Bayou Decade Marsh Creation and Ridge Restoration Project

TE-0138

Coastal Wetland Planning, Protection, and Restoration Act PPL 26

Preliminary (30%) Design Report

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1.0 INTRODUCTION

1.1 Authority

The Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) is federal legislation enacted in 1990 to plan, design, and construct coastal wetlands restoration projects. The legislation (Public Law 101-646, Title III CWPPRA) was approved by the U.S. Congress and signed into law by former President George H. W. Bush.

The Bayou Decade Ridge Restoration and Marsh Creation Project (herein referred to as TE-0138) was selected as part of the CWPPRA 26th Priority Project List and funded for Engineering and Design with the National Oceanic and Atmospheric Administration's National Marine Fisheries Services (NOAA/NMFS) serving as the lead federal sponsor and the Louisiana Coastal Protection and Restoration Authority serving as the local sponsor and is also performing the engineering and design.

1.2 2017 Coastal Master Plan

The 2017 Coastal Master Plan for Louisiana identifies projects designed to build and maintain land, reduce flood risk to citizens and communities, and provide habitats to support ecosystems. The master plan consists of eight different project types, including ridge restoration and marsh creation. Master Plan Project Number 03a.MC.101 includes the creation of 12,100 acres of marsh between Lake Decade and Lake Mechant to restore wetland habitat and degraded marsh. TE-0138 is located within the footprint of this project and is considered to be consistent with the plan.

1.3 Project Setting

The TE-0138 project is located in the Lake Mechant Sub-basin of the Terrebonne deltaic complex in the south-central portion of the Mississippi River Delta Plain. The Lake Mechant basin is located in the over-lapping portions of the Teche and Lafourche delta complexes and was formed approximately 3,000 to 4,000 years before present. The project area experiences high rates of subsidence as the Holocene deltaic sediments continue to compact at various depths. Additionally, the project area is no longer adequately nourished by the sediment and water of the Mississippi River. Subsidence rates in the region are estimated to be between 6 and 20 mm. Since 1932, the Terrebonne Basin has lost approximately 20 percent of its wetlands. Current loss rates range from approximately 4,500 to 6,500 acres per year. This rate amounts to the loss of 90,000 to 130,000 acres over the next 20 years.

1.4 Project Goals

The primary goals of TE-138 are to create 397 acres and nourish approximately 104 acres of intermediate marsh adjacent to Lake Decade and restore 11,726 linear feet of ridge habitat along the northern bank of Bayou Decade. Sediment for marsh creation will be hydraulically dredged from a borrow source located in Lake Decade and sediment for ridge restoration will be mechanically dredged from Bayou Decade.

1.5 Land Rights Assessment

The entire marsh creation fill area is located on property owned by Apache Louisiana Minerals, LLC (Figure 1). The borrow area, pipeline conveyance corridor and equipment access routes are located within State-owned water bottoms.

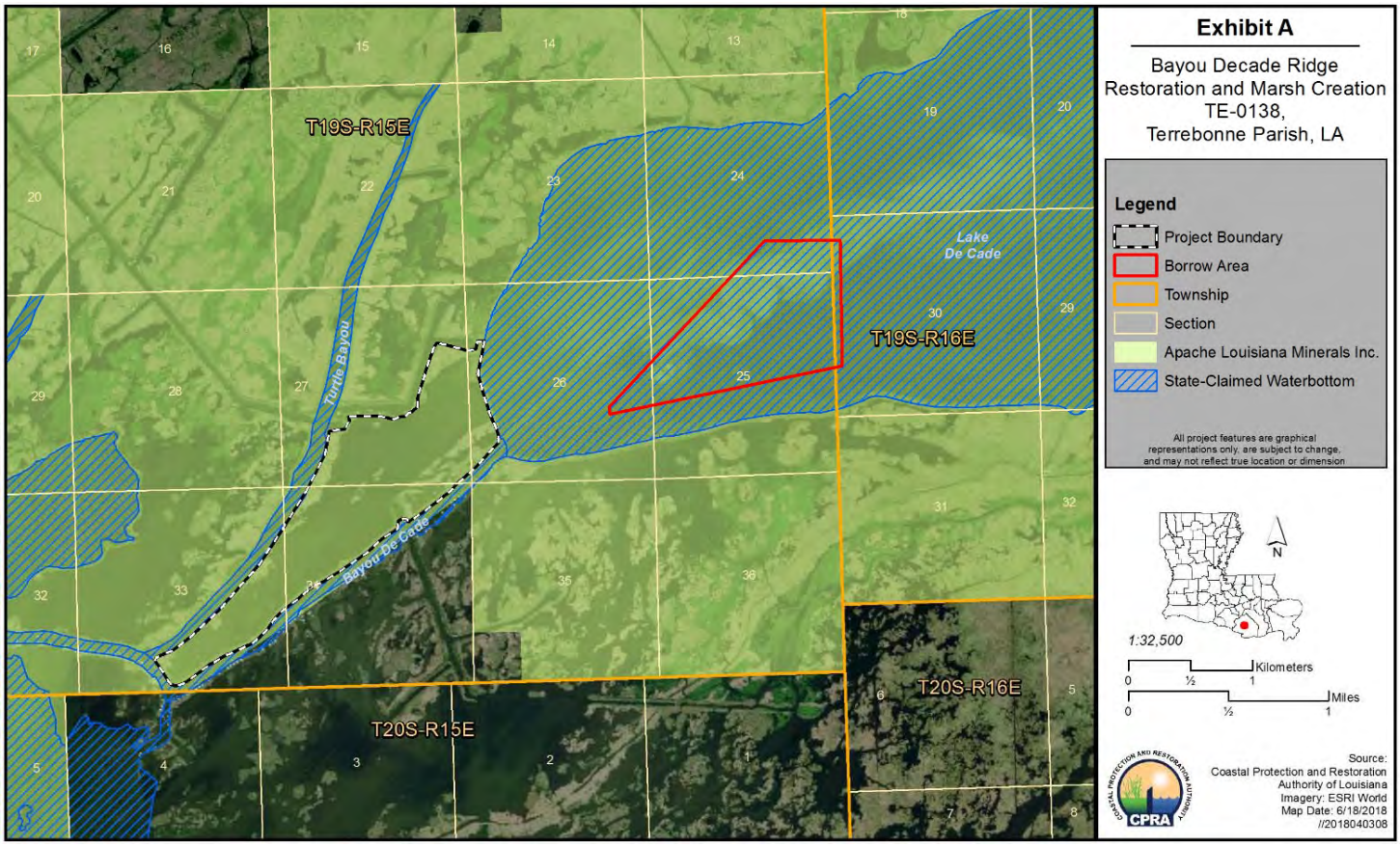

Figure 1: Land Ownership Map

2.0 PRELIMINARY CULTURAL RESOURCES INVESTIGATION

The NMFS submitted a letter to the State Historic Preservation Office (SHPO) on June 28, 2018 requesting a determination of effect for any Area of Potential Effects (APE) within the project area, proposed borrow area, and dredge access corridor. The National Historic Preservation Act allows SHPO 30 days to process and respond to the request. Prior to the submission, the NMFS and CPRA reviewed historic records and archives of potential cultural resources in the project vicinity and do not anticipate construction activities disturbing any of the known sites. SHPO correspondence is included in Appendix 1.

3.0 OYSTER LEASE ASSESSMENT

According to the CPRA Oyster Lease database, no active oyster leases are present in the proposed borrow area and the marsh fill areas.

4.0 WATER LEVEL INVESTIGATION

4.1 Tidal Datum Determination

The tidal datum is a standard elevation defined by a certain phase of the tide and is used to measure local water levels. The primary objective for computing the tidal datum is to establish the target construction fill elevation that maximizes the duration that the restored marsh will be at intertidal elevations throughout the 20-year project life. Establishment of the tidal datum for TE-0138 occurred in the early

stages of preliminary engineering since it pertains to many aspects of the project design including surveys, geotechnical analysis, and constructability.

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 of time. 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 mean of the MHW and MLW for that time period. A normal tidal epoch lasts approximately 19 years; however, since this project is located near the Gulf of Mexico and has anomalous sea level changes, a water level data set covering 10 years was used.

The Coastwide Reference Monitoring System (CRMS) monitoring station CRMS0398, located at 29.389°N, 90.9168°W (shown in Figure 2) was utilized to obtain water level for the 10-year analysis period. Water surface elevations were collected on an hourly basis from August 21, 2007 through August 21, 2017. A detailed summary of the tidal datum calculations is shown in the Design Calculations Packet in Appendix F. The results of the tidal datum determination for the CRMS0398 Station are as follows:

- MHW = 0.76 ft, NAVD88 - Geoid 12A
- MLW = 0.37 ft, NAVD88 - Geoid 12A
- MTL = 0.57 ft, NAVD88 - Geoid 12A

Figure 2: CRMS0398 Station Location

4.2 Percent Inundation Determination

The vertical positioning of marsh platforms and the frequency with which the marsh floods strongly influence plant communities and marsh health. Historically, tidal range between mean high water (MHW) and mean low water (MLW) has been the accepted range for healthy marsh. This approach has worked well in tidal salt marshes where most of the water level variability is due to astronomical tides. Across Louisiana's coastal wetlands, however, non-tidal influences such as meteorological events, river

discharge, and management regimes often have significantly more influence on water levels than astronomical tides. Therefore, we propose using percent inundation in combination with tidal range as a proxy for marsh health. Percent inundation refers to the percentage of the year a certain elevation of land would be flooded based on the water levels found in that region.

To determine percent inundation the CRMS0398 water level data was utilized. For example, the 10 percent inundation elevation was determined to be 1.119 ft., NAVD88 – Geoid12A. This elevation correlates to the 10% exceedance probability over a 1-year period. The results of the percent inundation determination for CRMS0398 during the 10-year data set are shown in Table 1.

Table 1: Percent Inundation Elevations (ft., NAVD88 – Geoid 12A)

Percent Inundation	TY0 Elevation	TY20 Elevation (Including SLR)
1%	1.649	2.129
10%	1.119	1.599
20%	0.939	1.419
30%	0.839	1.319
MHW	0.796	1.276
40%	0.739	1.219
50%	0.649	1.129
60%	0.549	1.029
65%	0.489	0.969
70%	0.429	0.909
MLW	0.414	0.894
80%	0.259	0.739
90%	0.039	0.519

The mean salinity at CRMS0398 is 1.58 part per thousand, which correlates to the project being classified as in intermediate marsh. Table 2 provides the optimal marsh inundation ranges within the Louisiana Coastal Zone for each marsh type. The Intermediate marshes, as found within the TE-0138 project area are most productive when flooded between 10% and 90% of the time. The project team utilized best professional judgment to identify target constructed marsh elevations that would maximize short-term and long-term marsh function while taking into account sea level rise (SLR). This determination is further discussed in Section 7.0.

Table 2: Optimal Marsh Inundation Ranges within the Louisiana Coastal Zone

Marsh Type	Optimal Inundation Range
Fresh	10% - 90%
Intermediate	10% - 90%
Brackish	10% - 65%
Saline	20% - 80%

4.3 Sea Level Rise

All projects within the CWPPRA program are built and evaluated based on a 20-year project life and are expected to continue to perform the objectives mentioned in Section 1 throughout the design life. Therefore, to properly design the project to meet the 20-year goal, certain natural processes are assessed.

One process is Sea Level Rise (SLR). SLR can be broken down into two components, Eustatic (or Global) Sea Level Rise and Subsidence; the latter of which will be described in Section 6.3. Sea Level Rise refers to a global change in water level. The value associated with Sea Level Rise is based on an average rate of increase of global water level.

To determine a most likely change in sea level over time at the project site, CPRA utilized its Planning Division to assist with calculating this value. The Planning Division attempted to bracket this rate by providing a lower and higher value to account for uncertainty. The calculated range for possible relative sea level rise by 2032 is 0.5 ft to 0.9 ft. Given the assumption of rising sea level, the marsh elevation required to attain a given percentage of annual inundation increases over the duration of the project life (Figure 3).

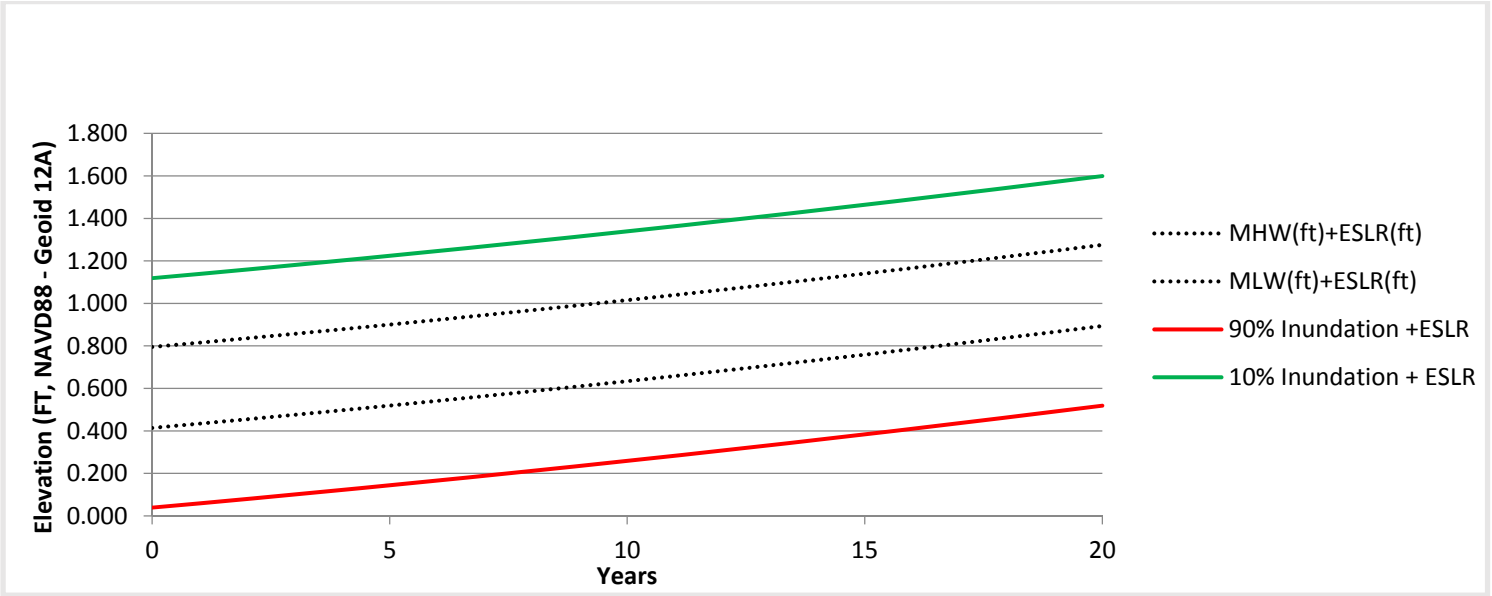

Figure 3: Eustatic Sea Level Rise (ESLR) Calculated Over 20 Year Project Life

5.0 DATA COLLECTION

In order to properly design and construct the proposed marsh creation and ridge restoration project, an accurate and concise representation of the marsh landscape and the underlying soils is required. This was accomplished through the use of bathymetric, topographic, magnetometer, and subsurface geotechnical investigations.

5.1 Bathymetric, Topographic and Magnetometer Surveys

A detailed topographic and bathymetric survey of the project area was performed from October 2017 to February 2018 by Oceaneering International, Inc. The surveying team utilized two permanent secondary monuments, TE-34-SM-01 and TE-28-SM-A, to establish horizontal and vertical control during the survey. The positions of these monuments were verified by performing static observations on each monument.

The horizontal positions are referenced to LA State Plane NAD83 and the vertical positions are referenced to NAVD88 – Geoid 12A. The revised monument data sheets are provided in Appendix 2.

Topographic and bathymetric survey transects were surveyed with a 250-foot spacing within the marsh fill area and a 1,000 foot spacing within the borrow area (Figure 4). Additional centerline and transect surveys were collected along all spoil banks and the lake rim. Existing mudline elevations were collected at 25-foot intervals along each transect utilizing both bathymetric and topographic survey methods. Topographic surveys were performed on board an airboat, shallow draft flat bottom boat, and by foot. Bathymetric surveys were performed on board a 26-foot aluminum hull vessel with an Odom Echotrac 3200 digital fathometer. The data was uploaded in real time to the Hypack navigation software so that water depths would be recorded and merged with the Leica RTK positions.

In addition to the planned topographic and bathymetric survey lines, the survey team also performed an average marsh elevation survey. This survey consisted of 20 elevation shots located in 5 different areas near the project area. The average elevation at each location is summarized in Table 3.

Table 3: Average Marsh Elevation Summary

Survey Location	Average Elevation (NAVD88, Geoid - 12A)
M-1	0.88
M-2	0.77
M-3	0.71
M-4	0.60
M-5	0.80
Average	0.75

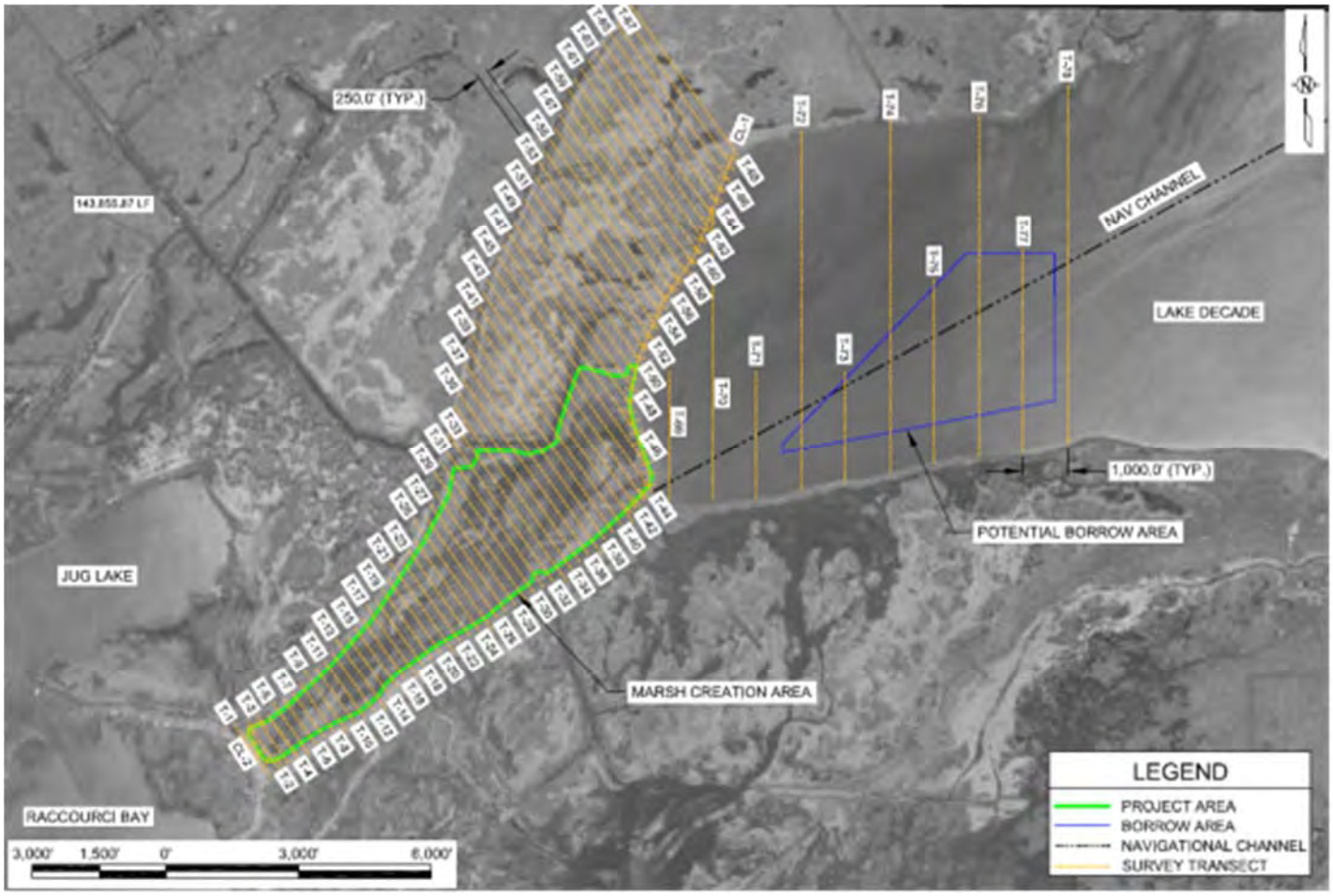

Figure 4: Bathymetric and Topographic Survey Layout

Oceaneering, Inc. also performed a magnetometer survey for the marsh fill area and the borrow area to locate any pipelines or obstructions (Figure 5). A Geometrics 882 cesium magnetometer was utilized and correlated to a position with RTK GPS using the Hypack Navigation Software package. For each magnetic finding, a closed loop path was run with the magnetometer. The path completely enclosed the original finding location, while maintaining a distance of approximately 25 feet from that location.

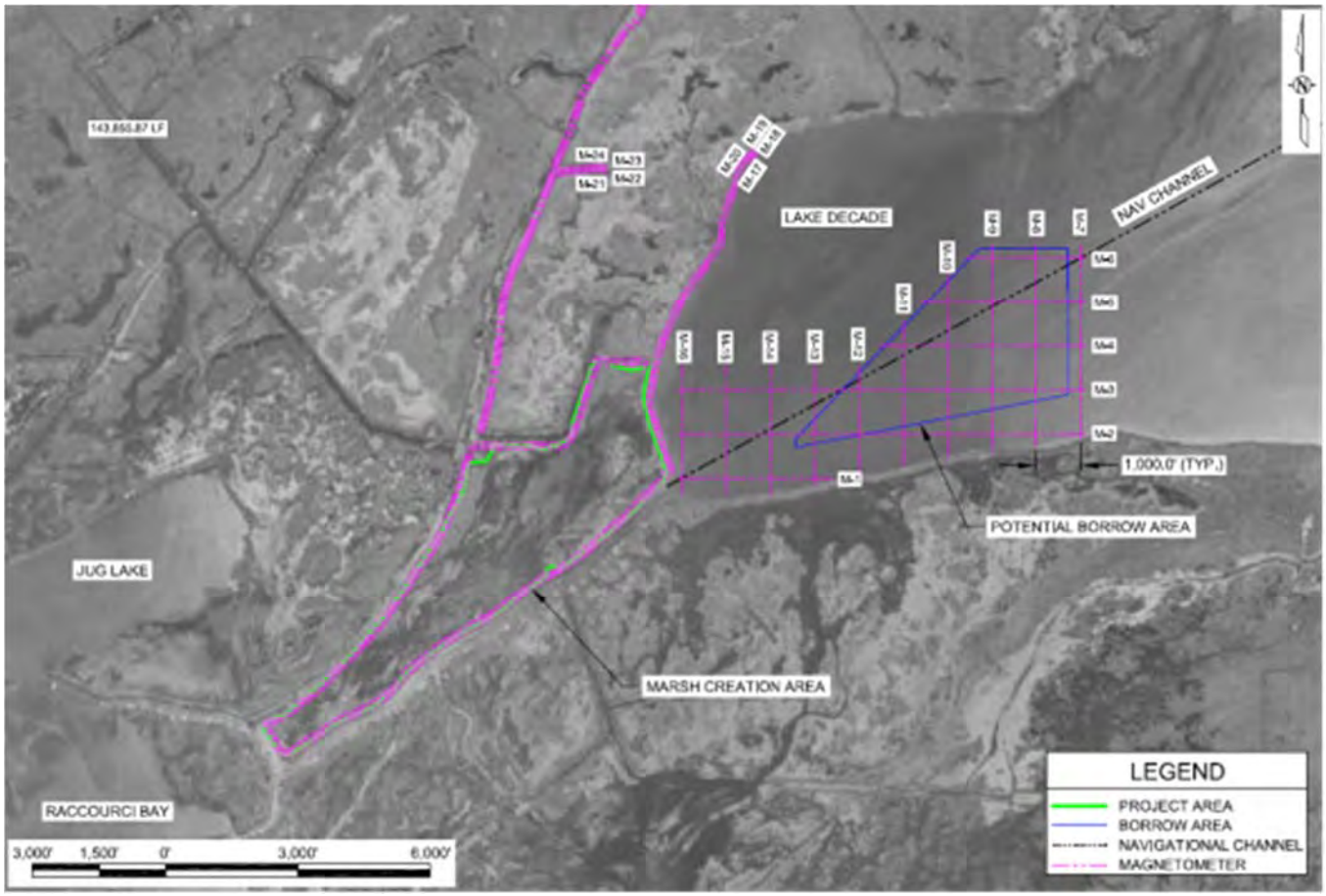

Figure 5: Magnetometer Survey Layout

The magnetometer survey recorded 397 unidentified magnetic anomalies within the survey area. Of these anomalies, 268 were adjacent to the marsh fill area and 105 of these anomalies were within or adjacent to the borrow area. All magnetic anomalies were further investigated and are shown in the survey drawings found in Appendix 3. In the cases where magnetic anomalies were related to existing pipeline infrastructure, the existing lines were hand probed in order to determine the depth of cover along the line throughout the entire project area. Many of the magnetic anomalies were determined to be insignificant ferrous objects that are buried or submerged. There were no pipelines located within any of the proposed project features.

5.2 Geotechnical Field Investigation

In order to determine the suitability and physical characteristics of the soils in the TE-138 project area, a geotechnical subsurface investigation and geotechnical engineering analysis was conducted by Fugro USA Land, Inc. Fugro was tasked to collect soil borings, perform laboratory tests to determine soil characteristics, perform global slope stability analysis of the proposed earthen containment dikes and ridge, estimate the total settlement of the proposed earthen containment dikes, earthen ridge and marsh creation fill areas, and determine an adequate cut-to-fill ratio for the dredge operations.

Soil conditions were evaluated in the marsh creation fill areas and the marsh creation borrow area by advancing 15 soil borings to depths ranging from approximately 16 to 60 feet below the existing mudline.

Additionally, 15 cone penetration test (CPT) soundings were advanced to an approximate depth ranging from 40 to 60 feet below mudline within the confines of the marsh creation area. The soil boring and CPT locations are shown in Figure 6. Additional field exploration information can be found in Appendix 4: Geotechnical Data Report.

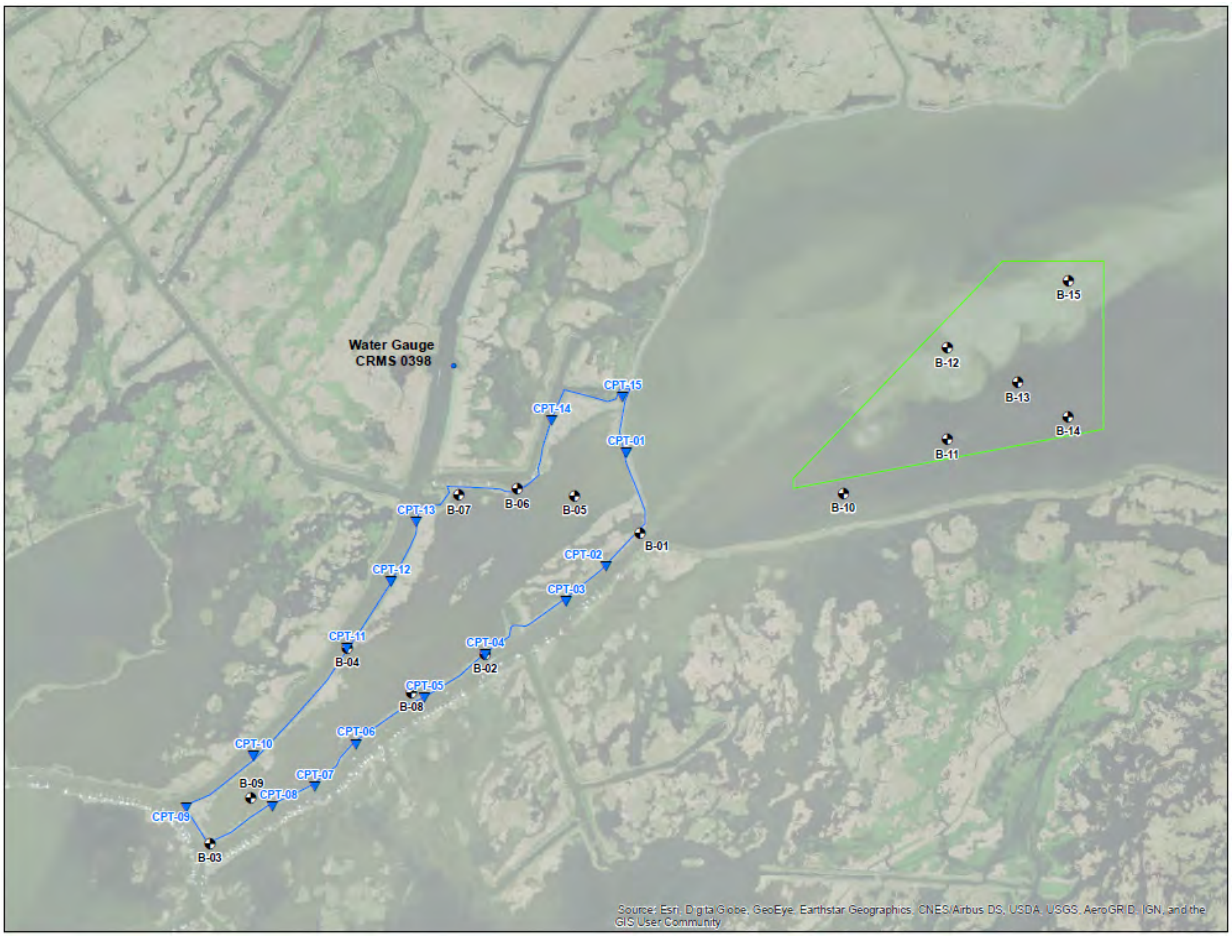

Figure 6: Geotechnical Investigation Site Plan

5.3 Geotechnical Laboratory Analysis

Fugro, Inc. developed a laboratory testing program for all geotechnical samples to establish adequate information on classification and soil strength to facilitate engineering and design. The laboratory testing included material classifications, shear strength testing, compressibility and corrosion characteristics, and settling column tests on borrow area samples. The geotechnical data collection and data analysis report can be found in Appendix 4: Geotechnical Data Report.

6.0 MARSH CREATION AND RIDGE RESTORATION DESIGN

6.1 Marsh Creation Area Description

The proposed marsh creation area is located along the northern bank of Bayou Decade and adjacent to the western shoreline of Lake Decade. The site consists of 397 acres of open water and 104 acres of broken marsh. Survey data indicates that approximately 74% of existing mudline elevations are between -1.0 and -3.0 ft. NAVD88, Geoid – 12A (Table 4).

Table 4: Existing Elevation Distribution within Fill Area

Elevation Range (NAVD88 - Geoid 12A)	Percent Occurrence
-4.0 to -3.0	0%
-3.0 to -2.0	38%
-2.0 to -1.0	36%
-1.0 to 0	15%
0.0 to +1.0	10%
+1.0 to +2.0	1%

The marsh creation area is impounded and it is nearly 100% contained by existing spoil banks along Bayou Decade, Turtle Bayou, and unnamed oilfield access canals. The elevations of the spoil banks range from +0.5 feet to +7.5 feet NAVD88.

A fixed crest weir is located on the northern boundary of the marsh creation area and has historically been used to control the water level within the impounded area. In recent years this weir has become damaged and is no longer inhibiting water flow as originally designed.

The boundary of the marsh creation area along Lake Decade is frequently repaired by Apache Corporation in order to prevent breaching of the lake rim. Several inhabited camps are located along the northern boundary of the marsh creation area. These camps and their associated infrastructure have been considered and will continue to be considered during final design of the marsh creation area.

The SONRIS database maintained by Louisiana Department of Natural Resources (DNR) indicates that up to three oil and gas pipelines are located within the marsh creation area; however, the magnetometer survey did not confirm the presence of these pipelines. The landowner has confirmed that there are no pipelines within the marsh creation area.

6.2 Marsh Creation Area Layout

The features described above played an important role in the development of the marsh creation area footprint. The location and orientation of the marsh creation area could affect dredging logistics, dredging production rates, and construction duration. Additionally, the environmental impacts to existing coastal landscape should be minimized as much as practically possible.

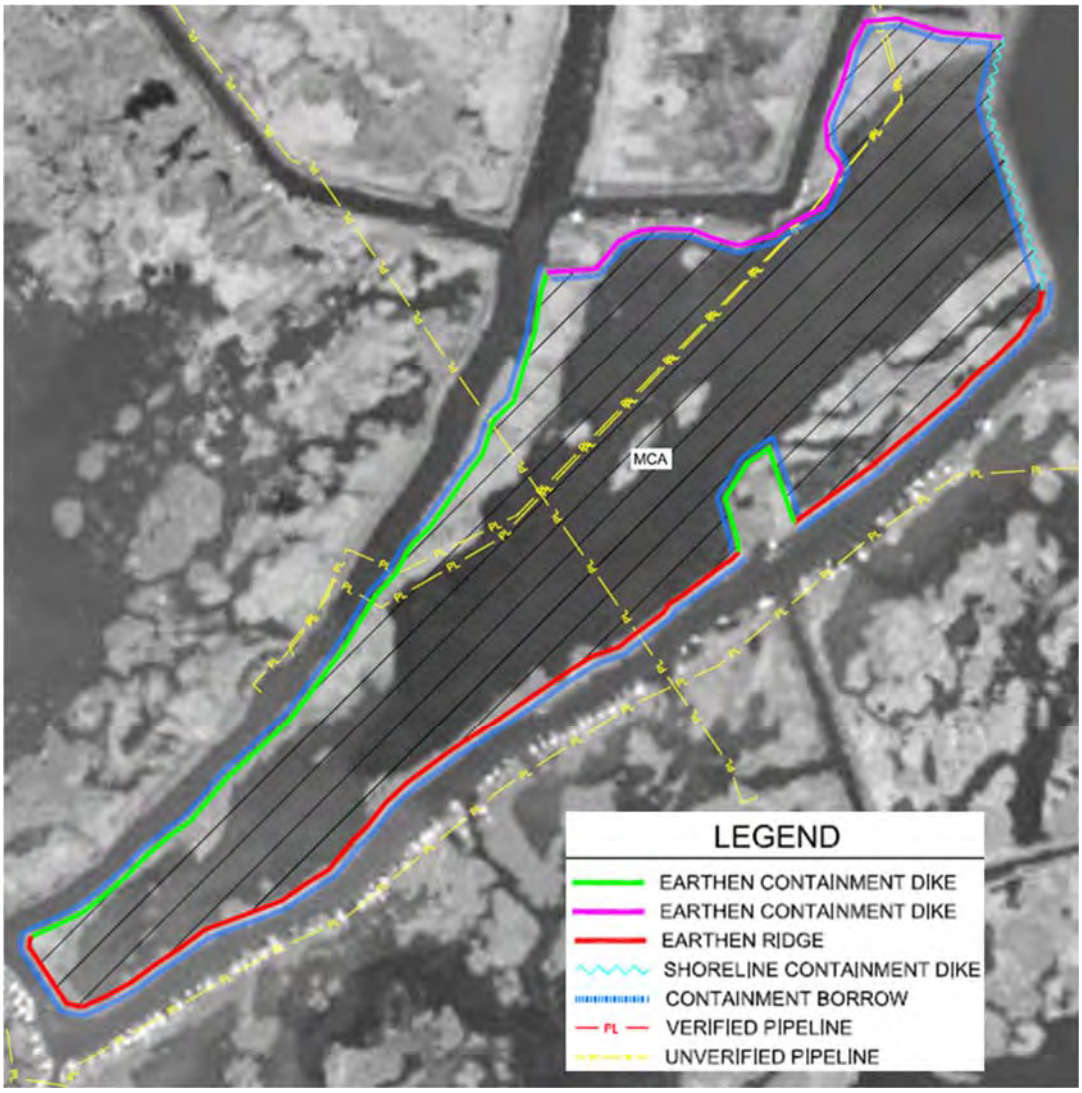

Figure 7: Marsh Creation Area Layout

The layout of the marsh creation area (Figure 7 and Table 5) minimizes the required fill volumes for containment dike and ridge restoration by utilizing the existing spoil banks along Bayou Decade, Turtle Bayou, and the Lake Decade shoreline. In addition, several reaches of the containment dike and the entire earthen ridge will be constructed by mechanically dredging earthen material from the exterior of the marsh creation fill area. This practice will eliminate the need to backfill these borrow areas with hydraulically dredged material.

The earthen ridge project feature is located along the northern bank of Bayou Decade. Much of this alignment is located along the remnants of a shoreline berm, which minimizes the amount of mechanically dredged material required for construction. In addition, the primary borrow area for the ridge feature is located in Bayou Decade rather than the interior of the marsh creation area. A secondary borrow area is located on the interior of the marsh creation area to provide for additional borrow area should it be needed at the time of construction.

Two lengths of containment dike will borrow material from the interior of the marsh creation fill area: the northern reach in the vicinity of existing camps and the eastern reach along Lake Decade. The northern

reach borrow area is located on the interior in order to eliminate impacts to the camps. The eastern reach of earthen containment dike, also referred to as shoreline containment dike, is located along the western shoreline of Lake Decade. In order to protect the dike from the high wave energy associated with the lake, the dike will be located on the interior of the existing earthen shoreline protection berm. The borrow area for this dike is also located on the interior of the marsh creation fill area.

Table 5: Summary of Project Features

Project Feature	Length (ft)	Footprint Area (Acres)
Marsh Creation Area	-	473
Earthen Containment Dike (Interior Borrow)	1,789	1
Earthen Containment Dike (Exterior Borrow)	13,411	9
Shoreline Containment Dike (Interior Borrow)	2,342	2
Earthen Ridge (Exterior Borrow)	11,133	16

6.3 Marsh Creation Settlement Analysis

A settlement analysis was performed to determine the optimal construction elevation of the marsh creation fill area. The final elevation of the created marsh (at Target Year 20) is governed by two forms of settlement: (1) the settlement of the underlying soils in the marsh creation areas caused by the loading exerted by the placement of the dredged fill material, and (2) the self-weight consolidation of the dredged material. These processes are illustrated in Figure 8 below. Data from low-pressure consolidation tests, self-weight consolidation tests, and settling column tests were used to produce time-rate settlement estimates of both the underlying soils and the dredged fill material.

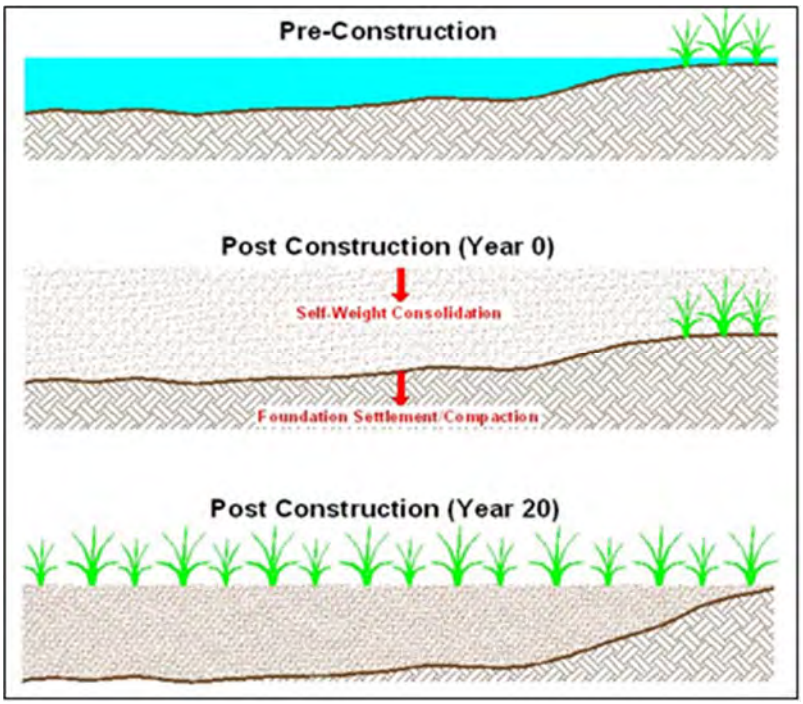

Figure 8: Marsh Creation Settlement Processes

Settlement curves of differing initial construction marsh fill elevations and sequencing were analyzed over the 20-year design life. As discussed in Section 5.0, the goal of the project is to have the 20-year elevation fall within the intertidal and ideal percent inundation range.

The project team evaluated three different construction fill scenarios with differing target elevations (Figure 9). The first scenario, "1 lift @ 5 Total Feet" produced an initial elevation of +3.0 ft. NAVD88, Geoid - 12A and a final elevation of 1.13 ft. NAVD88, Geoid – 12A. This assumed that the entire volume of marsh creation material would be placed within the fill area at the same time. It was determined that this construction scenario did not accurately represent the actual marsh creation construction process due to the large volume of dredge material needed to fill the marsh creation area.

The next construction scenario, "9 Lifts @ 10 Total Feet", consisted of raising the marsh creation elevation 2 ft in the first 15 days of dredging, followed by 1-foot increments every 15 days for a total of 150 days. This methodology allows the marsh creation settlement model to account for settlement of the marsh fill during the duration of construction.

A final construction scenario, "9 Lifts @ 10 Total Feet", consisted of raising the marsh creation elevation in 1-foot increments every 15 days for a total of 150 days. This third scenario was needed to provide a range of potential marsh fill elevations to be evaluated.

All marsh creation construction scenarios were evaluated with the assumption that the pre-construction mudline elevation is -2.0 ft NAVD88, Geoid - 12A. This elevation was determined based on the existing elevation distribution shown in Table 4.

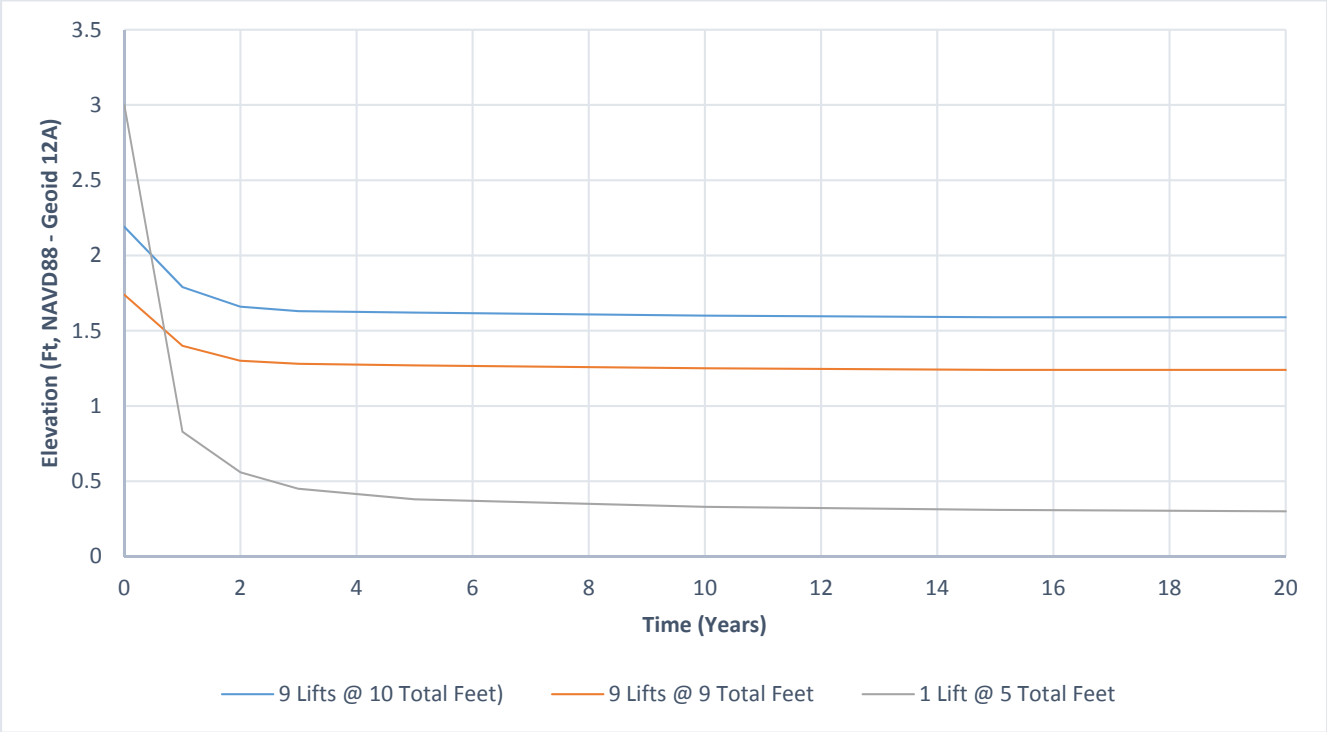

Figure 9: Time Rate Settlement of Marsh Fill (without subsidence)

6.4 Subsidence Rates

In addition to the settlement caused by marsh fill, the natural process of subsidence is considered when evaluating the final elevation of the marsh fill. Subsidence is defined as the rate of local vertical land movement. Causes of subsidence include natural processes such as tectonics (faulting), Holocene sediment compaction, and removal of subsurface fluids associated with the oil and gas industry.

The CPRA Planning Division has produced a range of subsidence values across coastal Louisiana for use in the design of restoration projects (Figure 10).

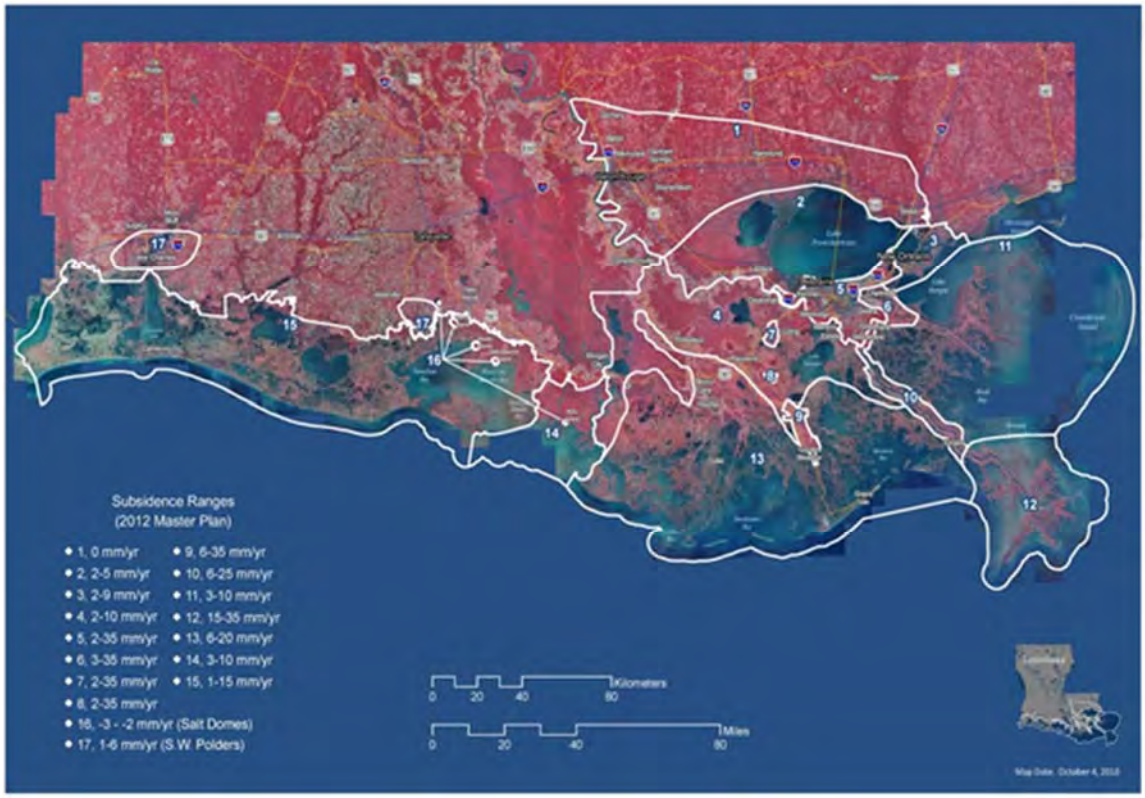

Figure 10: Coastal Louisiana Subsidence Rates (CPRA Planning Division)

The TE-0138 project falls within the area having a subsidence range of 6-20 mm/year. The project team has chosen to use 7 mm/year as the governing rate due to past experiences near the project area. This value equates to a total of 140 mm (5.5 inches) of total subsidence over the project life. This rate was used to develop an alternate set of settlement curves that includes settlement due to subsidence (Figure 11).

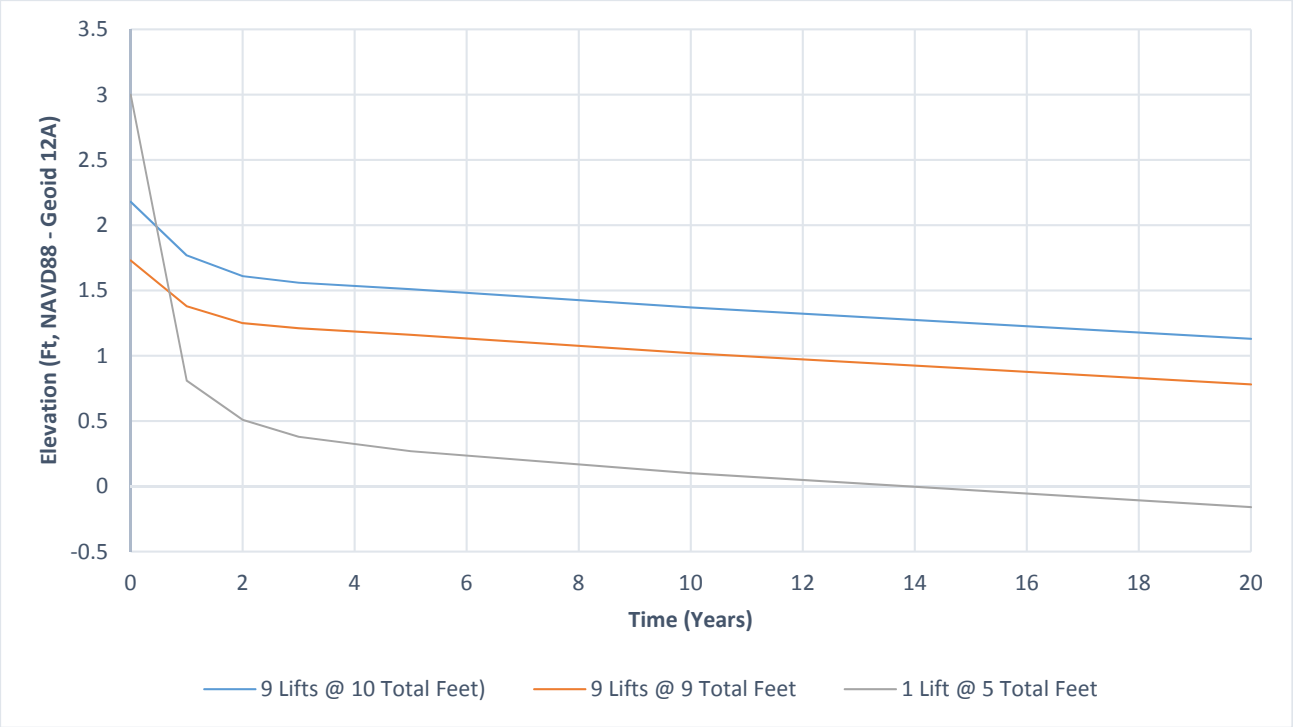

Figure 11: Time Rate Settlement of Marsh Fill (with Subsidence)

After including all forms of settlement (self-weight consolidation, foundation settlement, and subsidence), the settlement curves were added to the water level data discussed in Section 5.0. After review of this data (Figure 12), the project team determined that a CMFE of 1.75 ft. NAVD88 – Geoid12A would achieve the marsh elevation goals established in Section 5.0. This construction elevation would achieve a marsh elevation within the 10% inundation range by Year 4 and within the intertidal range by Year 10. The marsh would not be expected to settle below the intertidal range until Year 18 and would remain within the 90% inundation range for the life of the project. It is important to note that the CMFE is the elevation of the marsh fill slurry 30 days after the completion of dredging activities.

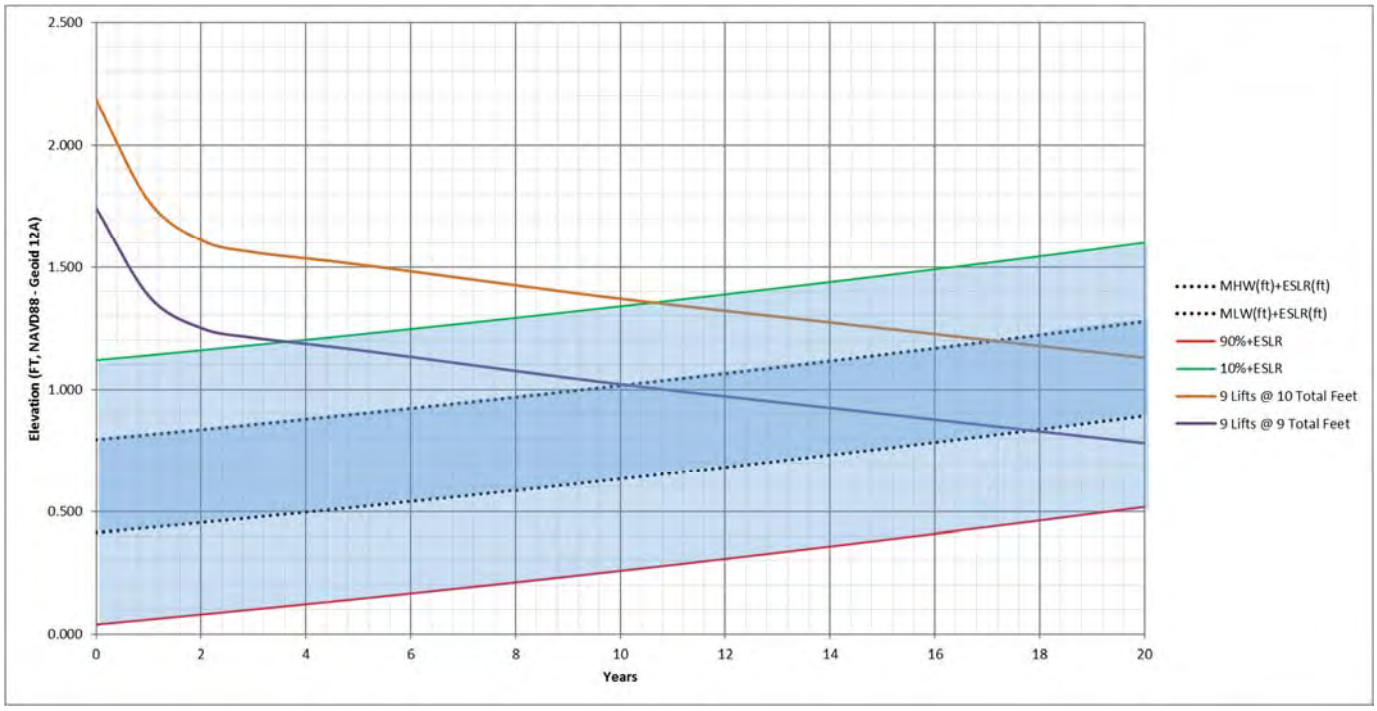

Figure 12: Time Rate Settlement Compared with Tidal Datum

6.5 Earthen Containment Dike Design

Earthen containment dikes are required to contain the hydraulically placed fill material within the marsh creation area. As mentioned above, most of this project area is contained by surrounding spoil banks; however, in order to fully contain the placed slurry material, the elevation of these spoil banks will be increased to +4.0 feet NAVD88 – Geoid 12A. This elevation will provide nearly 2.25 feet of freeboard above the construction marsh fill elevation of +1.75 feet NAVD88 – Geoid 12A, described above. This amount of freeboard will provide the dredge contractor the ability to pump above the +1.75 elevation in order to reach the CMFE after the required 30-day wait period.

In order to perform this elevation lift, a thorough understanding of the subsurface soil conditions and the construction methodology is required for containment dike design. The subsurface investigation described in Section 6.2 provides the needed information to analyze the slope stability of the dike and borrow areas, total settlement, and recommended cut to fill ratio for the mechanical dredging activities. Figure 13 and Figure 14 summarizes the typical cross section for the earthen containment dike. This containment dike section will be further evaluated following Preliminary Design.

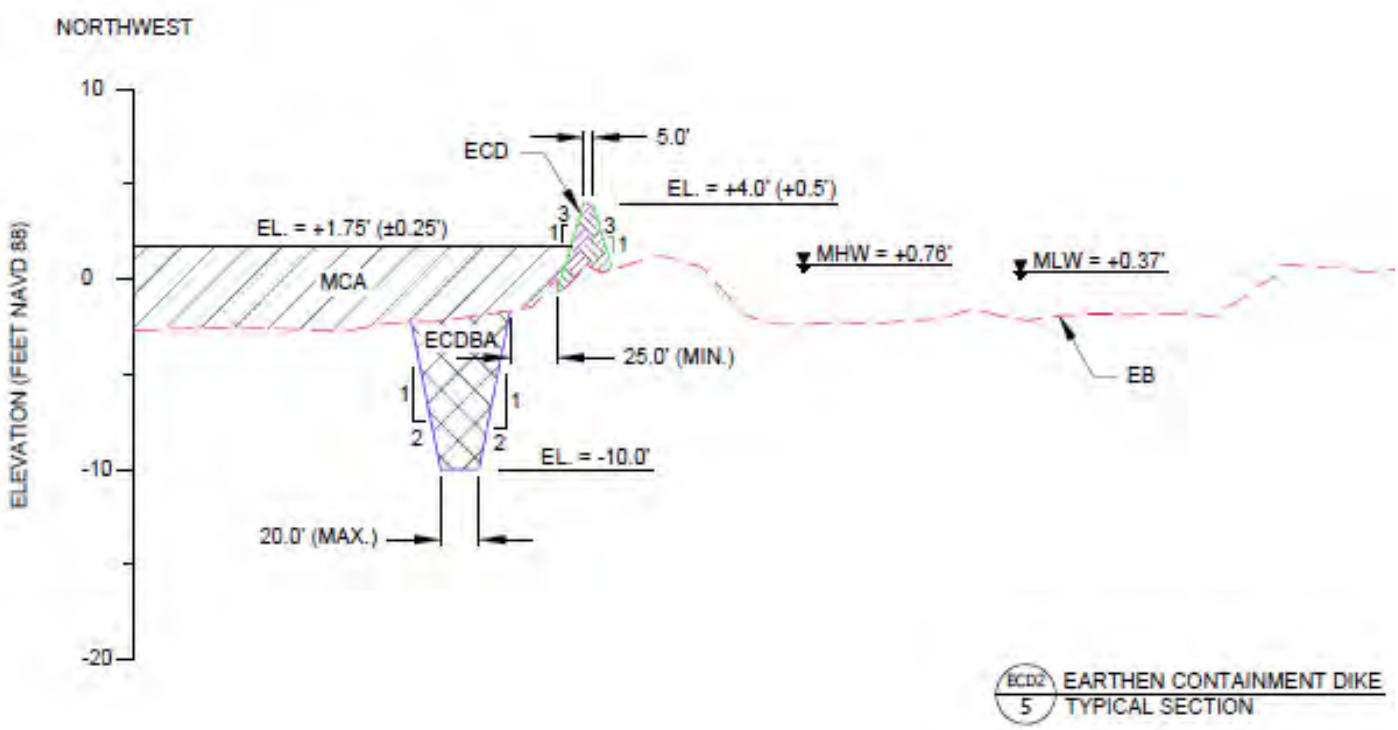

Figure 13: Earthen Containment Dike Typical Cross Section – Interior Borrow

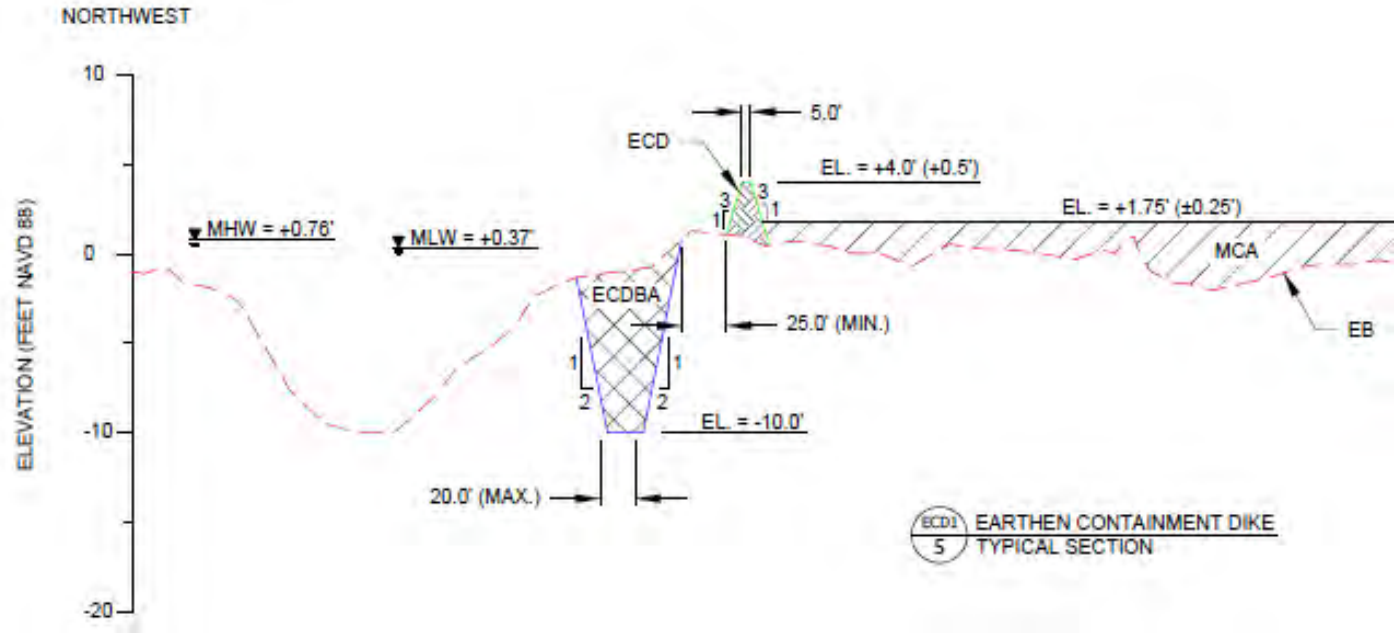

Figure 14: Earthen Containment Dike Typical Cross Section – Exterior Borrow

In order to account for erosion of the shoreline along Lake Decade during the duration of construction activities, a shoreline containment dike will be utilized. This dike will consist of a 10' crest width and

5H:1V side slopes in order to endure additional erosion from the high wave energy environment associated with Lake Decade. In addition to this larger dike, the required construction volume has been doubled so that the dike can be maintained, if needed, throughout construction. Figure 15 shows the typical cross section for the Shoreline Containment Dike.

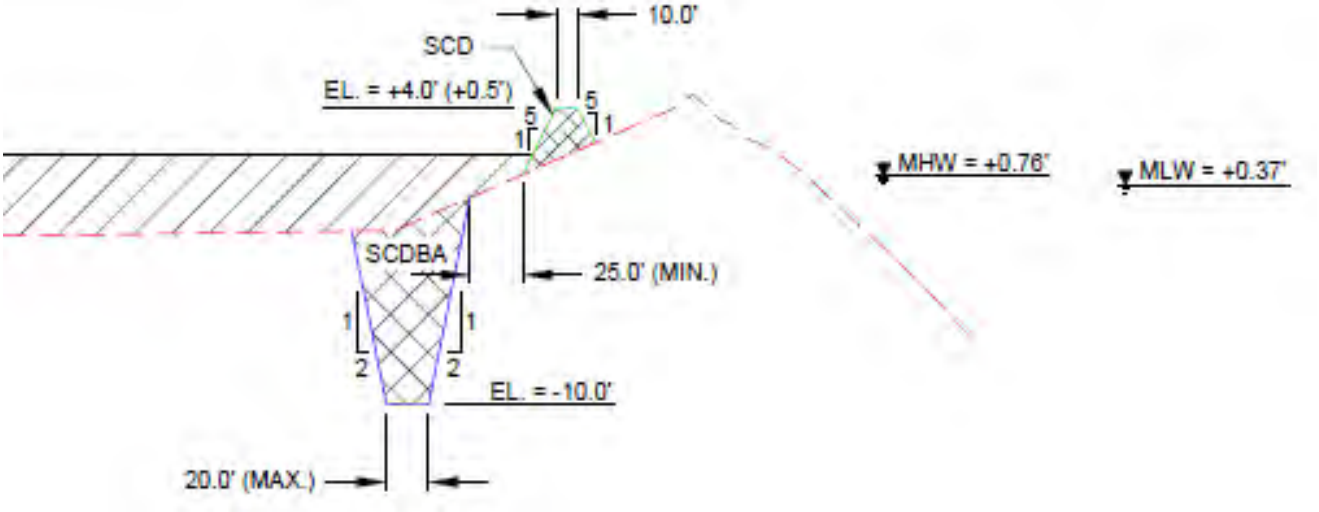

Figure 15: Shoreline Containment Dike Typical Cross Section

6.6 Ridge Restoration Design

The primary goal of ridge restoration is to provide a platform of dredged material to an elevation sufficient to support woody vegetation. This elevation was identified in the initial planning phase as +5.0 feet NAVD88 – Geoid 12A. As shown above in Section 5.0, the elevation is above the 1% inundation threshold and will allow for additional settlement for the duration of the project life. The total settlement of the ridge feature will be further evaluated following Preliminary Design. Similar to the earthen containment dike, the ridge restoration feature will primarily consist of material that has been mechanically dredged from the exterior of the marsh fill area and will be placed along the historical ridge along the northern shoreline of Bayou Decade. Additional fill material for the ridge restoration will be dredged from the interior of the marsh creation fill area.

The subsurface geotechnical investigation described in Section 6.2 provided the needed information to analyze the slope stability of the ridge and borrow area, total settlement, and recommended cut to fill ratio for the mechanical dredging activities. The proposed cross section (Figure 16) will be further evaluated following Preliminary Design.

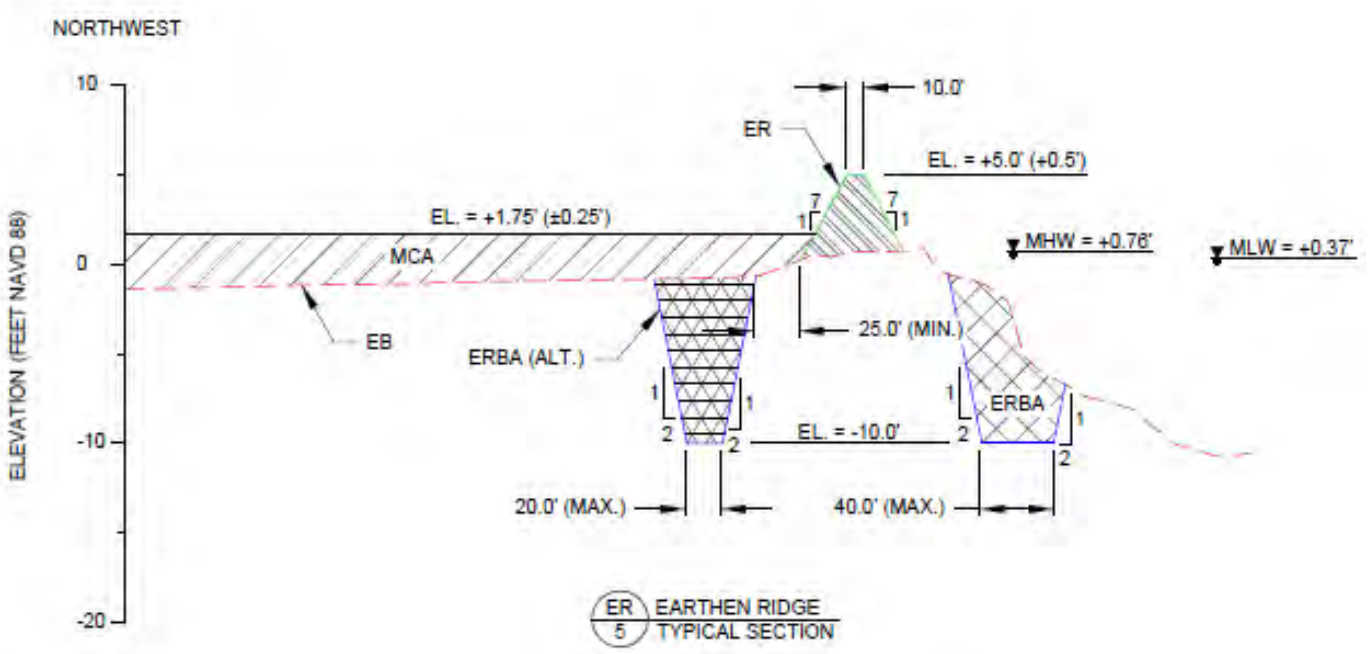

Figure 16: Ridge Restoration Typical Cross Section

6.7 Project Feature Volume Estimates

The volume of material needed to construct all project features, including the marsh creation area, earthen containment dikes, and earthen ridge, is needed in order to properly design the borrow area for each feature and to produce an accurate construction cost estimate. The fill volume quantities (Table 6) are based on the existing elevation within the marsh fill area, the construction marsh fill elevation, and the hydraulic dredge fill material properties. The properties of all fill materials were obtained during the subsurface geotechnical investigation described in Section 6.2. A cut to fill ratio of 1.5 was applied to the quantities to be dredged for all mechanical dredging. A cut to fill ratio of 1.2 was applied to the quantities to be dredged for all hydraulic dredging. This value is used to account for losses that occur during the dredging processes. In addition, the required cut volume for the shoreline dike was doubled so that the dike could be repaired as shoreline erosion occurs.

Table 6: Summary of Required Fill and Available Borrow Volumes

Feature	Required Fill Volume (Cu. Yds.)	Required Cut Volume - Interior (Cu. Yds.)	Required Cut Volume – Exterior (Cu. Yds.)	Available Borrow Volume - Interior (Cu. Yds.)	Available Borrow Volume – Exterior (Cu. Yds.)
Earthen Containment Dike	37,819	6,791	49,938	18,631	136,486
Shoreline Containment Dike	8,453	25,359	-	30,562	-
Earthen Ridge Restoration	94,660	41,310	100,680	137,656	100,680
Marsh Creation Fill Area	2,203,335	2,644,001	-	4,871,719	-

6.8 Marsh Creation Borrow Area Design

The marsh creation borrow area is approximately 348 acres in size and is located in the southwestern portion of Lake Decade (Figure 17). This borrow area was carefully chosen to avoid the oil and gas infrastructure located in this area. In order to minimize water quality impacts, the cut depth of the borrow area will be limited to 10 feet below the existing mudline (Figure 18).

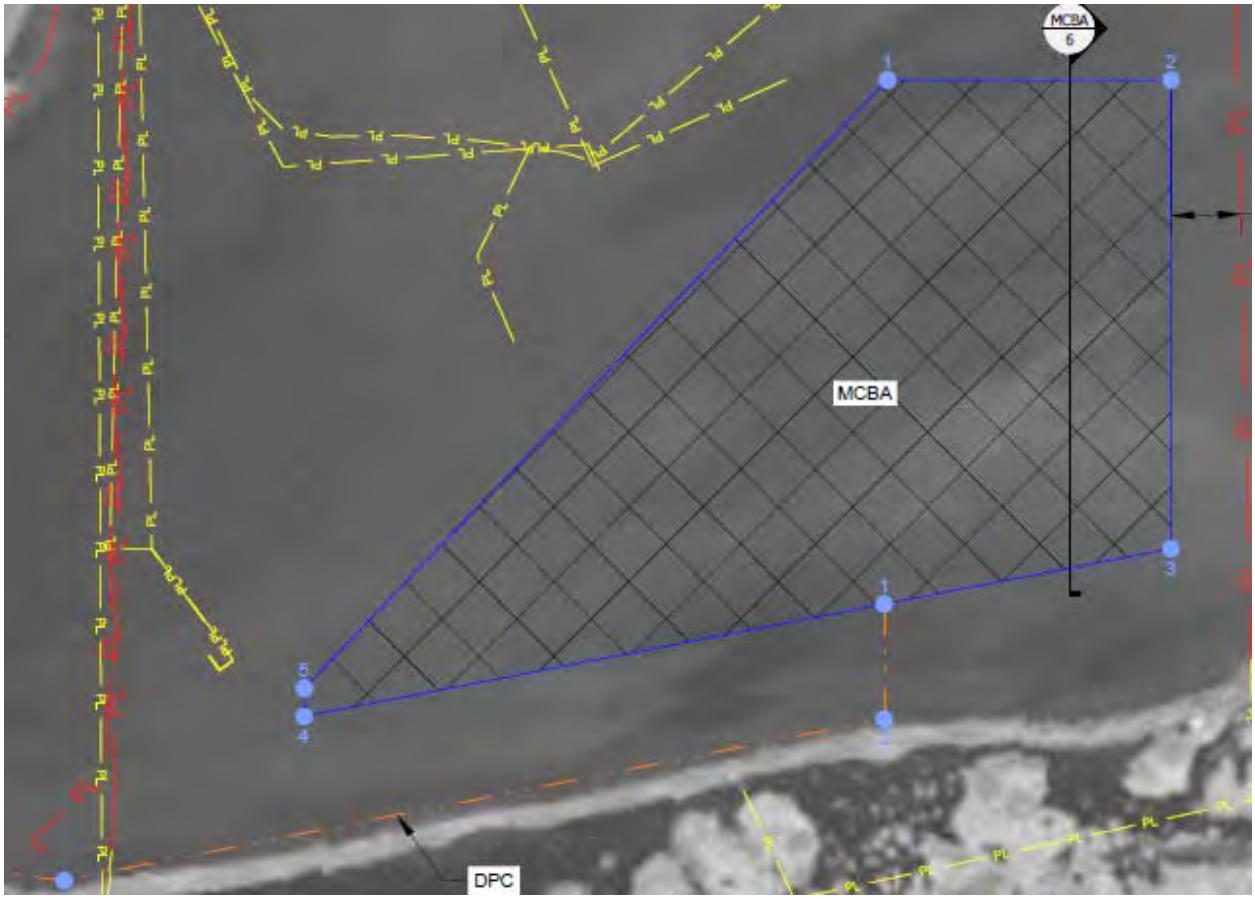

Figure 17: Marsh Creation Borrow Area Layout

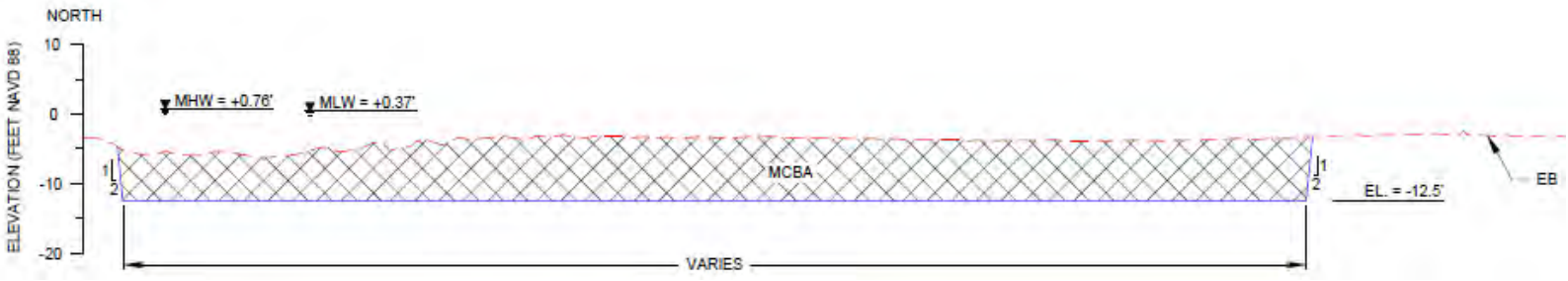

Figure 18: Marsh Creation Borrow Area Typical Cross Section

7.0 CONSTRUCTION COST ESTIMATE

An Engineer's Estimate of Probable Construction Cost was prepared for this project using the CWPPRA PPL 28 spreadsheet, CPRA Bid Tabulations of past projects, the CDS Dredge Unit Rate Cost Estimation

spreadsheet, and additional CPRA developed cost estimation spreadsheets. The estimated construction cost has been provided to the CWPPRA Engineering Workgroup in the current PPL 28 format.

8.0 MODIFICATIONS TO THE PHASE 0 PROJECT

The project features remain largely unchanged from the originally proposed Phase 0 project features. A few minor revisions were made in order to adapt the project features to the ever changing topography within the project area. A summary of these changes are shown below (Table 7).

Table 7: Summary of Changes From Phase 0 Project

Project Feature	Phase 0	Preliminary (30%) Design	Percent Change
Marsh Creation Area	501 Acres	473 Acres	-5.5%
Earthen Ridge	11,726 LF	11,133 LF	-5.0%