CS-0078 No Name Bayou Marsh Creation and Nourishment Project

Coastal Wetland Planning, Protection, and Restoration Act PPL 24

95% Design Report

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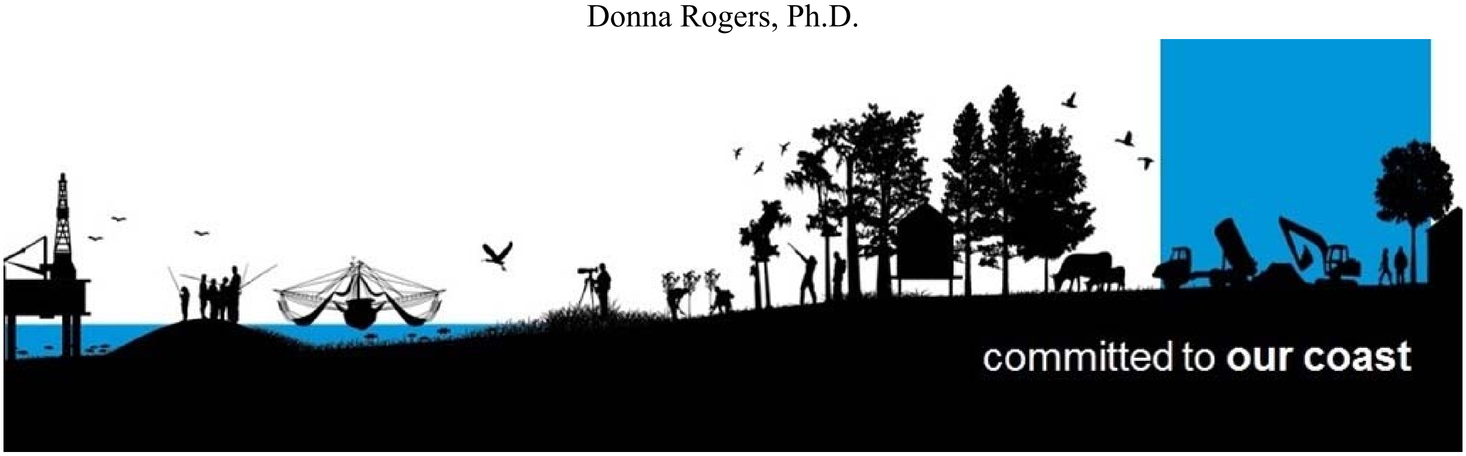

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ABBREVIATIONS

AAI	Ardaman & Associates, Inc.
AC	Acre
APE	Area of Potential Effects
ASTM	American Society of Testing and Materials
CAMO	Coastal and Marine Operators Pipeline Industry Initiative
CCTPC	Cheniere Creole Trail Pipeline Company
CCW	Cameron Creole Watershed
CDF-M	Confined Disposal Facility “M”
CMFE	Constructed Marsh Fill Elevation
CORS	Continuous Operating Reference System
CP NWR	Cameron Prairie National Wildlife Refuge
CPRA	Coastal Protection and Restoration Authority of Louisiana
CRMS	Coastwide Reference Monitoring System
CSC	Calcasieu Ship Channel
CSI	Chustz Surveying, Inc.
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
DPC	Dredge Pipe Corridor
EAC	Equipment Access Corridor
ECD	Earthen Containment Dike
EL	Elevation
EM	Engineer Manual
ESLR	Eustatic Sea Level Rise
FS	Factor of Safety
FT	US Survey Foot
FUL	Fugro USA Land, Inc.
GPS	Global Positioning System
HTRW	Hazardous, Toxic, and Radioactive Waste
LDNR	Louisiana Department of Natural Resources
LDWF	Louisiana Department of Wildlife and Fisheries
LF	Linear Foot
LONO	Letter of No Objection
MCDG	Marsh Creation Design Guidelines
MHW	Mean High Water
MI	Mile
MLW	Mean Low Water
MTL	Mean Tide Level
MTR	Mean Tide Range
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OLACP	Oyster Lease Acquisition and Compensation Program
OPUS	Online Positioning User Service
PL	Pipeline

PPL	Priority Project List
PSDDF	Primary Consolidation, Secondary compression, and Desiccation of Dredge Fill
PSF	Pounds per Square Foot
REC	Recognized Environmental Condition
RSLR	Relative Sea Level Rise
RTK	Real Time Kinematic
SHPO	State Historic Preservation Office
SOP	Standard Operating Procedure
SOS	Scope of Service
TBS	T. Baker Smith, LLC
TIN	Triangulated Irregular Network
TY	Target Year
USACE	United States Army Corps of Engineers
UU	Unconsolidated Undrained

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.

In response to the devastating effects of Hurricanes Katrina and Rita in 2005, the Louisiana Legislature was directed to respond to this event through Act 8 of the First Extraordinary Session. Act 8 created the Coastal Protection and Restoration Authority (CPRA) of Louisiana, which is mandated to develop, implement, and enforce a comprehensive protection and restoration master plan for coastal Louisiana, as defined by the Louisiana Coastal Zone. As part of CPRA's mandate, the Authority has oversight over all matters relating to the study, planning, engineering, design, construction, extension, improvement, repair and regulation of integrated coastal protection projects and programs including CWPPRA projects. Further information pertaining to the CPRA may be obtained at http://coastal.la.gov.

Louisiana's Comprehensive Master Plan for a Sustainable Coast (hereinafter referred to as Master Plan) identifies projects designed to build and maintain land, reduce flood risk to citizens and communities, and provide habitats to support ecosystems. **Figure 1** depicts the 2017 Master Plan project concepts called for in the Calcasieu-Sabine basin. As shown, the CS-0078 restoration area (approximate vicinity shown) is consistent with Master Plan polygon 004.MC.23.

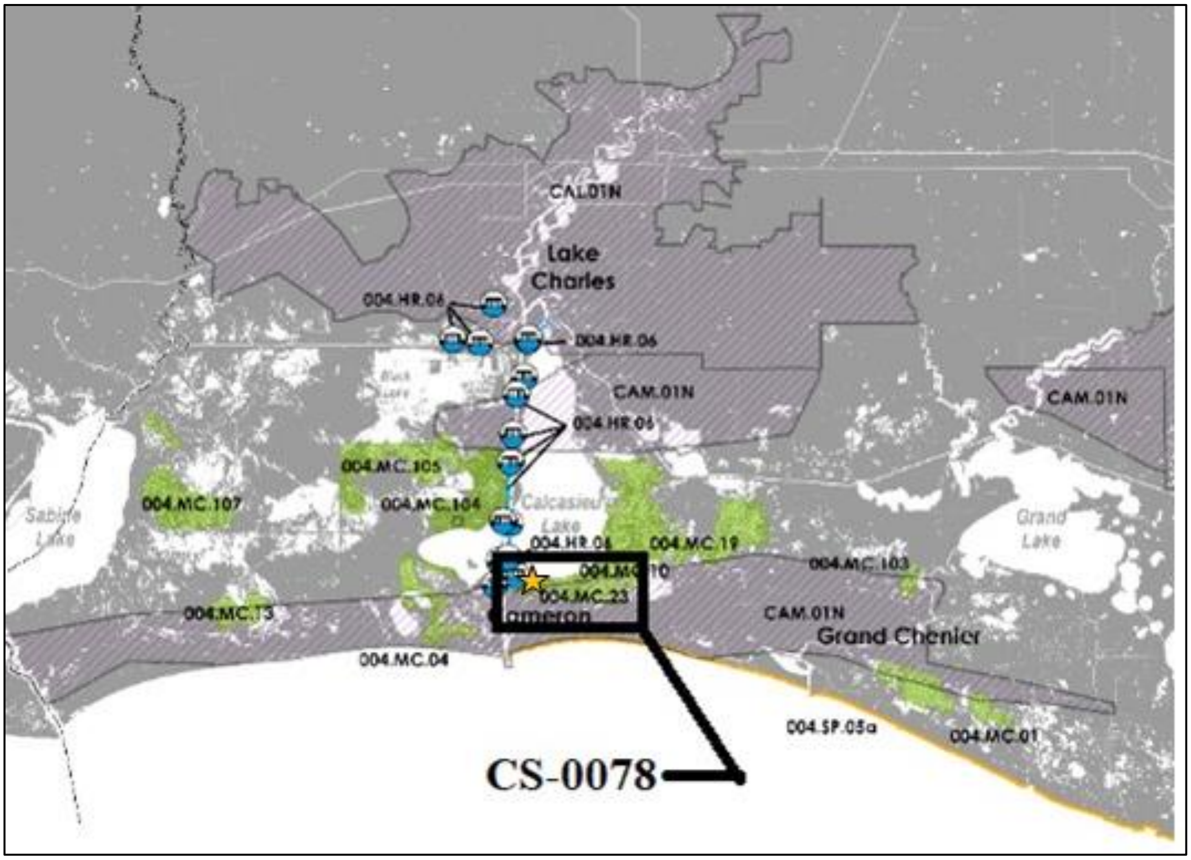


Figure 1: 2017 Master Plan Projects in Vicinity of CS-0078 (Marsh Creation Area Indicated by Star Symbol)

1.2 Project Funding, Sponsors, and Team

The No Name Bayou Marsh Creation and Nourishment Project (hereinafter referred to as CS-0078) is a CWPPRA project currently funded for Phase I (engineering and design) under the 24th Priority Project List (PPL 24). The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) is the Federal Sponsor and is also providing oversight on environmental compliance and cultural resources. CPRA is the Local Sponsor and is also the engineering and design lead. CPRA also entered into contracts with Ardaman & Associates, Inc. (AAI), Chustz Surveying, Inc. (CSI), T. Baker Smith, LLC (TBS), Tetra Tech, Inc., and associated subcontractors in order to support data collection needs for CS-0078, which are further explained in this report. **Figure 2** shows the CWPPRA Phase 0 authorized project map.

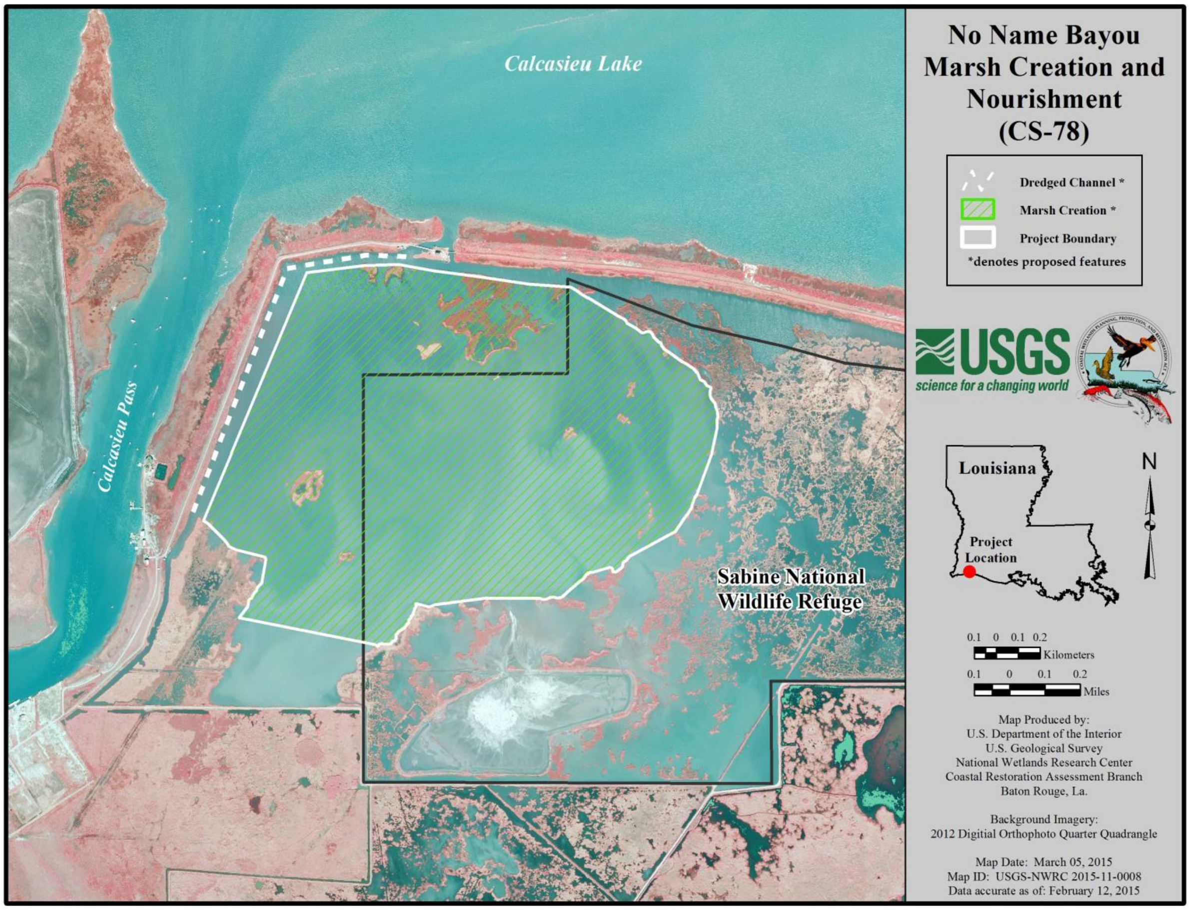


Figure 2: CS-0078 Phase 0 Authorized Project Map

1.3 Project Site Characteristics and Location

CS-0078 is located within the Calcasieu-Sabine Hydrologic Basin in Cameron Parish, with the proposed marsh creation area located approximately three (3) miles north of Cameron, LA. The proposed CS-0078 borrow area is located approximately four (4) miles to the northeast of the CS-0078 marsh creation area in Calcasieu Lake, along a straight-line distance. Equipment access is located to the north of the borrow area, along an east-west corridor connecting the northern extents of the borrow area to the Calcasieu Ship Channel (CSC). The proposed dredge pipe corridor is located predominantly within Calcasieu Lake and provides access connectivity between the marsh creation area and borrow area. A segment of the dredge pipe corridor is located within a canal adjacent to the southern end of the Cameron Creole Watershed (CCW) Levee. The dredge pipe corridor requires a levee crossing over the southern rim of Calcasieu Lake. **Figure 3** contains a vicinity map, with **Figure 4** showing a project layout. Higher resolution versions of these figures are available in the 95% Design Drawings in **APPENDIX H**.

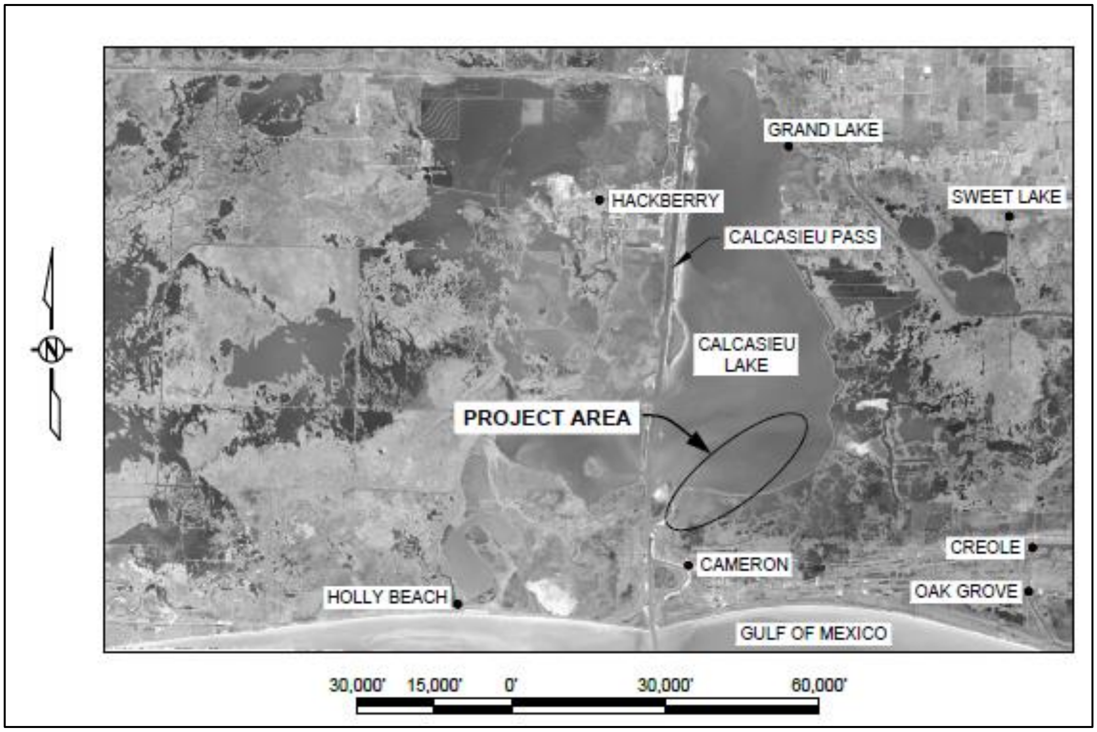
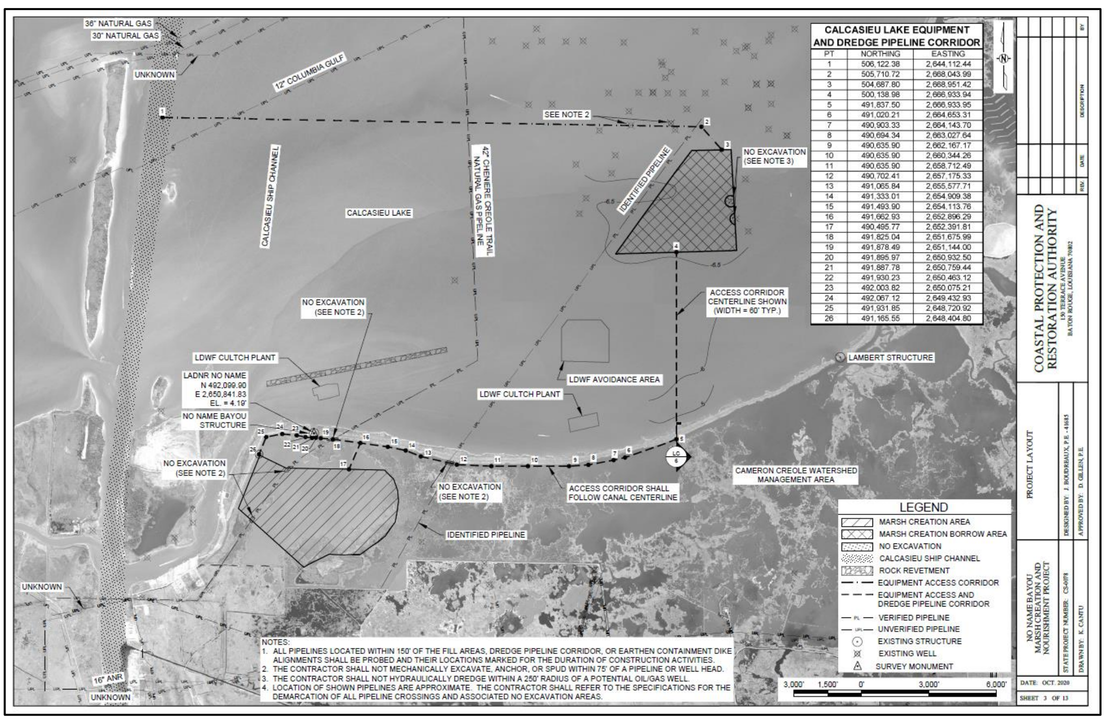


Figure 3: CS-0078 Site Vicinity



PT	NORTHING	EASTING
1	506,122.38	2,644,112.44
2	505,710.72	2,668,043.99
3	504,687.80	2,668,951.42
4	500,138.98	2,666,933.94
5	491,837.50	2,666,933.95
6	491,020.21	2,664,653.31
7	490,903.33	2,664,143.70
8	490,694.34	2,663,027.64
9	490,635.90	2,662,167.17
10	490,635.90	2,660,344.26
11	490,635.90	2,658,712.49
12	490,702.41	2,657,175.33
13	491,065.84	2,655,577.71
14	491,333.01	2,654,909.38
15	491,493.90	2,654,113.76
16	491,662.93	2,652,896.29
17	490,495.77	2,652,391.81
18	491,825.04	2,651,675.99
19	491,878.49	2,651,144.00
20	491,895.97	2,650,932.50
21	491,887.78	2,650,759.44
22	491,930.23	2,650,463.12
23	492,003.82	2,650,075.21
24	492,067.12	2,649,432.93
25	491,931.85	2,648,720.92
26	491,165.55	2,648,404.80

Figure 4: CS-0078 Project Layout

Note: The as-shown project features do not show the originally proposed Phase 0 borrow area. Further discussion is available on project feature modifications in **Section 3.0**.

1.4 Project Goals

The primary goals of CS-0078, as established in Phase 0 and as stated on the CWPPRA PPL 24 Project Fact Sheet, are to create and/or nourish 533 acres of saline marsh (502 acres marsh creation, 21 acres marsh nourishment, and 10 acres of creeks/ponds) south of Calcasieu Lake. In order to achieve this, the Phase 0 project concept called for approximately 3.5 million cubic yards of sediment to be hydraulically dredged from an upland disposal site east of the CSC. In addition to hydraulic dredging, the Phase 0 project included the clean out of approximately 5,000 linear feet (LF) of the CCW Levee borrow channel to facilitate water movement into the newly created area. Containment dikes were proposed around the marsh creation area to retain sediment during pumping. After pumping, the containment dikes would be degraded to the current platform elevation and gaps are to be excavated. Additionally, 251 acres of vegetative plantings would occur within the newly created areas to stabilize the platform and reduce time for full vegetation establishment. Construction of approximately 10,000 LF of tidal creeks and two (2) 2.5 acre (AC) ponds were proposed to facilitate the flow of water in and out of the project area. See **APPENDIX A** for the CWPPRA PPL 24 Project Fact Sheet and map.

Throughout Phase I, several changes occurred for CS-78. One major change entailed further evaluation and ultimately dropping use of the upland disposal site for borrow. Specific challenges include landrights complications, quantity of material available, and challenges in accessing the upland disposal site (see **Section 3.4**). This led to a borrow area alternatives analysis, in which three additional borrow area concepts were evaluated. Based on the results of this analysis, a final borrow area concept was established in Calcasieu Lake, which resulted in modifications to not only the borrow area feature but also the equipment access and dredge pipe corridor features. The marsh creation area also underwent revisions and was realigned slightly from its original configuration. Additionally, vegetative plantings and tidal creeks and ponds were removed during the course of Phase I, with vegetative plantings proposed during post-construction maintenance. The original project concept and project feature modifications made throughout Phase I are more fully discussed in **Section 3.0**.

2.0 EXISTING SITE CONDITIONS

2.1 Land Ownership

The entire marsh creation area is located on property owned by Henry McCall and the Cameron Prairie National Wildlife Refuge (CP NWR). The entirety of the borrow area is located in Calcasieu Lake on waterbottoms owned by the State of Louisiana. The access corridors are located on property owned by Henry McCall, CP NWR, Cameron Parish School Board, and the State of Louisiana. **Figure 5** contains a land ownership map of the entire project area, which was developed by CPRA using an internal land ownership database. The ownership will be verified prior to construction of CS-0078.

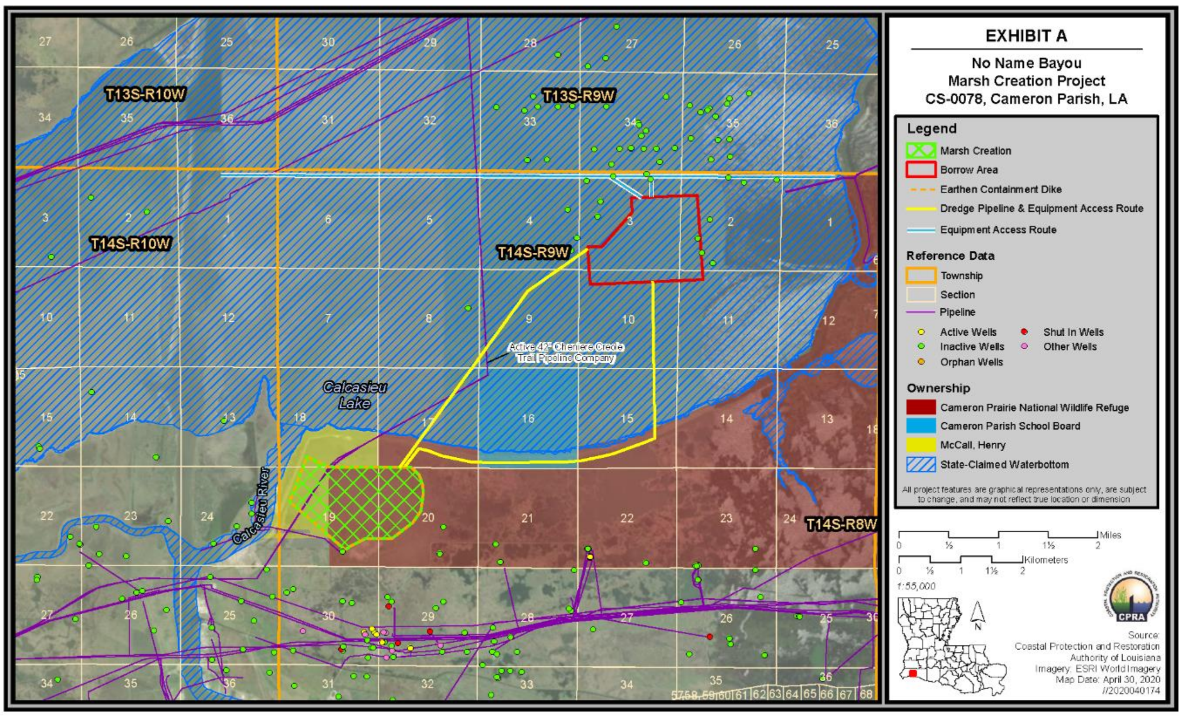


Figure 5: Land Ownership Map

2.2 Cultural Resources

The NMFS submitted a letter to the State Historic Preservation Office (SHPO) requesting a determination of effort for any Area of Potential Effects (APE) within the Phase 0 project area and borrow area. SHPO concurrence was received in January 2016. 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 known cultural sites. When the borrow area and access corridors were relocated to Calcasieu Lake, the NMFS and CPRA again reviewed historic records for the new APE and NMFS met with SHPO about the project in November 2019. The NMFS and CPRA do not anticipate project construction activities disturbing any known cultural sites. SHPO correspondence is included in **APPENDIX B**.

2.3 Oyster Resources

The Louisiana Department of Wildlife and Fisheries (LDWF) maintains oyster seed grounds that extend the entirety of the waterbottoms within Calcasieu Lake. The southeastern portion of Calcasieu Lake contains Tier II public oyster seed grounds. There are no oyster leases in the lake and the grounds have been recently closed or had limited openings. During the initial steps of scouting a potential borrow site within this area, NOAA and CPRA initiated formal correspondence with LDWF. Throughout this ongoing correspondence, CPRA tasked TBS with performing an oyster resources survey to identify potential CS-0078 project impacts to oyster resources within the area. CPRA compiled the findings of the TBS oyster resources survey together with a layout of CS-0078 project features with Oyster Lease Acquisition and Compensation Program (OLACP)-informed offset distances. The TBS oyster resource survey findings indicated the following.

1) The borrow area, western dredge pipe and access corridor, and eastern dredge pipe and access corridor were configured such that any potential CS-0078 project feature would maintain a distance of at least 1,500 FT from any known LDWF avoidance areas or LDWF cultch plant.

2) No newly identified oyster resource of any kind was found within the CS-0078 borrow area. The OLACP-expanded survey area was not found to contain any exposed shell resource or surficial firm substrate; however, buried shell was encountered in the southern end of this polygon.

3) The western dredge pipe and access corridor contained minimal amounts of newly identified resource, and overlapped with exposed shell and firm substrate only in two areas within the lower 100-foot section of the corridor. The OLACP-expanded survey area was found to contain some instances of exposed shell, firm substrate, and buried shell. The CS-0078 project team is prepared to realign the western dredge pipe and access corridor to minimize overlap with exposed shell, firm substrate, and buried shell.

4) The eastern dredge pipe and access corridor contained minimal amounts of newly identified resource, with only buried shell found within the upper and middle portions of the corridor. The OLACP-expanded buffer zone contained some areas of exposed shell, firm substrate, and buried shell. As currently positioned, the eastern dredge pipe and access corridor does not overlap with exposed shell. The CS-0078 project team is prepared to realign the eastern dredge pipe and access corridor to minimize overlap with exposed shell, firm substrate, and buried shell.

Figure 6 contains a plan-view depiction of this information.

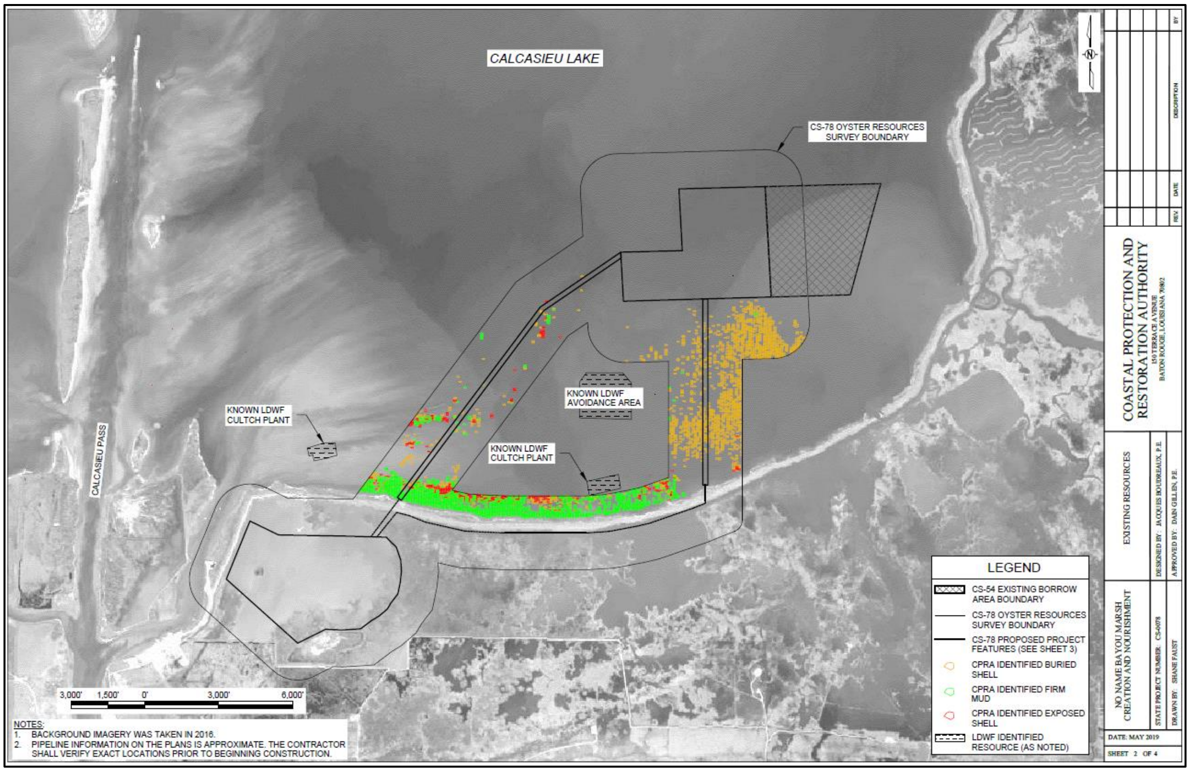


Figure 6: Oyster Resources at CS-0078

As required for geotechnical sampling, a Coastal Use Permit (CUP) application was submitted by CPRA. During review of the borrow area geotechnical sampling CUP, the permit was put on hold at the request of LDWF, who required formal consultation due to the geotechnical sampling activities being proposed within the Tier II oyster seed ground. CPRA shared the results of the TBS oyster survey together with the layout of CS-0078 project features (shown in **Figure 6**) with LDWF.

LDWF required that the CUP include special permit conditions. CPRA agreed to make data collection service providers aware of the requested special conditions. CPRA also agreed to maintain formal correspondence throughout the design of CS-0078 and to hold a future meeting with LDWF following Phase II funding in order to verify that all LDWF permit conditions would be made known to construction contractors. LDWF produced a Letter of No Objection (LONO) allowing permit issuance to proceed with geotechnical sampling operations within Calcasieu Lake. This letter is included in **APPENDIX C**. **APPENDIX D** contains the oyster resource survey deliverables submitted by TBS.

2.4 Hydrologic Conditions

Throughout the design of CS-0078, the project team looked to the CS-0054 project as a key reference. Because both projects have fill areas existing within the CCW, hydrologic site conditions were understood to be similar, and therefore the CS-0078 team felt it important to compare decision-making across both projects.

Marsh creation projects are conventionally designed with respect to key hydrologic site conditions, such as tidal datum. Typically, the primary objective for computing the tidal datum is to establish the constructed marsh fill elevation (CMFE) that maximizes the duration that the restored marsh will exist within an intertidal elevation range throughout the 20 year project life. With the primary goal of designing saline marsh, the CS-0078 team began calculating a tidal datum and considered the tidal datum throughout design. In comparison with CS-0054, it is noteworthy that both projects experience a tidal range of somewhere around 2 to 3 inches.

The small tidal range observed in the CS-0078 and CS-0054 projects is a function of the management and operations of the structures associated with the CS-04A Cameron Creole Maintenance Project. The CS-04A project comprises five (5) total hydrologic control structures. The closest structure (No Name Bayou Structure) is located within one (1) mile from the CS-0078 project site. The effect of this management regime on the CS-0078 and CS-0054 project areas result in an extreme attenuation of the natural tidal signature experienced in nearby areas not located within the CCW management area. The CCW management area is the hydrologically managed area that exists within the marshes along the southeastern and south central portions of Calcasieu Lake. The CS-0078 marsh creation area is within the CCW management area. Both project teams determined that it was not feasible to base the selection of CMFE on a tidal signature that is less than a realistic hydraulic dredging construction tolerance, which is typically no less than 3 to 6 inches.

In order to design within the hydrologically managed CCW, other hydrologic indicators, such as percent inundation and mean tide level (MTL), were incorporated throughout the CS-0078 design process, which are further explained in **Section 4.0**. The marsh creation area design process is also further explained for the as-proposed CS-0078 95% design and is available in **Section 7.0**. **Figure 7** below shows the CS-0054 project site in relation to CS-0078.

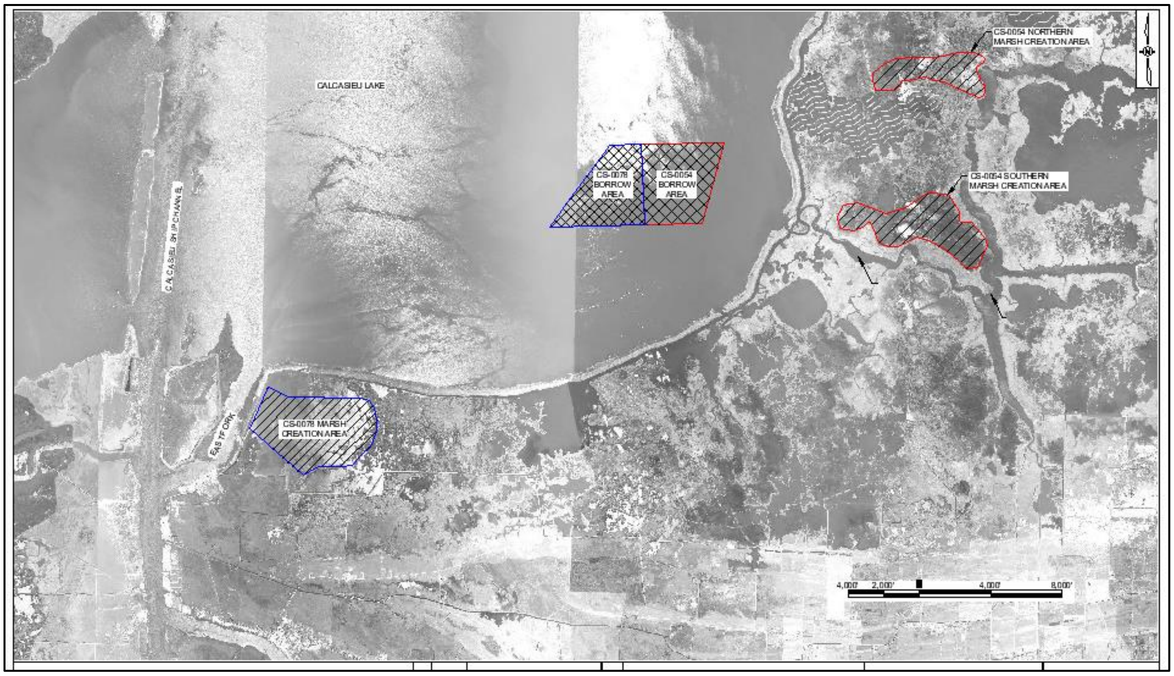


Figure 7: CS-0054 In Relation to CS-0078

2.5 Hazardous, Toxic, and Radioactive Waste

CPRA procured hazardous, toxic, and radioactive waste (HTRW) data collection services from Tetra-Tech as part of a Phase I Environmental Site Assessment. Findings indicate that no evidence of recognized environmental conditions (RECs) were discovered at the subject property. The full HTRW report is available in **APPENDIX I**.

3.0 PROJECT FEATURE MODIFICATIONS DURING PHASE I

3.1 General

The original CS-0078 project concept called for the use of borrow material from the United States Army Corps of Engineers (USACE) Confined Disposal Facility "M" (CDF-M) bordered by the CSC to the west and south, Calcasieu Lake to the north, and East Fork to the east. The idea was that the hydraulically placed material located in CDF-M was a readily available source of dredge fill material that could be beneficially used to restore the nearby CS-0078 fill site located just to the east of East Fork. However, due to the encountered complexity in hydraulically mining sediment from the upland disposal site, the CS-0078 project team abandoned the original project concept and elected to perform a borrow area alternatives analysis which is further discussed in **Section 3.4**. The final selection of the borrow area also resulted in a modification to the equipment access and dredge pipe corridors. The original marsh creation area was twice reconfigured, once to satisfy a requirement of the landowner and another time to improve containment dike constructability. This is further discussed in **Section 3.3**.

3.2 Phase 0 Project Layout

Figure 8 below depicts the originally proposed project concept with the CDF-M site shown to the west as the originally intended borrow site. **Figure 2** shows the originally proposed fill area, with **Figure 8** below showing a slightly modified fill cell configuration (further explained in **Section 3.3**).

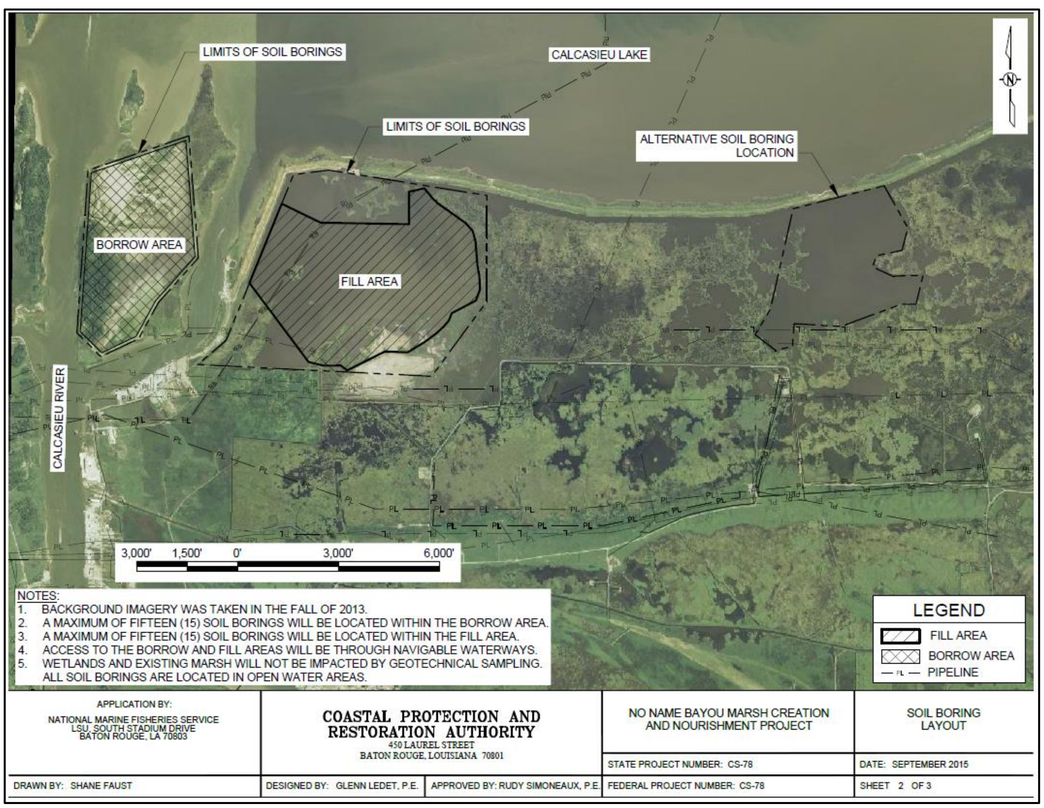


Figure 8: CS-0078 Project Concept with CDF-M Borrow

3.3 Marsh Creation Area

Figure 9 through **Figure 12** below show the four (4) marsh creation area alternatives analyzed throughout Phase I for CS-0078. Additional information is included in **Table 1** such as acreage, estimated in-place cubic yardage, estimated containment dike length, and additional notes. In August 2015, the Phase 0 alternative (MCA Alternative 1) was changed to remove the northwest section of the marsh creation area (MCA Alternative 2) at the request of the landowner of that property. The northeast corner of the marsh creation area was removed in May 2017 following geotechnical analysis (MCA Alternative 3). MCA Alternative 4 was also delineated, which is an option that is located completely on the refuge in case an issue occurs with landrights. **Table 1** contains summary information for the marsh creation area alternatives.

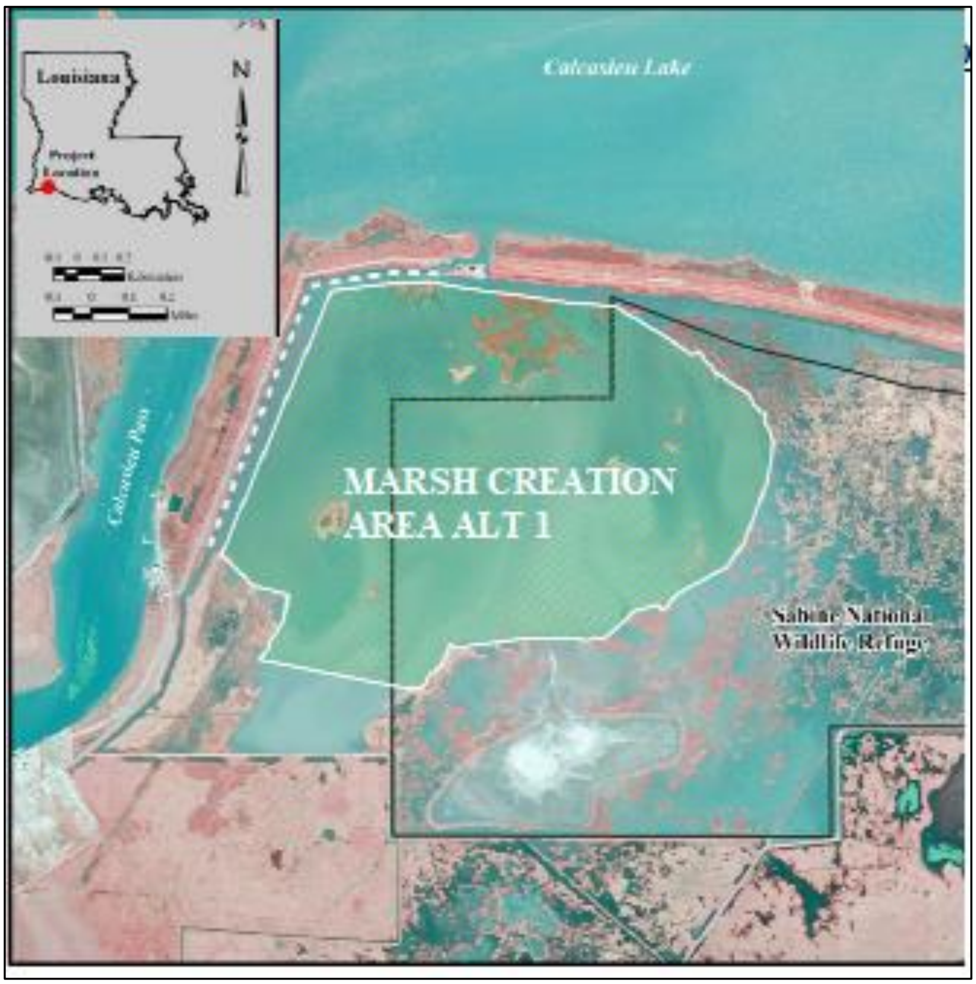


Figure 9: Marsh Creation Area Alternatives (1 of 4)

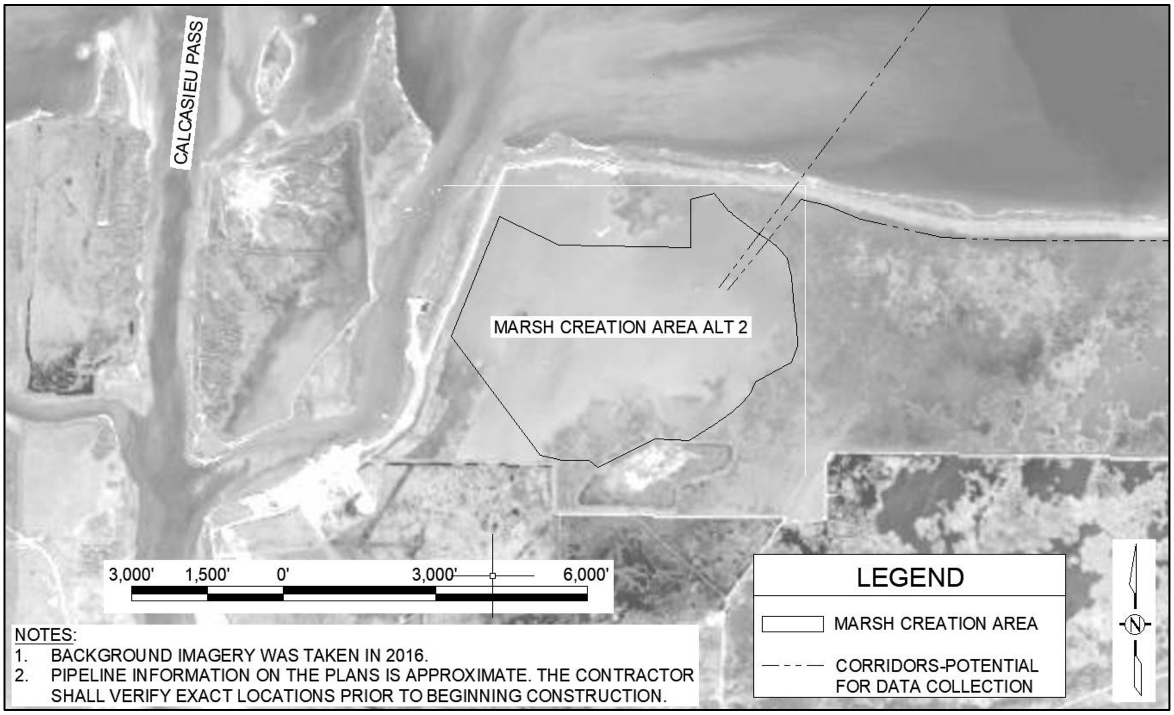


Figure 10: Marsh Creation Area Alternatives (2 of 4)

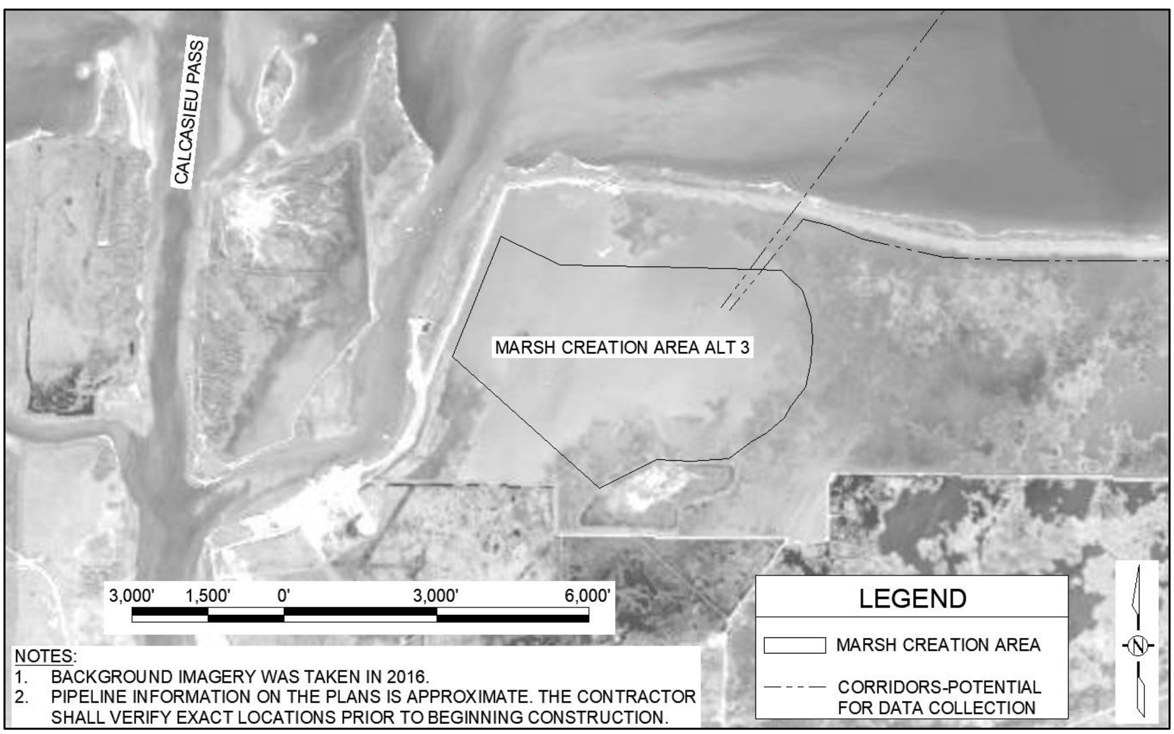


Figure 11: Marsh Creation Area Alternatives (3 of 4)

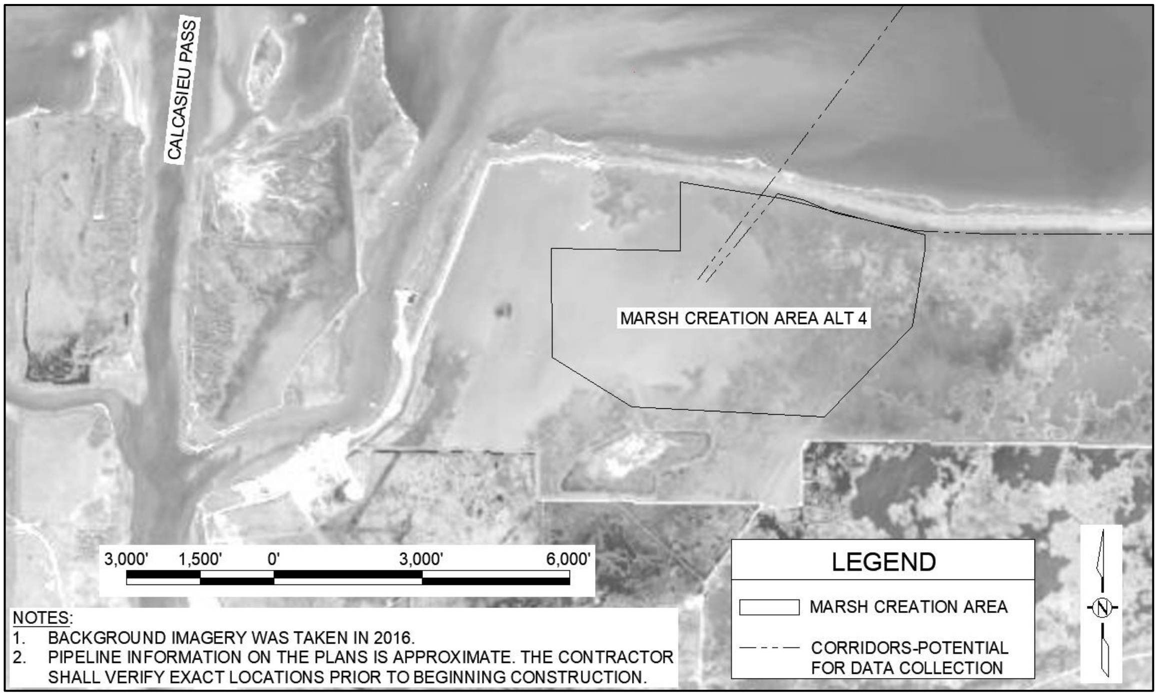


Figure 12: Marsh Creation Area Alternatives (4 of 4)

Table 1: Summary of Marsh Creation Area Alternatives

MCA Alternative	Total Proposed Creation Acreage	Total In-Place Cubic Yardage	Total Containment Dike Linear Footage	Additional Details
1	533 AC	2,281,624 CY	19,258 LF	• Phase 0 polygon • includes external dike borrow • located on private and refuge property • offset from southern mitigation site
2	557 AC	2,126,945 CY	20,630 LF	• Phase I revision (July 2016) • includes external dike borrow • located on private and refuge property • shares boundary with mitigation site
3	540 AC	2,010,243 CY	19,424 LF	• Phase I revision (May 2017) • includes external dike borrow • located on private and refuge property (with northeastern boundary modified from Alt. 2) • shares boundary with mitigation site
4	606 AC	2,051,166 CY	21,597 LF	• Phase I revision (September 2019) • does not include external dike borrow • located only on refuge property, maintains 100’ offset from property line • does not share boundary with southern mitigation site, maintains 200’ boundary • extends to limit of survey data collection coverage • dredge pipe corridor landing centralized

3.4 Borrow Area

3.4.1 Borrow Area Alternatives Analysis

As previously mentioned, the CDF borrow area concept was further evaluated and was ultimately ruled out on the basis of constructability and landrights concerns. Significant access dredging would be required in order to access CDF-M with a large hydraulic dredge. In addition, dredging CDF-M would necessitate the removal of a substantial portion of the original (native) land leaving a large open water area with no certainty of refilling rates. The existing landrights agreements that are in place are not sufficient to dredge the required quantity of material and would require updating.

Similar to the marsh creation area feature, the borrow area feature for CS-0078 went through an alternatives analysis and three (3) alternatives were compared. Contrary to the marsh creation area alternatives analysis, the Phase 0 borrow area concept was ruled out prior to the commencement of the borrow area alternatives analysis. Factors considered in the borrow area alternatives analysis included constructability, practicability, and cost. The below sections display figures that show the spatial orientation of each borrow area alternative and the envisioned conveyance corridor relative to the marsh creation area. **Section 3.5** then discusses the Phase I preferred project layout, with emphasis on the selected borrow area alternative.

3.4.2 Borrow Area Alternative 1 – Monkey Island Loop Pass

Figure 13 shows a plan-view depiction of the alternative developed for Borrow Area Alternative 1, the Monkey Island Loop Pass borrow area. This borrow area was selected because a permit application to dredge the Cameron Loop, on the east side of Monkey Island, had previously been submitted by Lonnie G. Harper & Associates, Inc.

Figure 13: Borrow Area Alternatives (1 of 3)

3.4.3 Borrow Area Alternative 2 – Offshore

Figure 14 shows a plan-view depiction of the alternative developed for Borrow Area Alternative 2, the offshore borrow area. This borrow area would be located in nearshore waters west of the CSC, adjacent to the CS-0059 and CS-0079 borrow areas. Although these borrow areas are slightly more than three (3) miles offshore, they are not located in Outer Continental Shelf waters and would not require a Bureau of Ocean Energy Management sand lease. The sediment pipeline would likely be laid along the Cameron Loop around Monkey Island instead of the CSC to reduce the number of landowner agreements necessary to construct the project.

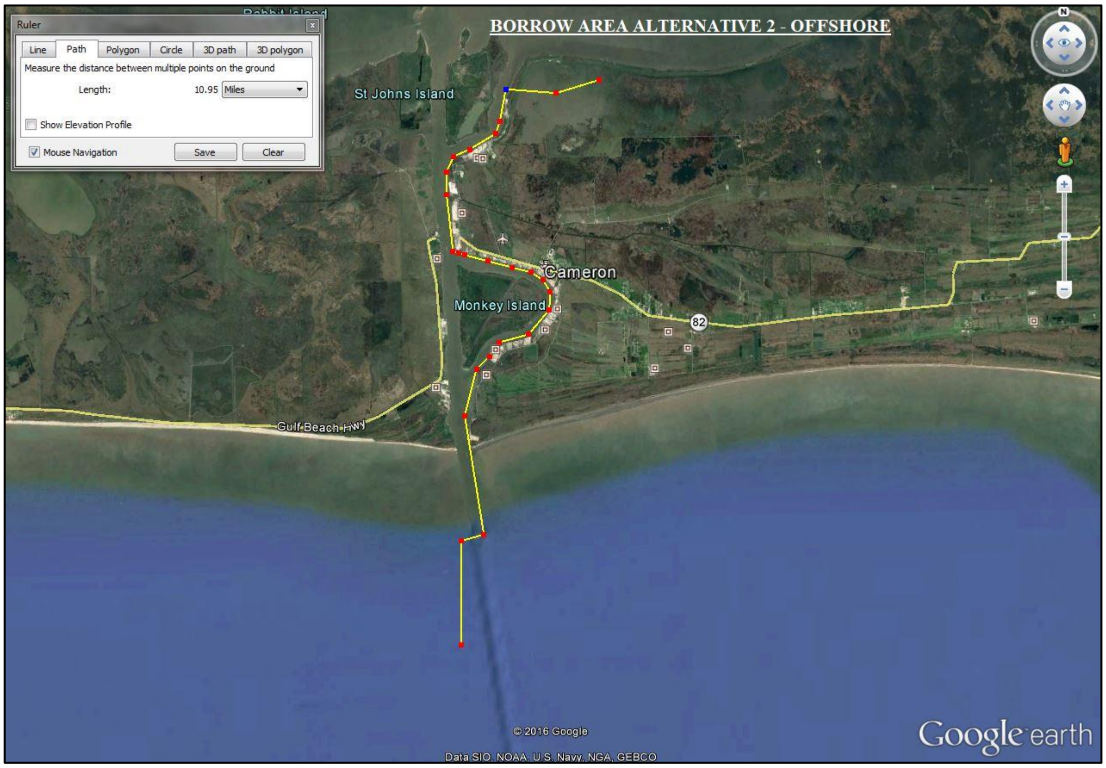


Figure 14: Borrow Area Alternatives (2 of 3)

3.4.4 Borrow Area Alternative 3 – Calcasieu Lake

Figure 15 shows a plan-view depiction of the alternative developed for Borrow Area Alternative 3, the Calcasieu Lake borrow area. This alternative is adjacent to the CS-0054 borrow area. Two (2) sediment pipeline routes were considered. The first route would be southwest from the borrow area along a straight line route between the borrow area and the marsh creation area. The second route would be due south of the borrow area and would connect to the marsh creation area via the CCW Levee rim canal. **Section 3.5** contains more discussion.

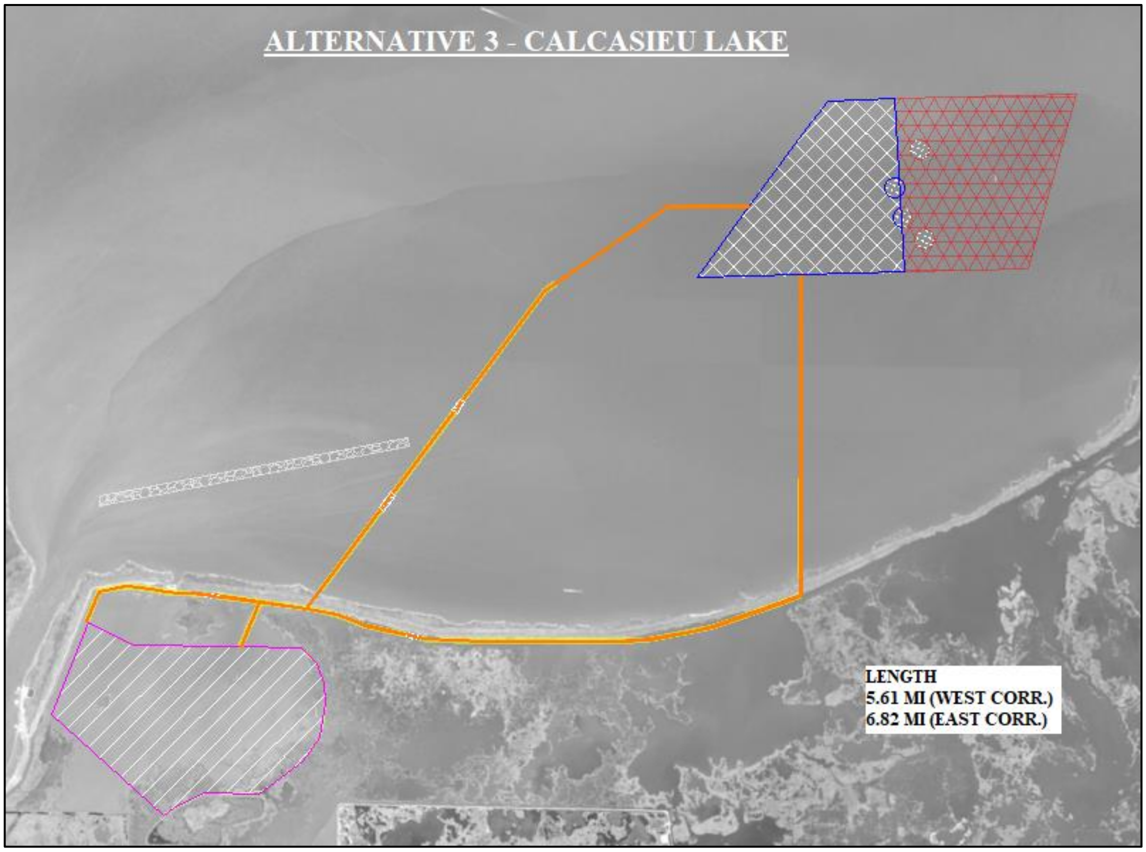


Figure 15: Borrow Area Alternatives (3 of 3)

3.4.5 Borrow Area Alternatives Analysis

During analysis of the Monkey Island Loop Pass (BA Alternative 1), existing geotechnical data and geotechnical analysis indicated that the material was not preferable for a borrow source due to the preponderance of organic content and associated settlement issues. There were concerns that the site would have insufficient material and that access dredging outside the proposed project area would be necessary, creating potential cultural issues around Monkey Island and dredging around existing infrastructure. Because of this and other risk factors, BA Alternative 1 was dropped from consideration.

The Offshore Borrow Area (BA Alternative 2) was dropped from consideration due to the excessive pump distance, potentially unfavorable offshore marine conditions, potential landrights issues along the CSC for the dredge pipe corridor, and possible geotechnical issues.

The Calcasieu Lake Borrow Area (BA Alternative 4) is subject to more favorable inshore conditions, benefits from a shorter pump distance, and has the history of the CS-0054 dredging effort having been successful for marsh creation. As revealed through the borrow area alternatives analysis, BA Alternative 4 was the preferred borrow area alternative, in terms of constructability, practicability, and cost.

3.5 Phase I Preferred Project Layout (30% Design)

Figure 4 shows the as-proposed CS-0078 project layout presented for the 30% Design milestone. This design utilizes marsh creation area Alternative 3 (shown in **Figure 11**) along with borrow area Alternative 3 (shown in **Figure 15**). The following further details out the results of the borrow area alternatives analysis.

Table 2 through **Table 4** summarize the conclusions reached during the borrow area alternatives analysis for each borrow area alternative.

Table 2: Borrow Area Alternatives Analysis, Summary Table - Alternative 1

ALTERNATIVE 1 – INSHORE CHANNEL BORROW (CALCASIEU LOOP PASS)	
Attribute	**Risk Level**
Maximum Pump Distance (7 MI[1])	Moderate
Estimated Level of Complexity on Mobilization /Demobilization Regime[2]	High
Expected Engineering Risk of Developing Borrow Area[3]	High
Degree of Certainty that Borrow Volume Can Meet Project Goals	Moderate
Preliminary Assessment of Material Quality and Expected Performance for Marsh Creation Application	Low to Moderate
Total Estimated Construction Cost Plus Contingency[4]	Moderate to High

1. **MI stands for "Miles".**
2. **Mobilization/Demobilization includes estimated costs for equipment and plant positioning plus associated access dredging and surveying. In Alternative 1, additional costs are envisioned for crossing with LA HWY 82 and CSC.**
3. **Due to the existence of port infrastructure, combined with the knowledge that maintenance dredging seldom occurs within Alternative 1, the CS-0078 project team identified the engineering risk of this borrow area to be high, given that virgin cuts into the existing borrow area channel bank were likely be required.**
4. **25% construction contingency utilized in preliminary construction cost estimate.**

Table 3: Borrow Area Alternatives Analysis, Summary Table - Alternative 2

ALTERNATIVE 2 – OFFSHORE BORROW (CS-59, CS-79 BORROW AREA)	
Attribute	**Risk Level**
Maximum Pump Distance (11 MI)	High
Estimated Level of Complexity on Mobilization /Demobilization Regime[1]	High
Expected Engineering Risk of Developing Borrow Area	Moderate
Degree of Certainty that Borrow Volume Can Meet Project Goals	High
Preliminary Assessment of Material Quality and Expected Performance for Marsh Creation Application	Moderate to High
Total Estimated Construction Cost Plus Contingency[2]	High

1. **Mobilization/Demobilization includes estimated costs for equipment and plant positioning plus associated access dredging and surveying. In Alternative 2, additional costs are envisioned for crossing with LA HWY 82 and CSC.**
3. **25% construction contingency utilized in preliminary construction cost estimate.**

Table 4: Borrow Area Alternatives Analysis, Summary Table - Alternative 3

ALTERNATIVE 3 – INSHORE BORROW (CS-54 BORROW AREA)	
Attribute	**Risk Level**
Maximum Pump Distance (5 MI)	Low
Estimated Level of Complexity on Mobilization /Demobilization Regime[1]	Low to Moderate
Expected Engineering Risk of Developing Borrow Area	Low to Moderate
Degree of Certainty that Borrow Volume Can Meet Project Goals	High
Preliminary Assessment of Material Quality and Expected Performance for Marsh Creation Application	Moderate
Total Estimated Construction Cost Plus Contingency[2]	Moderate

1. **Mobilization/Demobilization includes estimated costs for equipment and plant positioning plus associated access dredging and surveying.**
2. **25% construction contingency utilized in preliminary construction cost estimate.**

As revealed through the borrow area alternatives analysis, the lowest cost increase borrow alternative was Alternative 3, Calcasieu Lake. While the Calcasieu Lake borrow area does have potential regulatory challenges involving oyster resources, the CS-0078 project team felt this was the preferred borrow area alternative when comparing across other available options.

Regarding oyster resources, **Section 2.3** goes into detail on the considerations taken in selecting the Calcasieu Lake alternative as the preferred borrow site for CS-0078 Phase I. Much of the discussion in **Section 2.3** has to do with first identifying known LDWF oyster resources and then procuring additional data collection services to identify more known resource. **Figure 16** below illustrates a preliminary depiction of the orientation of CS-0078 project features in relation to known LDWF oyster resources infrastructure.

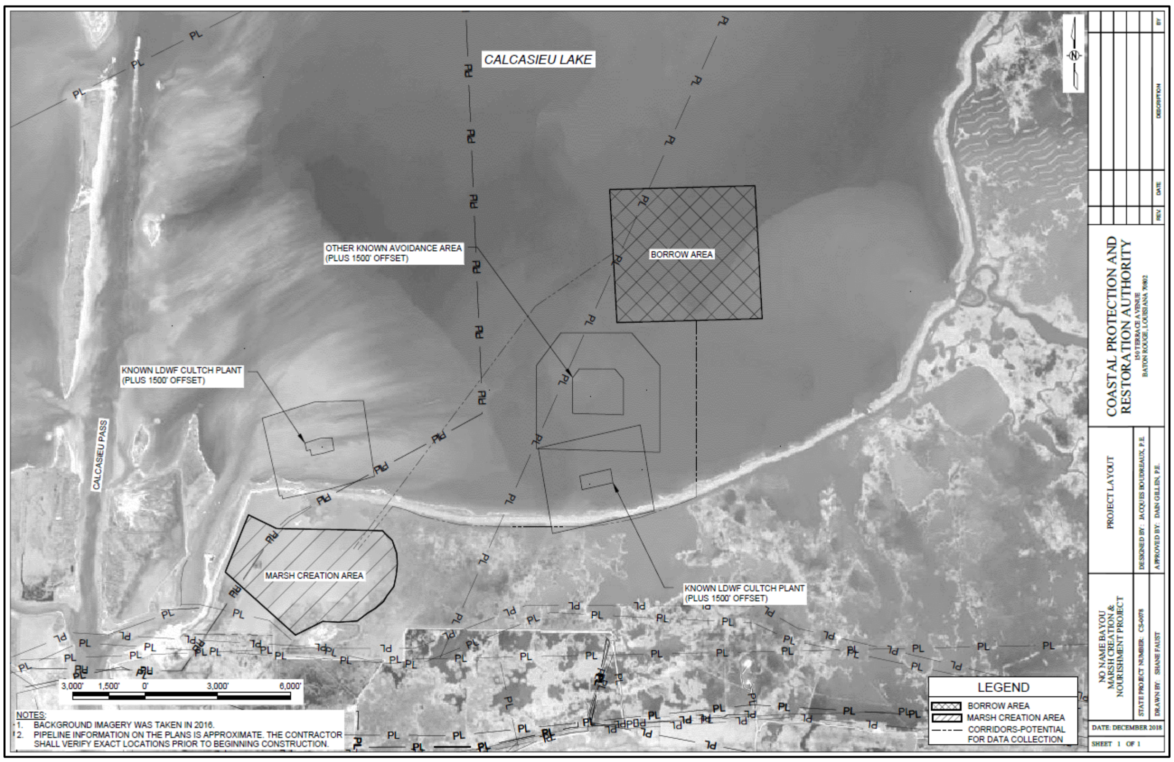


Figure 16: Preliminary CS-0078 Project Features in Relation to LDWF Polygons

4.0 HYDROLOGIC SITE CONDITIONS

4.1 Introduction and Site-Specific Considerations

As discussed in **Section 2.4**, conventional marsh creation design relies on a tidal datum determination. For the reasons explained in that section, it was determined that basing the selection of CMFE on the compressed tidal datum observed at CS-0078 would not be suitable for the project site, and therefore the design team elected to execute marsh fill settlement analyses in an alternate fashion. During geotechnical design, the CS-0078 design team requested preliminary submittals from the geotechnical engineering team at AAI (see **Section 6.0** for more information) while hydrologic project design was ongoing. While contrary to the typical course of action on most marsh creation projects, these preliminary settlement curves were instrumental in assisting the team for the decision making process of not only target pump elevation, but also in how to best interpret hydrologic data extracted from the hydrologically restricted site at CS-0078.

The sections that follow discuss the steps taken leading up to the commencement of geotechnical tasking, where conventional analyses of hydrologic site conditions were performed. Following these sections, **Section 4.5** details the modifications made to this conventional approach, for the project-specific case of CS-0078, wherein marsh creation settlement analyses were conducted in conjunction with hydrologic analyses.

4.2 Tidal Conditions

The tidal datum is a standard elevation defined by a certain phase of the tide and is used to measure local water levels and establish design criteria. Typically, the primary objective for computing the tidal datum is to establish the CMFE that maximizes the duration that the restored marsh will be at intertidal elevation throughout the 20-year project life. The tidal datum for CS-0078 was established and utilized in the early stages of preliminary design for surveys, geotechnical analysis, and assessing 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), MTL, and mean tidal range (MTR) over a specified period of time. MHW is the arithmetic mean of all daily high water surface elevations observed over one tidal epoch. MLW is the arithmetic mean of all daily low water surface elevations observed over one tidal epoch. MTL is the mean of MHW and MLW for that time period, and MTR is the difference between MHW and MLW.

Coastwide Reference Monitoring System (CRMS) monitoring station CRMS0644, located approximately one (1) mile east of the marsh creation area, was utilized to obtain water surface elevation data. This control station was selected because of its location in relative proximity to the CS-0078 marsh creation area and because it is known that CRMS0644 experiences similar hydrologic conditions as the CS-0078 marsh creation area. The period of record used CRMS0644 was August 2014 to August 2019, a five-year period as per Appendix D of the CPRA Marsh Creation Design Guidelines (MCDG). A detailed summary of the tidal datum calculations is shown in the Calculations Packet in **APPENDIX E**. The results of the tidal datum determination for the CS-0078 project are shown in **Table**

5. **Figure 17** depicts the spatial orientation of CRMS0644 in relation to the as-proposed project features.

Table 5: Tidal Datum Evaluation

CRMS Station	MHW [FT[1], NAVD88, GEOID12B]	MLW [FT[1], NAVD88, GEOID12B]	MTL [FT[1], NAVD88, GEOID12B]	MTR [FT[1]]
CRMS0644	+0.91	+0.78	+0.84	0.13

1. FT stands for "US Survey Foot".

Figure 17: Location of CRMS0644 Continuous Recorder near CS-0078

4.3 Sea Level Rise Conditions

All projects funded through CWPPRA are designed and constructed based on a 20-year project life. In order to properly design CS-0078 and ensure it is built and performs in accord with project goals, certain natural processes such as eustatic sea level rise (ESLR) and subsidence must be assessed. The combination of these two processes, termed relative sea level rise (RSLR), was analyzed for the purposes of the CS-0078 project.

ESLR is defined as the global change in water level that accounts for a number of variables such as thermal expansion, the loss of glaciers and ice caps, and runoff from thawing permafrost, to name a few. CPRA's Planning & Research Division has produced guidance literature for use in forecasting ESLR rates of change consistent with the 2017 Master Plan. These rates are parameterized across multiple sea level rise scenarios that range from 0.5 to 1.98 total meters of sea level rise by 2100 to account for uncertainty. It is recommended by the CPRA Planning & Research Division to use the 1.0 meter (medium) scenario for the purposes of marsh creation project design having a 20-year design life. The annual rate of increase in ESLR under this scenario is approximately 0.29 in/yr (7.3 mm/yr). In the case of CS-0078, this accounts to 0.48 ft of ESLR over the 20-year project life.

Subsidence is defined as the local decrease (settlement) in land surface elevation relative to a fixed datum. For the CS-0078 project area, the expected rate of subsidence was determined using information obtained from the 2017 Master Plan and guidance literature produced by CPRA's Planning & Research Division. According to these sources, the CS-0078 project area experiences a subsidence rate of 4.3 mm/yr and a corresponding 0.76 ft of RSLR for the "1.0-m by the year 2100" scenario over the 20-year project life. See **Figure 18** for a graphic depicting subsidence rates across coastal Louisiana.

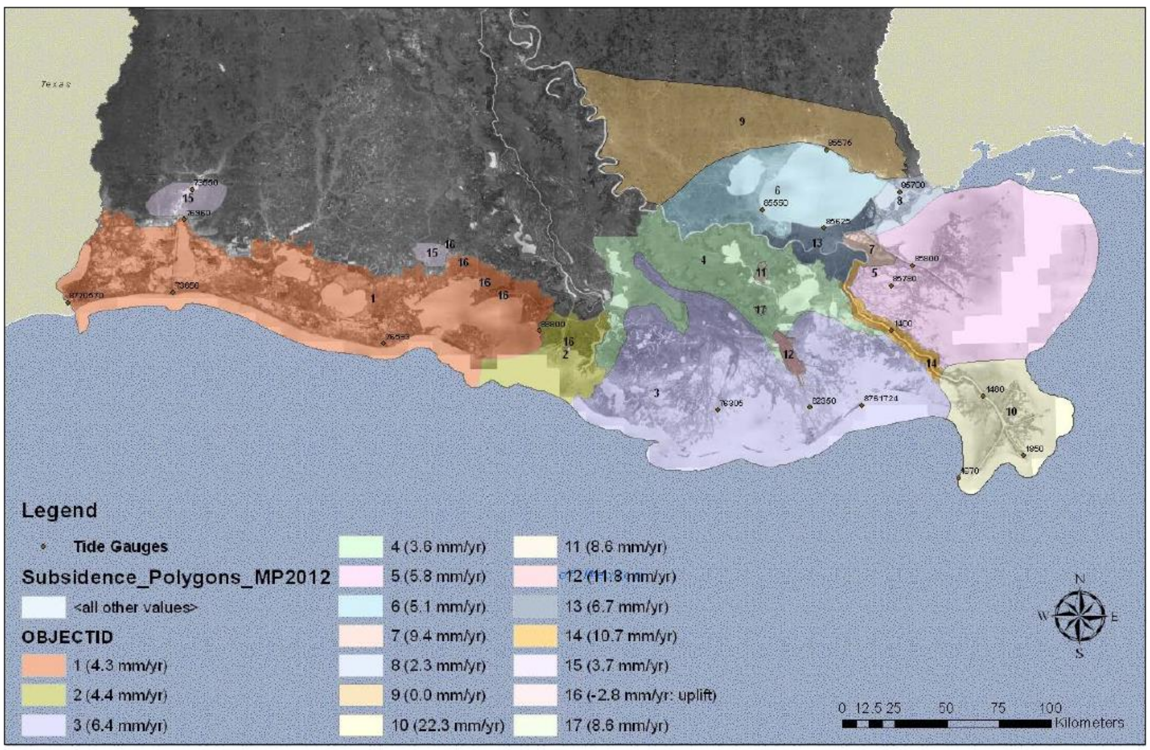


Figure 18: Master Plan Subsidence Rates by Region

ESLR rates were used to project expected increases in tidal datum values calculated. **Table 6** contains an array of these values combined with the expected rates of subsidence applied to predict RSLR across the CS-0078 design life. Note that future sections of this report detail how CS-0078 applies subsidence directly to geotechnical settlement simulation outputs, while ESLR is applied directly to hydrologic indices.

Table 6: Subsidence, ESLR, and RSLR According to TY

Target Year (TY[1])	Subsidence[2] [FT]	ESLR[2] [FT]	RSLR[2] [FT]
2021 (TY0)	0.0000	0.0000	0.0000
2022	0.0141	0.0240	0.0381
2023	0.0282	0.0479	0.0761
2024	0.0423	0.0719	0.1142
2025	0.0564	0.0958	0.1522
2026	0.0705	0.1198	0.1903
2027	0.0846	0.1437	0.2283
2028	0.0987	0.1677	0.2664
2029	0.1128	0.1916	0.3044
2030	0.1269	0.2156	0.3425
2031	0.1410	0.2395	0.3805
2032	0.1551	0.2635	0.4186
2033	0.1692	0.2874	0.4566
2034	0.1833	0.3114	0.4947
2035	0.1974	0.3353	0.5327
2036	0.2115	0.3593	0.5708
2037	0.2256	0.3832	0.6088
2038	0.2397	0.4072	0.6469
2049	0.2538	0.4311	0.6849
2040	0.2679	0.4551	0.7230
2041 (TY20)	0.2820	0.4790	0.7610

1. **TY stands for "target year".**
2. **Values shown for an annual incremental basis relative to TY0.**

4.4 Percent Inundation Determination

Historically the tidal range between MHW and MLW has been the accepted range for marsh creation design. However, this approach only takes into account the tidal influences on 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 observed water levels in any given region. In order to account for tidal and non-tidal influences, observed tide elevations, versus predicted tide elevations, are considered.

An additional method to bracket the marsh elevation range is the Percent Inundation Method, which was utilized for CS-0078. The vertical positioning of marsh platforms and the frequency with which the marsh floods strongly influences plant communities and marsh health (Visser 2003, Mitsch 1986). Percent inundation refers to the percentage of the year a certain elevation of wetlands is expected to be inundated and has become utilized as a proxy for marsh inundation occurrence in addition to tidal range. To determine percent inundation, percentiles were calculated based on data gathered from CRMS0644 that were then ranked statistically. In consult with Appendix D of the MCDG, the preferred percent inundation for vegetative saline marsh function, which is the marsh type classification for the project area, is between 20% and 80% (Snedden and Swenson 2012). **Table 7** presents the results of the percent inundation determination along with MTL (note the decision to produce settlement analyses with MTL shown in lieu of MHW and MLW) for the design life of CS-0078. Additionally, the 50^{th} and 80^{th} percent inundation values are presented. **Figure 19** shows a graphical representation of the preferred inundation range for CS-0078, with percent inundation data and tidal datum obtained from CRMS0644 shown, as well as the average elevation of reference marsh surveys. A detailed summary of the percent inundation calculations is available in the Calculations Packet in **APPENDIX E**.

Table 7: Percent Inundation Calculated Values

Percentile/ Tidal Datum	TY0 Percent Inundation Elevation [FT NAVD88 GEOID12B]	TY20 Percent Inundation Elevation [FT NAVD88 GEOID12B]
1	+2.07	+2.55
20	+1.22	+1.70
50	+0.86	+1.34
MTL	+0.84	+1.32
80	+0.50	+0.98
99	+0.00	+0.48

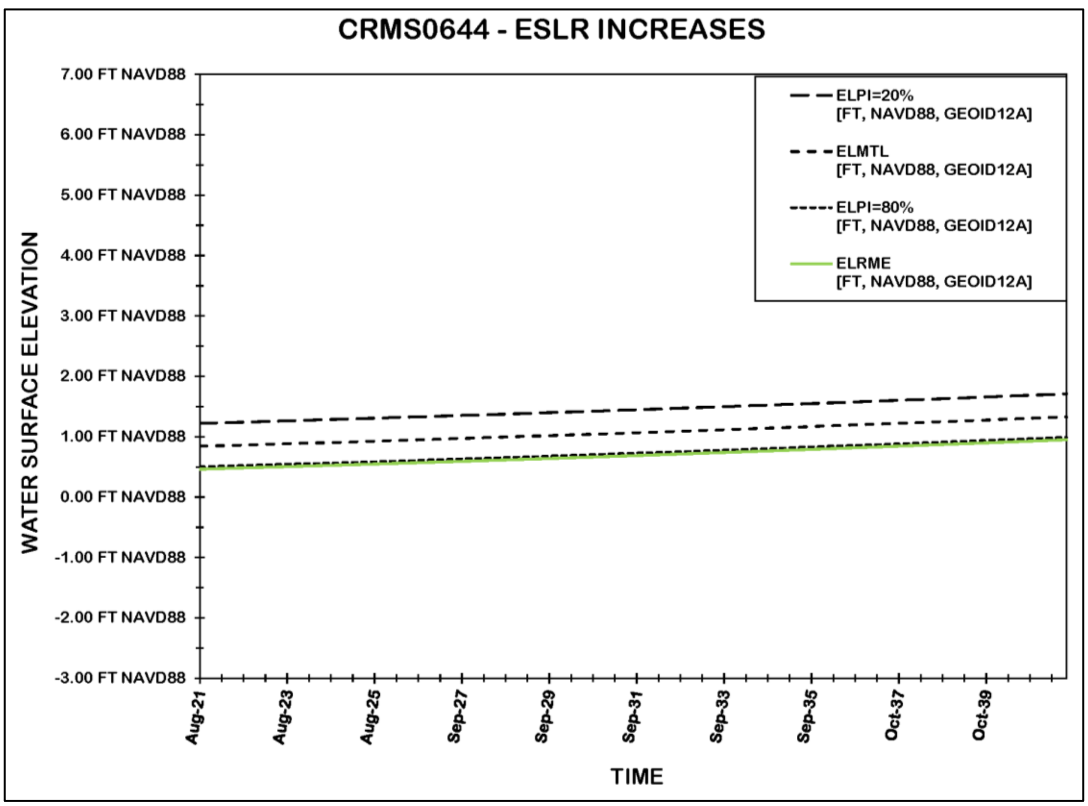


Figure 19: Percent Inundation, MTL, and Reference Marsh Elevations for CS-0078

Accretion is another physical process that has the potential to affect marsh creation design. In environments where alluvial deposition of sediments are anticipated, marsh creation design calls for the assumption of some elevation change resulting from accretion rates. In the case of CS-0078, accretion guidance suggests that a rate of accretion of 0.3 cm/yr can be attributed beginning at Target Year 6 (TY6) and beyond. For the purposes of 30% design, this value is being excluded for the purposes of making conservative cost estimation assumptions. However, the team has consulted with internal CPRA personnel on accretion and have discussed incorporating accretion into the design for 95%. However, due to uncertainty with alluvial deposition capability within the CCW, and in order to remain conservative for volume estimation purposes, volume calculations did not take into account any elevation gain due to accretion for 95% design.

4.5 Modifications to Conventional Hydrologic Design Approach Implemented for CS-0078

As stated in previous sections of this report, implementing restoration projects within the CCW poses challenges to the hydrologic design process typically utilized in marsh creation project design. For the CS-0078 project as well as the CS-0054 project, the CCW management regime results in the occurrence of highly attenuated tidal signatures, which in turn produce difficulties in properly identifying criteria for successful marsh creation project design. In particular, the lack of a tidal prism makes it challenging to establish the identification of a successful settled marsh platform or preferred range of percent inundation thresholds, for which to base the selection of CMFE.

With the hydrologic challenges recognized, the CS-0078 team opted to proceed according to the following.

1) Contrary to typical marsh creation project design, CS-0078 hydrologic design criteria would not be identified leading up to and prior to geotechnical analysis. Alternatively, hydrologic design criteria would require receipt of preliminary geotechnical settlement analyses to better interpret existing hydrologic data for the impounded project site. This interpretation would then aid the guidance of future settlement analyses.

2) While typical marsh creation design entails the analysis of a range of geotechnical settlement curves against a tidally influenced hydrologic dataset—often to maximize the duration of project life that the marsh platform exists within the bounds of optimally performing thresholds of tidal datum or percent inundation—CS-0078 would need to first determine target settled marsh elevation based on reference marsh classifications elsewhere within the CCW. The idea was that TY20 settled marsh elevation (based on marsh elevation surveys) would be first provided to geotechnical engineers to initiate an iterative settlement analysis procedure.

3) Following the identification of the desired TY20 settled marsh elevation and the submittal of the first geotechnical settlement curve, the CS-0078 team would decide

if the CMFE was too low or too high based on the behavior of the curve throughout the design life. Successive settlement analyses would be prescribed accordingly.

4) After viewing more settlement analyses, the CS-0078 would then decide on a desired target pump elevation. Remaining settlement analyses would be generated with varying preconstruction mudline elevations to be pumped to the same CMFE.

5.0 SURVEYS

5.1 General Scope

In order to facilitate design of the CS-0078 project, survey data was collected across multiple areas throughout the project site. Topographic, bathymetric, and magnetometer survey data was collected within the marsh creation area and surrounding vicinity, within the USACE CDF-M upland disposal site and surrounding vicinity, within the southeastern portion of Calcasieu Lake and the southern rim of the CCW Levee and rim canal, and within portions of the CP NWR located to the northeast of the marsh creation area. The design survey effort conducted at the marsh creation area and surrounding vicinity occurred from January 2016 to July 2016. The design survey effort conducted at the USACE CDF-M upland disposal site and surrounding vicinity occurred from August 2016 to January 2017. The design survey effort performed as part of the Calcasieu Lake, CCW Levee/rim canal, and CP NWR data collection event occurred from February 2020 to June 2020. All design survey efforts were carried out by CSI, with Fugro USA Land, Inc. (FUL) as a sub to CSI performing magnetometer surveying services. The deliverables received by CPRA as part of the three CSI tasks are available in **APPENDIX F**.

5.2 Horizontal and Vertical Control

All horizontal coordinates are referenced to the Louisiana State Plane Coordinate System, North American Datum of 1983 (NAD83). All elevations are referenced to the North American Vertical Datum of 1988 (NAVD88) GEOID12B. A State of Louisiana monument (LADNR NO NAME) is located at the southern rim of Calcasieu Lake, near the inlet of the East Fork of the Calcasieu River into Calcasieu Lake in Cameron Parish. CSI used LADNR NO NAME as the primary control point for their survey activities throughout all surveying events. Three (3) separate four (4) hour static Global Positioning System (GPS) sessions were conducted in January 2016, wherein CSI collected, processed, and uploaded the GPS data to the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) system. Following the OPUS upload, CSI further processed the GPS data to eliminate unwanted portions of the dataset, thereby constraining the reduced dataset to a local Continuous Operations Reference System (CORS) network. This was done in order to validate the accuracy of the dataset and to properly establish horizontal and vertical control in accord with CPRA's Survey Standards, titled "A Contractor's Guide to the Standards of Practice" (Appendix A of the MCDG).

One (1) temporary benchmark was set by CSI in January 2016 near the marsh creation area in Cameron Parish. Two (2) temporary benchmarks were set by CSI on August 2016 near CDF-M in Cameron Parish. CSI did not establish any temporary benchmarks during the 2020 surveying effort. CSI utilized LADNR NO NAME as well as the aforementioned temporary benchmarks for the applicable portions of their surveying activities. During the 2016 magnetometer surveying event, FUL established horizontal and vertical control the NGS monument A 357, located near Monkey Island to the south of the CS-0-078 project area. This monument was used in conjunction with the LADNR NO NAME monument to achieve accurate positioning of the magnetometer survey transects. All temporary benchmarks were set using real time kinematic (RTK) survey methods, with the elevation shots being taken on newly installed 60D nails in accord with CPRA's Survey Standards. **Figure 20** depicts the spatial orientation of LADNR NO NAME and A 357 in the CS-0078 site vicinity.

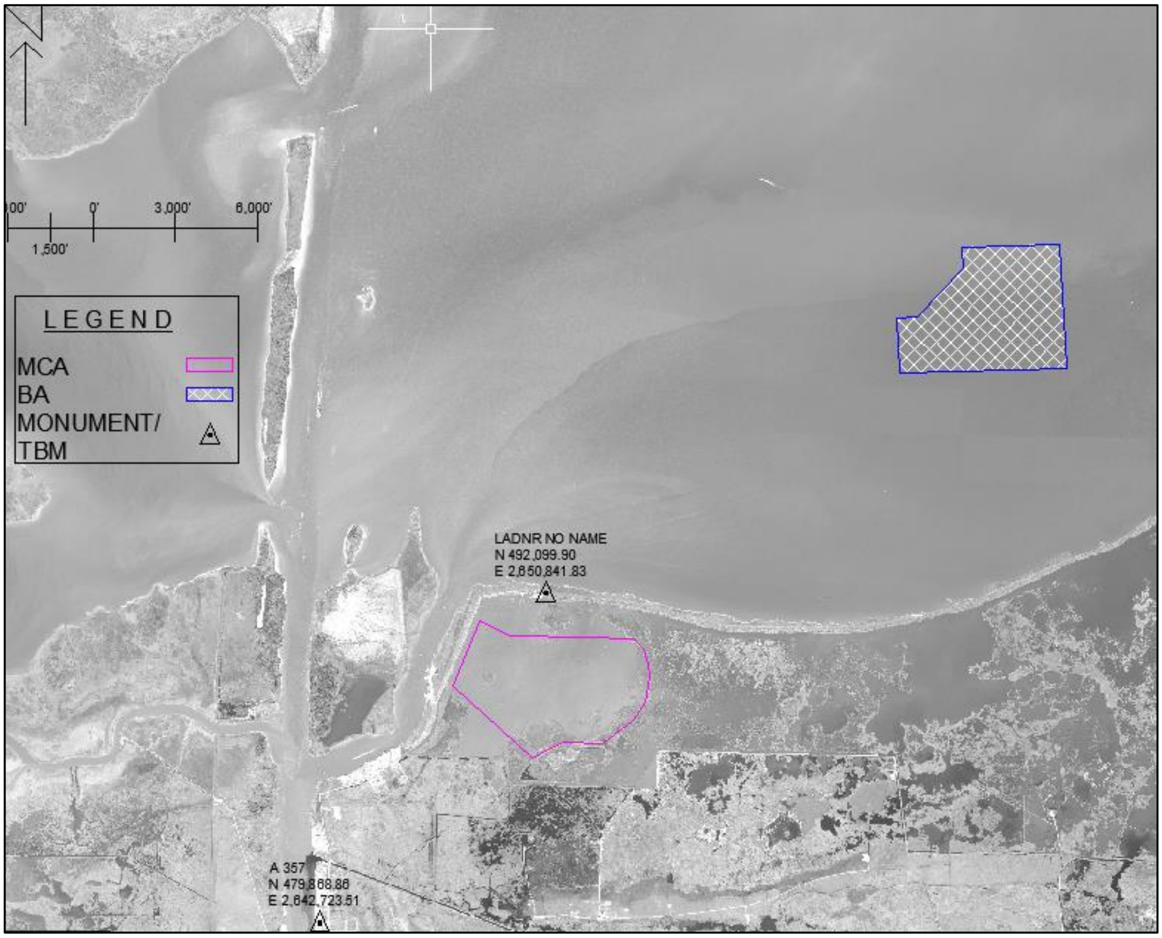


Figure 20: Locations of Survey Control Points at CS-0078

5.3 Marsh Creation Area and Surrounding Vicinity Surveys

5.3.1 General Information

The following subsections discuss the professional land surveying methodology utilized to perform the marsh creation and surrounding vicinity design surveys. These subsections are summarized based on the July 2016 Final Survey Report submitted to CPRA by CSI (**APPENDIX F**).

5.3.2 Topographic/Bathymetric Surveys

5.3.2.1 Baseline Surveys

Two (2) survey baselines were established and surveyed using RTK survey methods in March 2016. **Figure 21** below shows the survey layout for the marsh creation area and surrounding vicinity design survey conducted by CSI; the baselines are shown in blue.

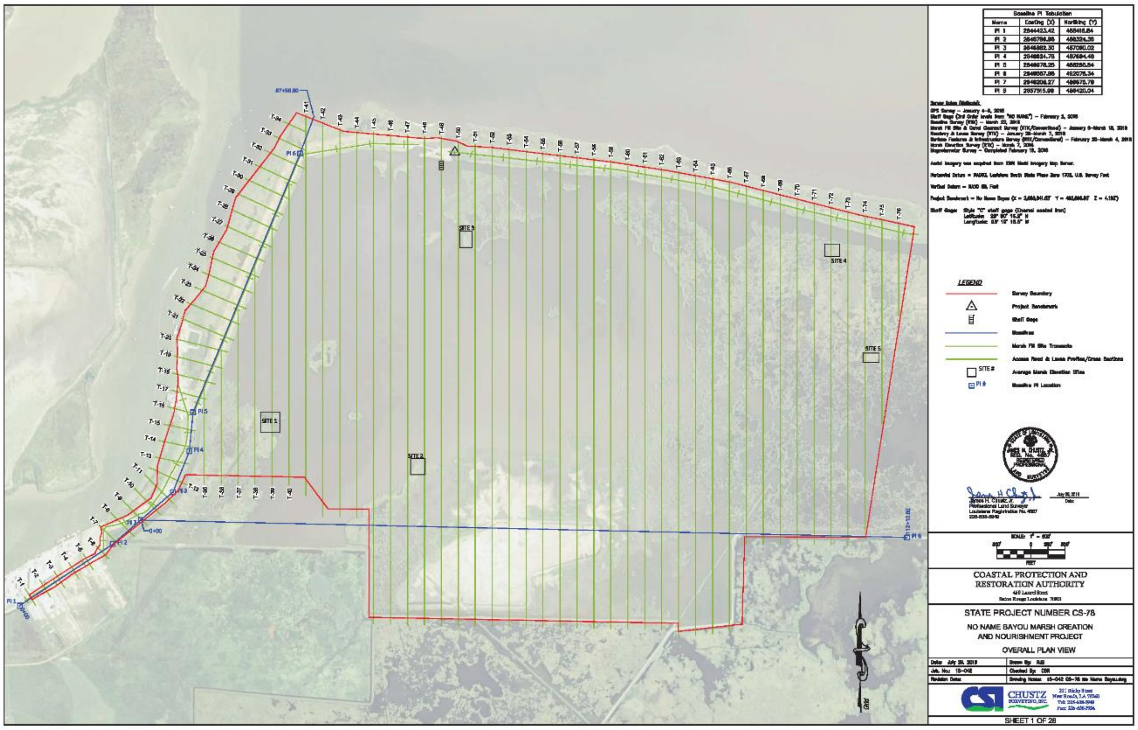


Figure 21: Marsh Creation Area Topographic/Bathymetric Survey Layout

5.3.2.2 Staff Gage Surveys

To accurately measure daily water level fluctuations during the survey effort, one (1) staff gage was set and surveyed using RTK survey methods in February 2016. The staff gage was constructed and installed in accord with CPRA's Survey Standards. The water surface was recorded twice each day and referenced to the gage. **Figure 21** above shows the location of the staff gage in relation to the marsh creation area survey, and **Figure 22** below shows a photograph of the staff gage taken during fieldwork.

Figure 22: Staff Gage at Marsh Creation Area, Pictured Feb. 2016

5.3.2.3 Marsh Creation Fill Site and Canal Clean-Out Surveys

Following the establishment of horizontal and vertical control (as discussed in **Section 5.2**), survey data was collected along 76 transects spaced 250 feet apart covering approximately two (2) square miles. Transects T-1 through T-34 were aligned perpendicular to the westernmost baseline shown on **Figure 21**. Transects T-35 through T-76 were aligned perpendicular to the southernmost east-west running baseline also shown on **Figure 21**. RTK methods were utilized to collect all data shown. Position, elevation, and water depths were recorded every 25 feet along each transect or where elevation changes were observed to occur greater than 0.5 feet. Sideshots were taken as necessary to pick up variations in topographic features (highs and lows) such as trenasses, meandering channels, broken marsh areas, and any other existing features such as utility lines, pipelines, wellheads, and warning signs. A fixed height aluminum rod with a six (6) inch diameter metal plate attached to the base of the rod was used to prevent the rod from sinking during topographic survey data collection. All surveying was performed in accord with CPRA's Survey Standards. **Figure 23** below shows all of the survey transects superimposed onto a color spectrum distribution to show elevation change throughout the site.

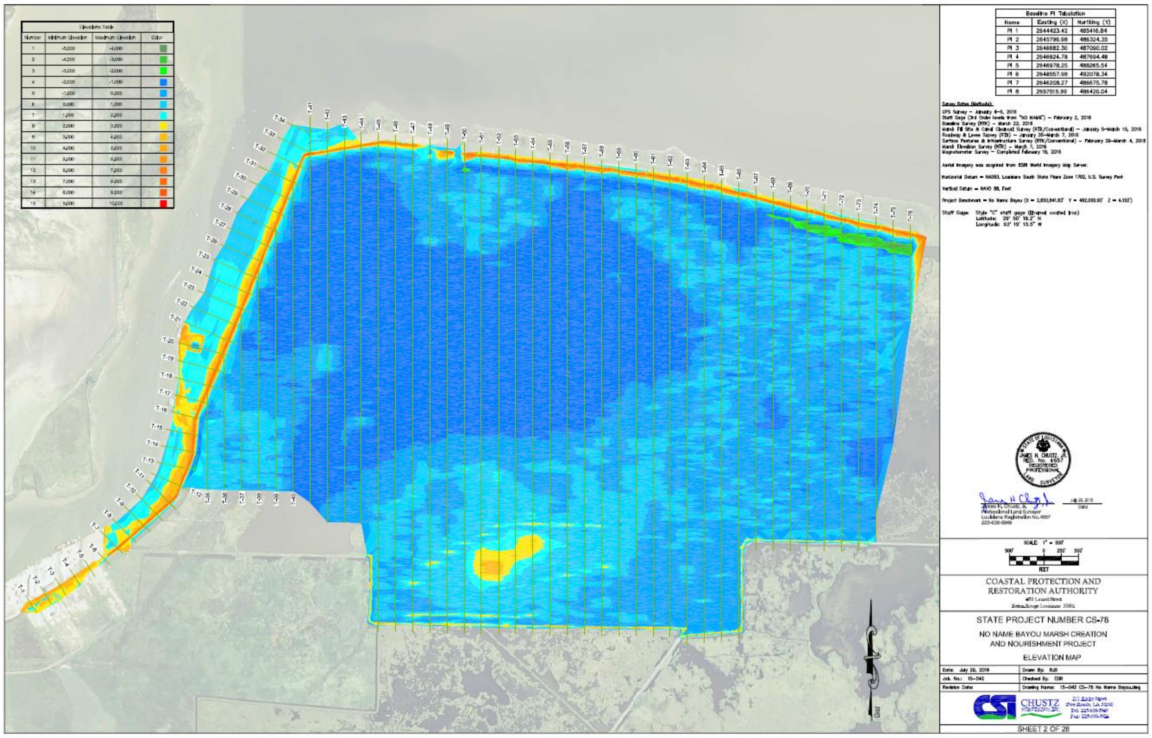


Figure 23: Marsh Creation Area Survey Layout, With Color Spectrum Distribution

5.3.2.4 Surface Features and Infrastructure Surveys

To properly account for surface features and infrastructure present within the area, a second crew was deployed between February 2016 and March 2016. CSI surveyed and marked infrastructure such as roads, levees, breaks in natural ground, piers, docks, buildings, power lines, power poles, utility boxes, culverts, inverts, fences, structures, etc. **Figure 24** contains an example of the surface features surveyed at the marsh creation area and surrounding vicinity.

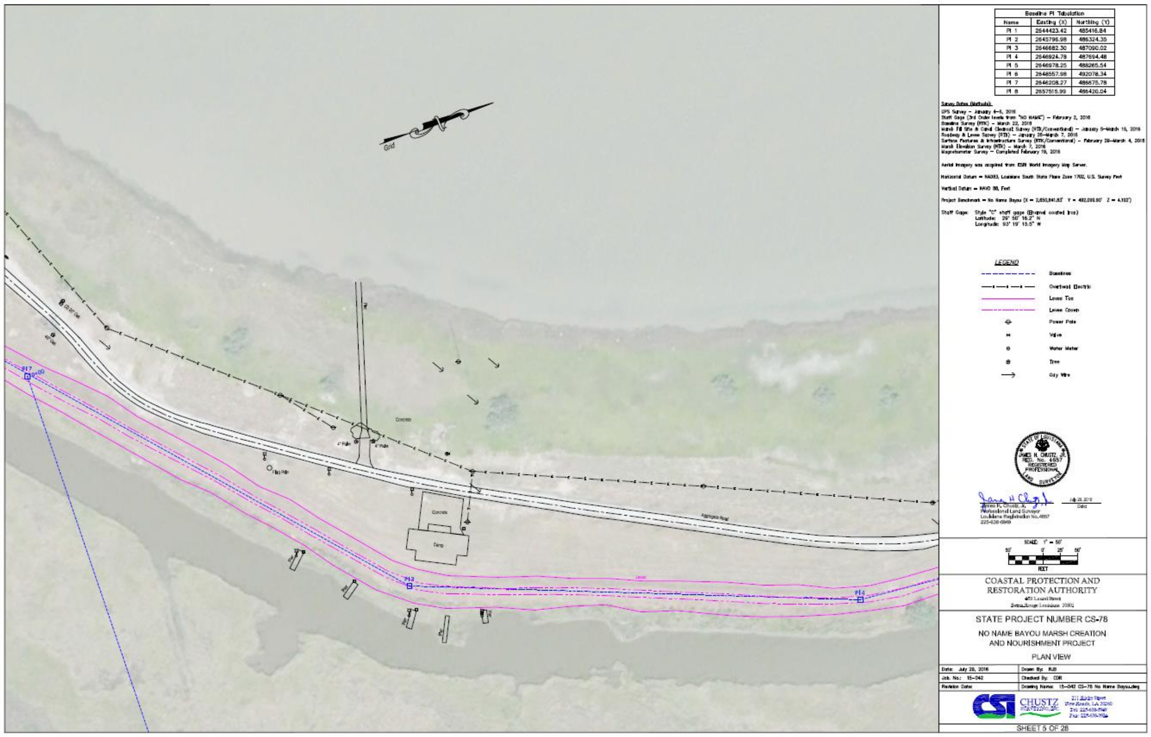


Figure 24: Example Surface Features and Infrastructure Surveys at MCA

5.3.2.5 Reference Marsh Elevation Surveys

To better understand what elevations coincide with remaining, productive marsh habitat in the marsh creation area, average marsh elevations were gathered at select locations in March 2016. CSI contacted a representative from the CPRA Lafayette Regional Office to determine the marsh elevation survey locations. Upon observing marsh quality, field locations were specified to the CSI field crew and five (5) locations were selected for reference marsh elevation surveys. Within those sites, CPRA specified that marsh survey elevations would be conducted according to the predominant vegetation species existing at that location. At the CS-0078 project site, CPRA determined that there were two predominant types of vegetation—*Spartina alterniflora* and *Spartina patens*. CSI performed marsh elevation surveying using RTK methods. For each location containing *Spartina alterniflora*, elevation data was collected by surveying the bottom of the marsh platform in each area. In areas including *Spartina patens*, elevation data was not only collected at the bottom of the marsh platform, but also at the top portions of the vegetative cover. Approximately 30 to 40 elevation shots were taken for each of the marsh elevation survey locations, with the average elevations for each site computed and included in the final survey report. **Table 8** contains the average reference marsh elevation computations for each of the five sites, with an average of all reference marsh sites shown. Note the shown averages include the combined average for all sites that surveyed both the tops and bottoms of each vegetation type. **Figure 25** contains a sample marsh elevation drawing at one of the marsh elevation sites surveyed by CSI, with the locations of all five (5) reference marsh sites shown in **Figure 21**. More information on reference marsh elevation surveys is available in the July 2016 Final Survey Report submitted to CPRA by CSI (**APPENDIX F**).

Table 8: Reference Marsh Elevations

Location	Average Elevation [FT NAVD88 GEOID12B]	Corresponding Percent Inundation
SITE 1	+0.54	77%
SITE 2	+0.62	71%
SITE 3	+0.57	76%
SITE 4	+0.36	86%
SITE 5	+0.30	89%
Average (All)	**+0.48**	**82%**

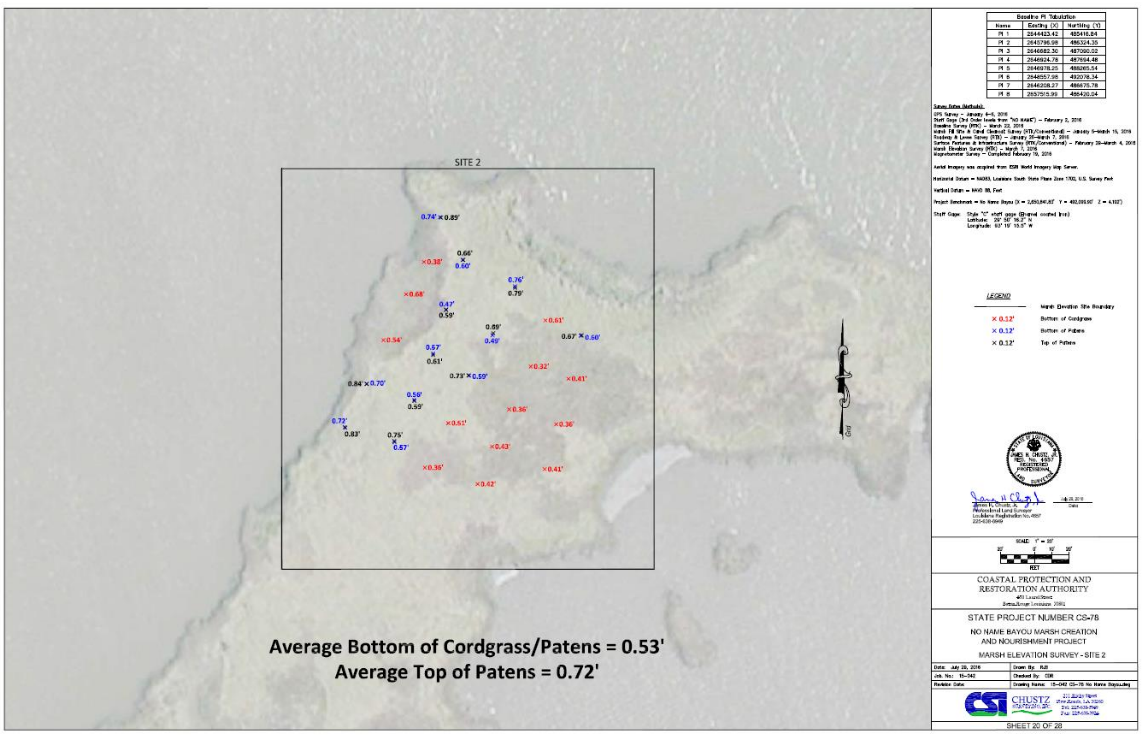


Figure 25: Reference Marsh Elevation Survey (SITE 2)

5.3.3 Magnetometer Surveys

Magnetometer survey data was collected in a 500 ft spaced grid formation spanning the marsh creation area and surrounding vicinity. In February 2016, FUL (formerly known as Fugro Geospatial, Inc. and John Chance Land Surveying, Inc.) established an RTK base station at the NO NAME temporary benchmark. Additional GPS observations were performed on NGS monument A 357 (located near the northern end of the Monkey Island Loop Pass on the eastern banks of the CSC). Static GPS was performed to link the base station to an RTK rover device used to accurately direct the magnetometer surveying equipment along the proper tracklines.

Magnetometer surveys were performed in the marsh creation fill site and canal clean-out locations. Unidentified anomalies were located from an airboat to identify potential hazards. In areas where significant magnetic anomalies such as pipelines were located, probing was performed in order to collect top of pipe position and elevation data. For each probing, contact was first made with a probe rod, and then water depth and depth of cover were recorded at each location. After recordation, a cane pole was placed in the location and then flagged. This information was processed and then included in the CSI report.

Two (2) pipelines were discovered, one confirmed to be a 42-inch active gas and natural gas transmission line owned by Cheniere Creole Trail Pipeline Company (CCTPC), and the other not able to be determined for size or for ownership. Other locations of the marsh creation area and surrounding vicinity were observed to have insignificant debris, likely associated with crab traps. In particular, CSI reports on the existence of this debris in the canal clean-out survey data collection area.

Section 5.6 contains additional information on pipelines encountered during the marsh creation area and surrounding vicinity survey. **Figure 26** below contains the magnetometer survey layout and anomalies for the marsh creation area and surrounding vicinity design survey conducted by FUL.

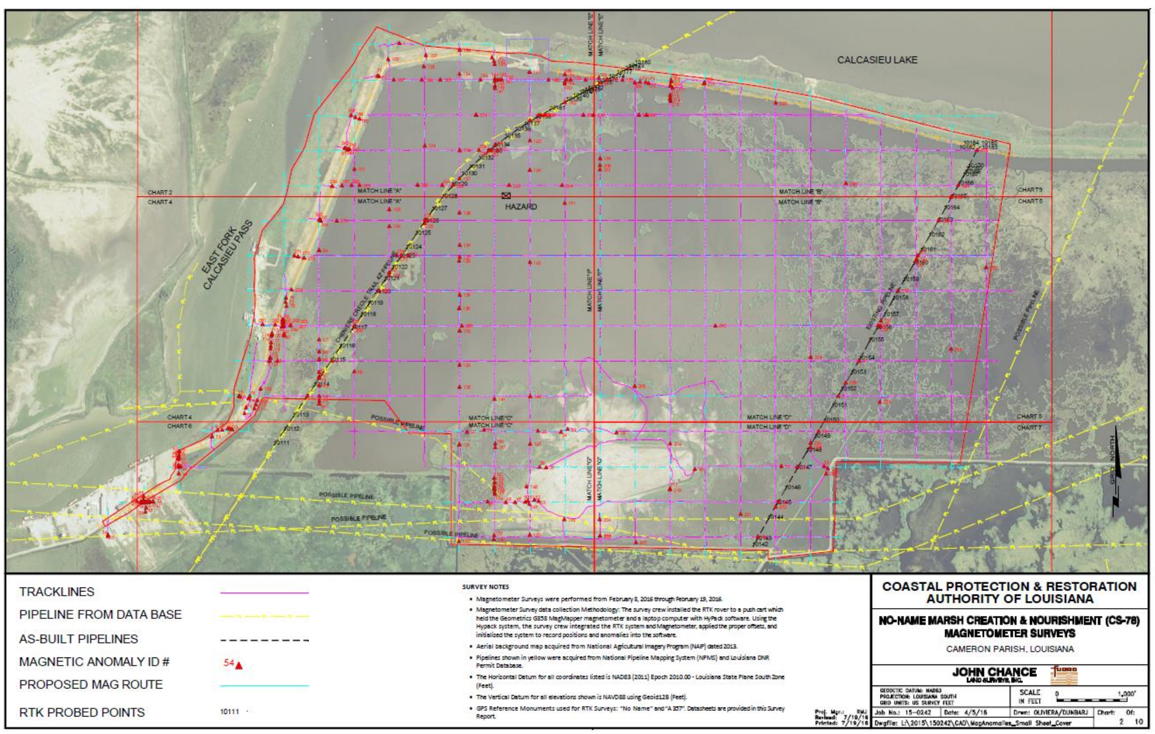


Figure 26: Marsh Creation Area Magnetometer Survey Layout and Anomalies

5.4 USACE CDF-M Upland Disposal Site and Surrounding Vicinity Surveys

5.4.1 General Information

The following subsections discuss the professional land surveying methodology utilized to perform the design surveys in and around the USACE CDF-M upland disposal site, portions of the CSC, and in East Fork of the Calcasieu River located at the southcentral portion of Calcasieu Lake. These subsections are summarized based on the January 2017 Preliminary Survey Report submitted to CPRA by CSI (**APPENDIX F**).

It is important to note that the USACE CDF-M borrow area concept was ultimately dropped during CS-0078 Phase I (see **Section 3.4**), which occurred during the ongoing survey data collection task order. Because of this, no final deliverables were ever produced for this task. The following subsections discuss the survey methodology; however, this data was not used in the CS-0078 95% design.

5.4.2 Topographic/Bathymetric Surveys

5.4.2.1 Baseline Surveys

Three (3) survey baselines were established and surveyed using RTK survey methods in August 2016. **Figure 27** below shows the survey layout for the CDF-M upland disposal site and surrounding vicinity design survey conducted by CSI; the baselines are shown in blue.

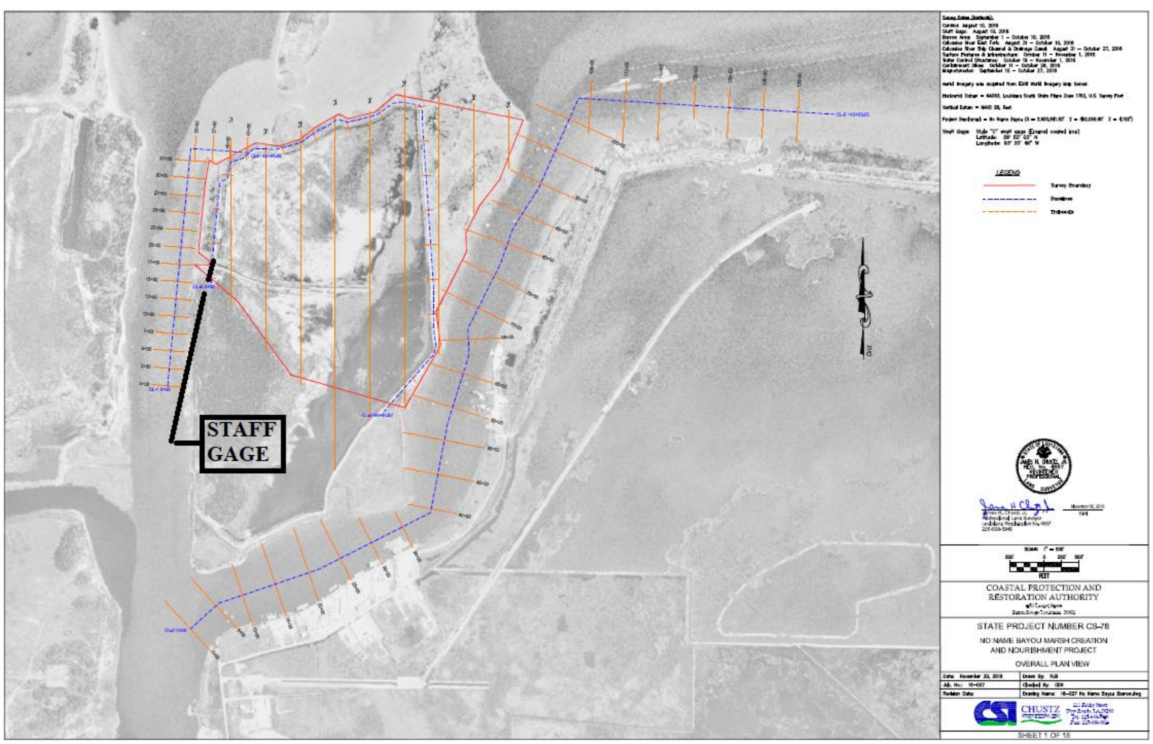


Figure 27: USACE CDF-M Topographic/Bathymetric Survey Layout

5.4.2.2 Staff Gage Surveys

To accurately measure daily water level fluctuations during the survey effort, one (1) staff gage was set and surveyed using RTK survey methods in August 2016. The staff gage was constructed and installed in accord with CPRA's Survey Standards. The water surface was recorded twice each day and referenced to the gage. **Figure 27** above shows the location of the staff gage in relation to the CDF-M survey, and **Figure 28** below shows a photograph of the staff gage taken during fieldwork.

Figure 28: Staff Gage at USACE CDF-M, Pictured Sep. 2016

5.4.2.3 CDF-M Surveys

Following the establishment of horizontal and vertical control (as discussed in **Section 5.2**), survey data was collected along nine (9) total transects spaced 500 feet apart covering just over one (1) square mile. Transects T-1 through T-9 were oriented north-south so as to intersect the CDF-M baseline at perpendicular intersections shown on **Figure 27**. RTK methods were utilized to collect all data shown. Position, elevation, and water depths were recorded every 25 feet along each transect or where elevation changes greater than 0.5 feet were observed to occur. Sideshots were taken as necessary to pick up variations in topographic features (highs and lows) such as trenasses, meandering channels, broken marsh areas, and any other existing features such as utility lines, pipelines, wellheads, and warning signs. A fixed height aluminum rod with a six (6) inch diameter metal plate attached to the base of the rod was used to prevent the rod from sinking during topographic survey data collection. All surveying was performed in accord with CPRA's Survey Standards. **Figure 29** below shows all of the survey transects superimposed onto a color spectrum distribution to show elevation change throughout the site.

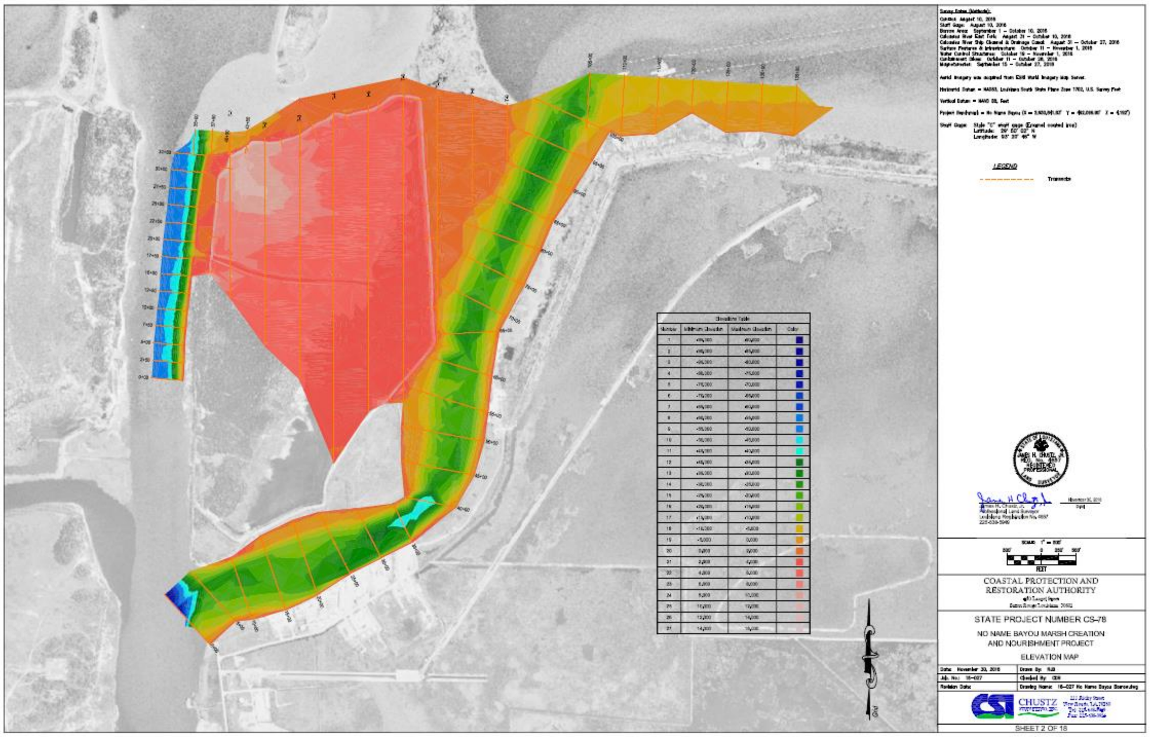


Figure 29: USACE CDF-M Survey Layout, With Color Spectrum Distribution

5.4.2.4 East Fork of the Calcasieu River and CSC Surveys

Following the establishment of horizontal and vertical control (as discussed in **Section 5.2**), survey data was collected along 64 total transects spaced roughly 500 feet apart. The westernmost baseline was used to lay out all CSC perpendicular transects 0+00 to 42+50 as shown in **Figure 27** and **Figure 29**. The easternmost baseline was used to lay out all East Fork perpendicular transects 0+00 to 135+00 as shown in **Figure 27** and **Figure 29**. Hydrographic methods were utilized to collect all data corresponding to the CSC and East Fork transects. Position, elevation, and water depth were recorded along each transect in accord with CPRA's Survey Standards. **Figure 29** above shows all of the survey transects superimposed onto a color spectrum distribution to show elevation change throughout the site.

5.4.2.5 Surface Features and Infrastructure Surveys

To properly account for surface features and infrastructure present within the area, CSI performed RTK surveying between October 2016 and November 2016. As part of this survey, the containment levees surrounding the CDF-M were surveyed and demarcated on preliminary survey drawings. Additional data was collected along the main ditch running from the weir box across the site. CSI surveyed and marked infrastructure such as roads, levees, breaks in natural ground, piers, docks, buildings, power lines, power poles, utility boxes, culverts, inverts, fences, structures, etc. **Figure 30** contains an example of the surface features and infrastructure surveyed at the CDF-M and surrounding vicinity.

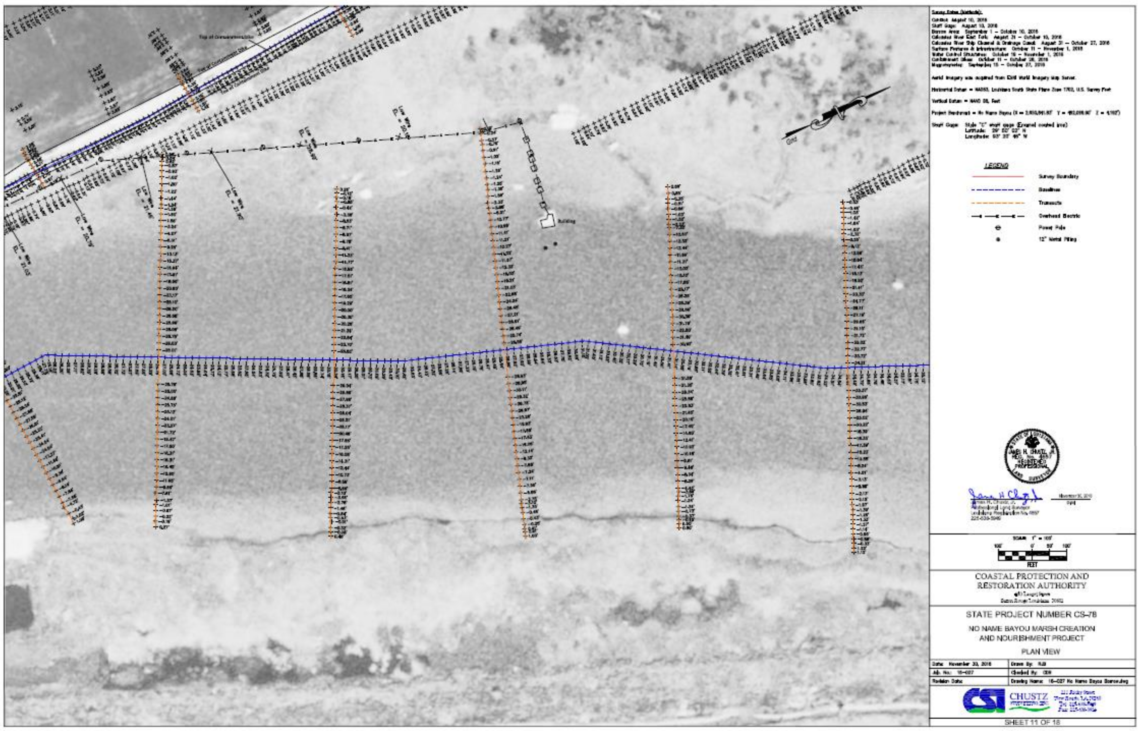


Figure 30: Surface Features and Infrastructure Surveys at USACE CDF-M

5.4.3 Magnetometer Surveys

Magnetometer survey data was collected in a 500 ft spaced grid within the CDF-M borrow site and surrounding vicinity. For the CSC and East Fork portions of the survey, magnetometer data was collected along a centerline and two (2) 250 foot offsets on either side. Perpendicular cross-ties spaced 500 feet apart were also surveyed in CSC and East Fork. Land- and marine-based equipment was used to perform all magnetometer surveying across the site. FUL conducted all surveying operations within the CDF-M and surrounding vicinity between September 2016 and December 2017.

Following magnetometer data collection and post-processing, potentially significant and potentially hazardous magnetic anomalies were identified and FUL initiated a secondary magnetometer and probing investigation. This began by establishing control at the NO NAME temporary benchmark. Using RTK methods, the potentially significant magnetic anomalies were located and then investigated again with a gradiometer, in order to pinpoint the source of the magnetic deflection. In areas where significant magnetic anomalies such as potential pipelines were located, probing was performed with a steel T-bar. In all areas probed, no pipelines were discovered. While the results of the secondary magnetometer and probing investigation revealed no pipelines, several debris sources were identified. This information was processed and then included in the FUL appendix to the CSI report. **Figure 31** below contains the magnetometer survey layout and anomalies for the CDF-M upland disposal site and surrounding vicinity design survey conducted by FUL. **Figure 32** and **Figure 33** show examples of subsurface and surficial debris encountered at the CDF-M site.

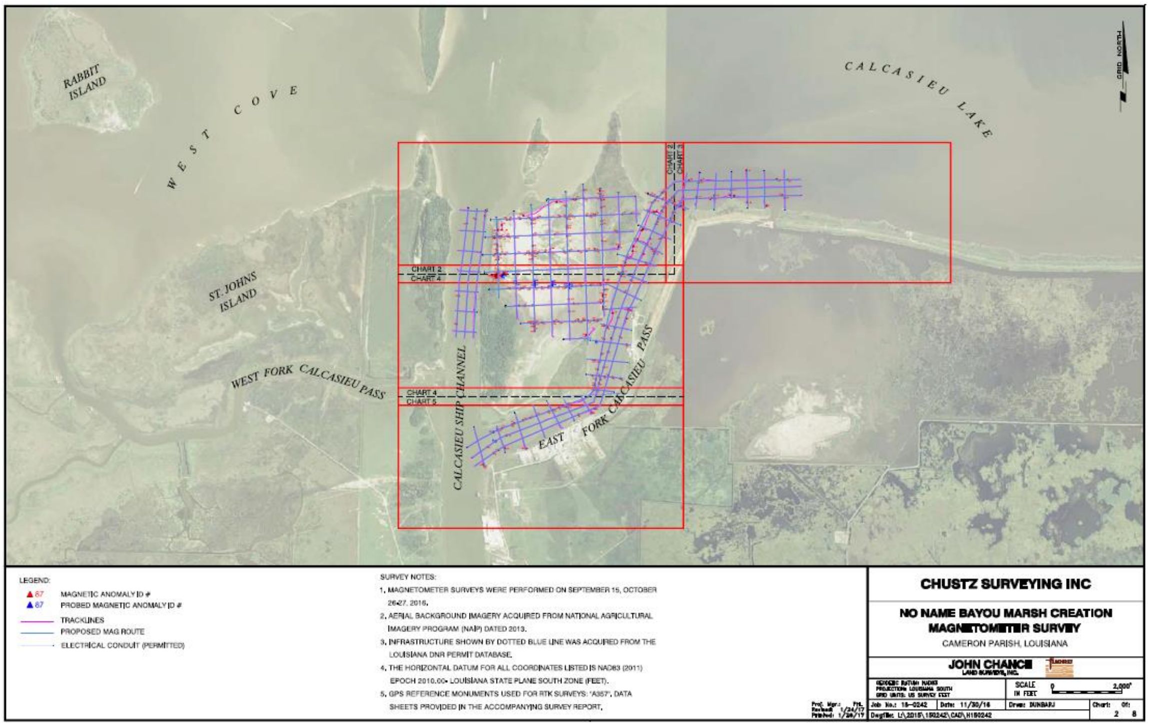


Figure 31: USACE CDF-M Magnetometer Survey Layout and Anomalies

Figure 32: Subsurface Debris Encountered at USACE CDF-M

Figure 33: Surficial Debris Encountered at USACE CDF-M

5.5 Calcasieu Lake, CCW Levee/Rim Canal, and CP NWR Surveys

5.5.1 General Information

The following subsections discuss the professional land surveying methodology utilized to perform the design surveys in and around the southeastern portion of Calcasieu Lake, portions of the CCW Levee and adjacent interior lake rim canal, at two (2) locations having the potential for CCW Levee crossings, and in portions of the CP NWR that are located to the northeast of the marsh creation area. These subsections are summarized based on the June 2020 Preliminary Survey Report submitted to CPRA by CSI (**APPENDIX F**).

This survey event was performed in order to facilitate design of the as-proposed CS-0078 borrow area and adjoining equipment access and dredge pipe corridors, as shown in **Figure 4**. The Calcasieu Lake borrow area was selected based on CS-0054 project knowledge and shares a boundary with the borrow site used for that project. As utilized during construction of CS-0054, navigable equipment access is known to exist between the CSC and the northern extents of the borrow area, and as such no data collection was performed in this area. It is important to note that two (2) access corridors were developed prior to 30%, which were both surveyed during this data collection event. For the two corridors, topographic, bathymetric, and magnetometer survey data collection was necessary. Portions of the eastern corridor required additional survey data collection for the areas of the CP NWR that were not surveyed as part of the 2016 marsh creation area and surrounding vicinity design survey effort. However, some portions of the 2016 survey data were able to be used in the design of both equipment access and dredge pipe corridors.

5.5.2 Topographic/Bathymetric Surveys

5.5.2.1 Staff Gage Surveys

To accurately measure daily water level fluctuations during the survey effort, the existing staff gage (installed as part of the 2016 survey) was surveyed using RTK survey methods from March 2020 to April 2020. The staff gage was constructed and installed in accord with CPRA's Survey Standards. The water surface elevation was recorded twice each day and referenced to the gage. **Figure 21** shows the location of the staff gage, with **Figure 22** showing a photograph of the staff gage taken during the 2016 fieldwork event.

5.5.2.2 Calcasieu Lake, CCW Levee, and CP-NWR Topographic/Bathymetric Surveys

Following the establishment of horizontal and vertical control (as discussed in **Section 5.2**), survey data was collected with hydrographic and RTK survey equipment, across different portions of the survey area. Hydrographic survey data was collected in Calcasieu Lake along 29 total transects spaced 1,000 feet apart covering approximately 10 square miles. Transects T-1 through T-3 were oriented southwest to northeast along the western equipment access corridor and dredge pipe corridor. Transects T-3 through T-29 were oriented in a grid pattern with lines running north-south and east-west. Transects T-12 through T-14 were oriented north-south with the upper portion located in the borrow area and the southern portion located along the eastern equipment access corridor and dredge pipe corridor. RTK survey data was collected along the CCW Levee and associated rim canal within the adjacent CP NWR marshes. Transects L-1 through L-31 were oriented perpendicular to the L-32 canal centerline transect. The perpendicular transects were spaced predominantly 2,000 FT apart, with 100 FT spacings near the two (2) levee crossings. Position, elevation, and water depths were recorded every 25 feet along each transect or where elevation changes greater than 0.5 feet were observed to occur. Sideshots were taken as necessary to pick up variations in topographic features (highs and lows) such as trenasses, meandering channels, broken marsh areas, and any other existing features such as utility lines, pipelines, wellheads, and warning signs. A fixed height aluminum rod with a six (6) inch diameter metal plate attached to the base of the rod was used to prevent the rod from sinking during topographic survey data collection. All surveying was performed in accord with CPRA's Survey Standards. **Figure 34** below shows all of the survey transects' locations throughout the site.

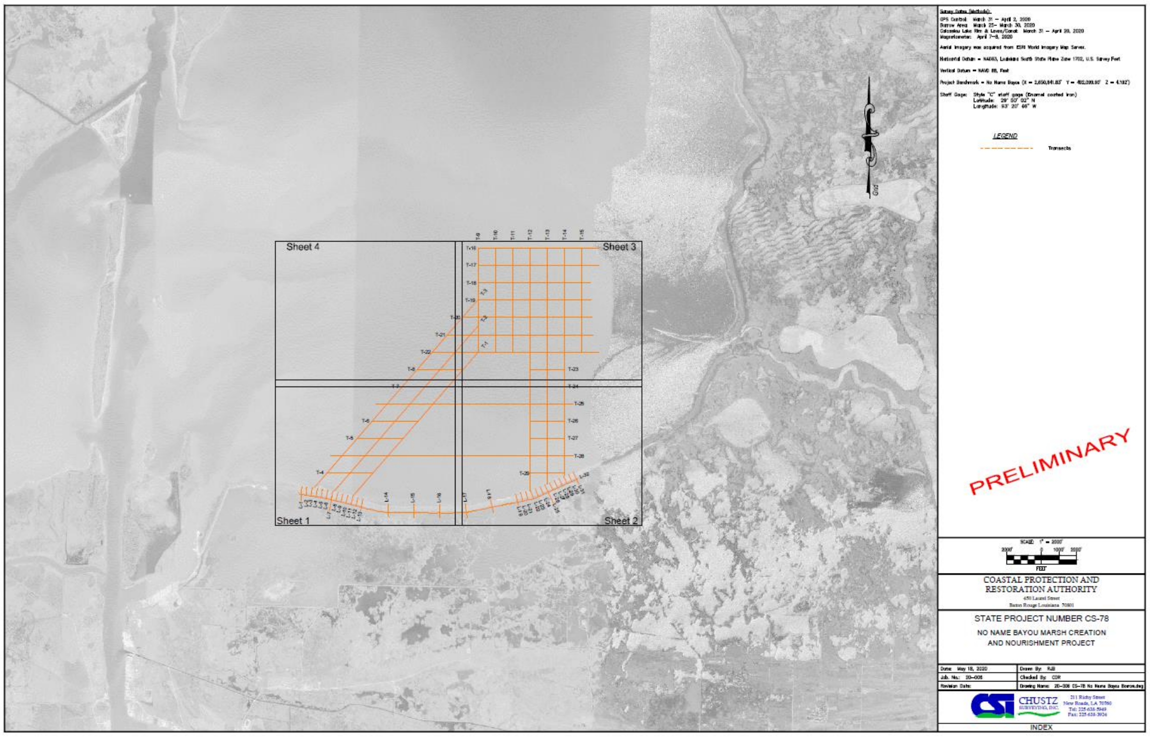


Figure 34: Calcasieu Lake, CCW Levee/Rim Canal, and CP NWR Survey Layout

5.5.3 Magnetometer Surveys

Magnetometer survey data was collected along a similar orientation as shown in **Figure 34**. Within the Calcasieu Lake portions of the survey effort, a 1,000 FT grid spacing was utilized. In total, 29 magnetometer transects were surveyed. Within the portions of the survey effort located in the CP NWR, a similar survey layout was utilized as the bathymetric/topographic portion of the survey, with two parallel offsets applied to the canal centerline survey. In total, 34 magnetometer transects were surveyed. Land- and marine-based equipment was used to perform all magnetometer surveying across the site. FUL conducted all surveying operations within the Calcasieu Lake, CCW Levee/Rim Canal, and CP NWR vicinity from April to May 2020.

A total of 385 magnetic anomalies (**APPENDIX F**) were identified and interpreted in the full dataset. Of these anomalies, 26 were interpreted to be possibly associated with pipelines. All remaining anomalies were associated with unidentified debris. In areas where significant magnetic anomalies such as possible pipelines were located, a probing investigation was conducted in May 2020. A total of 20 probing data points were collected. For each probing, contact was first made with a probe rod, and then water depth and depth of cover were recorded at each location. After recordation, a cane pole was placed in the location and then flagged. This information was processed and then included in the CSI report.

Similar to the 2016 surveying effort, a total of two (2) pipelines were discovered. One was confirmed to be the 42-inch CCTPC active gas and natural gas transmission line that is located near the equipment access corridor and marsh creation area. This pipeline was discovered along an area that was surveyed for the western equipment access and dredge pipe route that was presented in 30% design. The other pipeline was identified near the western side of the proposed borrow area, with the western borrow area boundary positioned so as to avoid the verified pipeline probing locations in this area. Based on interpretation of magnetometer findings, the observed orientation of probing locations, and the overlap with a pipeline alignment obtained from pipeline database research, FUL reported that the pipeline located near the borrow area is likely the same pipeline identified during the 2016 survey effort within CP NWR property. This second pipeline was not able to be determined for size or for ownership.

Section 5.6 contains additional information on pipelines encountered during surveying work. **Figure 35** below contains the magnetometer survey layout for the marsh creation area and surrounding vicinity design survey conducted by FUL. **Figure 36** shows one of the cane pole markings deployed at the CS-0078 site by FUL.

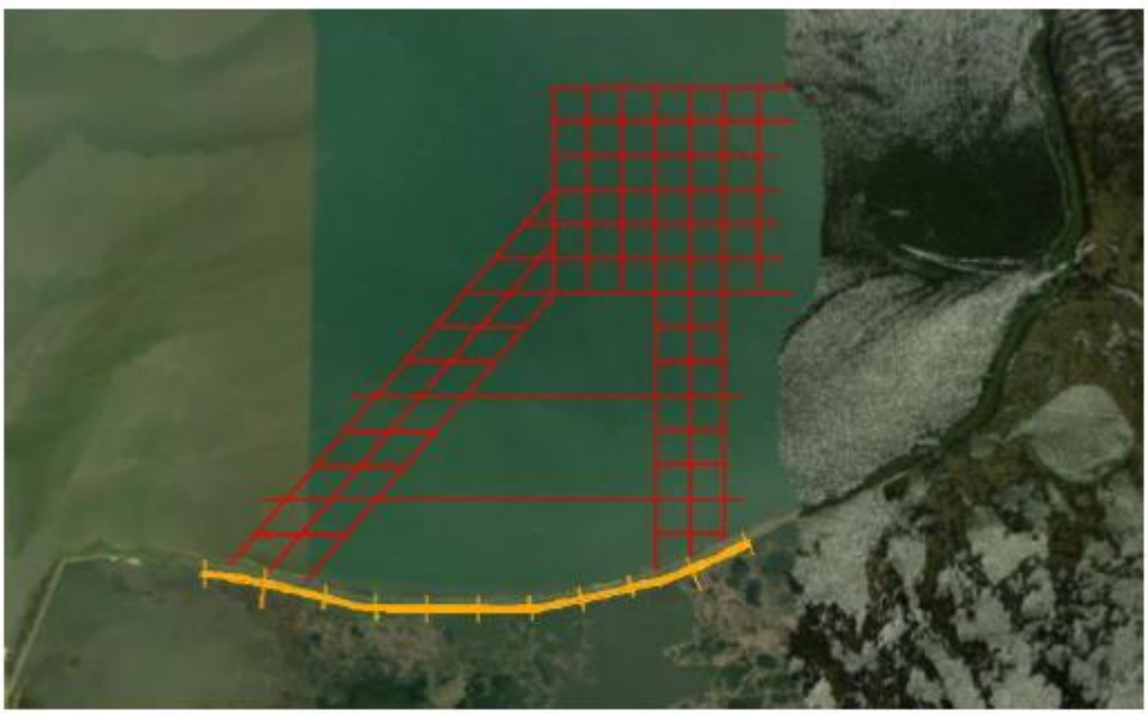


Figure 35: Calcasieu Lake CCW Levee-Rim Canal and CP NWR Magnetometer Survey Layout

Figure 36: Cane Pole Demarcating Pipeline at CS-0078 Borrow Area

5.6 Pipeline Information

Table 9 contains a list of all pipeline information identified for the CS-0078 project as informed through the CSI survey effort.

Table 9: CS-0078 Pipeline Information

Pipeline/Flowline Identification	Location in Relation to Project Features; Potential for Impact
42" Chenier-Creole Trail Pipeline	MCA[1], Western EAC[2]/DPC[3]; Overlap with Mechanical Dredging for Dikes and Corridor
Unknown Size/Unknown Owner Pipeline	MCA, BA[4]; Overlap with Hydraulic Dredging for Borrow, Proximity to ECD[5] in MCA

1. MCA stands for "marsh creation area".
2. EAC stands for "equipment access corridor".
3. DPC stands for "dredge pipe corridor".
4. BA stands for "borrow area".
5. ECD stands for "earthen containment dike".

Figure 37 below shows the locations of the two pipelines identified in **Table 9**.

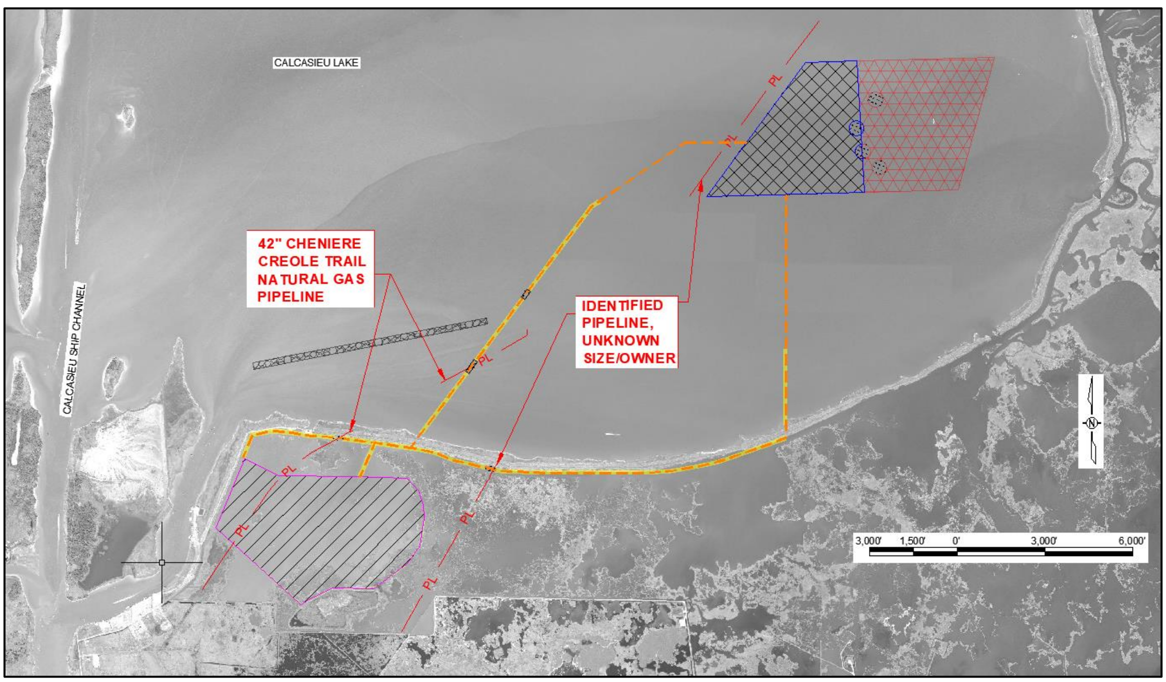


Figure 37: Pipelines Encountered at CS-0078

Based on survey data collection and magnetometer findings, the following has been incorporated into the design of CS-0078 pertaining to pipelines:

- A 500 FT recommended offset is shown from the locations of verified probings of the unknown pipeline on the western side of the borrow area.

- Two (2) no excavation sections are shown where proposed earthen containment dike construction and adjacent mechanical dredging crosses the 42-inch CCTPC natural gas pipeline.
- One (1) crossing over the 42-inch CCTPC natural gas pipeline is proposed along the equipment access route within the CCW Levee rim canal north of the marsh creation area. One (1) crossing over the unidentified pipeline is also proposed along the same equipment access route within the CCW Levee rim canal, which is located further east and northeast of the marsh creation area.
- The 42-inch CCTPC pipeline extends to the south and overlaps with a portion of the marsh creation area. The equipment access corridor also crosses this pipeline in one (1) location within the CCW Levee rim canal to the north of the marsh creation area. CPRA has initiated communication with the CCTPC.
- The unknown pipeline is located approximately 1,000 FT from this eastern marsh creation area boundary at its closest location. At the borrow area, this unknown line is located 500 FT from the western boundary of the borrow polygon.
- Although no information was obtained on ownership for the second pipeline, a records search was performed and revealed that no active pipelines are known to exist in the areas surveyed and identified near this unknown pipeline. CPRA has initiated communication with the Coastal and Marine Operators Pipeline Industry Initiative (CAMO) in regard to this unknown line as well as the CCTPC pipeline.
- Additional investigations into pipeline ownership and coordination are ongoing.

6.0 GEOTECHNICAL INVESTIGATIONS

6.1 General Scope

In order to facilitate design of the CS-0078 project, geotechnical investigations were performed that entailed field sampling, laboratory analyses, geotechnical engineering analysis and design, and the furnishing of geotechnical recommendations for design and construction. Geotechnical activities were conducted by AAI at different times throughout project design and at different locations, which are explained further within this report section. The deliverables received by CPRA as part of the AAI geotechnical tasks are available in **APPENDIX G**.

6.2 Geotechnical Field Investigations

6.2.1 Geotechnical Field Investigations—Summary

Table 10 contains a breakdown of information pertaining to geotechnical data collection investigations carried out for CS-0078. All geotechnical sampling, including soil sample identification, classification, storage, transport, and electronic data logging, were performed according to the most applicable standard as part of American Society for Testing and Materials (ASTM) standard methods and to the provisions stated in MCDG for geotechnical investigations.

Table 10: Breakdown of CS-0078 Geotechnical Investigations

Investigation No.	Timeframe	Sampling	Additional Details
1	2016 – 2017	14 borings	• MCA in situ sampling and CDF-M borrow area sampling • laboratory testing program executed • various engineering analyses conducted • parametric containment dike analysis performed • final engineering report deliverable not completed, due to relocation of borrow area during alternatives analysis (see **Section 3.4**)
2	2019 - 2020	10 borings	• Calcasieu Lake borrow area sampling only • borrow area settling column and low stress consolidation testing performed • various engineering analyses conducted • findings established in Investigation No. 1 used as a starting point • parametric study performed exploring sensitivity for different settlement computational platforms (PSDDF and SLURRY) • cut-to-fill ratios developed for recommendation • construction recommendations furnished

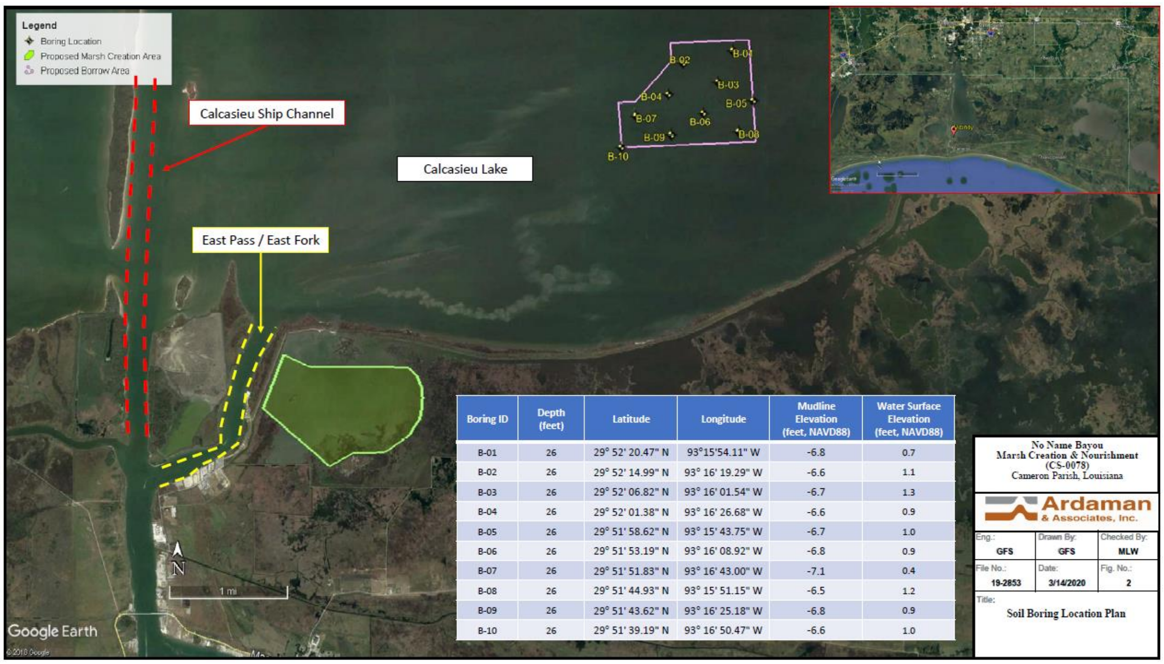
6.2.2 Geotechnical Investigation No. 1—Field Investigation of Marsh Creation Area and CDF-M Site

Soil conditions were evaluated in the marsh creation area and CDF-M sites by conducting 14 total borings across both sites. Eight (8) borings were sampled at the marsh creation area, which ranged from 30 to 40 feet below the existing mudline. Five (5) of the eight (8) borings were positioned along the containment dike layout, with the remaining three (3) positioned within the interior portions of the marsh creation area. Six (6) borings were sampled at the CDF-M site, which ranged from 20 to 30 feet below the existing ground surface. As-drilled boring locations were determined using GPS, and closed-loop magnetometer transects were conducted around each boring prior to the arrival of geotechnical sampling equipment and crew in order to clear the soil sampling operations of any magnetic hazards. The borings in the marsh creation area were performed using an airboat-mounted rotary-type drilling rig. The borings in the CDF-M site were performed using a marsh buggy-mounted rotary-type drilling rig. Samples were recovered in accord with CPRA's Geotechnical Standards (Appendix B of MCDG) and transported to the soil testing laboratory for processing. **Figure 38** contains the exploratory marsh creation area geotechnical sampling layout map provided by AAI.

Figure 38: Marsh Creation Area and CDF-M Geotechnical Sampling Layout

6.2.3 Geotechnical Investigation No. 2—Field Investigation of Calcasieu Lake Borrow Area

Following the borrow area alternatives analysis discussed in **Section 3.4**, the team collected geotechnical data at the Calcasieu Lake borrow site. Ten (10) soil borings were conducted at this site, sampled at 25 feet below the existing waterbottom. T. Baker Smith, LLC (TBS) located each boring location and performed a 25-ft radius closed-loop magnetometer survey around each proposed boring location prior to the arrival of geotechnical sampling equipment and crew in order to clear the soil sampling operations of any magnetic hazards. TBS also performed bathymetric surveying at each sampling location to determine mudline elevation. The Calcasieu Lake borings were all performed using a spud barge-mounted rotary-type drilling rig. The boreholes were stabilized using a mixture of water from Calcasieu Lake and the soil particles mobilized and suspended during drilling. Discrete samples were obtained continuously to termination. The boreholes were grouted upon completion. Samples were recovered in accord with CPRA's Geotechnical Standards (Appendix B of MCDG) and transported to the soil testing laboratory for processing. **Figure 39** contains the Calcasieu Lake borrow area geotechnical sampling layout map provided by AAI.



Boring ID	Depth (feet)	Latitude	Longitude	Mudline Elevation (feet, NAVD88)	Water Surface Elevation (feet, NAVD88)
B-01	26	29° 52' 20.47" N	93°15'54.11" W	-6.8	0.7
B-02	26	29° 52' 14.99" N	93° 16' 19.29" W	-6.6	1.1
B-03	26	29° 52' 06.82" N	93° 16' 01.54" W	-6.7	1.3
B-04	26	29° 52' 01.38" N	93° 16' 26.68" W	-6.6	0.9
B-05	26	29° 51' 58.62" N	93° 15' 43.75" W	-6.7	1.0
B-06	26	29° 51' 53.19" N	93° 16' 08.92" W	-6.8	0.9
B-07	26	29° 51' 51.83" N	93° 16' 43.00" W	-7.1	0.4
B-08	26	29° 51' 44.93" N	93° 15' 51.15" W	-6.5	1.2
B-09	26	29° 51' 43.62" N	93° 16' 25.18" W	-6.8	0.9
B-10	26	29° 51' 39.19" N	93° 16' 50.47" W	-6.6	1.0

Figure 39: Calcasieu Lake Borrow Area Geotechnical Sampling Layout

6.3 Geotechnical Laboratory Testing Program

All geotechnical engineering laboratory procedures were performed according to the applicable standard as required by ASTM standard language and to the provisions stated in the MCDG for geotechnical laboratory testing. Note that settling column testing was performed based on the sample preparation and test procedure presented in the USACE Confined Disposal of Dredged Material engineer manual (EM 1110-2-5027), with modifications made under the supervision of a geotechnical engineer.

6.4 Geotechnical Engineering Analyses

6.4.1 General Information

The following subsections discuss the professional geotechnical engineering methodology utilized to perform the marsh creation area geotechnical analyses and design. These subsections are summarized based on the June 2020 Final Design Report submitted to CPRA by AAI, with select sections from the April 2017 Draft Interim Design Report also submitted by AAI (**APPENDIX G**).

6.4.2 Site Geology

At the commencement of geotechnical investigation activities, AAI performed a geologic assessment of the historical geotechnical conditions in and around the CS-0078 project vicinity. **Figure 40** and **Figure 41** contain geologic figures provided by AAI.

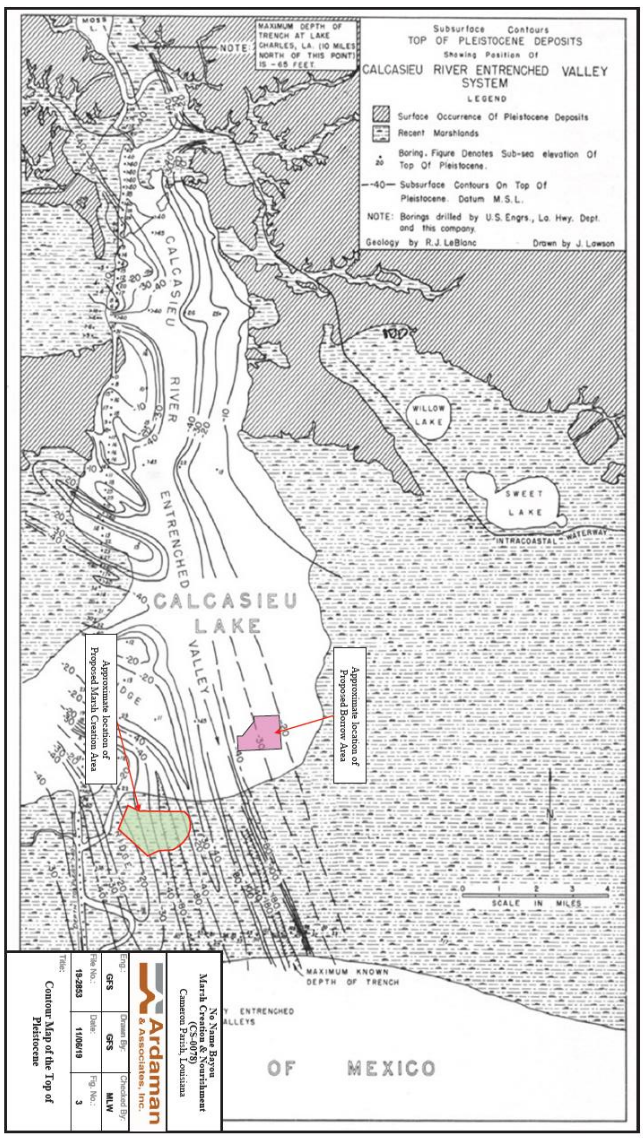


Figure 40: Geology Map Showing Top of Pleistocene

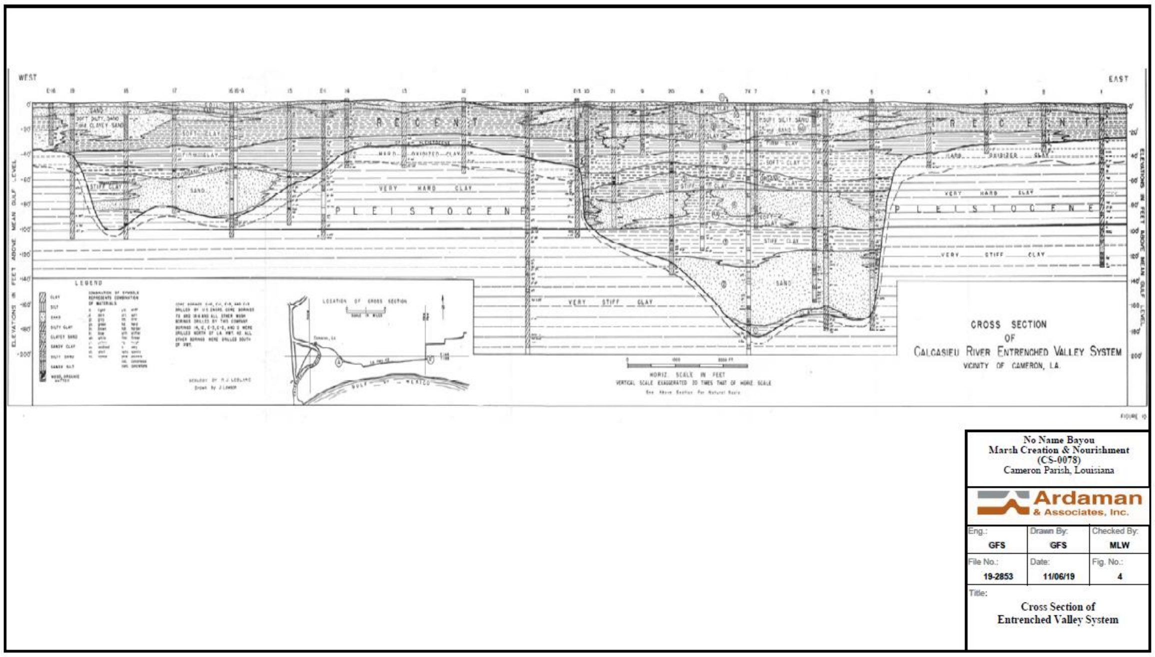


Figure 41: Geology Map Showing Geologic Cross Section

6.4.3 Generation of Subsurface Design Profiles

Following soil sampling and geotechnical laboratory testing, AAI produced two (2) subsurface design profiles using analytical data generated on in situ soil samples extracted from the marsh creation area. These profiles were created during Investigation No. 1 and were later used by AAI to develop the containment dike cross sectional design and to perform marsh fill settlement analyses. **Figure 42** and **Figure 43** below show the subsurface design profiles generated by AAI.

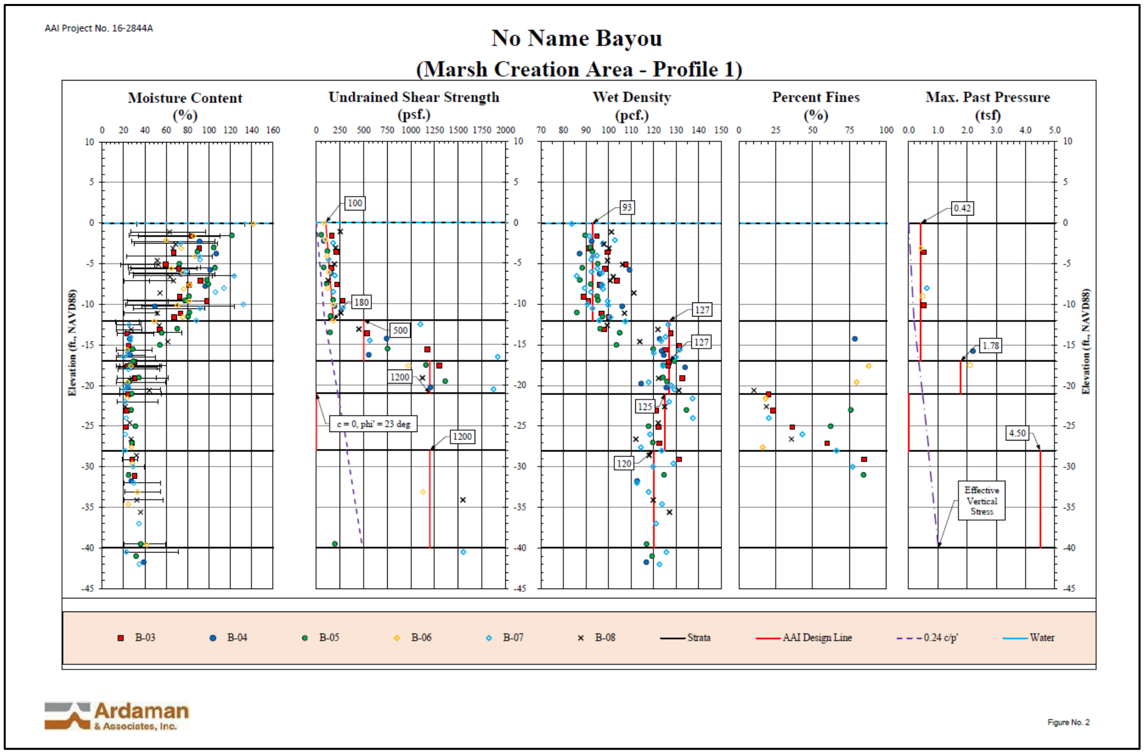


Figure 42: Subsurface Design Profile 1

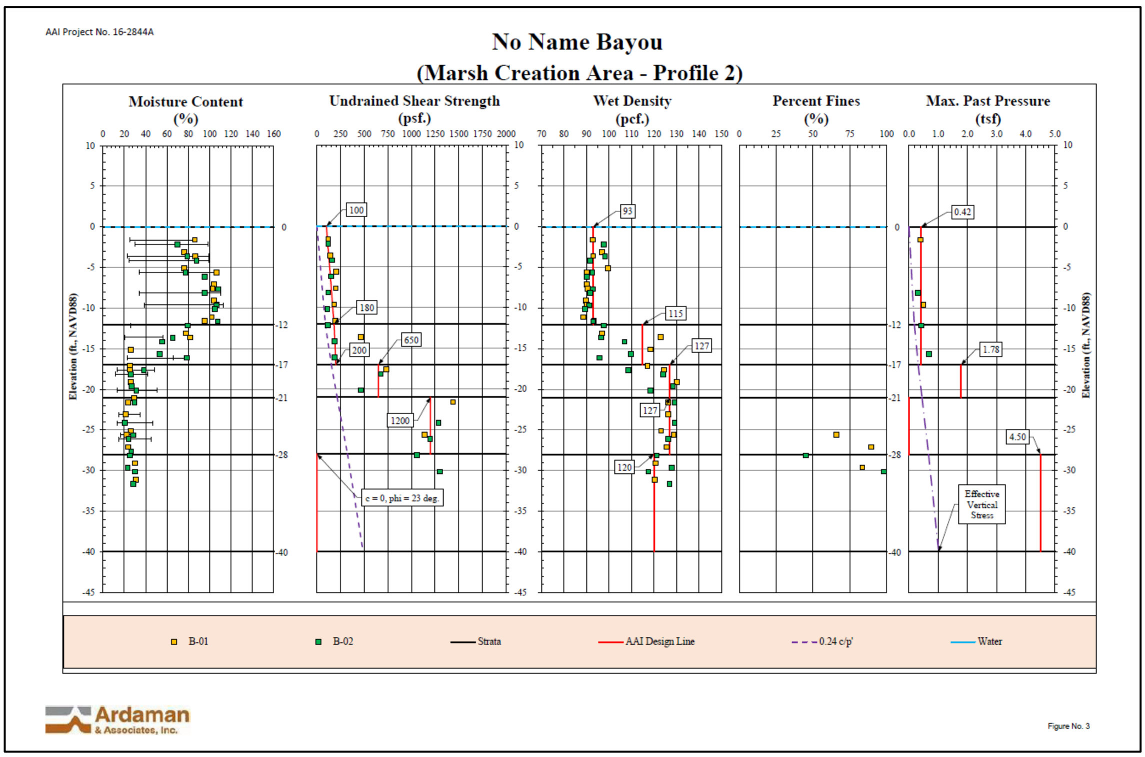


Figure 43: Subsurface Design Profile 2

6.4.4 Parametric Earthen Containment Dike Slope Stability Analysis

Also performed during Investigation No. 1 was a parametric containment dike analysis using assumed properties of hydraulic dredge fill at varying fill elevations, corresponding to varying containment dike dimensions. At this time, the CS-0078 project team was in the process of abandoning the CDF-M borrow site. AAI performed this parametric analysis which was then included in the Draft Interim Report submitted April 2017, which was later used to by AAI during Investigation No. 2 (see **Section 6.4.6**). More information is available in **APPENDIX G**.

6.4.5 Marsh Fill Settlement Analyses

AAI performed a settlement analysis that aided the CS-0078 team in determining the optimal CMFE of marsh fill. The settlement analysis also facilitated the interpretation of the long-term settlement performance of the restored marsh platform throughout the 20-year design life of the project.

The final elevation of the marsh creation area (at TY20) is governed by two forms of settlement: (1) the settlement of in situ soils in the marsh creation area caused by the applied loading of hydraulic dredge slurry deposition; and (2) the self-weight consolidation of the dredged material itself. Note that desiccation is considered as well, but is often considered to be secondary to items (1) and (2). Data from settling column test and low pressure consolidation tests was used to estimate the total magnitude of settlement and the time-rate of settlement of the slurry, and data from traditional consolidation testing was used to determine the settlement of the in situ soil at the marsh creation area. Note that subsidence has also been factored into settlement analyses and is depicted on the settlement curves shown in **Figure 45** and **Figure 46** below.

As stated throughout this report, geotechnical settlement curves were instrumental in assisting the project team in determining how to best design for the hydrologic challenges brought on by the CCW. **Section 4.5** in particular accounts how geotechnical settlement curves were performed in an iterative fashion. Throughout this iterative process, AAI first produced a total of three (3) settlement curves. These analyses were done to examine how differing pump elevations would perform to meet TY20 settled elevations consistent with reference marsh elevations located elsewhere within the CCW. After CS-0078 team review of these three (3) curves, a target pump elevation of +1.5 FT NAVD88 was selected, and then two (2) final curves were produced according to differing mudline elevations observed across the site.

The existing mudline elevations assumed for marsh fill settlement analysis can greatly affect the required construction elevation to achieve the desired TY20 settled elevation. Another factor that plays a role is the type of marsh fill operation and the accompanying dredge infill rate. In the case of CS-0078, AAI performed a settlement analysis for the following conditions, while utilizing guidance from CPRA on how to best factor in a realistic dredge infill rate.

Case 1) TY20 Marsh EL = +0.8 FT NAVD88; Mudline EL = -1.5 FT NAVD88

Case 2) TY20 Marsh EL = +1.3 FT NAVD88; Mudline EL = -1.0 FT NAVD88

Case 3) TY20 Marsh EL = +0.3 FT NAVD88; Mudline EL = -1.0 FT NAVD88

Case 4) TY0 Marsh EL = +1.5 FT NAVD88; Mudline EL = -1.5 FT NAVD88

Case 5) TY0 Marsh EL = +1.5 FT NAVD88; Mudline EL = +0.5 FT NAVD88

Figure 44 below depicts all settlement curves for Cases 1 through 5, as obtained from the AAI report. Case 4 and Case 5 are considered to be the most representative preconstruction mudline conditions for the marsh creation area, and as such the results of these curves were used for project design (as discussed in **Section 7.0**). **Figure 45** and **Figure 46** show the results of Case 4 and Case 5, respectively, shown along with the hydrologic indices discussed in **Section 4.4** (see **Figure 19**).

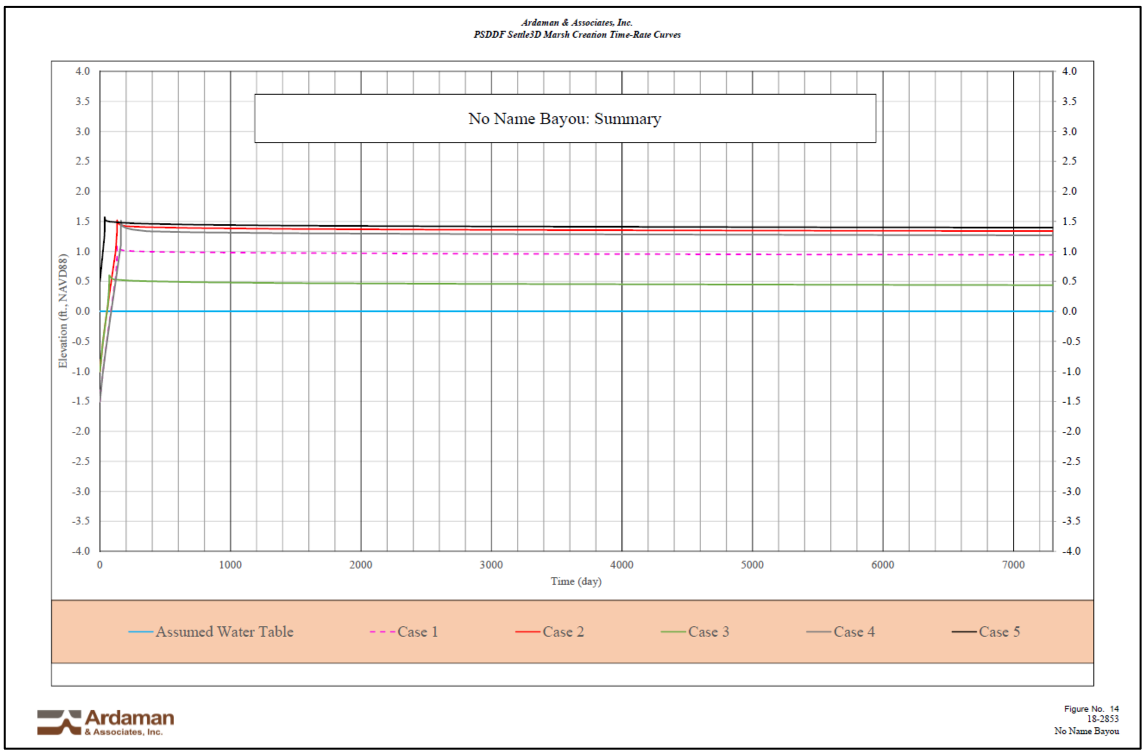


Figure 44: Settlement Curve Array

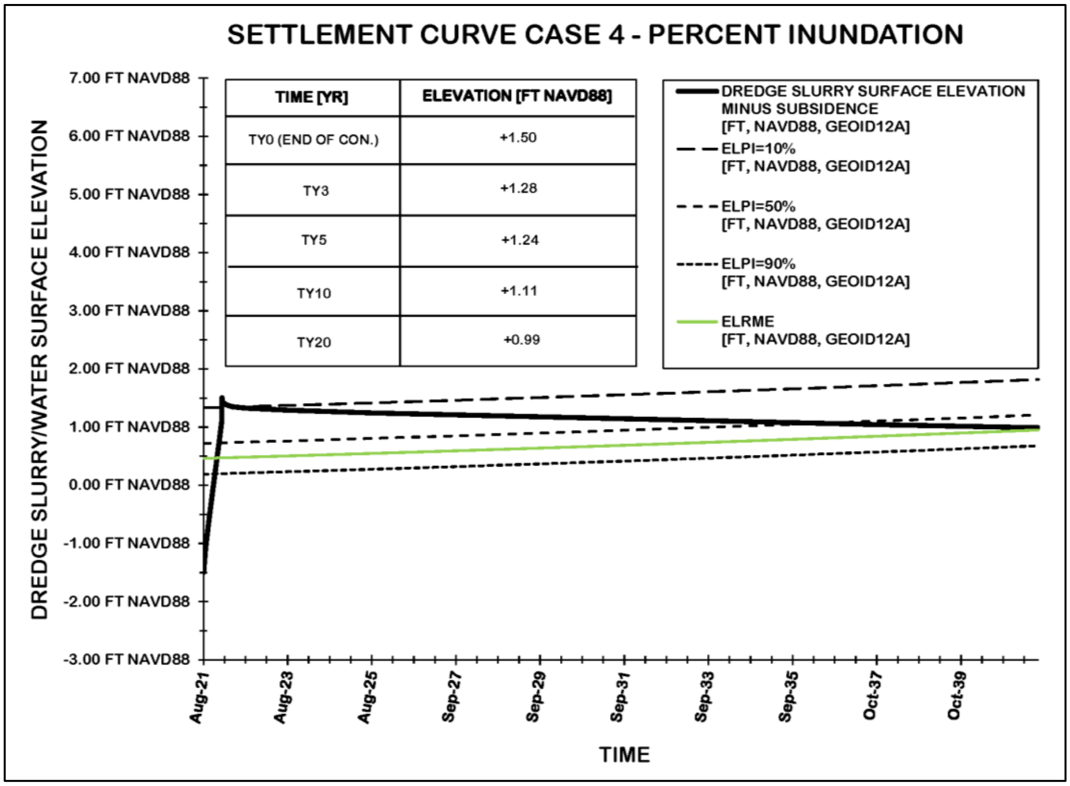


Figure 45: Settlement Curve Case 4, with Hydrologic Indices

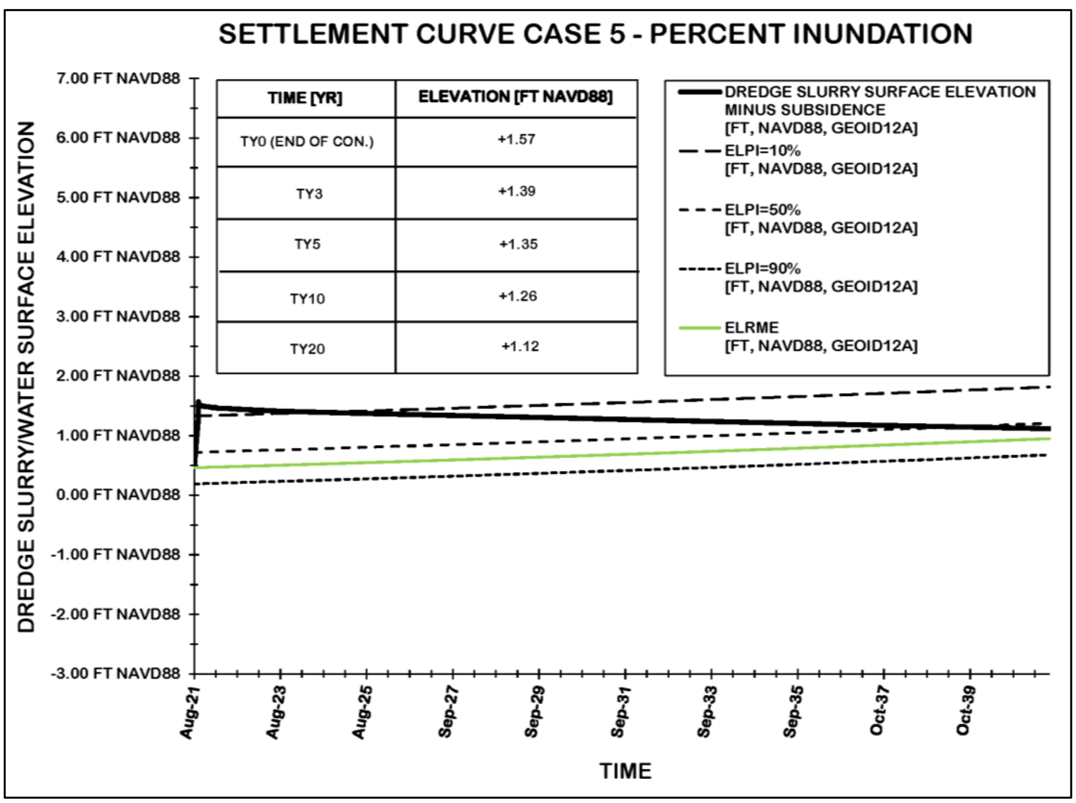


Figure 46: Settlement Curve Case 5, with Hydrologic Indices

6.4.6 Earthen Containment Dike Slope Stability Analyses

AAI performed a containment dike slope stability analyses in order to facilitate the selection of a final containment dike cross-sectional design. As stated in **Section 6.4.4**, a parametric analysis was done during Investigation No. 1, with assumed properties of dredge fill. This was later used by AAI to perform the dike stability analyses as part of Investigation No. 2.

Global and local slope stability analyses were performed on various earthen containment dike (ECD) cross-sectional configurations at different crown elevations and dike geometries in accordance with the CPRA MCDG, Appendix B Figure B-5 (shown as **Figure 47** below). The slope stability of a typical ECD has two types of driving forces: (1) forces induced by the weight of the soil; and (2) seepage forces, which tend to cause the soil to slide. In response to these driving forces, the subsurface soils have a resistant force in the form of shear strength, which attempts to keep the slope from sliding. Both driving forces and the resisting forces are dependent on the geometry and soil parameters of the proposed features. AAI performed slope stability analyses that computed factors of safety against potential failure based on limit equilibrium theory.

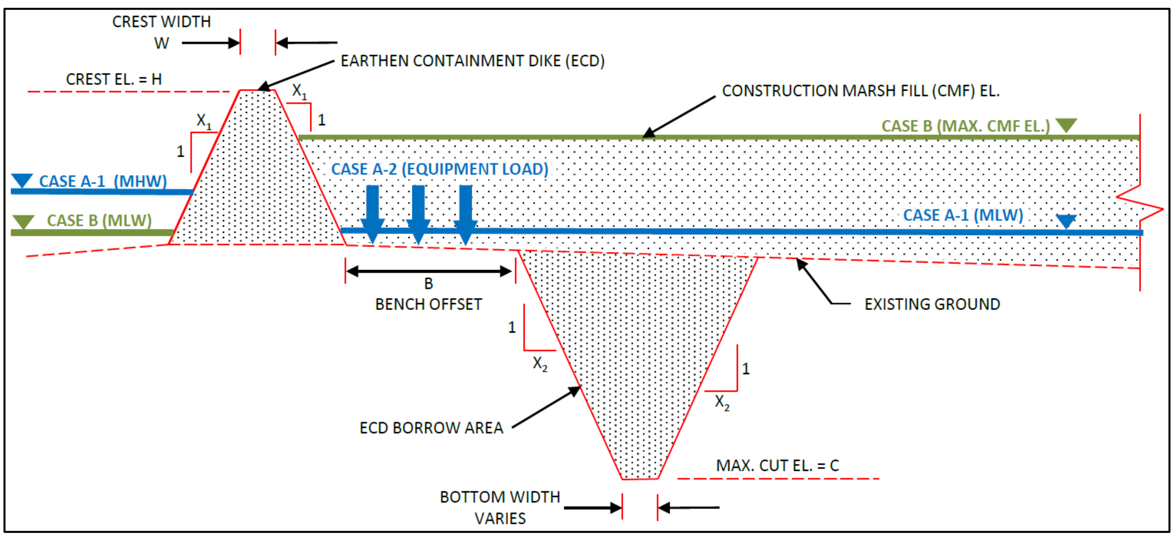


Figure 47: Typical ECD Section Diagram

For CS-0078, multiple scenarios were run across the following four (4) stability cases as follows:

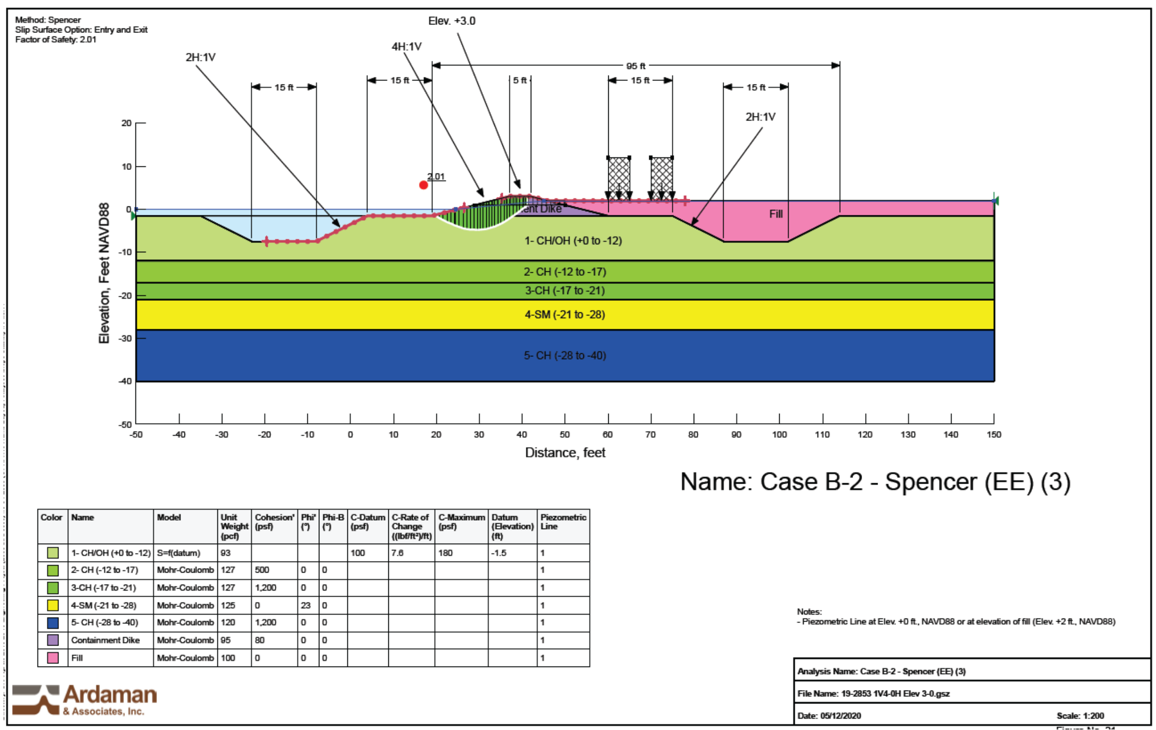
Case A-1) Global Stability Check During Dike Borrow Pit Excavation, Internal Dike Borrow Pit

Case A-2) Stability Check During Borrow Excavation With Construction Equipment Surcharge

Case B-1) Global Stability Check During Marsh Creation Construction With Fluid Level 1.0 FT From Dike Crest

Case B-2) Global Stability Check During Marsh Creation Construction With Fluid Level 1.0 FT From Dike Crest, External Dike Borrow Pit

The above-listed four (4) stability cases were run on containment dike configurations of varying crest elevations, with a maximum crest elevation of +3.0 FT NAVD88 being selected for design. Side slopes of 1V:4H were incorporated and can be increased if necessary, provided the stability berm minimum width dimension (15 ft) is not reduced. **Figure 48** depicts a sample output of a stability run performed on a containment dike being analyzed for Case B-2 provided by AAI. **APPENDIX G** contains more in-depth information on the ECD slope stability analyses performed by AAI. Note that additional slope stability checks were performed at the request of CPRA, which showed that factors of safety against slope failure remained above 1.2 for an interior borrow excavation down to -10 FT NAVD88. The CS-0078 project plans to utilize the containment dike dimensions shown in **Section 7.4**, but is prepared to modify the interior dike borrow design moving forward towards construction should deeper drafting vessels need increased flotation.



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	C-Datum (psf)	C-Rate of Change ((lbf/ft²)/ft)	C-Maximum (psf)	Datum (Elevation) (ft)	Piezometric Line
	1- CH/OH (+0 to -12)	S=f(datum)	93				100	7.6	180	-1.5	1
	2- CH (-12 to -17)	Mohr-Coulomb	127	500	0	0					1
	3-CH (-17 to -21)	Mohr-Coulomb	127	1,200	0	0					1
	4-SM (-21 to -28)	Mohr-Coulomb	125	0	23	0					1
	5- CH (-28 to -40)	Mohr-Coulomb	120	1,200	0	0					1
	Containment Dike	Mohr-Coulomb	95	80	0	0					1
	Fill	Mohr-Coulomb	100	0	0	0					1

Figure 48: ECD Slope Stability Output

6.4.7 Earthen Containment Dike Settlement Analyses

AAI performed earthen containment dike settlement analyses on the various containment dike geometries analyzed throughout CS-0078 geotechnical design. Consolidation settlement of the foundation soils beneath the ECDs was computed based on the dike geometries determined from slope stability analyses and the soil properties of the in situ soils near the proposed dike alignments. Total settlement factors include regional subsidence and elastic settlement of the in situ soils. Note that shrinkage and self-weight consolidation of the ECD soils also factor into ECD settlement calculations. Elastic settlement (construction settlement) of the in situ soils is expected to occur quickly and will likely result in an increase in the quantity of fill volume required to reach the design construction elevation. Multiple cases of ECD settled elevations were analyzed, with a construction ECD crown elevation of +3.0 FT NAVD88 being the maximum required containment dike elevation, given the target pump elevation of +1.5 FT NAVD88 discussed in **Section 6.4.5**. For the +3.0 FT NAVD88 crest elevation case, AAI estimates approximately 2 inches of settlement may occur during the envisioned construction window. **APPENDIX G** contains more information on containment dike settlement analyses.

6.4.8 Borrow Excavation for Containment Dike Cut-to-Fill Ratio

AAI performed an analysis procedure for mechanical dredging cut-to-fill ratios that was based on the relationships of compacted and uncompacted unit weight between the containment dike borrow pit and containment dike construction template, respectively. **Section 6.5** contains more discussion on the recommended cut-to-fill ratio for mechanical dredging provided by AAI, and **APPENDIX G** contains the analysis performed by AAI.

6.4.9 Borrow Excavation Cut to Marsh Fill Ratio Calculations

AAI similarly performed an analysis procedure for hydraulic dredging cut-to-fill ratios. This analysis procedure dealt with dry density, moisture content, void ratio, and moisture content compared between the in situ soil conditions at select locations within the marsh creation area and the borrow area. The actual recommended hydraulic dredging cut-to-fill ratio by AAI is discussed in **Section 6.5**, along with discussion on the hydraulic dredging cut-to-fill ratio selected for CS-0078 project design. The cut-to-fill analysis procedure is contained in AAI’s report included in **APPENDIX G**.

6.5 Cut-to-Fill Recommendation

Cut-to-fill ratios were recommended by AAI to compensate for losses during hydraulic dredging and disposal, containment, and dewatering, as well as mechanical dredging and sidecasting/placement of ECD borrow material.

As recommended by AAI, a mechanical dredging cut-to-fill ratio of 1.5:1 was used for design of CS-0078. Additional discussion available in **Section 6.4.8**.

A hydraulic dredging cut-to-fill ratio of 1.0:1 was used for design of CS-0078. AAI recommends a cut-to-fill ratio of 0.8:1 for hydraulic dredging. However, due to uncertainty with the calculation procedure utilized by AAI, CPRA is electing to move forward with a more conservative cut-to-fill ratio of 1.0:1 for hydraulic dredging. Additional discussion is available in **Section 6.4.9**.

7.0 DESIGN

7.1 Engineering and Design Scope

The CS-0078 project proposal includes construction of one (1) marsh creation area shown in the figure below by hydraulically dredging sediment from an open water borrow area in Calcasieu Lake. The 95% Design Drawings are available in **APPENDIX H**.

The CS-0078 project design is further broken up into the following subsections: engineering and design methodology, marsh creation area design, earthen containment dike design, borrow area design, and equipment access/dredge pipe corridor design. See **Figure 4**.

7.2 Engineering and Design Methodology

The overarching CWPPRA Phase I objective of the CS-0078 project is to explore restoration options consistent with the project goals discussed in **Section 1.4** and as outlined in the CWPPRA PPL 24 Project Fact Sheet (**APPENDIX A**).

In order to produce a marsh creation project design solution capable of meeting the goals listed in **Section 1.4**, the specific engineering and design objectives are as follows:

- Compute the design tidal datum, with emphasis on hydrologic challenges presented by the management regime of the CCW;
- Establish a preferred range of percent inundation elevations, analyze reference marsh survey elevations, and identify target settled marsh fill elevations for TY20;
- Determine required target pump elevation for marsh creation design via the generation of geotechnical settlement curves;
- Generate an optimized cross-sectional design for ECDs;
- Produce an integrated canal cleanout design consistent with ECD design;
- Produce a general civil layout for marsh creation and nourishment area/ECD geometric design, calculate the total proposed marsh creation acreage, and calculate the total required in-place fill volume quantity;
- Produce a general civil layout for equipment access and dredge pipe corridor geometric design; and
- Produce a general civil layout for borrow area geometric design, calculate the total available borrow area acreage, and calculate the total available borrow volume quantity.

7.3 Marsh Creation Area Design

Including the Phase 0 marsh creation area polygon (**Figure 2**), the marsh creation area project feature went through four (4) alternative layouts during Phase I before arriving at the current configuration shown in the 95% Design Drawings (**APPENDIX H**). **Figure 4** contains a project layout for the as-proposed 95% project layout for CS-0078. **Figure 49** below contains an inset of the marsh creation area that is shown on the project layout figure.

Figure 50 contains a profile view of the two typical sections called out on the plan view figure shown in **Figure 49**.

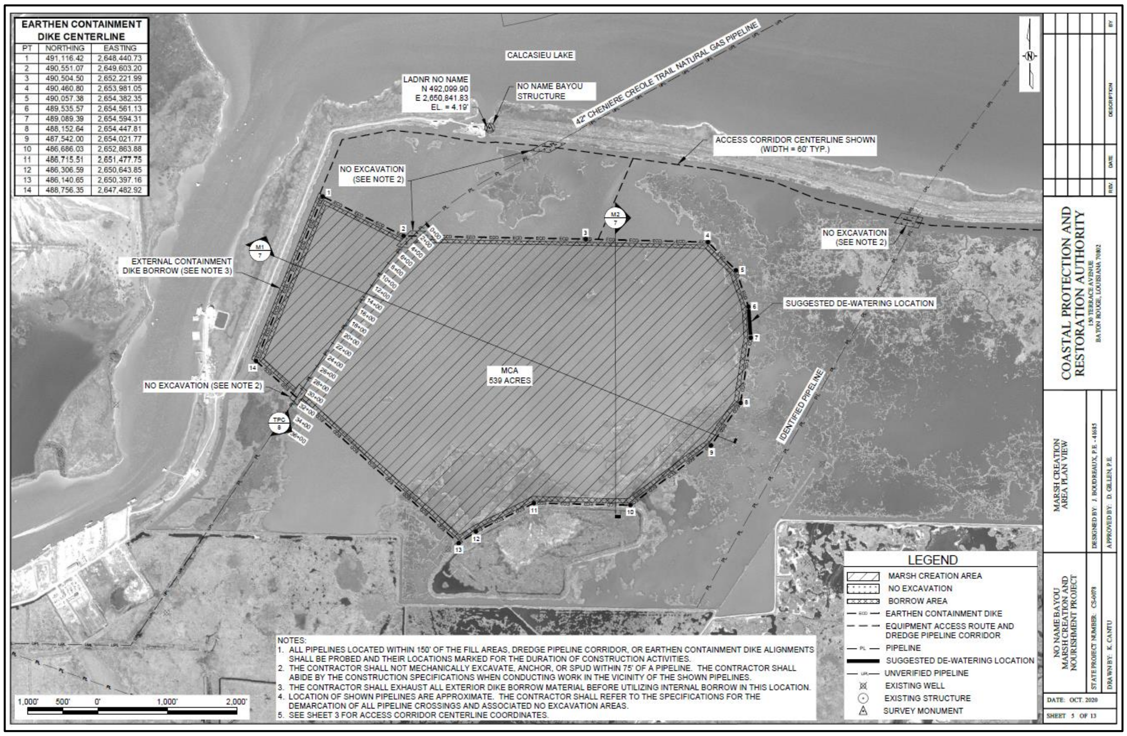


Figure 49: MCA, Plan View

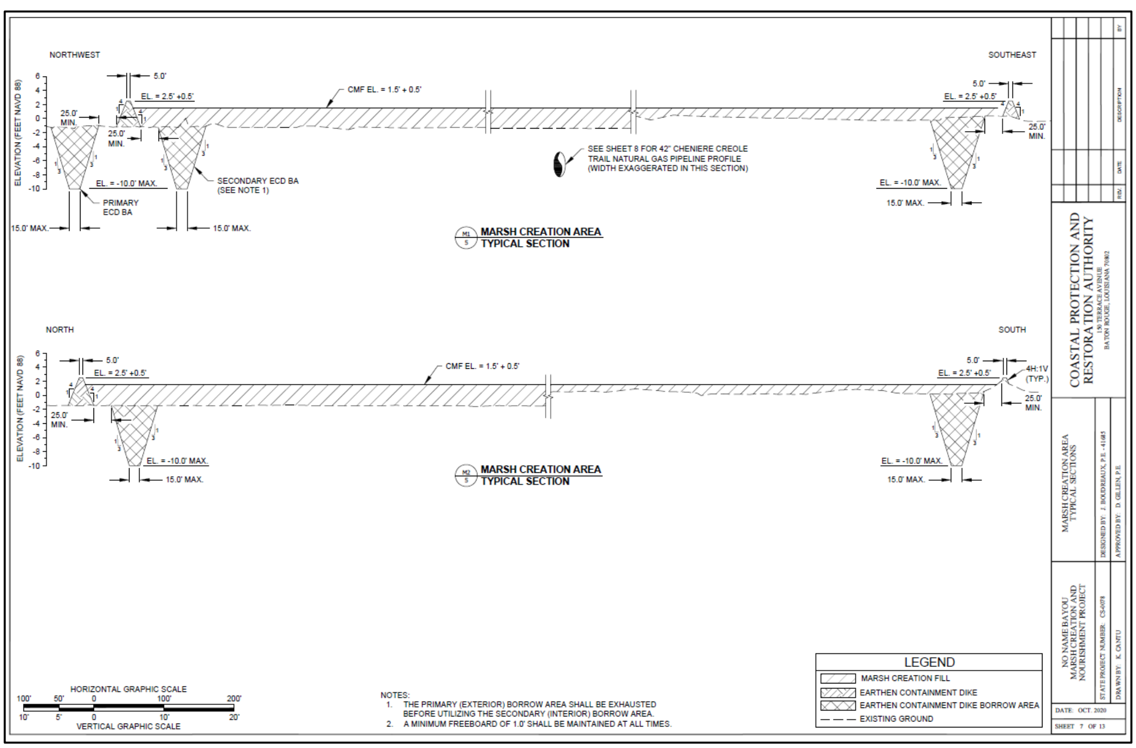


Figure 50: MCA, Typical Sections

Following selection of the preferred marsh creation area configuration, the next step in marsh creation area design involved determining an appropriate CMFE. CMFE is governed by several factors including the tidal range, percent inundation, reference marsh elevation, physical properties of borrow material, and bearing capacity of foundation soils within the marsh creation area. Typically, CMFE is determined based on an analysis of percent inundation and the use of a tidal datum calculation. As discussed previously (see **Section 2.4** and **Section 4.5**), the conventional determination of CMFE was not possible for CS-0078 due to hydrologic site conditions resulting from the management regime of the CCW. Instead, marsh creation area design was performed by generating geotechnical settlement curves in an iterative fashion, where AAI produced a set of curves parameterized across differing fill heights. The project team selected the +1.50 FT NAVD88 pump elevation with the understanding that this pump elevation was optimal, in terms of maximizing the duration of the project life that the restored marsh platform would exist within the preferred percent inundation range (20%-80% inundated).

During construction of CS-54, the design pump elevation of approximately +3.3 FT NAVD88 (average of the two marsh creation cells) was reduced to an elevation that was comparable with the CS-0078 design target elevation of +1.5 FT NAVD88. This change was made during construction and was based on geotechnical differences observed with the higher solids concentration and slower infill rate than was estimated during geotechnical design of CS-0054. This topic was discussed during the question and answer period of the CS-0078 30% Design Conference.

Additionally, the +1.50 FT NAVD88 pump elevation was observed to converge with the representative marsh elevation of a nearby site within the CCW that was prescribed for analysis by the CPRA Lafayette Regional Office monitoring biologist for CS-0078. This marsh elevation at present day status exists at approximately +0.8 FT NAVD88.

Over the 20-year project life, including sea level rise and subsidence conditions stated in **Section 4.3**, the preferred percent inundation range is expected to rise from +1.22 FT NAVD88 and +0.50 FT NAVD88 (20% inundation at TY0 and 80% inundation at TY0, respectively) to +1.71 FT NAVD88 and +0.99 FT NAVD88 (20% inundation at TY20 and 80% inundation at TY20, respectively). MTL is expected to rise from +0.84 FT NAVD88 to +1.33 FT NAVD88 (TY0 and TY20, respectively). The hydrologic index correlating to reference marsh elevation surveys (discussed in **Section 5.3.2.5**) is expected to rise from +0.46 FT NAVD88 (TY0) to +0.95 FT NAVD88 (TY20). It is worth pointing out that there is uncertainty in making projections of hydrologic indices at the CS-0078 project site, due to the fact that CCW management operations are ongoing and expected to continue into the future. **Table 11** contains a tabular array of this information.

Table 11: Hydrologic Indices for CS-0078 Marsh Creation Area Design

Hydrologic Index	Elevation at TY0 [FT NAVD88 GEOID12B]	Elevation at TY20 [FT NAVD88 GEOID12B]
$EL_{PI=20\%}$	+1.22	+1.71
EL_{MTL}	+0.84	+1.33
$EL_{PI=80\%}$	+0.50	+0.99
EL_{REF-M}	+0.46	+0.95

1. The following abbreviations are used in this table:
   "EL" stands for elevation.
   "PI=20%" stands for percent inundation equals twenty percent.
   "MTL" stands for mean tide level.
   "PI=80%" stands for percent inundation equals eighty percent.
   "REF-M" stands for reference marsh.

Settlement analyses are performed to determine CMFE for marsh creation project design and in order to compute the total volume of fill material required for construction. The final year 20 elevation of the restored marsh platform is governed by two forms of settlement: (1) the settlement of underlying soils in the marsh creation areas caused by the applied load of dredge slurry; and (2) the self-weight consolidation of the hydraulically dredged material itself. **Figure 51** contains a schematic of the marsh fill settlement process.

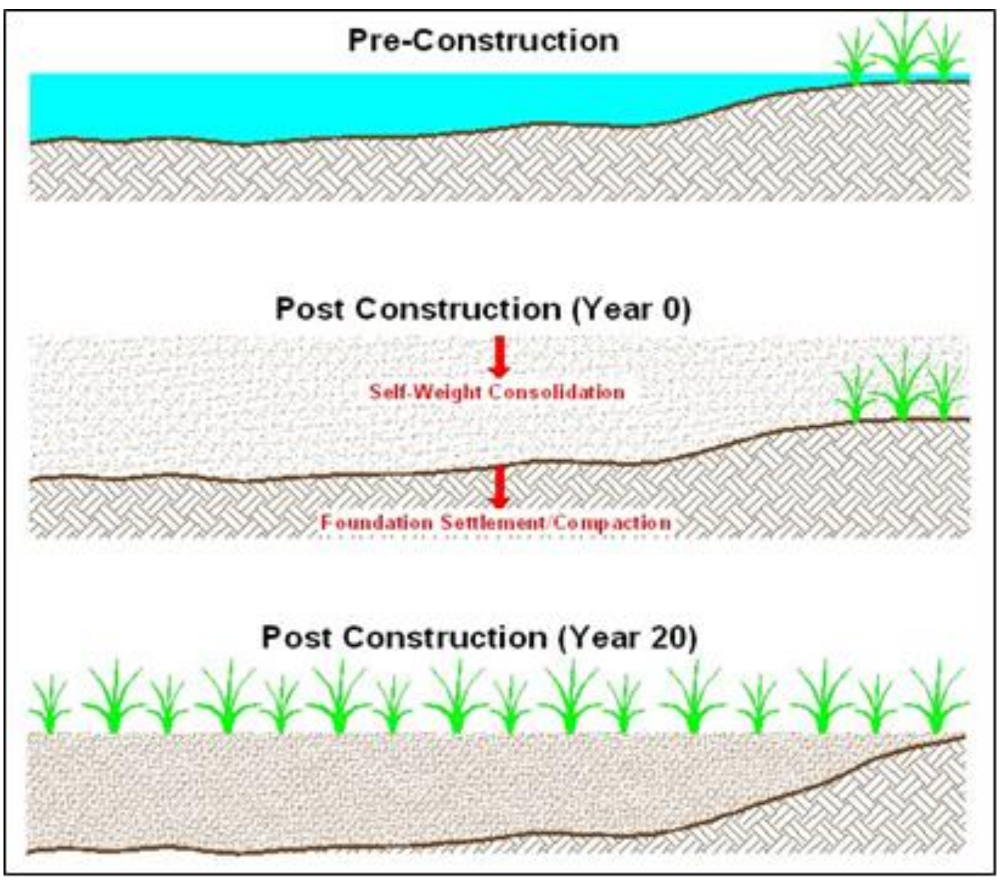


Figure 51: Marsh Fill Settlement Schematic

To achieve project goals, dredge slurry will be hydraulically transported from the borrow area and placed into the marsh creation area to an elevation of +1.5 FT NAVD88. The dredged materials will undergo settlement during construction and a predetermined amount of time will be incorporated into construction specifications prior to the allowance of dewatering operations.

The currently proposed marsh creation area layout includes a single marsh creation cell. Because the existing mudline elevation used for marsh fill settlement analysis can greatly affect the construction elevation required to achieve end of project 20-year elevations, a mudline elevation histogram was produced to aid the team's selection of CMFE. The purpose of this histogram is to facilitate the selection of an elevation that is representative of the entire marsh creation area while also accounting for deeper areas as applicable. This histogram, shown in **Figure 52**, was produced by processing survey data collected at the marsh creation area to clip out all portions of the dataset that fell outside of the extents of the marsh creation area boundary.

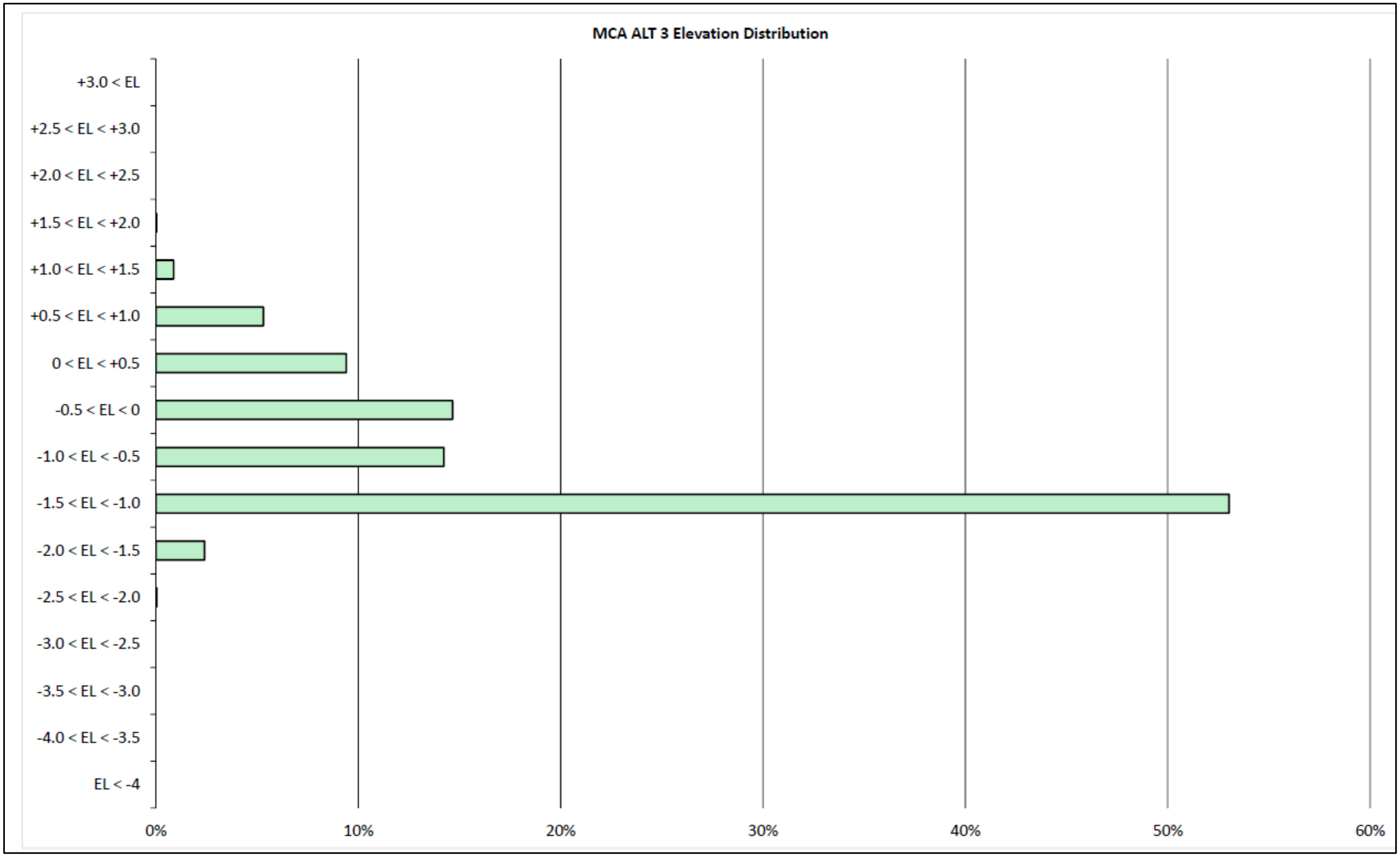


Figure 52: MCA Histogram of Existing Mudline Elevations

As shown in **Figure 52**, the majority of the existing mudline elevations exist between the -1.5 FT NAVD88 and -1.0 FT NAVD88 elevation contours. Based on the above data, the mean elevation is -0.81 FT NAVD88, median elevation is -1.12 FT NAVD88, and mode elevation is -1.35 FT NAVD88. The CSI figure showing a color spectrum distribution is consistent with this, as shown in **Figure 23**. As such, the selection of the +1.5 FT NAVD88 CMFE was based on settlement analyses for the predominant condition of a -1.5 FT NAVD88 mudline elevation. Note that an additional geotechnical settlement curve was produced using a mudline elevation of +0.5 FT NAVD88, in order to understand how the +1.5 FT NAVD88 pump elevation would perform in some of the shallower ponded areas and existing marsh areas across the site. Discussion on the settlement analyses showcasing the +1.5 FT NAVD88 pump elevation corresponding to the -1.5 FT NAVD88 preconstruction mudline elevation case (**Figure 45**) and the +0.5 FT NAVD88 preconstruction mudline elevation case (**Figure 46**) are available in **Section 6.4.5**.

Though the final constructed fill elevation of the marsh fill area is being targeted at +1.5 FT NAVD88, volume calculations were determined near the final settled CMFE to allow for primary consolidation settlement of the fill to occur. This process accounts for the decrease in voids, primarily water, as the material dewaters and begins to consolidate. As shown in the geotechnical settlement curves, the fill elevation decreases rapidly during the earlier portion of the curve as compared to the mid to later years due to the draining of excess porewater. Near the completion of primary consolidation settlement, the material has dewatered giving a more accurate estimate of the actual contract volume of dredged material needed to achieve the target marsh elevation.

After determining the CMFE, the total volume of the marsh creation area was calculated using AutoCAD Civil software and then checked with average end area calculations. Since the interior containment borrow must be also be refilled, a maximum cut template ECD borrow pit was similarly imported into AutoCAD in that was sized utilizing an ECD cut-to-fill ratio of 1.5:1. Volume computations were then performed, with the sum of the dike backfill volume and the TY20 CMFE with foundation settlement factored in being taken as the total in-place volume. In order to best incorporate the findings from the settlement analyses generated by AAI, CPRA produced two (2) separate volumetric estimates, as listed below.

Calculation "A") Using TY20 Settled EL Corresponding to Case 4 for Entire MCA

Calculation "B") Combined Approach According to the Following:

- -Using TY20 Settled EL Corresponding to Case 4 for Majority of Open Water Portions of MCA;
- -Using TY20 Settled EL Corresponding to Case 5 for Southeastern Boundary (Generally Shallower Water Depths/Higher Mudline Elevations);
- -Taking Sum of Both Case 4 and Case 5 as Total In-Place Fill Volume.

Fill volume calculations are shown in **Table 12**.

Table 12: Marsh Creation Area Design Quantities (30% Design)

Fill Volume	In-Place Volume [CY]	Acreage [AC]
TY20 Settled EL (Calculation "A")	1,889,168	539
TY20 Settled EL (Calculation "B")	1,928,726	539
Selected For Design	1.93M	**539**

As shown in the above table, the fill volume corresponding to Calculation "A" is 1.89M CY, and that of Calculation "B" is 1.93M CY. The reason for the higher quantity shown for Calculation "B" is that the TY20 settled elevation corresponding to the Case 5 settlement attains a higher elevation value than that of Case 4. Being that Calculation "A" incorporated sole use of the Case 4 settlement curve

During 30%, the decision to utilize the more conservative of the two was made, and therefore a fill volume of 1.93M CY was selected for design. This decision was based on the following:

- The largely sized marsh creation area polygon will likely be constructed with the use of training dikes during construction, and the separation between the southeastern portion of the project site from the generally deeper remaining portion of the project site was a logical choice to separate volume calculations. Note that the 95% design drawings do not depict this training dike location, as the location of training dikes are expected to be determined during construction with submittal of the prospective contractor's work plan. The ensuing volumetric computation for this conditions was chosen to be that of Calculation "B".
- Further design may consider re-evaluating marsh creation area geometries that could be larger, and as such the CS-0078 project team wanted to move forward with a conservative volumetric estimate of marsh fill for the 30% milestone.

Table 13 below summarizes the fill volume calculations for 95% Design, with additional discussion further below.

Table 13: Marsh Creation Area Design Quantities (95% Design)

Fill Volume	In-Place Volume [CY]	Acreage [AC]
Average of Calculation “A” and Calculation “B”	1,908,947	539
30% Assumed Dike Backfill Volume	155,986	N/A
Revised Dike Backfill Volume (Utilizing C:F = 1.5:1)	72,010	N/A
Recomputed Marsh Fill Volume Including Dike Backfill	1,824,971	539
Subgrade Settlement within Marsh Creation Area	289,862	N/A
Marsh Fill Volume Including Subgrade Settlement	2,114,833	539
Total In-Place Marsh Fill Volume Selected For Design	2.12M	**539**

For 95%, it was decided to re-evaluate the selected fill quantity to achieve a higher degree of accuracy. Based on this, the following were performed:

- The average volume yielded from Calculation “A” and Calculation “B” was computed, approximately 1.90M CY.
- To further refine the volume calculation for dike backfill, dike backfill quantity was modified based on from 30% design, as follows:
    1. The maximum containment dike borrow pit volume value of 160K CY (used during 30% design) was eliminated from in-place volume calculations;
    2. Subtracting this value from 1.9M CY (from first bullet above), the in-place volume excluding dike backfill yielded approximately 1.8M CY;

3. The containment dike cut volume (using C:F of 1.5:1) for the as proposed dike geometry with positive 0.5 FT construction tolerance (crest EL +3.0 FT NAVD88) was measured in AutoCAD at approximately 70K CY;
4. Adding this 70K dike backfill quantity to the quantity shown in Item 2 above, the final in-place marsh fill quantity was recalculated to the value shown in row 4 in **Table 13** above.

- From there, the subgrade settlement within the marsh creation area was estimated by multiplying 4 inches of total settlement by the total marsh creation area acreage of 450 AC; this yielded approximately 290K CY;
- Adding the subgrade settlement (approximately 209K CY) to the in-place marsh fill volume including dike backfill (from row 4 in Table 13 above) totaled out to approximately 2.1M CY;
- The final in-place marsh fill volume selected for design was 2.12M CY.

7.4 Earthen Containment Dike Design

7.4.1 Earthen Containment Dike Design—General Information

The primary design parameters associated with ECD design include crown elevation, crown width, and side slopes. A minimum of one (1) foot of freeboard is recommended to contain dredge slurry within the proposed marsh creation fill area while maintaining an acceptable factor of safety. The ECDs are required to be maintained to the target construction elevations throughout the duration of hydraulic dredging and disposal operations. CS-0078 95% design calls for an ECD crest elevation of +2.5 FT NAVD88, which is based on the aforementioned freeboard requirement relative to the target pump elevation of +1.5 FT NAVD88. The crown width is called out at 5 FT, with side slopes of 1V:4H (4 FT vertical rise for every 1 FT horizontal run). As proposed, interior containment dike borrow is available for the entirety of the ECD alignment. Exterior borrow shall be required for prioritized use along the shown locations in the 95% Design Drawings and as indicated in **Figure 49**, with the corresponding cross-section figures shown in **Figure 50**.

The following two subsections discuss both the internal and external borrow pit design for the ECD. **Table 14** below contains ECD design information.

Table 14: Earthen Containment Dike Design Quantities

ECD Feature	ECD Length Along CL [LF]
Interior Borrow Only	16,902
Interior and Exterior Borrow	2,547
Total	19,449
Selected for Design	**19,450**

7.4.2 Earthen Containment Dike Design—Interior Borrow

For internal borrow pit ECD design, the dike dimensioning is the same as stated in **Section 7.4.1**, with the following called out for the borrow pit. The only difference between interior borrow and external borrow is the allowance of bottom of cut elevation down to -10.0 FT NAVD88.

- 15 FT bottom width across bottom of cut contour at -10.0 FT NAVD88
- 1V:3H side slopes
- 25.0 FT minimum bench offset between toe of fill of ECD and top of cut of borrow pit

7.4.3 Earthen Containment Dike Design—External Borrow

For internal borrow pit ECD design, the dike dimensioning is the same as stated in **Section 7.4.1**, with the following called out for the borrow pit. Note that all portions calling for external borrow also have interior borrow available, with the requirement for external borrow volume to be exhausted prior to any use of internal borrow in these regions. Also note that stability analyses demonstrate that the bench offset can be reduced to 15.0 FT in the event equipment limitations necessitate.

- 15 FT bottom width across bottom of cut contour at -10.0 FT NAVD88
- 1V:2H side slopes
- 25.0 FT bench offset between toe of fill of ECD and top of cut of borrow pit

7.5 Borrow Area Design

As shown in **Table 12**, the total in-place marsh creation volume selected for design is 2.12M CY. Utilizing a cut-to-fill ratio for hydraulic dredging of 1.0:1, the contract borrow quantity was estimated equivalent to the in-place marsh creation volume of 2.12M CY.

As discussed throughout this report, the CS-0054 project's borrow area was used as a starting point to perform CS-0078 project's borrow area design. Based on as-built survey data obtained from the CS-0054 project, approximately 2.64M CY remain within that polygon. However, much of the available dredge cut depth was exhausted during construction of CS-0054, such that excavation of all 2.64M CY of remaining material would be challenging without the allowance of overdredging below the -16.0 FT NAVD88 bottom of cut contour.

During CS-0078 project design, an adjacent borrow polygon was designed next to the CS-0054 borrow area. With the knowledge of prevailing rangia shells located within the CS-0054 area, as well as to allow for flexibility during construction, the CS-0078 team felt it necessary to include sufficient volumetric contingency. Additionally, a pipeline was discovered within the originally scouted borrow investigation area during data collection (see **Section 5.6** for pipeline information). With a recommended offset of 500 FT from the known pipeline, the borrow area polygon developed for CS-0078 contains approximately 5.45M CY of available material.

The combined borrow area as currently sized contains up to 8.09M CY, which offers a volumetric contingency for the as-proposed project of over 400%. During 30%, it was considered to include language that would require the use of the remaining CS-0054 borrow area quantity prior to dredging further west into the CS-0078 borrow area. At 95% design, the decision has been revised to not require prioritized dredging of CS-0054 borrow area material. This decision was made due to the complications involved in the dredging process if requiring to excavate the residual CS-0054 borrow area, and associated cost increases. However, the CS-0078 team plans to submit construction permit drawings that will allow for the use of all CS-0054 material if a prospective contractor is able to adequately dredge this material. The CS-0078 team also envisions requiring that the hydraulic dredging plan progress from east to west during construction, to remain contiguous with past project use of the Calcasieu Lake borrow material resource.

One area that is frequently of concern with marsh creation projects is the possibility of impacting wave dynamics and increasing shoreline erosion due to changing the bathymetry from the dredging of borrow areas. Wave modeling results from the CS-0054 project show that no measurable changes (>+/-0.20 ft) to wave patterns near the shoreline are not large enough to change erosion rates along adjacent shores. The project team also considered the following in concert with the previous wave model findings: 1) the borrow area's distance from the shoreline; 2) the size of the borrow area relative to the body of water from which the material will be borrowed; and 3) the cumulative size and orientation of the borrow area when combined with the CS-0054 borrow area.

Based on findings from that hydrodynamic modeling effort, CS-0054 was anticipated to exhibit small increases in wave heights, such as 0.2 ft, which is on the order of elevation survey accuracy. As such, the project team decided that numerical modeling for the CS-0078 marsh creation project was not deemed necessary. The CS-0054 borrow area wave modeling report is available at the following URL:
https://cims.coastal.louisiana.gov/outreach/projects/ProjectView?projID=CS-0054.

Table 15 below contains borrow area quantities and other information. **Figure 53** and **Figure 54** contain plan and section drawings for the borrow area. Note the section drawings sheet shown in **Figure 54** also contains a typical section of the CCW Levee crossing proposed for CS-0078.

Table 15: Borrow Area Design Quantities

Volumetric Feature	Volume [CY]
Total Volume Demand (C:F = 1.0:1)	2,120,000
CS-0054 Remaining Volume (369 AC)	2,637,956
CS-0078 Available Volume (407 AC)	5,448,620
Sum of CS-0054 and CS-0078 Borrow Available Volume (776 AC)	8,086,576

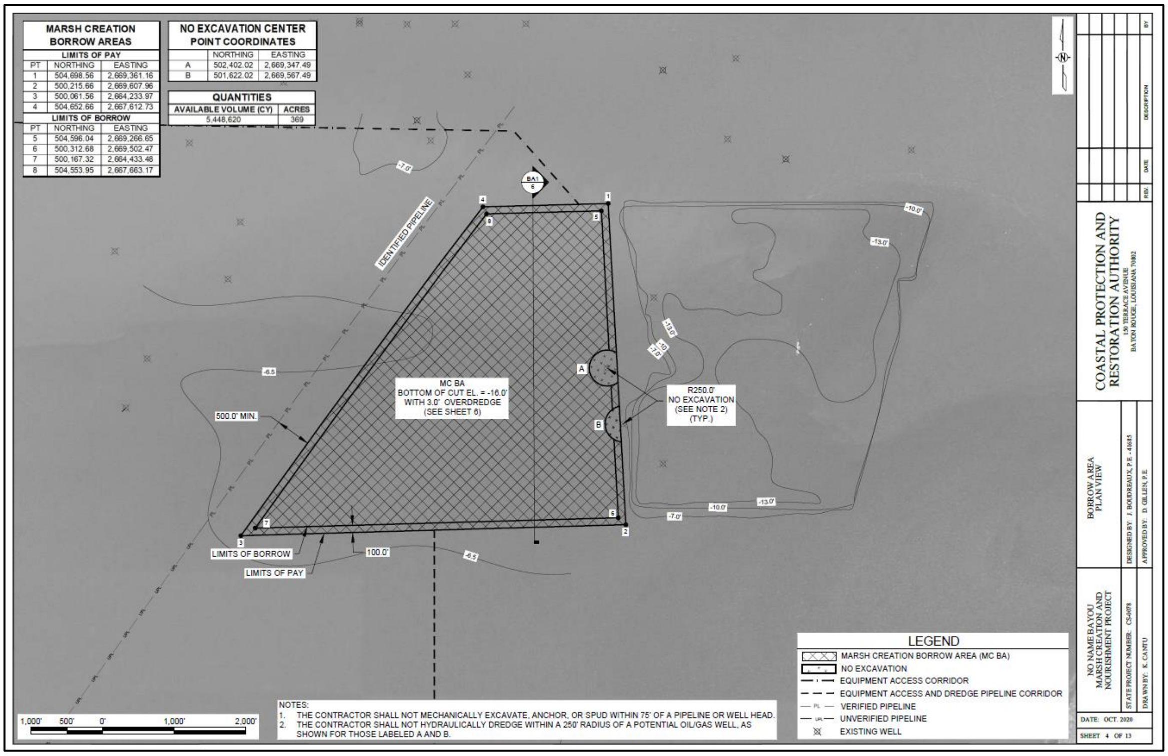


Figure 53: BA Design, Plan View

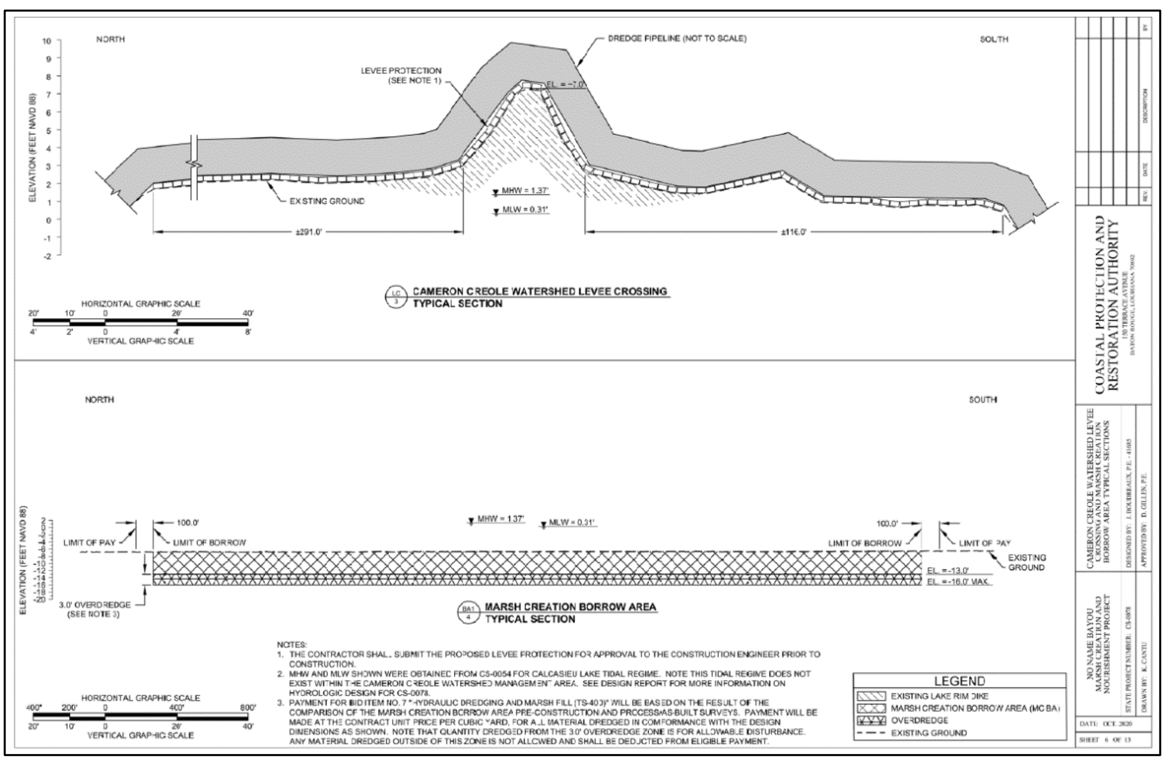


Figure 54: BA and Levee Crossing Design, Typical Section

7.6 Equipment Access and Dredge Pipe Corridor Design

7.6.1 30% Design

The following language was modified from 30% design status to document what was done for that milestone, while the below section (**Section 7.6.2**) covers modifications incorporated for 95% design.

During 30% design, one equipment access corridor and two (2) equipment access and dredge pipe corridors were proposed. The total length of combined access and dredge pipe corridor, as measured along the as-proposed corridor centerlines, was approximately 60,000 LF (approximately 11 miles). This 60,000 LF of corridor was proposed along a total of three (3) separate corridor alignments. All corridors were proposed with 60 FT of maximum bottom of cut width and side slopes of 1V:3H.

See the CS-0078 30% report for more information.

7.6.2 95% Design

As shown on **Figure 4**, the CS-0078 project layout shows a single dredge pipeline and equipment access corridor stretching between the borrow area and marsh creation area. During 30%, there had been two (2) separate dredge pipeline and equipment access corridors, with the reasoning being that the eastern dredge pipe corridor (which is pictured on **Figure 4**) would serve as a backup option in the event that complications would arise with oyster resource or with the two (2) crossing locations shown over the CCTPC 42-inch natural gas pipeline. LDWF requested that the CS-0078 project team prioritize the eastern dredge pipe corridor over the western pipe corridor. CPRA produced an incremental cost analysis that showed a marginal cost savings, when comparing between the estimated costs for construction using the western dredge pipe corridor versus that of the eastern dredge pipe corridor. Access dredging was also eliminated for 95%. This decision was informed with knowledge of CS-0054 construction, primarily due to a shallow controlling water depth observed along the Calcasieu Lake equipment access route used during that project. This knowledge was obtained through discussion with project team members affiliated with the project, as the CS-0054 construction completion report remains in development. **Section 10.0** contains additional discussion on revisions made past 30%.

7.7 Future Engineering and Design

With regard to post 95% engineering and design for the CS-0078 project, the following is recommended for consideration.

- Ongoing stakeholder engagement will continue. As discussed throughout this report, communication with CCTPC and landowners will continue and are critical for post 95% design.
- A fourth marsh creation area layout has been discussed by the team, and it is possible to relocate the polygon as a backup plan for landrights and pipeline stakeholdership

reasons. Geotechnical conditions need to be verified, but it is not likely additional data collection will be necessary.

8.0 CONSTRUCTION

8.1 Duration

An approximate construction duration was developed using the Texas Agricultural and Mechanical University Center for Dredging Studies (CDS) Dredge Production and Cost Estimation Software and Microsoft Project. Assuming a 16-18 inch hydraulic cutter suction head dredge and incorporating weather days, a total construction time from mobilization to demobilization is approximately 537 days. Note that mobilization, demobilization, and mechanical dredging was also incorporated into this estimate of construction duration.

8.2 Cost Estimate

An Engineer's Estimate of Probable Construction Cost Plus Contingency was prepared for this project using the CWPPRA PPL 30 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 30 format.

8.3 Draft Construction Specifications

As per CWPPRA Standard Operating Procedures (SOP), it is required to submit as part of a 95% design submittal a draft set of construction specifications. This has been provided to NOAA as part of 95% design review.

9.0 MODIFICATIONS FROM PHASE 0 APPROVAL

As a result of Phase I activities, the features originally approved in Phase 0 have been modified to present a more constructible project for consideration of Phase II funding. Specific modifications include the following.

- Borrow area complications arose during Phase I that ruled out the possibility of implementing the original project concept to mine sediment from CDF-M. This produced a modification from the Phase 0 project concept.
- An alternatives analysis was performed for marsh creation area feature, wherein four (4) separate alternatives were presented and one of the revised alternatives was selected for design. This produced a modification from the Phase 0 marsh creation area polygon.
- An alternatives analysis was performed for the borrow area feature, wherein three (3) separate alternatives were presented and the Calcasieu Lake borrow site was selected for design. This produced a modification to the Phase 0 borrow area polygon, which in turn modified the equipment access and dredge slurry conveyance approach to the project.

10.0 MODIFICATIONS FROM 30% DESIGN

Between the 30% milestone and the 95% milestone, specific modifications include the following.

- Continued correspondence with LDWF occurred regarding the western dredge pipe corridor. Due to concerns with impacts to oyster resources, LDWF requested that the eastern dredge pipe corridor be prioritized over the western dredge pipe corridor. CPRA performed a cost analysis which indicated the western corridor would result in an incremental cost savings of approximately 5% as compared to the western corridor. Note that the 30% construction cost estimate elected to utilize the more expensive eastern corridor to be conservative. As such, the 95% design calls for use of the eastern corridor only, with plans to further refine post 95% for potential cost savings.
- Additional correspondence occurred with other stakeholders, including CCTPC, CP NWR, and private landowners. The most notable revision resulting from such correspondence was the application of a 75 FT offset for mechanical access dredging along the two (2) containment dike crossing locations with the CCTPC 42-inch. This 75 FT offset was not prescribed by CCTPC and was implemented based on best practices on other CPRA projects. This 75 FT offset is different from the 30% drawing package, as an actual offset distance had not been specified. It is expected that further correspondence and engagement with CCTPC will occur moving towards construction in order to select an appropriate offset distance, to discuss equipment crossing logistics, and to further refine construction specification language for utility owner requirements. Due to the aftermath of Hurricane Laura within the vicinity of the CS-0078 project, communications have been delayed. For 95% design, costs for potential extra handling near the containment dike crossing locations is expected to be absorbed in the somewhat conservatively selected unit rate for containment dike costs and construction contingency.
- Additional slope stability analyses were conducted that demonstrated acceptable factors of safety down to bottom of cut elevations of -10 FT NAVD88 for all interior containment dike borrow channels.

See **APPENDIX J** for all comments received following the CS-0078 30% design conference. The CS-0078 project team’s responses are also included.

11.0 REFERENCES

Mitsch, W.J., Gosselink, J.G., 1986.Wetlands. Van Norstrand Reinhold Company, New York, NY, USA, p. 539.

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