and the guidance provided in MCDG1.0, Appendix E. The estimated construction cost is available as a government cost estimate retained by the EPA. The current construction cost estimate is 41.0% higher than the Phase 0 cost estimate. A scope change is required because the current cost estimates exceed the 25% threshold. The total MCA footprint is 7.23% larger than the Phase 0 MCA footprint, which is within the 25% threshold and does not require a scope change. Removal of Canal Plugs as official project features will also be included in the scope change.

7.5 Risk

Engineering Design Documents, Plans and Specifications were prepared by or under the direct supervision of a licensed professional engineer and registered in the state of Louisiana following professional engineering standards as per La. R.S. Title 37, and Louisiana Administrative Code Title 46, Part LXI, Professional and Occupational Standards, as governed by the Louisiana Professional Engineering and Land Surveying Board. The engineering analyses effort completed for this 95% design report provides guidance and insight pertaining to the construction of the proposed project features based on the data acquired to date and shall not be used for bidding. These documents are not to be used for construction, bidding, recordation, conveyance, sales, or as the basis for the issuance of a permit.

It is recommended that the contractor should adhere to the most current publication of "Recommended Best Practices Guide for Safe Dredging near Underwater Gas & Hazardous Liquid Pipelines", developed by the Council for Dredging and Marine Construction Safety, www.cdmcs.org, and the "Working Safely Near Underwater Pipelines" document, developed by the Coastal and Marine Operators Group (CAMO).

8.0 SUMMARY OF CHANGES TO THE PROJECT

8.1 Summary of Changes from Phase 0

As a result of Phase I activities, the features originally approved in Phase 0 were modified during the design phase to present a more constructible and cost effective project for construction funding consideration. The project team met with local community stakeholders in July 2023 to gage interest in the project and hear feedback. The local stakeholders and residents of Reggio were given a brief overview of the project design as it stood at that point in time. Throughout the meeting, local stakeholders expressed their opinions on the design of the project, including the canal plugs and the marsh fill area footprint. The majority of the stakeholders present were displeased with the shift of the western boundary of the fill area from its original Phase 0 design to the 30% design layout. They expressed concerns over flooding and inundation between their back yards and the western Earthen Containment Dike (ECD). A runoff analysis was conducted on the area west of the proposed ECD to determine that amount of runoff that would occur during a 10-year or 20-year storm. The project team then calculated the type and size of a drainage canal would be required to prevent inundation without scouring. It was determined that exterior borrow would not be constructible in the area due to a low factor of safety, thus deeming the drainage canal impractical. The project team decided to shift the western boundary of the ECD westward to incorporate all existing open water areas between the proposed marsh fill area and Hwy. 300, without modifying the other areas of the marsh creation area layout. This shifting of the western ECD added 40 acres of marsh to the fill area.

Major changes from the 30% design presented in June 2023 include an increase in the marsh fill area by 40 acres, the addition of a third ITD, and the removal of the proposed Canal Plugs from the project. **Figure 46** and **Table 33** detail additional changes between the 30% design and the current 95% design. **Table 34** and **Figure 47** summarize changes between the Phase 0 project and the current 95% design.

Table 33: Summary of Changes from 30% Design to 95% Design

Project Feature	30% Design	95% Design	Percent Change from 30% Design
Marsh Creation Areas	479 acres	519 acres	+8.35%
Earthen Containment Dike	25,669 LF	26,145 LF	+1.85%
Internal Training Dikes	3,860 LF (2)	6,562 LF (3)	+70.00%
Construction Cost Estimate Percent Change from Phase 0	+45.3%	+41.0%	-2.93%
Dredge Pipeline Corridor	7.70 miles	6.95 miles	-9.74%

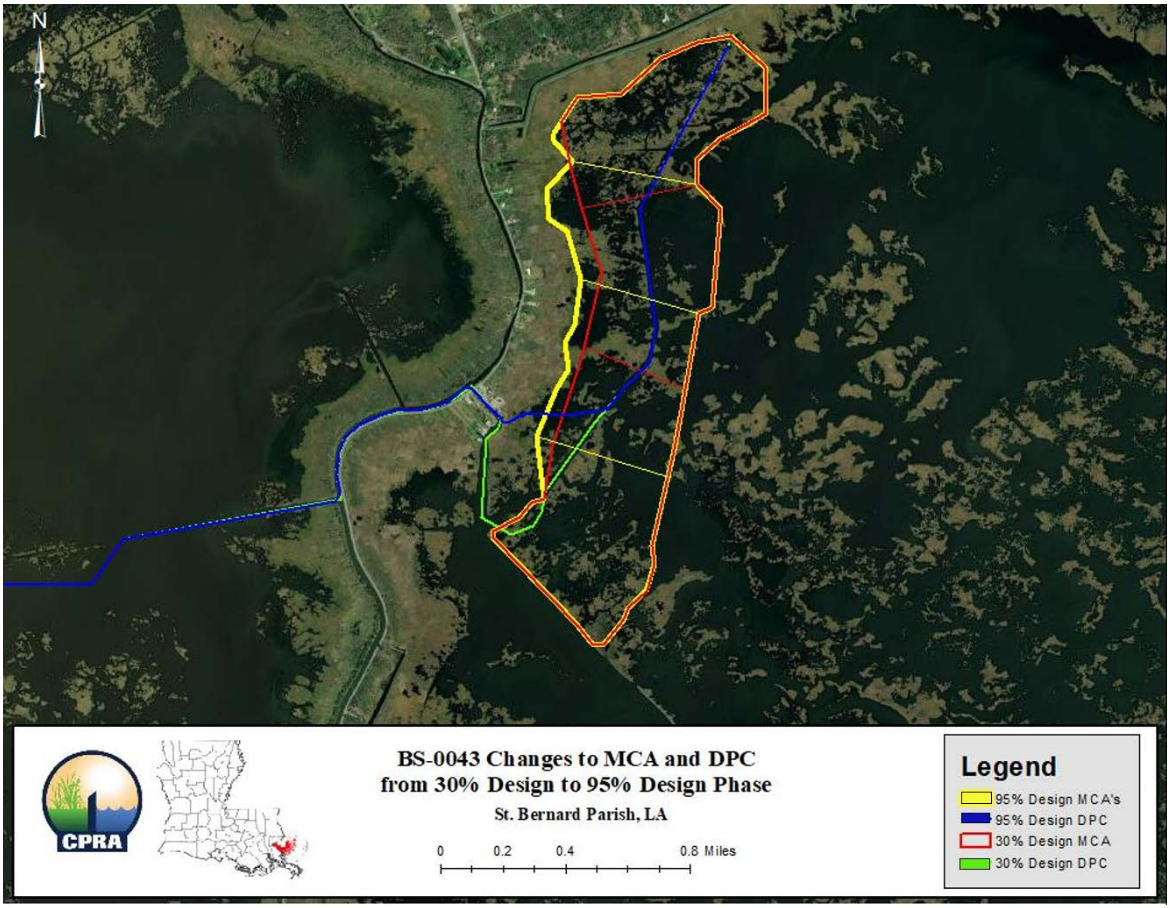


Figure **46**: Changes to the MCA and DPC from Phase 1: 30% Design Phase to 95% Design Phase

Table 34: Summary of Changes from Phase 0 Design to Phase 1 95% Design

Project Feature	Phase 0 Design	95% Design	Percent Change
Marsh Creation Areas	484 acres	519 acres	+7.23%
Earthen Containment Dike	22,646 LF	26,145 LF	+15.45%
Internal Training Dikes	0 LF	6,562 LF	N/A
Canal Plugs	2	0	N/A

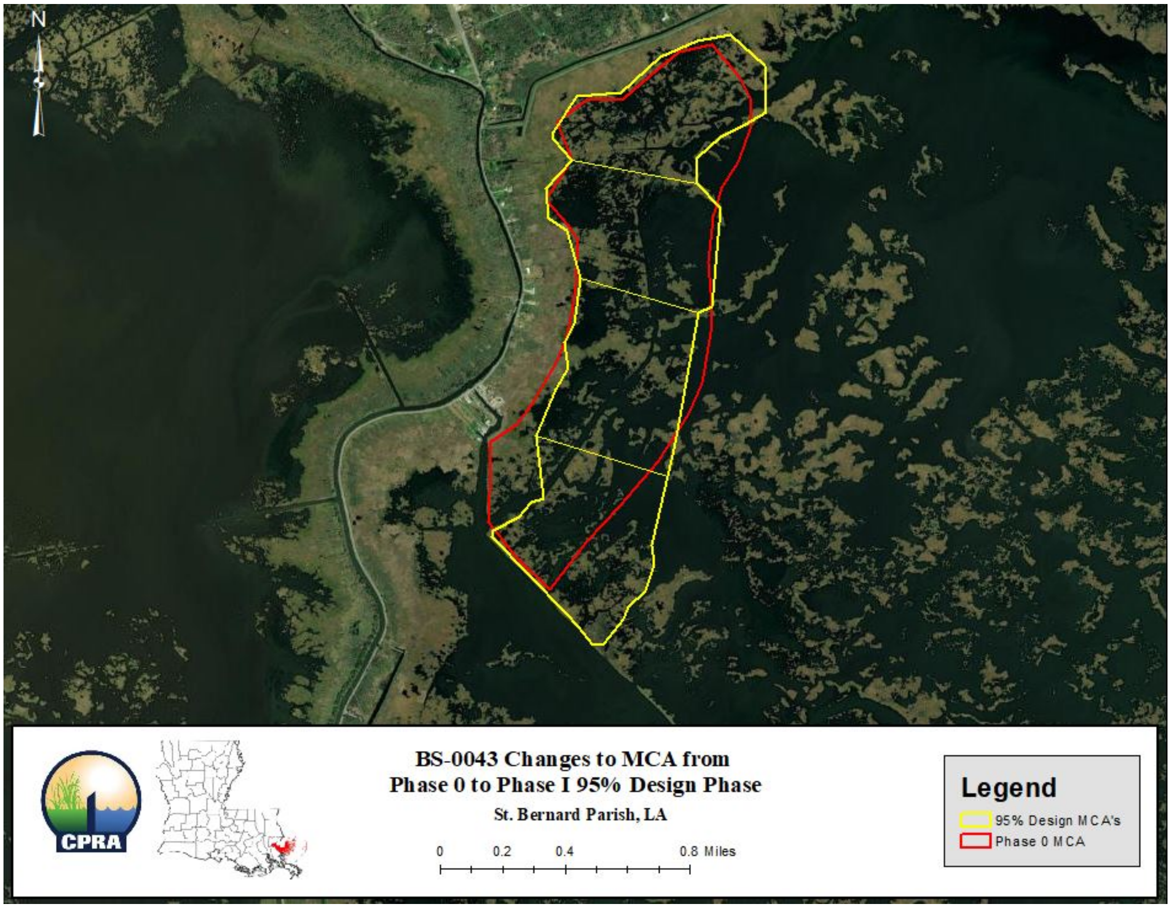


Figure 47: Changes to the Marsh Fill Area from Phase 0 Design to Phase 1: 95% Design Phase

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Appendix: Wetland Value Assessment (WVA)

Reggio Marsh Creation

Thirtieth Priority
Project List
of the
Coastal Wetlands Planning, Protection and Restoration Act

Revised Project Information Sheet for Wetland Value Assessment

Prepared by

U. S. Environmental Protection Agency

November 1, 2023

Project Name: Reggio Marsh Creation

Sponsoring Agency: U.S. Environmental Protection Agency
Primary Contact: Sharon Osowski, Ph.D. (EPA), (214) 665-7506, osowski.sharon@epa.gov

Project Location:
Region Two of the Breton Sound Basin in St. Bernard Parish, Louisiana. The community of Reggio, LA is located approximately twenty-one (21) miles southeast of New Orleans, in St. Bernard Parish.

Problem:
St. Bernard Parish may incur some of the highest wetland loss as a percentage of total parish land area over the next fifty (50) years of any coastal parish (CPRA, 2017). With no further coastal protection or restoration actions, the parish could lose an additional two hundred thirty-seven (237) square miles, or seventy-two percent (72%) of the parish land area over the next fifty (50) years (CPRA, 2017). In this area, coastal wetland loss can be attributed to both anthropogenic and natural factors, such as drilling and dredging for oil and gas, flooding marshes from sea-level rise, storm-driven erosion from Hurricanes Katrina (2005), Rita (2005), Isaac (2012) and Ida (2021), and subsidence.

Goals:
The Reggio Marsh Creation project area is bounded on the north by an existing tidal levee, on the south by the Reggio Canal, and on the west by the Reggio community, and will serve as an important buffer to protect this coastal community from storm surge. The goal of this project is to restore marsh habitat east of the community of Reggio by creating and nourishing an area to be tidal marshes during the twenty-year project life. The project will aid in stopping wetland loss and buffering future storm surge events for the long-term protection of the community of Reggio. Specific objectives are to 1) create 346 acres of emergent marsh, and 2) nourish 173 acres of emergent marsh, to the east of Reggio, LA. This project helps to further EPA CWPPRA Team goals by improving local community resilience, restoring wetland habitats and protecting critical infrastructure, and supporting stakeholder priorities in synergy with EPA's mission.

Proposed Project Features:
The project will create and nourish approximately 519 acres of intermediate marsh by hydraulically dredging sediment from Lake Lery. Marsh creation projects involve raising the marsh elevation with dredged sediment so that the marsh can support healthy marsh vegetation for the twenty-year project design life. The Marsh Creation Borrow Area is located approximately 7 miles southwest of the project footprint within Lake Lery. Temporary containment dikes will be constructed and gapped within three years of construction to allow greater tidal exchange and estuarine organism access. Restoration in this area would build the area's defenses against hurricanes and flooding. The average target constructed marsh fill elevation is +2.00 ft. NAVD88 envisioned to enhance longevity of this land form.

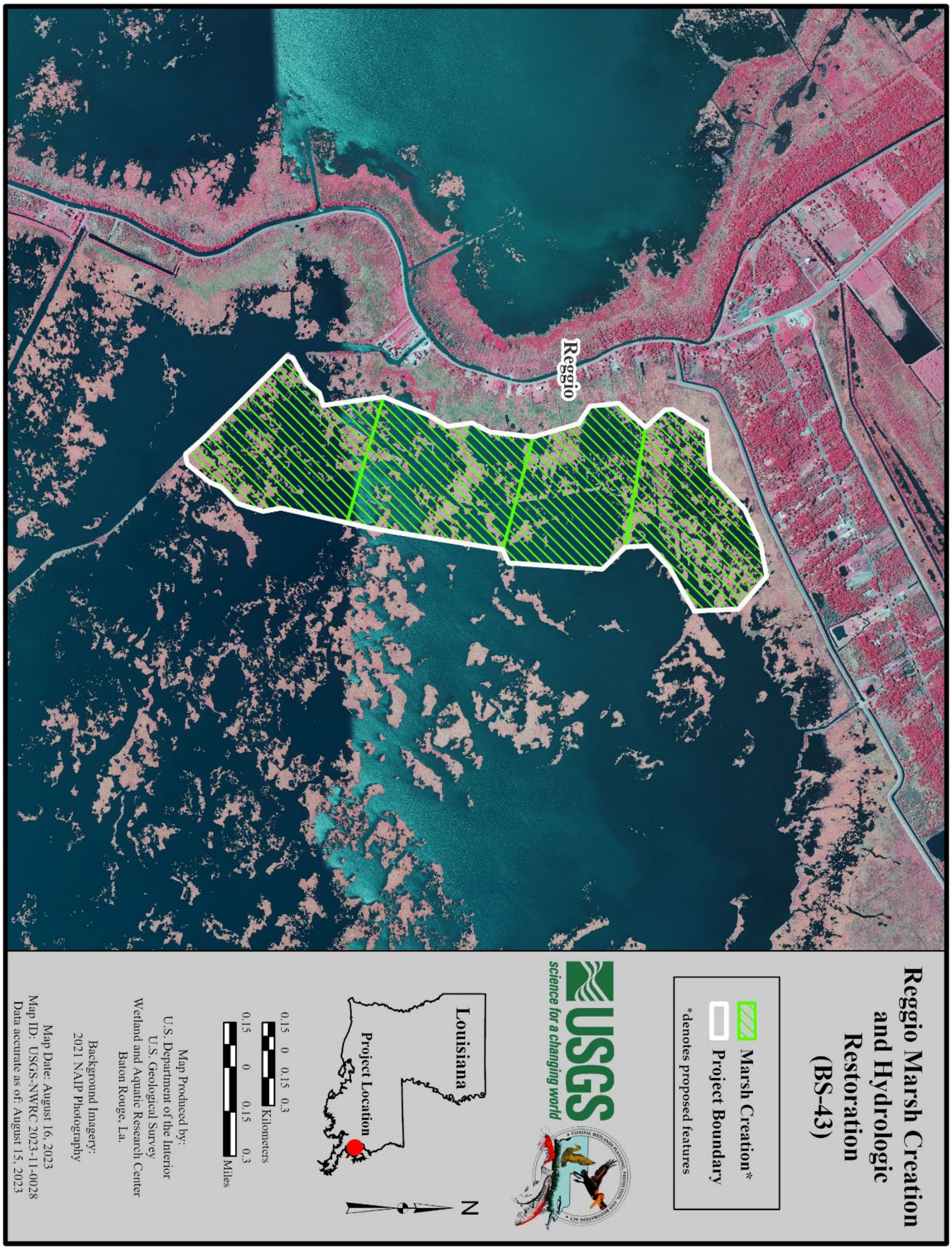

Figure 1. Project location

The proposed project features will help maintain the marshes adjacent to Reggio and will provide support for local infrastructure and communities. Infrastructure such as the Delacroix LA Hwy 300 will benefit from this project. The project would provide a synergistic effect with the E Delacroix Marsh Creation and Terracing (BS-37) and North Delacroix Marsh Creation and Terracing (BS-41) projects as well as other Breton Sound landbridge projects.

Historical and Present Vegetation Community and Hydrology:
CRMS Station 4355 (Figure 2) is approximately 4.5 mi west of the marsh creation polygon and is referred to here for hydrology, salinity, and vegetation comparisons. According to the CRMS 4355 marsh classification, the area has been consistently classified as fresh or intermediate marsh (Figure 3).

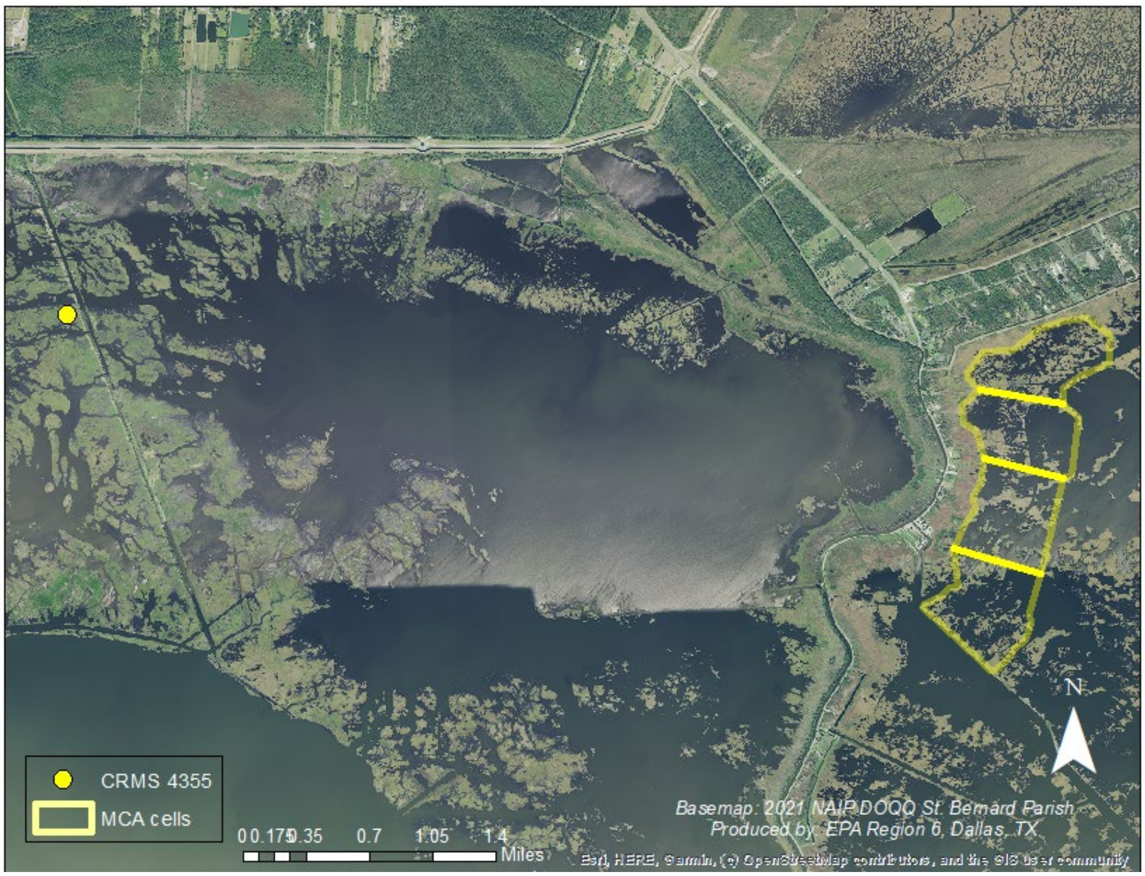

Figure 2. Project features and CRMS 4355 station.

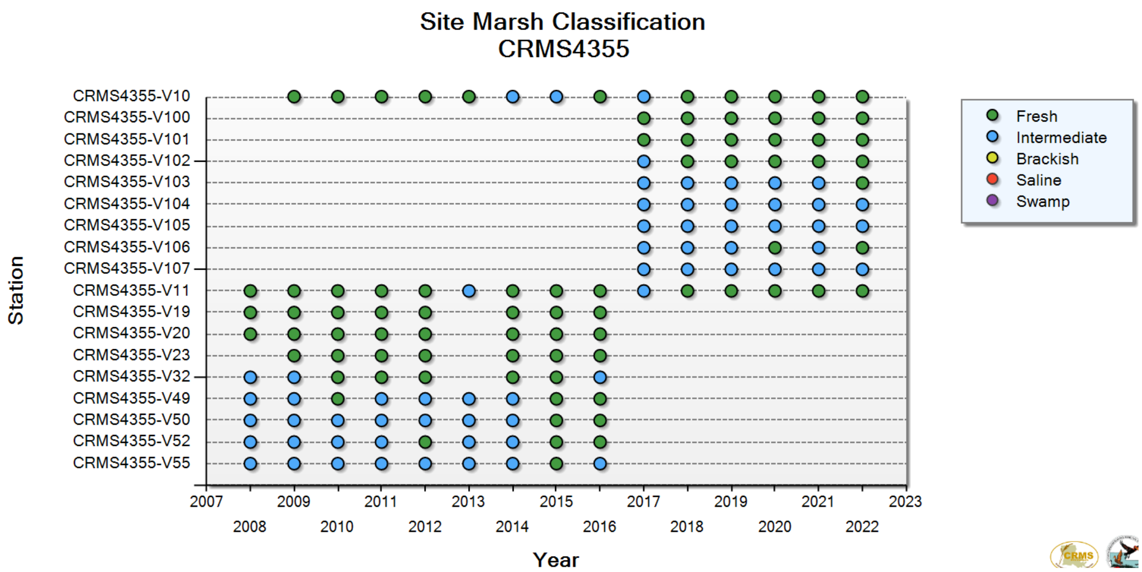

Figure 3. CRMS 4355 site marsh classification, 2007-2022.

Mean annual salinity for CRMS 4355 for the entire period of record (2009 - 2023) was 1.51 ppt while mean salinity during the growing season was 1.39 ppt (Figure 4). During the data collection field trip on June 30 June 2020, salinity measurements averaged 1.4 ppt. The average salinity for CRMS4355 on 30 June 2020 averages 1.294 ppt.

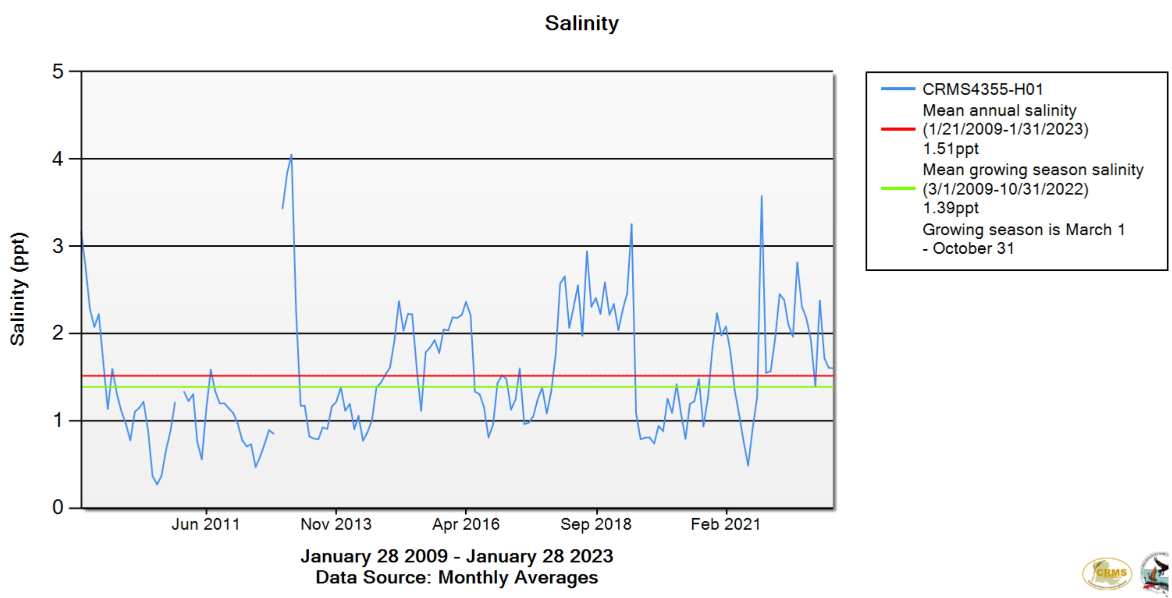

Figure 4. Salinity levels at CRMS 4355 for January 2009 through January 2023.

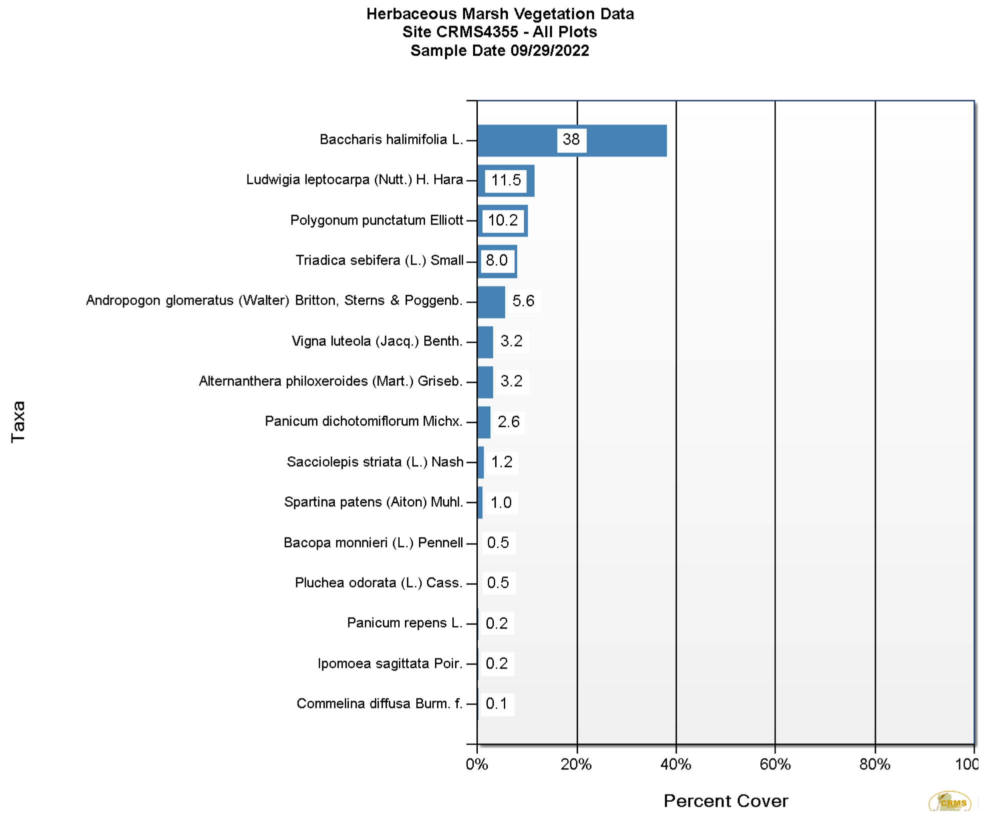

Figure 5. Herbaceous marsh vegetation cover for CRMS 4355, 29 September 2022

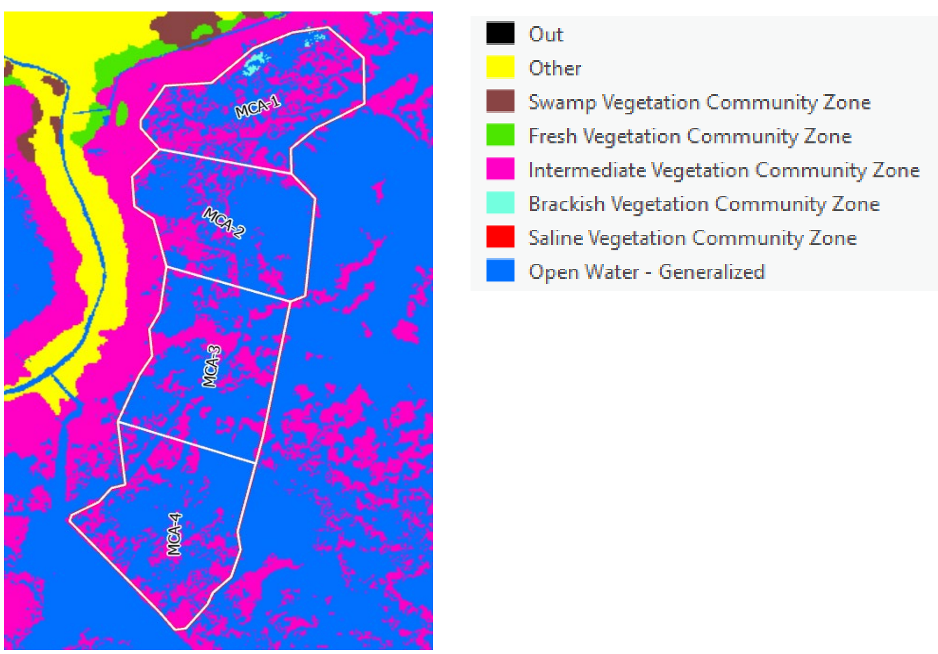

Figure 6. 2021 marsh type survey (Nyman et al. 2022). The Project is 34% Intermediate Marsh and 66% Water.

Herbaceous vegetation survey data from 29 September 2022 at CRMS 4355 (Figure 5) indicates *Baccharis halimifolia* may dominate the project area. Field observations during the data collection trip (30 June 2020) showed 40% Eurasian milfoil and widgeon grass as well as saltmarsh bulrush (*Bolboschoenus robustus*), *Schoenoplectus americanus*, marshay cordgrass *(Spartina patens*), *Ipomea sagittata*, and *Lythrum lineare.* Based on the salinity, vegetation, Sasser marsh type survey, the fresh/intermediate marsh WVA model is proposed for project evaluation.

Interior Land Loss Data:
For interior marsh loss, USGS evaluated land/water data within an extended boundary (Figure 7) surrounding the project area. Using a hyper-temporal analysis (1985-2023) for the extended boundary, USGS calculated the historical rate of land change -1.22%/yr or -30.56 acres/yr, a declining trend since 2015 (Figure 8).

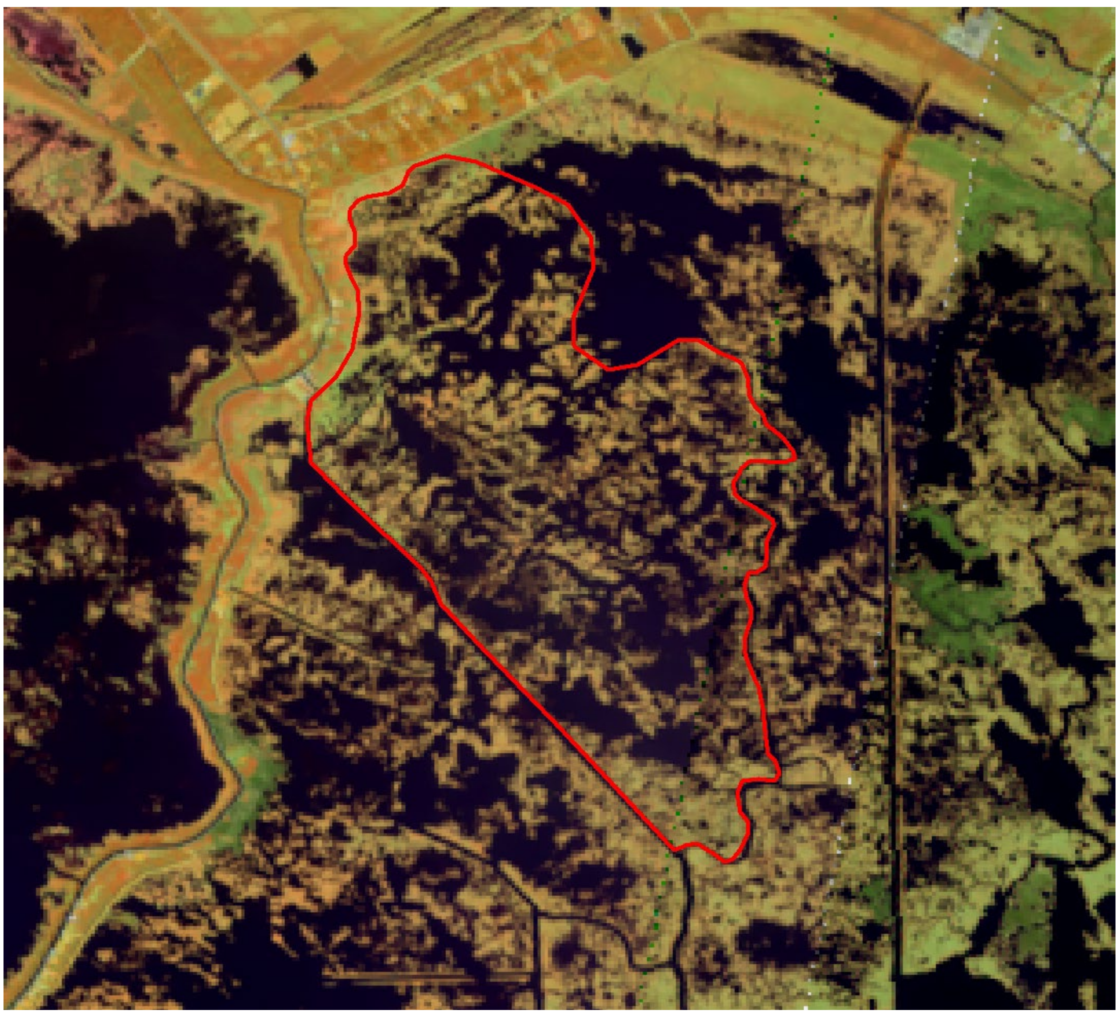

Figure 7. Extended boundary used for USGS land loss calculation (2016 Landsat Imagery; Bands 5, 2, 3).

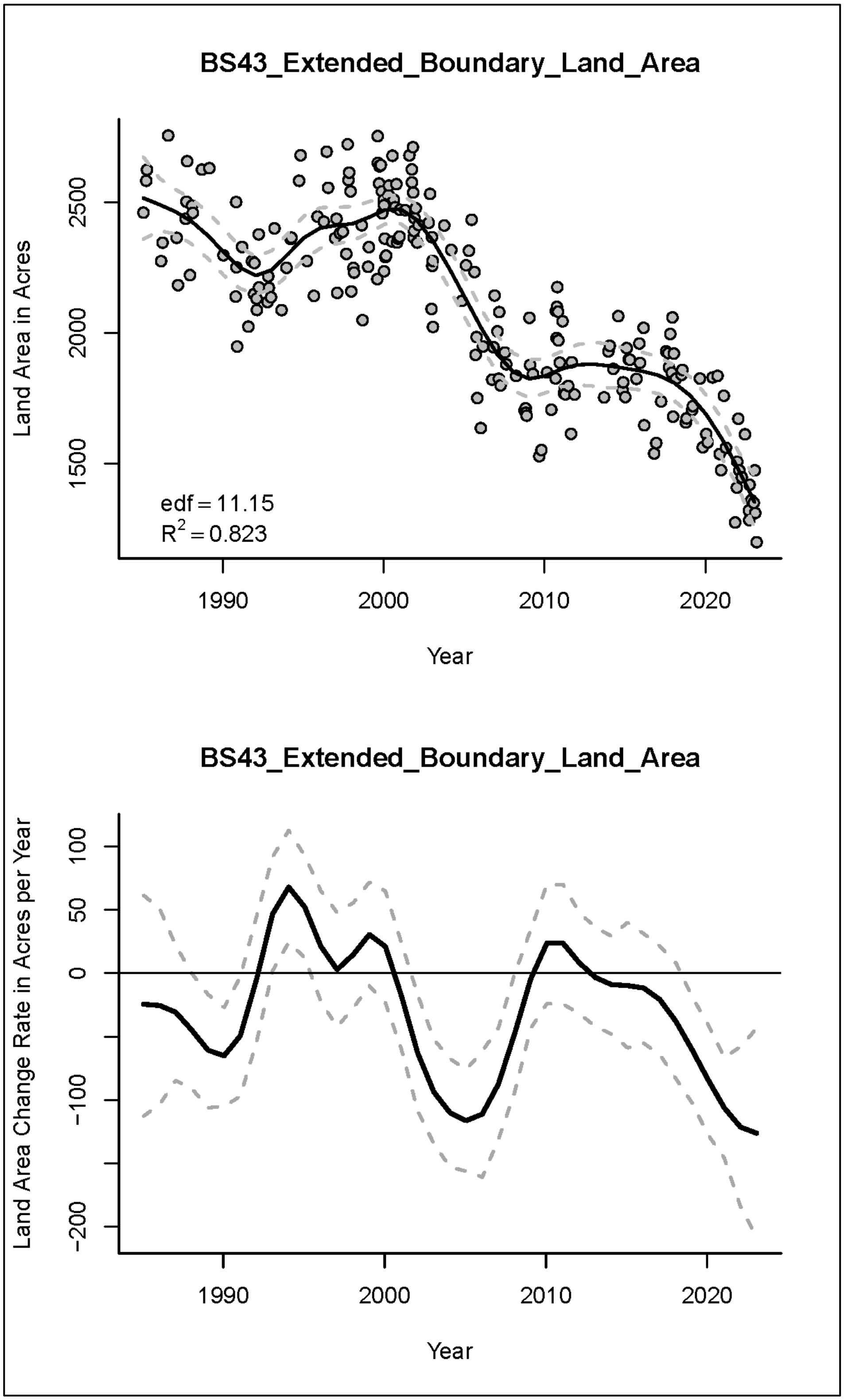

Figure 8. Change in project extended boundary area by acres and acres per year.

V1: % of Wetland Area Covered by Emergent Vegetation

FWOP

Five years of loss was applied to the land acreage from the USGS analysis of 2021 NAIP DOQQ photoimagery data to calculate the TY0 project acreage for 2023 (Appendix A). Land loss rates within the project area show a negative trend; hyper-temporal analysis for the extended project boundary shows a land loss rate of -1.22% per year (1985 to 2023) in the project area according to the experimental land loss analysis (Figure 8). V1 land loss spreadsheet is located in the BS43_WVA_supportinginformation XL file.

FWOP	Marsh Acres	Water Acres	V1
TY0	173	346	33%
TY1	171	348	33%
TY20	135	384	26%

FWP

We are not proposing any plantings or tidal creeks/ponds for this project.

FWP	Marsh Acres	Water Acres	V1
TY1	120	3	23%
TY3	272	9	52%
TY5	503	16	97%
TY20	459	60	88%

Net acres at TY20 = 324 acres

Settlement curves (Figure 9) show the changes in elevation over the 20-year design life of the project and were used to compare different construction marsh fill elevations. The average target constructed marsh fill elevation is +2.00 ft. NAVD88. Based on water level for the last 5 years (27 June 2017 to 27 June 2022) from CRMS 4355, the 5% inundation +1.83 ft. NAVD88. The average target constructed marsh fill elevation is +2.00 ft. (NAVD88) which is above the 5% inundation elevation; however, the constructed marsh elevation settles below the 5% inundation level within 6 months of construction (Figure 9). Over the 20-year project life, the preferred inundation range is expected to rise from -0.01 ft. (TY0 90% inundated) to 0.595ft (TY20 90% inundated) and 1.55ft (TY0 10% inundated) to 2.155ft (TY20 10% inundated) (All NAVD88 12B).

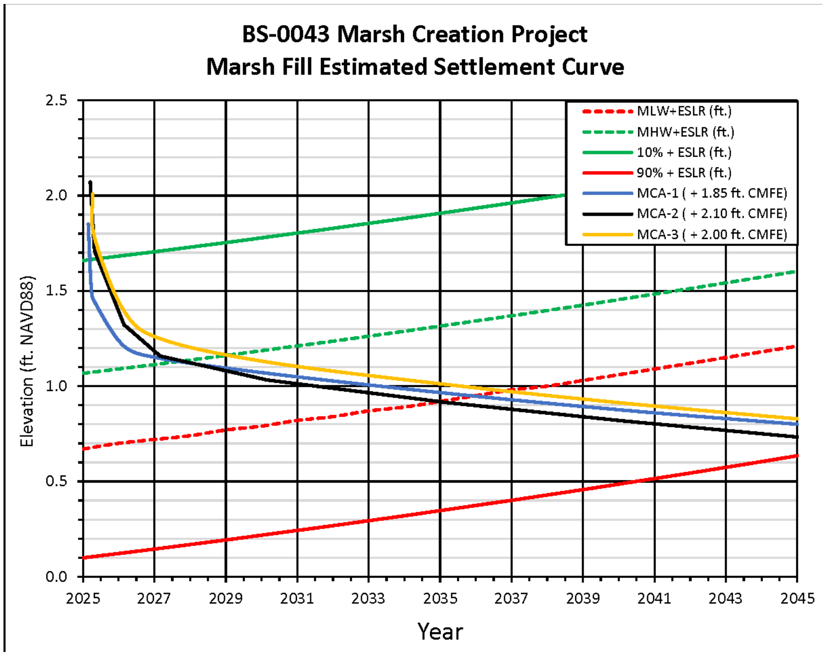

Figure 9. Estimated Total Settlement Curve.

V2: % Open Water Covered by Submerged Aquatic Vegetation (SAV)

Data were collected on a field trip on 30 June 2020. SAV were present in the open water areas of the site. While some areas had up to 100% cover, other areas had 0% cover and the average SAV cover was 39%. We propose an overall SAV coverage of 39% for the entire project area for all target years in FWOP, based on observations from the 2020 data collection field trip. This value represents the average of all SAV cover observations.

FWOP	V2
TY0-TY20	39%

For FWP, we expect that no SAVs would be present in the area post-construction at TY01. At TY03, we assume the newly created and nourish marsh area will be more conducive to shallow water SAV growth, and therefore, propose 45% SAV cover at this target year. SAV communities are predicted to expand in subsequent target years, increasing to 90% cover for TY05-TY20.

FWP	V2
TY1	0%
TY3	45%
TY5	90%
TY20	90%

V3: Marsh Edge and Interspersion

For FWOP, USGS land/water analysis indicates the project area is an Interspersion Class 4.

FWOP	Class	V3
TY0-TY20	4	100%

Standard workgroup convention for marsh creation was used at FWP target years. We assume that the marsh will be classified as Class 3 at TY3-TY05 and as Class 1 for TY7-TY20.

FWP	Class	V3
TY1	5	100%
TY3	3	100%
TY5	1	100%
TY20	1	100%

V4: % of the Open Water Area <= 1.5 ft Deep

Survey data collected from March 3, 2022 – April 28, 2022, was used to calculate V4 (Appendix B). For TY0, 2,005 of the 15,052 (20%) survey measurements can be considered as shallow open water (SOW). Therefore, a value of 20% is proposed. MHW, MLW, and MTL information below from CRMS 4355. V4 calculation is located in the BS43_WVA_ supporting information XL file.

MHW = +0.96 ft., NAVD88 (GEOID12B)
MLW = +0.56 ft., NAVD88 (GEOID12B)
MTL = +0.76 ft., NAVD88 (GEOID12B)

For TY0, the lower limit of shallow open water is calculated as +0.76ft - 1.5 ft. depth = -0.74 ft. All points with an elevation lower than -0.74 ft. are classified as deep open water (DOW). Survey points greater than 0.059ft NAVD88 are considered to be emergent marsh. Therefore, all points between +0.059ft and -0.74 ft are identified as SOW (shallow open water). TY20 bottom elevations are estimated by applying 20 years of subsidence (0.256 ft) to all TY0 elevations. ESLR is located in Appendix H of 95% report (ACRE 2019). Local subsidence rates in this region are approximately 3.9 mm per year (-0.154 in/yr.). This equates to a decrease in the project area elevation of 3.08 in. (0.256 ft.) over the 20-year project design life. To calculate V4 estimates for TY20, 0.256ft of subsidence was added to the surveyed elevations, with results showing 1,832 of 15,052 (18%) survey measurements being shallow open water.

TARGET YEAR 0

MTL	0.76	ft NAVD88
V4 lower limit	-0.74	ft NAVD88
Marsh lower limit	0.059	ft NAVD88
Total Pts	15052	
Deep Open Water	7844	
Shallow Open Water	2005	
Marsh	5203	
% OW ≤ 1.5' deep	**20%**	

TARGET YEAR 20

MTL	0.76	ft NAVD88
V4 lower limit	-0.74	ft NAVD88
Marsh lower limit	0.595	ft NAVD88
Subsidence rate (20 yrs)	0.256	ft
Total Pts	15052	
Deep Open Water	8501	
Shallow Open Water	1832	
Marsh	4719	
% OW ≤ 1.5' deep	**18%**	

FWOP	V4
TY0 TY1 TY20	20% 20% 18%

For future projections of shallow open water within the project area, the formation of open water habitat ≤ 1.5ft was considered. Subsidence was applied to the open water areas to estimate the change in shallow open water over the project life.

Convention is that all open water is assumed to be less than 1.5 ft deep at TY1 through TY5. For TY20, it is estimated that 80% of the open water would remain shallow due to the formation of some open water areas greater than 1.5 feet deep.

FWP	V4
TY1 TY3 TY5 TY20	100% 100% 100% 80%

V5: Salinity

Mean growing season salinity for the full period of record (21 January 2009 –31 January 2023) at CRMS 4355 measured from monthly averages was 1.39 ppt. On the data collection field trip on 30 June 2020, salinity was measured as 1.1-1.9 ppt (average 1.4 ppt). Salinity is not predicted to change throughout the project life in FWOP or FWP scenarios.

FWOP and FWP	V5
TY0-TY20	1.39

V6: Aquatic Organism Access

We assume that aquatic organism access would not change under FWOP over the 20-year life. The project area and surrounding area is open with many avenues for aquatic organism access.

FWOP	V6
TY0-TY20	1

For FWP, an access value of 0.0001 will be assumed at TY1 since the marsh platform will be impounded by containment dikes. These will be degraded in TY3, and an access value of 1.0 will be assumed at this target year and all subsequent target years.

FWP	V6
TY1 TY3-TY20	0.0001 1.0

LITERATURE CITED

Applied Coastal Research and Engineering (ACRE), 2019. Determining Recent Subsidence Rates for Breton Sound and Eastern Pontchartrain Basins, Louisiana: Implications for Engineering and Design of Coastal Restoration Projects. Final Report prepared for Louisiana Coastal Protection and Restoration Authority. Contract 4400009020, Task 8, 58 p.

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