GRAND LIARD
MARSH AND RIDGE RESTORATION
(BA-68)

FINAL DESIGN REPORT
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Coastal Protection and Restoration Authority of Louisiana

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1.0 INTRODUCTION

The Grand Liard Marsh and Ridge Restoration Project (herein referred to as BA-68) is located within the Barataria Basin of Plaquemines Parish, Louisiana, to the west of the community of Venice and southeast of the community of Boothville as shown in Figure 1. The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Task Force approved BA-68 for Phase I (Engineering and Design) as part of the 18th Priority Project List. The National Oceanic and Atmospheric Administration (NOAA) was designated as the lead federal sponsor with funding approved through the Coastal Wetlands Planning, Protection and Restoration Act of 1990 and the Wetlands Conservation Trust Fund by the State of Louisiana. The Coastal Protection and Restoration Authority (CPRA) is serving as the local sponsor and is also performing the engineering and design work.

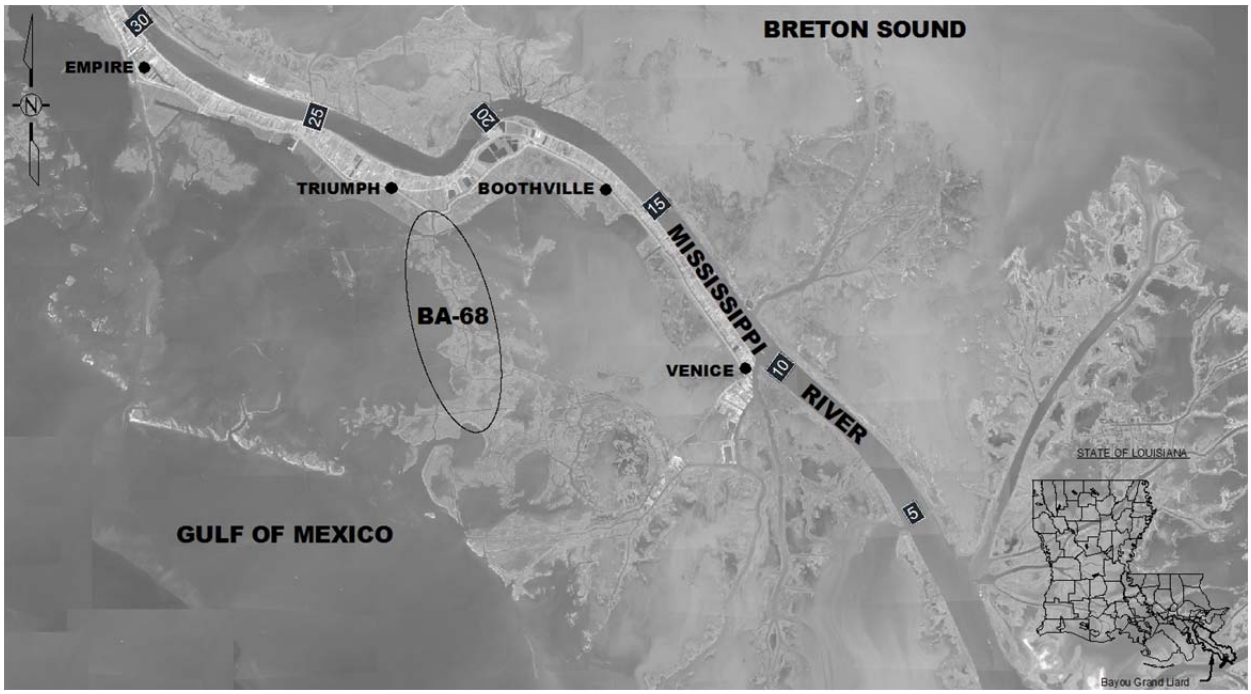

Figure 1 BA-68 Vicinity Map

The BA-68 Project Area has experienced wetland loss due to a variety of forces including relative sea level rise, salt-water intrusion, a lack of sediment supply, and oil and gas exploration/infrastructure. Past land loss projections indicate a loss rate of -1.7% per year; and also suggest that the remaining bayou bank wetlands will be completely converted to open water by 2050. Figure 2 illustrates this loss from 1998 to 2010.

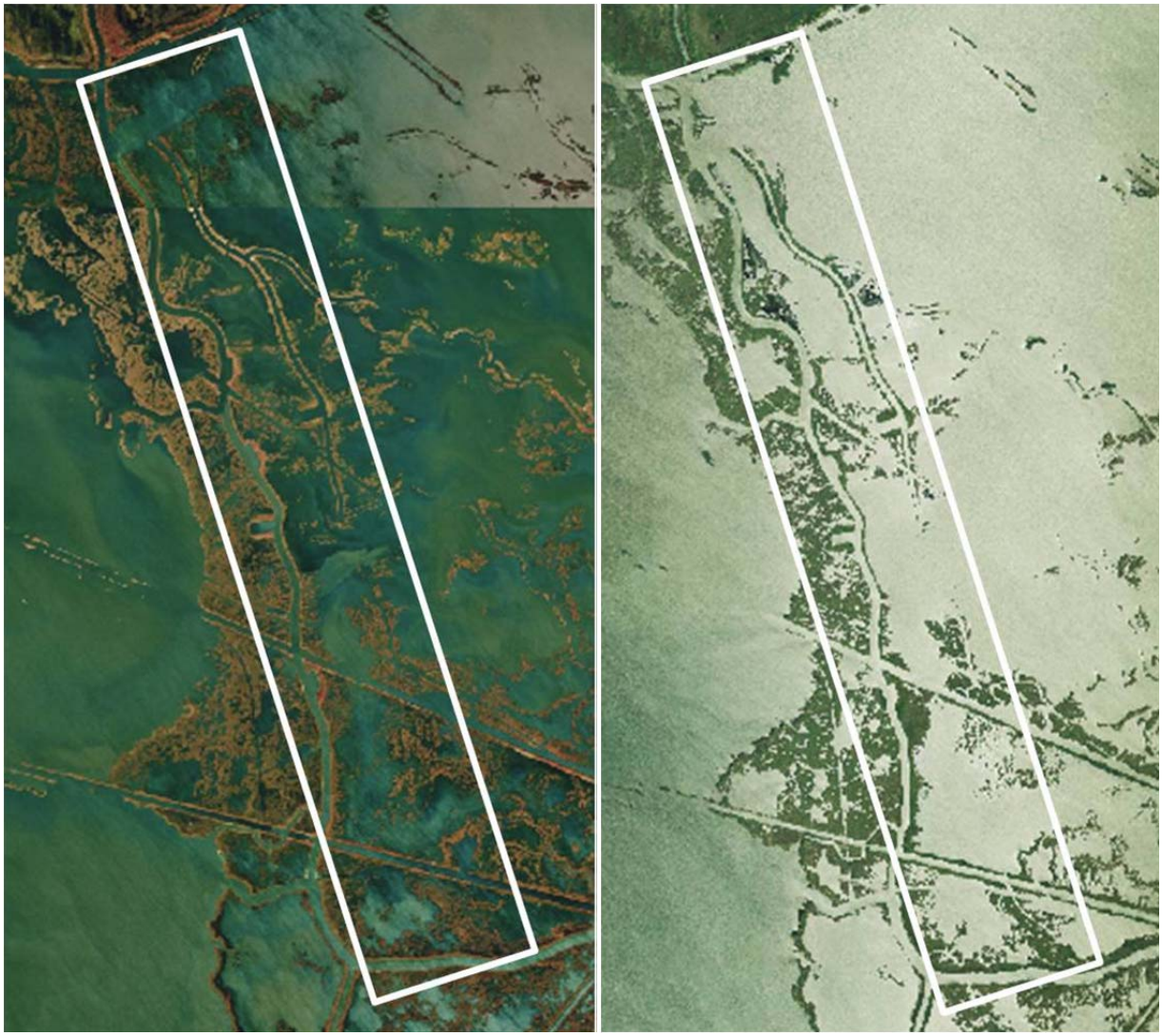

Figure 2 Grand Liard Aerials, 1998 (left) 2010 (right)

The areas within the Bastion Bay and Grand Liard mapping units were historically structured by a series of north-south oriented bayous and associated ridges (see Figure 3). Over the preceding decades the majority of these bayou ridges and the marshes flanking them have disappeared. Ridge loss combined with interior wetland loss has resulted in large expanses of open water. The marshes adjacent to Bayou Grand Liard are the most prominent remaining landscape feature, and this feature separates the open bays of the Bastian Bay and Grand Liard mapping units. The proposed project would re-establish some ridge and marsh function in the Bayou Grand Liard vicinity in addition to potentially reducing water level setup and wave fetch.

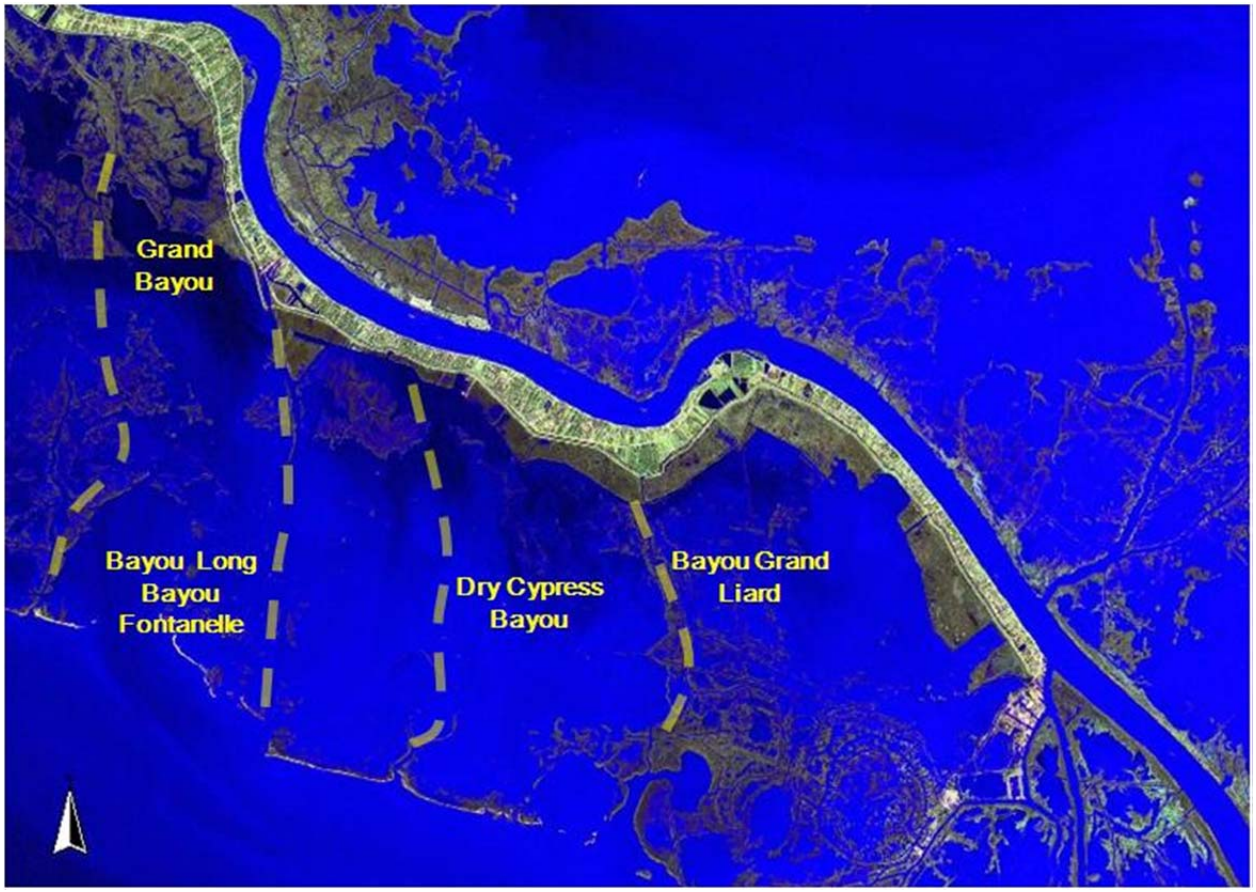

Figure 3 Historical Ridges of the Bastion Bay and Bayou Grand Liard Mapping Units

The primary goal of BA-68 is to restore the eastern ridge of Bayou Grand Liard and re-create marsh habitat in the open water areas that lie directly to its east (see Figure 4). Phase 0 (planning level) goals included:

1. Creating/nourishing 468 acres of saline marsh habitat;
2. Restoring approximately 20,000 linear feet (34 acres) of maritime ridge habitat.

The construction of the marsh creation sites for BA-68 involves hydraulically dredging sediment from a designated borrow source to fill in open water areas located within the marsh. Containment dikes will be constructed around the designated fill sites to contain the dredge slurry. Sediment from Bayou Grand Liard and in-situ marsh fill material will be used to construct the earthen ridge. Topographic/bathymetric surveys, magnetometer surveys, geophysical surveys, geotechnical investigations/analyses, and wave analysis of the offshore borrow site have been completed. Additionally, a tidal datum analysis has been performed by CPRA to determine the mean water elevations in the project area. These efforts have been carried out in order to determine site conditions, suitable target fill elevations, and quantity of fill material needed for the project features.

The Project Team, consisting of members of NOAA and CPRA, performed an on-site kick-off meeting on June 17 and 18, 2009. Based on that meeting, a work plan was developed to identify and address the project requirements. The engineering and design, environmental compliance, real estate negotiations, operation/maintenance planning, and cultural resources investigations have been executed to the 95% level of completion as required by the CWPPRA standard operating procedures.

Current project features include:

- 436 acres of marsh nourishment/creation including construction of earthen containment dikes and four sheet pile wall structural closures.
- Restoration of 16,600 feet of earthen ridge including four sheet pile wall structural closures. Material for earthen ridge construction will be obtained from both Bayou Grand Liard and within the marsh fill footprint.

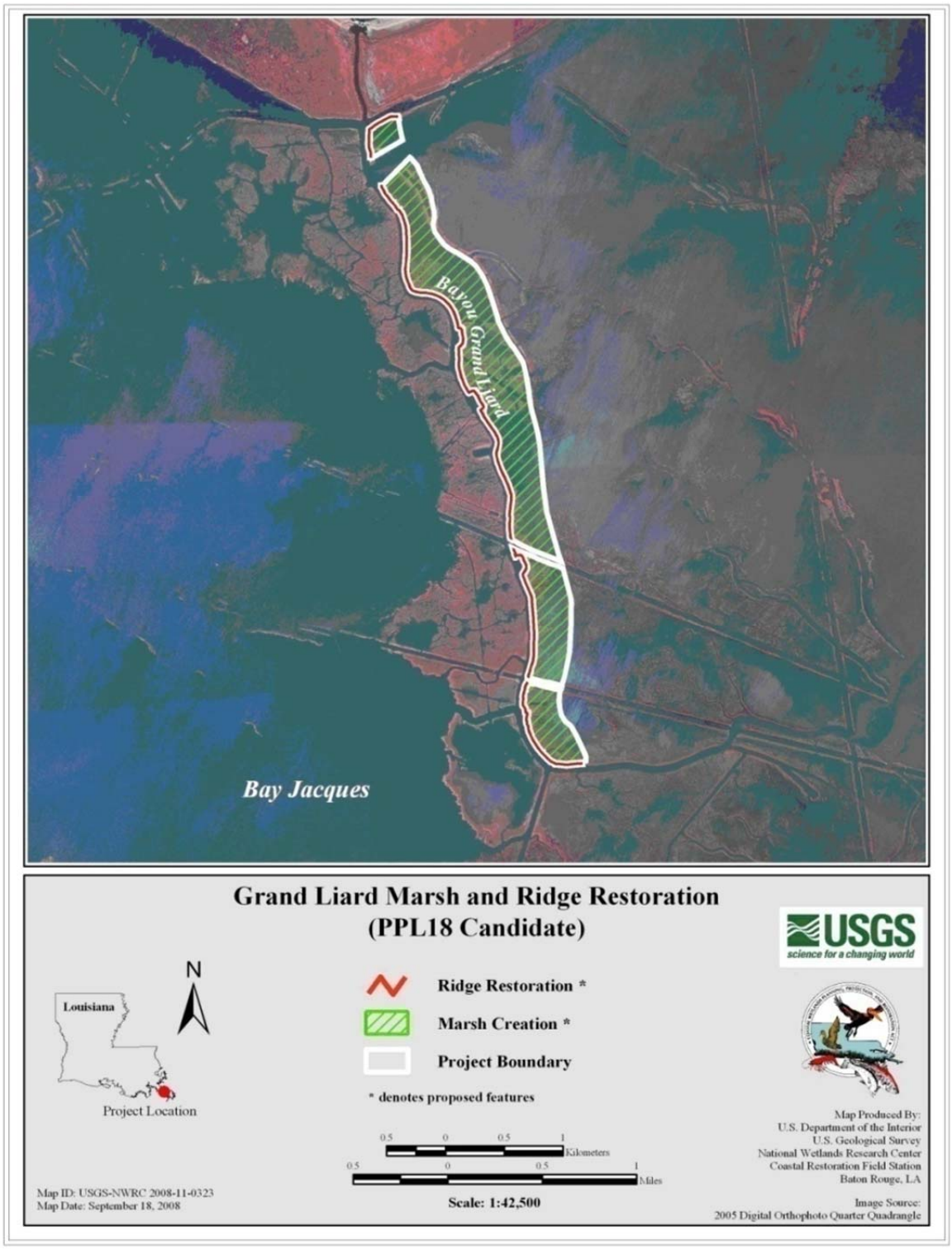

Figure 4 BA-68 Phase 0 Layout

2.0 TIDAL DATUM

The tidal datum is a standard elevation defined by a certain phase of the tide and is used to measure local water levels. Establishment of the tidal datum for BA-68 occurred in the early stages of preliminary engineering since it pertains to many aspects of the project design including surveys, geotechnical analysis, and constructability. However, an objective for computing the tidal datum is to establish the target construction fill elevation that maximizes the duration that the restored marsh will be at intertidal elevations throughout the 20 year project life.

A tidal datum is referenced to a fixed point known as a benchmark and is typically expressed in terms of mean high water (MHW), mean low water (MLW), and mean tidal levels (MTL) over the observed period of time. MHW is the average of all the high water heights observed over one tidal epoch. MLW is the average of all the low water heights observed over one tidal epoch. MTL is the mean of the MHW and MLW for that period of time. A normal tidal epoch lasts approximately 19 years. In order to accurately estimate MHW and MLW elevations, a data set which has less than 19 years of data should be correlated to a gage which has data from a full tidal epoch using a technique known as the Range-Ratio method.

The Coastwide Reference Monitoring System (CRMS) monitoring station CRMS0163 was selected to determine historical water levels as it is the closest water level gage to the project area. This gage is located at 29°13’0.22”N, 89°25’15.82”W, approximately six miles southeast of the project area. Hourly water level data was recorded from June 25, 2007 to June 22, 2010. The NOAA station #8761724 located at Grand Isle, Louisiana near Barataria Pass at 29°15'48"N, 89°57'24"W was used as the control station for tidal epoch correlation. The period of record used for the 19 year tidal epoch was from June 25, 1991 to June 22, 2010. A detailed summary of the tidal datum calculations is shown in the Design Calculations Packet located in Appendix H. The results of the tidal datum determination for BA-68 are as follows:

- MHW = 1.35 ft. NAVD 88
- MTL = 0.82 ft. NAVD 88
- MLW = 0.30 ft. NAVD 88

Since the water elevations within the BA-68 project area are heavily influenced by subsidence and sea level rise, the Project Team determined that the calculated tidal datum should be adjusted to reflect Relative Sea Level Rise (RSLR) over the 20 year project life. It was decided that an Intergovernmental Panel on Climate Change (IPCC) eustatic sea level rise rate of 3.5 mm/year (0.0115 ft/year), which generally represents an intermediate Coastal Louisiana rate for a 25 year period, be applied to the tidal datum. Additionally, a subsidence rate of 8.9 mm/year (0.0292 ft/year) was used. This was derived from researching and comparing subsidence rates utilized in

several project designs/studies near the BA-68 project area. Table 1 shows the adjusted BA-68 tidal datum over the 20 year project life using a RSLR rate of 12.40 mm/year (0.04 ft/year). Since construction of the project would not be anticipated until funding approval is granted, the project life will not begin until the year 2012.

Table 1 BA-68 Tidal Datum Adjusted for RSLR

	Year		MHW (ft. NAVD 88)	MTL (ft. NAVD 88)	MLW (ft. NAVD 88)
	2010	-2	1.35	0.82	0.30
	2011	-1	1.39	0.86	0.34
2	2012	0	1.43	0.90	0.38
0	2013	1	1.47	0.94	0.42
	2014	2	1.51	0.98	0.46
Y	2015	3	1.55	1.02	0.50
E	2016	4	1.59	1.06	0.54
A	2017	5	1.63	1.10	0.58
R	2018	6	1.67	1.14	0.62
	2019	7	1.71	1.18	0.66
P	2020	8	1.75	1.22	0.70
R	2021	9	1.79	1.26	0.74
O	2022	10	1.83	1.30	0.78
J	2023	11	1.87	1.34	0.82
E	2024	12	1.91	1.38	0.86
C	2025	13	1.95	1.42	0.90
T	2026	14	1.99	1.46	0.94
	2027	15	2.03	1.50	0.98
L	2028	16	2.07	1.54	1.02
I	2029	17	2.11	1.58	1.06
F	2030	18	2.15	1.62	1.10
E	2031	19	2.19	1.66	1.14
	2032	20	2.23	1.70	1.18

3.0 SURVEYS

Topographic, bathymetric, and magnetometer survey data was collected within the project area in order to facilitate the design of the ridge restoration feature and marsh creation cells. In addition, a secondary survey was performed along a potential construction access corridor. The majority of the design survey tasks were performed from August 21 to September 23, 2010 by Sigma Consultant Group, Inc. Sigma also performed separate surveys for the North and South access routes. The offshore borrow area survey was performed by Coastal Planning and Engineering, Inc. All horizontal coordinates are referenced to Louisiana State Plane Coordinate System, North American Datum of 1983 (NAVD 83). All elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).

3.1 Horizontal and Vertical Control

One National Geodetic Survey (NGS) monument and one Louisiana Department of Natural Resources monument exist in the vicinity of Bayou Grand Liard. NGS monument "N 367" is located along LA Highway 23, 4.65mi east-southeast of Buras High School, at coordinates 29°21'08.23" N, 89°27'25.68" W. "CRMSBA-SM-14" is located south southeast of the project boundary, at coordinates 29°14'40.69" N, 89°26'54.29" W. These two secondary monuments were used as horizontal and vertical control for the fill site survey and access survey. In order to set control at "CRMSBA-SM-14", a static network survey was performed. Observations lasting four hours on different days and at different times were conducted to ensure different satellite geometry. The data sheets for these monuments are located in Appendix A.

3.2 Staff Gages

One staff gage was set at the project site to monitor the water levels during the topographic survey. The staff gage was located near the north end of the project site at 29˚19'00.88"N, 089˚28'52.80"W. This staff gage was used to monitor the Mean High Water (MHW) and Mean Low Water (MLW) elevations throughout the duration of the survey effort.

3.3 Fill Site Surveys

Survey transects were collected using Leica System 1200 GPS receivers in RTK mode and taken at 500 foot increments. Position, elevation, and description was recorded every 25 feet along each transect or where elevation changes of greater than 0.5 feet occurred. Where water depth was too deep for the Leica GPS receivers, bathymetric data was collected using an Odom Hydrotrac portable Echosounder and 2000KHz Transducer. Side shots were additionally taken to pick up variations in topographic features, such as meandering channels and other obstructions that may affect the project design. The survey transects are shown on the Sigma survey drawings located in Appendix B. Review of design surveys indicated that eight significant gaps

exist within the earthen ridge and containment dike alignments. These gaps were determined to require structural closures which are addressed in Section 7.

3.4 Marsh Elevation Survey

Average healthy marsh elevation surveys were conducted at four sites that were believed to have visibly healthy marsh. This survey was used to establish a baseline for target marsh elevation for BA-68. GPS positions were collected using the Leica System 1200 GPS receivers in RTK mode. These surveys consisted of a minimum of 20 spot elevations at each location utilizing the same equipment used to acquire the elevation in the marsh creation cells. Survey shots were taken such that the tip of the rod was resting on the surface of the marsh. Average marsh elevations for each location were derived by using the following procedure: (sum of elevations at location # divided by total number of elevations at same location # = Average Marsh Elevation). Upon review of this survey, the Project Team determined that Marsh Site 3 was not a good representation of average healthy marsh and was excluded from the target marsh height calculations. Table 2 shows the results from data acquired from the four marsh elevation surveys. All elevations shown are referenced to the North American Vertical Datum of 1988 (NAVD 88).

Table 2 Average Healthy Marsh Elevations

Spot Elevation	Site No. 1 N= 298,097.22 E=3,870,754.57	Site No. 2 N= 292,259.12 E= 3,873,551.13	Site No. 3 N= 289,630.56 E=3,875,801.34	Site No. 4 N= 281,098.00 E=3,873,780.76
1	1.53	1.18	1.26	1.09
2	1.40	1.41	0.82	0.95
3	1.59	1.41	0.97	1.11
4	1.18	1.02	0.63	0.86
5	0.57	1.22	0.57	1.06
6	1.10	1.46	0.22	1.14
7	1.06	1.24	1.40	1.10
8	1.48	1.23	0.68	0.96
9	1.62	1.46	0.76	0.93
10	1.40	1.12	0.64	0.88
11	1.82	1.17	0.47	0.64
12	1.77	0.51	0.30	1.09
13	1.45	0.83	0.75	0.95
14	1.06	1.32	0.16	0.94
15	1.25	1.29	0.39	1.28
16	1.69	1.55	0.82	1.31
17	1.44	1.70	0.76	1.13
18	1.58	1.03	0.62	1.03
19	1.23	1.13	0.15	1.13
20	1.60	1.39	0.42	1.01
21	1.44	1.12	0.79	NA
22	NA	NA	0.75	NA
Average	**1.39**	**1.23**	**0.65**	**1.03**

3.5 Inshore Magnetometer Survey

A magnetometer survey of Bayou Grand Liard and the proposed fill sites was conducted to identify potential existing pipelines and other obstructions within the project area. A GEOMETRIC-858 Cesium magnetometer on board a 28 foot aluminum hull survey vessel was used to conduct the survey. A 17 foot Gator Tail™ vessel was also used for the shallow water areas. All anomalies were investigated by means of a 25 foot radius surveyed around the anomaly and manually probing for pipelines. Horizontal positions for the survey were derived utilizing the C-NAV 2050 DGPS with stated sub-meter accuracy.

The magnetometer survey verified the existence of six pipelines in the bayou and fill sites, which vary in size from eight inches to 30 inches. These pipelines had depths of cover ranging from no cover to 8.9 feet below the mud line. Additionally, this survey revealed two small pipelines in the bayou and one small pipeline in the fill site (all four inches or less in diameter). The magnetometer survey lines and location of anomalies are shown on the C&C Technologies survey drawings in Appendix B.

3.6 Construction Access Surveys

Proper access to the project area is crucial to project construction while minimizing costs. Therefore additional bathymetric access surveys were performed on the North and South ends of the project area. The South survey data was collected from the southern end of the project area to the offshore borrow site designated as Grand Liard Offshore East Borrow Site. The purpose of this survey was to identify a potential access route for the dredge pipeline and marine construction equipment. This survey was completed on March 3, 2011 and consisted of 12 additional transects. The survey bathymetry showed elevations from -6.0 to -12.0 feet NAVD 88 in the Gulf of Mexico and -3.0 to -6.0 feet NAVD 88 in the expected inshore access route. Figure 5 shows the survey and transect lines.

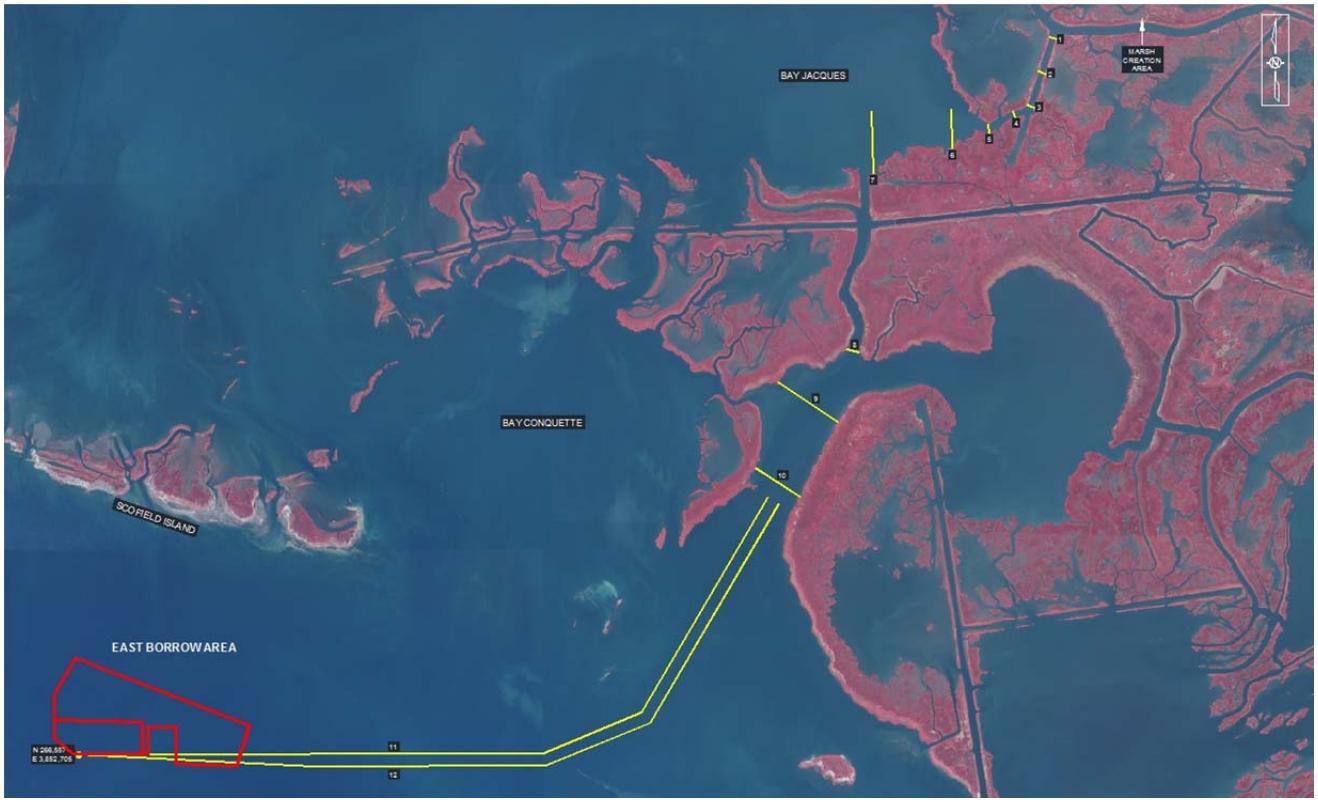

Figure 5 Southern Access Survey

The North survey data was collected from the northern most end of the project area to the Mississippi River locks at Empire Waterway. The purpose of this bathymetric survey was to determine that there are adequate depths, greater than 6.0 feet of draft, in the "Back Levee" canal should a contractor choose to bring a booster pump or other support equipment in from the North. On August 3rd, 2011, Sigma Consulting Group was tasked to perform this survey. This task was completed on September 6th, 2011**.** This survey revealed adequate depths to the project area**.** Figure 6 shows the survey profile line.

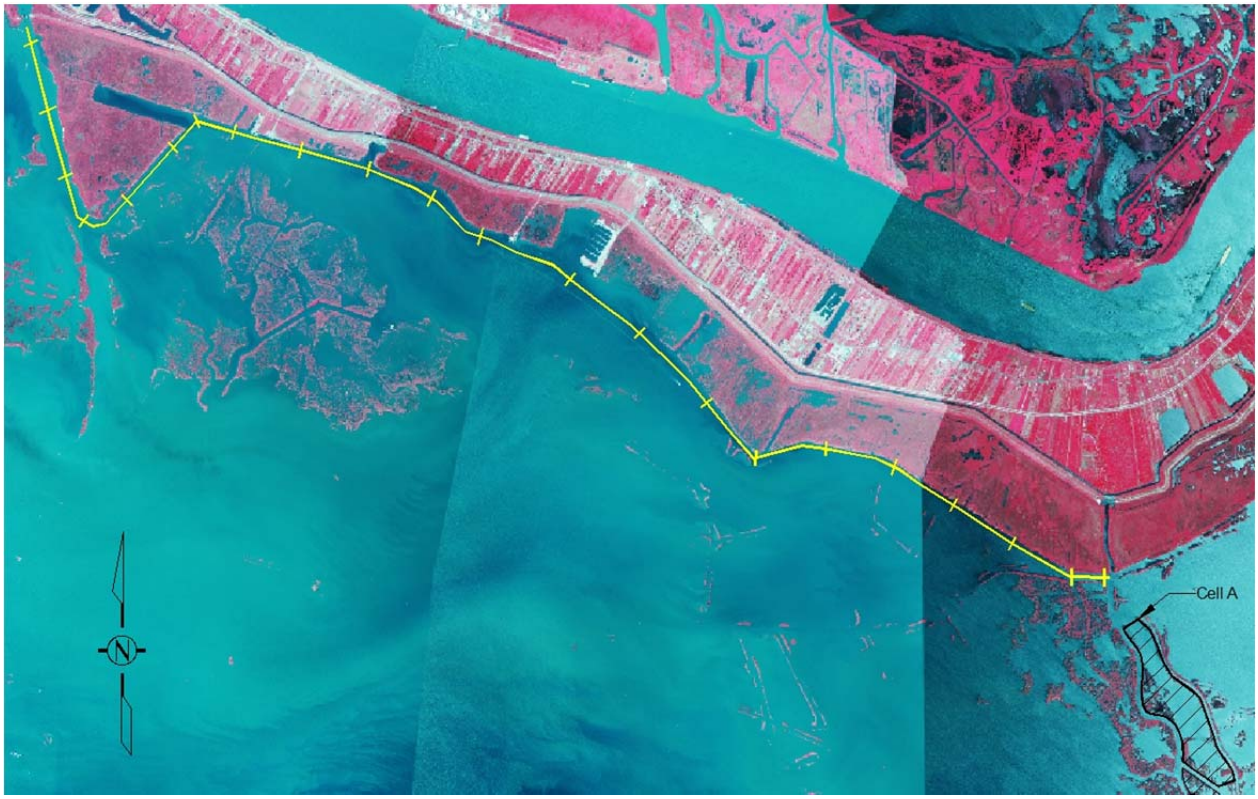

Figure 6 North Access Survey

3.7 Borrow Area Surveys

A geophysical investigation was performed in the offshore borrow area by CPE. The purpose of the investigation was to assess the thickness of potential sediment resources, delineate a borrow source avoiding cultural resource and pipeline impacts, and model wave impacts from the recommended borrow site design. This investigation was conducted using the R/V Thunderforce (see Figure 7) and consisted of magnetometer surveys, seismic reflection profiling, sidescan sonar, and bathymetric surveys.

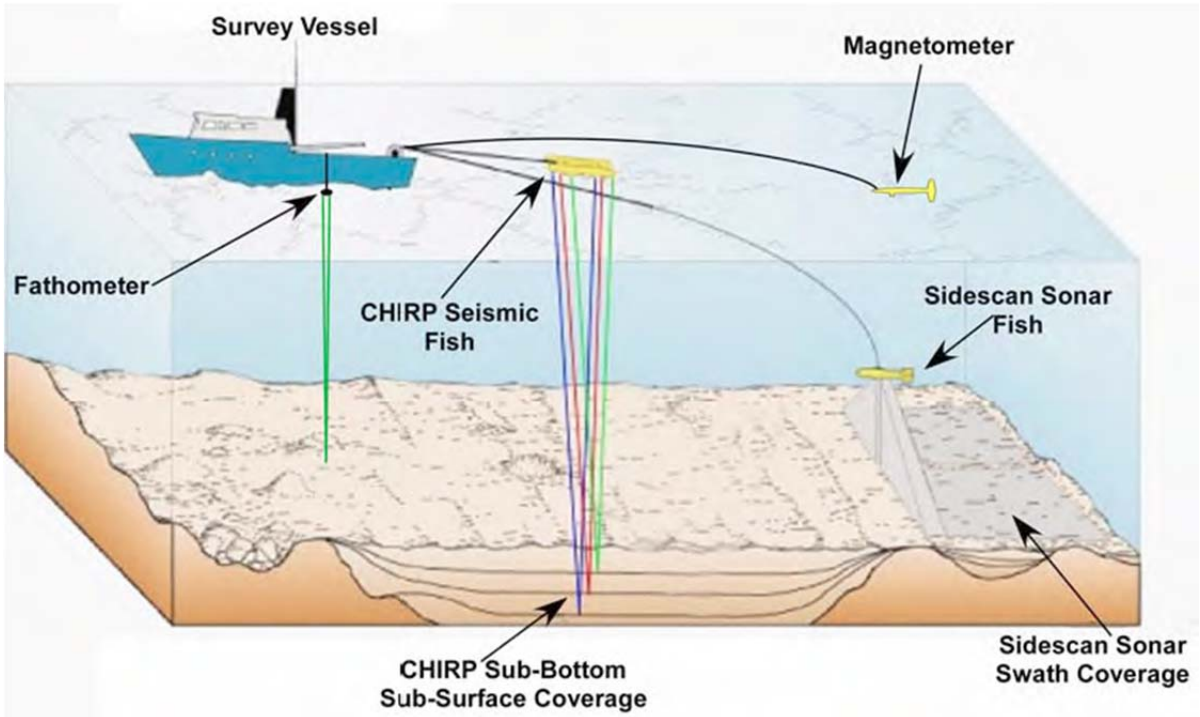

Figure 7 Offshore Survey Instrumentation Layout

An Odom Hydrographic Systems, Inc.'s Hydrotrac was used to perform the bathymetric survey. The sounder was calibrated via bar-checks and/or a sound velocity probe at the beginning and end of each survey day. In addition to bar-checks a DIGIBAR PRO sound velocity meter was used for calibration checks. Bar-checks are performed from a depth of five feet to a minimum depth of 25 feet for a shallow water survey. Soundings were collected at intervals sufficient to provide an accurate depiction of the seafloor.

A Geometrics G-882 Digital Cesium Marine Magnetometer sensor was used to perform an investigation for magnetic anomalies within potential sediment sources. The purpose of the magnetometer survey was to establish the presence, and subsequent exclusion zones around any potential underwater wrecks, submerged hazards, or any other features that would affect borrow area delineation and dredging activities. Data from the survey area was contoured using

Quicksurf (or equivalent) software to facilitate anomaly location and definition of target signature characteristics.

An EdgeTech X-STAR SB-512 was used to conduct the seismic reflection profile surveys. This instrumentation generates cross-sectional images of the seabed by transmitting an FM pulse that is linearly swept over a full spectrum frequency range. The sub-bottom seismic reflection data allows common stratigraphic layers to be mapped throughout the study area while determining the thickness and extent of potential project sediment.

Side-scan sonar data was acquired using an EdgeTech 4200-HFL dual frequency towfish running in high definition mode. The sidescan was towed from the survey vessel at a position and depth that limited exposure to sources of interference and provided the best possible record quality. This data is required to verify the location and extent of unconsolidated sediment and to map ocean bottom features such as benthic habitats, exposed pipelines, cables, underwater wrecks, and potential cultural resources. The sidescan survey was conducted to identify features that may affect borrow area delineation, introduce hazards to dredging, or adversely impact the environment.

Analysis of the geophysical data identified a total of 122 magnetic and seven acoustic anomalies in the two borrow areas. Grand Liard Offshore East Borrow area contains 70 individual magnetic anomalies and six acoustic anomalies. Six of the magnetic targets have signature characteristics suggestive of potentially significant submerged cultural resources. Avoidance of these anomalies was accomplished by the creation of a 300 foot radius buffer zone. The remaining 64 magnetic targets have signatures suggestive of modern debris and thus were not buffered. Grand Liard Offshore West borrow area contains 52 individual magnetic anomalies and one acoustic anomaly. 16 individual magnetic anomalies exhibited signatures characteristics suggestive of potentially significant submerged cultural resources. Avoidance of these anomalies was accomplished by the creation of a 300 foot radius buffer zone. The remaining 36 individual anomalies, two of which have an associated sonar target suggestive of dredge pipe, have signature characteristics suggestive of modern debris. Figure 8 shows the survey lines taken at the offshore borrow site. Magnetic anomalies, acoustic anomalies, sidescan mosaics, and avoidance buffers are shown on the CPE survey drawings in Appendix C.

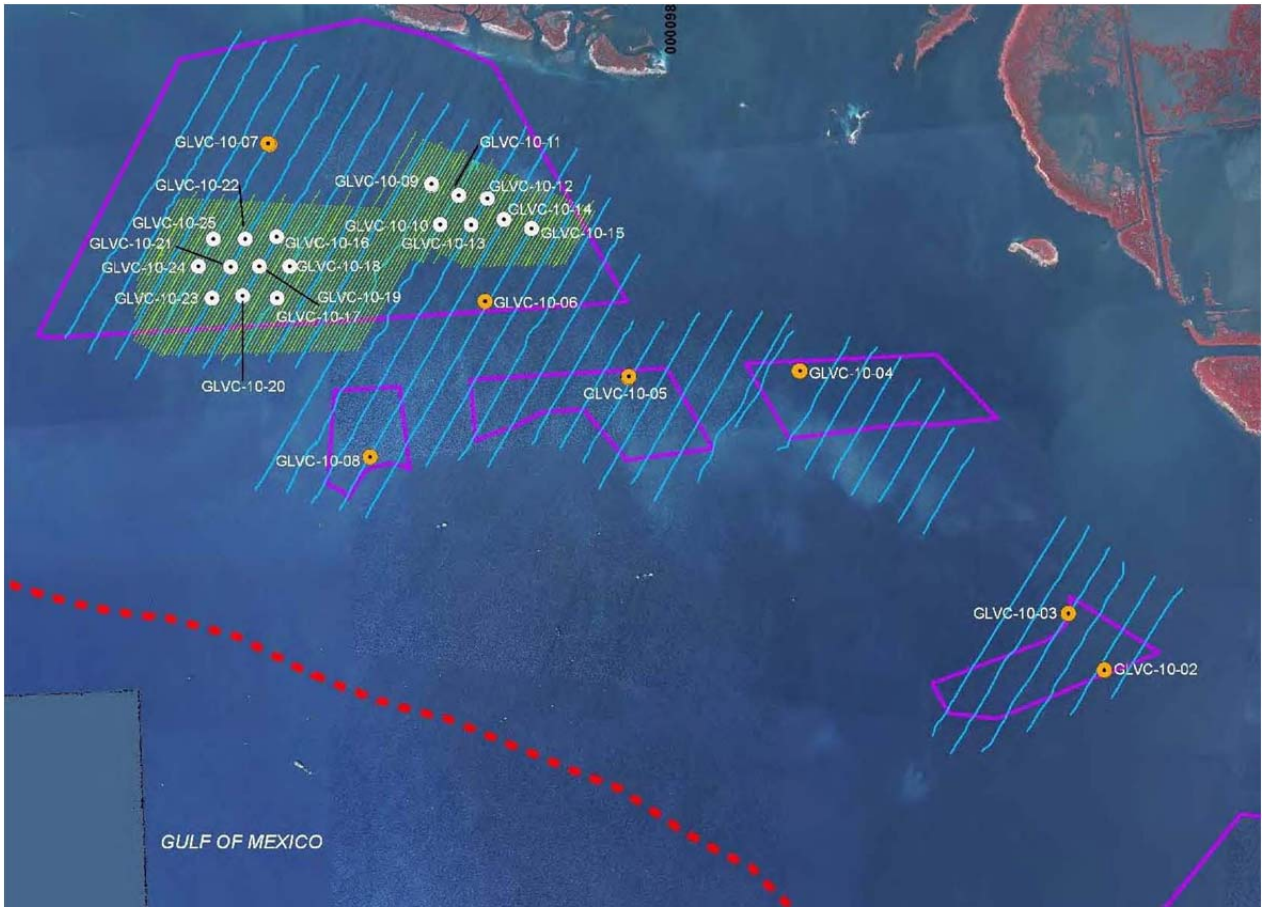

Figure 8 Offshore Survey Lines and Boring Locations

4.0 GEOTECHNICAL INVESTIGATIONS AND ANALYSES

In order to determine the physical characteristics and behavior of the soils associated with BA-68, geotechnical investigations and analyses were performed. GeoEngineers, Inc. was tasked to collect soil borings, perform laboratory tests to determine soil characteristics, perform stability analyses on the proposed containment dikes and earthen ridge restoration features, and calculate the settlement of the proposed containment dikes, earthen ridge restoration, and marsh fill sites. A total of 18 subsurface borings were drilled in the project area during the period of August 2010 through September 2011 at locations shown in Figure 9. Calculations for ridge restoration were performed using three different potential borrow sources; Bayou Grand Liard, Grand Liard Offshore East Borrow Site, and within the proposed Marsh Fill Area.

The subsurface investigation of the offshore borrow area was analyzed separately by CPE. CPE was tasked to collect soil borings, perform laboratory tests to characterize physical properties, and delineate a suitable borrow source for the purposes of marsh creation. During reconnaissance level investigations six areas were selected as potential borrow sites based on the analysis of historic data. On January 29-31, 2010, CPE collected and analyzed eight vibracore samples. In design level investigation 16 vibracores were collected from two borrow sites, later identified as Grand Liard Offshore East and Grand Liard Offshore West, on February 10, 2010. These boring locations are depicted in Figure 8.

4.1 Field Investigation

4.1.1 Inshore

Three borings were drilled in Bayou Grand Liard to a depth of 30 feet, 11 borings were drilled in the ridge restoration area to depths of 60 and 80 feet, and four borings were drilled in the marsh fill area to a depth of 40 feet (Figure 9). Undisturbed soil samples were obtained with rotary type drilling equipment. Borings were collected using a marsh buggy and barge mounted drilling rigs. Soil samples were laboratory tested for classification, strength, and compressibility.

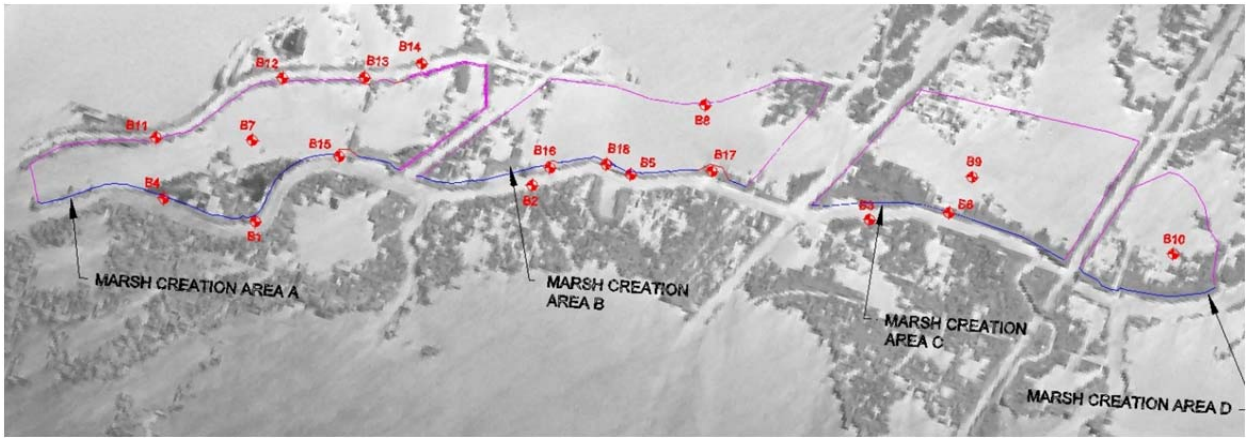

Figure 9 Inshore Boring Layout

4.1.2 Offshore

Vibracores were collected using an American Vibracore Service Pneumatic Vibracore System (see Figure 10). The vibracore unit was deployed from the R/V Thunderforce. This system contains an air-driven vibratory hammer, an aluminum H-beam which acts as the vertical beam upright on the seafloor, 20 foot long steel tubes measuring four inches in diameter, and a drilling bit with a cutting edge. Vibracores were measured, marked, and cut into three foot sections upon removal. They were then analyzed for sediment grain size, Atterberg limits, incremental consolidation, unconsolidated undrained and consolidated undrained triaxial compression, and permeability. The offshore boring locations are shown in Figure 8.

Figure 10 Thunderforce with Pneumatic Vibracore System

4.2 Subsurface Evaluation

4.2.1 Inshore

Based on the field exploration data and subsequent laboratory testing of the 18 borings, nine design soil profiles were developed. Due to significant variation in soil borings, only soil borings B-2 and B-5 were grouped together. All borings, except B-1, encountered high organic content soil and/or cohesive soil in the upper 6-14 feet. Beneath the high organic content soil, semi-cohesive and/or non-cohesive soils were encountered. Below this high organic layer, cohesive soils with intermittent layers were found throughout the full depth of most of the borings. The inshore boring logs for BA-68 can be found in Appendix D.

4.2.2 Offshore

Coupled with the geophysical data, the vibracores were used to determine sediment quality and suitability for marsh creation. Based on the results of this subsurface investigation, two sediment resource areas were identified for further analysis. Grand Liard Offshore East and Grand Liard Offshore West borrow areas showed suitable material for marsh creation and predominantly consisted of soft clay material with trace sand and shell hash. The offshore boring logs for BA-68 can be found in Appendix D.

4.3 Slope Stability

Slope stability analyses were performed on proposed earthen containment dikes and the earthen ridge restoration feature. The slope stability of any embankment or dike has two types of driving forces: (1) the forces induced by the soil weight, and (2) any 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 the driving forces and the resisting forces are dependant on the geometry of the situation: the “Failure Surface”. GeoEngineers, Inc. performed stability analyses using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International, Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory. The acceptable factor of safety for this analysis was equal to or greater than 1.3 on the bayou side slopes and 1.2 on the marsh side slopes.

4.3.1 Stability Analysis – Earthen Containment Dikes

GeoEngineers, Inc. performed analyses on the containment dikes using data from each of the marsh fill borings, B-7 through B-10. It was assumed that the containment dikes would be constructed from in-situ marsh fill material. Containment dikes were analyzed with a top elevation of +5.5 feet NAVD88 and a crown width of five feet. GeoEngineers, Inc. recommended a 20 foot stability berm be maintained between the toe of the dike and the edge of the borrow area channel. Analysis results indicated that 5H:1V side slopes for dikes and 3H:1V

side slopes for excavation will provide a factor of safety of 1.3 or greater for all cells. These results are illustrated in Figures II-B1 through II-B4 of Appendix F.

4.3.2 Stability Analysis – Earthen Ridge

GeoEngineers, Inc. analyzed the stability of the earthen ridge feature with a base width of 100 feet and a crown width of 20 feet, as specified by the Project Team, given four different borrow scenarios:

1. Borrow from Bayou Grand Liard (Borings B-2 and B-3)
2. Borrow from Grand Liard Offshore East Borrow Site (GLCV-10-9 through GLVC-10-25)
3. Borrow from within the Proposed Marsh Fill Area (Borings B-7 through B-10)
4. Borrow from both Bayou Grand Liard and Proposed Marsh Fill Area

For scenarios 1, 2, and 4 the stability of the bayou side of the ridge was most critical. For scenario 3 the stability of the marsh side of the ridge was the most critical. Based on the typical ridge section stated above, a factor of safety greater than 1.3 was achieved on both the Bayou Grand Liard and marsh side of the earthen ridge for scenarios 1 through 3. For scenario 4 a factor of safety or 1.3 was achieved on the bayou side and 1.2 on the marsh side. GeoEngineers, Inc. is confident that the earthen ridge can be built using a 1.2 factor of safety on the marsh side. A stability berm width from 15 to 40 feet was recommended for all scenarios. Scenarios 1 through 3 were evaluated based on the appropriate geometry with a top elevation of +5.5 feet NAVD88. Scenario 4 was evaluated based on the appropriate geometry with a top elevation of +5.0 feet NAVD 88. These results are illustrated in Figures II-C1a through II-C5c of Appendix G.

4.4 Settlement Analysis

Settlement analyses for BA-68 were performed using two methods: Terzaghi's one-dimensional linear consolidation theory, and the Primary consolidation, Secondary compression, and Desiccation of Dredged Fill (PSDDF) program developed by Dr. Timothy D. Stark at the University of Illinois. Settlement parameters were developed using actual consolidation test results. For soils without consolidation tests, parameters were developed using published correlations and correlations based on test data from this project and similar projects. Settlement analyses were performed for the marsh fill area, containment dikes, and earthen ridge.

4.4.1 Settlement Analysis – Marsh Fill

The primary purpose of the settlement analysis in marsh creation design is to determine the target construction fill elevation and total volume of material required. The final elevation of the marsh fill at year 20 is governed by two forms of settlement: (1) The settlement of the underlying soils in the fill cells caused by the loading exerted by the dredged material, and (2) the self-

weight consolidation of the dredged material. The sum of the dredged fill settlement and the underlying soil settlement was used to determine the total settlement of the fill area after construction is complete. For the marsh fill settlement calculations, borings B-7 through B-10 were used to analyze the settlement of the underlying soils, and borings GLVC-10-9 through GLVC-10-25 were used to analyze the self-weight consolidation of the dredge fill material.

Marsh fill settlement evaluations were initially performed for a single lift construction scenario with dredge fill material placed to an elevation of +2.0 and +4.5 feet. These fill elevations did not meet the project goals: (1) obtain intertidal marsh within 3-4 years of construction completion and (2) remaining above MLW for most of the design life. Hence, the settlement for dredged fill was analyzed using a two construction lift scenario. Settlement days between lifts were estimated based on production rates of a 30 inch dredge pumping 30,000 cubic yards of dredged material per day. These calculations assumed cells would be filled from North to South and the second construction lift would not begin until all cells received their first construction lift. Table 3 below shows the three different two construction lift scenarios analyzed by GeoEngineers, Inc. All figures of marsh fill settlement curves showing the total time-rate settlement for each lift scenario can be found in Figures II-A1 through II-A12 of Appendix E.

Table 3 Marsh Fill Lift Scenarios

	Initial Marsh Fill Elevation (Feet NAVD 88)	Time Gap (End of Lift 1 to beginning of lift 2) (days)
Cell A	Lift 1@4.0 / Lift 2@4.0	60
	Lift 1@3.5 / Lift 2@3.5	80
	Lift 1@3.5 / Lift 2@3.0	80
Cell B	Lift 1@4.0 / Lift 2@4.0	60
	Lift 1@4.0 / Lift 2@3.0	75
	Lift 1@3.5 / Lift 2@3.5	75
Cell C	Lift 1@4.0 / Lift 2@4.0	60
	Lift 1@3.5 / Lift 2@3.0	85
	Lift 1@3.5 / Lift 2@2.8	85
Cell D	Lift 1@4.0 / Lift 2@4.0	60
	Lift 1@3.5 / Lift 2@3.5	85
	Lift 1@3.5 / Lift 2@3.0	85

4.4.2 Settlement Analysis – Earthen Containment Dikes

Settlement calculations for the earthen containment dikes were based on side slopes of 5H:1V with a five foot crown width and earthen fill to elevation +5.5 feet, NAVD 88. The rate of settlement versus elevation over a 20-year period is shown for each of the design profiles in

Figures II-B5 through II-B8 of Appendix F. Due to immediate construction consolidation, six inches of settlement is expected to occur for the containment dike.

4.4.3 Settlement Analysis – Earthen Ridge

Settlement for the earthen ridge was calculated using the three different fill sources:

1. Bayou Grand Liard
2. Grand Liard Offshore East Borrow Site
3. Proposed Marsh Fill Area

Influence from the adjacent marsh fill was evaluated with respect to earthen ridge settlement. However, due to the large base width of the ridge, the marsh fill will cause little to no additional settlement. The relationship between rate of settlement and elevation over a 20-year period can be found in Figures II-C6a through II-C10c of Appendix G. Due to immediate construction consolidation, six inches of settlement is expected to occur for the earthen ridge.

4.5 Settlement Results/Recommendations

After reviewing the geotechnical analyses presented in Sections 4.3 and 4.4, the Project Team concluded that the following marsh fill, containment dike, and earthen ridge parameters should be carried forward through preliminary design:

Marsh Fill (two lift):

- Cell A: Lift 1@3.5 feet NAVD 88 / Lift 2@3.0 feet NAVD 88
- Cell B: Lift 1@3.5 feet NAVD 88 / Lift 2@3.5 feet NAVD 88
- Cell C: Lift 1@3.5 feet NAVD 88 / Lift 2@2.8 feet NAVD 88
- Cell D: Lift 1@3.5 feet NAVD 88 / Lift 2@3.0 feet NAVD 88

Containment Dikes:

- Crown Elevation: +5.0 and +5.5 feet NAVD 88*
- Side Slope: 1(V):5(H)
- Crown Width: 5.0 feet
- Accepted Safety Factor: 1.3

Earthen Ridge:

- Crown Elevation: +5.0 and +5.5 feet NAVD 88*
- Side Slope: 1(V):7.3(H)
- Crown Width: 20.0 feet
- Accepted Safety Factor: 1.2 to 1.3
- Base Width: 100 feet at 0.0 feet NAVD 88

*These recommended parameters represent maximum allowable scenarios to obtain reasonable safety factors. According to communications with GeoEngineers, Inc., any reduction in these elevations would result in a more favorable safety factor.

4.6 Closure/Sheet Pile Analysis

GeoEngineers, Inc. also performed a second geotechnical investigation to determine a constructible solution to close eight gaps in the earthen ridge and containment dike sections (See Section 7). In August 2011, GeoEngineers retrieved eight additional soil borings (B-11 through B-18) at or near the mid point of each gap. These borings were taken to the lab and analyzed to determine the constructability and stability of a cantilever sheet pile wall. At the request of CPRA and NOAA, the sheet pile wall structures were analyzed for two construction scenarios: 1) No sand foundation and 2) with sand fill foundation. Both analyses were performed assuming the sheet pile wall would be encapsulated in the earthen ridge, or containment dike, prior to filling the cell with dredge material. Table 4 below shows GeoEngineers, Inc.'s recommendations for a sheet pile wall with no sand fill foundation, which have a factor of safety of 1.5.

Table 4 Summary of Sheet Pile Analyses (Without Sand Fill)

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile (feet)	Recommended Minimum Section Modulus (cubic inch/feet)
B-11	4.5	3.5	-6.5	30	5
B-12	4.5	3.5	-12	35	11
B-13	4.5	3.5	-13	50	14.5
B-14	4.5	3.5	-6.5	25	4.5
B-15 (Side wall)	4.5	3.5	-13	35	12
B-15 (Channel wall)	4.5	3.5	-17	45	19
B-16	4.5	3.5	-15.5	35	16
B-17	4.5	3.5	-17.5	55	22.5
B-18	4.5	3.5	-17.6	25	5.5

Table 5 below shows the recommendations for a sheet pile wall constructed with a sand fill foundation, which have a factor of safety of 2.0. The sand fill will be placed prior to driving the sheet piles. The sand fill will give additional support to the cantilever sheet pile wall. This

translates to shallower sheet pile depths for each closure. Table 6 below gives GeoEngineers, Inc.'s sand fill recommendations.

Table 5 Summary of Sheet Pile Analyses (with Sand Fill)

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Recommended Elevation of Top of Sand (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile (feet)
B-11	4.5	3.5	-1.5	-6.5	25
B-12	4.5	3.5	-2	-12	25
B-13	4.5	3.5	-3	-13	25
B-14	4.5	3.5	-1.5	-6.5	25
B-15 (Side wall)	4.5	3.5	-7	-13	35
B-15 (Channel wall)	4.5	3.5	-7	-17	35
B-16	4.5	3.5	-5.5	-15.5	30
B-17	4.5	3.5	-7.5	-17.5	35
B-18	4.5	3.5	-3	-8	25

.

Table 6 Summary of Recommended Sand Fill

Boring No.	Top Elevation of Sand (feet, NAVD 88)	Thickness (feet)	Crown Width on Marsh Side* (feet)	Crown Width on Water Side* (feet)
B-11	-1.5	5	15	20
B-12	-2.0	10	15	25
B-13	-3.0	10	15	25
B-14	-1.5	5	15	20
B-15 (Side Wall)	-7.0	6	15	25
B-15 (Channel Wall)	-7.0	10	15	25
B-16	-5.5	10	15	25
B-17	-7.5	10	15	25
B-18	-3.0	5	15	20
*3H:1V side slopes				

5.0 MARSH CREATION DESIGN

This project proposes to create marsh by dredging material from an offshore borrow site for placement into the designated fill sites shown in Figure 11 and the Preliminary Design Drawings located in Appendix I. The marsh creation design is separated into three components: fill site, borrow site, and containment dike design.

5.1 Fill Site Design

The primary goals of the marsh creation features are to address the land loss in this area. These goals governed the configuration of the marsh fill cells, which vary slightly from the Phase 0 layout, as a result of Phase 1 activities. As shown in Figure 11, Phase 0 project included 468 acres of marsh creation and nourishment and restoration of 20,000 linear feet of ridge.

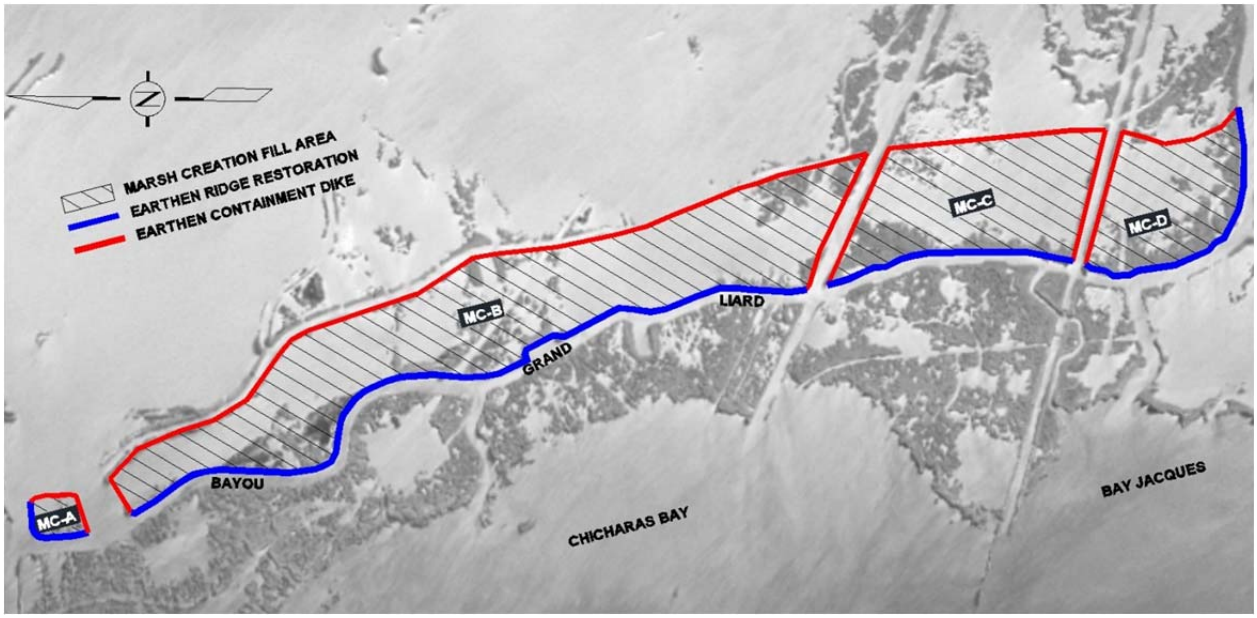

Figure 11 Phase 0 Project Layout

The Phase 1 project now includes 436 acres of created and nourished marsh and 16,600 linear feet of ridge restored. The Phase 0 MC-A cell was removed from the fill site design due to constructability issues associated with its small size and excessive water depths. Fill MC-B was originally one large cell, which was modified to avoid pipeline crossings through the middle and southern ends of the cell. Lastly, Phase 0 Cell MC-D was reduced in footprint due to excessively deep areas created by a relict bayou and pipeline dissecting the fill area. Figure 12 illustrates the final marsh creation/nourishment and ridge restoration layout for the project (BA-68).

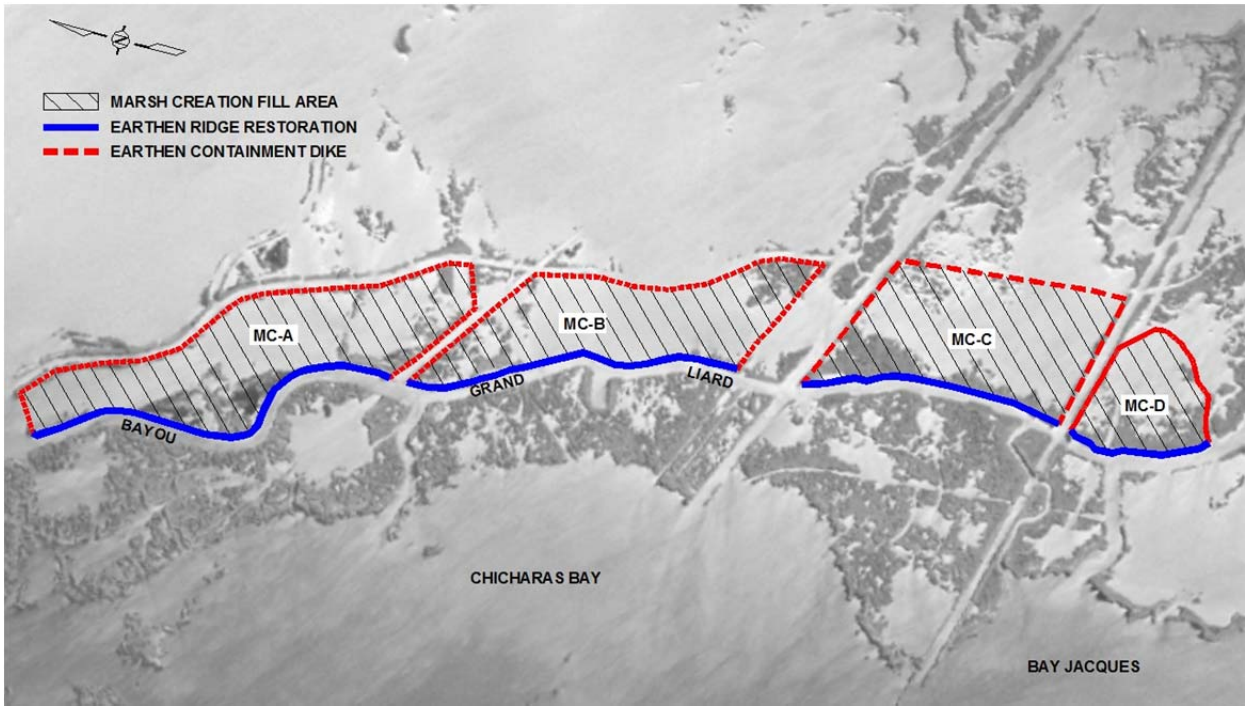

Figure 12 Phase 1 Project Layout

In addition to the fill site configuration, a key design component of BA-68 involves the calculation of fill site volumes. Before this could be accomplished, a target construction fill elevation had to be determined. This elevation was selected using several factors including average healthy marsh elevation, tidal datum, relative sea level rise, the physical properties of the borrow material, and the bearing capacity of the foundation soils in each fill site.

The first step of the target fill elevation design involved an examination of the existing marsh conditions. The marsh elevation survey performed during the fill site survey revealed that the highest healthy marsh elevation in the surrounding area was approximately +1.4 feet NAVD 88 (see Section 3.4 for additional details). The calculated tidal datum (MHW=+1.35 feet NAVD 88, MLW=+0.30 feet NAVD 88) discussed in Section 2 verified that the existing marsh platform, within the project area, fell within the intertidal zone defined as the range of elevation that lies between MHW and MLW. Additionally, the Project Team concluded that incorporating RSLR into the computation of the target fill elevation was critical to the long term success of the project. Per Section 2, RSLR was estimated to be +0.04 feet per year in this area. This data was provided to GeoEngineers, Inc. and plotted on each marsh fill settlement curve. Through further analysis the Project Team decided that an ideal target marsh fill elevation would be one that settles to the inter-tidal range within three to four years post-construction and stays intertidal for the remainder of the 20 year project life. Figures 13 through 16 below illustrate the inclusion of RSLR and the two construction lift system in a marsh fill settlement curve. The red dashed line illustrates the settlement using a single lift construction method.

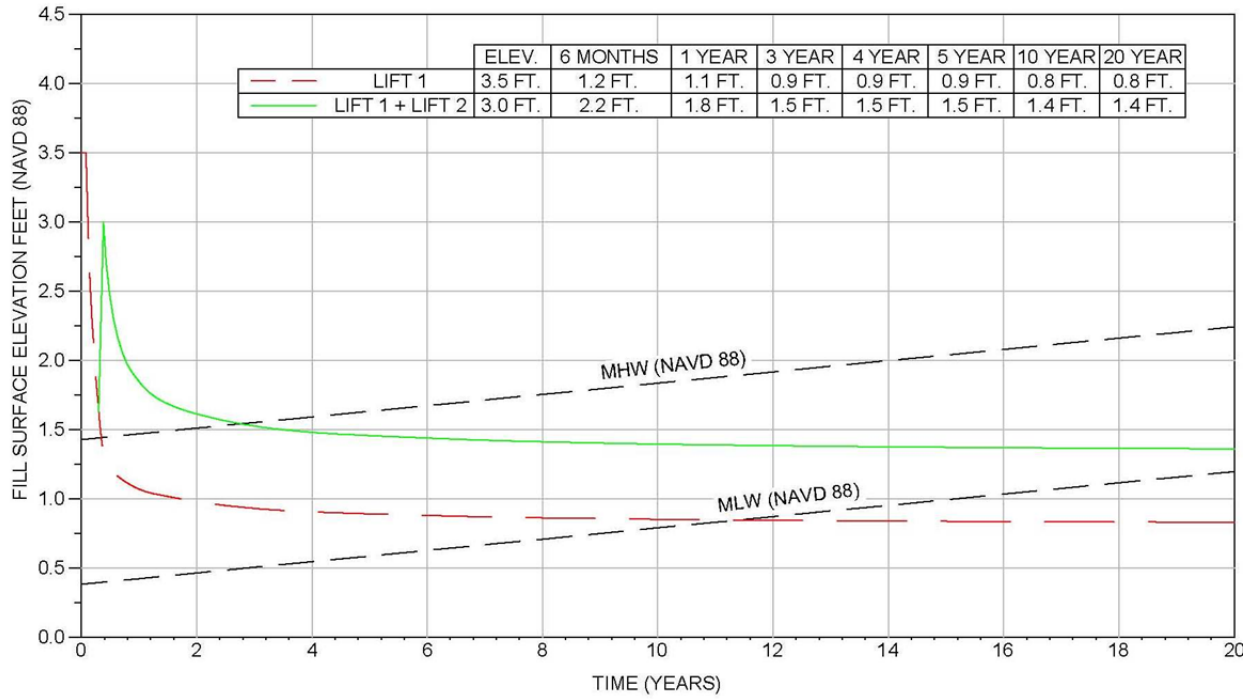

Figure 13 Marsh Fill Settlement Curve (Cell A)

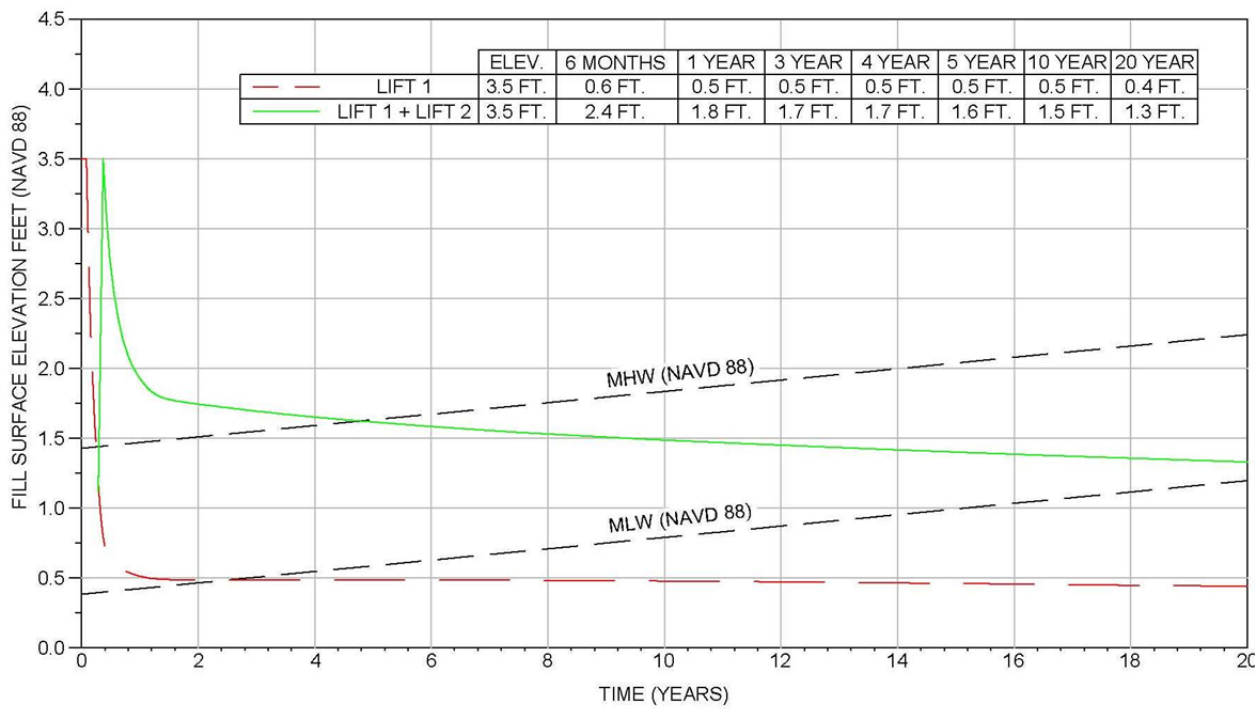

Figure 14 Marsh Fill Settlement Curve (Cell B)

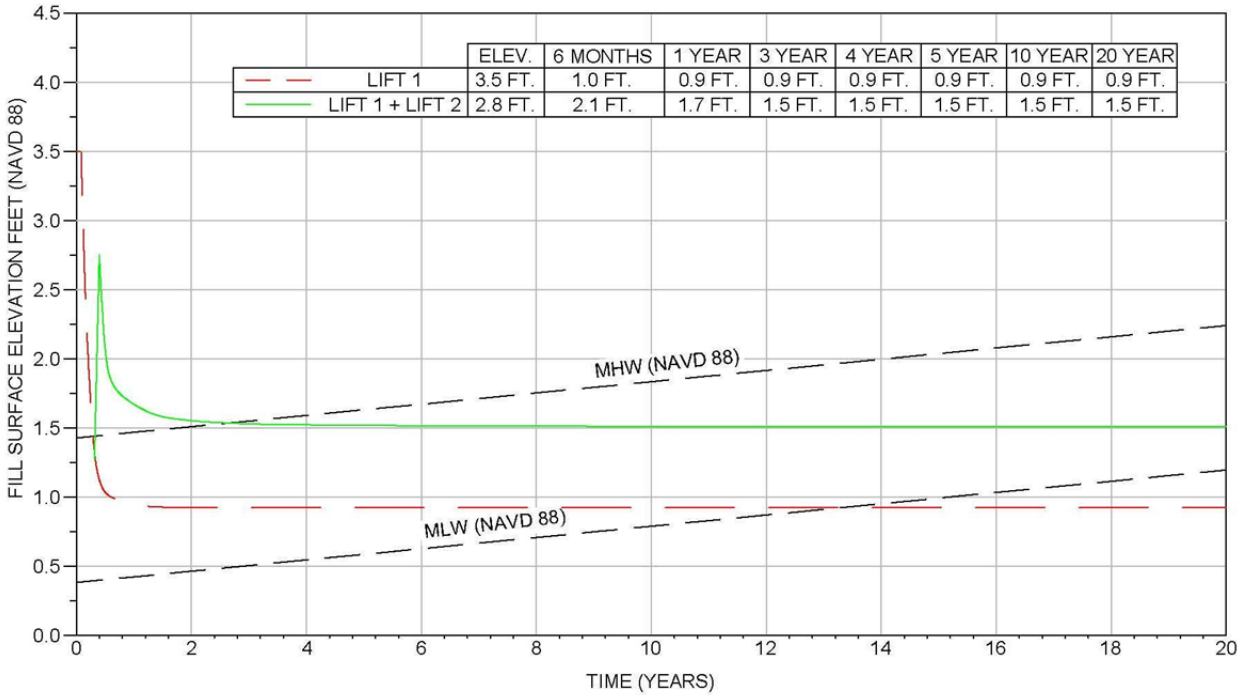

Figure 15 Marsh Fill Settlement Curve (Cell C)

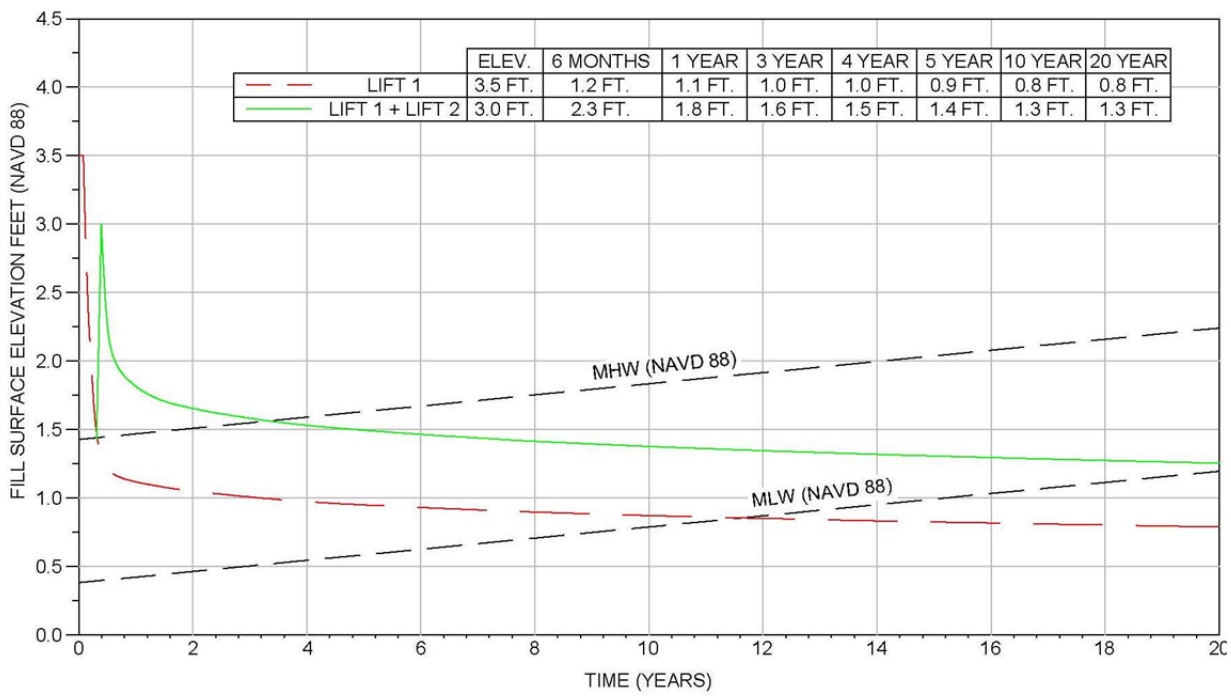

Figure 16 Marsh Fill Settlement Curve (Cell D)

In order to determine the construction fill elevation for each cell, CPRA tasked GeoEngineers, Inc. to perform consolidation settlement calculations on borings B-7 through B-10 from the

marsh fill areas and GLVC-10-9 through GLVE-10-25 from the offshore borrow sites. Calculations were performed for each construction lift scenario as stated in Table 3. The purpose of these analyses was to assist in the determination of the best construction lift scenario to meet project goals. Table 7 below shows the chosen lift scenarios as calculated by GeoEngineers, Inc. for each cell. The settlement curves for each lift scenario are shown in Figures II-A1 through II-A12 of Appendix E. The settlement values reflect both foundation settlement and self-weight consolidation.

Table 7 Final Construction Lift Elevations for Marsh Fill

	Lift 1 (ft)	Lift 2 (ft)	Target Year 5 (ft)	Target Year 10 (ft)	Target Year 20 (ft)
Cell A	3.5	3	1.5	1.4	1.4
Cell B	3.5	3.5	1.6	1.5	1.3
Cell C	3.5	2.8	1.5	1.5	1.5
Cell D	3.5	3	1.4	1.3	1.3

Once the target fill elevations were determined, the marsh fill volumes were calculated. As shown on the Preliminary Design Drawings located in Appendix I, the marsh creation portion of the project is broken up into four cells, each having two construction lifts. Cross sectional areas of the transects in each cell were calculated using the data produced by the Fill Site Survey described in Section 3.3. The lift heights stated in the settlement curves show the fill height of the dredge slurry. The dredge slurry is the mix of both sediment and water as it exits in the dredge pipe. The project engineer determined that the most practical way to estimate the volume of borrow material needed for construction was to use the target year 20 fill elevations from the settlement curves. As shown in Figures II-A9 through II-A12 of Appendix E, virtually all settlement has taken place at year 20. The assumption here is that the void ratio of the slurry is as low as possible at this point. Settlement of the underlying soil was derived from the calculation results from the settlement analysis performed by GeoEngineers, Inc. This settlement, along with the 20 years marsh fill settled height, was used to determine the volume required to construct the marsh fill portion of the project. Marsh fill volumes were calculated by finding the cross-sectional area of each survey transect, assuming it would be filled to the target 20-year elevation of that cell. Placement of dredged material into the borrow areas used for the construction of containment dikes were included in these cross-sectional areas. Marsh fill acreages were calculated from centerline of ridge to centerline of containment dikes for each cell. Table 8 below summarizes the results of the volume calculation for each cell. A more detailed summary of the fill site design is provided in the Design Calculations Packet located in Appendix H.

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Table 8 Summary of Marsh Fill Volumes and Acreage

Fill Cell	Area (acres)	Volume of Fill (yd^3)
A	150	917,632
B	109	781,437
C	124	700,657
D	53	267,651
Totals	436	2,667,377

5.2 Borrow Site Design

Due to its close proximity to the project area, the Mississippi River was first considered as a source of fill material for project construction. Review of existing information revealed a source of high quality sand just upstream of the project area, but it was determined that this material would be better suited for barrier island restoration projects like the Scofield Island Restoration Project (BA-40). The remaining area for sediment mining was further constrained by revetments and deep water bathymetry beyond the practical limits of dredging. Additionally, due to its proximity to Forts Jackson and St. Phillip, this area is suspected to include several cultural resource issues. Given these constraints and potential impacts it was determined that the Mississippi River would not be a suitable sediment source for construction of this project. Therefore an investigation for an offshore sediment source was conducted by CPE.

The marsh fill borrow site was designed based on the geotechnical recommendations made by CPE. CPE used a three stage systematic approach in developing the borrow site. First, they looked at existing data of the offshore area near the project site. This included reviewing the geological background, geophysical, and geotechnical data previously collected within this area. In the second stage, reconnaissance level geophysical and geotechnical surveys were taken and analyzed to produce a design level investigation plan for stage three. The third and final stage consisted of design level geotechnical and geophysical investigations and a cultural resources investigation. The subsurface and survey analyses of the offshore borrow area revealed two possible borrow sources suitable for marsh creation. The borrow site alignments, shown in Figure 17, were delineated to avoid any pipelines, magnetic anomalies, and cultural resource issues.

The potential changes to wave climate were assessed using a SWAN model. This model was configured based on the recent and historic surveys, aerial photographs, the USACE wave hindcasts, and the model parameters determined during the West Belle Pass Barrier Headland Restoration (TE-52) model study. The model results show that measureable changes to wave patterns could occur near the borrow areas themselves. However, near the shoreline (i.e., at the -6-foot contour) wave heights due to borrow area excavation either did not increase, or increased

by a maximum of about 0.10 feet for all modeled wave cases. Further analysis of changes to the wave patterns near the shoreline also suggest that changes in the sediment transport rates are not anticipated. Given these findings, modifications to the designs of the borrow areas should not be necessary. The complete borrow area impact wave analysis from CPE is located in Appendix L.

The borrow sites are located approximately one mile south of Scofield Island and 7.5 miles from the middle of the marsh fill area. Borrow areas include a total of 9.96 MCY of dredge material; 5.28 MCY from Grand Liard Offshore East, and 4.68 MCY from Grand Liard Offshore West. The borrow area for Grand Liard Offshore East has two cut elevations that range from -33.5 to -35.0 feet NAVD 88. The borrow area for Grand Liard Offshore West has five cut elevations ranging from -35.0 to -39.5 feet NAVD 88. Grand Liard Offshore East was chosen as the preferred borrow site because it was closer to the project area. The layout of the borrow areas are shown in Figure 17 and the complete report from CPE is located in Appendix K.

Figure 17 Offshore Borrow Site Layout

Various losses occur during dredging (suspension of material during cutterhead operations, inefficiencies in complete excavation of borrow areas, losses during transportation of material, and losses associated with dewater of the cells). Therefore a 1.3:1 cut to fill ratio was applied to the computed fill volume of each cell and tabulated in Table 9 below.

Table 9 Volume of Borrow Material Required

Fill Cell	Volume of Borrow (yd^3)
A	1,192,921
B	1,015,868
C	910,854
D	347,946
Totals	3,467,589

5.3 Containment Dike Design

The primary design parameters associated with the containment dike design include crown elevation, crown width, and side slopes. CPRA tasked GeoEngineers, Inc. to determine these parameters using slope stability and settlement analyses. GeoEngineers, Inc. recommended that a containment dike would be stable with a crown width of 5.0 feet and side slopes 1V:5H when the crown elevation is less than or equal to +5.5 feet NAVD 88. The Project Team decided the containment dikes shall be constructed to an elevation of +5.0 feet NAVD 88, and maintained throughout the construction period. This height will yield the required freeboard of at least 1 foot for the design marsh fill lifts in each cell. Once these parameters were determined, cross-sectional areas and containment volumes were calculated using the methods described in the Design Calculations Packet located in Appendix H. A mechanical dredging cut:fill ratio of 2:1 was applied to the calculated fill volumes for the purpose of ensuring adequate borrow volume available.

The containment dikes shall be constructed using in-situ material from within each fill site. However, the backside containment dike in Cell A will be constructed using material from the adjacent remnant bayou. An access channel is needed through this bayou to allow passage for the equipment required to construct the gap closures. Instead of placing all this material aside and backfilling once the closure structures are complete, most of it will be used beneficially to construct the containment dikes. This will reduce the quantity of material required from the interior marsh fill area. The dredging of the remnant canal for dike creation was proposed at the Plaquemines Parish Coastal Zone Management Meeting on April 13, 2011 with no objections.

6.0 RIDGE RESTORATION DESIGN

This project proposes to restore approximately 16,600 linear feet of earthen ridge along the east bank of Bayou Grand Liard. The earthen ridge will also function as a containment dike for the western boundary of the marsh fill areas. The earthen ridge restoration design consists of: borrow site alternatives, typical cross section, and alignment.

6.1 Borrow Site Analysis

Several different borrow sites were considered for the purpose of building the earthen ridge restoration feature of BA-68. The first was the use of material from the Grand Liard Offshore East Borrow Site. This source of ridge material was considered because the dredging process involved would result in minimal impacts to the existing marsh fill area, and not leave permanent areas of low elevation. Offshore borrow sources were determined to contain enough material to build the ridge and marsh fill area, though this may require the use of both Grand Liard Offshore East and West borrow areas. The Project Team dismissed the offshore borrow site due to constructability issues. First; this material would need to be pumped and dewatered before it would be suitable for ridge restoration. This requires some amount of containment which would come from the interior marsh fill area. Second; the use of this material would require both offshore borrow sites or only Grand Liard Offshore West. Moving to, or pumping from, the Grand Liard Offshore West borrow site requires more pipe and would increase the mob/demob cost and cost per cubic yard for the project. Third; Grand Liard Offshore East and West borrow areas were chosen for their marsh building qualities. Due to the low percentage of coarse grain soils, this material would not be well-suited for ridge construction using slurry transport methods.

The second option for ridge restoration material was the interior marsh fill area. A barge mounted mechanical dredge would be required to span the distance from the borrow/access channel to the ridge alignment. The volume of material dredged from the access channel would yield more material than that needed to build the ridge feature, thus available material is not a concern. This excessive amount of material displaced in the interior marsh fill area would be significant and leave permanent low elevation areas in the marsh fill area.

The third, and preferred alternative, would borrow material from Bayou Grand Liard to build the ridge feature. Bayou Grand Liard will require some access dredging to bring necessary equipment to the job site. This alternative would place the material on the existing remnant ridge while a marsh buggy grades the ridge to the design cross section. Through analysis of the survey cross sections it was determined that an elevation lower than -12.0 feet NAVD 88 would generate a significant portion of the material required to build the ridge feature. The

magnetometer survey also showed seven pipelines in the bayou. No dredging would occur within a 50 foot radius of these pipelines.

The Project Team chose to combine Alternatives 2 and 3 to build the earthen ridge restoration feature. An access/borrow channel will be dredged to an elevation of -12.0 feet NAVD 88 in Bayou Grand Liard while avoiding impacts due to pipeline crossings. On April 13, 2011 dredging to an elevation of -12.0 feet NAVD 88 was proposed in the Plaquemines Parish Coastal Zone Management Meeting. The board members concurred that the public would not be opposed to dredging Bayou Grand Liard to -12.0 feet NAVD 88. A maximum width of 60 feet is to be maintained at a water elevation of -6.0 feet NAVD 88 to ensure access for a barge mounted mechanical dredge. The Project Team also considered the effect of induced saltwater intrusion due to dredging Bayou Grand Liard to an elevation of -12.0 feet NAVD 88. Through analysis of available survey data, it was determined that dredging Bayou Grand Liard would not likely have a significant impact on saltwater intrusion. Currently, there are many sections of Bayou Grand Liard that are greater than -12.0 feet NAVD 88; including one that is deeper than -19.0 feet NAVD 88. Additionally, several pipeline canals that dissect the project area have depths in excess of 12.0 feet.

As dredging Bayou Grand Liard to an elevation of -12.0 feet NAVD 88 will not yield enough material to construct the entire ridge, some material from the interior marsh will be dredged to complete the earthen ridge. Accessing this material will not require the use of a barge mounted dredge and would likely be constructed using marsh buggy excavators. Additionally, GeoEngineers, Inc. was tasked to analyze a cut elevation of -12.0 feet NAVD 88 for ridge stability with a fill elevation of +5.0 feet NAVD 88. Through this analysis it was found that a 20 foot stability berm would yield a factor of safety of 1.3 or greater for fill Cells B and D. And that a 35 foot stability berm would yield a factor of safety of 1.3 or greater for fill Cells A and C.

6.2 Typical Cross Section

The recommendations by GeoEngineers, Inc. for ridge construction were incorporated in this design. These features included a top elevation of +5.5 feet NAVD 88, side slopes of 1V:7H, 20 foot top width, and 100 foot bottom width. The stability berm width and borrow side slopes were dependent on which borrow source was used to build the ridge. The Project Team decided to use the Bayou Grand Liard and fill area borrow source. This meant that the stability berm would be at least 20 feet on the bayou side and 40 feet on the marsh fill side of the earthen ridge. Both borrow areas would require a side slope of 1V:3H. The Project Team decided to lower the fill height of the ridge from +5.5 to +5.0 feet NAVD 88 because the construction fill height of the marsh fill area was lowered from +4.0 to +3.5 feet NAVD 88 (see Marsh Creation Design), and reducing the ridge fill height would also reduce the material required to build the ridge. This change was incorporated by maintaining a top width of 20 feet and reducing the bottom width to 90 feet. This reduced the volume of material needed to build the ridge by 15%. The typical

cross section of the ridge is shown in Figure 18. Due to the stability berm and width of the ridge it is expected that a barge mounted clam shell dredge will be required for its construction.

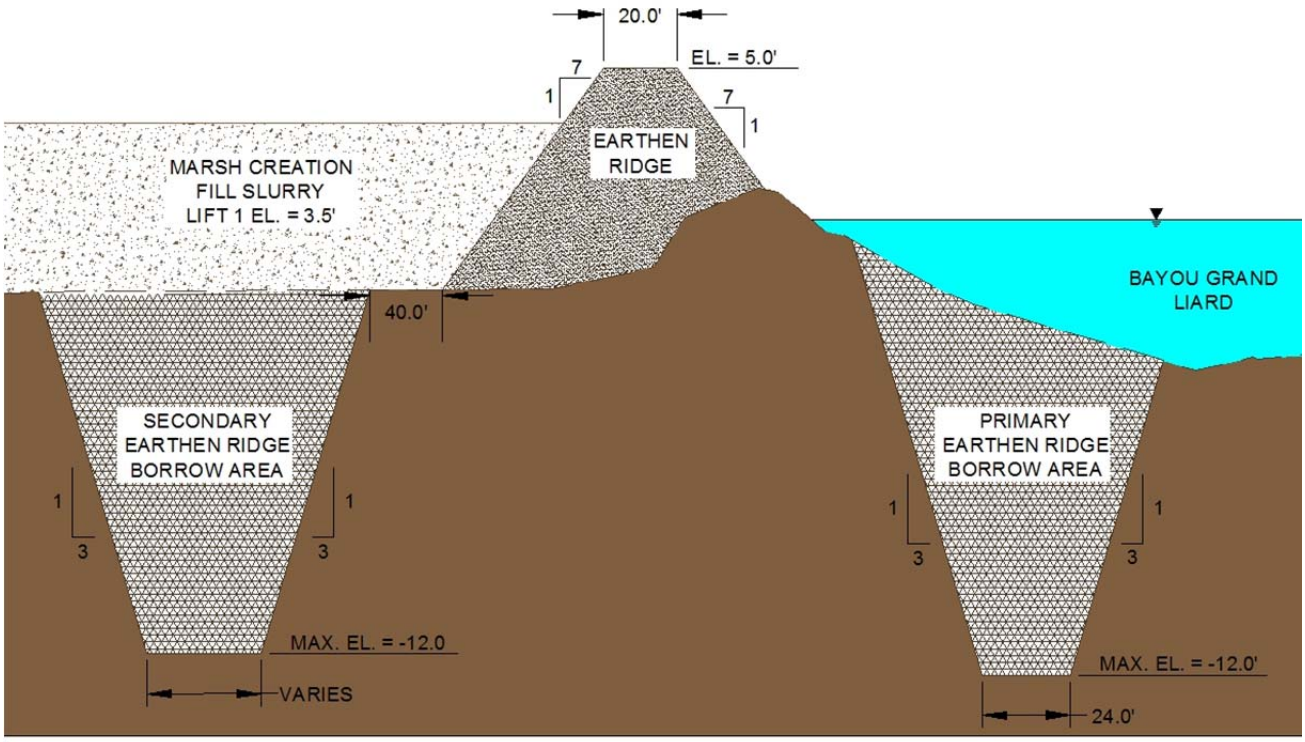


Figure 18 Ridge Design Cross Section (Not to Scale)

6.3 Alignment

Design surveys showed the existing remnant ridge at elevations ranging from +1.0 to +3.9 feet NAVD 88 along the eastern bank of Bayou Grand Liard. The alignment of the ridge restoration template placed its western toe (bayou side) on the centerline of the existing ridge. The ridge restoration feature will follow the existing ridge as much as possible. The plan view for the alignment of the ridge restoration feature is shown on the Final Design Drawings located in Appendix I. Once constructed, a separate contract would be issued for plantings on the new ridge template.

7.0 GAP CLOSURES

Some sections of the proposed earthen ridge and containment dikes have gaps that cut through at an approximate 90 degree angle to the current alignment. These gaps are either manmade or hydraulically made by tidal exchange in this area. These gaps must be closed to provide containment for marsh fill material. Due to higher flow rates these gaps will require alternative structural construction methods for complete closure. There are four gaps along the ridge and four gaps along the eastern containment dike alignment. Figure 19 and Table 10 show the locations of the eight gaps and boring locations relative to the project area, and the gap dimensions. Closing these gaps will require a sheet pile structure. The sheet pile wall will be encased in the earthen ridge or containment dike. Based on the recommendations made by GeoEngineers, Inc., CPRA chose to construct the sheet pile wall with a sand foundation.

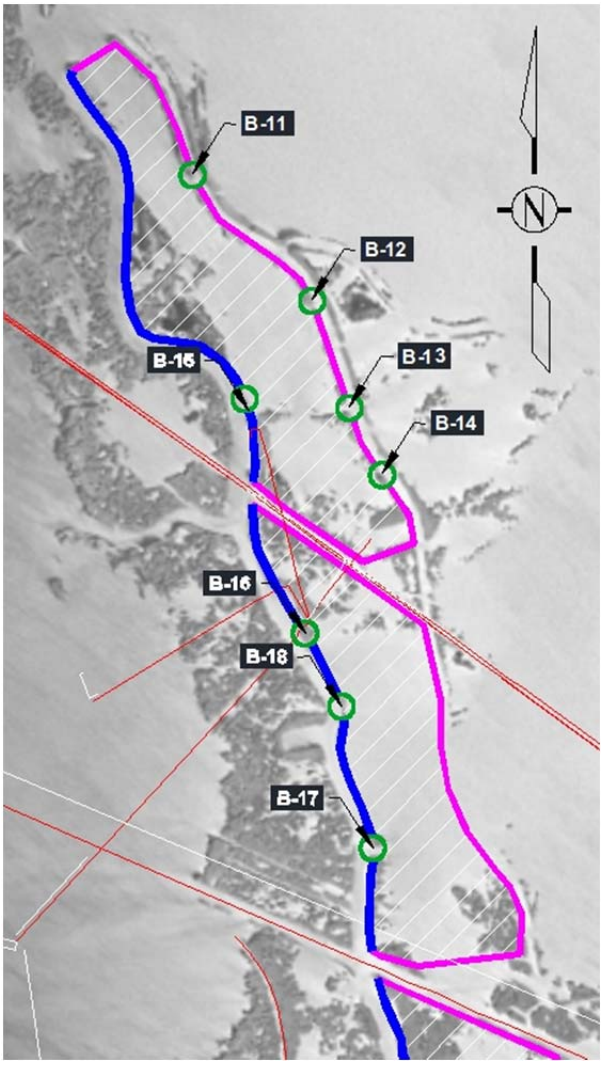


Figure 19 Boring and Gap Locations

Table 10 Gap Dimensions

Boring	Gap Width (ft)	Gap Depth (ft)
B-11	100	-6.5
B-12	125	-12
B-13	140	-13
B-14	145	-6.5
B-15	225	-21
B-16	100	-15.5
B-17	60	-17.5
B-18	195	-10

7.1 Sheet Pile Structure

The sheet pile structure will close the gaps in the earthen ridge and containment dike. This will help retain the material used to construct the containment dike, earthen ridge, and/or marsh fill platform. The calculated depth and length of sheet pile needed for closure is based upon a 2.0 factor of safety, and varies based upon the closure gap. The sheet pile closures on the ridge sections were offset into the marsh fill area. This was done to ensure that no sand fill would be placed in Bayou Grand Liard. The offset earthen ridge closure structure must be reconnected to the historical alignment of the earthen ridge. To do this, a 45 degree angle extending the sheet pile wall to the center line of the proposed earthen ridge was designed. Table 11 below shows the top elevation, total lengths, and square footage of each sheet pile wall for its respective gap. All structures will be constructed using a PZ-27 sheet pile. This pile meets the minimum section modulus, for all closures, as recommended by GeoEngineers, Inc.

Table 11 Sheet Pile Lengths and Dimensions

Sheet Piling			
Boring No.	Top Elevation (feet, NAVD 88)	Total Length (feet)	Total Square Footage of Piling
B-11	4.5	25	2,500
B-12	4.5	25	3,125
B-13	4.5	25	4,375
B-14	4.5	25	3,500
B-15 (Side Wall)	4.5	35	10,255
B-15 (Channel Wall)	4.5	35	5,285
B-16	4.5	30	7,590
B-17	4.5	35	20,545
B-18	4.5	25	4,075

Figure 20 Sheet Pile Wall (Example)

7.2 Sand Fill

Each closure structure will require the placement of sand on each side of the sheet pile wall. The sand fill will give the sheet pile wall more support and strength to resist the lateral forces exerted on the wall. These lateral forces will come from the marsh fill being pumped into the fill area during construction and head differences from the ingress and egress of the tide. The thickness of sand will vary for each gap closure depending on the depth and width of that gap. Table 12 below shows the different dimensions of the sand fill. Additionally, the sand fill used for the foundation of the sheet pile wall will reduce the quantity of material required to construct the earthen ridge, or containment dike, in that section.

Table 12 Sand Dimensions and Quantities

Boring	Top of Sand Elevation (feet, NAVD 88)	Thickness (feet)	Crown Width on Marsh Side	Crown Width on Water Side	Volume (Cu. Yd.)
B-11	-1.5	5	15	20	55
B-12	-2.0	10	15	25	94
B-13	-3.0	10	15	25	373
B-14	-1.5	5	15	20	100
B-15 (Side Wall)	-7.0	6	15	25	422
B-15 (Channel Wall)	-7.0	10	15	25	
B-16	-5.5	10	15	25	291
B-17	-7.5	10	15	25	417
B-18	-3.0	5	15	20	76
* side slopes are 3:1					

7.3 Construction Recommendations

GeoEngineers, Inc. recommends that the gap closures located at borings B-11 through B-14, along with the containment dikes of Cell A, be constructed before the gap closure located at boring B-15 is constructed. This will reduce the flow of water through the existing gap at boring B-15 and allow the contractor a more manageable flow of water; thereby increasing the constructability of the gap closure. For this matter CPRA recommends all containment dikes be constructed before the earthen ridge, where possible.

8.0 DREDGE PIPELINE TRANSPORT

The proposed dredge pipeline access route initially entered the project area from the Gulf of Mexico, through Sandy Point Pass and a bayou located on the northeastern end of Bay Jacques. This proposed access route was later dismissed due to land rights issues identified by CPRA's Land Rights division. Therefore another access route was proposed by the Project Team and surveyed by Sigma Consulting Group, Inc. This survey revealed water depths that are acceptable for installation of dredge sub-line and the associated equipment. The dredge slurry discharge pipeline follows the path from the offshore borrow source to the project area as shown in Figure 21 and on Sheet 3 of the Preliminary Design Drawings located in Appendix I.

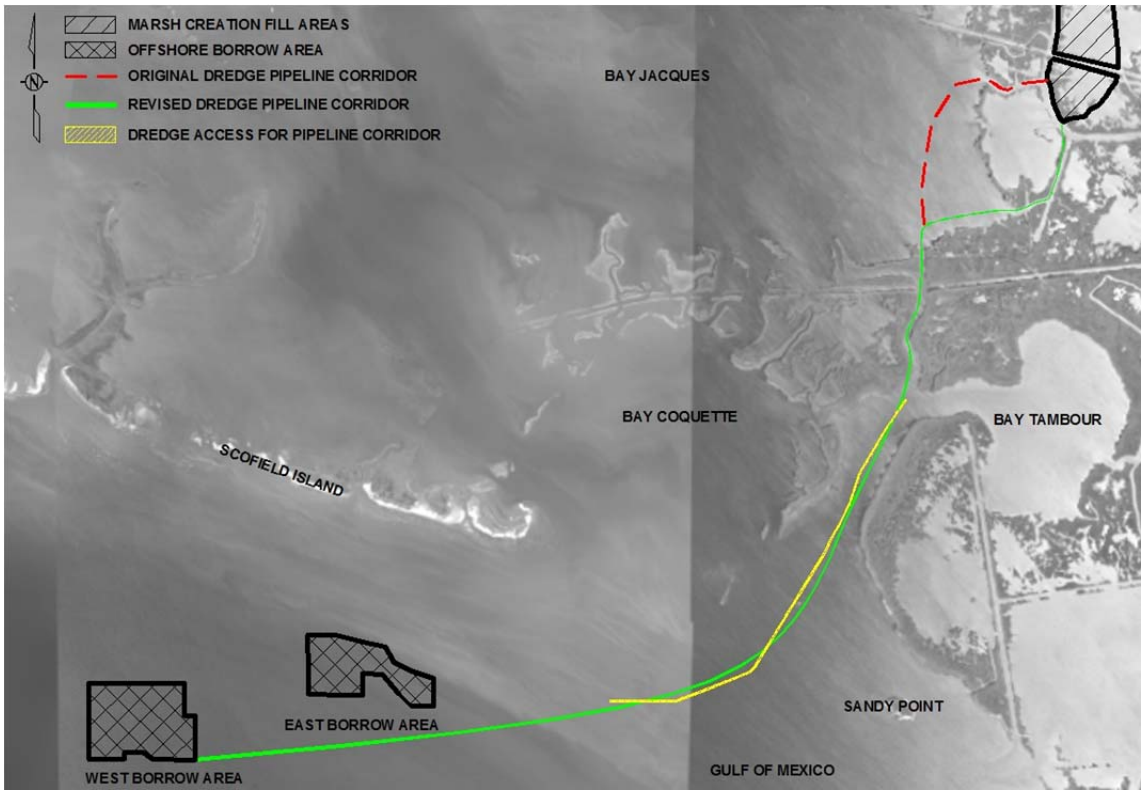


Figure 21 Dredge Pipeline Access Route (Note to Scale)

9.0 MODIFICATIONS TO APPROVED PHASE 0 PROJECT

As stated in Section 5.1 of the Marsh Creation Design section, the marsh fill area was reduced due to pipelines and deep water depths. These changes are illustrated in Figures 11 and 12. Unknown at the time of the Phase 0 analysis, there are a total of eight deep gaps in the earthen ridge of Cells A and B, and containment dikes of Cell A. These gaps must be closed before the marsh fill platform can be constructed. This proposed feature is discussed in Section 7.

10.0 COMMENTS ON PRELIMINARY (30%) DESIGN

The Preliminary Design Review Meeting for BA-68 was held on June 29th, 2011 at the Baton Rouge office of CPRA. The meeting announcement was sent to all CWPPRA agencies, as well as several other agencies and organizations involved in the project. This meeting included a detailed presentation on the history of the project, the design process, and the status of all CWPPRA Standard Operation Procedure (SOP) requirements. Figure 22 shows the attendance for the BA-68 Preliminary Design Review Meeting.

GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68)
CWPPRA 30% DESIGN MEETING
JUNE 29, 2011

NAME	REPRESENTING	PHONE NUMBER	E-MAIL
Kenneth Bahlinger	OCPR	(225) 342-7362	Kenneth.Bahlinger@la.gov
Tye Fitzgerald	OCPR	(225) 342-4496	tyefitzgerald@la.gov
Barry Richard	OCPR	504 280 4059	Barry.Richard@LA.GOV
Rachel Sweeney	NOAA	225-389-0508	rachel.sweeney@noaa.gov
Rudy Simoneaux	OCPR	225-342-0981	rudy.simoneaux@la.gov
Joy Merino	NOAA	337 852 6669	joy.merino@noaa.gov
Phillip Parke	NOAA	225-578-3341	phillip.parke@noaa.gov
Darryl Clark	USFWS	337-291-3111	Darryl_Clark@fws.gov
Summer Langlois	OCPR	225-342-1594	Summer.langlois@la.gov
Stuart Brown	OCPR	225-342-4596	Stuart.brown@la.gov
Chris Allen	"	225-342-4736	chris.allen@la.gov
Kristi Cantu	OCPR	225 342 0242	Krist.cantu@la.gov
Clayton Breland	OCPR	225 342 4102	clayton.breland@la.gov
John Troutman	OCPR	504 280-4068	John.Troutman@la.gov
Charles Killeen	LACES-OCPR	225-342-1474	CHARLES.KILLEEN@LA.GOV
Chris Llewellyn	EPA	214-665-7239	~~Llewellyn@~~
Adrian Chavarria	EPA	214-665-7103	llewellyn.chris@epa.gov chavarria.adrian@epa.gov
Scott Wandell	USACE	504-862-1878	Scott.W.Wandell@USACE.army.mil
Steve Roberts	"	2517	
V.J. MARRETTA	OCPR	225-342-5266	VICTOR.MARRETTA@LA.GOV

Figure 22 30% Design Sign-in Sheet

The BA-68 Project Team received formal comments on the Preliminary Design Documents from the Environmental Protection Agency (EPA), National Resources Conservation Service (NRCS), the Army Corps of Engineers (COE), and the United States Fish and Wildlife Service (USFWS). A majority of these comments were discussed at the Preliminary Design Meeting. Most comments centered around the two construction lift design of the marsh fill area. Other comments requesting additional figures and change in acreage calculations were included in this report. The PDR comments and responses can be found in Appendix N.

The first comment was on the two construction lifts of the marsh fill cells. The second lift is not the same height as the first lift, which is how previous two construction lift projects were constructed. Borings in the marsh fill cells show significant soil property variations and therefore were not combined for analysis. The first construction lift was set to the same maximum fill height of all four cells, therefore the second construction lift must vary from cell to cell depending on the resulting settlement predictions. The first construction lift was purposely set higher than the second lift as it will increase the initial consolidation of the underlying soil. This will reduce the amount of settlement in the second construction lift and allow the marsh fill height to reach an intertidal range sooner and remain there for the duration of the project life. This fill configuration is beneficial for the earthen ridge and containment dikes. They can be constructed for the same design fill height for the first construction lift, rather than having them change with each fill cell design.

The second comment was in response to the volume calculation for marsh fill. This volume was calculated using the settlement curves provided by GeoEngineers, Inc. As the elevations given in the settlement curves represent slurry elevations (extremely high void ratio), using these values for fill volume determination would grossly over estimate the actual volume required. Therefore an elevation on the curve which had the least void ratio (TY20) was used for this calculation. Also included in this calculation was the settlement of the underlying soil. This part of the volume calculation captures the change in elevation of the mudline (i.e. fill area bottom elevation) from beginning of construction to TY 20.

11.0 REFERENCES

Coastal Planning & Engineering, Inc. Grand Liard Marsh and Ridge Restoration (BA-68). Boca Raton, Florida, September 2010.

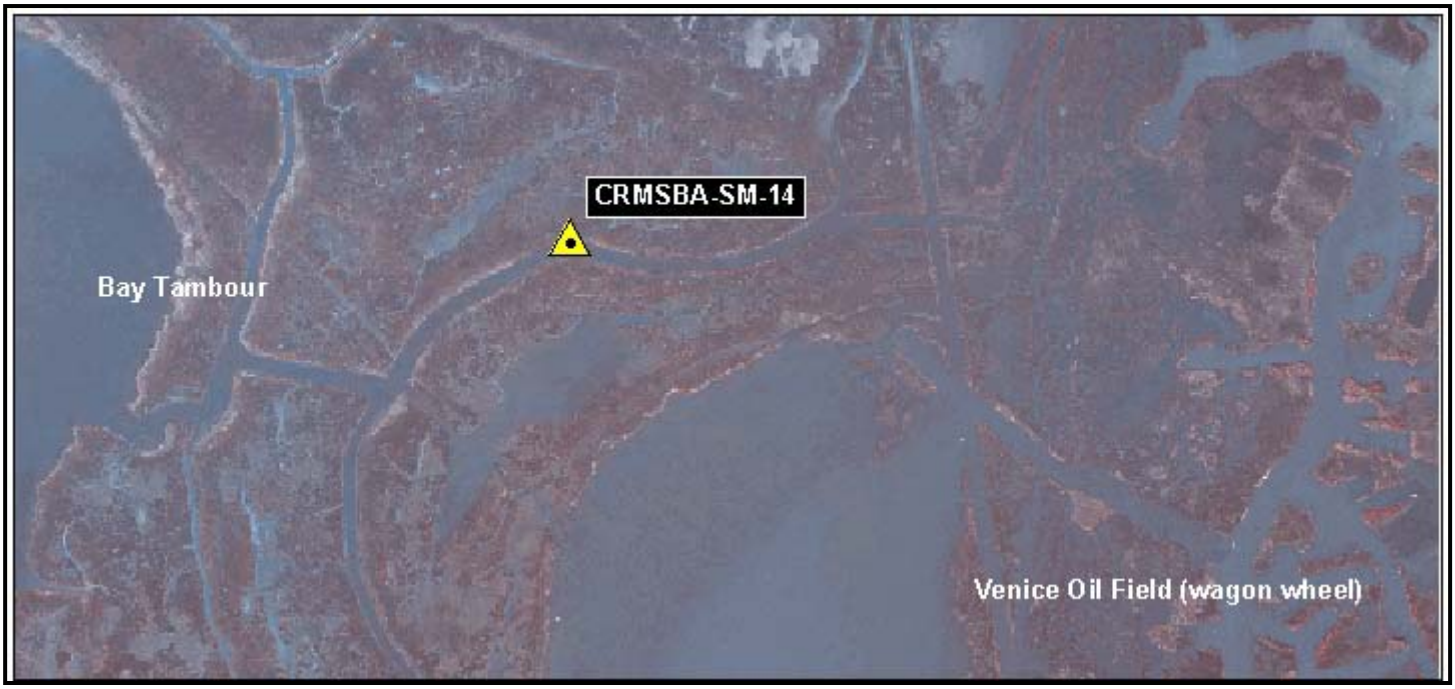
Coduto, Donald P. Foundation Design Principles and Practices, 2nd ed. Upper Saddle River, New Jersey: Prentice Hall, January, 2001.

GeoEngineers, Inc. Grand Liard Marsh and Ridge Restoration (BA-68): Geotechnical Engineering Report. Baton Rouge, LA, March 2011.

Sigma Consulting Group, Inc. Survey Methodology Report, Grand Liard and Ridge Restoration (BA-68), Topographic & Bathymetric Survey. Baton Rouge, LA, November 2010.

Appendix A

Secondary Monument Data Sheets

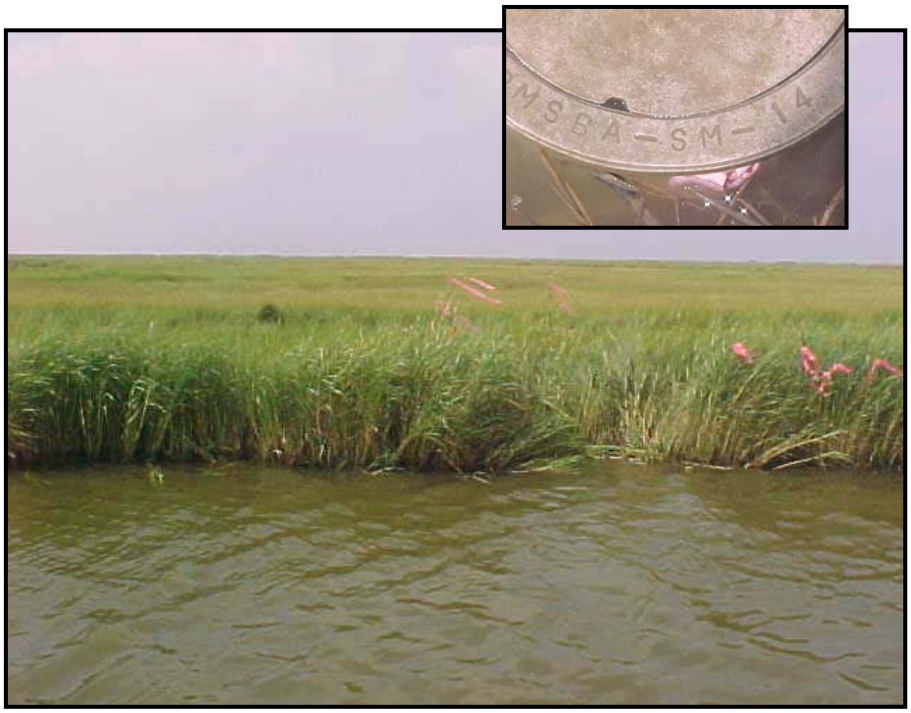


VICINITY MAP Scale: 1" = 2000' Reproduced from USC&GS "PASS TANTE PHINE" Quadrangle

Station Name: CRMSBA-SM-14

Monument Location: By boat from the Venice Marina Harbor, go west along the canal (Red Pass) for +/- 3.8 miles to the "Wagon Wheel" in the Venice Oil Field. Continue west northwest around the western quadrant of the "Wagon Wheel" for +/- 3.2 miles to a canal on the left. Go northwest along this canal for +/- 0.7 miles to a small canal on the right. Go north on this canal for +/- 0.3 miles to a 4-way intersection at Spanish Pass. Go west +/- 0.7 miles on Spanish Pass canal to the monument on the right.

Monument Description: 9/16" steel rod driven to refusal within a 6" PVC sleeve set in concrete with protective metal access cover stamped **CRMSBA-SM-14.**



Date: August 2005

Monument Established By:
Chustz Surveying, Inc. for
Louisiana Department of
Natural Resources

Adjusted NAD 83 Geodetic Position*
Lat. 29°14'40.68698"N
Long. 89°26'54.29070"W

Adjusted NAD 1983 Datum*
LSZ (1702) Feet
N= 275747.40
E= 3881961.78

Adjusted NAVD88 (Feet) /Geoid99*
Elevation = 2.27

*** As surveyed for LaDNR CRMS project, contract NO: 2503-05-56**

VICINITY MAP Not to Scale

Reproduced from Louisiana 2005 DOQQ

Station Name: "N 367"

Location: Described by National Geodetic Survey 1984, located 8.2 km (5.1 mi) east-southeast from Buras. 7.5 km (4.65 mi) east-southeast along Old Route 23 from the Buras High School in Buras, thence 0.73 km (0.45 mi) southerly along New Route 23, at the brick entrance and iron archway leading north-northwest to Fort Jackson, 15.2 meters (49.9 ft) northwest of the centerline of route 23, 4.6 meters (15.0 ft) southwest of the center shell road entrance leading to the fort, 1.6 meters (5.4 ft) southeast of the southeast face of most westerly one of two brick entrance pillars, 10.5 meters (34.4 ft) north of a power line pole with a street light and 11.9 meters (39.0 ft) west-southwest of bench mark V195 RESET 1970. The mark is 1.30 meters southeast from a witness post.

Monument Description: Flange Encased Stainless Steel Rod driven to refusal at a depth of 96.1 ft. with sleeve.

Stamping: N 367 1984

Installation Date: 1984 **Date of Survey:** May 2006

Monument Established By: NGS

For: NGS

Adjusted NAD83 Geodetic Position (NSRS2007)
Lat. 29°21'08.29719" N
Long. 089°27'25.67584" W

Adjusted NAD83 Datum LSZ (1702) Ft (NSRS2007)
N= 314,850.54
E= 3,878,540.64

Adjusted NAVD88 Height (2006.81)
Elevation = 0.97 feet (0.295 mtrs)

Ellipsoid Height = -23.832 mtrs.
Geoid03 Height = -24.127 mtrs. (2004.65)

NO PHOTO AVAILABLE

Adjusted Position Established John Chance Land Surveys, Inc. for the Coastal Protection & Restoration Authority of Louisiana, OCPR

VICINITY MAP Not to Scale

Reproduced from Louisiana 2005 DOQQ

Station Name: "C 279"

Location: Described by National Geodetic Survey 1971, located 2.0 mi northwest from Buras about 2.0 miles northwest along State Highway 23 from the high school at Buras, or about 2.9 miles southeast along State Highway 23 from the draw bridge over the Doullut Canal at empire, 0.8 mile southeast of the Sunrise High School, at the junction of the highway and the more northwesterly of two driveways that leads southwest to the Phillips Petroleum Companies Production Department and radio tower, set in the top of the northeast side of the round portion of sewer lift station No. 29-A, 75 feet southwest of the center line of the highway, 39 feet southeast of the center line of the driveway, 2.7 feet east of the north corner of the square portion of the sewer station, 0.6 foot northeast of the northeast side of the sewer station, 0.6 foot below the top of the square portion of the station, and about level with the highway.

Monument Description: Bench Mark Disk set in concrete slab.

Stamping: C 279 1970

Installation Date: 1970 **Date of Survey:** April 2006

Monument Established By: NGS **For:** NGS

Adjusted NAD83 Geodetic Position (NSRS2007)
Lat. 29°21'50.30266" N
Long. 089°33'22.42573" W

Adjusted NAD83 Datum LSZ (1702) Ft (NSRS2007)
N= 318,589.90
E= 3,846,907.74

Adjusted NAVD88 Height (2006.81)
Elevation = -0.93 feet (-0.283 mtrs)

Ellipsoid Height = -24.433 mtrs.
Geoid03 Height = -24.150 mtrs. (2004.65)

NO PHOTO AVAILABLE

Adjusted Position Established John Chance Land Surveys, Inc. for the Coastal Protection & Restoration Authority of Louisiana, OCPR

VICINITY MAP Not to Scale

Reproduced from Louisiana 2005 DOQQ

Station Name: "J 370"

Location: Described by National Geodetic Survey 1984, located 4.35 km (2.7 mi) southeast from Boothville. 4.35 km (2.7 mi) southeast along State Highway 23 from the Boothville-Venice School, near pumping station, 14.33 meters (47.0 ft) northeast of the centerline of Route 23, 22.56 meters (74.0 ft) southeast of east corner of a chain link fence, 9.14 meters (30.0 ft) northwest of a fire hydrant and 0.49 meters (1.6 ft) southeast of a power line pole number 272. The mark is 0.30 meters southeast from a witness post.

Monument Description: Flange Encased Stainless Steel Rod driven to refusal at a depth of 87.9 ft without sleeve.

Stamping: J 370 1984

Installation Date: 1984 **Date of Survey:** April 2006

Monument Established By: NGS

For: NGS

Adjusted NAD83 Geodetic Position (NSRS2007)
Lat. 29°19'02.27838" N
Long. 089°23'17.79784" W

Adjusted NAD83 Datum LSZ (1702) Ft (NSRS2007)
N= 302,488.49
E= 3,900,689.99

Adjusted NAVD88 Height (2006.81)
Elevation = -4.20 feet (-1.281 mtrs)

Ellipsoid Height = -25.331 mtrs.
Geoid03 Height = -24.050 mtrs. (2004.65)

NO PHOTO AVAILABLE

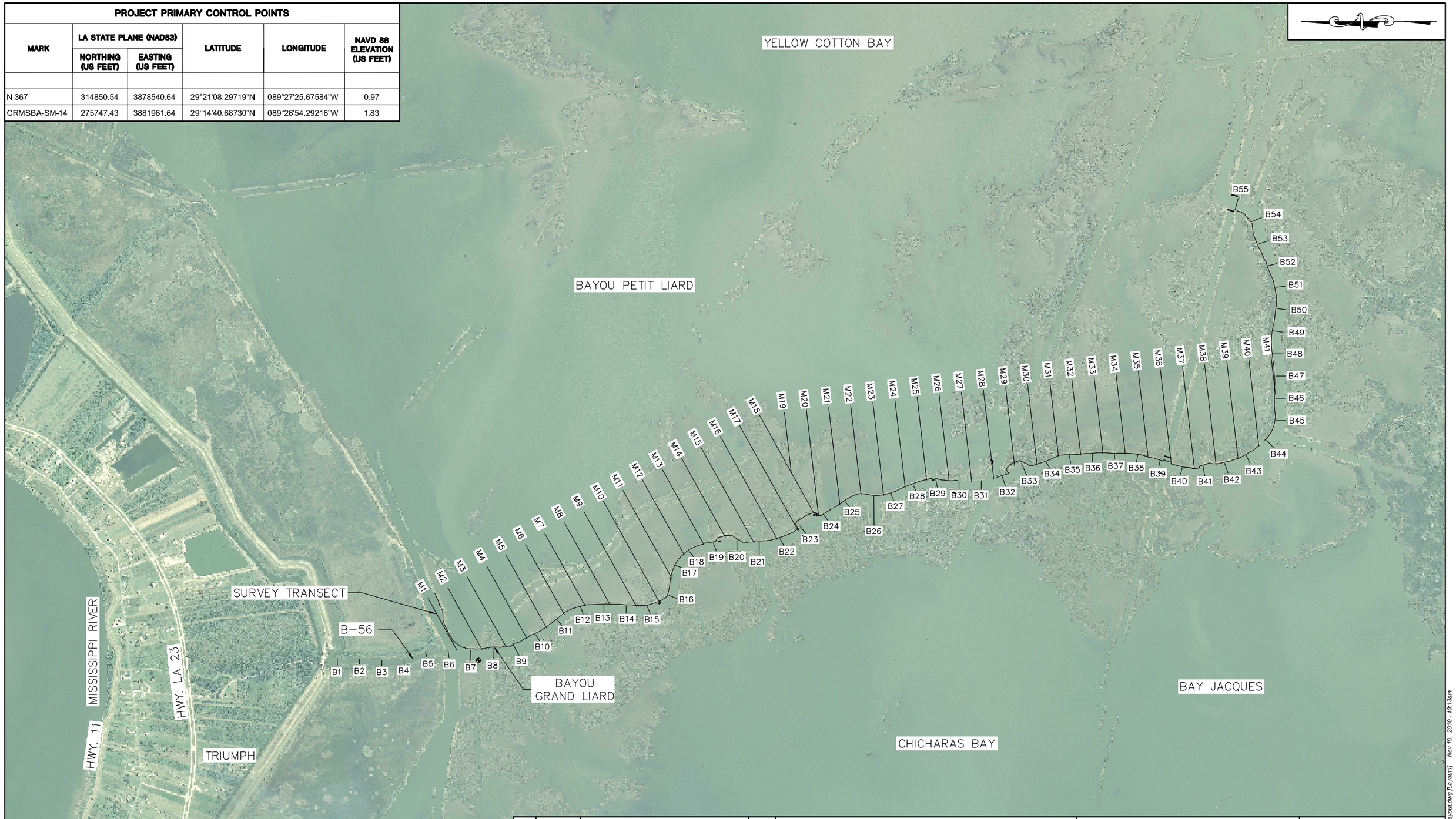
Adjusted Position Established John Chance Land Surveys, Inc. for the Coastal Protection & Restoration Authority of Louisiana, OCPR

Appendix B

Inshore Survey Transects

PROJECT PRIMARY CONTROL POINTS

MARK	LA STATE PLANE (NAD83)		LATITUDE	LONGITUDE	NAVD 88 ELEVATION (US FEET)
	NORTHING (US FEET)	EASTING (US FEET)			
N 367	314850.54	3878540.64	29°21'08.29719"N	089°27'25.67584"W	0.97
CRMSBA-SM-14	275747.43	3881961.64	29°14'40.68730"N	089°26'54.29218"W	1.83



REV.	DATE	DESCRIPTION	BY

GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68)

TRANSECT LAYOUT MAP

DRAWN BY: D. THYMES
DESIGNED BY: R. LEAR

OFFICE OF COASTAL PROTECTION & RESTORATION
COASTAL ENGINEERING DIVISION

STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY:

SIGMA CONSULTING GROUP, INC.

DATE: OCTOBER 2010
SHEET: 1 OF 2

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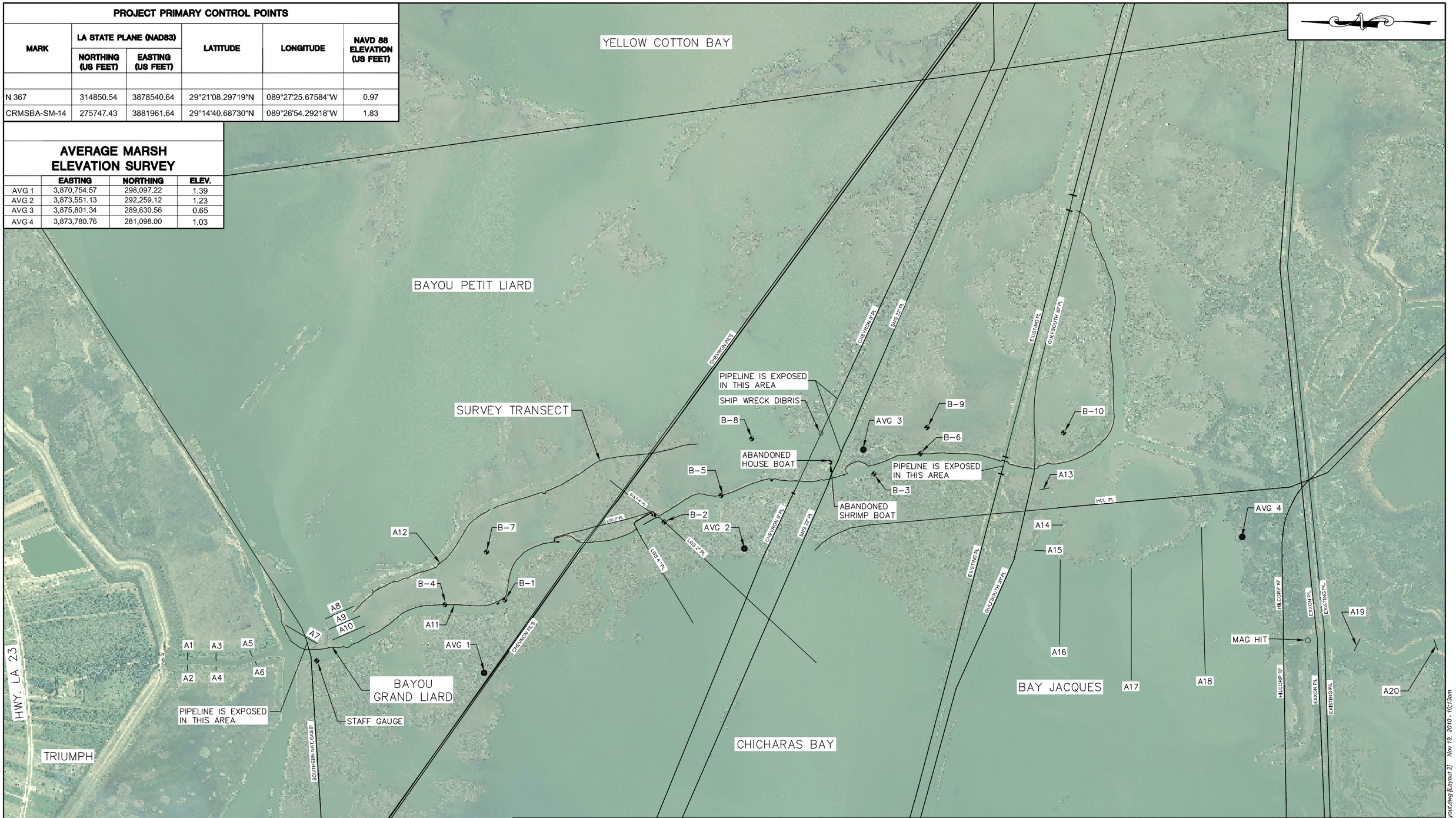
PROJECT PRIMARY CONTROL POINTS

MARK	LA STATE PLANE (NAD83)		LATITUDE	LONGITUDE	NAVD 88 ELEVATION (US FEET)
	NORTHING (US FEET)	EASTING (US FEET)			
N 367	314850.54	3878540.64	29°21'08.29719"N	089°27'25.67584"W	0.97
CRMSBA-SM-14	275747.43	3881961.64	29°14'40.68730"N	089°26'54.29218"W	1.83

AVERAGE MARSH ELEVATION SURVEY

	EASTING	NORTHING	ELEV.
AVG 1	3,870,754.57	298,097.22	1.39
AVG 2	3,873,551.13	292,259.12	1.23
AVG 3	3,875,801.34	289,630.56	0.65
AVG 4	3,873,780.76	281,098.00	1.03



GRAPHIC SCALE

2000 0 1000 2000 4000 8000

(IN FEET)
1 inch = 2000ft.

REV.	DATE	DESCRIPTION	BY

GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68)

TRANSECT LAYOUT MAP

DRAWN BY: D. THYMES
DESIGNED BY: R. LEAR

OFFICE OF COASTAL PROTECTION & RESTORATION
COASTAL ENGINEERING DIVISION

STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY:

SIGMA CONSULTING GROUP, INC.

DATE: OCTOBER 2010
SHEET: 2 OF 2

P:\02020\100519\0180\100519 Layout.dwg [Layout 2] Nov 19, 2010 - 10:13am

GRAPHIC SCALE

2000 0 1000 2000 4000 8000

(IN FEET)
1 inch = 2000ft.

REV.	DATE	DESCRIPTION	BY

GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68) ALIGNMENTS LAYOUT MAP

DRAWN BY: D. THYMES

DESIGNED BY: R. LEAR

OFFICE OF COASTAL PROTECTION & RESTORATION
COASTAL ENGINEERING DIVISION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY:

SIGMA CONSULTING GROUP, INC.

DATE: OCTOBER 2010

SHEET: 2A OF 2

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POINT	X COORDINATE	Y COORDINATE	WATER DEPTH	COVER
1	3,871,445'	302,070'	7.80'	0.0'
2	3,871,774'	302,185'	5.90'	0.7'
3	3,872,076'	302,376'	5.80	0.3'
4	3,872,362'	302,558'	4.10'	2.0'
5	3,872,653'	302,751'	4.30'	1.3'
6	3,874,224'	294,854'	2.20'	2.0'
7	3,874,161'	295,128'	3.00'	3.2'
8	3,874,098'	295,393'	2.50'	5.3'
9	3,874,046'	295,629'	3.90'	2.2'
10	3,874,002'	295,769'	1.90'	2.1'
11	3,873,955'	295,965'	2.10'	2.8'
12	3,873,917'	296,127'	2.10'	2.9'
13	3,873,803'	296,530'	----	PI
14	3,873,703'	296,530'	Exp.	PL
15	3,873,706'	296,441'	OLD	LOC.
16	3,876,833'	293,553'	4.90'	1.2'
17	3,876,676'	293,670'	4.20'	1.4'
18	3,876,444'	293,840'	3.00'	3.5'
19	3,875,945'	294,204'	2.10'	4.2'
20	3,875,531'	294,507'	3.10'	6.7'
21	3,875,002'	294,892'	3.80'	7.5'
22	3,874,688'	295,119'	3.50'	8.4'
23	3,874,439'	295,288'	MAG	HIT
24	3,874,129'	295,517'	MAG	HIT
25	3,873,573'	295,956'	11.90'	0.0'
26	3,876,793'	293,529'	4.90'	4.1'
27	3,876,651'	293,632'	4.90'	4.1'
28	3,876,400'	293,814'	3.00'	3.1'
29	3,875,919'	294,169'	5.00'	1.1'
30	3,875,502'	294,484'	4.10'	3.0'
31	3,874,985'	294,860'	3.80'	10.9'
32	3,874,656'	295,099'	4.10'	12.0'
33	3,874,431'	295,270'	PL	SIGN
34	3,876,792'	293,528'	4.90'	3.1'
35	3,876,653'	293,627'	4.90'	3.1'
36	3,876,398'	293,811'	3.00'	2.6'
37	3,875,914'	294,166'	5.00'	1.0'
38	3,875,499'	294,468'	4.50'	4.0'
39	3,874,976'	294,853'	3.60'	11.3'
40	3,874,649'	295,092'	MAG	HIT
41	3,874,431'	295,267'	MAG	HIT
42	3,874,122'	295,496'	MAG	HIT
43	3,873,575'	295,901'	MAG	HITS
44	3,874,466'	294,500'	2.00'	3.2'
45	3,874,629'	294,706'	2.00'	3.5'
46	3,874,781'	294,892'	2.00'	3.6'
47	3,874,937'	295,095'	3.00'	2.7'
48	3,875,000'	295,167'	MAG	HIT
49	3,875,086'	295,272'	3.30'	2.0'
50	3,873,800'	294,578'	1.90'	6.9'
51	3,873,904'	294,627'	10.00'	5.9'
52	3,873,969'	294,669'	1.00'	10.2'
53	3,874,157'	294,059'	MAG	HIT
54	3,874,200'	294,115'	9.80'	1.0'
55	3,874,244'	294,152'	4.00'	2.7'
56	3,877,160'	290,065'	3.00'	4.00'
57	3,876,921'	290,174'	15.20'	−1.2'
58	3,876,560'	290,344'	3.20'	4.9'
59	3,876,337'	290,450'	3.00'	3.1'
60	3,876,080'	290,567'	3.70'	2.4'
61	3,875,881'	290,664'	3.60'	1.9'
62	3,875,683'	290,755'	4.30'	1.90'
63	3,875,498'	290,839'	3.20'	3.1'
64	3,875,337'	290,919'	6.00'	0.5'
65	3,875,012'	291,066'	7.10'	8.9'
66	3,874,948'	291,093'	9.90'	7.1'
67	3,874,864'	291,132'	1.50'	11.5'
68	3,877,138'	289,468'	12.10'	5.1'
69	3,876,659'	289,675'	15.20'	2.6'
70	3,876,257'	289,836'	15.00'	2.0'
71	3,875,869'	290,027'	BOUY TIED	ON PIPE
72	3,875,535'	290,158'	22.00'	0.0'
73	3,875,192'	290,322'	25.00'	0.0'
74	3,874,988'	290,392'	20.00'	MAG HIT
75	3,881,420'	284,897'	4.50'	14.4'
76	3,881,264'	284,935'	14.00'	5.7'
77	3,881,170'	284,960'	5.20'	14.5'
78	3,877,684'	285,871'	5.30'	6.6'
79	3,877,431'	285,925'	11.00'	7.2'
80	3,877,125'	286,009'	8.10'	8.8'
81	3,876,727'	286,110'	7.90'	9.1'
82	3,876,385'	286,202'	8.50'	9.4'
83	3,875,878'	286,334'	11.00'	5.0'
84	3,875,410'	286,453'	15.90'	0.1'
85	3,875,251'	285,766'	12.10'	4.8'
86	3,875,523'	285,744'	4.20'	4.3'
87	3,875,807'	285,741'	2.50'	4.8'
88	3,876,008'	285,744'	2.90'	4.4'
89	3,876,216'	285,756'	2.00'	5.8'
90	3,876,376'	285,763'	1.50'	6.0'
91	3,876,531'	285,767'	2.80'	5.8'
92	3,876,710'	285,765'	2.90'	5.8'
93	3,876,934'	285,750'	4.20'	4.9'
94	3,877,143'	285,725'	3.70'	4.0'
95	3,877,370'	285,690'	4.50'	3.0'
96	3,877,657'	285,629'	7.00'	1.5'
97	3,881,198'	284,708'	15.10'	2.4'
98	3,874,437'	285,532'	2.90'	7.1'
99	3,874,463'	285,251'	5.00'	4.3'
100	3,871,450'	280,172'	6.20'	6.7'
101	3,871,510'	280,169'	MAG	HIT
102	3,871,593'	280,171'	9.50'	2.5'
103	3,871,344'	279,406'	MAG	HIT
104	3,871,525'	279,407'	16.20'	1.8'
105	3,871,631'	279,425'	MAG	HIT
106	3,871,328'	279,241'	3.20'	2.8'
107	3,871,505'	279,242'	15.00'	5.4'
108	3,871,674'	279,252'	5.30'	11.2'

▲ 166γ

▲ = MAG HIT

166γ = GAMMA COUNT

SIGMA CONSULTING GROUP
10305 Airline highway
Baton Rouge, LA 70816

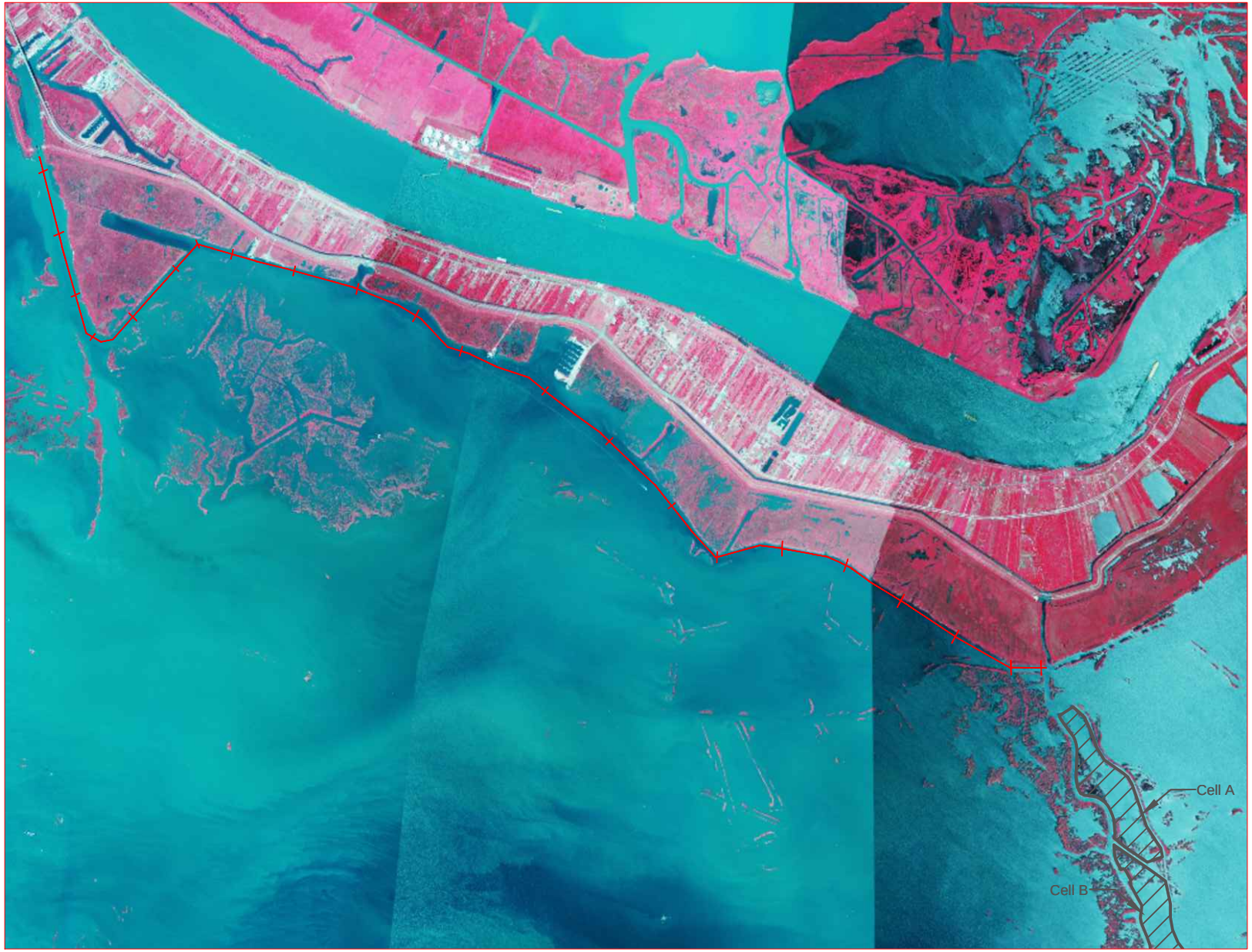
MAGNETOMETER SURVEY
Bayou Grand Liard Field
Plaquemines Parish

PREPARED BY C&C Technologies SURVEY SERVICES
730 E. KALISTE SALOOM ROAD, LAFAYETTE, LA. (337) 261-0860
LA. REGISTRATION NUMBER: 350

JOB NO. 100812 | DWG: SLH | CHK: REP | REVISED: | DATE: 08/27/2010

FILENAME: L:\20S30E\100812\M100812-83C.DWG

SHEET 1 OF 1


Cell A
Cell B

TRANSECT COORDINATES

	EASTING	NORTHING	EASTING	NORTHING
1	3,875,924.71	283,721.92	3,876,102.23	283,663.97
2	3,875,658.15	282,905.38	3,875,835.67	282,847.43
3	3,875,391.59	282,088.84	3,875,569.10	282,030.88
4	3,875,050.49	281,946.45	3,875,103.96	281,794.57
5	3,874,471.52	281,629.13	3,874,480.06	281,424.24
6	3,873,570.44	281,998.30	3,873,594.59	281,069.86
7	3,871,671.08	281,948.89	3,871,709.70	280,464.30
8	3,871,077.02	276,253.57	3,871,369.26	276,176.07
9	3,869,438.83	275,457.81	3,870,869.27	274,515.46
10	3,868,905.95	273,413.87	3,869,967.50	272,714.54
11	3,869,188.83	272,709.07	3,852,705.00	266,557.00
12	3,869,447.48	272,557.09	3,852,705.00	266,557.00

REV.	DATE	DESCRIPTION	BY

OFFICE OF COASTAL PROTECTION & RESTORATION
RESTORATION ENGINEERING DIVISION
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

ACCESS CHANNEL SURVEY LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: FEBRUARY 2011

DRAWN BY: KRISTI CANTU

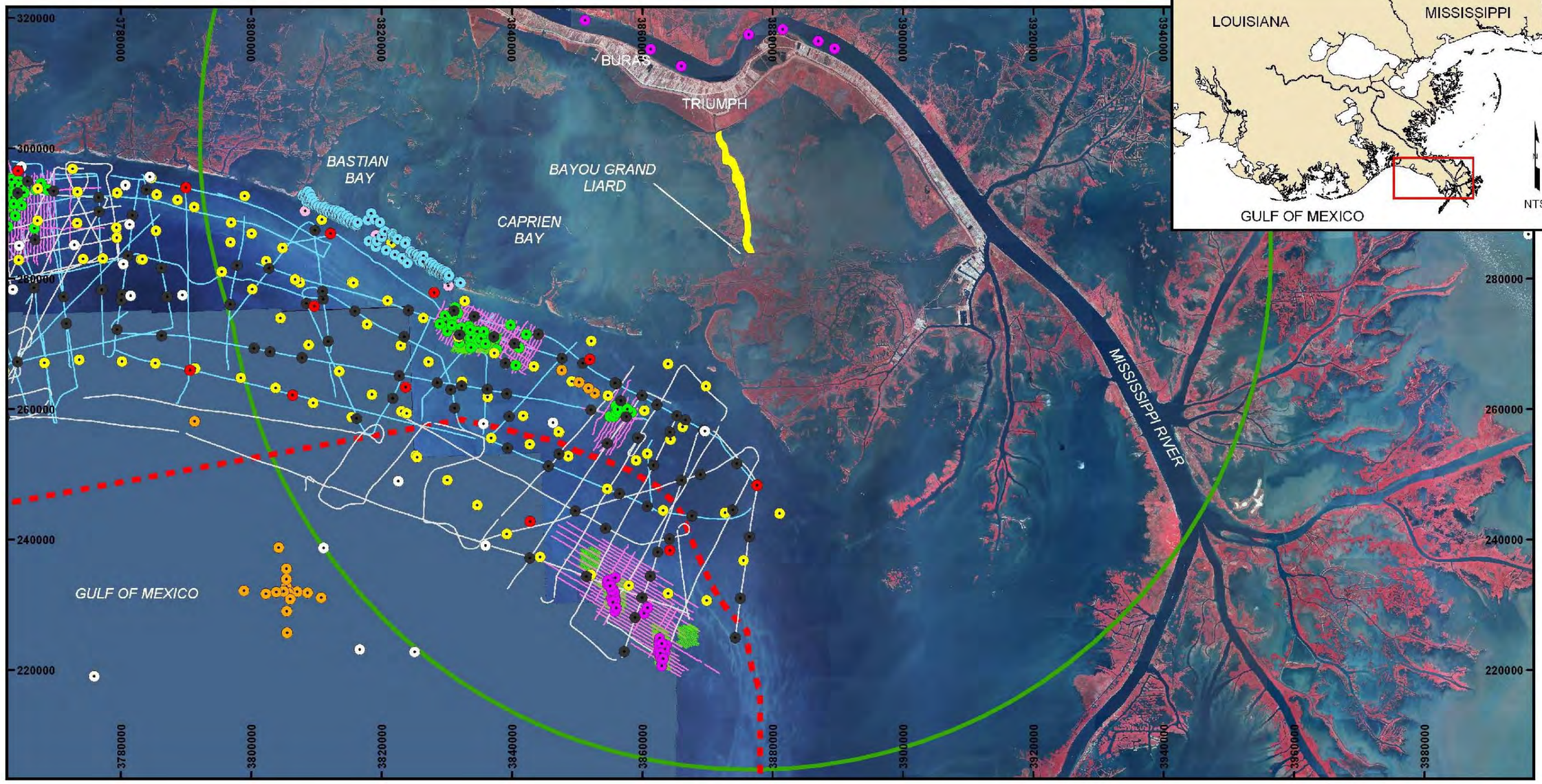
DESIGNED BY: TYE FITZGERALD, E.I.

APPROVED BY: RUDY SIMONEAUX, P.E.

SHEET 1 OF 1

Appendix C

Offshore Borrow Figures



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).
2. AERIAL PHOTOGRAPHY DATED 2005 FROM USGS.

LEGEND

- TEXAS A M (1978)
- MCCLELLAND (1987)
- UNO (2003)
- LGS/USGS (1983-1992)
- USGS (2000)
- HASTINGS ET AL (2000)
- CPE 2002 VIBRACORES
- CPE 2003 VIBRACORES
- ACOE VIBRACORES (DATE UNKNOWN)
- USGS CRUISE 00SCC04 (2004) GEOPHYSICAL TRACKLINES
- CPE (2003) GEOPHYSICAL TRACKLINES
- CPE (2002) GEOPHYSICAL TRACKLINES
- USGS CRUISE 00SCC02 (2002) GEOPHYSICAL TRACKLINES
- FEDERAL STATE BOUNDARY
- GRAND LIARD MARSH AND RIDGE RESTORATION PROJECT (BA-68)
- INVESTIGATION AREA

0 8,000 16,000 Feet

1 inch = 16,000 feet

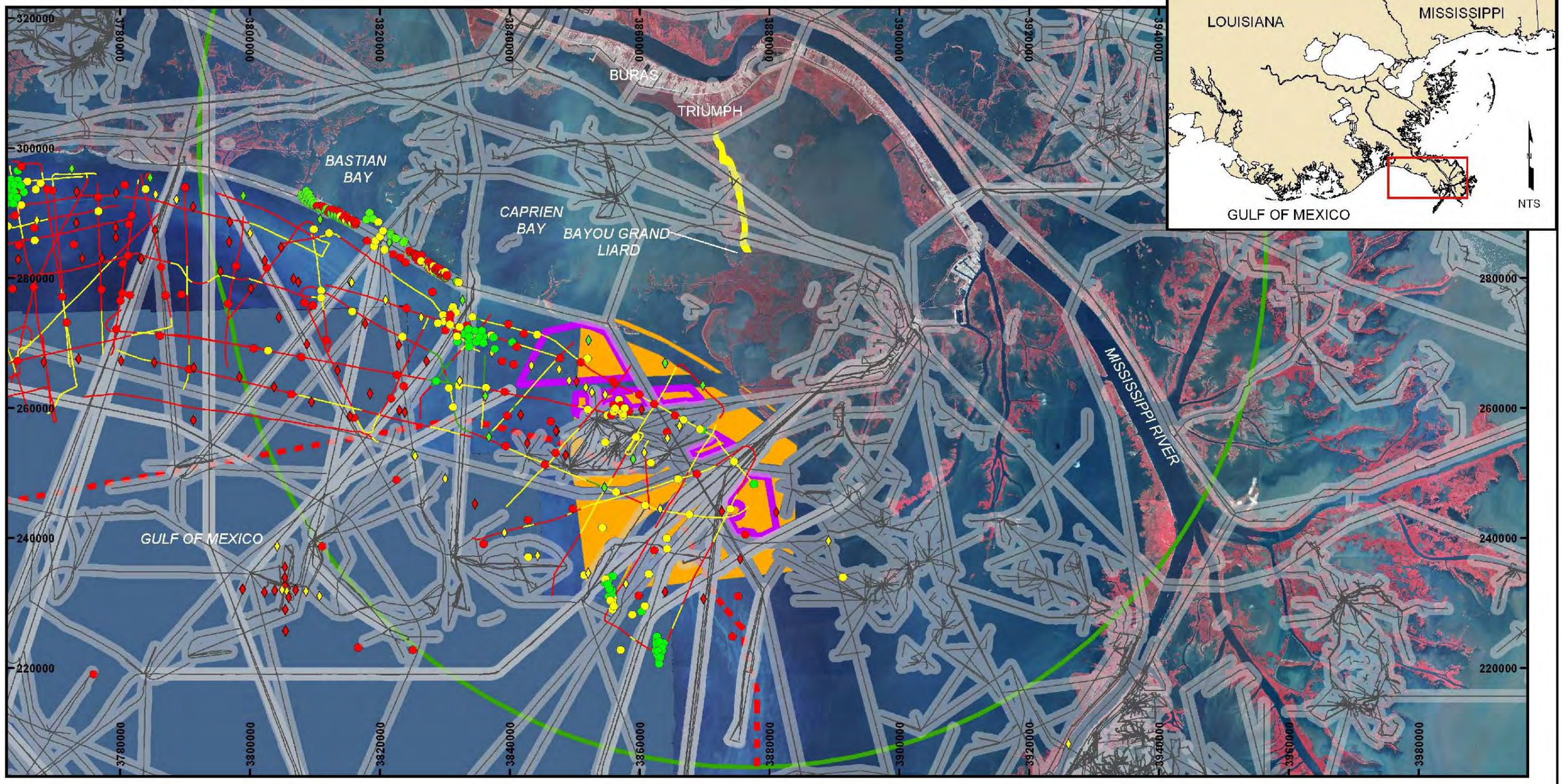
N

TITLE:

FIGURE 3. GEOPHYSICAL AND GEOTECHNICAL DATA COMPILED DURING THE PHASE I INVESTIGATION

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 03/04/10	BY: BF	COMM NO: 7900.26	FIGURE 3



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).
2. AERIAL PHOTOGRAPHY DATED 2005 FROM USGS.

LEGEND

VIBRACORE CLASSIFICATION
- CLAY
- SAND
- SANDY CLAY

GRAB SAMPLE CLASSIFICATION
- CLAY
- SAND
- SANDY CLAY

SEISMIC LINE CLASSIFICATION
- CLAY
- SAND
- MIXED SEDIMENT
- PIPELINES (LA OCM V7, MMS)
- 1000 FT PIPELINE BUFFER
- AREAS RECOMMENDED FOR FURTHER INVESTIGATION
- OCPR POTENTIAL BORROW AREAS

- GRAND LIARD MARSH AND RIDGE RESTORATION PROJECT
- FEDERAL STATE BOUNDARY
- INVESTIGATION AREA

0 8,000 16,000 Feet

1 inch = 16,000 feet

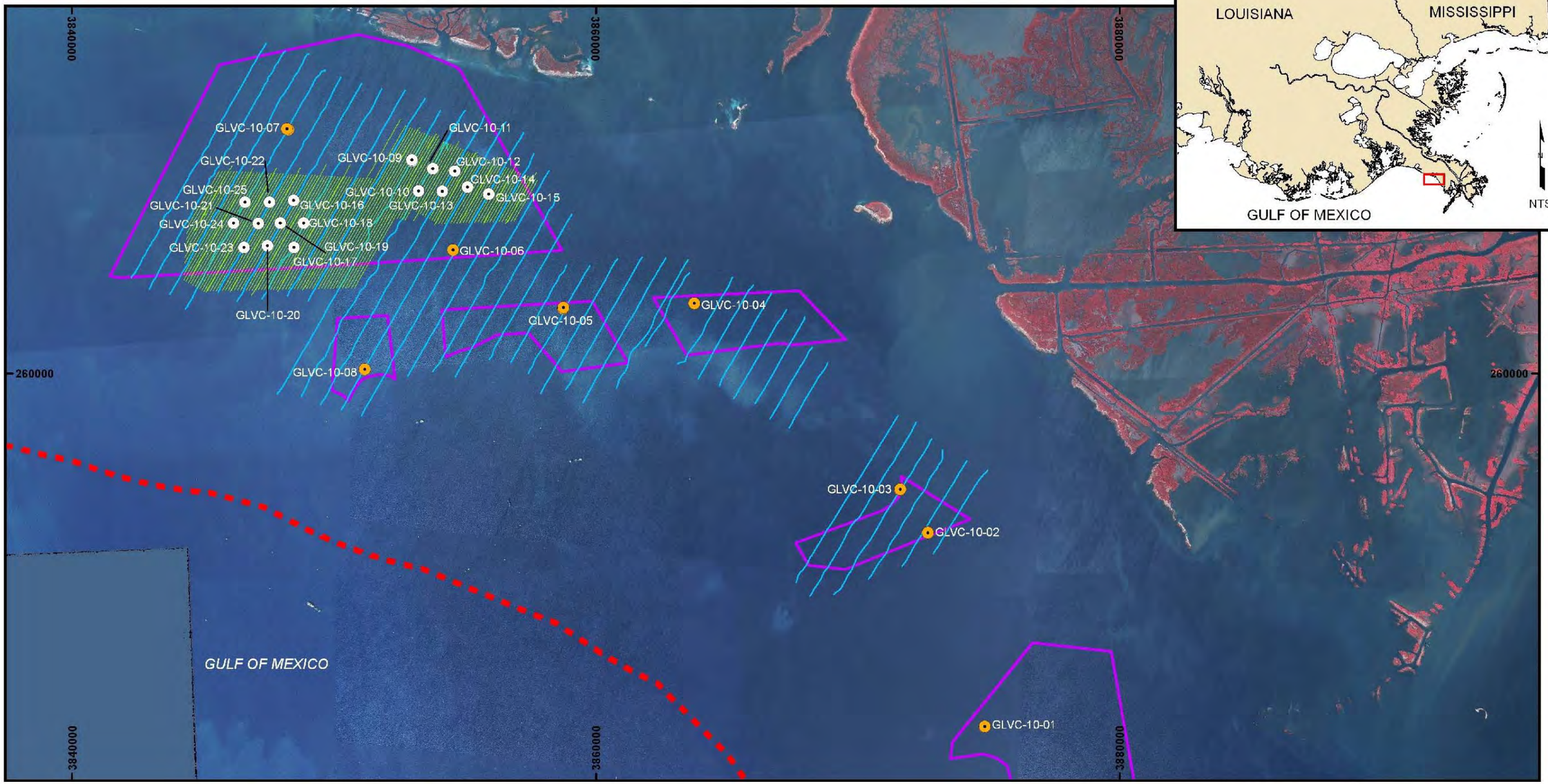
N

TITLE:

FIGURE 4. COLOR CODED GEOTECHNICAL AND GEOPHYSICAL DATA AND AREAS IDENTIFIED FOR FURTHER INVESTIGATION

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 03/04/10	BY: BF	COMM NO: 7900.26	FIGURE 4



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).
2. AERIAL PHOTOGRAPHY DATED 2005 FROM USGS.

LEGEND

- 2010 CPE RECONNAISSANCE VIBRACORES
- 2010 CPE DESIGN LEVEL VIBRACORES
- 2010 PHASE III & CULTURAL RESOURCE TRACKLINES
- 2010 CPE RECONNAISSANCE TRACKLINES
- POTENTIAL SURVEY AREAS
- FEDERAL STATE BOUNDARY
- INVESTIGATION AREA

0 2,000 4,000 Feet

1 inch = 4,000 feet

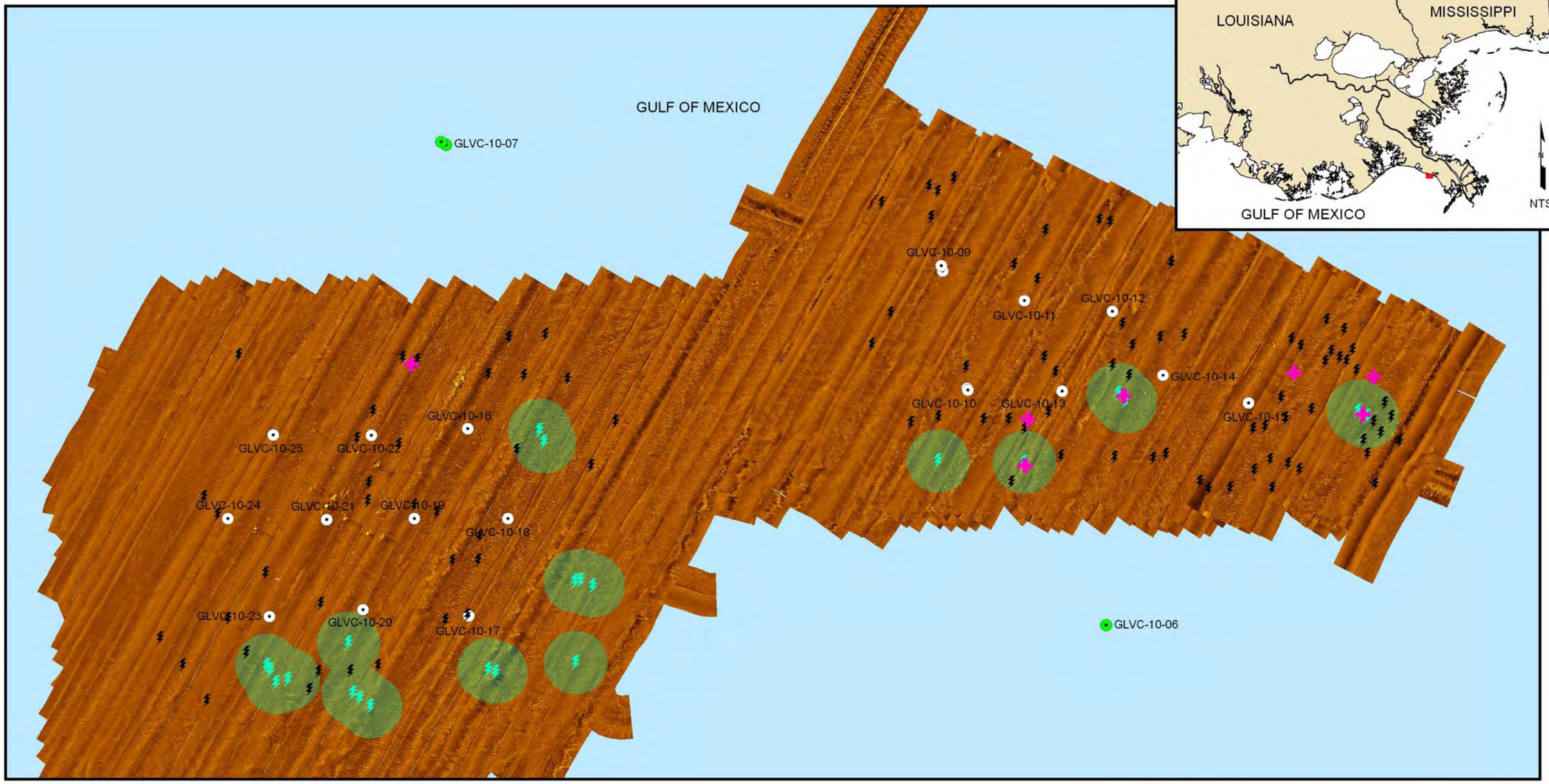
N

TITLE:

FIGURE 5. RECONNAISSANCE AND DESIGN LEVEL GEOPHYSICAL AND GEOTECHNICAL DATA

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 03/04/10	BY: BF	COMM NO: 7900.26	FIGURE 5



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).

LEGEND

- ACOUSTIC TARGETS
- MAGNETIC ANOMALIES
- 2010 CPE RECONNAISSANCE VIBRACORES
- 2010 CPE DESIGN LEVEL VIBRACORES
- POTENTIALLY SIGNIFICANT MAGNETIC ANOMALIES
- 300 FT CULTURAL RESOURCE BUFFER

0 500 1,000 Feet

1 inch = 1,000 feet

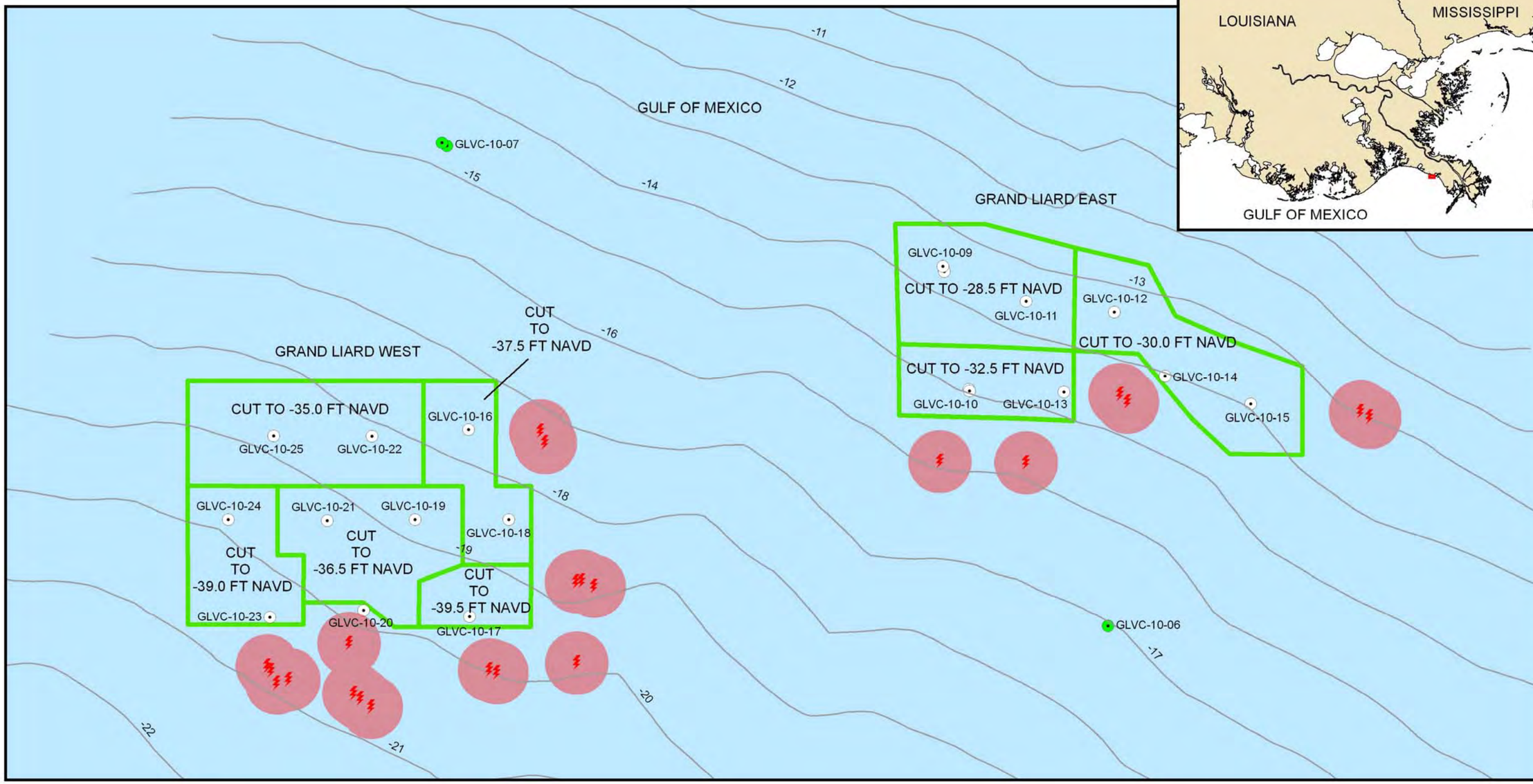
N

TITLE:

FIGURE 13. SIDESCAN SONAR MOSAIC.

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/10/10	BY: BF	COMM NO: 7900.26	FIGURE 13



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).

LEGEND

- POTENTIALLY SIGNIFICANT MAGNETIC ANOMALIES
- 2010 CPE BATHYMETRY
- 300 FT CULTURAL RESOURCE BUFFER
- 2010 CPE RECONNAISSANCE VIBRACORES
- 2010 CPE DESIGN LEVEL VIBRACORES

0 500 1,000 Feet

1 inch = 1,000 feet

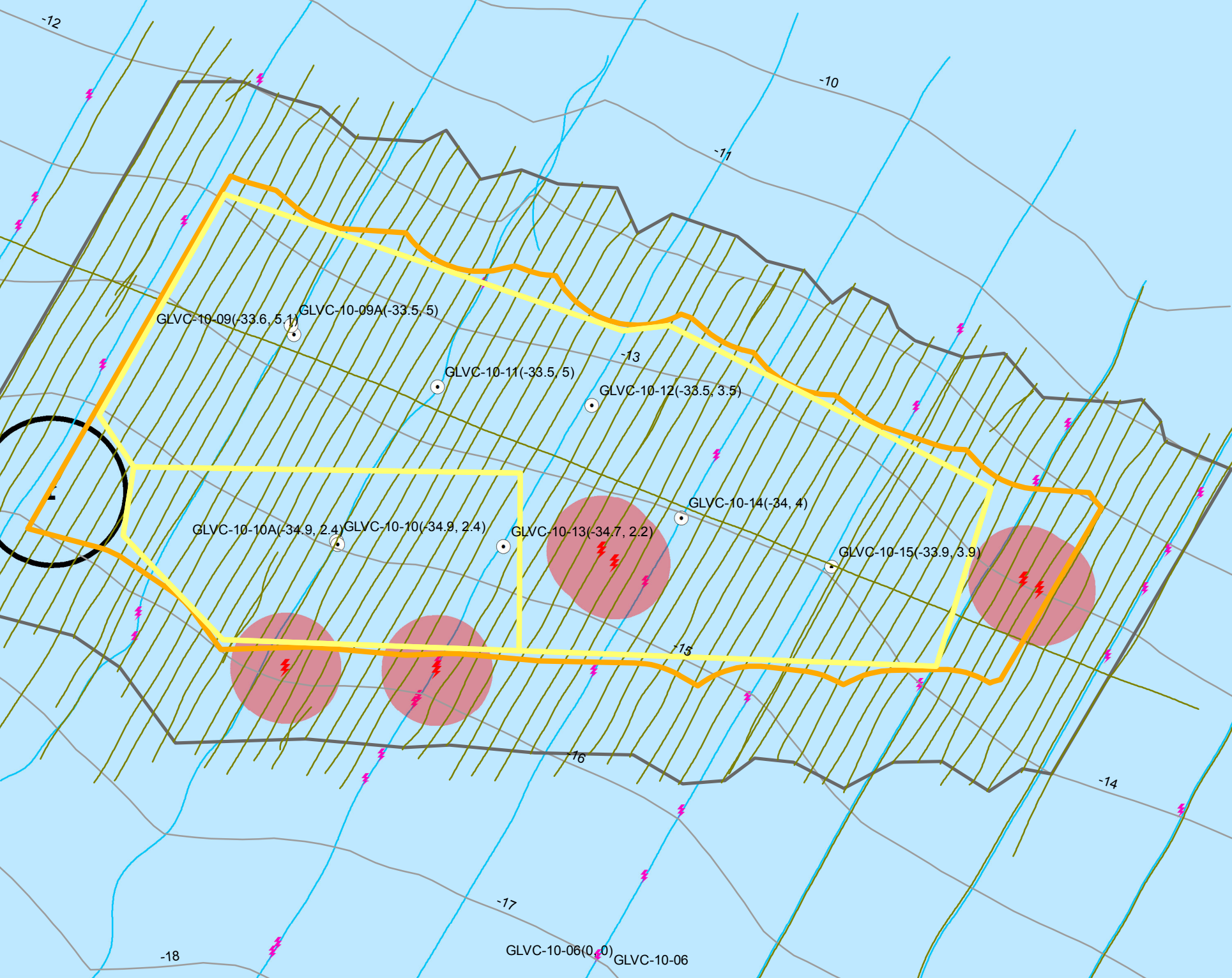
N

TITLE:

FIGURE 14. BORROW AREA DESIGN.

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/10/10	BY: BF	COMM NO: 7900.26	FIGURE 14


-12
-10
-11
GLVC-10-09(-33.6, 5.1)
GLVC-10-09A(-33.5, 5)
-13
GLVC-10-11(-33.5, 5)
GLVC-10-12(-33.5, 3.5)
GLVC-10-14(-34, 4)
GLVC-10-10A(-34.9, 2.4)
GLVC-10-10(-34.9, 2.4)
GLVC-10-13(-34.7, 2.2)
GLVC-10-15(-33.9, 3.9)
-15
-16
-14
-17
-18
GLVC-10-06(0, 0)
GLVC-10-06

Appendix D

Geotechnical Boring Logs

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	CC	Cement Concrete
	AC	Asphalt Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Measured groundwater level in exploration, well, or piezometer

Groundwater observed at time of exploration

Perched water observed at time of exploration

Graphic Log Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Material Description Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GEOENGINEERS

FIGURE I-B1

Drilled	Start 8/10/2010	End 8/10/2010	Total Depth (ft)	35.5	Logged By	DAS	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Checked By	VT									

Surface Elevation (ft) Vertical Datum	4.9	Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy
Latitude Longitude	N29° 18' 18.90" W89° 28' 38.17"	System Datum	Geographic NAVD88	Groundwater Date Measured	Depth to Water (ft) / Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols. Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of marsh buggy deck									
0	5						▽			Mudline @ El. -0.56 feet									
		☒		1/WOH		1			OH	Very soft gray organic clay with grassy vegetation	192								
						2				Gray organic clay (organic content = 15%)	164								
-5	10		15			3			CH	Very soft gray clay with organic matter (FVS* = 0.035 KSF @ 10') (organic content = 7.51%)	43	71.9	0.18	0.60	11	61	35	0.14	
			8			4			CL	Very soft gray slightly silty clay with silt lenses (specific gravity = 2.63) (organic content = 6.2%)	48	74.5				42	20	0.16	
			7			5				Very soft gray silty clay with organic matter (organic content = 6.6%)	48	74.2	0.13	0.81	15	39	17		100
-10	15		13			6				Very soft gray very silty clay with 2" silt layer and 3" organic matter (organic content = 6.5%)	41					34	15		99
			14			7				Very soft gray silty clay with 2½" silt layer and sand streaks	32	88.3	0.22	1.04	15				
-15	20		5.5			8				Very soft gray silty clay with 2" silt layer (FVS* = 0.074 KSF @ 20')	64					38	17		99
			15			9				Very soft gray slightly silty clay with organic matter	40	73	0.07		14	49	24		
						10				Gray silty clay									
-20	25		18			11				Soft gray silty clay with organics and shell	74	56.2	0.13		14			0.27	
			3			12				Very soft gray silty clay with sand streaks and organic matter	68					40	20	0.09	86
-25	30		16			13				Soft gray silty clay with silt traces	63	61.5	0.11		14			0.19	
			19			14				Very soft gray silty clay with 1½" fine sand layer and sand streaks	58	60.1	0.08		10				
-30	35		11			15		◇	SM	Gray silty fine sand with 3" clay layer	31								47

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-1

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B2

Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF) [1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35																	

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-1 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/17/2010	End 8/17/2010	Total Depth (ft)	35	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum		4.0			Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop			Drilling Equipment	Marsh Buggy
Latitude / Longitude		N29° 17' 43.25" / W89° 28' 19.04"			System Datum	Geographic NAVD88			Groundwater: Date Measured	Depth to Water (ft) / Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of marsh buggy deck									
0										Mudline @ El. -1.0 feet									
	5					1			OH	Gray organic clay (organic content = 15.1%)	177								
						2				Gray organic clay with grassy vegetation (organic content = 19%)	201								
-5			16			3				Very soft gray organic clay (specific gravity = 2.43) (organic content = 16.4%)	94	46.6				99	68	0.14	
	10		9			4			CL	Very soft gray silty clay	63	63.2	0.21	0.69	15	48	26		
-10			15			5			CH	Very soft gray clay with organic matter	52	65.2	0.12	0.81	15			0.16	
	15		10			6				Very soft gray clay with organic matter (FVS* = 0.043 KSF @ 15')	59	63.1	0.09	0.92	15	62	37	0.18	
			13			7			CL	Very soft gray laminated silt and clay	54	68.9	0.07		15	38	16		99
-15			10			8			ML	Firm gray sandy silt with clay traces (FVS* = 0.038 KSF @ 20')	44	69.5	0.36	1.15	3				82
	20		7			9				Gray sandy silt with clay traces	29								
-20			16			10				Firm gray sandy silt with 3" clay layer	66	65.2	0.18	1.38	15				94
	25		9			11				Firm gray sandy silt with clay streaks	38	78.9	0.05	1.50	15			0.08	97
			17			12				Firm gray silt with clay streaks	79							0.11	98
-25			2			13				Firm gray silt with clay streaks								0.05	
	30		10			14			CH	Very soft gray clay with silt streaks	70					77	45	0.09	
-30			7			15				Very soft gray clay	74					78	49	0.08	
	35																		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-2

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B3
Sheet 1 of 1

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/17/2010	End 8/17/2010	Total Depth (ft)	36	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum		4.9			Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop			Drilling Equipment	Marsh Buggy
Latitude / Longitude		N29° 16' 56.53" / W89° 28' 07.76"			System Datum	Geographic NAVD88			Groundwater: Date Measured	Depth to Water (ft) / Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of marsh buggy deck									
0	5						▽			Mudline @ El. -0.65 feet									
						1			OH	Gray organic clay (organic content = 16.5%)	191					175	127		
						2				Gray organic clay (organic content = 15.2%)	204								
-5	10		18			3			CH	Very soft gray clay with organic matter (roots) (FVS* = 0.035 KSF @ 10')	47	65.5	0.10	0.63	15	56	34	0.16	
			18			4				Very soft gray clay with organic matter	55	70.8				55	33	0.21	
-10	15		17			5			CL	Very soft gray silty clay with 3" silt layer (FVS* = 0.052 KSF @ 14') (specific gravity = 2.64) (organic content = 5.2%)	40	80				37	19		
			8			6			ML	Gray silt with organic matter and clay	35					26	7		98
			13.5			7				Firm gray silt with clay streaks and sand								0.09	71
-15	20		13			8			CL	Very soft gray silty clay with two 1½" clayey silt layers	38	72.9	0.09	1.21	12	45	22		
			16			9			CH	Very soft gray clay with silt streaks	42	74.4				55	31		
-20	25		21			10				Very soft gray clay with sand streaks and shell traces	73					80	45	0.17	97
			16			11				Very soft gray clay	73	57.2						0.19	
			22			12				Very soft gray clay with sand streaks and 2" sand layer	60	63.3	0.08	1.67	15				98
-25	30					13				Very soft gray clay with 3½" clayey silt layer and 2½" fine sand layer	71								100
			17			14			SM	Firm gray silty fine sand	28								31
			15			15			CL	Very soft gray silty clay with 1½" clayey silt layer	63					41	20		
-30	35		17			16			SM	Firm gray silty fine sand with two 3" clay layers	26								

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-3

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B4
Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate:LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF) [1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35																	

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-3 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B4

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/10/2010	End 8/10/2010	Total Depth (ft)	65.5	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum			6.9		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy		
Latitude / Longitude			N29° 18' 32.19" / W89° 28' 39.09"		System Datum	Geographic NAVD88	Groundwater	Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of marsh buggy deck									
5																			
0																			
	5						▽			Mudline @ El. +1.4 feet									
			2.5			1			CH	Gray clay with silt	44					60	36	0.09	74
			4			2				Very soft gray clay with organic matter	54							0.07	
	10		10			3				Very soft gray clay with organic matter and 3" silt traces (organic content = 8.4%)	56	73	0.23	0.58	15	66	40	0.14	
-5			8.5			4			CL	Very soft gray slightly silty clay with organic matter and ¾" and ½" silt layers (organic content = 6.2%)	76					45	21		
			15			5			CH	Very soft gray clay with 2" sand layer (organic content = 11.5%)	65	61.1	0.18	0.81	14	81	50		
	15		2			6			SM	Gray silty fine sand with clay traces (FVS* = 0.144 KSF @ 15.5')									27
-10			9			7				Gray silty fine sand with clay traces									31
	20		11			8				Gray silty fine sand with clay traces									38
-15										No sample recovererd									
			17			9			SM	Gray silty fine sand with 1" clay layer								0.09	36
	25		21.5			10				Gray silty fine sand with 9" clay layer (FVS* = 0.057 KSF @ 25.5')								0.18	40
-20			23			11			CH	Very soft gray clay with sand streaks and 10" sand layer	46	69	0.09		15	73	46		
	30		15			12			ML	Gray sandy silt with clay traces									52
-25			14			13			SP	Gray sand with two 1" clay layer and traces	37								
			5			14				Gray sand with 2" clay layer	61							0.19	
	35																		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-4

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B5
Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35		20			15			CH	Soft gray clay with sand streaks and 3" sand layer (specific gravity = 2.64)	59					71	45		
-30			16			16			CL	Soft gray slightly sandy clay with 4" sand layer and streaks	32					45	24		81
	40		17			17				Very soft gray silty clay with sand pockets and 3" sand layer	64	61.7	0.16		15				90
-35			19			18				Very soft gray very sandy clay with 5" sand layer	37	86.4	0.23	2.42	15	34	14		
			14			19			ML	Gray sandy silt with clay streaks									61
	45		20			20			CH	Soft gray clay with fine sand and silt streaks	49	68.8	0.43		11				
-40			18			21				Soft gray clay with sand streaks and lenses	41					67	41		94
	50		20			22			SM	Gray silty fine sand with clay streaks								0.21	25
-45			5			23			CH	Soft gray clay	63					62	35	0.17	
			8			24			SM	Gray silty fine sand with clay and shell traces	65								22
	55		21			25			CH	Soft gray clay with fine sand streaks	64	61.4	0.41		13	87	56	0.39	
-50			19			26				Soft gray clay with sand streaks and pockets	63	60.6	0.15		2	99	62	0.36	
	60		22			27				Gray clay with silt and sand streaks	56					80	51		
-55			16			28				Very soft gray clay with 1" sand layer and pockets	46	68.3	0.16		15				
			21			29				Medium gray clay with sand pockets and streaks	58								
	65																		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-4 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B5

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GE18_GEOTECH_LAB

Drilled	Start 8/14/2010	End 8/14/2010	Total Depth (ft)	65	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum			6.8		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy		
Latitude / Longitude			N29° 17' 30.50" / W89° 28' 12.55"		System Datum	Geographic NAVD88	Groundwater	Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
0								Zero (0) feet top of marsh buggy deck									
								Mudline @ El. +1.8 feet									
5		7			1		OH	Very soft gray organic clay with organic matter (specific gravity = 2.50) (organic content = 11.3%)	106	40				129	91	0.1	
		4			2			Gray organic clay (organic content = 13.3%)	94					137	98		
10		10			3			Very soft gray slightly organic clay (FVS* = 0.027 KSF @ 10')	82	55.2	0.06	0.58	15	91	61	0.1	
		8			4		CL	Very soft gray silty clay with silt streaks, organic matter, and clayey silt layer	36	72.5	0.08	0.69	15	47	25		
		10			5			Very soft gray silty clay	43	78.2	0.13	0.81	15				
15		10			6			Very soft gray silty clay with 4" sandy silt layer	41	73.4	0.10	0.92	15	41	21		
		7			7		ML	Gray sandy silt with organic matter (FVS* = 0.057 KSF @ 18')	37	81.5	0.55	1.04	13				53
		5			8			Gray sandy silt with clay streaks	40								54
20		13			9			Gray sandy silt with clay streaks and organic matter	41	77.7	0.38	1.27	15				
		8			10			Gray sandy silt with clay streaks	50	74.5	0.08	1.38	15				52
25		16			11			Gray sandy silt with 6" clay layer at top	77								
		14			12			Gray sandy silt with clay traces	40	85.2	0.47	1.61	15	24	2		78
		9.5			13		CL-ML	Gray clayey silt	40								92
30		11			14		CH	Very soft gray clay	66	56.1	0.08	1.84	14	81	57	0.13	
		9.5			15		ML	Firm gray sandy silt with 4" clay layer	37	76.5	0.13	1.90	15			0.2	55
35																	

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-5

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B6
Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35		9			16			CH	Very soft gray clay with sand streaks	62					82	55	0.18	
-30			5			17				Gray clay with sand pockets	59							0.2	
			9			18				Soft gray clay	50	65.9	0.20	2.30	15			0.34	
	40																		
-35			4			19				Gray clay	57							0.23	
			8			20				Very soft gray clay	62	62.5	0.13	2.53	13			0.2	
	45		10.5			21				Soft gray clay	70							0.27	
-40			14			22				Soft gray clay with fine sandy silt lenses and streaks	49	68.4	0.41		6			0.32	
			12			23				Soft gray clay with 2" clayey sand layer at bottom and sand pockets	55	64.7	0.17		11			0.24	
	50																		
-45			8			24				Soft gray clay	70								
						25				No sample recovered									
	55		11			26			CH	Soft gray clay with 2½" fine sand layer	70	63.1	0.13		15				99
-50			16			27				Soft gray clay with silt streaks and lenses	68							0.47	
			12			28				Soft gray clay with silt lenses	60	64.7	0.23		15				
	60																		
-55			17			29				Soft gray clay with silt traces	60	64.4	0.17		15				
			6			30				Soft gray clay with silt streaks	63								
	65																		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-5 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B6

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/16/2010	End 8/16/2010	Total Depth (ft)	65	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum			7.0		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy		
Latitude / Longitude			N29° 16' 46.16" / W89° 28' 02.83"		System Datum	Geographic NAVD88	Groundwater	Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
0									Zero (0) feet top of marsh buggy deck									
									Mudline @ El. +1.96 feet									
5					1			PT	Dark gray peat (organic content = 20.1%)	301								
					2				Gray peat	219								
		11			3			CH	Very soft gray clay with organics (specific gravity = 2.54) (organic content = 12.3%)	109	42.5				93	58	0.12	
10		13			4			ML	Firm gray sandy silt with trace organics (organic content = 3.4%)	36	80.7	0.66	0.69	15				73
		5			5				Firm gray silt with fine sand and clay traces (FVS* = 0.105 KSF @ 13')	27								86
15		12			6				Firm gray silt with fine sand traces and streaks	31	91	0.39	0.92	14				84
		11			7				Firm gray silt with 2" clay layer	32								98
20		11			8				Firm gray sandy silt with two 1½" clay layer and streaks	35	86.9	0.16	1.15	15			0.12	67
		11			9			SC	Firm gray clayey sand with organic matter and silt streaks	70								41
		11			10			CH	Very soft gray clay with trace organics	77	56.5	0.13	1.38	15	98	68		
25		23			11				Very soft gray clay with trace organics (FVS* = 0.044 KSF @ 25')	89					85	55		
		19			12				Very soft gray clay with 8" sandy silt layer and trace organics	88	54.2	0.11	1.61	14				
30		14			13			ML	Firm gray sandy silt with clay streaks	31	87.8	0.26		10				88
		12			14			SM	Firm gray fine sand with silt traces	25	92.2	0.93	1.84	6				18
35		19			15				Firm gray fine sand with silt	26								30

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-6

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B7
Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35		10.5			16			CH	Soft gray clay with sand streaks and 1" fine sand layer	40	73.3	0.18		15	68	46	0.35	
-30			18			17				Soft gray clay with sand streaks and 5" sand layer	60					70	41	0.3	
			16			18				Very soft gray clay with silt streaks	51								
	40																		
-35			20			19				Very soft gray clay with sand streaks	52	69.3	0.15		15			0.17	
			21			20				Very soft gray clay with sand streaks	43								
	45		20			21				Very soft gray clay with sand streaks and 3" sand layer at top and 2" sand layer at bottom	36	79.1	0.10		14				
-40			18			22				Soft gray clay with sand streaks	47								
			21			23			CL	Soft gray slightly sandy clay with 3" sandy silt layer	29	92.5	0.36		15				90
	50																		
-45			5			24			SM	Firm gray silty sand	26								
			18			25			CL	Medium gray sandy clay with 3" clayey sand layer	26	94.3	0.58		14				63
	55		18			26			ML	Firm gray sandy silt with 6" clay layer	24								
-50			14			27			CL	Soft gray sandy clay with fine sand streaks and 4½" sandy silt layer	32								59
			11			28				Soft gray slightly sandy clay with 3" silt layer	47							0.27	
	60																		
-55			9			29			CH	Soft gray clay with sand streaks	43	76.1	0.23		15			0.37	
			21			30				Soft gray clay with sand streaks	52							0.43	
	65																		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-6 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B7

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/14/2010	End 8/14/2010	Total Depth (ft) 46.5	Logged By DAS / Checked By VT	Driller Specialized Environmental Resources, LLC	Drilling Method Wet Rotary
Surface Elevation (ft) Vertical Datum	7.6		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy
Latitude / Longitude	N29° 18' 22.81" / W89° 28' 25.89"		System Datum	Geographic NAVD88	Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	

Notes: See Figure I-B1 for explanation of symbols. Cement-bentonite grout backfill top 25 feet.

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
0									Zero (0) feet top of marsh buggy deck									
5						▽												
					1			OH	Mudline @ El. +1.06 feet Dark gray organic clay (organic content = 11.1%)	164					129	89		
					2				Dark gray organic clay	206								
10		17			3			PT	Very soft dark gray peat (FVS* = 0.021 KSF @ 11.5') (organic content = 16%)	302	19.8	0.04	0.63	14	320	192	0.12	
		18			4				Very soft dark gray peat (specific gravity = 2.08) (organic content = 43%)	429	12.8				288	192		
15		7			5			ML	Gray sandy silt with organic matter	29					24	2		83
		2			6				Gray silt with clay	26								
		10			7				Gray sandy silt with 3" sand layer	28	87.9	0.23	1.12	15				73
20		10			8			CH	Very soft gray clay with 3" silt pockets (FVS* = 0.058 KSF @ 21.5')	27	78	0.11	1.24	13	88	56	0.15	
		12			9				Very soft gray clay with sand streaks	37	70.3	0.12	1.35	15	85	52	0.19	
25		13			10				Very soft gray clay with silt streaks and trace organics	89	49.7	0.14	1.47	15			0.16	
		7			11				Gray clay with trace organics	78							0.05	
		13			12				Soft gray clay with 4" sandy silt layer and trace organics	74	54	0.09	1.70	15	98	62		
30		8			13			ML	Gray silt with 3" sandy silt layer	29								65
		11			14				Gray sandy silt	26								60
35		16			15				Gray sandy silt with organic matter	42								59

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-7

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B8

Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35																	
30		6.5			16				Gray sandy silt with 1" clay layer	49								62
		10			17			SM	Gray silty fine sand with clay streaks	40	74.3	0.11	2.30	2				48
	40	13			18			CH	Soft gray clay with silt traces and streaks	63								
35		15			19				Very soft gray clay with sand streaks	52	68	0.10		15	80	54	0.2	
	45	16			20				Very soft gray clay with silt streaks	52							0.23	

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-7 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B8

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/15/2010	End 8/15/2010	Total Depth (ft)	47	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum			4.3		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy		
Latitude / Longitude			N29° 17' 23.49" / W89° 27' 58.30"		System Datum	Geographic NAVD88	Groundwater	Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of marsh buggy deck									
0	5						▽												
										Mudline @ El. -2.74 feet									
						1			PT	Gray peat (organic content = 12.8%)	385					153	115		
-5	10					2				Gray peat	536								
			12			3				Gray peat	115					158	120	0.06	
-10			10			4			ML	Gray silt with organic matter and 1" clay layer and fine sand traces (FVS* = 0.047KSF @ 14')	55	64.6	0.14	0.81	15				93
	15		2.5			5				Gray silt with clay traces	32								
			6			6				Gray sandy silt	30								76
-15	20		8			7			SM	Gray silty sand	37	84.7	0.40	1.15	15				30
			7.5			8				Gray silty sand with organic matter	24								
-20			9			9			CL	Very soft gray silty clay (organic content = 7.0%) (specific gravity = 2.62)	47	80.2				40	19	0.07	
	25		14			10			CH	Very soft gray clay	67	60.2	0.44	1.50	2	78	46	0.22	
			21			11				Very soft gray clay with silt streaks and shell (FVS* = 0.101 KSF @ 27')	75								97
-25	30		21			12				Very soft gray clay with silt streaks and trace organics	70	59.2	0.10	1.73	15			0.13	
			8			13				Gray clay								0.12	
-30	35		8			14				Very soft gray clay with organic matter and trace silt	71	57.9	0.18	1.96	15			0.11	100

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-8

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B9
Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate\LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35		21			15				Very soft gray clay with trace organics	74							0.15	
			18.5			16				Very soft gray clay with trace organics	71	58.9	0.06		15			0.19	
-35			23			17				Very soft gray clay with trace organics	83							0.16	
	40		18.5			18				Very soft gray clay with trace organics	83	54	0.03		15	85	53	0.21	
			23			19				Very soft gray clay with trace organics	87								
-40	45		10			20				Soft gray clay with trace organics	77	57.8	0.10		15			0.27	

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-8 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B9

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/16/2010	End 8/16/2010	Total Depth (ft)	47	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum			6.1		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy		
Latitude / Longitude			N29° 16' 44.59" / W89° 27' 56.26"		System Datum	Geographic NAVD88	Groundwater	Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of marsh buggy deck									
5																			
0	5						▽			Mudline @ El. -0.9 feet									
						1			OH	Gray organic clay (organic content 33.1%)	122								
						2				Gray organic clay	109								
-5	10		2			3				Gray organic clay (auger cuttings) (FVS* = 0.022 KSF @ 12')								0.05	
			6			4			ML	Gray silt with sand and clay traces and organic matter	71							0.06	90
-10	15		16			5				Gray silt with fine sand and clay traces	29	89.5	0.37	0.92	8				88
			16			6				Gray silt with fine sand and clay traces	31	86	0.67	1.04	15				87
			18			7				Gray silt with fine sand and clay traces	33								88
-15	20		16			8				Gray silt with fine sand and 2" clay layer (FVS* = 0.124 KSF @ 22')	34	87.8	0.17	1.27	15			0.1	86
			9			9			CH	Very soft gray clay with organic matter (specific gravity = 2.55) (organic content = 11.2%)	96	46.7				80	53	0.13	
-20	25		14			10				Very soft gray clay with silt traces and organic matter	89	46.5	0.12	1.50	15			0.14	98
			13			11				Very soft gray clay with trace silt	85							0.17	99
			10			12			SM	Gray silty fine sand	27								31
-25	30		22			13			CH	Very soft gray clay with 8" sandy silt layer	87	48.6	0.12	1.84	15				
			18			14				Very soft gray clay with 7" sandy silt layer	56	62.6	0.11	1.96	15				
	35																		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-9

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B10
Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF) [1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35		9			15			SM	Gray silty fine sand	24								38
-30			7			16			SP	Gray fine sand with silt traces	27								10
			12			17				Gray fine sand with silt and clay traces	32	87.8	2.30	2.30	15				24
	40																		
-35			7			18				Gray fine sand with silt traces	26								9
			22			19				Gray fine sand with silt pockets and clay layer	39	82.5	0.56	2.53	15			0.1	32
	45		21			20				Gray silty fine sand with 6" clay layer	34							0.22	
-40																			

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-9 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B10

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/16/2010	End 8/16/2010	Total Depth (ft)	46	Logged By / Checked By	DAS / VT	Driller	Specialized Environmental Resources, LLC	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum		5.9			Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop			Drilling Equipment	Marsh Buggy
Latitude / Longitude		N29° 16' 14.25" / W89° 27' 58.11"			System Datum	Geographic NAVD88			Groundwater	Date Measured / Depth to Water (ft) / Elevation (ft)

Notes: See Figure I-B1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of marsh buggy deck									
5	5						▽												
										Mudline @ El. -0.06 feet									
						1			PT	Gray peat	486								
						2				Gray peat (organic content = 19.3%)	512					237	152		
	10					3				Gray peat	465								
			24			4			OH	Very soft gray organic clay with 6-7" silt layer (organic content = 17.2%) (specific gravity = 2.43)	175	30				98	67		
			11			5			ML	Gray silt with sand and clay traces (FVS* = 0.028 KSF @ 16')	27	93.9	0.55	0.86	15				92
	15		9.5			6				Gray silt with sand and clay traces	33								88
			8			7				Gray silt with fine sand traces and clay pockets	40	73.8	0.16	1.09	15			0.12	90
	20		14			8			CH	Very soft gray clay with sand streaks	68	65.1	0.07	1.21	15	75	46	0.12	
			13			9				Very soft gray clay with silt streaks and trace organics	87	54.9	0.07	1.32	14			0.12	
			17			10				Very soft gray clay with trace organics (FVS* = 0.034 KSF @ 26')	88	54.8	0.12	1.44	15	98	69	0.12	
	25		20.5			11				Very soft gray clay with silt streaks and trace organics	98							0.14	
			18			12				Very soft gray clay with organics	126	39.7	0.10	1.79	9			0.13	
	30		10.5			13				Very soft gray organic clay with trace organics	83					86	55	0.09	
			17			14				Very soft gray clay with trace organics	121	39.3	0.07	1.90	15				
	35		16			15				Very soft gray clay with silt streaks and organics	87	47.7	0.12	2.02	15	126	90		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-10

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-00

Figure I-B11
Sheet 1 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35																	
-30					16				No sample recovered									
		11			17			CH	Very soft gray clay	68	60.5	0.16	2.25	14			0.16	
	40	15			18				Very soft gray clay	68					75	43	0.17	
-35		14			19				Very soft gray clay	66	61.2	0.21	2.48	15			0.18	
		15			20				Very soft gray clay	56	65.3	0.18	2.59	15	70	39		
	45																	
-40																		

NOTE: When no PI available, field vane reading corrected as 1.0 times field reading for CL/ML/SM, 0.75 for CH and 0.65 for OH with moisture content less than 120%. For moisture content greater than 120%, reading corrected as 0.58 times field reading. *FVS - Shear strength from field vane test.

Log of Boring B-10 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68)

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-00

Figure I-B11

Sheet 2 of 2

Baton Rouge, Louisiana: Date:1/5/11 Path:P:\16\16715018\GINT\1671501800_LOGS.GPJ DBTemplate\LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Coastal Planning & Engineering, Inc.
2481 N.W. Boca Raton Blvd.
Boca Raton, Florida 33431
Phone # 1-561-391-8102

Legend for Geotechnical Data

(SP), (SM), etc. — Refers to the Army Corps of Engineers Unified Soils Classification System. Class types are defined primarily by grain size, sorting and percent of material passing the 200 sieve. Classification of materials on the core logs based on visual field examinations are identified on the core logs under the Classification of Materials Description. Classifications based on laboratory sieve analyses are identified on the core logs in the Legend and under Remarks.

Grain Size Terms

Cobble – retained on the 3.0" sieve

Gravel – greater than the #4 sieve and less than the 3.0" sieve
- Coarse: greater than the ¾" sieve and less than the 3.0" sieve
- Fine – greater than the #4 sieve and less than the ¾" sieve

Sand - greater than the #200 sieve and less than the #4 sieve
- Coarse - greater than the #10 sieve and less than the #4 sieve
- Medium - greater than the #40 sieve and less than the #10 sieve
- Fine - greater than the #230 sieve and less than the #40 sieve

Fines – (silt or clay) passing the #230 sieve

Proportional definition of descriptive terms

Descriptive Term	Range of Proportions
Sandy, gravelly, etc.	35 % to 50 %
Some	20 % to 35 %
Little	10 % to 20 %
Trace	1 % to 10 %

Note: Information is after ACOE Atlantic Division Manual # 1110-1-1 titled *Engineering and Design Geotechnical Manual for Surface and Subsurface Investigations*

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Legend for Geotechnical Data

GW	Well graded gravels or gravel-sand mixtures, little or no fines	ML	Inorganic silts and very fine sands, rock flour, sandy silts or clayey silts with slight plasticity
GP	Poorly graded gravels or gravel-sand mixtures, w/ little or no fines	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soild, elastic silts
GM	Silty gravels, gravel-sand-silt mixtures	OL	Organic silts and organic silt-clays of low plasticity
GC	Clayey gravels, gravel-sand-clay mixtures	OH	Organic clays of medium to high plasticity, organic silts
SW	Well graded sands or gravelly sands, little or no fines	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
SP	Poorly graded sands or gravelly sands, little or no fines	CH	Inorganic clays of high plasticity, fat clays
SM	Silty sands, sand-silt mixtures	PT	Peat and other highly organic soils
SC	Clayey sands, sand-clay mixtures	SP-SM	Poorly-graded silty sand
SW-SM	Well-graded silty sand	SM-SC	Silty clayey sand
GW-GM	Well-graded silty gravel	ML-CL	Inorganic silty lean clay
GM-GC	Clayey silty gravel		

Note: Information is after ACOE Atlantic Division Manual # 1110-1-1 titled *Engineering and Design Geotechnical Manual for Surface and Subsurface Investigations*

Coastal Planning & Engineering, Inc.
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Boca Raton, Florida 33431
Phone # 1-561-391-8102

Legend for Geotechnical Data

The naming convention used by Coastal Planning and Engineering incorporates key information about the item in the title. The naming format uses the following information:

- Abbreviated area name (two letters that will be used throughout the project)
- Abbreviated data type: jet probe (JP), vibracore (VC) or surface sample (SS)
- Collection year (YY)
- Identification number
- Sample or composite identification in the case of jet probes or vibracores. Composite samples are indicated by COMP following the identification number. COMP represents a composite developed to characterize beach compatible material.

Format examples:

A) GLVC-10-07

B) GLVC-10-13 S#1

Example A is vibracore number 07, collected in the Grand Liard area in the year 2010.

Example B refers to sample number 1 taken from vibracore number 13, which was collected in the Grand Liard area in 2010.

Note: Information is after ACOE Atlantic Division Manual # 1110-1-1 titled *Engineering and Design Geotechnical Manual for Surface and Subsurface Investigations*

Boring Designation GLVC-10-01

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-01
LOCATION COORDINATES	X = 3,874,865 Y = 246,486
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Brian McCord
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 01-29-10 10:20
COMPLETED	01-29-10 10:22
16. ELEVATION TOP OF BORING	-20.2 Ft.
17. TOTAL RECOVERY FOR BORING	14.5 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	KD

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-20.2	0.0					
-21.1	0.9		CLAY, very soft clay, olive gray (5Y-4/2), (CL).		1	Sample #1, Depth = 0.7' Ave. Field Vane (tsf): 0.01
-28.3	8.1		CLAY, trace shell hash, very soft clay, (1.0"x0.25") sandy pockets @ 4.2', 4.4', 5.0', 5.1' and 7.8', dark gray (5Y-4/1), (CL).		2	Sample #2, Depth = 4.4' Ave. Field Vane (tsf): 0.01
-31.0	10.8		CLAY, trace sand, very soft clay, sand distributed in sandy pockets up to 1.0", (1.5"x1.0") silty pockets @ 10.2' and 10.4', dark gray (5Y-4/1), (CL).		3	Sample #3, Depth = 9.5' Ave. Field Vane (tsf): 0.04
-32.9	12.7		Sandy SILT, trace clay, soft clay distributed in pockets up to 1.5", very dark gray (5Y-3/1), (ML).		4	Sample #4, Depth = 12.2' Mean (mm): 0.08, Phi Sorting: 0.31 Fines (230): 59.28% (ML)
-34.7	14.5		CLAY, very soft clay, sandy laminae @ 12.8', 12.9' and 13.1', bit sample from 14.0' to 14.5', very dark gray (5Y-3/1), (CL).		5	Sample #5, Depth = 13.3' Ave. Field Vane (tsf): 0.04
-40.2	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-02

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-02
LOCATION COORDINATES	X = 3,872,694 Y = 253,924
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Brian McCord
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 01-30-10 10:30
COMPLETED	01-30-10 10:31
16. ELEVATION TOP OF BORING	-14.6 Ft.
17. TOTAL RECOVERY FOR BORING	11.8 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	PB

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-14.6	0.0					
-17.6	3.0		CLAY, very soft clay, sandy lamina @ 0.3', 1.0" sandy pockets with trace shell hash @ 0.7', 1.1' and 1.6', dark gray (5Y-4/1), (CL).		1	Sample #1, Depth = 1.8' Ave. Field Vane (tsf): 0.01
-18.3	3.7		Silty SAND, fine grained, quartz, trace shell hash, 0.5" shell fragment @ 3.1', shell hash decreases with depth, dark gray (5Y-4/1), (ML).		2	Sample #2, Depth = 3.4' Mean (mm): 0.09, Phi Sorting: 0.33 Fines (230): 36.59% (ML)
-19.6	5.0		CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to (1.5"x1.0"), dark gray (2.5Y-4/1), (CL).		3	Sample #3, Depth = 4.6' Ave. Field Vane (tsf): 0.05
-25.1	10.5		CLAY, trace shell hash, very soft clay, dark gray (2.5Y-4/1), (CL).		4	Sample #4, Depth = 7.0' Ave. Field Vane (tsf): 0.05
-25.5	10.9		Sandy SILT, trace clay, dark gray (5Y-4/1), (ML).		5	Sample #5, Depth = 10.7' Mean (mm): 0.08, Phi Sorting: 0.30 Fines (230): 73.63% (ML)
-26.4	11.8		CLAY, very soft clay, dark gray (2.5Y-4/1), (CL).		6	Sample #6, Depth = 11.3' Ave. Field Vane (tsf): 0.08
-34.6	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-02A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	HORIZONTAL NAD 1983 / VERTICAL NAVD 88
2. BORING DESIGNATION GLVC-10-02A	LOCATION COORDINATES X = 3,872,688 Y = 253,891	11. MANUFACTURER'S DESIGNATION OF DRILL Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER Brian McCord		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED 01-30-10 11:20 / COMPLETED 01-30-10 11:24
6. THICKNESS OF OVERBURDEN 0.0 Ft.		16. ELEVATION TOP OF BORING -14.6 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		17. TOTAL RECOVERY FOR BORING 8.3 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR PB	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-14.6	0.0					
			Jetted to 9.7'.			
-24.3	9.7					
-25.3	10.7		CLAY, very soft clay, dark grayish brown (2.5Y-4/2), (CL).		1	Sample #1, Depth = 10.3' Ave. Field Vane (tsf): 0.09
			CLAY, very soft clay, (1.0"x3.0") sandy pockets @ 13.4' and 16.2', 0.5" light olive gray (5Y-6/2) clay pocket @ 14.6', (1.0"x1.5") sandy pockets @ 16.9' and 17.3', dark gray (5Y-4/1), (CL).		2	Sample #2, Depth = 15.0' Ave. Field Vane (tsf): 0.09
-32.3	17.7					
-32.6	18.0		Sandy CLAY, some silt, soft clay, bit sample from 17.7' to 18.0', dark gray (5Y-4/1), (SM-SC). No Recovery.			
-34.6	20.0					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-03

DRILLING LOG

DIVISION		**INSTALLATION**	**SHEET 1 OF 1 SHEETS**
1. PROJECT Grand Liard Restoration, Grand Liard, Louisiana		**9. SIZE AND TYPE OF BIT** 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	**HORIZONTAL** NAD 1983 / **VERTICAL** NAVD 88
2. BORING DESIGNATION GLVC-10-03	**LOCATION COORDINATES** X = 3,871,620 Y = 255,547	**11. MANUFACTURER'S DESIGNATION OF DRILL** Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	**CONTRACTOR FILE NO.**	**12. TOTAL SAMPLES**	**DISTURBED** / **UNDISTURBED (UD)**
4. NAME OF DRILLER Brian McCord		**13. TOTAL NUMBER CORE BOXES**	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	**DEG. FROM VERTICAL** / **BEARING**	**15. DATE BORING**	**STARTED** 01-30-10 12:14 / **COMPLETED** 01-30-10 12:16
6. THICKNESS OF OVERBURDEN 0.0 Ft.		**16. ELEVATION TOP OF BORING** -14.0 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		**17. TOTAL RECOVERY FOR BORING** 12.6 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		**18. SIGNATURE AND TITLE OF INSPECTOR** BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-14.0	0.0					
-15.0	1.0		CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 1.0", very dark gray (2.5Y-3/1), (CL).		1	Sample #1, Depth = 0.5' Ave. Field Vane (tsf): 0.00
-17.0	3.0		CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 1.0" and laminae, 2.0" shell hash pocket @ 1.2', very dark grayish brown (2.5Y-3/2), (CL).		2	Sample #2, Depth = 2.5' Ave. Field Vane (tsf): 0.02
-17.6	3.6		Clayey SAND, trace shell hash, very dark gray (5Y-3/1), (SC).		3	Sample #3, Depth = 3.3' Mean (mm): 0.13, Phi Sorting: 0.99 Fines (230): 31.81% (SC)
-18.4	4.4		CLAY, trace shell hash, very soft clay, very dark grayish brown (2.5Y-3/2), (CL).		2	
-19.0	5.0		Clayey SAND, trace shell hash, very dark gray (5Y-3/1), (SC).		3	
-26.6	12.6		CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 1.5" and laminae, very dark grayish brown (2.5Y-3/2), (CL).		4	Sample #4, Depth = 6.8' Ave. Field Vane (tsf): 0.10
-34.0	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-03A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	HORIZONTAL NAD 1983 / VERTICAL NAVD 88
2. BORING DESIGNATION GLVC-10-03A	LOCATION COORDINATES X = 3,871,640 Y = 255,554	11. MANUFACTURER'S DESIGNATION OF DRILL Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER Brian McCord		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER	
		15. DATE BORING	STARTED 01-30-10 12:45 / COMPLETED 01-30-10 12:46
6. THICKNESS OF OVERBURDEN 0.0 Ft.		16. ELEVATION TOP OF BORING -13.9 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		17. TOTAL RECOVERY FOR BORING 6.7 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-13.9	0.0					
			Jetted to 10.0'.			
-23.9	10.0					
			CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 1.0" and laminae, 1.0" rock fragment @ 11.8', 0.5" organic pockets @ 14.6' and 14.9', 2.0" sandy pocket @ 15.4', very dark grayish brown (2.5Y-3/2), (CL).		VC-03 #4	
-29.5	15.6					
-30.6	16.7		Sandy CLAY, soft clay, sand distributed in pockets up to 1.0" and laminae, bit sample from 16.4' to 16.7', dark olive gray (5Y-3/2), (SC).			Sample #1, Depth = 16.0'
			No Recovery.			
-33.9	20.0					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-04

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	HORIZONTAL NAD 1983 / VERTICAL NAVD 88
2. BORING DESIGNATION GLVC-10-04	LOCATION COORDINATES X = 3,863,768 Y = 262,663	11. MANUFACTURER'S DESIGNATION OF DRILL Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER Brian McCord		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER	
		15. DATE BORING	STARTED 01-30-10 14:30 / COMPLETED 01-30-10 14:32
6. THICKNESS OF OVERBURDEN 0.0 Ft.		16. ELEVATION TOP OF BORING -12.8 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		17. TOTAL RECOVERY FOR BORING 7.3 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-12.8	0.0					
			CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 1.0", color is mottled olive brown (2.5Y-4/3) and, dark olive gray (5Y-3/2), (CL).		1	Sample #1, Depth = 2.5' Ave. Field Vane (tsf): 0.03
-17.9	5.1					
			Sandy CLAY, trace shell hash, soft clay, sand distributed in pockets up to 2.0", 0.5" organic pocket @ 6.4', very dark grayish brown (2.5Y-3/2), (SC).			
-19.5	6.7					
-20.1	7.3		CLAY, soft clay, (0.75"x0.25") rock fragment in bit sample, bit sample from 6.7' to 7.3', dark olive gray (5Y-3/2), (CL).			
			No Recovery.			
-32.8	20.0					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-05

DRILLING LOG

DIVISION		INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: Grand Liard Restoration, Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT: 3.0 In.	
		10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane	HORIZONTAL: NAD 1983 / VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-05	LOCATION COORDINATES: X = 3,858,757 Y = 262,459	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER: Brian McCord		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED: 01-30-10 15:46 / COMPLETED: 01-30-10 15:48
6. THICKNESS OF OVERBURDEN: 0.0 Ft.		16. ELEVATION TOP OF BORING: -16.5 Ft.	
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.		17. TOTAL RECOVERY FOR BORING: 13.5 Ft.	
8. TOTAL DEPTH OF BORING: 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: KD	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-16.5	0.0					
-17.4	0.9		CLAY, very soft clay, olive gray (5Y-4/2), (CL).		1	Sample #1, Depth = 0.6' Ave. Field Vane (tsf): 0.01
-22.2	5.7		CLAY, trace organics, trace shell hash, very soft clay, (1.0"x0.5") organic pocket @ 2.3', dark gray (5Y-4/1), (CL).		2	Sample #2, Depth = 3.8' Ave. Field Vane (tsf): 0.04
-23.0	6.5		CLAY, soft clay, trace very soft clay pockets up to 1.5", 1.0" light gray (5Y-7/1) clay pocket @ 6.2', dark gray (5Y-4/1), (CL).		3	Sample #3, Depth = 5.9' Ave. Field Vane (tsf): 0.20
-26.7	10.2		SAND, fine grained, quartz, some clay, some silt, clay distributed in pockets up to 2.0" and laminae, olive gray (5Y-4/2), (SM-SC).		4	Sample #4, Depth = 8.8' Mean (mm): 0.09, Phi Sorting: 0.32 Fines (230): 29.65% (SM-SC)
-27.3	10.8		CLAY, trace sand, very soft clay, dark olive gray (5Y-3/2), (CL).		5	Sample #5, Depth = 10.5' Ave. Field Vane (tsf): 0.12
-30.0	13.5		CLAY, very soft clay, trace soft clay distributed in laminae, 1.0" wood fragment @ 12.1', dark olive gray (5Y-3/2), (CL).		6	Sample #6, Depth = 12.2' Ave. Field Vane (tsf): 0.16
-36.5	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-05A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana	9. SIZE AND TYPE OF BIT: 3.0 In.
	10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane; HORIZONTAL: NAD 1983; VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-05A; LOCATION COORDINATES: X = 3,858,770 Y = 262,500	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore; ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.; CONTRACTOR FILE NO.	12. TOTAL SAMPLES; DISTURBED; UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	14. ELEVATION GROUND WATER
	15. DATE BORING: STARTED 01-31-10 09:00; COMPLETED 01-31-10 09:10
6. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. ELEVATION TOP OF BORING: -16.5 Ft.
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. TOTAL RECOVERY FOR BORING: 9.7 Ft.
8. TOTAL DEPTH OF BORING: 20.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: KD

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-16.5	0.0		Jetted to 10.0'.			
-26.5	10.0					
-27.7	11.2		CLAY, trace organics, very soft clay, dark gray (5Y-4/1), (CL).		1	Sample #1, Depth = 10.5' Ave. Field Vane (tsf): 0.02
-28.8	12.3		CLAY, some sand, very soft clay, 0.5" light gray (5Y-7/1) lithified clay pocket @ 11.3', very dark gray (5Y-3/1), (CL).		2	Sample #2, Depth = 11.8' Ave. Field Vane (tsf): 0.10
-30.0	13.5		CLAY, some sand, soft clay, olive gray (5Y-4/2), (CL).		3	Sample #3, Depth = 12.8' Mean (mm): 0.10, Phi Sorting: 0.45 Fines (230): 75.31% (CL)
-31.2	14.7		SAND, fine grained, quartz, some silt, (2.0"x2.5") clay pocket @ 14.3', olive gray (5Y-4/2), (SM).		4	Sample #4, Depth = 13.9' Mean (mm): 0.09, Phi Sorting: 0.29 Fines (230): 30.51% (SM)
-32.8	16.3		CLAY, some sand, trace organics, soft clay, olive gray (5Y-4/2), (CL).		3	
-35.2	18.7		CLAY, little sand, very soft clay, dark olive gray (5Y-3/2), (CL).		5	Sample #5, Depth = 17.8' Ave. Field Vane (tsf): 0.18
-36.2	19.7		CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).		6	Sample #6, Depth = 19.1' Ave. Field Vane (tsf): 0.10
-36.5	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

Boring Designation GLVC-10-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana	9. SIZE AND TYPE OF BIT: 3.0 In.
	10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane; HORIZONTAL: NAD 1983; VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-06; LOCATION COORDINATES: X = 3,854,557 Y = 264,709	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore; ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.; CONTRACTOR FILE NO.	12. TOTAL SAMPLES; DISTURBED; UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir	13. TOTAL NUMBER CORE BOXES
	14. ELEVATION GROUND WATER
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	15. DATE BORING: STARTED 01-31-10 09:26; COMPLETED 01-31-10 09:29
6. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. ELEVATION TOP OF BORING: -17.0 Ft.
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. TOTAL RECOVERY FOR BORING: 17 Ft.
8. TOTAL DEPTH OF BORING: 20.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-17.0	0.0					
-26.0	9.0		CLAY, trace organics, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 1.0", organics distributed in pockets up to 0.5", (1.0"x0.5") rock fragment @ 5.4', sand increases with depth, very dark gray (2.5Y-3/1), (CL).		1	Sample #1, Depth = 3.1' Ave. Field Vane (tsf): 0.04
					2	Sample #2, Depth = 6.0' Ave. Field Vane (tsf): 0.06
-27.6	10.6		CLAY, little sand, trace shell hash, soft clay, very dark grayish brown (2.5Y-3/2), (CL).		3	Sample #3, Depth = 9.9' Mean (mm): 0.09, Phi Sorting: 0.38 Fines (230): 86.82% (CL)
-30.0	13.0		CLAY, some sand, very soft clay, sand distributed in pockets up to 2.0", very dark gray (2.5Y-3/1), (SC).		4	Sample #4, Depth = 10.8' Ave. Field Vane (tsf): 0.09
-31.0	14.0		CLAY, trace sand, very soft clay, sand distributed in pockets up to 0.5", very dark gray (2.5Y-3/1), (CL).		5	Sample #5, Depth = 13.4' Ave. Field Vane (tsf): 0.02
-34.0	17.0		Clayey SAND, fine grained, quartz, trace silt, clay distributed in pockets up to 1.0", bit sample from 16.6' to 17.0', very dark grayish brown (2.5Y-3/2), (CL).		6	Sample #6, Depth = 15.0' Mean (mm): 0.11, Phi Sorting: 0.48 Fines (230): 43.45% (CL)
-37.0	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-07

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-07
LOCATION COORDINATES	X = 3,848,259 Y = 269,305
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Sean Kemnuir
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 01-31-10 10:04
COMPLETED	01-31-10 10:05
16. ELEVATION TOP OF BORING	-14.7 Ft.
17. TOTAL RECOVERY FOR BORING	14.3 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-14.7	0.0					
-15.9	1.2		CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets typically up to 0.5", 1.0" sand pocket @ 0.5', very dark grayish brown (2.5Y-3/2), (CL).		1	Sample #1, Depth = 0.9' Ave. Field Vane (tsf): 0.03
-18.4	3.7		CLAY, little sand, trace organics, trace shell hash, very soft clay, sand distributed in pockets up to 0.5", organics distributed in laminae, very dark gray (2.5Y-3/1), (CL).		2	Sample #2, Depth = 2.6' Ave. Field Vane (tsf): 0.03
-23.7	9.0		CLAY, trace organics, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 0.25", organics distributed in laminae, very dark gray (2.5Y-3/1), (CL).		3	Sample #3, Depth = 5.0' Ave. Field Vane (tsf): 0.04
-24.3	9.6		CLAY, soft clay, 2.0" sand pocket @ 9.4', very dark gray (2.5Y-3/1), (CL).		4	Sample #4, Depth = 9.3' Ave. Field Vane (tsf): 0.19
-27.6	12.9		CLAY, trace sand, very soft clay, sand distributed in pockets up to 0.5", very dark gray (2.5Y-3/1), (CL).		5	Sample #5, Depth = 11.0' Ave. Field Vane (tsf): 0.05
-28.4	13.7		Clayey SAND, trace shell hash, trace silt, olive brown (2.5Y-4/3), (CL).		6	Sample #6, Depth = 13.4' Mean (mm): 0.09, Phi Sorting: 0.29 Fines (230): 45.30% (CL)
-29.0	14.3		CLAY, trace sand, very soft clay, sand distributed in pockets up to 0.5", very dark gray (2.5Y-3/1), (CL).		5	
-34.7	20.0		No Recovery.			
			End of Boring			

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LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-07A

DRILLING LOG

DIVISION		INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: Grand Liard Restoration, Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT: 3.0 In.	
		10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane	HORIZONTAL: NAD 1983 / VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-07A	LOCATION COORDINATES: X = 3,848,211 Y = 269,338	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED: 01-31-10 10:40 / COMPLETED: 01-31-10 10:41
6. THICKNESS OF OVERBURDEN: 0.0 Ft.		16. ELEVATION TOP OF BORING: -14.7 Ft.	
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.		17. TOTAL RECOVERY FOR BORING: 11.9 Ft.	
8. TOTAL DEPTH OF BORING: 21.9 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-14.7	0.0		Jetted to 10.0'.			
-24.7	10.0		CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets typically up to 0.5", (1.0"x0.5") shell fragment @ 13.5', 2.0" sandy pocket @ 16.6', 1.0" sand pocket @ 17.6', dark gray (2.5Y-4/1), (CL).		1	Sample #1, Depth = 12.5' Ave. Field Vane (tsf): 0.03
					2	Sample #2, Depth = 15.5' Ave. Field Vane (tsf): 0.03
-32.5	17.8					Sample #3, Depth = 18.3' Mean (mm): 0.10, Phi Sorting: 1.22 Fines (230): 96.62% (ML-CL)
-33.2	18.5		SILT, some clay, trace sand, clay distributed in pockets up to 1.0", very dark gray (5Y-3/1), (ML-CL).		3	
-34.3	19.6		CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 0.5", dark gray (2.5Y-4/1), (CL).		1	
-36.0	21.3		SAND, fine grained, quartz, some clay, some silt, 1.0" clay pocket @ 20.5', very dark gray (5Y-3/1), (ML-CL).		4	Sample #4, Depth = 20.3' Mean (mm): 0.08, Phi Sorting: 0.27 Fines (230): 42.83% (ML-CL)
-36.6	21.9		CLAY, little sand, very soft clay, sand distributed in pockets up to 0.25", bit sample from 21.6' to 21.9', dark gray (2.5Y-4/1), (CL).		5	Sample #5, Depth = 21.5' Ave. Field Vane (tsf): 0.04
			End of Boring			

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LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-08

DRILLING LOG

DIVISION		INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: Grand Liard Restoration, Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT: 3.0 In.	
		10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane	HORIZONTAL: NAD 1983 / VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-08	LOCATION COORDINATES: X = 3,851,180 Y = 260,146	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER	
		15. DATE BORING	STARTED: 01-31-10 10:55 / COMPLETED: 01-31-10 10:56
6. THICKNESS OF OVERBURDEN: 0.0 Ft.		16. ELEVATION TOP OF BORING: -22.4 Ft.	
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.		17. TOTAL RECOVERY FOR BORING: 18.7 Ft.	
8. TOTAL DEPTH OF BORING: 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-22.4	0.0					
-27.0	4.6		CLAY, trace shell hash, very soft clay, 1.0" pocket of wood fragments @ 0.7', 0.25" whole shell @ 0.1', dark gray (2.5Y-4/1), (CL).		1	Sample #1, Depth = 2.3' Ave. Field Vane (tsf): 0.04
-29.4	7.0		CLAY, little sand, very soft clay, sand distributed in pockets up to 1.0", dark gray (2.5Y-4/1), (CL).		2	Sample #2, Depth = 5.4' Ave. Field Vane (tsf): 0.08
-30.0	7.6		Clayey SAND, fine grained, quartz, soft clay, dark gray (5Y-4/1), (CL).		3	Sample #3, Depth = 7.3' Mean (mm): 0.09, Phi Sorting: 0.36 Fines (230): 44.54% (CL)
-31.6	9.2		CLAY, trace sand, very soft clay, sand distributed in pockets up to 0.5", dark gray (2.5Y-4/1), (CL).		4	Sample #4, Depth = 8.0' Ave. Field Vane (tsf): 0.08
-34.0	11.6		CLAY, little sand, very soft clay, sand distributed in pockets up to 1.0", 1.0" pocket of gray (2.5Y-6/1) lithified clay @ 10.6', dark gray (2.5Y-4/1), (CL).		2	
-39.2	16.8		CLAY, trace sand, very soft clay, sand distributed in pockets up to 0.5", dark gray (2.5Y-4/1), (CL).		5	Sample #5, Depth = 13.2' Ave. Field Vane (tsf): 0.06
-41.1	18.7		CLAY, very soft clay, bit sample from 18.3' to 18.7', dark gray (2.5Y-4/1), (CL).		6	Sample #6, Depth = 17.5' Ave. Field Vane (tsf): 0.06
-42.4	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-09

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-09
LOCATION COORDINATES	X = 3,852,999 Y = 268,102
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Sean Kemnuir
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 02-10-10 08:58
COMPLETED	02-10-10 08:59
16. ELEVATION TOP OF BORING	-13.6 Ft.
17. TOTAL RECOVERY FOR BORING	10 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-13.6	0.0					
-13.8	0.2		CLAY, trace organics, trace shell hash, very soft clay, dark olive gray (5Y-3/2), (CL).		1	Sample #1, Depth = 0.1' Ave. Field Vane (tsf): 0.00
-14.8	1.2		CLAY, little organics, very soft clay, organics distributed in pockets up to 0.5", 0.5" wood fragment @ 0.7', dark olive gray (5Y-3/2), (CL).		2	Sample #2, Depth = 1.0' Ave. Field Vane (tsf): 0.03
-17.9	4.3		CLAY, some organics, very soft clay, organics distributed in pockets typically up to 1.0", (2.0"x1.0") organic pocket @ 2.3', (3.0"x2.0") organic pocket @ 3.8', dark olive gray (5Y-3/2), (CL).		3	Sample #3, Depth = 4.0' Ave. Field Vane (tsf): 0.05
-20.2	6.6		CLAY, trace organics, very soft clay, organics distributed in pockets typically up to 0.5", 1.0" organic pocket @ 4.3', dark olive gray (5Y-3/2), (CL).		4	Sample #4, Depth = 5.4' Ave. Field Vane (tsf): 0.07
-21.1	7.5		Clayey SILT, very soft clay, very dark grayish brown (2.5Y-3/2), (ML-CL).		5	Sample #5, Depth = 7.0' Ave. Field Vane (tsf): 0.03
-23.6	10.0		SAND, fine grained, quartz, some clay, (1.0"x2.0") clay pocket @ 7.6', (3.0"x0.5") clay pocket @ 7.8', very dark grayish brown (2.5Y-3/2), (SC).		6	Sample #6, Depth = 9.0' Mean (mm): 0.12, Phi Sorting: 0.42 Fines (230): 32.32% (SC)
-33.6	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-09A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana	9. SIZE AND TYPE OF BIT: 3.0 In.
	10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane; HORIZONTAL: NAD 1983; VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-09A; LOCATION COORDINATES: X = 3,852,984 Y = 268,152	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore; ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.; CONTRACTOR FILE NO.	12. TOTAL SAMPLES; DISTURBED; UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	14. ELEVATION GROUND WATER
	15. DATE BORING: STARTED 02-10-10 09:54; COMPLETED 02-10-10 09:57
6. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. ELEVATION TOP OF BORING: -13.5 Ft.
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. TOTAL RECOVERY FOR BORING: 10.8 Ft.
8. TOTAL DEPTH OF BORING: 20.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: KD

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-13.5	0.0					
-17.5	4.0		Jetted to 4.0'.			
-20.2	6.7		CLAY, very soft clay, 1.5" sandy pocket @ 4.1', dark gray (5Y-4/1), (CL).		1	Sample #1, Depth = 5.7' Ave. Field Vane (tsf): 0.05
-20.6	7.1		Sandy CLAY, very soft clay, 1.0" light gray (5Y-7/1) clay pocket @ 4.1', very dark gray (5Y-3/1), (CL).		2	Sample #2, Depth = 6.8' Ave. Field Vane (tsf): 0.02
-21.4	7.9		Clayey SILT, dark olive gray (5Y-3/2), (ML-CL).		2	
-22.5	9.0		Sandy CLAY, very soft cay, very dark gray (5Y-3/1), (CL).		3	Sample #3, Depth = 9.4' Mean (mm): 0.09, Phi Sorting: 0.42 Fines (230): 69.91% (CL)
-23.8	10.3		CLAY, some sand, soft clay, 1.0" organic pocket @ 9.6', dark olive gray (5Y-3/2), (CL).		4	Sample #4, Depth = 10.6' Mean (mm): 0.11, Phi Sorting: 0.42 Fines (230): 41.08% (SC)
-24.3	10.8		Clayey SAND, fine grained, quartz, dark olive gray (5Y-3/2), (SC).		3	
-25.2	11.7		CLAY, some sand, soft clay, dark olive gray (5Y-3/2), (CL).		2	
-25.8	12.3		Sandy CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).		3	
-26.5	13.0		CLAY, some sand, soft clay, dark olive gray (5Y-3/2), (CL).		2	
-27.0	13.5		Sandy CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).		3	
-28.3	14.8		CLAY, some sand, soft clay, dark olive gray (5Y-3/2), (CL).			
-33.5	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-10

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-10
LOCATION COORDINATES	X = 3,853,230 Y = 266,978
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Sean Kemnuir
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 02-10-10 10:11
COMPLETED	02-10-10 10:12
16. ELEVATION TOP OF BORING	-14.9 Ft.
17. TOTAL RECOVERY FOR BORING	15.6 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-14.9	0.0					
-15.8	0.9		CLAY, trace sand, trace shell hash, very soft clay, very dark grayish brown (2.5Y-3/2), (CL).			
-19.1	4.2		CLAY, trace sand, trace shell hash, trace wood, very soft clay, wood fragments typically up to 0.5", sand distributed in pockets up to 1.0", 1.0" organic pocket @ 0.9', 1.0" wood fragment @ 1.2', dark gray (2.5Y-4/1), (CL).		1	Sample #1, Depth = 2.4' Ave. Field Vane (tsf): 0.07
-19.7	4.8		SILT, some clay, clay distributed in pockets up to 2.0", very dark gray (2.5Y-3/1), (ML-CL).		2	Sample #2, Depth = 4.5' Mean (mm): 0.09, Phi Sorting: 0.34 Fines (230): 70.99% (ML-CL)
-26.8	11.9		CLAY, trace sand, very soft clay, sand distributed in pockets typically up to 0.5", (1.0"x0.5") whole shell @ 6.3', 1.0" sand pocket @ 9.2', sand increases with depth, dark gray (2.5Y-4/1), (CL).		3	Sample #3, Depth = 8.4' Ave. Field Vane (tsf): 0.05
-27.3	12.4		SAND, fine grained, quartz, some clay, some silt, very dark gray (2.5Y-3/1), (ML-CL).		4	Sample #4, Depth = 12.1' Mean (mm): 0.12, Phi Sorting: 0.39 Fines (230): 47.21% (ML-CL)
-28.1	13.2		CLAY, trace sand, soft clay, very dark gray (5Y-3/1), (CL).			
-29.9	15.0		CLAY, some sand, trace shell hash, soft clay, dark olive gray (5Y-3/2), (CL).		5	Sample #5, Depth = 14.0' Mean (mm): 0.09, Phi Sorting: 0.60 Fines (230): 75.15% (CL)
-30.5	15.6		CLAY, trace sand, very soft clay, sand distributed in pockets up to 0.5", bit sample from 15.2' to 15.6', dark olive gray (5Y-3/2), (CL).			
-34.9	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-10A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana	9. SIZE AND TYPE OF BIT: 3.0 In.
	10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane; HORIZONTAL: NAD 1983; VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-10A; LOCATION COORDINATES: X = 3,853,238 Y = 266,959	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore; ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.; CONTRACTOR FILE NO.	12. TOTAL SAMPLES; DISTURBED; UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir	13. TOTAL NUMBER CORE BOXES
	14. ELEVATION GROUND WATER
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	15. DATE BORING: STARTED 02-10-10 10:31; COMPLETED 02-10-10 10:33
6. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. ELEVATION TOP OF BORING: -14.9 Ft.
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. TOTAL RECOVERY FOR BORING: 7.1 Ft.
8. TOTAL DEPTH OF BORING: 20.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-14.9	0.0		Jetted to 10.0'.			
-24.9	10.0		CLAY, trace sand, very soft clay, sand distributed in pockets typically up to 0.5", (2.0"x3.0") sand pocket @ 12.4', (1.0"x0.5") wood fragment @ 12.6', dark gray (2.5Y-4/1), (CL).		1	Sample #1, Depth = 11.1' Ave. Field Vane (tsf): 0.01
-27.9	13.0		Sandy SILT, very dark gray (2.5Y-3/1), (ML).		2	Sample #2, Depth = 13.4' Mean (mm): 0.10, Phi Sorting: 0.43 Fines (230): 52.91% (ML)
-28.6	13.7		CLAY, little sand, trace shell hash, soft clay, sand distributed in pockets up to 1.0", very dark gray (2.5Y-3/1), (SC).			
-29.0	14.1		CLAY, trace sand, very soft clay, sand distributed in pockets up to 1.0", very dark gray (2.5Y-3/1), (CL).		3	Sample #3, Depth = 14.2' Ave. Field Vane (tsf): 0.02
-32.0	17.1		No Recovery.			
-34.9	20.0		End of Boring			

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LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-11

DRILLING LOG

DIVISION		**INSTALLATION**	**SHEET 1 OF 1 SHEETS**
1. PROJECT Grand Liard Restoration, Grand Liard, Louisiana		**9. SIZE AND TYPE OF BIT** 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	**HORIZONTAL** NAD 1983 / **VERTICAL** NAVD 88
2. BORING DESIGNATION GLVC-10-11	**LOCATION COORDINATES** X = 3,853,779 Y = 267,816	**11. MANUFACTURER'S DESIGNATION OF DRILL** Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	**CONTRACTOR FILE NO.**	**12. TOTAL SAMPLES**	**DISTURBED** / **UNDISTURBED (UD)**
4. NAME OF DRILLER Sean Kemnuir		**13. TOTAL NUMBER CORE BOXES**	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	**DEG. FROM VERTICAL** / **BEARING**	**15. DATE BORING**	**STARTED** 02-10-10 11:05 / **COMPLETED** 02-10-10 11:06
6. THICKNESS OF OVERBURDEN 0.0 Ft.		**16. ELEVATION TOP OF BORING** -13.5 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		**17. TOTAL RECOVERY FOR BORING** 15 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		**18. SIGNATURE AND TITLE OF INSPECTOR** BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-13.5	0.0					
-13.8	0.3		CLAY, little sand, trace shell hash, very soft clay, very dark gray (2.5Y-3/1), (CL).		1	Sample #1, Depth = 0.2' Ave. Field Vane (tsf): 0.03
-15.9	2.4		CLAY, trace organics, very soft clay, organics distributed in pockets up to 1.0", dark olive gray (5Y-3/2), (CL).		2	Sample #2, Depth = 1.2' Ave. Field Vane (tsf): 0.02
-17.5	4.0		CLAY, little organics, very soft clay, organics distributed in pockets typically up to 1.0", 2 (2.0"x1.0") pockets of organics @ 3.2', very dark gray (2.5Y-3/1), (CL).		3	Sample #3, Depth = 3.0' Ave. Field Vane (tsf): 0.03
-22.0	8.5		CLAY, trace organics, very soft clay, organics distributed in pockets up to 0.5", 0.5" rock fragment @ 5.6', very dark gray (2.5Y-3/1), (CL).		4	Sample #4, Depth = 6.0' Ave. Field Vane (tsf): 0.03
-22.5	9.0		CLAY, some sand, very soft clay, very dark grayish brown (2.5Y-3/2), (SC).		5	Sample #5, Depth = 8.9' Ave. Field Vane (tsf): 0.05
-27.5	14.0		Sandy CLAY, very soft clay, sand distributed in pockets up to 3.0", (0.5"x1.0") rock fragment @ 9.6', very dark grayish brown (2.5Y-3/2), (SC).		6	Sample #6, Depth = 12.0' Ave. Field Vane (tsf): 0.05
-28.3	14.8		SILT, trace clay, trace sand, trace shell hash, clay distributed in pockets up to 1.0", 1.0" wood fragment @ 14.4', dark olive gray (5Y-3/2), (ML-CL).		7	Sample #7, Depth = 14.4' Mean (mm): 0.08, Phi Sorting: 0.35 Fines (230): 85.06% (ML-CL)
-28.5	15.0		SILT, some clay, trace shell hash, dark olive gray (5Y-3/2), (ML-CL).		8	Sample #8, Depth = 15.0' Mean (mm): 0.10, Phi Sorting: 0.78 Fines (230): 93.06% (ML-CL)
-33.5	20.0		No Recovery.			
			End of Boring			

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LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-12

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-12
LOCATION COORDINATES	X = 3,854,618 Y = 267,714
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Sean Kemnuir
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 02-10-10 11:10
COMPLETED	02-10-10 11:11
16. ELEVATION TOP OF BORING	-13.5 Ft.
17. TOTAL RECOVERY FOR BORING	16.9 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-13.5	0.0					
-13.9	0.4		CLAY, very soft clay, dark olive brown (2.5Y-3/3), (CL).		1	Sample #1, Depth = 0.2' Ave. Field Vane (tsf): 0.02
-14.3	0.8				2	Sample #2, Depth = 0.6' Ave. Field Vane (tsf): 0.05
-15.4	1.9		CLAY, some sand, trace shell hash, very soft clay, dark olive gray (5Y-3/2), (SC).		3	Sample #3, Depth = 1.5' Ave. Field Vane (tsf): 0.05
-17.0	3.5		Clayey SILT, trace shell hash, very soft clay, dark olive gray (5Y-3/2), (ML-CL).		4	Sample #4, Depth = 2.5' Mean (mm): 0.09, Phi Sorting: 0.82 Fines (230): 93.30% (ML-CL)
-17.6	4.1		SILT, little clay, trace organics, trace shell hash, organics distributed in pockets up to 0.5", very dark gray (2.5Y-3/1), (ML-CL).		5	
-18.4	4.9		CLAY, little organics, trace sand, very soft clay, sand distributed in pockets up to 0.5", (2.0"x0.5") wood fragment @ 3.6', dark olive gray (5Y-3/2), (CL).		3	Sample #5, Depth = 3.9' Ave. Field Vane (tsf): 0.02
-22.6	9.1		Clayey SILT, trace shell hash, very soft clay, dark olive gray (5Y-3/2), (ML-CL). CLAY, little organics, very soft clay, organics distributed in pockets up to 0.5" and laminae, (0.5"x0.25") rock fragment @ 6.9', 2.0" sandy pocket @ 8.0', very dark gray (5Y-3/1), (CL).		6	Sample #6, Depth = 7.5' Ave. Field Vane (tsf): 0.08
-24.4	10.9		Sandy CLAY, trace organics, very soft clay, very dark gray (2.5Y-3/1), (SC).		7	Sample #7, Depth = 10.5' Ave. Field Vane (tsf): 0.01
-27.5	14.0		Clayey SILT, trace shell hash, very soft clay, very dark grayish brown (2.5Y-3/2), (ML-CL).		8	Sample #8, Depth = 13.5' Ave. Field Vane (tsf): 0.03
-30.0	16.5		CLAY, some sand, soft clay, sand distributed in pockets up to 2.0", (1.0"x0.5") rock fragment @ 13.9', very dark grayish brown (2.5Y-3/2), (SC).			
-30.4	16.9		SAND, fine grained, quartz, little clay, very dark grayish brown (2.5Y-3/2), (SC).			
-33.5	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-13

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-13
LOCATION COORDINATES	X = 3,854,137 Y = 266,949
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Sean Kemnuir
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 02-10-10 11:32
COMPLETED	02-10-10 11:33
16. ELEVATION TOP OF BORING	-14.7 Ft.
17. TOTAL RECOVERY FOR BORING	17.8 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-14.7	0.0					
-15.6	0.9		CLAY, trace shell hash, very soft clay, (1.0"x2.0") sand pocket @ 0.2', (2.0"x1.0") organic pocket @ 0.7', black (2.5Y-2.5/1), (CL).		1	Sample #1, Depth = 0.5' Ave. Field Vane (tsf): 0.00
			CLAY, trace organics, trace sand, trace shell hash, very soft clay, sand distributed in pockets typically up to 1.0", 3.0" sand pocket @ 1.1', organics distributed in pockets up to 0.5" and laminae, 0.25" rock fragment @ 3.4', (0.5"x1.0") wood fragment @ 7.5', 0.25" shell fragment @ 7.6', sand and organics increase with depth, very dark gray (2.5Y-3/1), (CL).		2	Sample #2, Depth = 3.0' Ave. Field Vane (tsf): 0.05
					3	Sample #3, Depth = 6.0' Ave. Field Vane (tsf): 0.05
-23.5	8.8					
-24.3	9.6		Sandy CLAY, very soft clay, very dark grayish brown (2.5Y-3/2), (SC).		4	Sample #4, Depth = 9.0' Ave. Field Vane (tsf): 0.03
-24.9	10.2		CLAY, very soft clay, (2.0"x1.0") rock fragment @ 10.7', very dark gray (2.5Y-3/1), (CL).		2	
-25.6	10.9		Clayey SAND, fine grained, quartz, very dark grayish brown (2.5Y-3/2), (SC).			
			CLAY, little sand, very soft clay, sand distributed in pockets up to 2.0", (0.25"x0.5") wood fragment @ 12.6', very dark grayish brown (2.5Y-3/2), (CL).		5	Sample #5, Depth = 12.0' Ave. Field Vane (tsf): 0.03
					6	Sample #6, Depth = 15.0' Ave. Field Vane (tsf): 0.05
-32.0	17.3					
-32.5	17.8		Sandy CLAY, very soft clay, 0.5" wood fragment @ 17.8', very dark grayish brown (2.5Y-3/2), (SC).			
			No Recovery.			
-34.7	20.0					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-14

DRILLING LOG

DIVISION		INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: Grand Liard Restoration, Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT: 3.0 In.	
		10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane	HORIZONTAL: NAD 1983 / VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-14	LOCATION COORDINATES: X = 3,855,103 Y = 267,103	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED: 02-10-10 12:09 / COMPLETED: 02-10-10 12:10
6. THICKNESS OF OVERBURDEN: 0.0 Ft.		16. ELEVATION TOP OF BORING: -14.0 Ft.	
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.		17. TOTAL RECOVERY FOR BORING: 15.3 Ft.	
8. TOTAL DEPTH OF BORING: 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: KD	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-14.0	0.0					
			CLAY, trace organics, trace sand, very soft clay, sand distributed in sandy pockets up to 0.5", very dark gray (5Y-3/1), (CL).		1	Sample #1, Depth = 3.2' Ave. Field Vane (tsf): 0.05
					2	Sample #2, Depth = 6.2' Ave. Field Vane (tsf): 0.08
-23.5	9.5					
			Clayey SILT, very soft clay, 0.5" pocket of lithified light gray (5Y-7/1) clay @ 12.7', very dark gray (5Y-3/1), (ML-CL).		3	Sample #3, Depth = 12.2' Ave. Field Vane (tsf): 0.03
-29.3	15.3					
			No Recovery.			
-34.0	20.0					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-15

DRILLING LOG

DIVISION		INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: Grand Liard Restoration, Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT: 3.0 In.	
		10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane	HORIZONTAL: NAD 1983 / VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-15	LOCATION COORDINATES: X = 3,855,919 Y = 266,837	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED: 02-10-10 12:28 / COMPLETED: 02-10-10 12:30
6. THICKNESS OF OVERBURDEN: 0.0 Ft.		16. ELEVATION TOP OF BORING: -13.9 Ft.	
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.		17. TOTAL RECOVERY FOR BORING: 17 Ft.	
8. TOTAL DEPTH OF BORING: 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: KD	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-13.9	0.0					
-16.9	3.0		CLAY, trace shell hash, very soft clay, color is mottled olive gray (5Y-4/2) and, black (5Y-2.5/1), (CL).		1	Sample #1, Depth = 2.0' Ave. Field Vane (tsf): 0.02
-18.1	4.2		Sandy CLAY, trace shell hash, soft clay, dark olive gray (5Y-3/2), (CL).			
-19.3	5.4		CLAY, very soft clay, 2.5" sandy pocket @ 5.0', color is mottled olive gray (5Y-4/2) and, black (5Y-2.5/1), (CL).		1	
-24.6	10.7		Clayey SILT, very soft clay, dark olive gray (5Y-3/2), (ML-CL).		2	Sample #2, Depth = 8.0' Ave. Field Vane (tsf): 0.05
-25.5	11.6		CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).		3	Sample #3, Depth = 11.0' Ave. Field Vane (tsf): 0.05
-26.4	12.5		Clayey SILT, very soft clay, dark olive gray (5Y-3/2), (ML-CL).		2	
-27.7	13.8		Sandy CLAY, dark olive gray (5Y-3/2), (CL).		4	Sample #4, Depth = 13.2' Mean (mm): 0.09, Phi Sorting: 0.31 Fines (230): 63.36% (CL)
-28.6	14.7		Sandy CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).		5	Sample #5, Depth = 14.0' Ave. Field Vane (tsf): 0.05
-29.3	15.4		Sandy CLAY, dark olive gray (5Y-3/2), (CL).		4	
-30.9	17.0		Sandy CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).		5	
-33.9	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

Boring Designation GLVC-10-16

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	HORIZONTAL NAD 1983 / VERTICAL NAVD 88
2. BORING DESIGNATION GLVC-10-16	LOCATION COORDINATES X = 3,848,463 Y = 266,592	11. MANUFACTURER'S DESIGNATION OF DRILL Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED 02-10-10 12:55 / COMPLETED 02-10-10 12:56
6. THICKNESS OF OVERBURDEN 0.0 Ft.		16. ELEVATION TOP OF BORING -17.6 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		17. TOTAL RECOVERY FOR BORING 20.3 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR KD	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-17.6	0.0		CLAY, trace sand, trace shell hash, very soft clay, (1.25"x0.25") wood fragment @ 0.7', 0.25" pocket of light gray (5Y-7/2) lithified clay @ 11.7', sand distributed in sandy pockets up to (2.0"x0.25"), bit sample from 20.0' to 20.3', expansion from 20.0' to 20.3', color is mottled olive gray (5Y-4/1) and, very dark gray (5Y-3/1), (CL).		1	Sample #1, Depth = 5.0' Ave. Field Vane (tsf): 0.05
					2	Sample #2, Depth = 17.0' Ave. Field Vane (tsf): 0.10
-37.9	20.3					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-17

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana	9. SIZE AND TYPE OF BIT: 3.0 In.
	10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane; HORIZONTAL: NAD 1983; VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-17; LOCATION COORDINATES: X = 3,848,476 Y = 264,798	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore; ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.; CONTRACTOR FILE NO.	12. TOTAL SAMPLES; DISTURBED; UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir	13. TOTAL NUMBER CORE BOXES
	14. ELEVATION GROUND WATER
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	15. DATE BORING: STARTED 02-10-10 13:15; COMPLETED 02-10-10 13:16
6. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. ELEVATION TOP OF BORING: -19.6 Ft.
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. TOTAL RECOVERY FOR BORING: 19.9 Ft.
8. TOTAL DEPTH OF BORING: 20.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: ML

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-19.6	0.0		CLAY, trace organics, very soft clay, 2.0" sandy pocket @ 3.8', dark olive gray (5Y-3/2), (CL).		1	Sample #1, Depth = 5.0' Ave. Field Vane (tsf): 0.02
-27.4	7.8		CLAY, very soft clay, color alternating with dark grayish brown (10YR-4/2) and, dark olive gray (5Y-3/2), (CL).		2	Sample #2, Depth = 11.0' Ave. Field Vane (tsf): 0.05
-33.9	14.3		CLAY, very soft clay, bit sample from 19.7' to 19.9', dark olive gray (5Y-3/2), (CL).		3	Sample #3, Depth = 17.0' Ave. Field Vane (tsf): 0.07
-39.5	19.9		No Recovery.			
-39.6	20.0		End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-18

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	HORIZONTAL NAD 1983 / VERTICAL NAVD 88
2. BORING DESIGNATION GLVC-10-18	LOCATION COORDINATES X = 3,848,849 Y = 265,732	11. MANUFACTURER'S DESIGNATION OF DRILL Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED 02-10-10 13:41 / COMPLETED 02-10-10 13:42
6. THICKNESS OF OVERBURDEN 0.0 Ft.		16. ELEVATION TOP OF BORING -18.4 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		17. TOTAL RECOVERY FOR BORING 19 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR KD	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-18.4	0.0					
-19.1	0.7		CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).			
			CLAY, trace sand, trace shell hash, very soft clay, sand distributed in sandy pockets up to (2.0"x0.5"), 0.5" shell fragment @ 8.9', (1.0"x0.5") light gray (5Y-7/1) clay pocket @ 10.5', bit sample from 17.4' to 17.8', color is mottled dark gray (5Y-4/1) and, dark olive gray (5Y-3/2), (CL).		1	Sample #1, Depth = 6.8' Ave. Field Vane (tsf): 0.03
					2	Sample #2, Depth = 15.8' Ave. Field Vane (tsf): 0.04
-37.4	19.0					
-38.4	20.0		No Recovery.			
			End of Boring			

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LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-19

DRILLING LOG

DIVISION		INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: Grand Liard Restoration, Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT: 3.0 In.	
		10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane	HORIZONTAL: NAD 1983 / VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-19	LOCATION COORDINATES: X = 3,847,954 Y = 265,731	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER	
		15. DATE BORING	STARTED: 02-10-10 14:02 / COMPLETED: 02-10-10 14:03
6. THICKNESS OF OVERBURDEN: 0.0 Ft.		16. ELEVATION TOP OF BORING: -18.8 Ft.	
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.		17. TOTAL RECOVERY FOR BORING: 17.8 Ft.	
8. TOTAL DEPTH OF BORING: 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: KD	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-18.8	0.0					
-19.2	0.4		CLAY, little sand, trace shell hash, soft clay, very dark gray (5Y-3/1), (CL).			
			CLAY, trace sand, trace shell hash, very soft clay, sand distributed sandy in pockets up to (2.5"x1.0"), (1.0"x0.5") whole shell @ 0.7', 0.75" shell fragment @ 3.6', colors alternating with dark grayish brown (10YR-4/2) from 9.2' to 14.0', color is mottled dark gray (5Y-4/1) and, black (5Y-2.5/1), (CL).		1	Sample #1, Depth = 5.3' Ave. Field Vane (tsf): 0.05
					2	Sample #2, Depth = 14.3' Ave. Field Vane (tsf): 0.04
-36.6	17.8					
			No Recovery.			
-38.8	20.0					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-20

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	HORIZONTAL NAD 1983 / VERTICAL NAVD 88
2. BORING DESIGNATION GLVC-10-20	LOCATION COORDINATES X = 3,847,466 Y = 264,860	11. MANUFACTURER'S DESIGNATION OF DRILL Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED 02-10-10 14:16 / COMPLETED 02-10-10 14:17
6. THICKNESS OF OVERBURDEN 0.0 Ft.		16. ELEVATION TOP OF BORING -19.8 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		17. TOTAL RECOVERY FOR BORING 16.7 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR KD	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-19.8	0.0		CLAY, trace sand, very soft clay, sand distributed in sandy pockets up to (1.0"x0.25"), colors alternating with dark grayish brown (10YR-4/2) from 7.4' to 15.0', color is mottled dark gray (5Y-4/1) and, dark olive gray (5Y-3/2), (CL).		1	Sample #1, Depth = 4.7' Ave. Field Vane (tsf): 0.02
					2	Sample #2, Depth = 13.7' Ave. Field Vane (tsf): 0.05
-36.5	16.7		No Recovery.			
-39.8	20.0		End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-21

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana		9. SIZE AND TYPE OF BIT 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	HORIZONTAL NAD 1983 / VERTICAL NAVD 88
2. BORING DESIGNATION GLVC-10-21	LOCATION COORDINATES X = 3,847,116 Y = 265,722	11. MANUFACTURER'S DESIGNATION OF DRILL Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED / UNDISTURBED (UD)
4. NAME OF DRILLER Sean Kemnuir		13. TOTAL NUMBER CORE BOXES	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	15. DATE BORING	STARTED 02-10-10 14:35 / COMPLETED 02-10-10 14:36
6. THICKNESS OF OVERBURDEN 0.0 Ft.		16. ELEVATION TOP OF BORING -19.3 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		17. TOTAL RECOVERY FOR BORING 16.9 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-19.3	0.0					
-20.3	1.0		CLAY, trace organics, trace shell hash, very soft clay, organics distributed in pockets up to 0.5", dark gray (2.5Y-4/1), (CL).		1	Sample #1, Depth = 0.5' Ave. Field Vane (tsf): 0.03
			CLAY, very soft clay, 0.5" whole shell @ 2.6', dark gray (2.5Y-4/1), (CL).		2	Sample #2, Depth = 1.5' Ave. Field Vane (tsf): 0.05
					3	Sample #3, Depth = 7.5' Ave. Field Vane (tsf): 0.06
-27.3	8.0					
-28.3	9.0		CLAY, very soft clay, (2.5"x1.0") sand pocket @ 8.0', very dark gray (5Y-3/1), (CL).		4	Sample #4, Depth = 8.5' Ave. Field Vane (tsf): 0.03
			CLAY, trace shell hash, very soft clay, (2.0"x1.0") sand pocket @ 12.0', bit sample from 16.5' to 16.9', dark gray (2.5Y-4/1), (CL).		2	
-36.2	16.9					
			No Recovery.			
-39.3	20.0					
			End of Boring			

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LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-22

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT Grand Liard Restoration Grand Liard, Louisiana	9. SIZE AND TYPE OF BIT: 3.0 In.
	10. COORDINATE SYSTEM/DATUM: Louisiana South State Plane; HORIZONTAL: NAD 1983; VERTICAL: NAVD 88
2. BORING DESIGNATION: GLVC-10-22; LOCATION COORDINATES: X = 3,847,544 Y = 266,529	11. MANUFACTURER'S DESIGNATION OF DRILL: Alpine Pneumatic Vibracore; ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: American Vibracore Services, Inc.; CONTRACTOR FILE NO.	12. TOTAL SAMPLES; DISTURBED; UNDISTURBED (UD)
4. NAME OF DRILLER: Sean Kemnuir	13. TOTAL NUMBER CORE BOXES
	14. ELEVATION GROUND WATER
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	15. DATE BORING: STARTED 02-10-10 14:51; COMPLETED 02-10-10 14:52
6. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. ELEVATION TOP OF BORING: -18.1 Ft.
7. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. TOTAL RECOVERY FOR BORING: 16.1 Ft.
8. TOTAL DEPTH OF BORING: 20.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: BF

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-18.1	0.0					
-18.8	0.7		CLAY, very soft clay, very dark gray (5Y-3/1), (CL).		1	Sample #1, Depth = 0.4' Ave. Field Vane (tsf): 0.03
			CLAY, trace sand, very soft clay, sand distributed in pockets typically up to 0.5", 2.0" sand pocket @ 5.5', 0.25" whole shell @ 5.6', 1.0" sand pockets @ 9.7' and 9.9', 2.0" pocket of slightly firmer clay @ 13.1', bit sample from 15.8' to 16.1', very dark gray (5Y-3/1), (CL).		2	Sample #2, Depth = 3.8' Ave. Field Vane (tsf): 0.02
					3	Sample #3, Depth = 6.8' Ave. Field Vane (tsf): 0.02
					4	Sample #4, Depth = 12.8' Ave. Field Vane (tsf): 0.05
-34.2	16.1					
			No Recovery.			
-38.1	20.0					
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-23

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Grand Liard Restoration Grand Liard, Louisiana
2. BORING DESIGNATION	GLVC-10-23
LOCATION COORDINATES	X = 3,846,569 Y = 264,794
3. DRILLING AGENCY	American Vibracore Services, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Sean Kemnuir
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	0.0 Ft.
7. DEPTH DRILLED INTO ROCK	0.0 Ft.
8. TOTAL DEPTH OF BORING	20.0 Ft.
9. SIZE AND TYPE OF BIT	3.0 In.
10. COORDINATE SYSTEM/DATUM	Louisiana South State Plane
HORIZONTAL	NAD 1983
VERTICAL	NAVD 88
11. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	
DISTURBED	
UNDISTURBED (UD)	
13. TOTAL NUMBER CORE BOXES	
14. ELEVATION GROUND WATER	
15. DATE BORING	STARTED 02-10-10 15:10
COMPLETED	02-10-10 15:11
16. ELEVATION TOP OF BORING	-20.3 Ft.
17. TOTAL RECOVERY FOR BORING	18.8 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	KD

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-20.3	0.0		CLAY, trace sand, very soft clay, sand distributed in sandy pockets up to 2.0", 1.0" light gray (5Y-7/2) clay pocket @ 5.2', bit sample from 18.5' to 18.8', color is mottled dark grayish brown (10YR-4/2) and, dark gray (5Y-4/1), (CL).		1	Sample #1, Depth = 6.7' Ave. Field Vane (tsf): 0.02
					2	Sample #2, Depth = 15.7' Ave. Field Vane (tsf): 0.07
-39.1	18.8					
-40.3	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 MODIFIED FOR THE FLORIDA DEP JUN 04

Boring Designation GLVC-10-24

DRILLING LOG

DIVISION		**INSTALLATION**	**SHEET 1 OF 1 SHEETS**
1. PROJECT Grand Liard Restoration, Grand Liard, Louisiana		**9. SIZE AND TYPE OF BIT** 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	**HORIZONTAL** NAD 1983 / **VERTICAL** NAVD 88
2. BORING DESIGNATION GLVC-10-24	**LOCATION COORDINATES** X = 3,846,174 Y = 265,733	**11. MANUFACTURER'S DESIGNATION OF DRILL** Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	**CONTRACTOR FILE NO.**	**12. TOTAL SAMPLES**	**DISTURBED** / **UNDISTURBED (UD)**
4. NAME OF DRILLER Sean Kemnuir		**13. TOTAL NUMBER CORE BOXES**	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	**DEG. FROM VERTICAL** / **BEARING**	**15. DATE BORING**	**STARTED** 02-10-10 15:28 / **COMPLETED** 02-10-10 15:29
6. THICKNESS OF OVERBURDEN 0.0 Ft.		**16. ELEVATION TOP OF BORING** -19.8 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		**17. TOTAL RECOVERY FOR BORING** 19.2 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		**18. SIGNATURE AND TITLE OF INSPECTOR** BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS (Depths and elevations based on measured values)	% REC.	BOX OR SAMPLE	REMARKS
-19.8	0.0		CLAY, trace shell hash, very soft clay, 0.25" whole shell @ 1.8', 1.0" sand pocket @ 6.3', (0.25"x1.0") sand pocket @ 9.1', (1.0"x2.0") sand pocket @ 9.6', very dark gray (5Y-3/1), (CL).		1	Sample #1, Depth = 3.6' Ave. Field Vane (tsf): 0.03
					2	Sample #2, Depth = 8.5' Ave. Field Vane (tsf): 0.02
-32.8	13.0		CLAY, very soft clay, (1.0"x0.25") sand pocket @ 14.1', very dark gray (5Y-3/1), (CL).		3	Sample #3, Depth = 15.6' Ave. Field Vane (tsf): 0.07
-36.8	17.0		CLAY, soft clay, bit sample from 18.8' to 19.2', very dark gray (5Y-3/1), (CL).			
-39.0	19.2		No Recovery.			
-39.8	20.0		End of Boring			

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LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SAJ FORM 1836 JUN 02 **MODIFIED FOR THE FLORIDA DEP** JUN 04

Boring Designation GLVC-10-25

DRILLING LOG

DIVISION		**INSTALLATION**	**SHEET 1 OF 1 SHEETS**
1. PROJECT Grand Liard Restoration, Grand Liard, Louisiana		**9. SIZE AND TYPE OF BIT** 3.0 In.	
		10. COORDINATE SYSTEM/DATUM Louisiana South State Plane	**HORIZONTAL** NAD 1983 / **VERTICAL** NAVD 88
2. BORING DESIGNATION GLVC-10-25	**LOCATION COORDINATES** X = 3,846,609 Y = 266,533	**11. MANUFACTURER'S DESIGNATION OF DRILL** Alpine Pneumatic Vibracore	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY American Vibracore Services, Inc.	**CONTRACTOR FILE NO.**	**12. TOTAL SAMPLES**	**DISTURBED** / **UNDISTURBED (UD)**
4. NAME OF DRILLER Sean Kemnuir		**13. TOTAL NUMBER CORE BOXES**	
		14. ELEVATION GROUND WATER	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	**DEG. FROM VERTICAL** / **BEARING**	**15. DATE BORING**	**STARTED** 02-10-10 15:44 / **COMPLETED** 02-10-10 15:45
6. THICKNESS OF OVERBURDEN 0.0 Ft.		**16. ELEVATION TOP OF BORING** -18.7 Ft.	
7. DEPTH DRILLED INTO ROCK 0.0 Ft.		**17. TOTAL RECOVERY FOR BORING** 16.5 Ft.	
8. TOTAL DEPTH OF BORING 20.0 Ft.		**18. SIGNATURE AND TITLE OF INSPECTOR** BF	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS Depths and elevations based on measured values	% REC.	BOX OR SAMPLE	REMARKS
-18.7	0.0					
			CLAY, trace sand, trace shell hash, very soft clay, sand distributed in pockets up to 0.25", dark olive gray (5Y-3/2), (CL).		1	Sample #1, Depth = 1.0' Ave. Field Vane (tsf): 0.02
					2	Sample #2, Depth = 7.0' Ave. Field Vane (tsf): 0.03
-26.5	7.8					
-27.7	9.0		CLAY, very soft clay, dark olive gray (5Y-3/2), (CL).			
-28.3	9.6		CLAY, some sand, soft clay, sand distributed in pockets up to 2.0", dark olive gray (5Y-3/2), (SC).			
			CLAY, trace shell hash, very soft clay, (0.5"x3.0") sand pocket @ 11.6', dark gray (5Y-4/1), (CL).		3	Sample #3, Depth = 13.0' Ave. Field Vane (tsf): 0.07
-33.5	14.8					
-35.2	16.5		CLAY, soft clay, bit sample from 16.2' to 16.5', very dark grayish brown (2.5Y-3/2), (CL).			
-38.7	20.0		No Recovery.			
			End of Boring			

0 5 10 15 20 25

LOUISIANA GRAND_LIARD_2010_VIBRACORES.GPJ JPBRAZIL.GDT 9/21/10

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	CC	Cement Concrete
	AC	Asphalt Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Measured groundwater level at time noted on log

Initial groundwater level observed at time of exploration

Perched water observed at time of exploration

Graphic Log Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Material Description Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PP	Pocket penetrometer
SA	Sieve analysis
UU	Triaxial compression
UC	Unconfined compression
VS	Vane shear

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GEOENGINEERS

FIGURE B-1

Drilled	Start 8/18/2011	End 8/18/2011	Total Depth (ft)	80	Logged By / Checked By	DAS / VT	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum	1.0		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy-Mounted Drill Rig				
Latitude / Longitude	N29° 18' 35.8" / W89° 28' 30.2"		System Datum	Geographic NAD83 (feet)	Groundwater	Date Measured: 8/18/2011	Depth to Water (ft): 0.0	Elevation (ft): 1.0		

Notes: See Figure A-1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
0									Zero (feet) at water surface									
									Mudline at EL. -1 foot									
		21			1			PT	Very soft dark gray peat	374	15.4	0.16	0.06	14	195	136	0.056	
		22			2			CH	Very soft gray clay with organic matter	63	60.4	0.15	0.17	11	56	31	0.074	
5		22			3			OH	Very soft gray organic clay	104	50.7	0.10	0.29	14	86	56	0.113	
		17			4			CL	Very soft gray silty clay	36	86.7	0.11	0.40	10	38	18	0.128	
10		14			5				Very soft gray very silty clay*	41					30	10	0.104	
15		15			6				Very soft gray very silty clay with organic matter and 1" sand layer	36	84.6	0.15	0.81	13	33	12	0.237	
20		20			7				Soft gray very silty clay	38	91.4	0.25	1.09	15	32	12	0.097	
								OH										
25		20			8				Very soft gray organic clay	89	53.6	0.17	1.38	10	91	58	0.11	
								CH										
30		23			9				Very soft gray clay with 2" fine sand layer	75	70.3	0.14	1.67	13	56	30		77
								CL-ML										
35																		

[1]Sample disturbed during extrusion.

Log of Boring B-11

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-01

Figure B-2
Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35	17			10				Firm gray clayey silt	28	93.7	0.35		5	23	5		
-35								ML										
	40	7			11				Very soft gray silt with clay, organic matter and fine sand	32					26	1	0.192	
-40								CH										
	45	14			12				Soft gray laminated clay and fine sand with 1½" clay layers	47	80.7	0.45	2.53	15			0.248	70
-45																		
	50	15			13				Very soft gray clay with silt streaks*	74					73	44	0.221	
-50																		
	55	13			14				Very soft gray clay with silt streaks	66	64.6	0.21	3.11	14	83	55	0.259	
-55																		
	60	19			15				Very soft gray clay with silt streaks	66					84	54	0.237	
-60																		
	65	18			16				Soft gray clay	39	78.4	0.30	3.69	14	62	35	0.293	
-65																		
	70	22			17				Very soft gray clay with trace shells	71	63.6	0.12	3.97	14	83	50	0.083	
-70								CL										
	75	22			18				Very soft gray clay with silt	55					49	24	0.288	
-75																		

[1]Sample disturbed during extrusion.

Log of Boring B-11 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-2

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
		23			19			CH	Very soft gray clay	67	61.9	0.24	4.44	12	71	43	0.293	
	80																	
-80																		

[1]Sample disturbed during extrusion.

Log of Boring B-11 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-2

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/18/2011	End 8/18/2011	Total Depth (ft)	80	Logged By / Checked By	DAS / VT	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum	1.0		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy-Mounted Drill Rig				
Latitude / Longitude	N29° 18' 21.4" / W89° 28' 14.9"		System Datum	Geographic NAD83 (feet)	Groundwater	Date Measured: 8/18/2011	Depth to Water (ft): 0.0	Elevation (ft): 1.0		

Notes: See Figure A-1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
0									Zero (feet) at water surface									
									Mudline at EL. -1 foot									
		17			1			PT	Very soft dark gray peat	599	10.3	0.11	0.06	15	270	193	0.068	
		20			2			OH	Very soft gray organic clay	182	30.8	0.13	0.17	14	148	122	0.101	
5		9			3			CH	Very soft gray clay	47	74	0.10	0.29	14	53	33	0.09	
		22			4			CL	Very soft gray clay with silt, organic matter and ferrous nodules	54	73.8	0.11	0.40	11	42	19	0.079	
10		20			5			CL-ML	Medium gray clayey silt	34	89.8	0.78	0.52	10	26	6	0.156	
								CH										
15		20			6				Very soft gray clay with silt streaks and shell fragments	63	62	0.16	0.81	11	86	62	0.201	
20		9			7				Very soft gray clay	64	61.7	0.23	1.09	9			0.18	
25		10			8				Very soft gray clay	63	60.6	0.23	1.38	9			0.21	
30		19			9				Very soft gray clay with silt lenses	60	61.4	0.14	1.67	14	72	41	0.192	
								CL										
35																		

[1]Sample disturbed during extrusion.

Log of Boring B-12

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-01

Figure B-3
Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35	14			10				Very soft gray clay with silt and 2" silt layer	41	77.3	0.14	1.96	15	44	21	0.165	
-35								CH										
	40	24			11				Very soft gray clay with 3" clayey silt layer at bottom	65					74	44	0.156	
-40								CL										
	45	24			12				Very soft gray clay with silt and 2½" silt layer	44	75.8	0.14	2.53	15	48	24	0.077	
-45		24			13			CL-ML	Firm gray clayey silt	26					25	5		
								CL										
	50	24			14				Very soft gray silty clay with silt pockets, silt lenses and silt streaks	29					40	17	0.365	
-50					15			CL-ML	Firm gray clayey silt	29					25	4	0.261	
								CH										
	55	22			16				Soft gray clay with silt streaks and 3" silt layer	44	76.9	0.26	3.11	13	64	36	0.327	
-55								CL										
	60	21			17				Very soft gray clay with silt and 3" clayey silt layer	39	84.7	0.21	3.40	15	45	22		
-60					18			SM	Firm tan sandy silt with two 1" clay layers and 3½" clay layer									69
								CH										
	65	22			19				Soft gray clay with silt pockets	43	83.3	0.26	3.80	13	53	30	145	
-65																		
	70	19			20				Very soft gray clay with 4" fine sand layer at bottom	58	65.6	0.18	3.97	13	66	36		
-70																		
	75	18			21				Very soft gray clay with 1½" clayey silt layer and 4½" fine sand layer at bottom	48					64	37		
-75																		

[1]Sample disturbed during extrusion.

Log of Boring B-12 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-3

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
		23			22			CL	Very soft gray silty clay with silt, 5" clayey silt layer and 4" fine sand layer at bottom	44	80.9	0.19	4.55	15	40	19		
	80																	
-80																		

[1]Sample disturbed during extrusion.

Log of Boring B-12 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-3

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/23/2011	End 8/24/2011	Total Depth (ft)	80	Logged By / Checked By	DAS / VT	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
Surface Elevation (ft) / Vertical Datum	1.0		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Pontoon-Mounted Drill Rig				
Latitude / Longitude	N29° 18' 10.4" / W89° 28' 10.8"		System Datum	Geographic NAD83 (feet)	Groundwater	Date Measured: 8/23/2011	Depth to Water (ft): 0.0	Elevation (ft): 1.0		

Notes: See Figure A-1 for explanation of symbols. Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (feet) at water surface									
0																			
	5																		
-5																			
										Mudline at EL. -9 feet									
	10		18			1			OH	Very soft gray organic clay	181	27.8	0.10	0.06	13	148	114	0.088	
-10			15			2				Very soft gray organic clay	173	29.2	0.10	0.17	13	131	97	0.059	
			14			3			CL	Very soft gray clay with silt and 1" organic matter layer	70	62.4	0.05	0.29	15	49	23	0.128	
	15		11			4				Very soft gray silty clay with organic matter	65	66.4	0.18	0.40	15	40	18		
-15			9			5				Very soft gray very silty clay with organic matter traces	40	85.6	0.42	0.52	15	33	14	0.119	
	20																		
-20									CH										
			16			6				Very soft gray clay	86	51.8	0.18	0.81	12	71	42	0.174	
	25																		
-25																			
			13			7				Very soft gray clay	90	56.1	0.12	1.09	15	76	46	0.119	
	30																		
-30																			
			15			8				Very soft gray clay with silt lenses	45	77.8	0.21	1.38	3	85	57	0.124	
	35																		

[1]Sample disturbed during extrusion.

Log of Boring B-13

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-4

Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35																	
35		16			9				Soft gray clay with silt lenses and pockets	49	70.2	0.28	1.67	9	64	38		
	40																	
40		14			10				Soft gray clay	44	77.1	0.47	1.96	13	58	34	0.318	
	45																	
45								CL										
		22			11				Soft gray clay with silt and 4" very silty clay layer	49	78	0.37	2.25	14	49	24		
	50																	
50								CH										
		14			12				Soft gray clay with silt trace	39					52	28	0.277	
	55																	
55								CL										
		15			13				Soft gray clay with silt	39	80.9	0.39	2.82	14	49	25	0.498	
	60																	
60								CH										
		15			14				Soft gray clay with silt lenses	65	61.2	0.31	3.11	3	87	63		
	65																	
65																		
		15			15				Soft gray clay	60							0.32	
	70																	
70																		
		13			16				Medium gray clay with silt lenses	62	62.9	0.78	3.69	7	88	56		
	75																	
75																		

[1]Sample disturbed during extrusion.

Log of Boring B-13 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-4

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	80	17			17				Medium gray clay with silt lenses	65								
-80																		

[1]Sample disturbed during extrusion.

Log of Boring B-13 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-4

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/19/2011	End 8/19/2011	Total Depth (ft)	80	Logged By / Checked By	DAS / VT	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
Surface Elevation (ft) Vertical Datum	1.0		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Marsh Buggy-Mounted Drill Rig				
Latitude / Longitude	N29° 18' 03.3" / W89° 28' 05.9"		System Datum	Geographic NAD83 (feet)	Groundwater	Date Measured: 8/19/2011	Depth to Water (ft): 0.0	Elevation (ft): 1.0		

Notes: See Figure A-1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
0								Zero (feet) at water surface									
								Mudline at EL. -1 foot									
		23			1		OH	Very soft gray organic clay	294	16.1	0.10	0.06	12	141	109	0.074	
		24			2			Very soft gray organic clay	175	27.4	0.05	0.17	12	142	111	0.072	
5		17			3		CH	Very soft gray clay	44	69.1	0.11	0.17	15			0.124	
		24			4		CL	Very soft gray silty clay with organic matter	44	77.8	0.12	0.40	14	37	16	0.115	
10		22			5			Very soft gray silty clay with 2" silt layer at bottom	51	75.6	0.15	0.52	15	36	14		
15		23			6			Very soft gray clay with silt, organic matter and 3" silt layer at bottom	43	83.2	0.13	0.81	15	44	20		
							CH										
20		22			7			Very soft gray clay with 5" silt layer at bottom	44					50	28		
25		20			8			Very soft gray clay with shell fragments	88	51.4	0.13	1.38	15	78	51	0.293	
30		21			9			Very soft gray clay with shell traces and organic matter	87	54.1	0.16	1.67	15	70	45	0.128	
35																	

[1]Sample disturbed during extrusion.

Log of Boring B-14

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-01

Figure B-5
Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
-35	35	23			10				Very soft gray clay with 1" and 3" clayey silt layers and shell fragments	43	72.7	0.19	1.96	5	82	56	0.117	
-40	40	23			11				Very soft gray clay with wood	85	53.3	0.16	2.25	13			0.142	
-45	45	22			12				Very soft gray clay	88	51.4	0.12	2.53	14	92	65	0.171	
-50	50	22			13				Very soft gray clay with 2½" clayey silt layer	65	60.7	0.15	2.82	12	74	50	0.153	
-55	55	23			14				Very soft gray clay with silt lenses	66	59.5	0.13	3.11	15	77	50	0.149	
-60	60	22			15				Very soft gray clay	85	52	0.21	3.40	13			0.119	
-65	65	22			16				Soft gray clay with 2" fine sand layer	68	60.7	0.39	3.69	8			0.214	
-70	70	23			17				Soft gray clay with 1½" fine sand layer	68					74	47	0.205	
-75	75	22			18				Very soft gray clay with 1" fine sand layer at bottom	76					93	60		

[1]Sample disturbed during extrusion.

Log of Boring B-14 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-5

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
		20			19				Very soft gray clay with silt streaks, silt pockets, and 2 x 1" clayey silt layers	54	66.2	0.17	4.44	15			0.201	
	80																	
-80																		

[1]Sample disturbed during extrusion.

Log of Boring B-14 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-5

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/23/2011	End 8/24/2011	Total Depth (ft)	80	Logged By / Checked By	DAS / VT	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
Surface Elevation (ft) / Vertical Datum	1.0		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Pontoon-Mounted Drill Rig				
Latitude / Longitude	N29° 18' 10.4" / W89° 28' 24.1"		System Datum	Geographic NAD83 (feet)	Groundwater	Date Measured: 8/23/2011	Depth to Water (ft): 0.0	Elevation (ft): 1.0		

Notes: See Figure A-1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
0									Zero (feet) at water surface									
5																		
10																		
15									Mudline at EL. -15 feet									
		9						CL-ML	Firm gray clayey silt with 2½" fine sand layer	41	89.3	0.42	0.06	12	26	7	0.043	
		9.5						CL	Very soft gray clay with silt	35	83	0.16	0.17	12	44	23	0.196	
20		19							Very soft gray silty clay	33	85.2	0.23	0.29	15	35	15	0.077	
		8						CH	Very soft gray clay with silt lenses and 2" clayey silt layer	44	70	0.18	0.40	11	77	47	0.201	
		13							Soft gray clay with shell fragments						81	52	0.169	
25																		
		15							Very soft gray clay	69	59.2	0.23	0.75	15	78	53	0.133	
30																		
								CL										
		15							Very soft gray silty clay with two 1" clay layers	32	85.7	0.25	1.04	15	41	21		
35																		

[1]Sample disturbed during extrusion.

Log of Boring B-15

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-01

Figure B-6
Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35																	
-35																		
		10.5							Very soft gray very silty clay with three ½" clay layers	39	84.6	0.31	1.32	14	32	12		
	40																	
-40																		
								CH										
		18							Soft gray clay	76	60	0.39	1.61	8	74	46	0.383	
	45																	
-45																		
		17							Soft gray clay	59	60.9	0.29	1.90	13	74	40	0.273	
	50																	
-50																		
		9.5							Soft gray clay	57	68.1	0.35	2.19	15	74	45	0.455	
	55																	
-55																		
		9							Soft gray clay	56					78	51	0.334	
	60																	
-60																		
		20							Soft gray clay	53	68	0.34	2.76	15	76	52	0.352	
	65																	
-65																		
		10.5							Medium gray clay	50	69.1	0.63	3.05	11	80	52	0.536	
	70																	
-70																		
		20							Medium gray clay	56					81	57		
	75																	
-75																		

[1]Sample disturbed during extrusion.

Log of Boring B-15 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-6

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
		10							Medium gray clay						76	46		
	80																	
-80																		

[1]Sample disturbed during extrusion.

Log of Boring B-15 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-6

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/23/2011	End 8/23/2011	Total Depth (ft)	80	Logged By / Checked By	DAS / VT	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
Surface Elevation (ft) / Vertical Datum	1.0				Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Pontoon-Mounted Drill Rig		
Latitude / Longitude	N29° 17' 41.6" / W89° 28' 15.5"				System Datum	Geographic NAD83 (feet)	Groundwater	Date Measured: 8/23/2011	Depth to Water (ft): 0.0	Elevation (ft): 1.0

Notes: See Figure A-1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (feet) at water surface									
0																			
	5																		
-5																			
										Mudline at EL. -9 feet									
	10		16						CH	Very soft gray clay with silt lenses and organic matter	65	61.9	0.20	0.06	14	62	40	0.183	
-10			15							Very soft gray clay with organic matter	65	60.6	0.12	0.17	15	72	46	0.133	
			9.5						CL	Very soft gray very silty clay with 2" silt layer and organic matter	37	85.9	0.22	0.29	12	32	12	0.068	
	15		10.5							Very soft gray silty clay with 1" silt layer and organic matter	40	88.3	0.21	0.40	15	37	16	0.092	
-15			10							Very soft gray very silty clay with organic matter	46	87.7	0.20	0.52	15	30	11	0.054	
	20																		
-20																			
			8							Very soft gray silty clay with 1" and ½" clay layers	36	79.4	0.19	0.81	14	40	23		
	25																		
-25																			
									CH										
			12							Soft gray clay with silt lenses and organic matter	69	60.7	0.36	0.92	13	79	53	0.205	
	30																		
-30																			
			16							Soft gray clay with silt lenses	66	60.8	0.27	1.39	14	82	51	0.201	
	35																		

[1]Sample disturbed during extrusion.

Log of Boring B-16

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-01

Figure B-7
Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
-35	35																	
		10							Very soft gray clay with silt lenses	71	63.1	0.20	1.67	15	79	53	0.261	
-40	40																	
		11							Soft gray clay	58	68.7	0.38	1.96	12	82	52		
-45	45																	
		15							Soft gray clay	44	74.1	0.31	2.25	15	79	55	0.288	
-50	50																	
		18							Soft gray clay	53	68.4	0.37	2.53	14	79	56	0.214	
-55	55																	
		18							Soft gray clay	59	64.8	0.31	2.82	15	79	51	0.198	
-60	60																	
		17							Soft gray clay with silt lenses	66	61.7	0.31	3.11	15			0.291	
-65	65																	
		18							Soft gray clay	65					85	53	0.527	
-70	70																	
		15							Soft gray clay with silt lenses	60					82	52	0.433	
-75	75																	

[1]Sample disturbed during extrusion.

Log of Boring B-16 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-7

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	80	10							Soft gray clay	53	67.8	0.44	3.97	11			0.435	

[1]Sample disturbed during extrusion.

Log of Boring B-16 (continued)

GeoEngineers

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-7

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/22/2011	End 8/22/2011	Total Depth (ft)	80	Logged By	DAS	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
					Checked By	VT				

Surface Elevation (ft) Vertical Datum	1.0	Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Pontoon-Mounted Drill Rig
Latitude Longitude	N29° 17' 19.7" W89° 28' 08.1"	System Datum	Geographic NAD83 (feet)	Groundwater	

Date Measured	Depth to Water (ft)	Elevation (ft)
8/22/2011	0.0	1.0

Notes: See Figure A-1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (feet) at water surface									
0																			
	5																		
-5																			
	10																		
-10																			
	15																		
-15										Mudline at -19 feet									
	20		10			1			OH	Very soft gray organic clay with shell fragments	83	51.8	0.23	0.06	13	101	73	0.185
-20			18			2				Very soft gray organic clay with silt and shell fragments	85	51.1	1.20	0.16	12	97	69	0.176
			18			3				Very soft gray clay with shell fragments and organic matter	79	55.3	0.18	0.29	15	86	60	0.169
	25																		
-25			20			4				Very soft gray clay with organic matter and shell fragments	78	53.5	0.12	0.40	8	82	54	0.117
			13			5			CH	Very soft gray clay with silt streaks and pockets	67	60.2	0.11	0.52	13	68	44	0.131
	30																		
-30																			
			14			6				Very soft gray clay	77	55.5	0.14	0.81	15	82	51	0.124
	35																		

[1]Sample disturbed during extrusion.

Log of Boring B-17

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-01

Figure B-8
Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
-35	35																	
		11			7				Very soft gray clay with silt lenses	70	62.2	0.23	1.10	11	64	40	0.119	
-40	40																	
		13			8				Soft gray clay with silt lenses	59	63.8	0.30	1.39	12	73	45	0.221	
-45	45																	
		11			9				Soft gray clay with silt lenses and pockets	61	65.4	0.27	1.67	14	59	34	0.288	
-50	50																	
		15			10				Soft gray clay with silt lenses	60					77	49	0.297	
-55	55																	
		15			11				Soft gray clay with silt lenses	65	64	0.33	2.25	12	83	59	0.331	
-60	60																	
		13			12				Medium gray clay with silt lenses	59	69.2	0.55	2.53	14	76	51	0.401	
-65	65																	
		17			13				Soft gray clay with silt lenses	52					67	41	0.352	
-70	70																	
		13			14				Medium gray clay	59	65.2	0.60	3.11	7	87	56		
-75	75																	

[1]Sample disturbed during extrusion.

Log of Boring B-17 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-8

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	80	16			15				Medium gray clay with silt lenses	60					84	51		

[1]Sample disturbed during extrusion.

Log of Boring B-17 (continued)

GeoEngineers

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-8

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Drilled	Start 8/23/2011	End 8/23/2011	Total Depth (ft)	80	Logged By / Checked By	DAS / VT	Driller	Geoengineers, Inc.	Drilling Method	Wet Rotary
Surface Elevation (ft) / Vertical Datum	1.0		Hammer Data	Safety Hammer/Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	Pontoon-Mounted Drill Rig				
Latitude / Longitude	N29° 17' 34.2" / W89° 28' 12.2"		System Datum	Geographic NAD83 (feet)	Groundwater	Date Measured: 8/23/2011	Depth to Water (ft): 0.0	Elevation (ft): 1.0		

Notes: See Figure A-1 for explanation of symbols.
Cement-bentonite grout backfill top 25 feet.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (feet) at water surface									
0																			
	5																		
-5																			
	10																		
-10																			
	15									Mudline at EL. -15									
-15			12			1			CH	Very soft gray clay with organic matter and silt lenses	60	63.6	0.18	0.58	11	75	52	0.178	
			15			2				Very soft gray clay with organic matter and silt streaks	76	57.9	0.21	0.17	7	74	44	0.284	
	20		16			3				Very soft gray clay with organic matter, silt streaks and shell fragments	70	58.9	0.16	0.29	13	75	50	0.207	
-20			17			4				Very soft gray clay with 5" sand layer	74	57.9	0.17	0.40	15	76	51		
			10			5				Very soft gray clay	80	56.9	0.20	0.52	15	70	43		
	25																		
-25									CL-ML										
			20			6				Firm gray clayey silt with 2½" clay layer	31	93.9	0.49	0.75	6	23	5	0.459	
	30																		
-30									OH										
			22			7				Very soft gray organic clay with silt lenses	96	47.2	0.13	1.04	13	91	69	0.21	
	35																		

[1]Sample disturbed during extrusion.

Log of Boring B-18

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures
Project Location: Plaquemines Parish, Louisiana
Project Number: 16715-018-01

Figure B-9
Sheet 1 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	35																	
-35								CH										
		17			8				Soft gray clay with silt pockets	61	61.1	0.27	1.32	13	82	51	0.238	
	40																	
-40																		
		22			9				Soft gray clay	60	61.9	0.27	1.61	15	83	56	0.318	
	45																	
-45																		
		19			10				Soft gray clay	50	72.2	0.40	1.90	15	72	48	0.428	
	50																	
-50																		
		23			11				Soft gray clay	49	70.1	0.49	2.19	15			0.354	
	55																	
-55																		
		22			12				Soft gray clay	48					73	48	0.385	
	60																	
-60																		
		22			13				Soft gray clay	51					69	44	0.444	
	65																	
-65																		
		19			14				Soft gray clay	65	63.5	0.31	3.05	15	67	40	0.282	
	70																	
-70																		
		23			15				Medium gray clay	55	67.1	0.64	3.34	10	73	43	0.778	
	75																	
-75																		

[1]Sample disturbed during extrusion.

Log of Boring B-18 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-9

Sheet 2 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA: Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	Mini Vane Shear Strength (KSF)	Passing No. 200 Sieve, %
	80	23			16				Medium gray clay with sand pockets	56					86	57	0.615	

[1]Sample disturbed during extrusion.

Log of Boring B-18 (continued)

GEOENGINEERS

Project: Grand Liard Marsh and Ridge Restoration (BA-68) - Structures

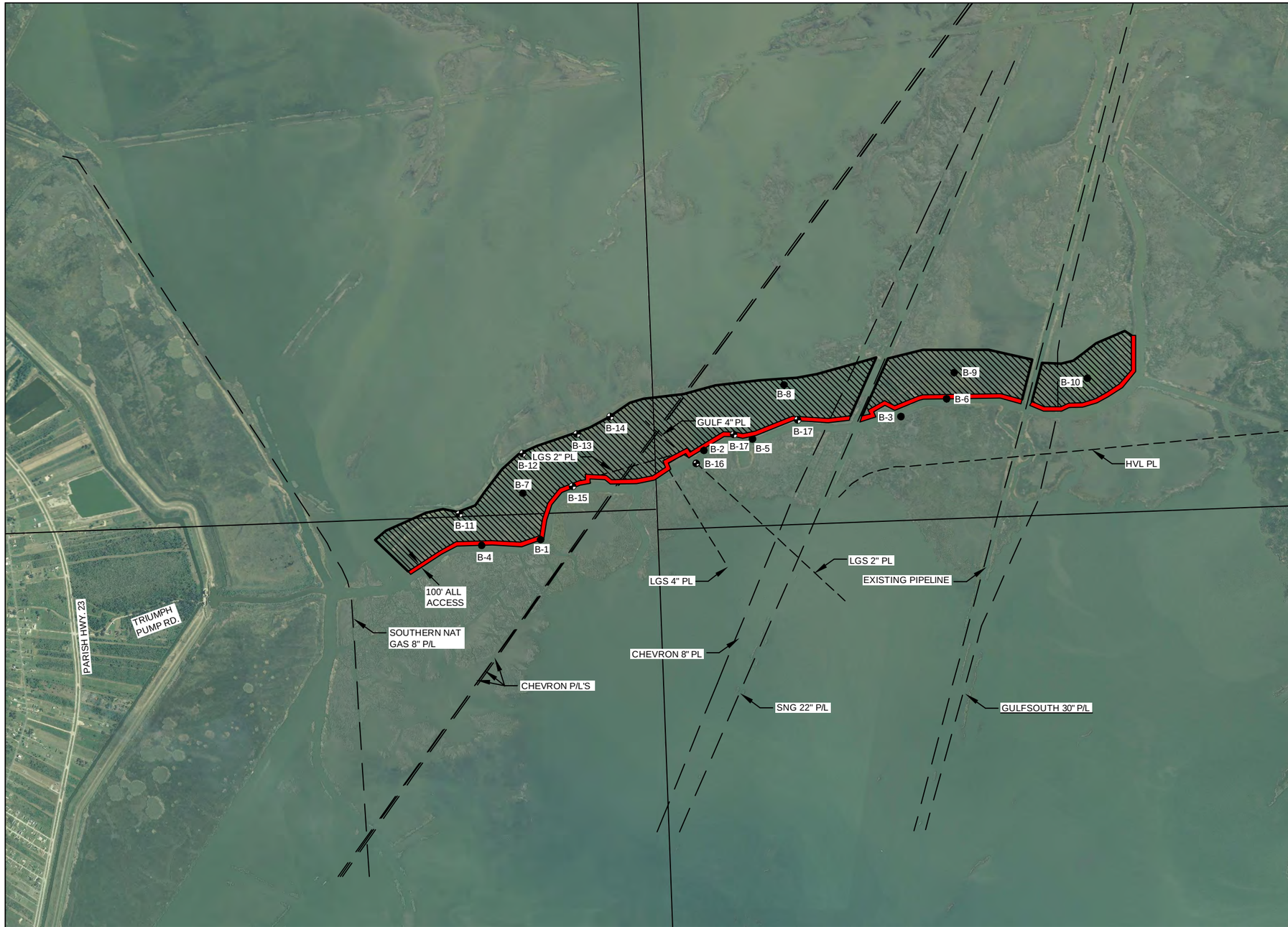
Project Location: Plaquemines Parish, Louisiana

Project Number: 16715-018-01

Figure B-9

Sheet 3 of 3

Baton Rouge: Date:10/4/11 Path:P:\16\16715\018\01\GINT\GRAND LIARD MARSH RIDGE RESTORATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB



BOREHOLE LOCATION

B-11	N29 18' 35.8"	W89 28' 30.2"
B-12	N29 18' 21.4"	W89 28' 14.9"
B-13	N29 18' 10.4"	W89 28' 10.8"
B-14	N29 18' 03.3"	W89 28' 05.9"
B-15	N29 18' 10.4"	W89 28' 24.1"
B-16	N29 17' 41.6"	W89 28' 15.5"
B-17	N29 17' 19.7"	W89 28' 08.1"
B-18	N29 17' 34.2"	W89 28' 12.2"

LEGEND

- B-1 — Borehole Location (From Previous Report)
- B-11 — Borehole Location (Proposed Location of Structures)
- Proposed Ridge Restoration
- Proposed Marsh Creation
- Proposed Earthen Containment Dike

N W E S

2500 0 2500
FEET

Notes:
1. The locations of all features shown are approximate.

Reference: 1. Aerial image taken from USGS, USGS High Resolution State Orthoimagery for the Louisiana Coastal Area, Dated 10/18/2008
2. Ridge Restoration and Marsh Creation Outlines provided by USGS, Grand Liard Marsh and Restoration (PPl18 Candidate), Dated 9/18/2008
3. Approximate location of existing pipelines taken from information provided by Sigma Consulting Group, Magnetometer Survey, Bayou Grand Liard Field, Plaquemines Paris, Dated 8/27/2010

SITE PLAN WITH SOIL BORING LOCATIONS

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

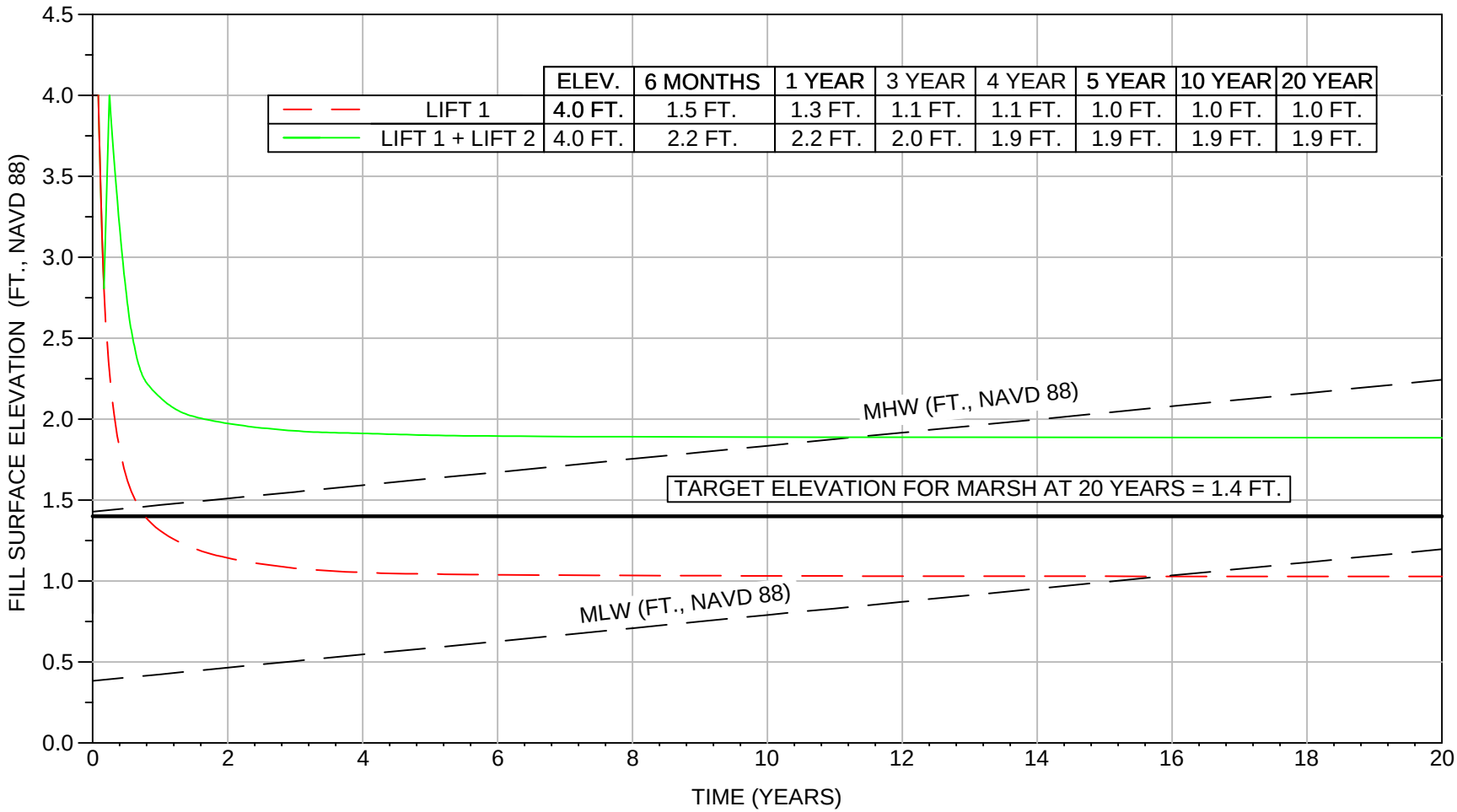
Figure 2

DPS : KMC

P:\16\1671501801\01\CAD\boring location plan.dwg\TAB:Layout1 modified on Oct 04, 2011 - 8:51am

Appendix E

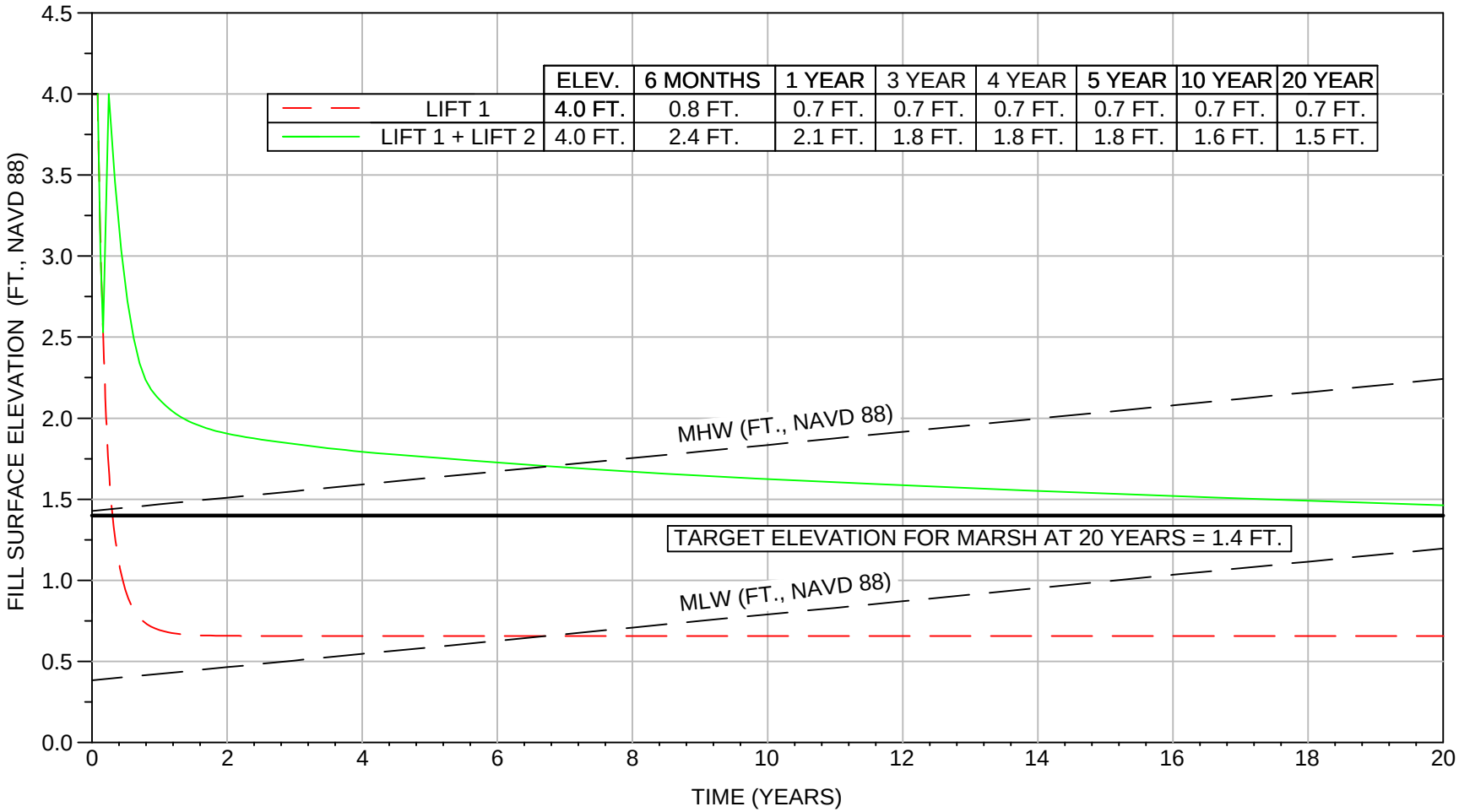
Marsh Fill Settlement Curves



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	1.5 FT.	1.3 FT.	1.1 FT.	1.1 FT.	1.0 FT.	1.0 FT.	1.0 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.2 FT.	2.2 FT.	2.0 FT.	1.9 FT.	1.9 FT.	1.9 FT.	1.9 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

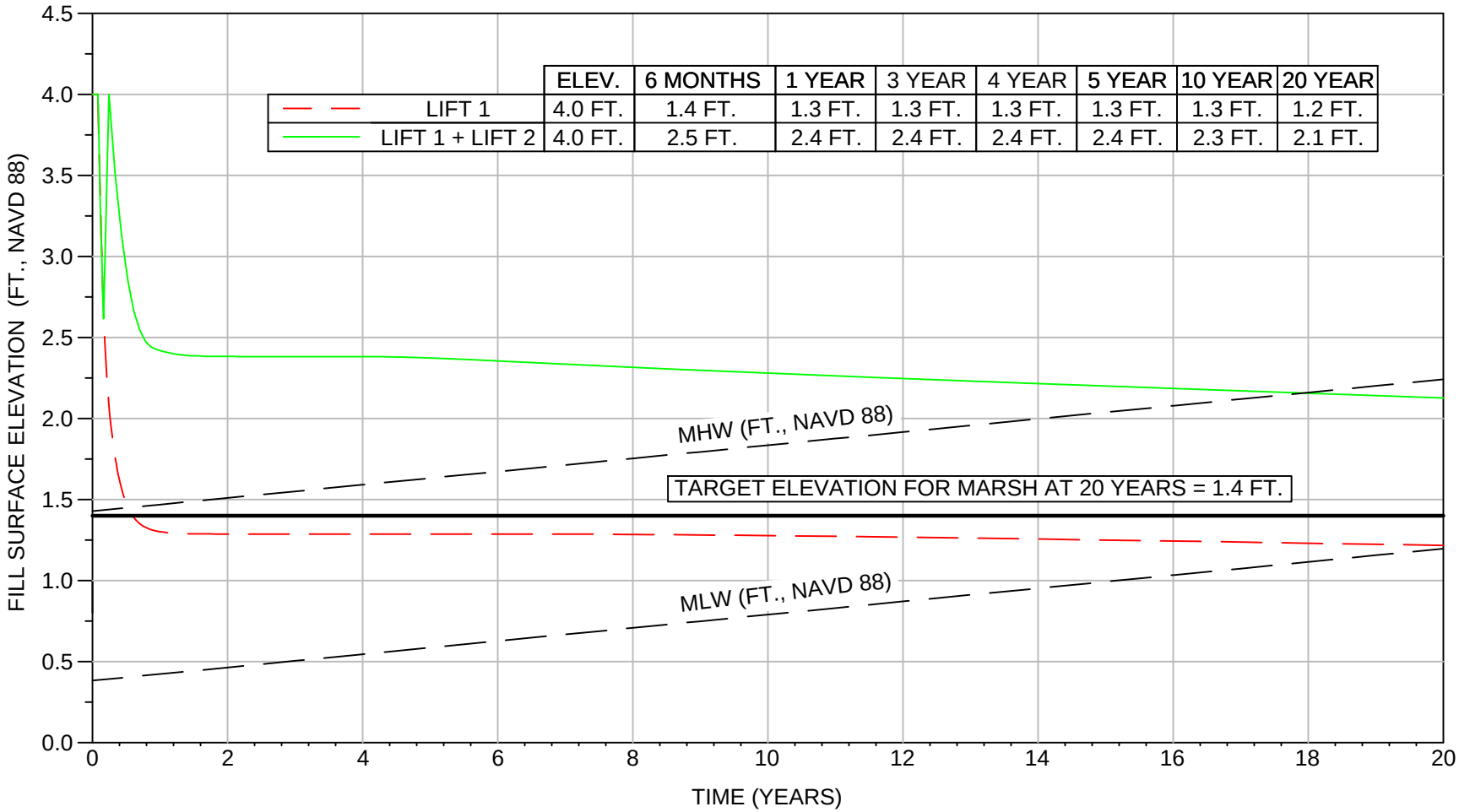
MARSH FILL SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A1**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	0.8 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.4 FT.	2.1 FT.	1.8 FT.	1.8 FT.	1.8 FT.	1.6 FT.	1.5 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

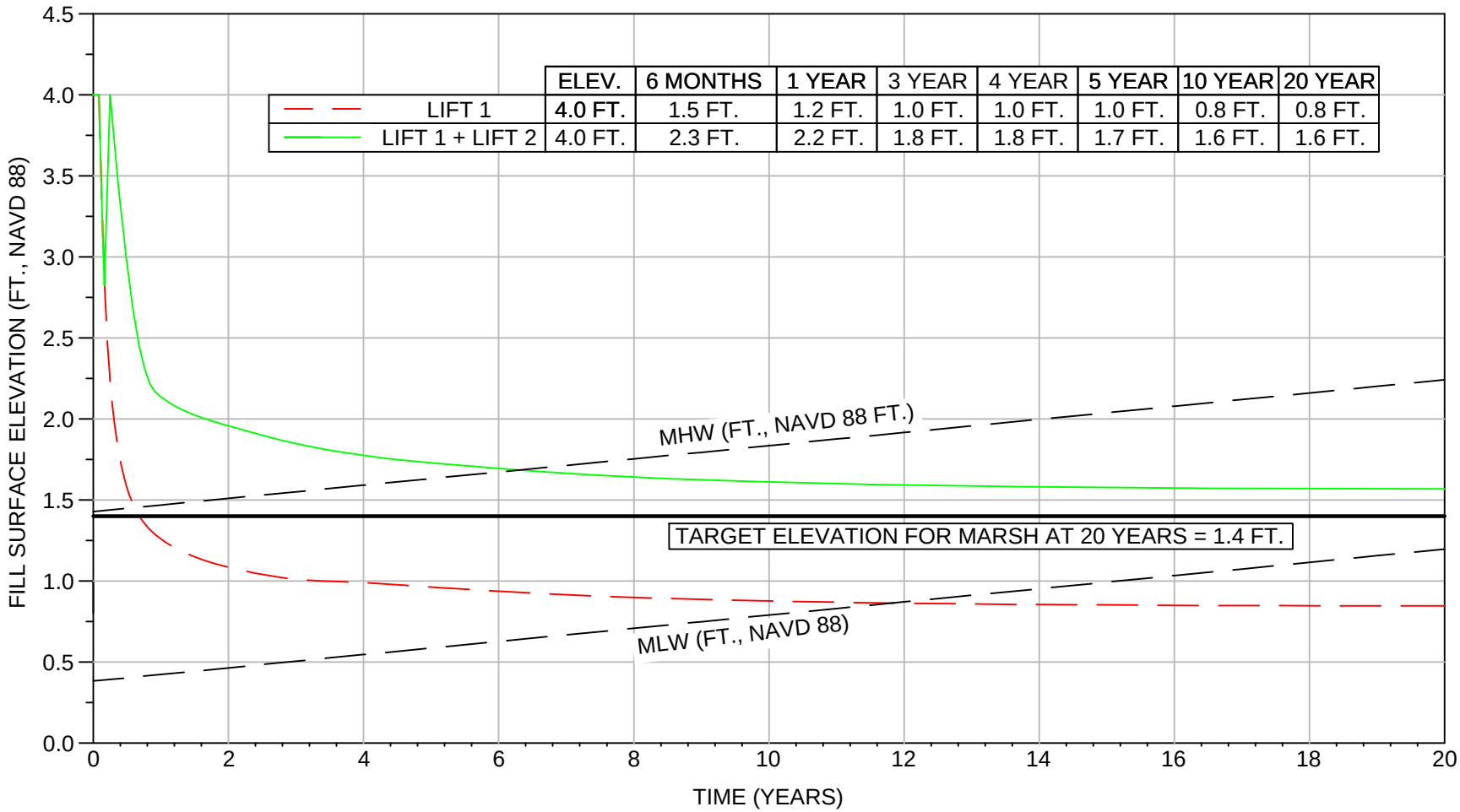
MARSH FILL SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A2**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	1.4 FT.	1.3 FT.	1.3 FT.	1.3 FT.	1.3 FT.	1.3 FT.	1.2 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.5 FT.	2.4 FT.	2.4 FT.	2.4 FT.	2.4 FT.	2.3 FT.	2.1 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

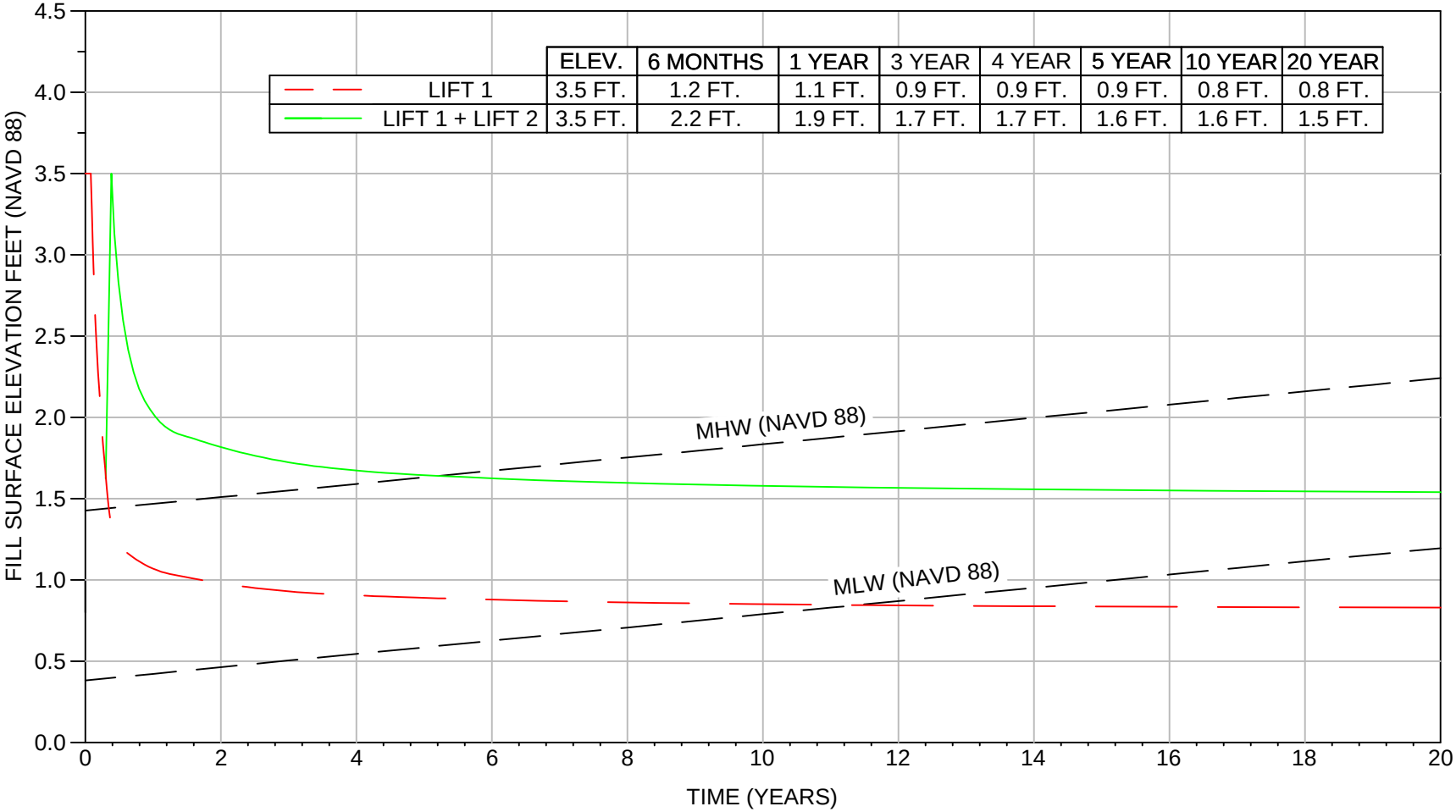
MARSH FILL SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A3**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	1.5 FT.	1.2 FT.	1.0 FT.	1.0 FT.	1.0 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.3 FT.	2.2 FT.	1.8 FT.	1.8 FT.	1.7 FT.	1.6 FT.	1.6 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

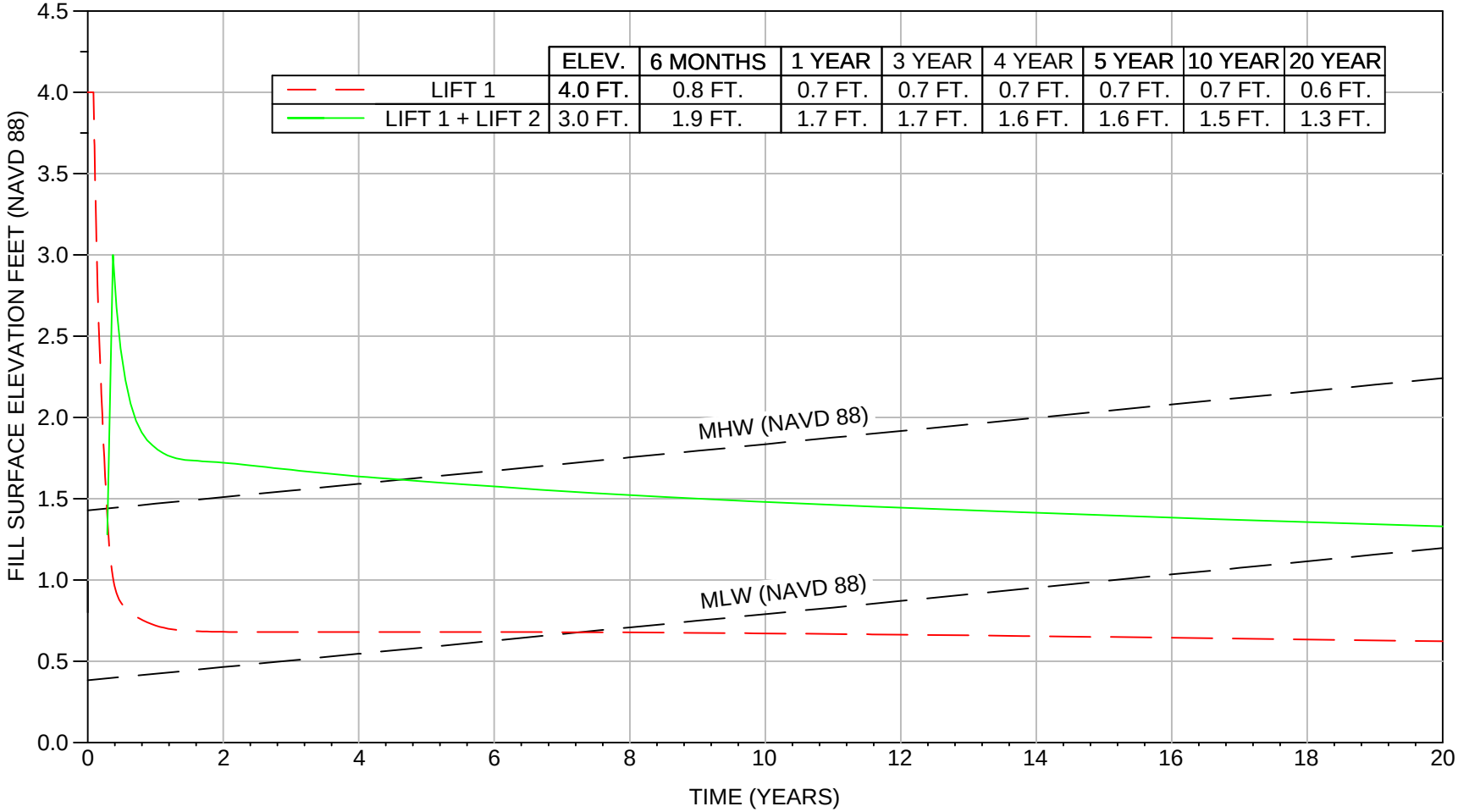
MARSH FILL SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A4**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.5 FT.	2.2 FT.	1.9 FT.	1.7 FT.	1.7 FT.	1.6 FT.	1.6 FT.	1.5 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 80 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

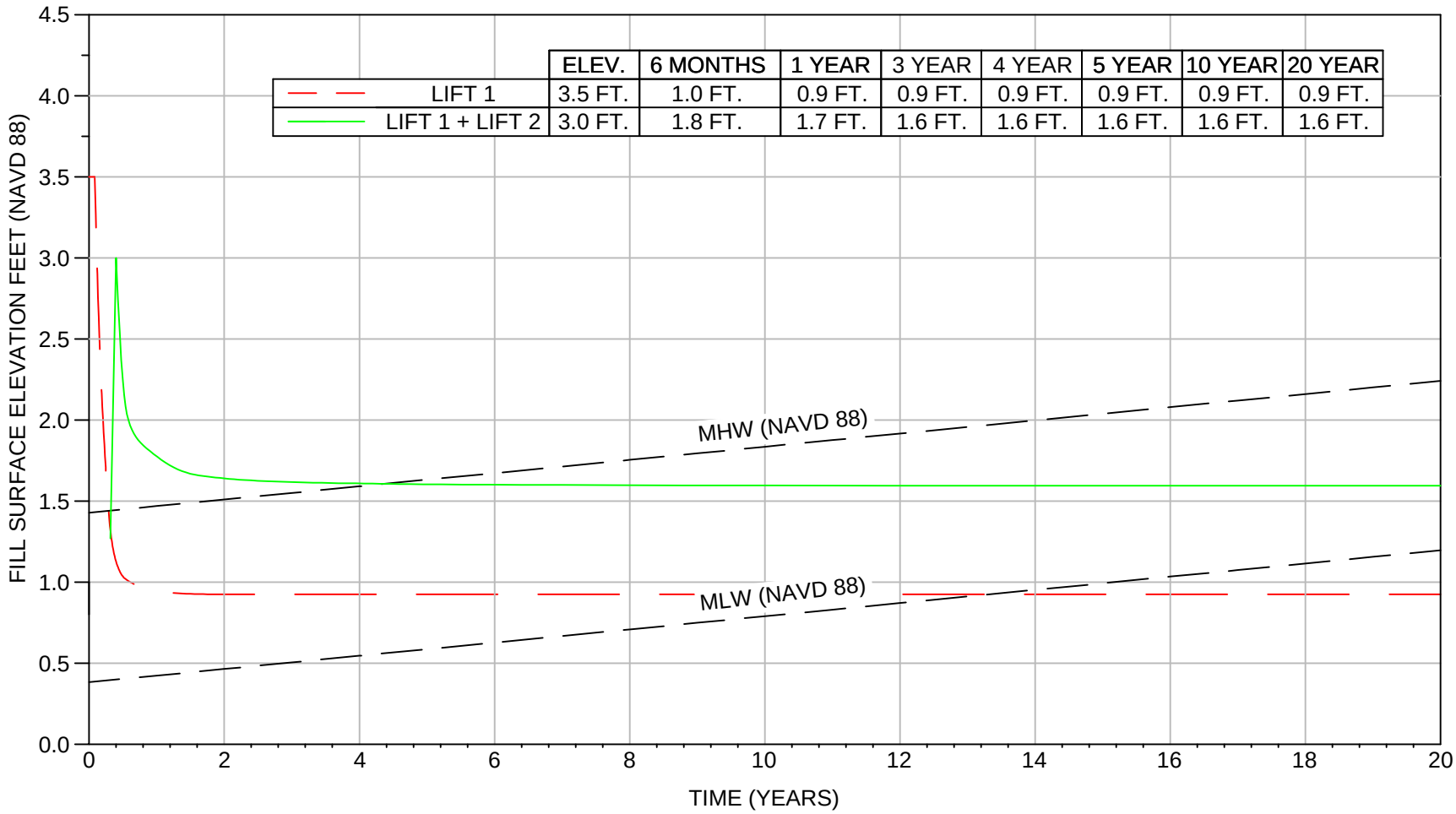
MARSH FILL SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A5**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	0.8 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.6 FT.
LIFT 1 + LIFT 2	3.0 FT.	1.9 FT.	1.7 FT.	1.7 FT.	1.6 FT.	1.6 FT.	1.5 FT.	1.3 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 75 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

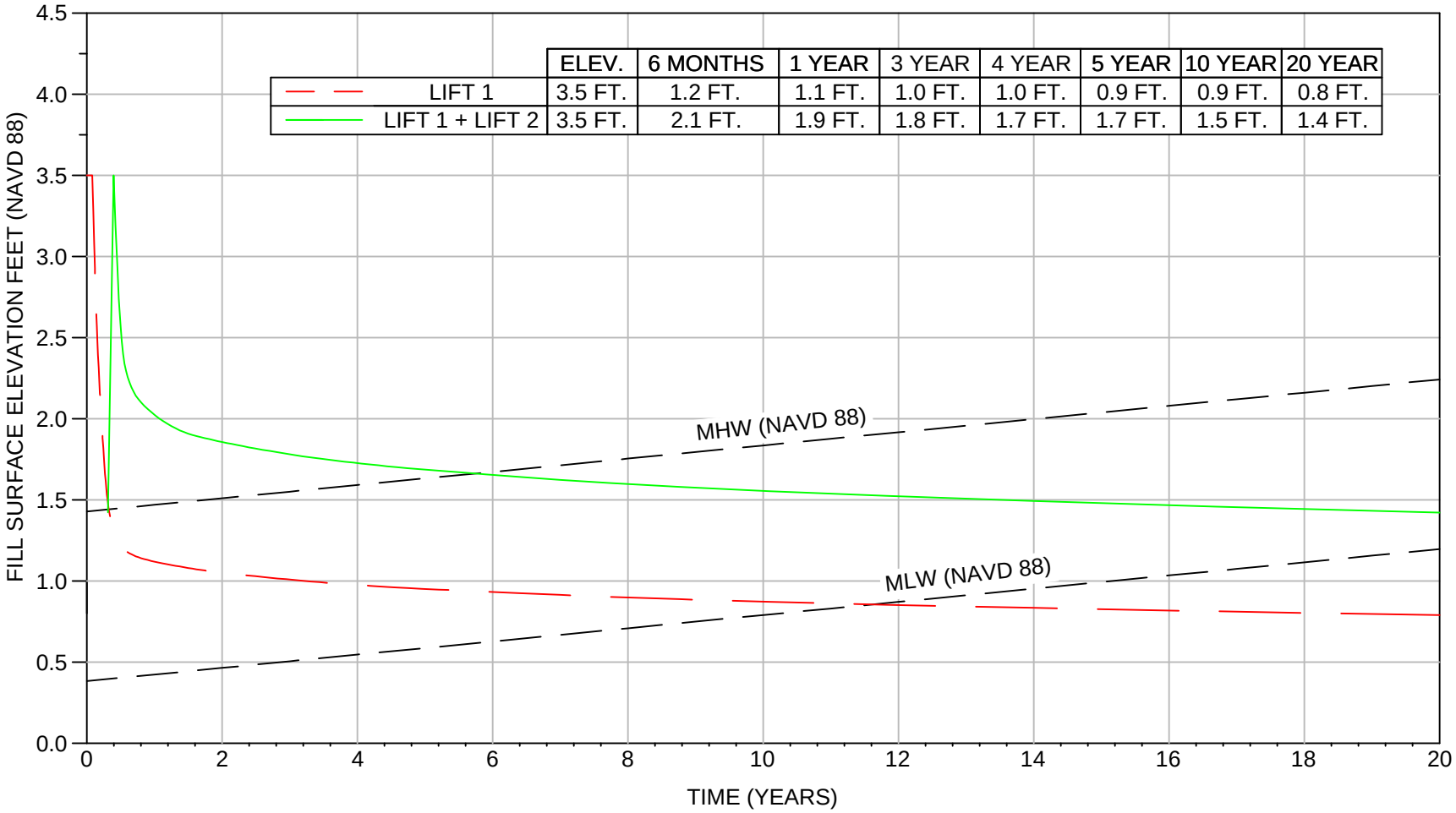
MARSH FILL SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A6**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.0 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.
LIFT 1 + LIFT 2	3.0 FT.	1.8 FT.	1.7 FT.	1.6 FT.	1.6 FT.	1.6 FT.	1.6 FT.	1.6 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

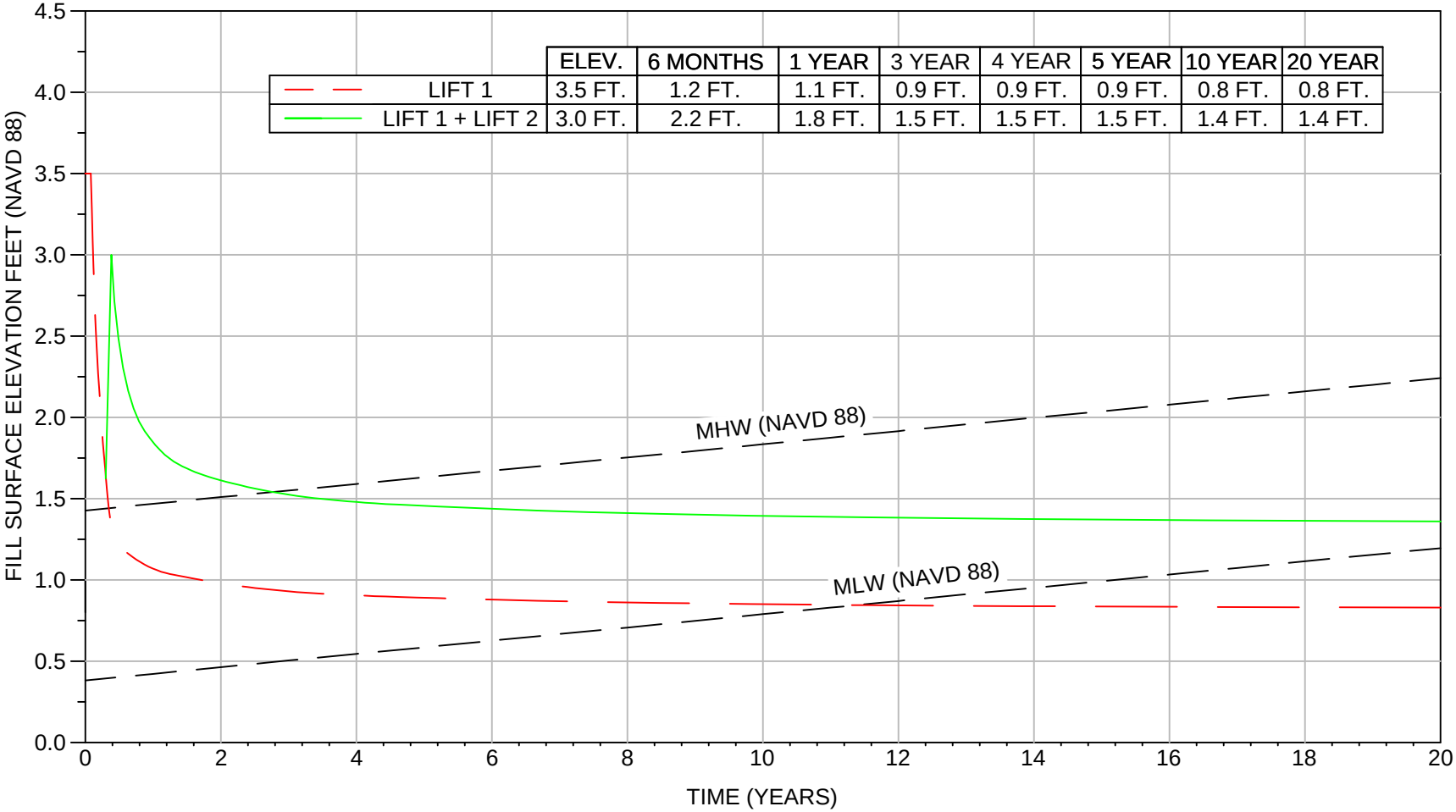
MARSH FILL SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A7**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	1.0 FT.	1.0 FT.	0.9 FT.	0.9 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.5 FT.	2.1 FT.	1.9 FT.	1.8 FT.	1.7 FT.	1.7 FT.	1.5 FT.	1.4 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

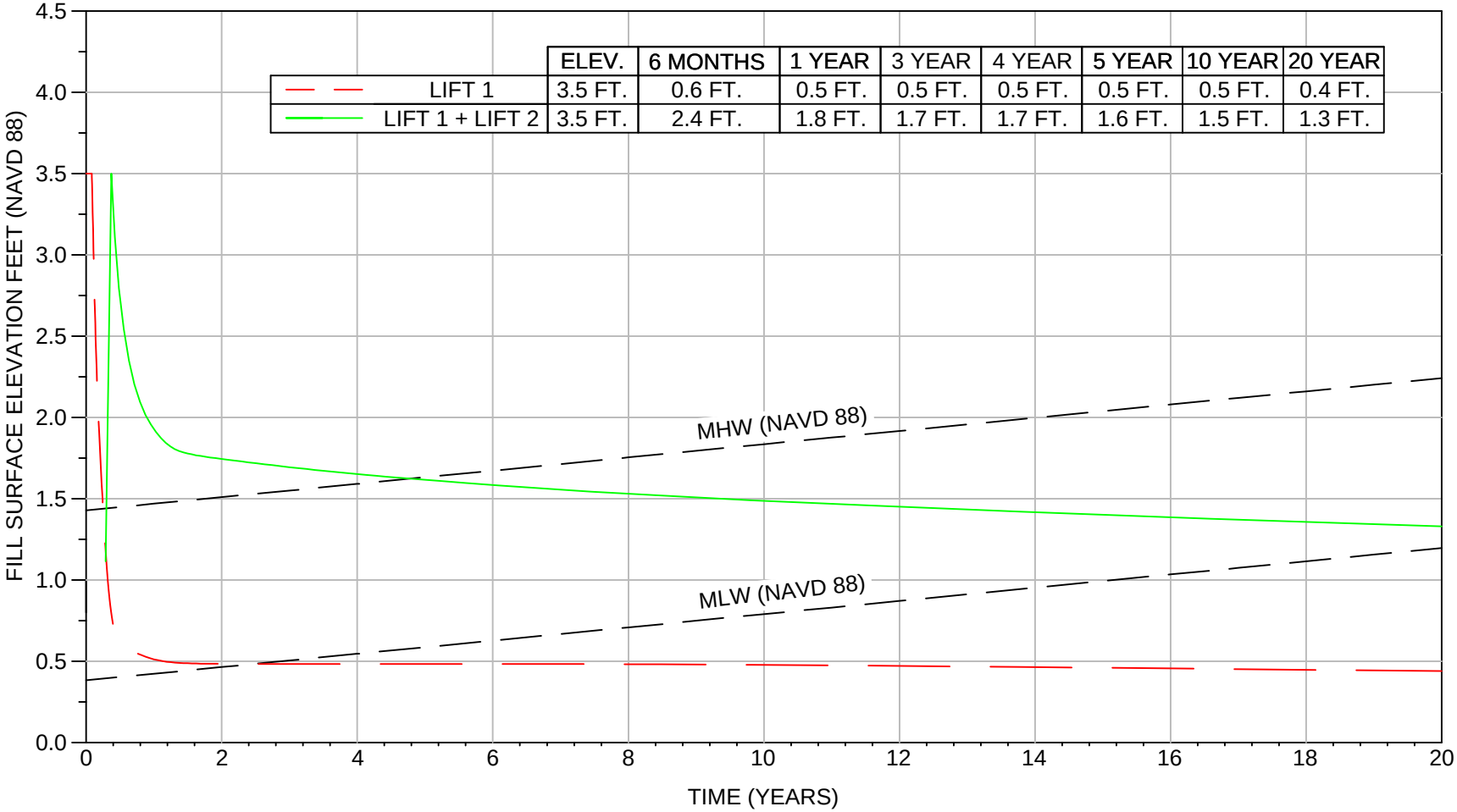
MARSH FILL SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A8**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.0 FT.	2.2 FT.	1.8 FT.	1.5 FT.	1.5 FT.	1.5 FT.	1.4 FT.	1.4 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 80 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

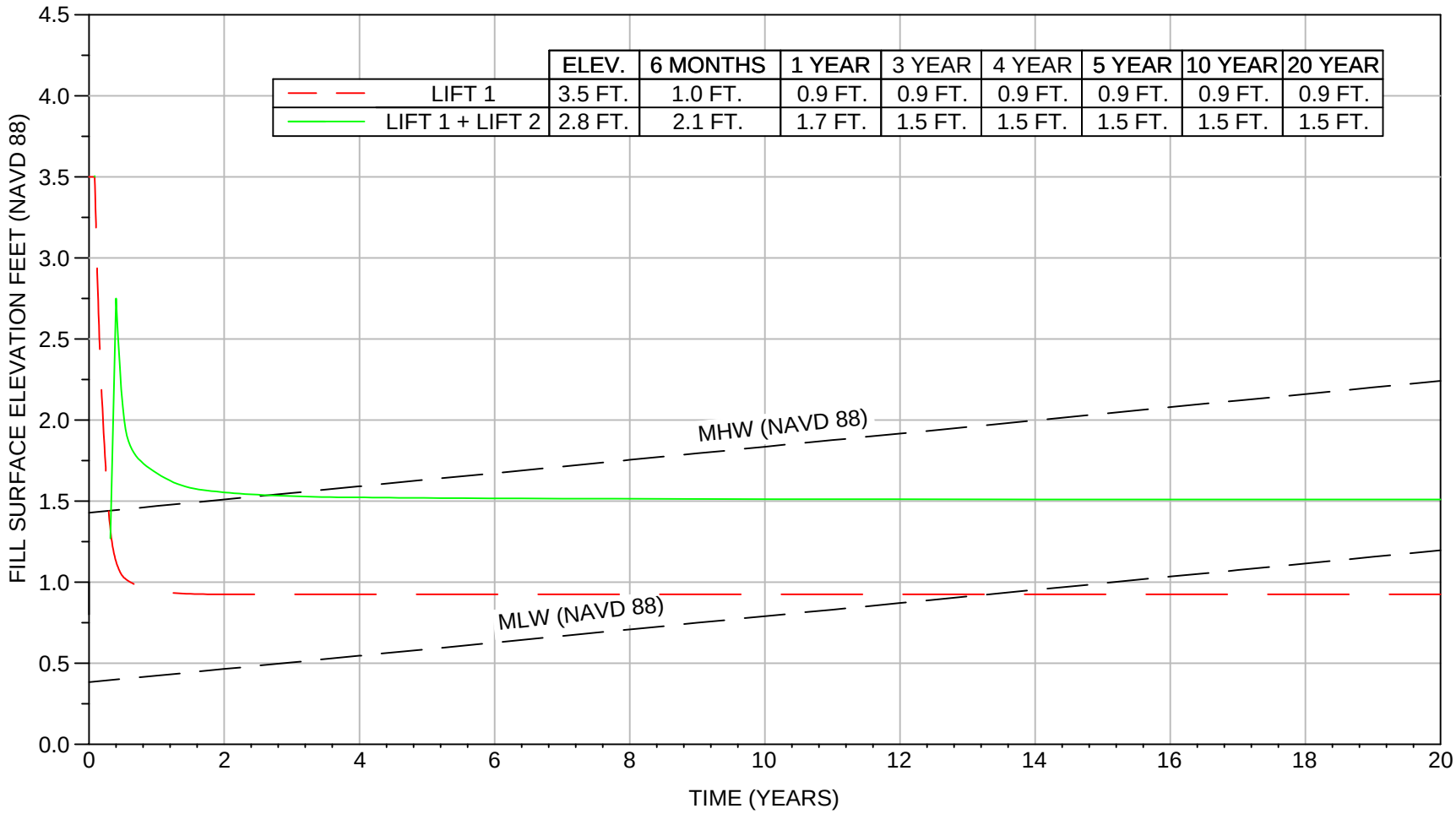
MARSH FILL SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A9**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	0.6 FT.	0.5 FT.	0.5 FT.	0.5 FT.	0.5 FT.	0.5 FT.	0.4 FT.
LIFT 1 + LIFT 2	3.5 FT.	2.4 FT.	1.8 FT.	1.7 FT.	1.7 FT.	1.6 FT.	1.5 FT.	1.3 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 75 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

MARSH FILL SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A10**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.0 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.
LIFT 1 + LIFT 2	2.8 FT.	2.1 FT.	1.7 FT.	1.5 FT.	1.5 FT.	1.5 FT.	1.5 FT.	1.5 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

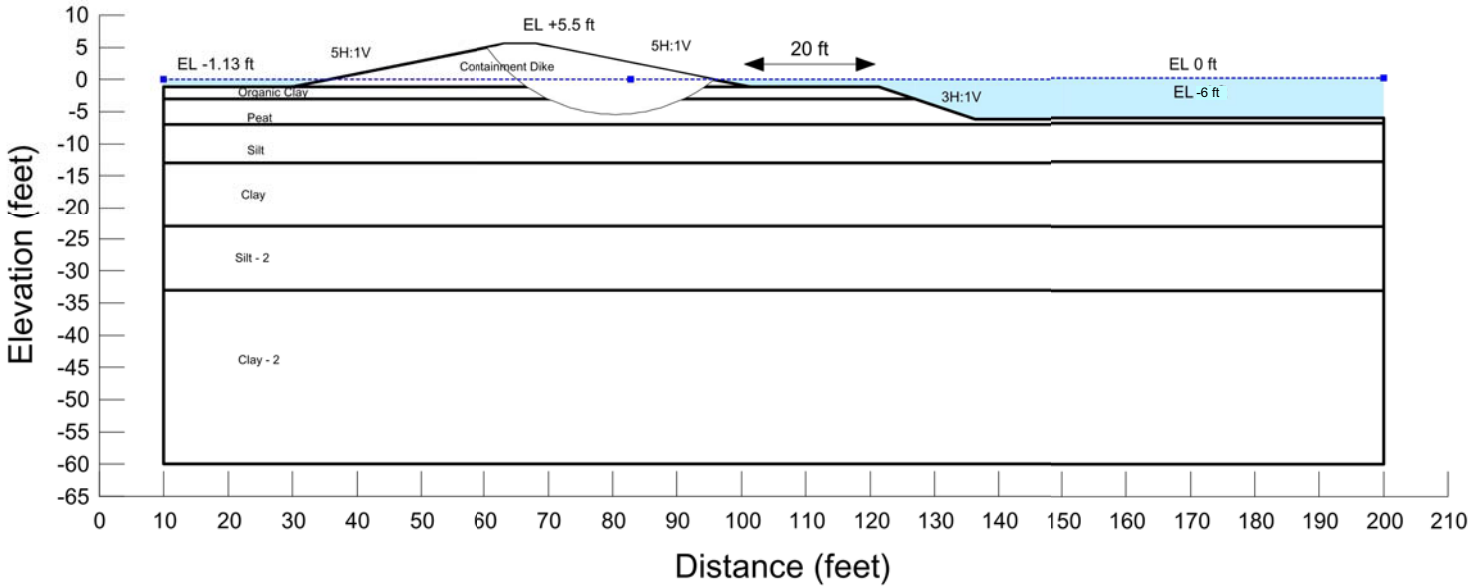
MARSH FILL SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A11**

Appendix F

Containment Cross-Sections and Settlement Curves

Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Silt Unit Weight: 112 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 95 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt - 2 Unit Weight: 104 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay - 2 Unit Weight: 104 pcf Cohesion: 200 psf Phi: 0 °

FOS: 1.54



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

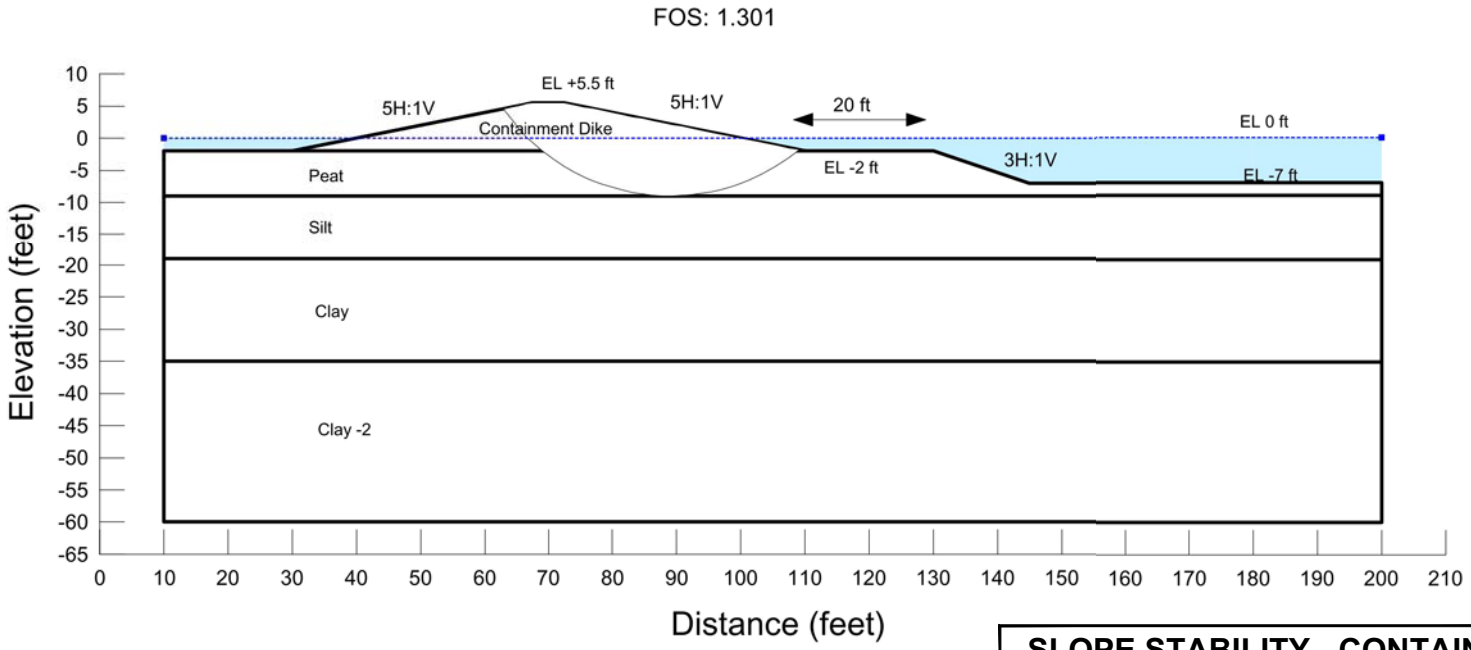
SLOPE STABILITY - CONTAINMENT DIKE - B-7

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-B1

Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Silt Unit Weight: 110 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Clay - 2 Unit Weight: 100 pcf Cohesion: 160 psf Phi: 0 °



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

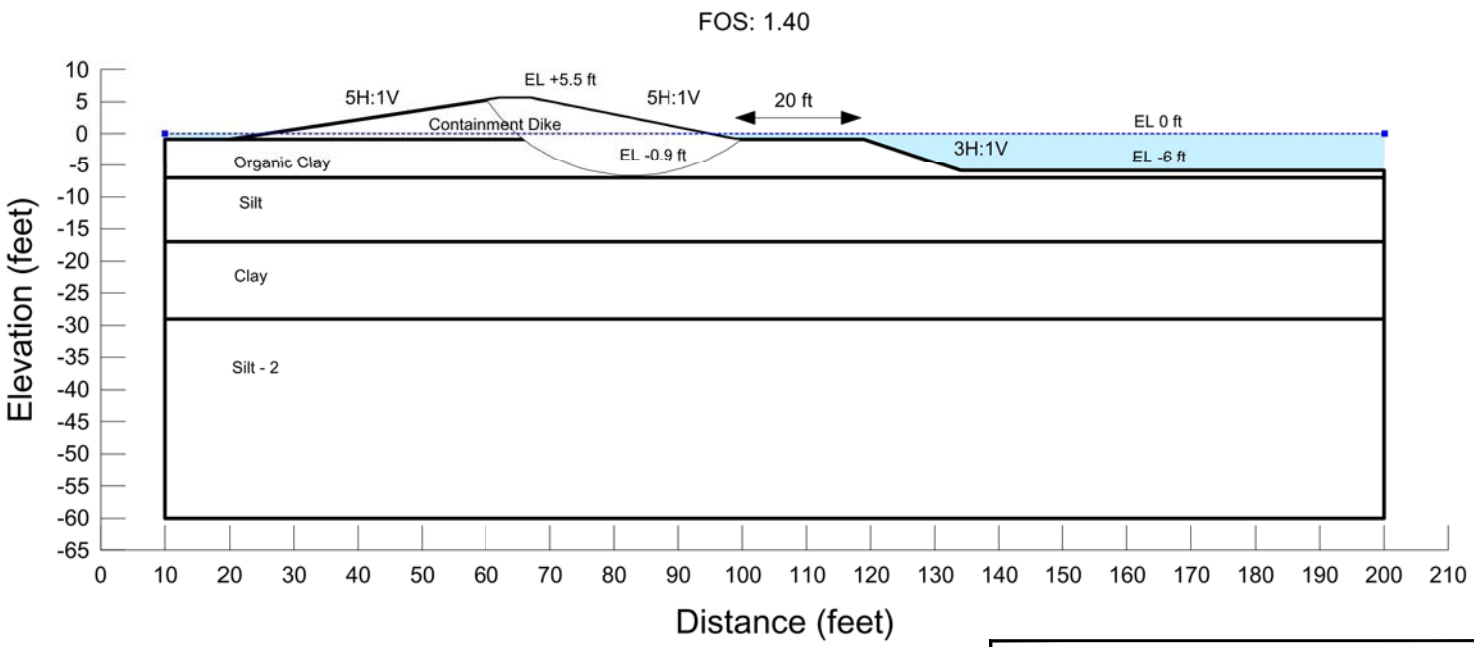
SLOPE STABILITY - CONTAINMENT DIKE - B-8

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-B2

Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 91 pcf Cohesion: 140 psf Phi: 0 °
Name: Silt - 2 Unit Weight: 115 pcf Cohesion: 100 psf Phi: 20 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 90 psf Phi: 0 °



SLOPE STABILITY - CONTAINMENT DIKE - B-9

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

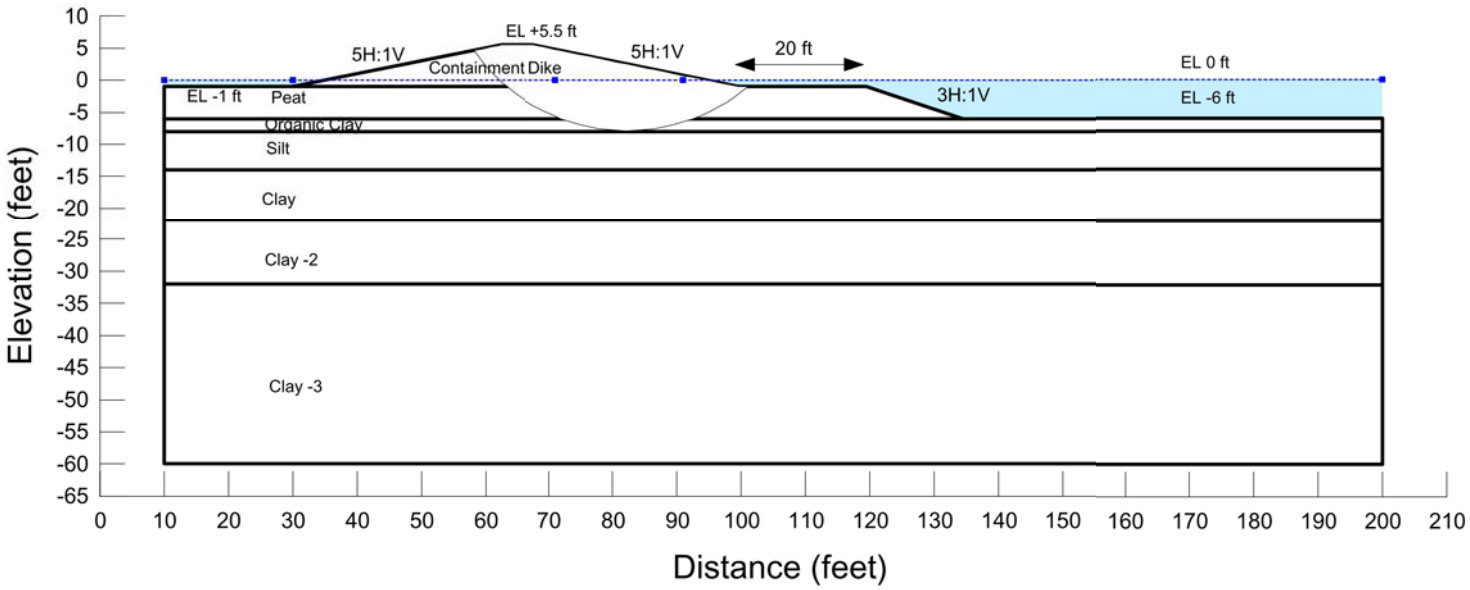
GEOENGINEERS

Figure II-B3

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Organic Clay Unit Weight: 83 pcf Cohesion: 90 psf Phi: 0 °
Name: Silt Unit Weight: 119 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 103 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay - 2 Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay - 3 Unit Weight: 102 pcf Cohesion: 170 psf Phi: 0 °

FOS: 1.37



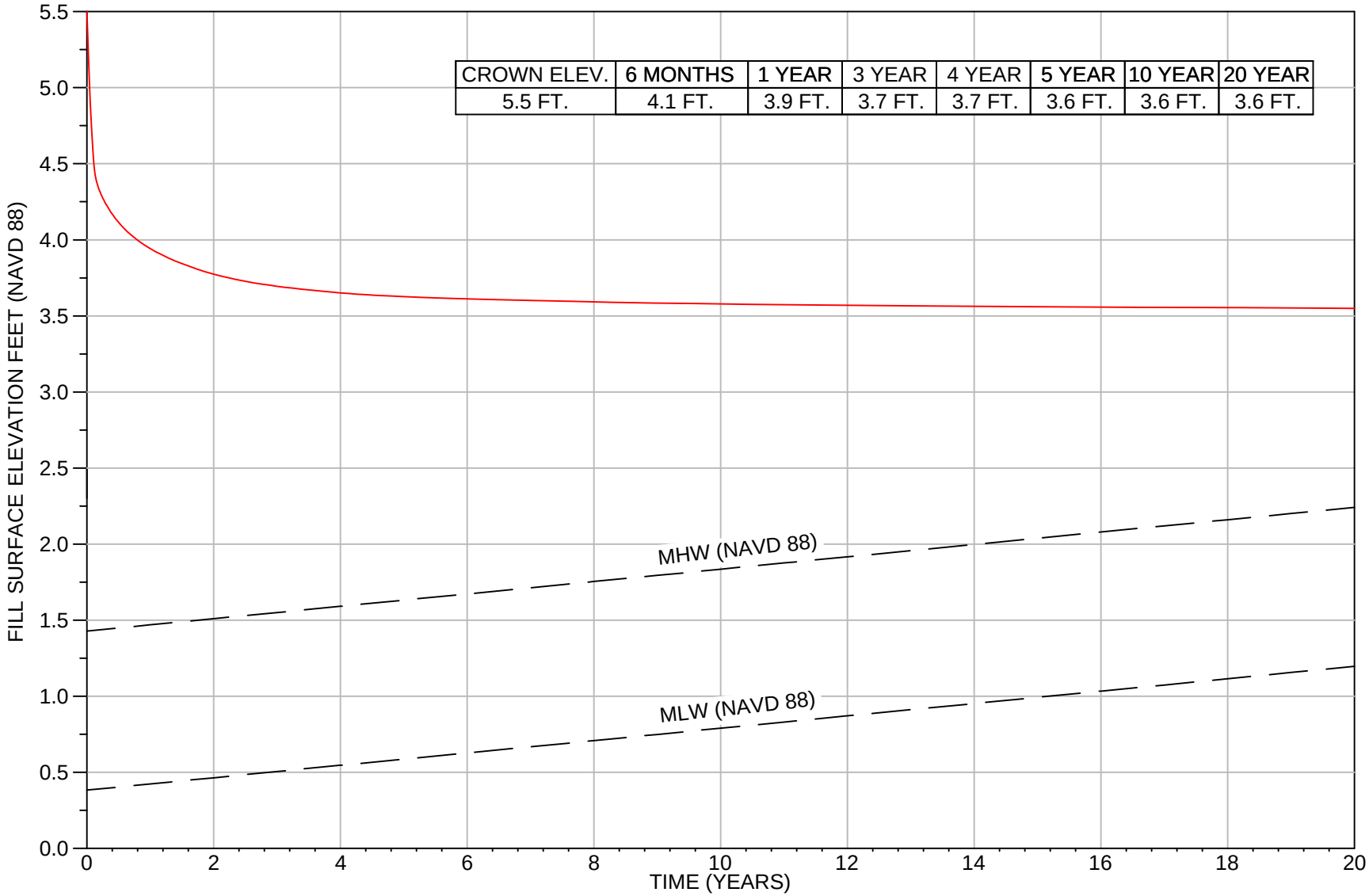
SLOPE STABILITY - CONTAINMENT DIKE - B-10

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

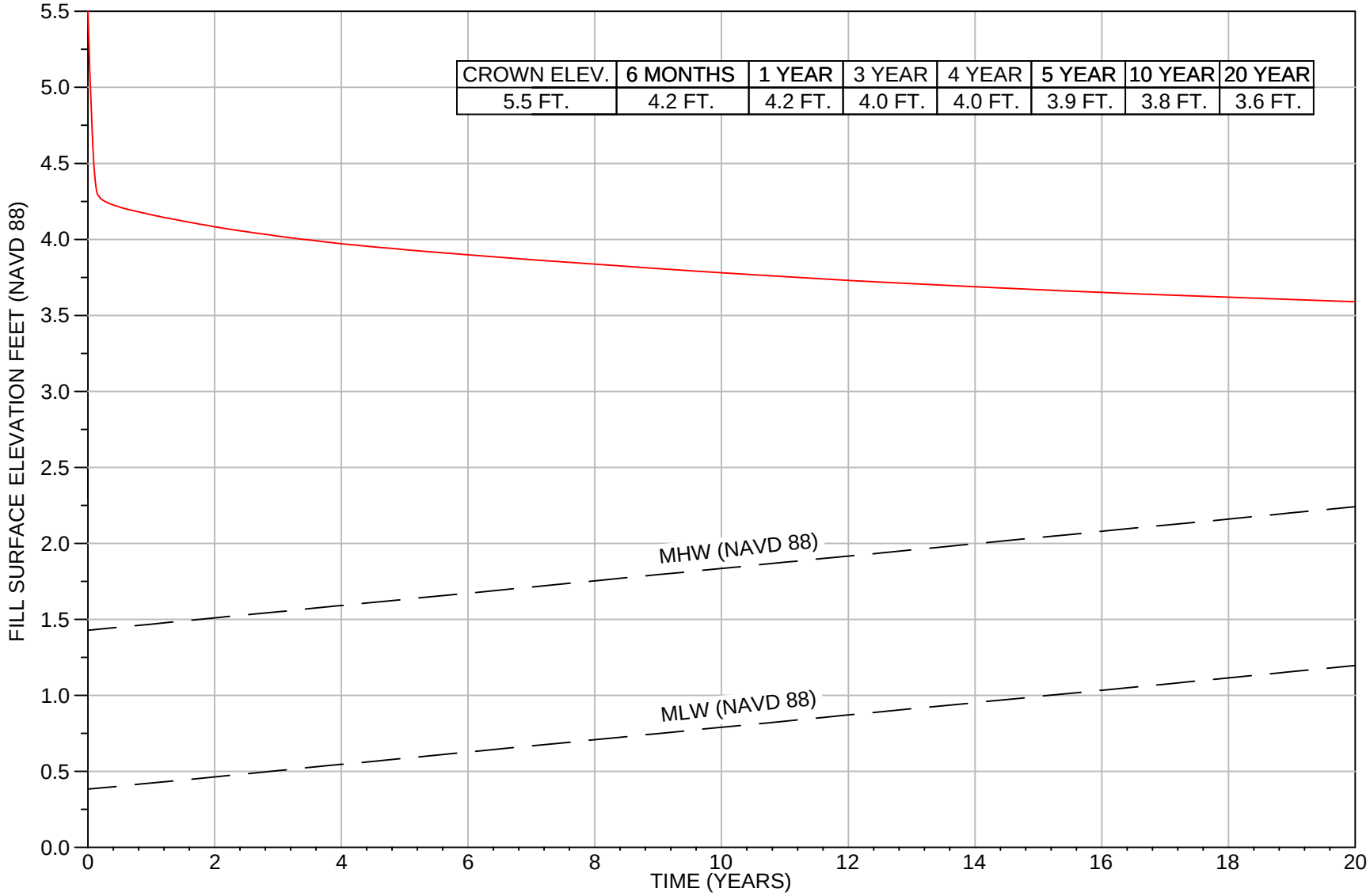
Figure II-B4

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.



Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

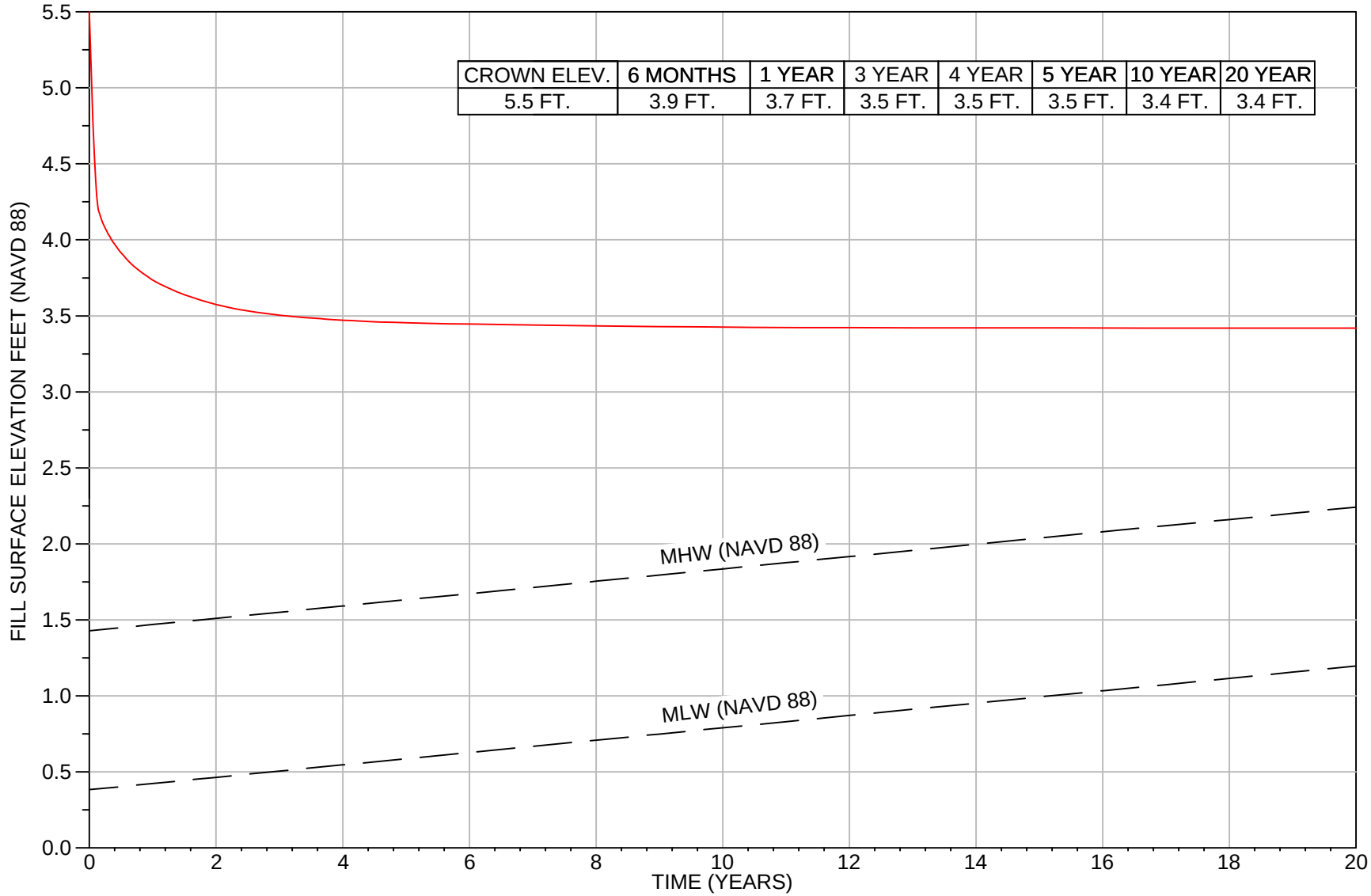
CONTAINMENT DIKE SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B5**



CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.2 FT.	4.2 FT.	4.0 FT.	4.0 FT.	3.9 FT.	3.8 FT.	3.6 FT.

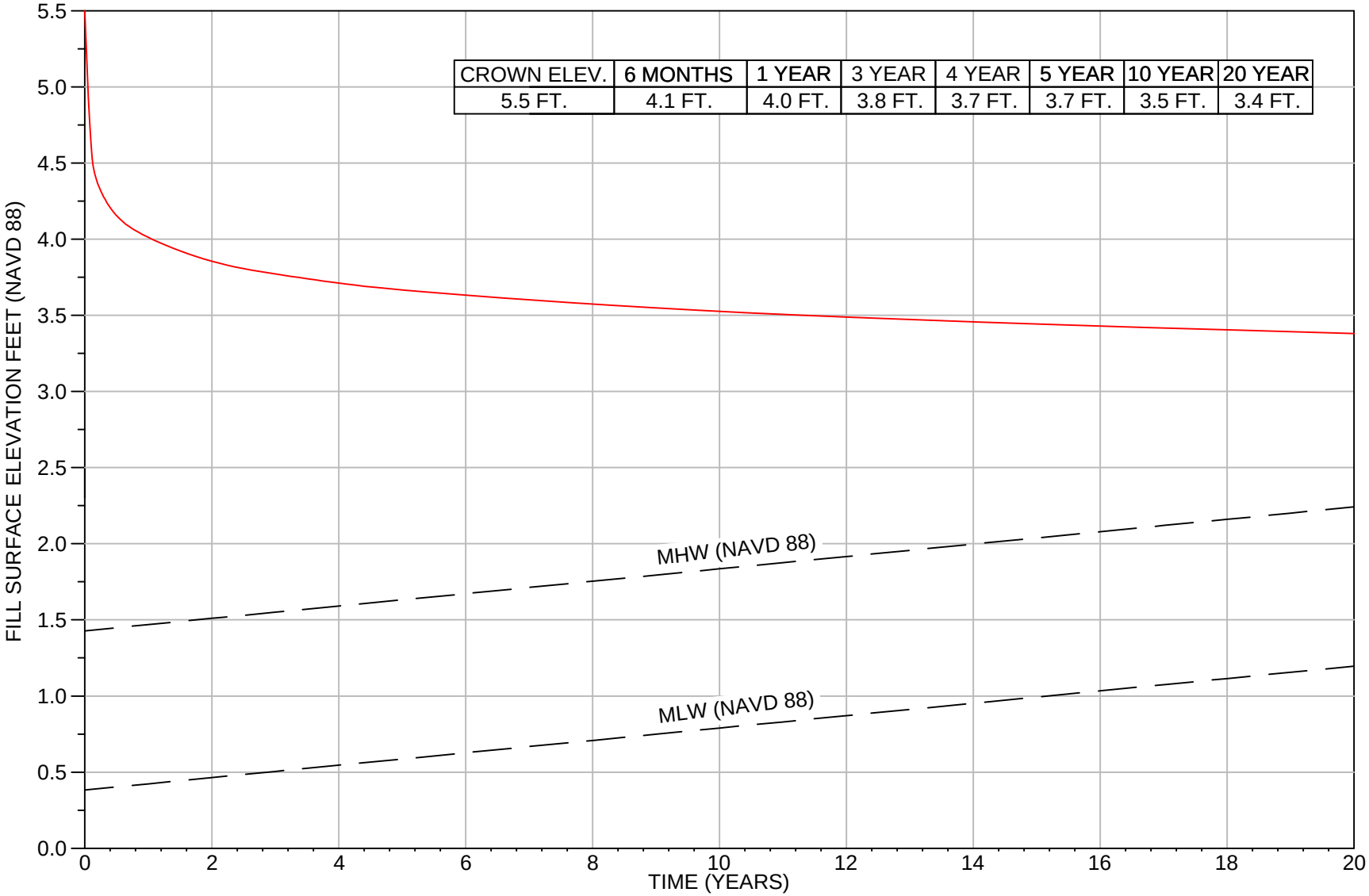
Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

CONTAINMENT DIKE SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B6**



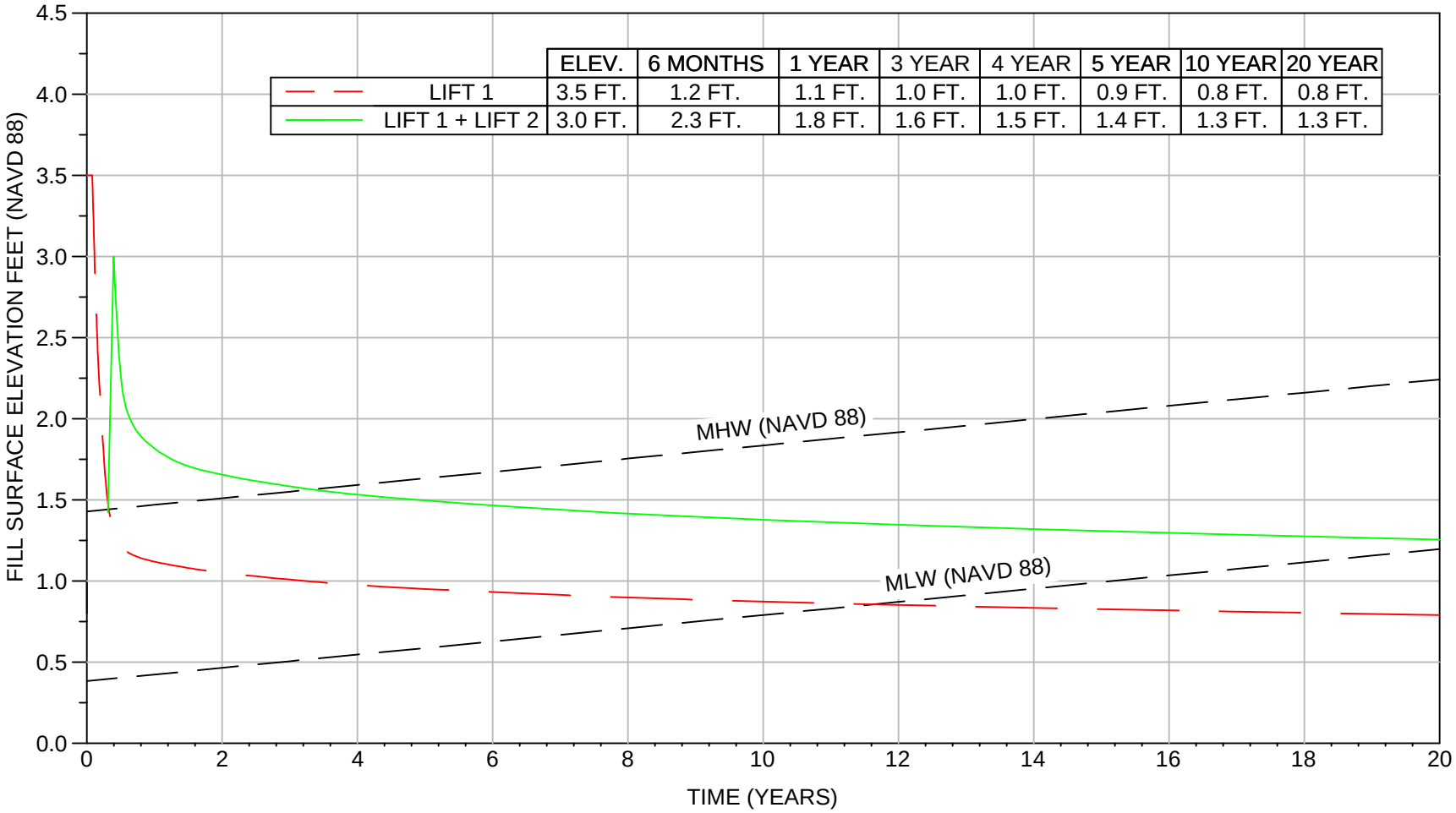
Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

CONTAINMENT DIKE SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B7**



Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

CONTAINMENT DIKE SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B8**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	1.0 FT.	1.0 FT.	0.9 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.0 FT.	2.3 FT.	1.8 FT.	1.6 FT.	1.5 FT.	1.4 FT.	1.3 FT.	1.3 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

MARSH FILL SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A12**

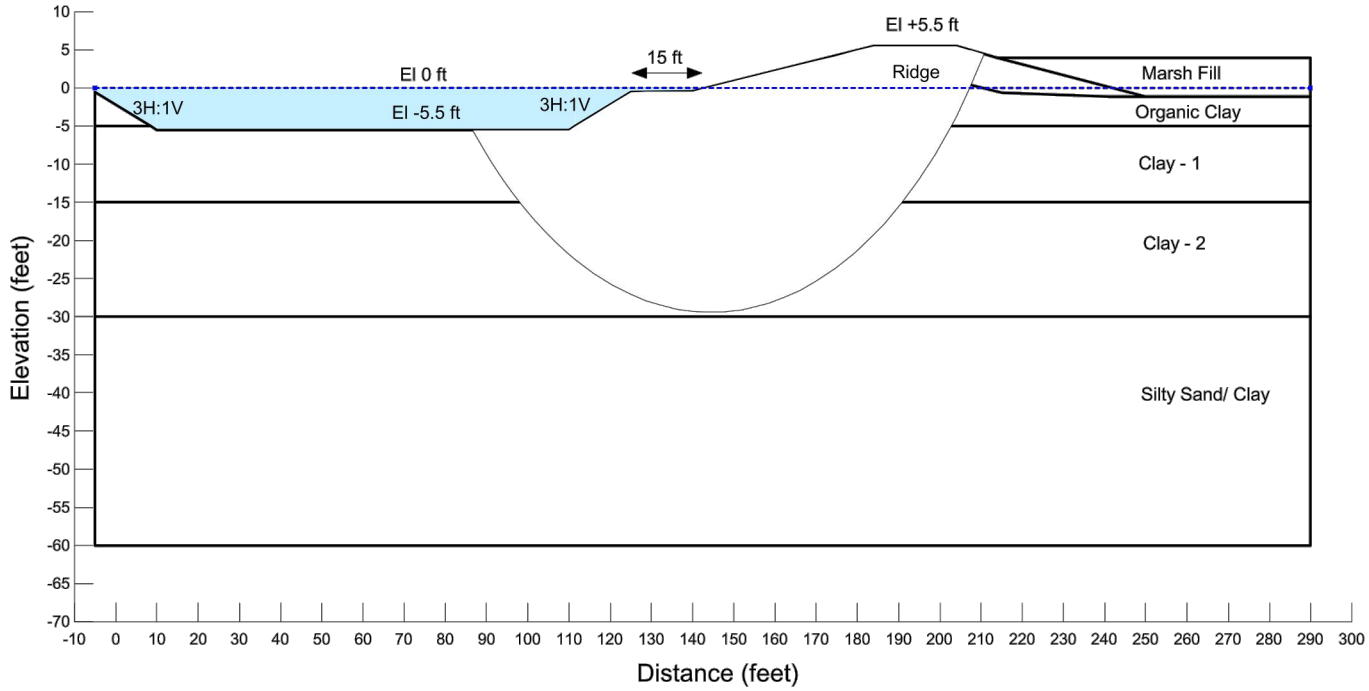
Appendix G

Earthen Ridge Cross-Sections and Settlement Curves

Borrow Material From Bayou Grand Liard
Boring B-1

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.428



SLOPE STABILITY - EARTHEN RIDGE
BORROW MATERIAL FROM BAYOU GRAND LIARD - B-1

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C1a

Notes:
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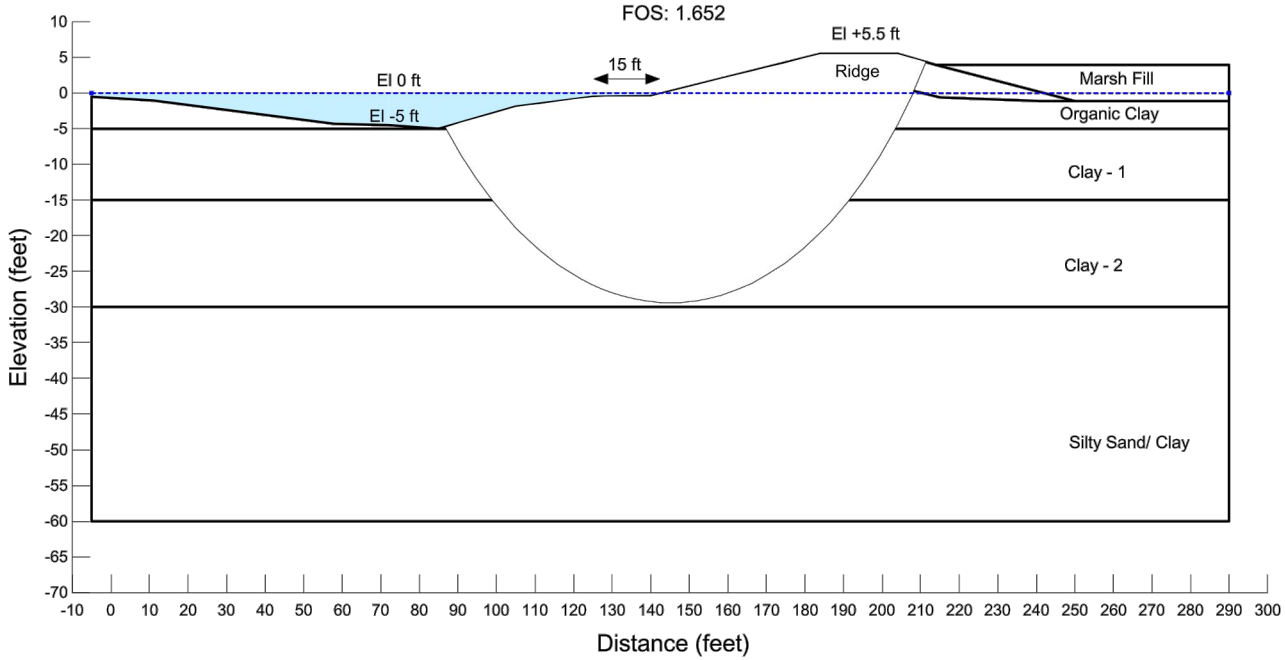
Borrow Material From Borrow Area
Boring B-1

Name: Ridge (Borrow Area) Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °



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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BORROW AREAS - B-1

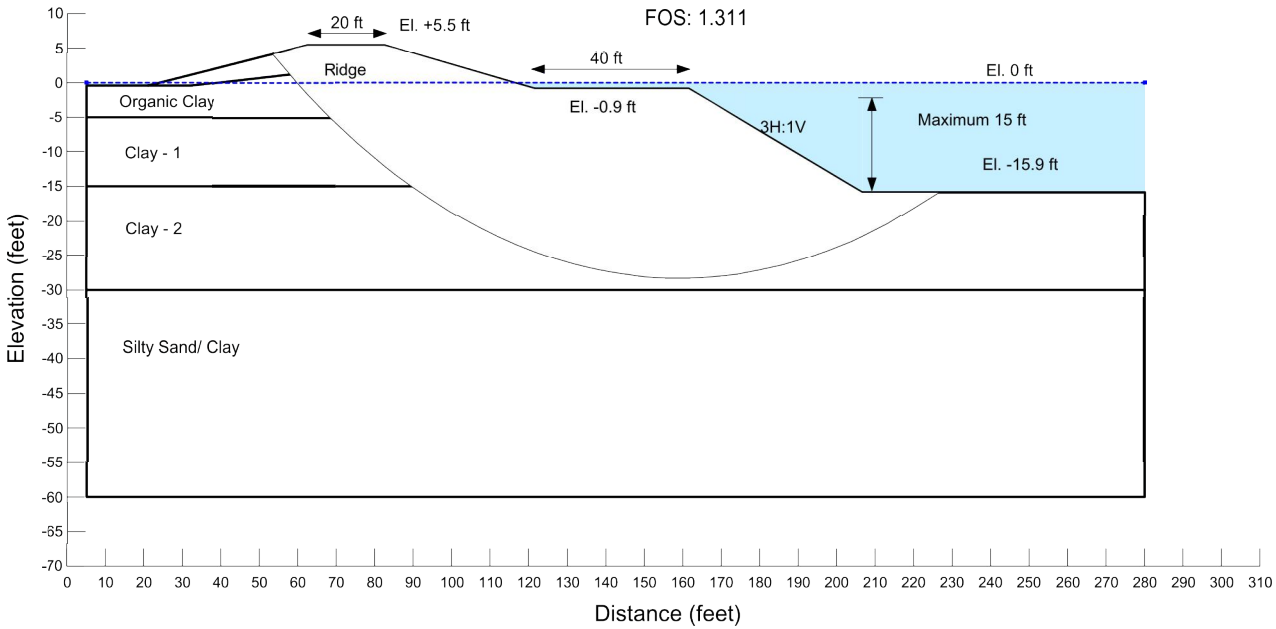
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C1b

Borrow Material From Existing Marsh
Boring B-1

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °



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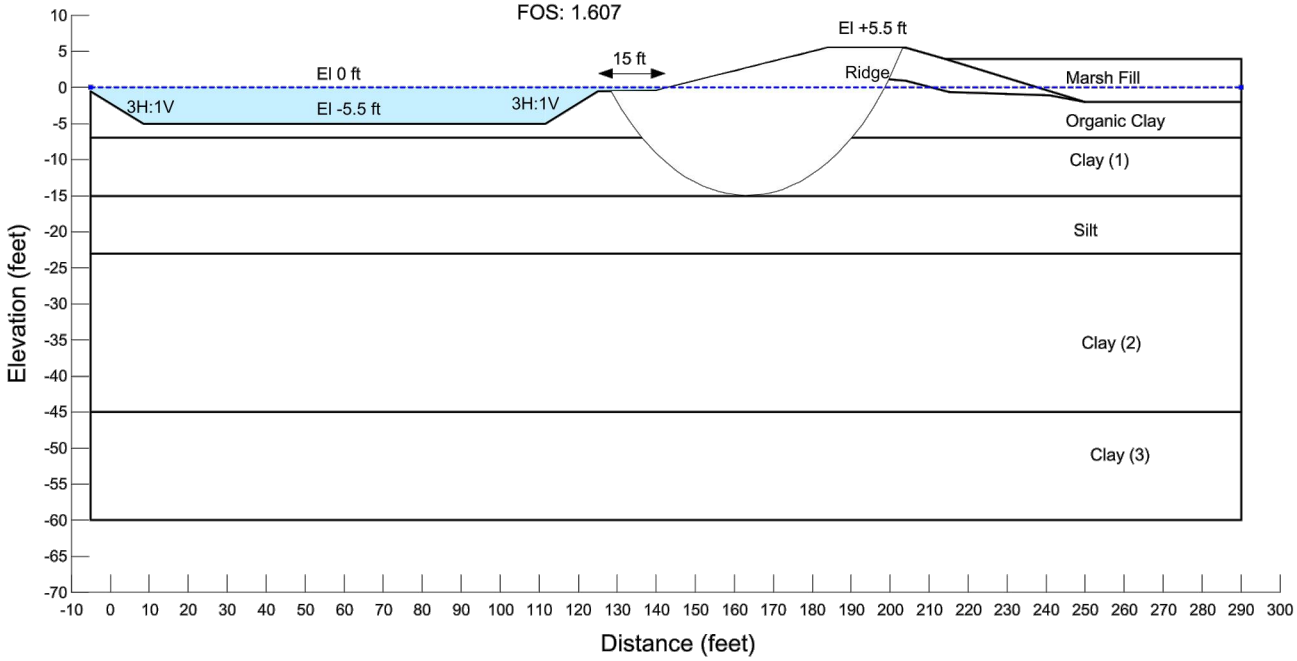
SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM EXISTING MARSH - B-1

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C1c

Borrow Material From Bayou Grand Liard
Boring B-2&5
Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °



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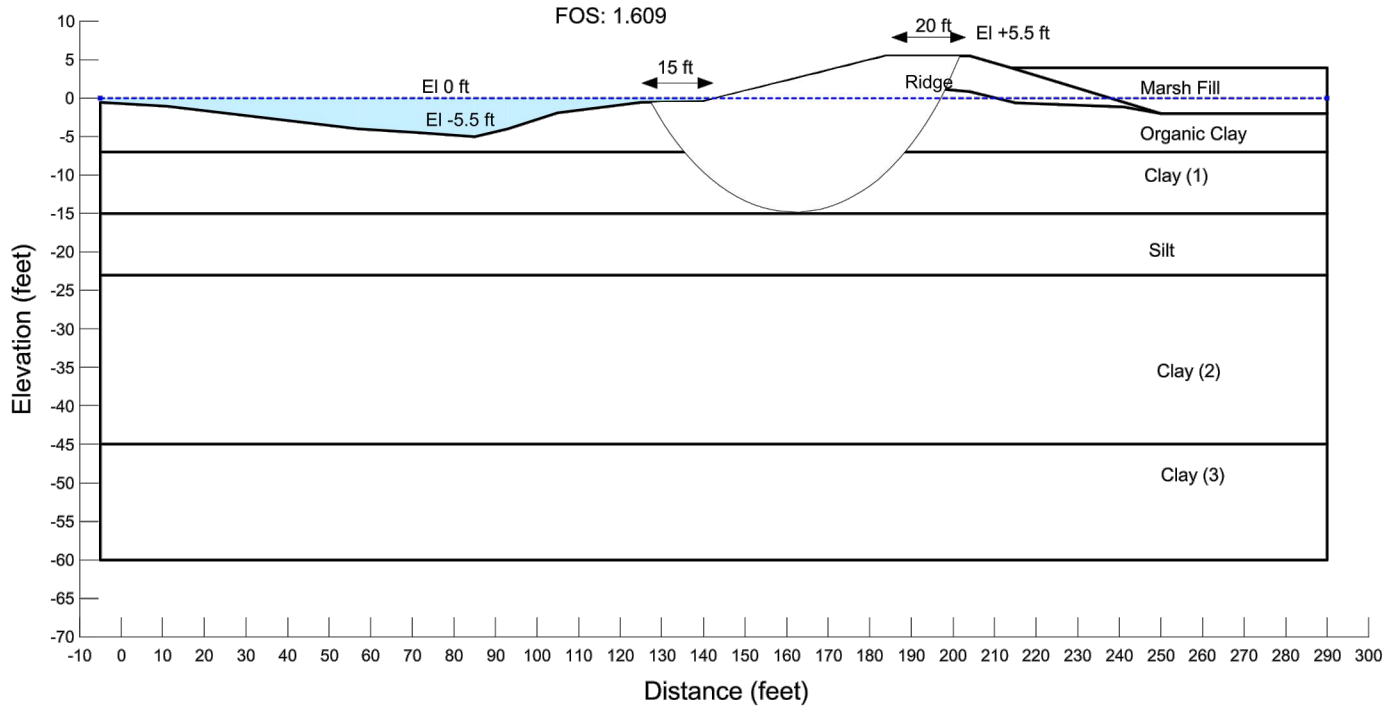
SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-2 & B-5

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C2a

Borrow Material From Borrow Area
Boring B-2&5
Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °



SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BORROW AREAS - B-2 & B-5

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C2b

Notes:
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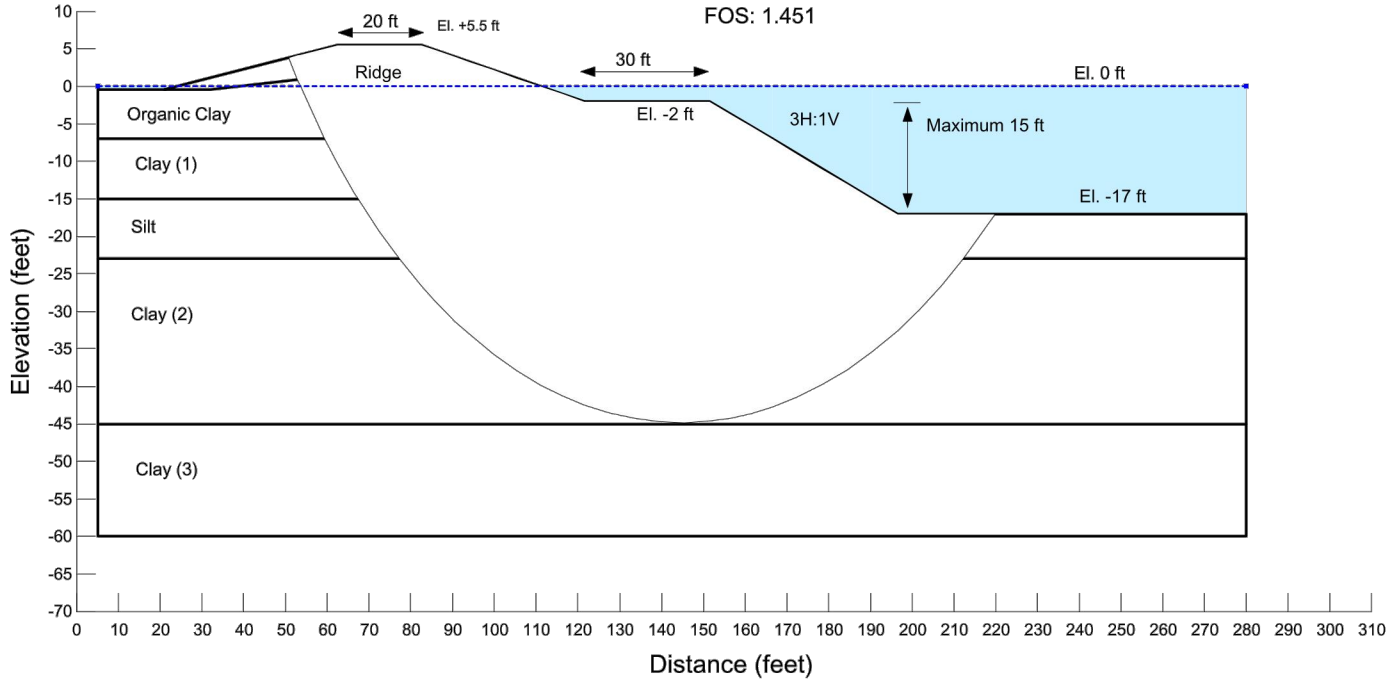
Borrow Material From Existing Marsh
Boring B-2&5

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °



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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM EXISTING MARSH - B-2 & B-5

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

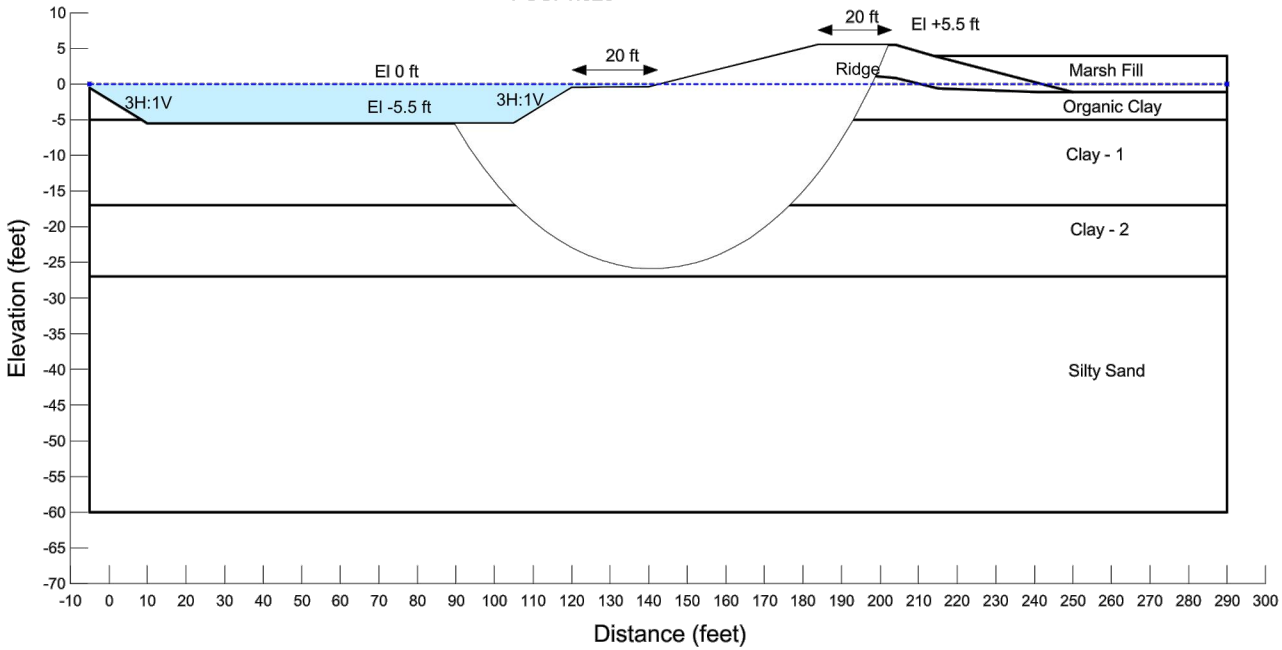
GEOENGINEERS

Figure II-C2c

Borrow Material From Bayou Grand Liard
Boring B-3

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.323



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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BAYOU GRAND LIARD - B-3

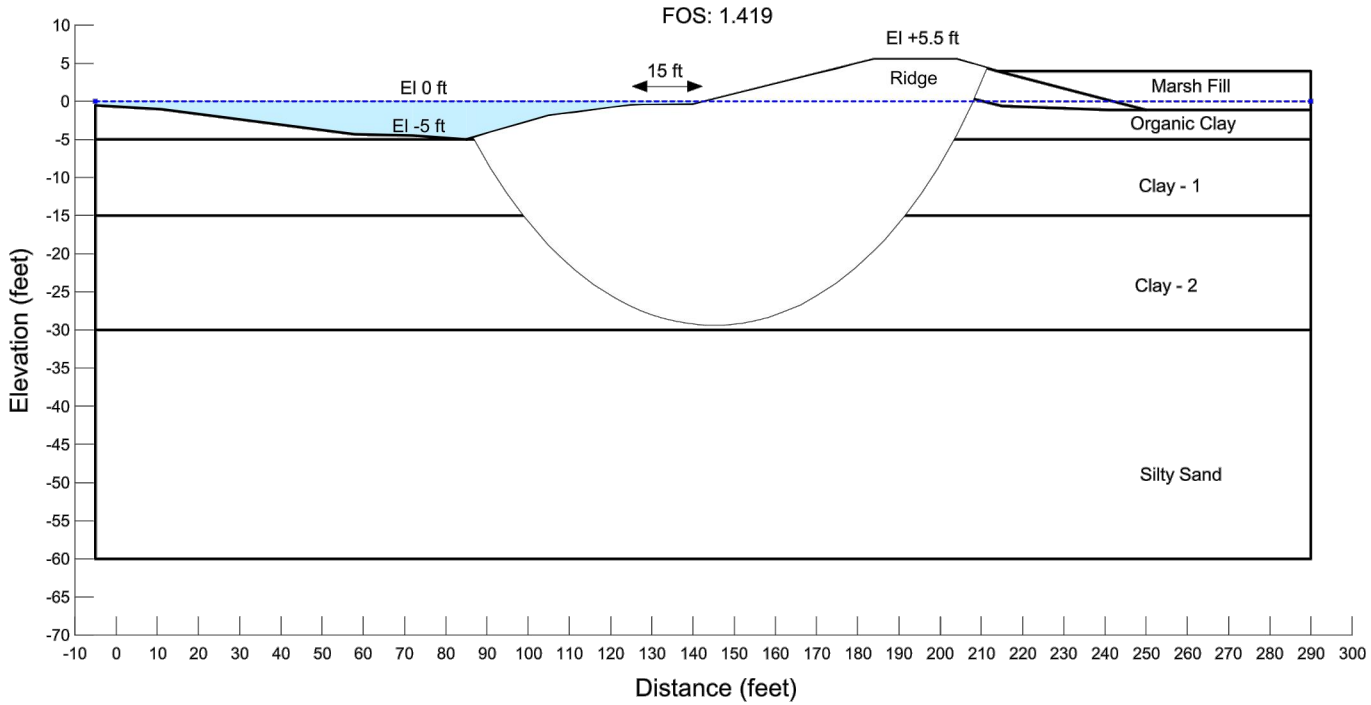
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C3a

Borrow Material From Borrow Area
Boring B-3

Name: Ridge (Borrow Area) Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °



SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BORROW AREAS - B-3

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C3b

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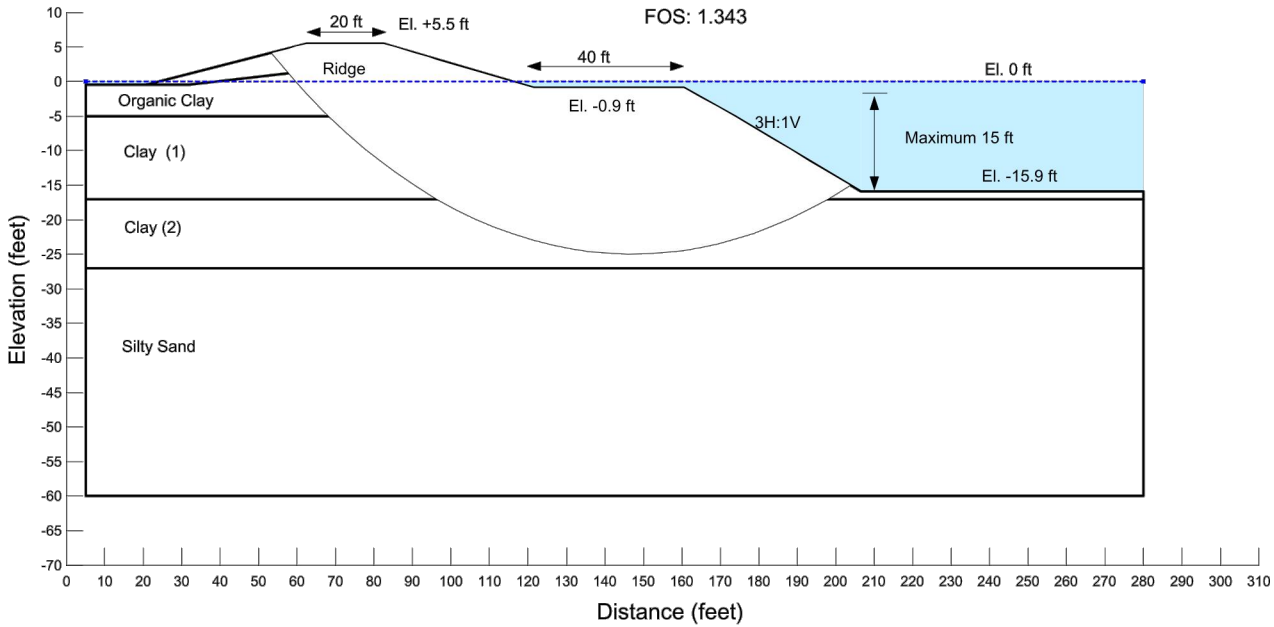
Borrow Material From Existing Marsh
Boring B-3

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM EXISTING MARSH - B-3

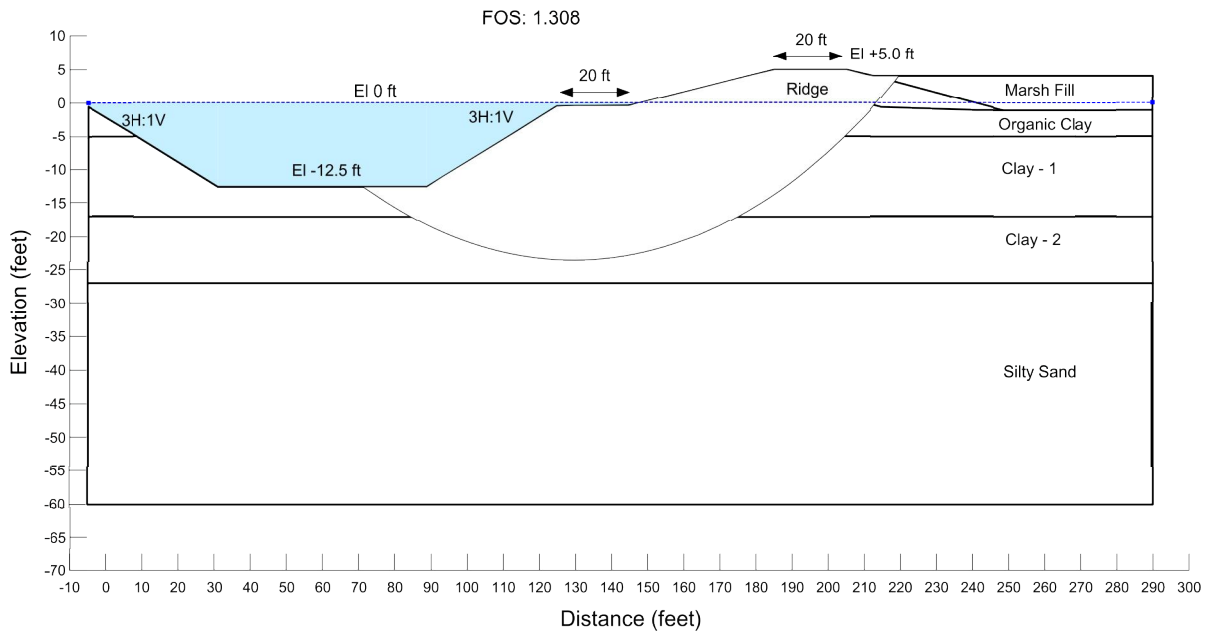
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C3c

Borrow Material From Bayou Grand Liard
Boring B-3

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °



SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BAYOU GRAND LIARD - B-3

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C3a (Revised)

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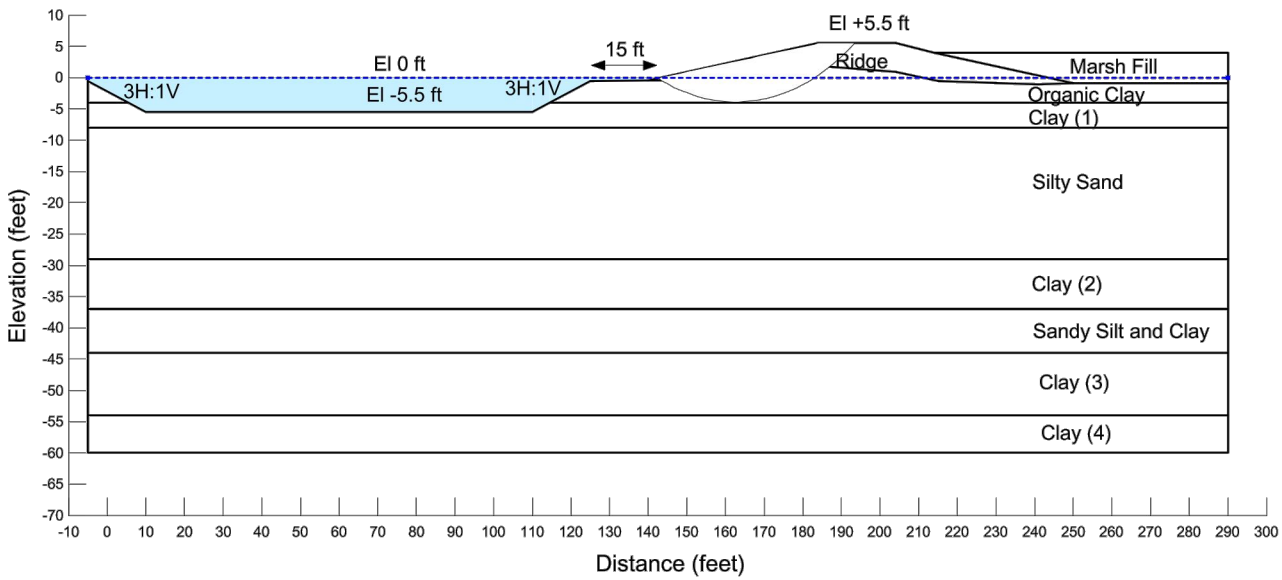
Borrow Material From Bayou Grand Liard
Boring B-4

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 0 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 2.096



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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BAYOU GRAND LIARD - B-4

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

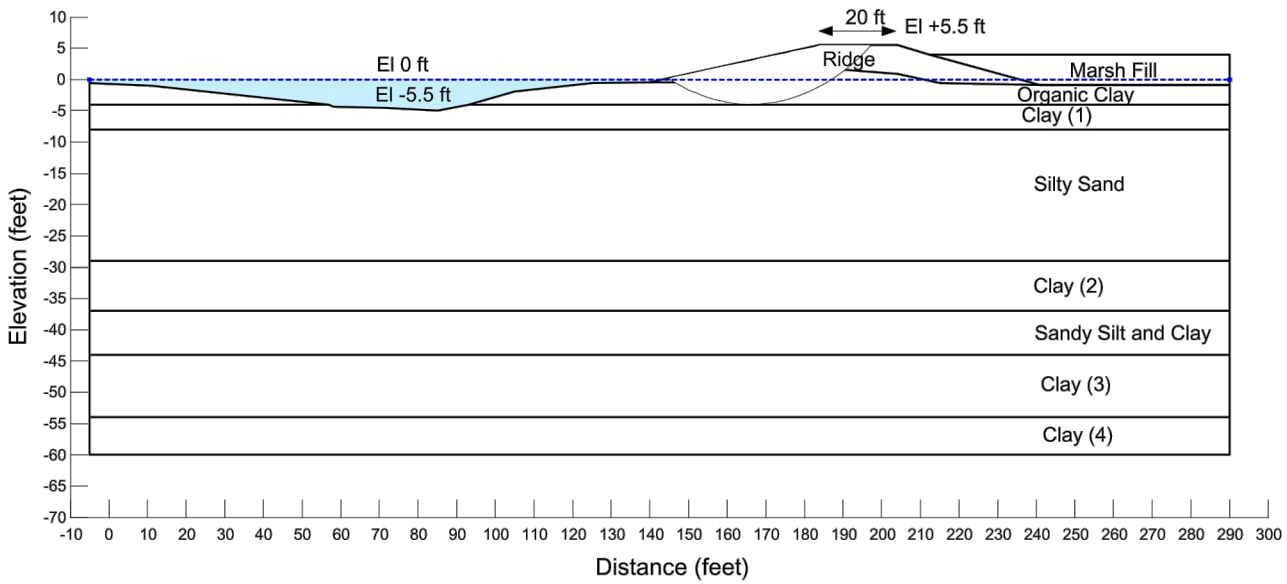
GEOENGINEERS

Figure II-C4a

Borrow Material From Borrow Area
Boring B-4

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 0 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 2.118



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BORROW AREAS - B-4

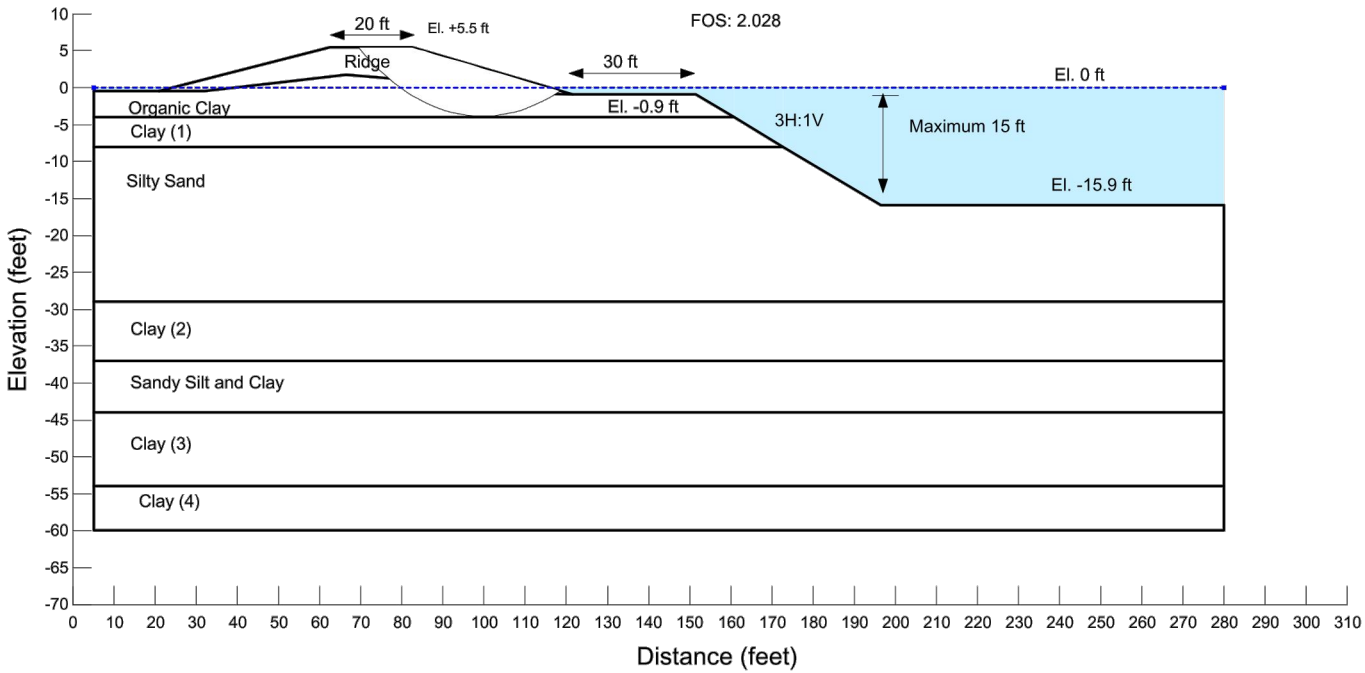
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C4b

Borrow Material From Existing Marsh
Boring B-4

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 10 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM EXISTING MARSH - B-4

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

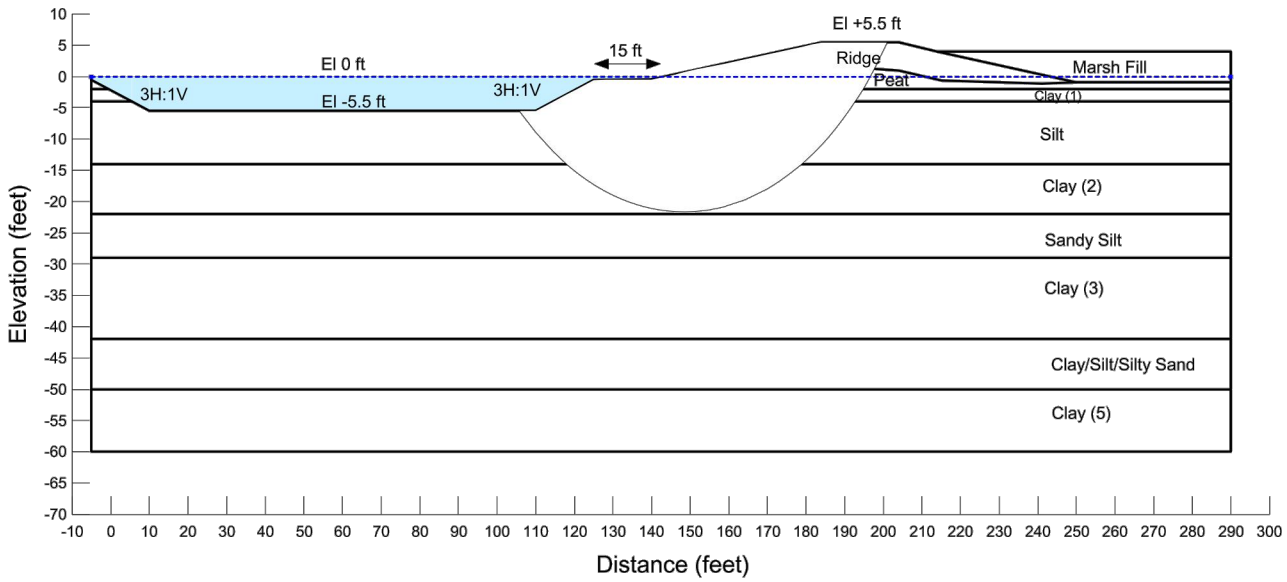
GEOENGINEERS

Figure II-C4c

Borrow Material From Bayou Grand Liard
Boring B-6

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay / Silt/ Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.873



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-6

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

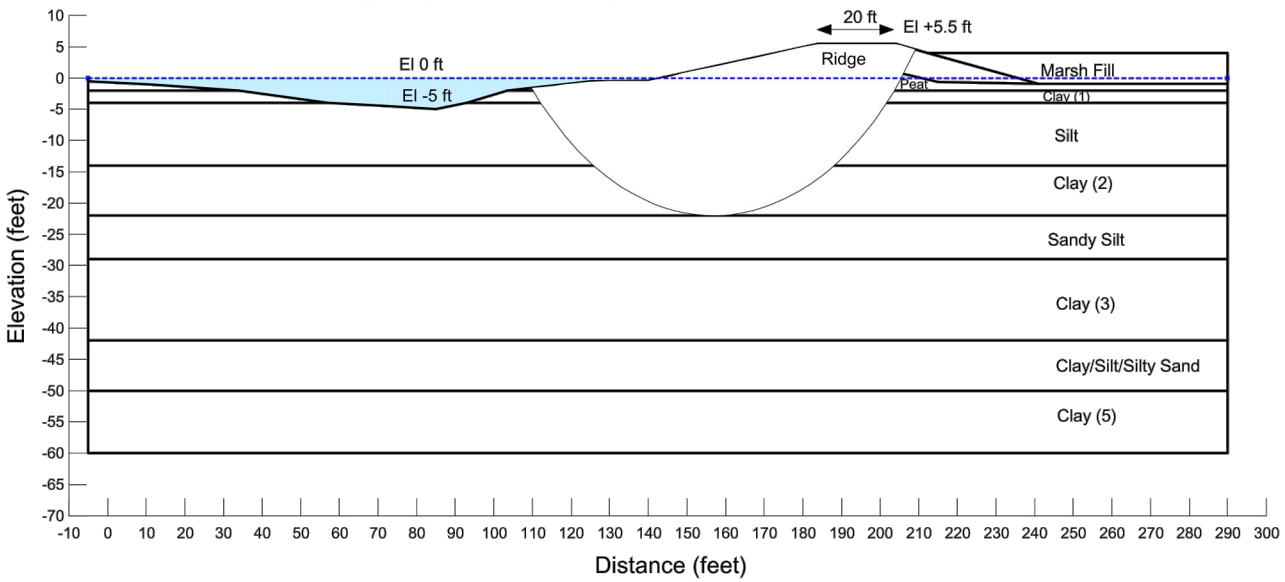
GEOENGINEERS

Figure II-C5a

Borrow Material From Borrow Area
Boring B-6

Name: Ridge (Borrow) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay/Silt/Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 2.105



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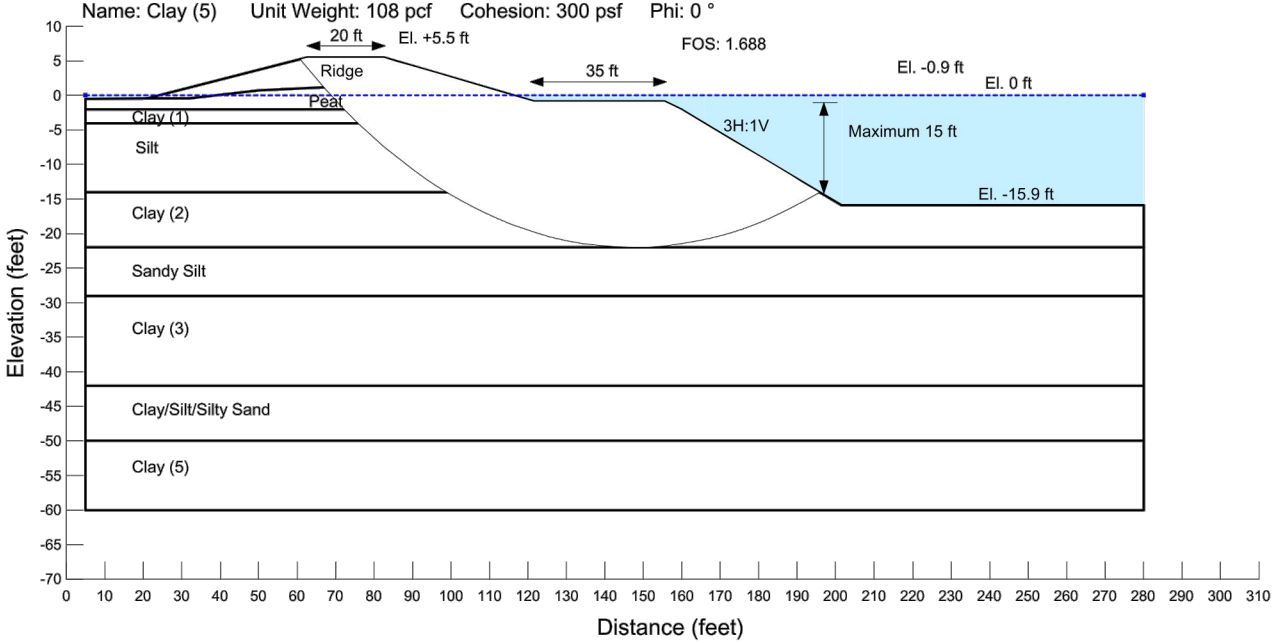
SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BORROW AREAS - B-6

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C5b

Borrow Material From Existing Marsh
Boring B-6
Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay/Silt/Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °



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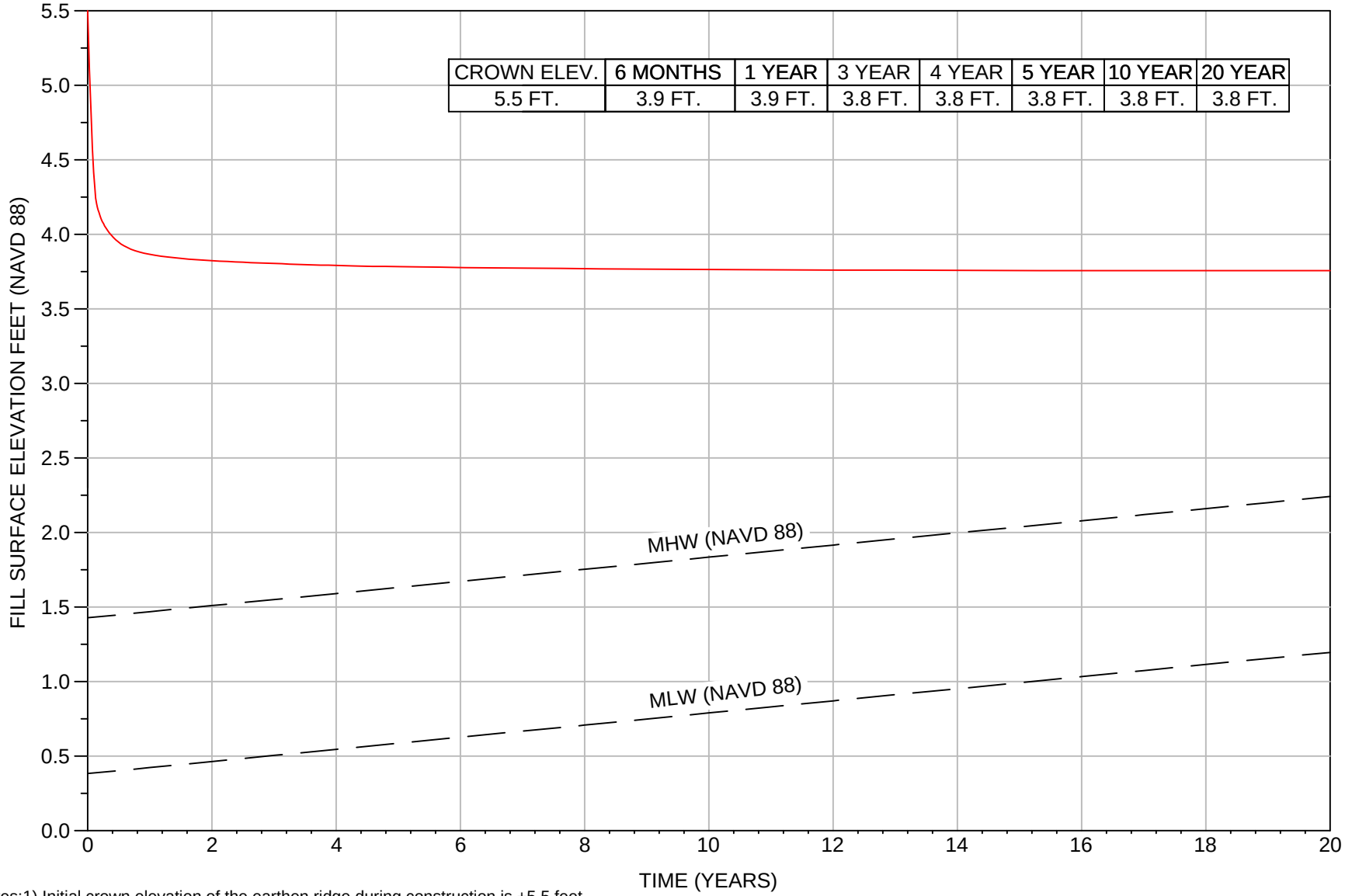
SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM EXISTING MARSH - B-6

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

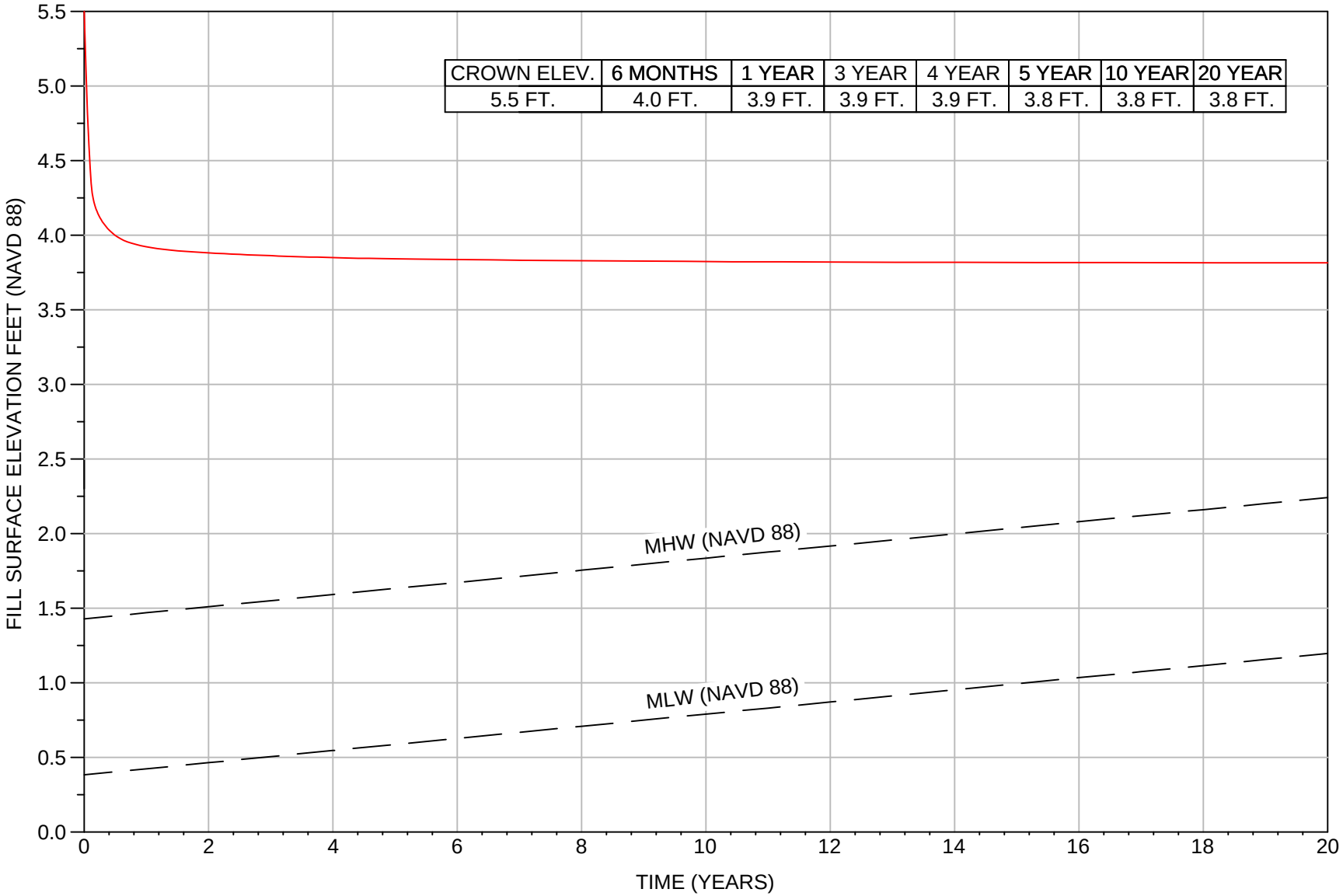
GEOENGINEERS

Figure II-C5c



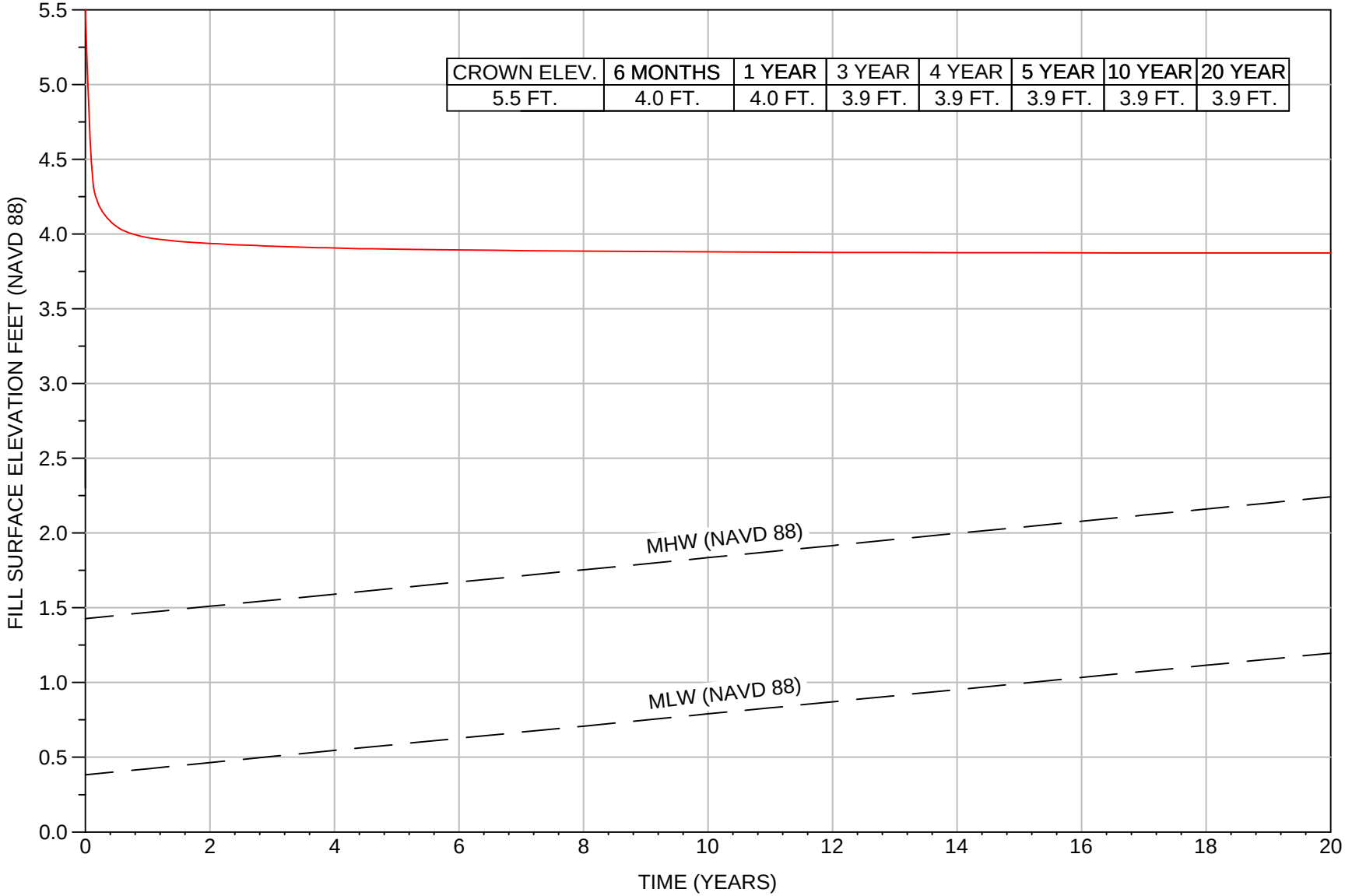
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-1	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C6a**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

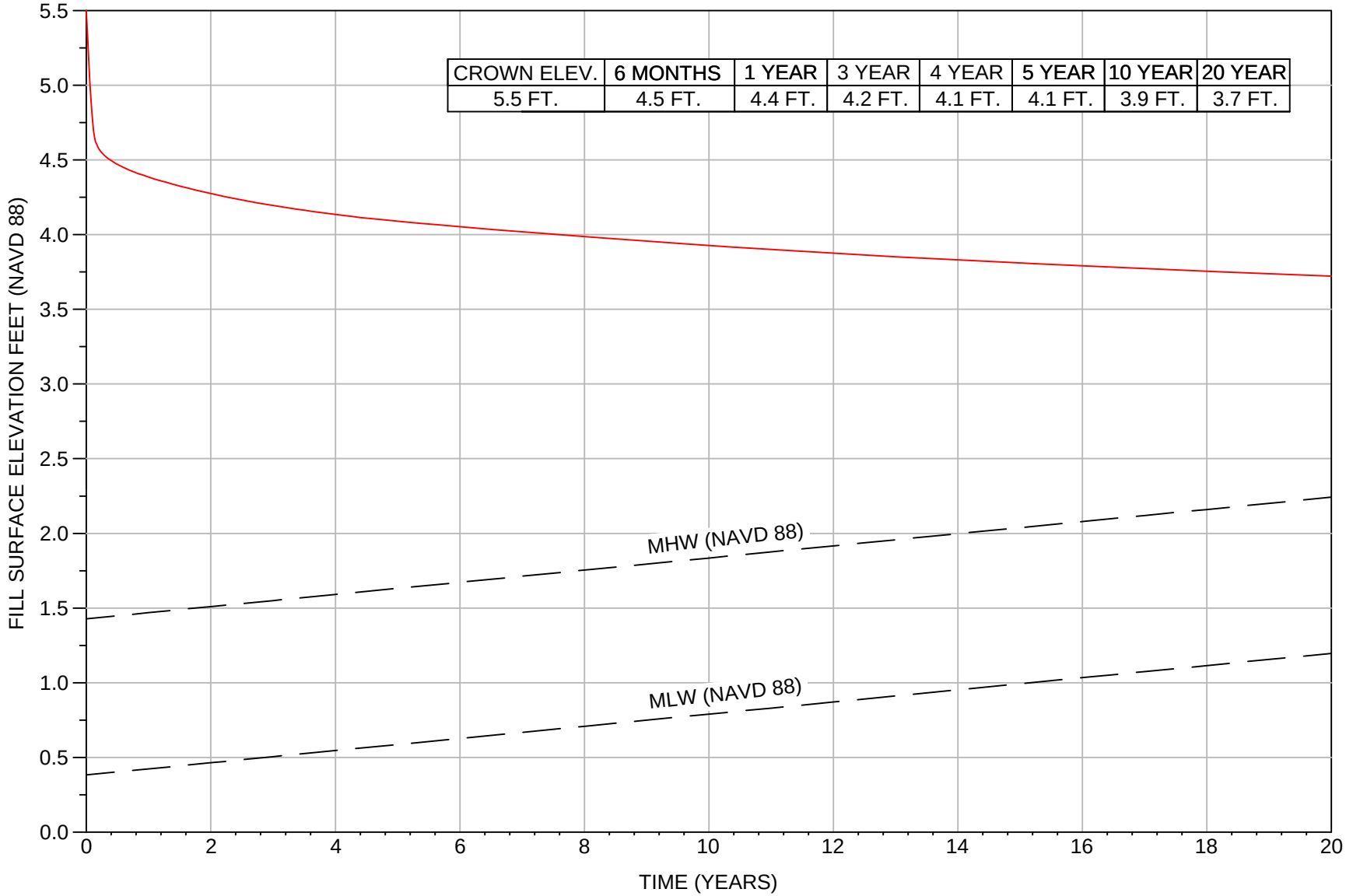
EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-1	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C6b**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-1	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C6c**

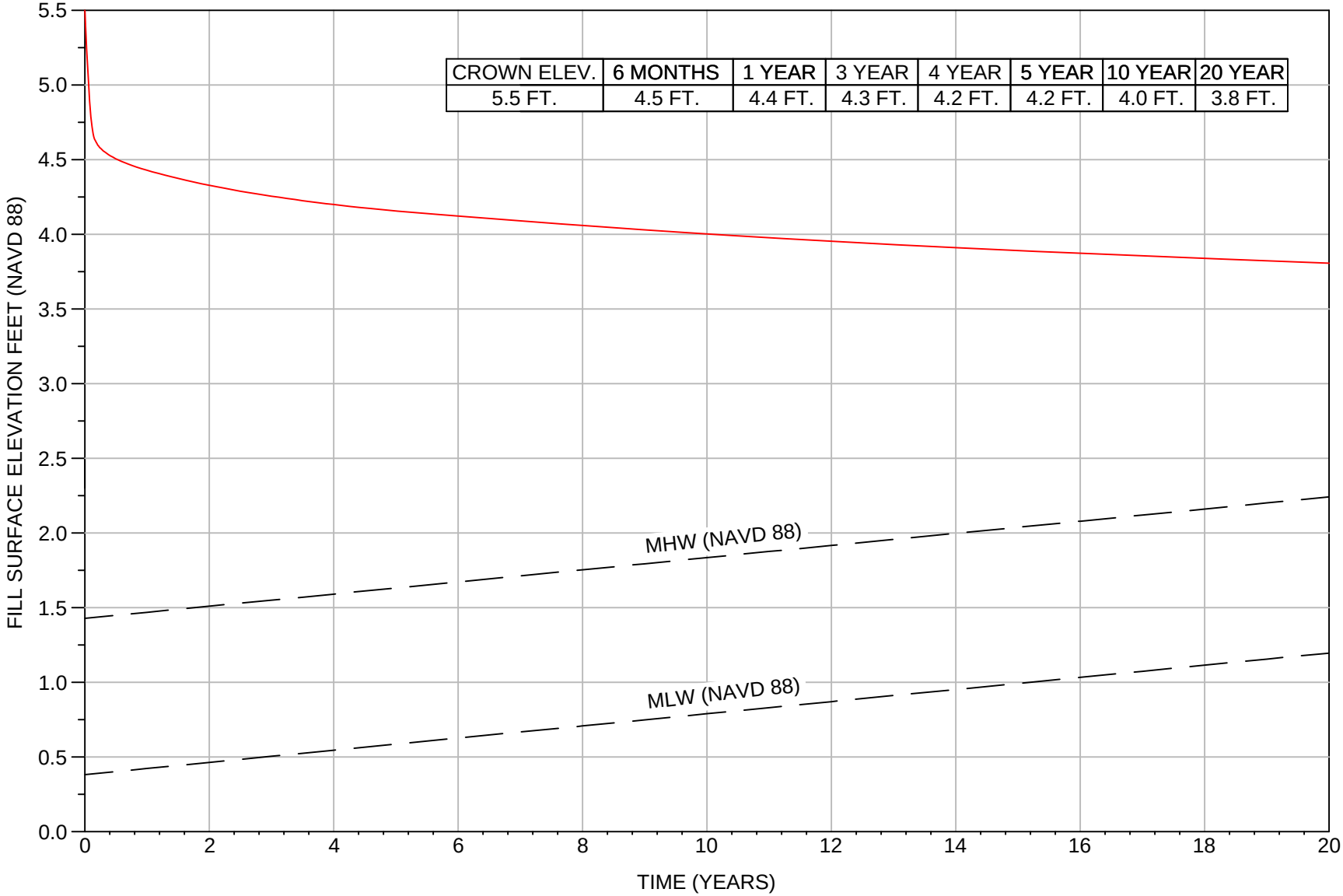
P:\16\16715018\00\CAD\RIDGE SETTLEMENT.dwg\TAB:C-17 modified on Jan 06, 2011 - 10:58am VT : KMC



CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.5 FT.	4.4 FT.	4.2 FT.	4.1 FT.	4.1 FT.	3.9 FT.	3.7 FT.

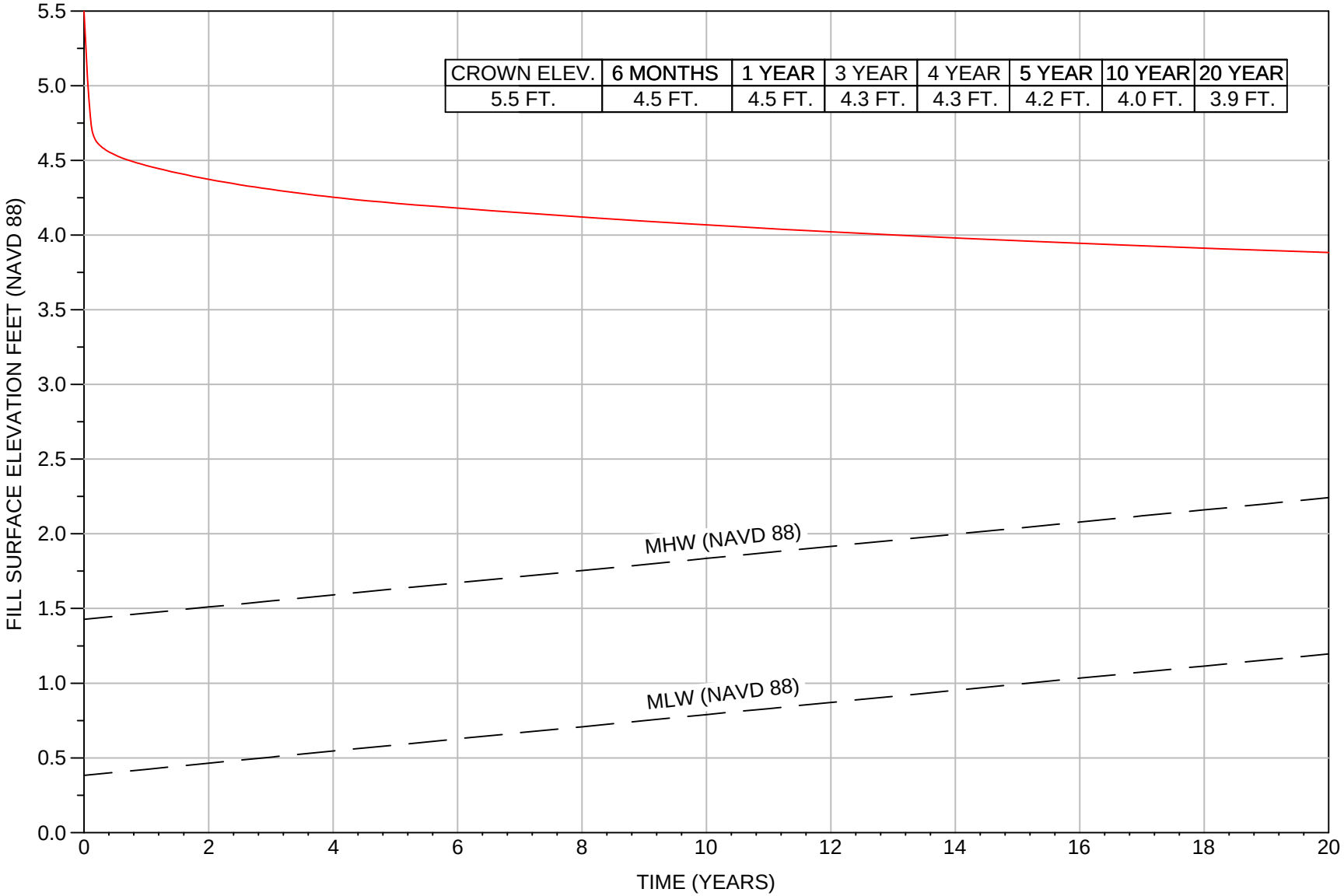
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-2 & B-5	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C7a**



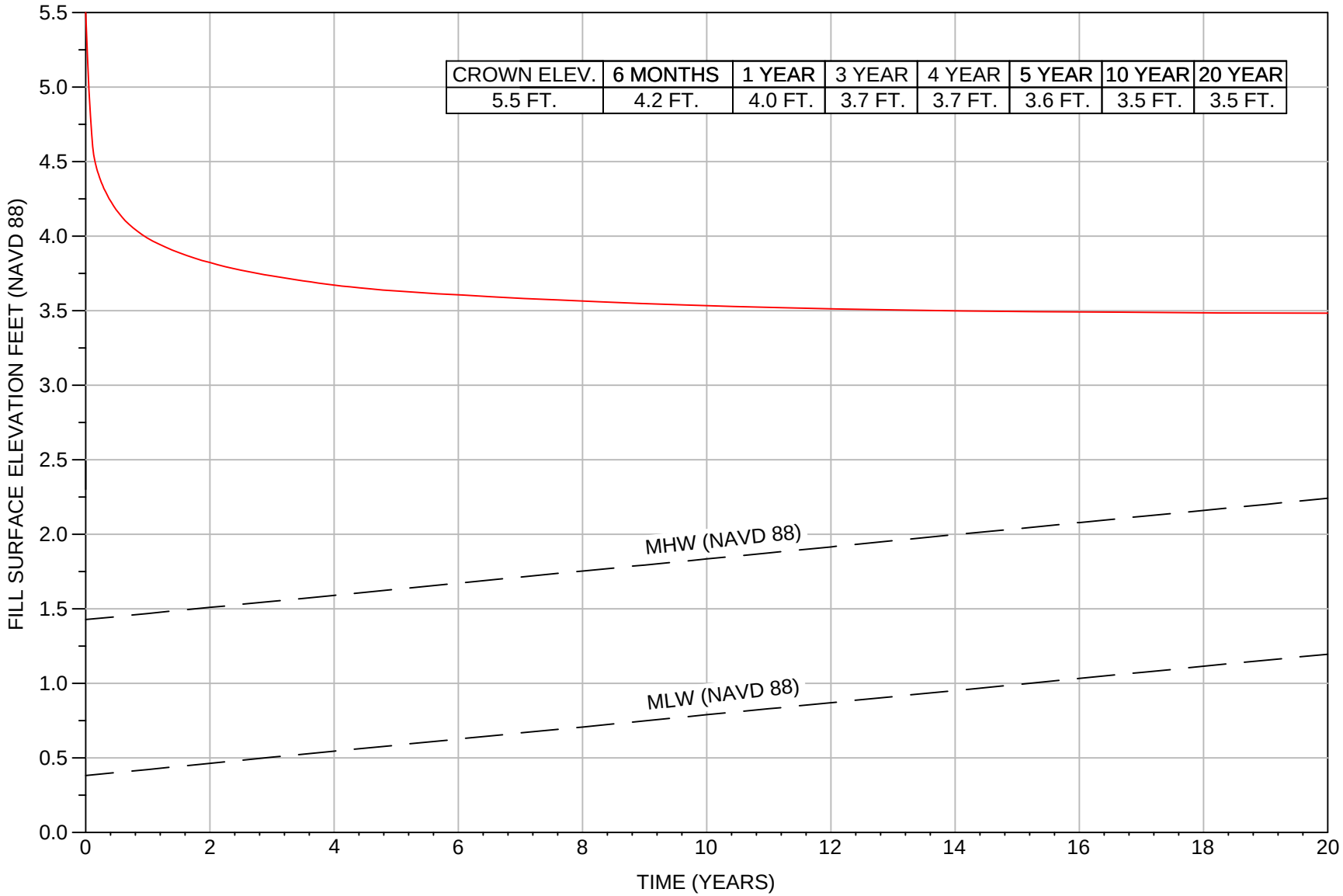
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-2 & B-5	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C7b**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-2 & B-5	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C7c**

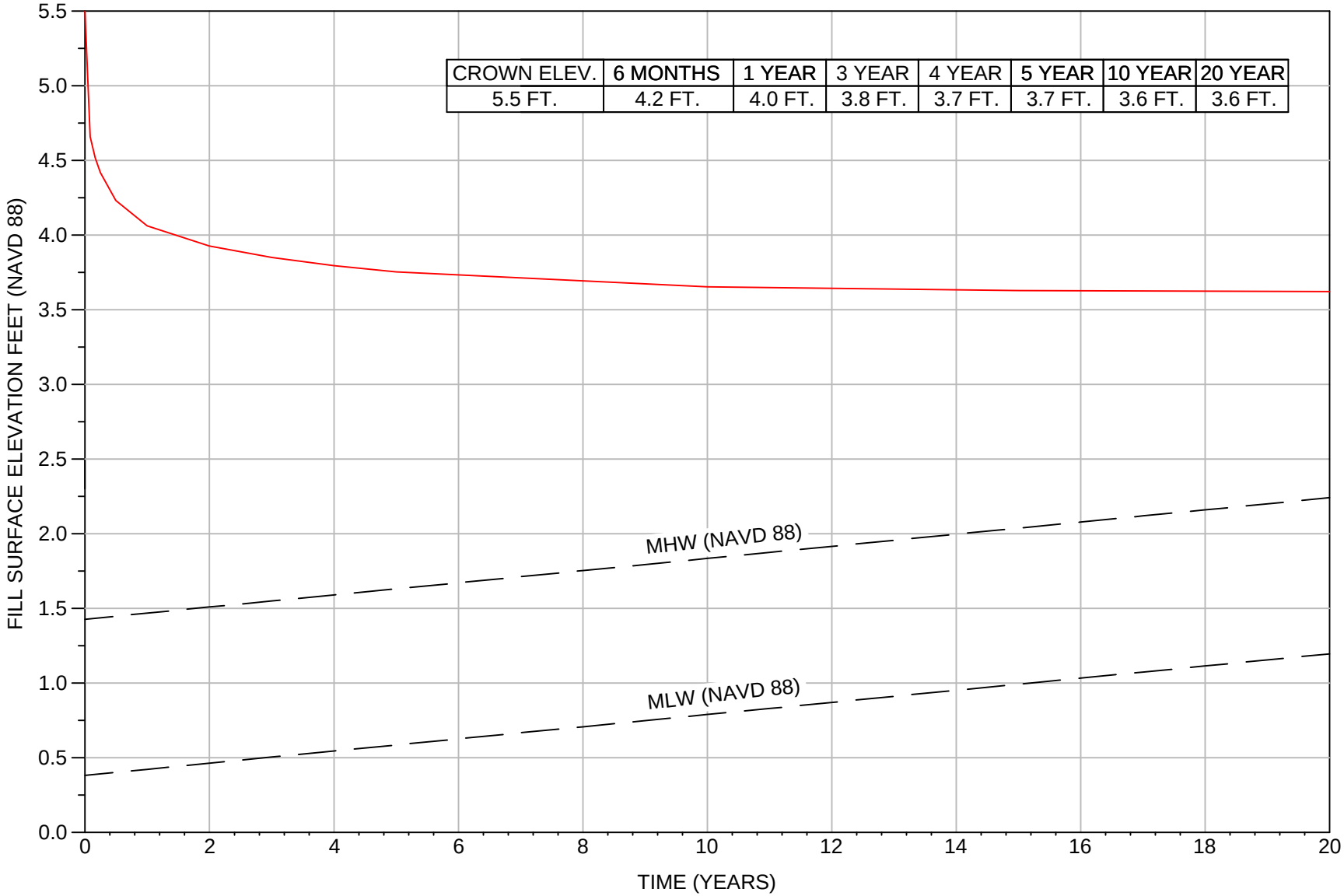


CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.2 FT.	4.0 FT.	3.7 FT.	3.7 FT.	3.6 FT.	3.5 FT.	3.5 FT.

Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-3	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C8a**

P:\16\16715018\00\CAD\RIDGE SETTLEMENT.dwg\TAB:C-23 modified on Jan 06, 2011 - 10:58am VT : KMC

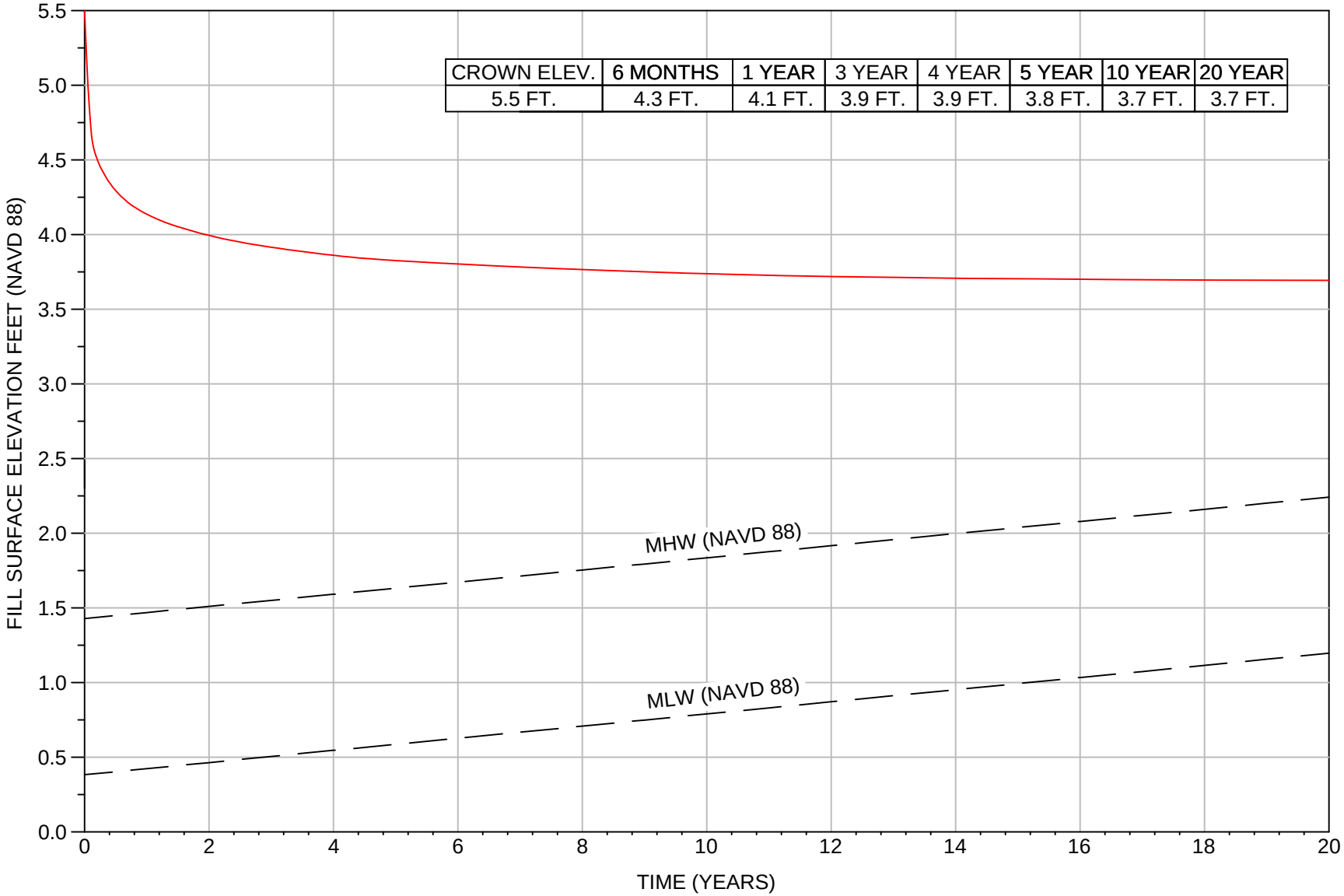


CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.2 FT.	4.0 FT.	3.8 FT.	3.7 FT.	3.7 FT.	3.6 FT.	3.6 FT.

Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-3	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C8b**

P:\16\16715018\00\CAD\RIDGE SETTLEMENT.dwg\TAB:C-28 modified on Jan 06, 2011 - 10:58am VT : KMC

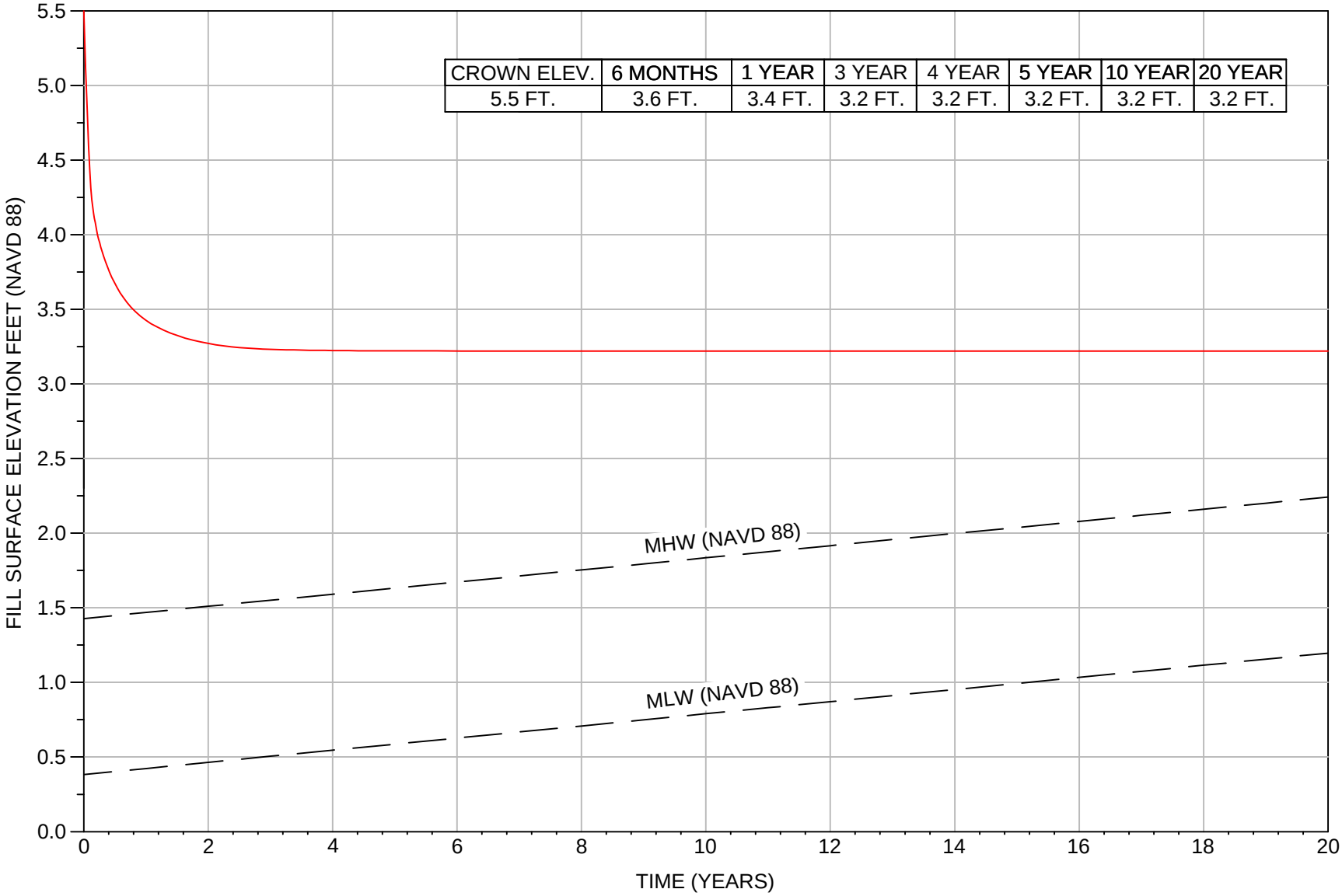


CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.3 FT.	4.1 FT.	3.9 FT.	3.9 FT.	3.8 FT.	3.7 FT.	3.7 FT.

Notes: 1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-3	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C8c**

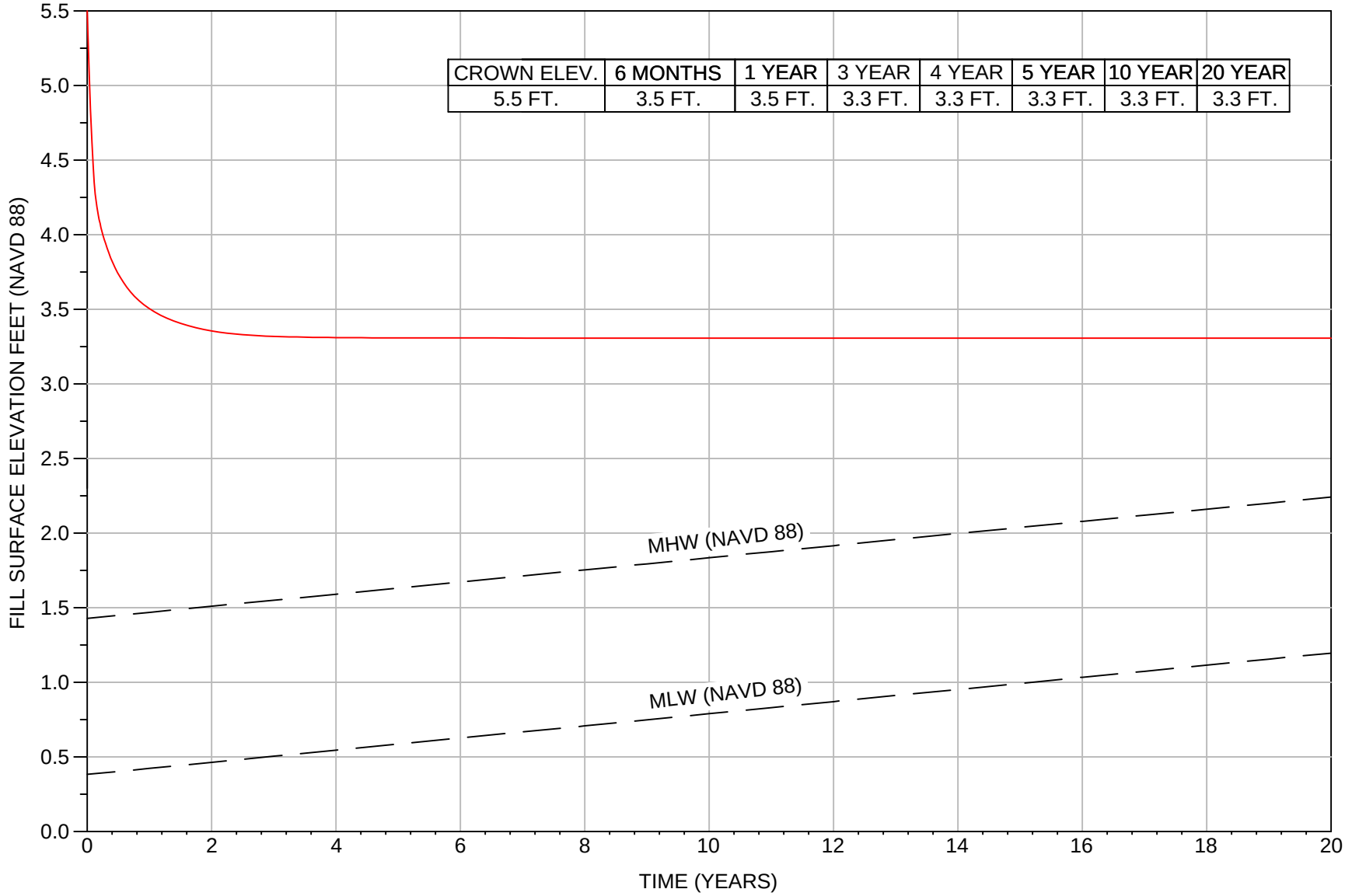
P:\16\16715018\00\CAD\RIDGE SETTLEMENT.dwg\TAB:C-19 modified on Jan 06, 2011 - 10:58am VT : KMC



CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	3.6 FT.	3.4 FT.	3.2 FT.	3.2 FT.	3.2 FT.	3.2 FT.	3.2 FT.

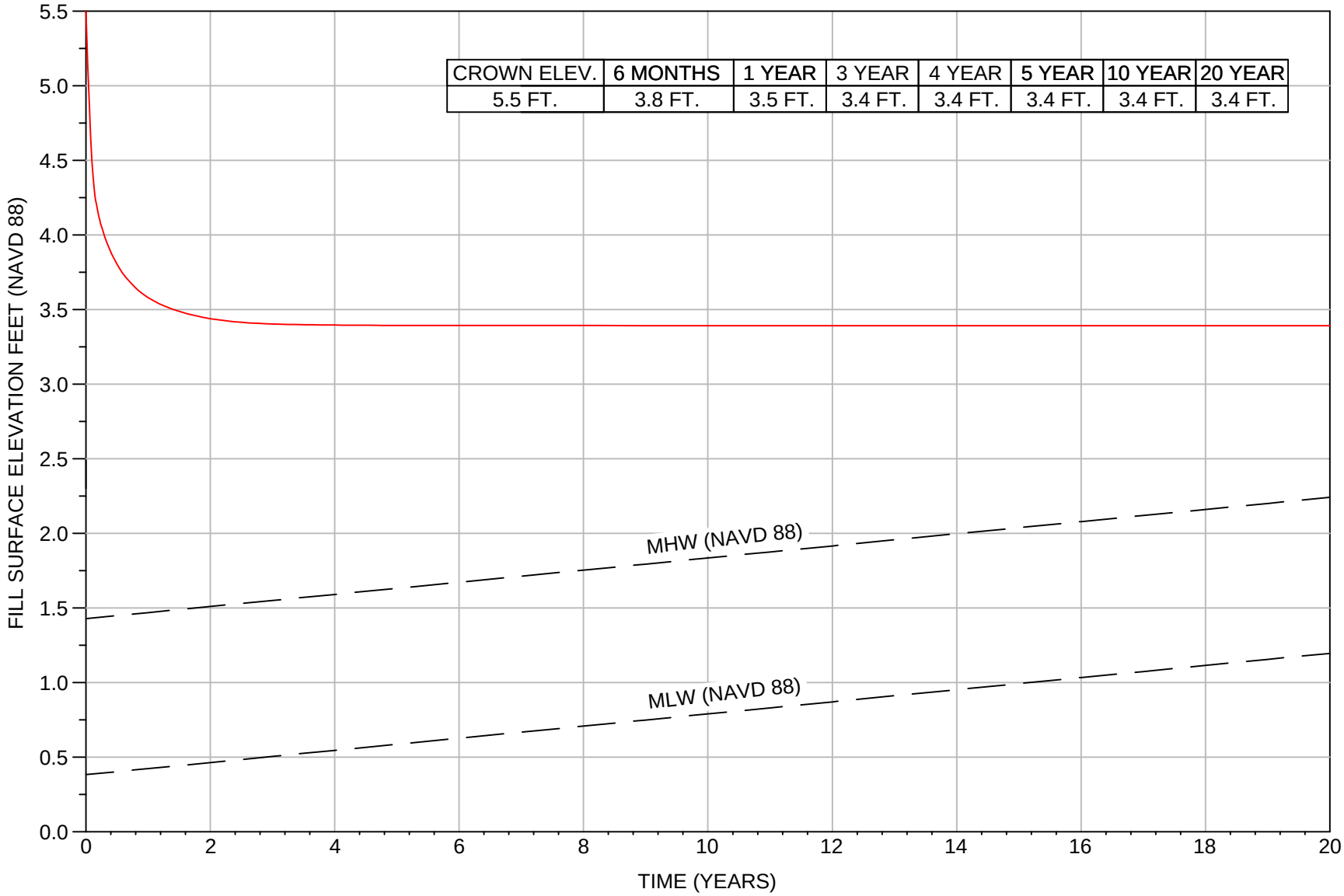
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-4	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C9a**



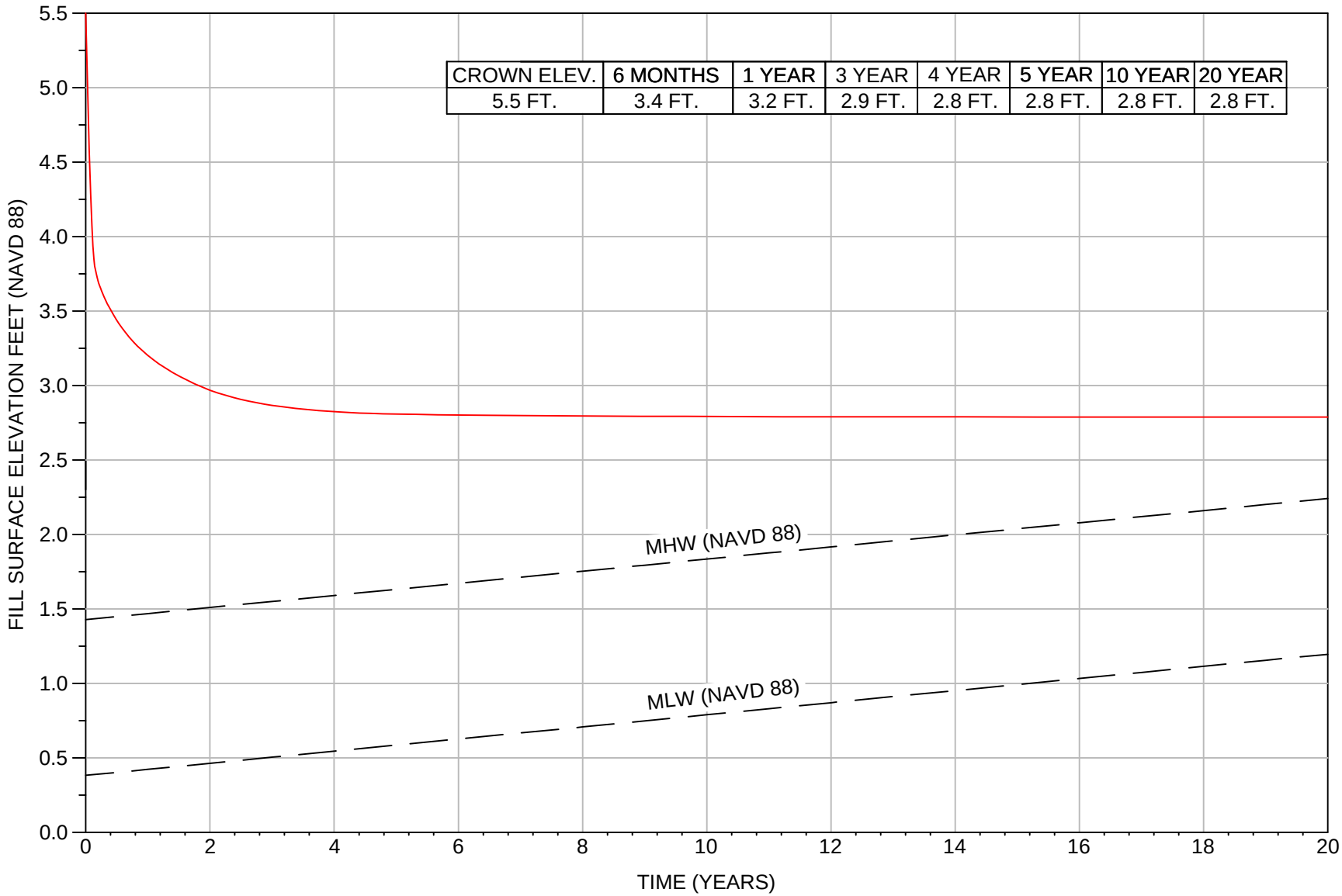
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-4	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C9b**



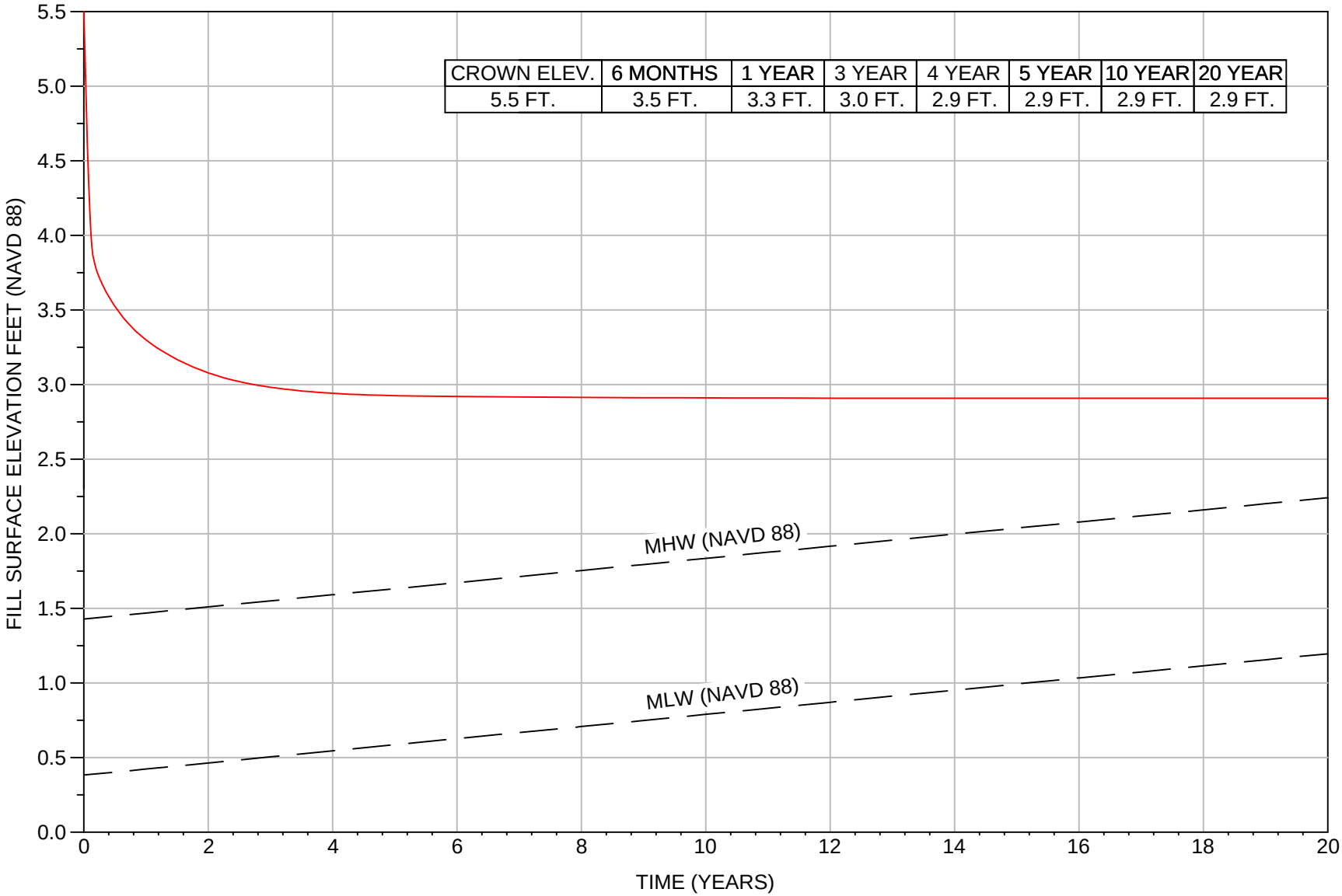
Notes: 1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-4	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C9c**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-6	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C10a**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-6	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C10b**

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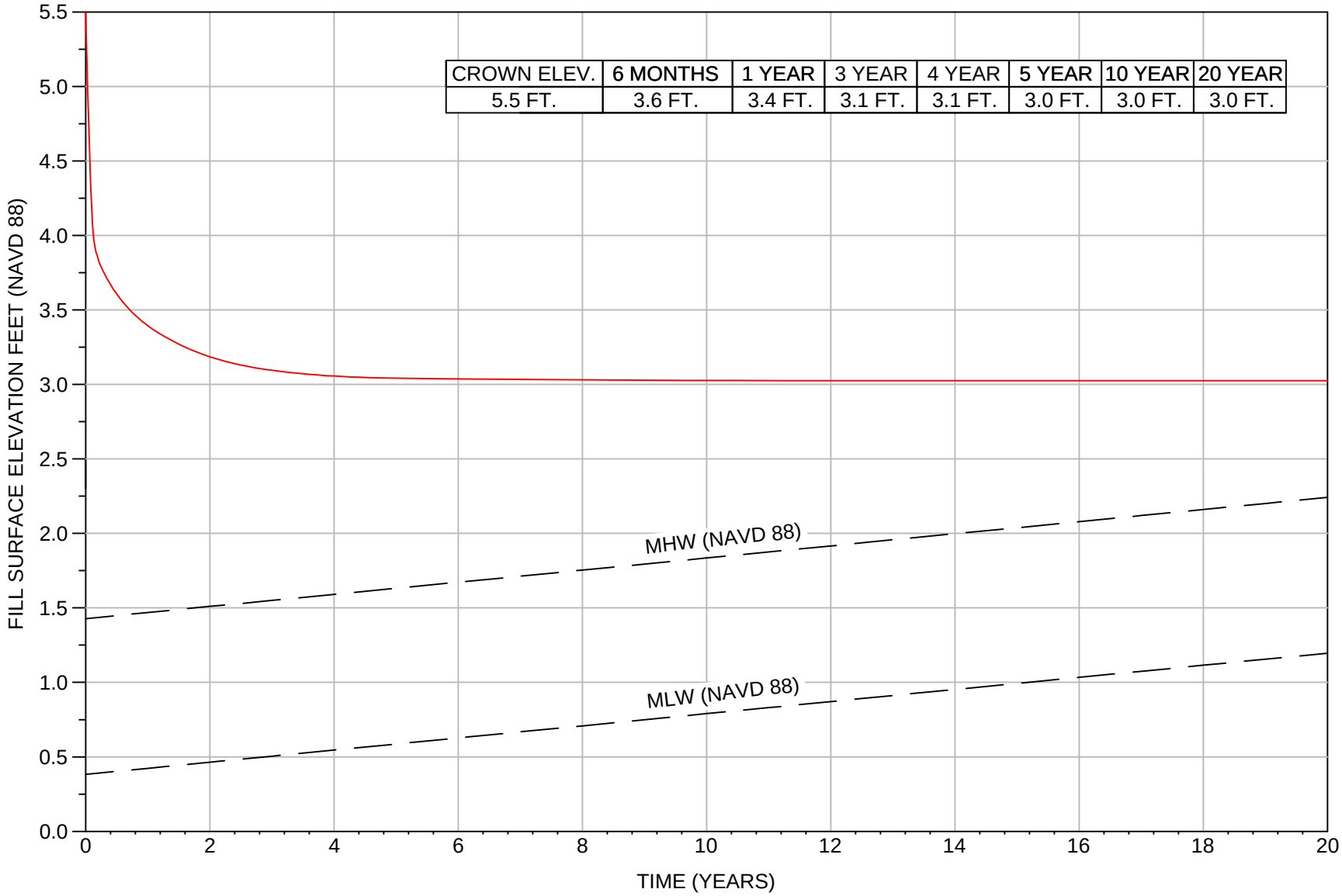
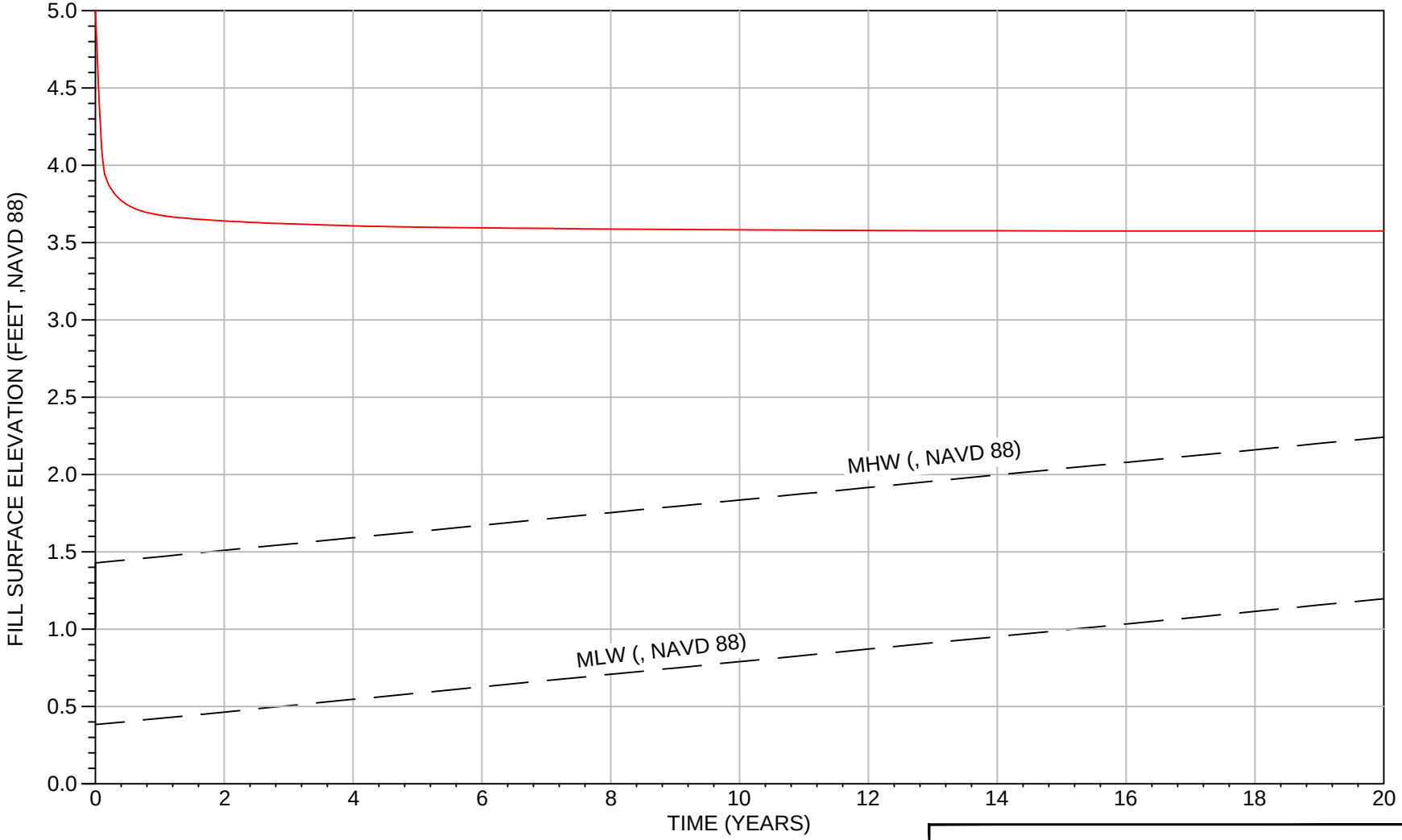


CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	3.6 FT.	3.4 FT.	3.1 FT.	3.1 FT.	3.0 FT.	3.0 FT.	3.0 FT.

Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-6	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C10c**



TIME	END OF CONSTRUCTION	6 MONTHS	1 YEAR	2 YEAR	3 YEAR	5 YEAR	10 YEAR	20 YEAR
ELEV. (FEET)	5.0	3.7	3.7	3.6	3.6	3.6	3.6	3.6

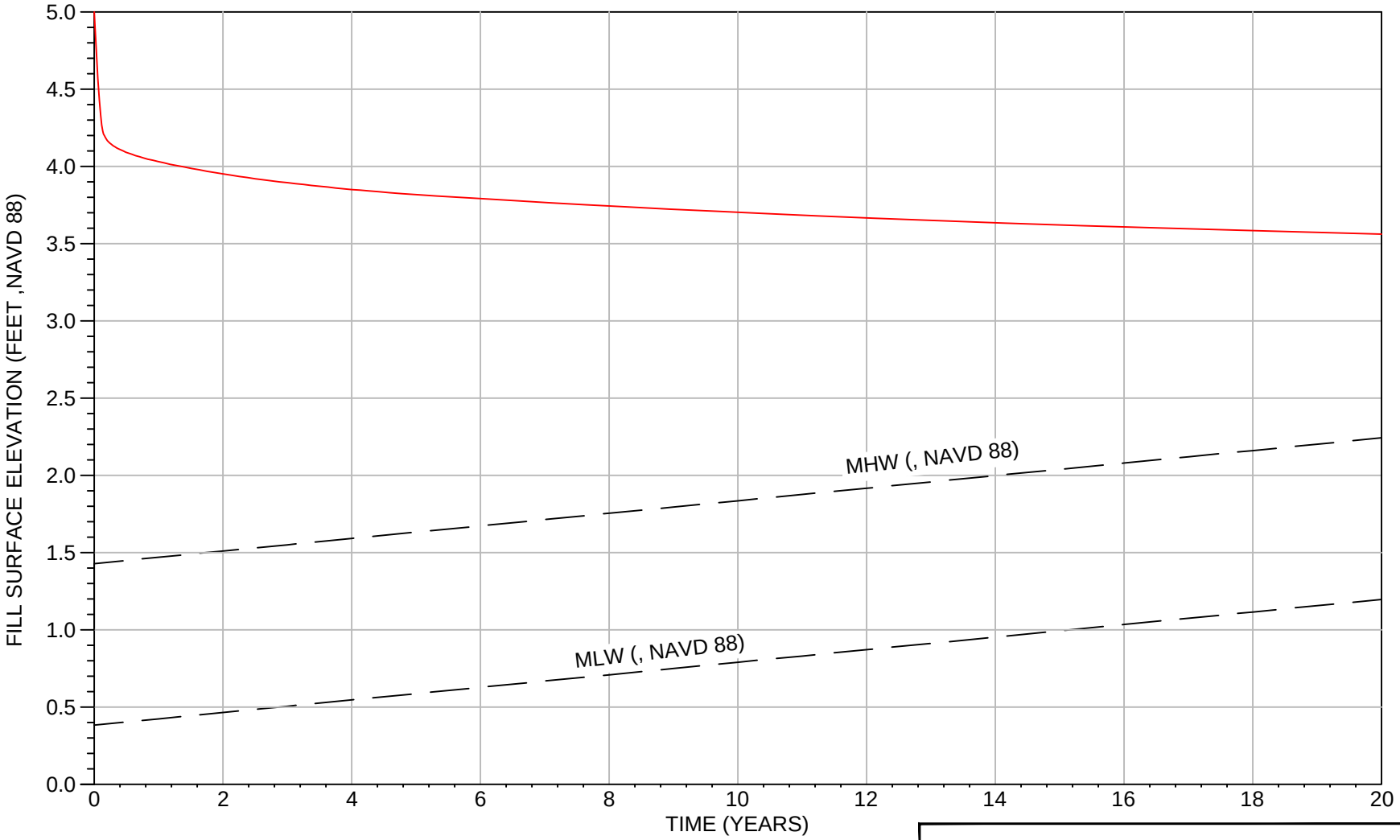
NOTE: Ridge constructed using combined material from bayou and existing marsh.

RIDGE SETTLEMENT VS. TIME B-1

Grand Liard Marsh and Ridge Restoration Project
(BA-68)-Structures
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure F-1



TIME	END OF CONSTRUCTION	6 MONTHS	1 YEAR	2 YEAR	3 YEAR	5 YEAR	10 YEAR	20 YEAR
ELEV. (FEET)	5.0	4.1	4.0	3.9	3.9	3.8	3.7	3.6

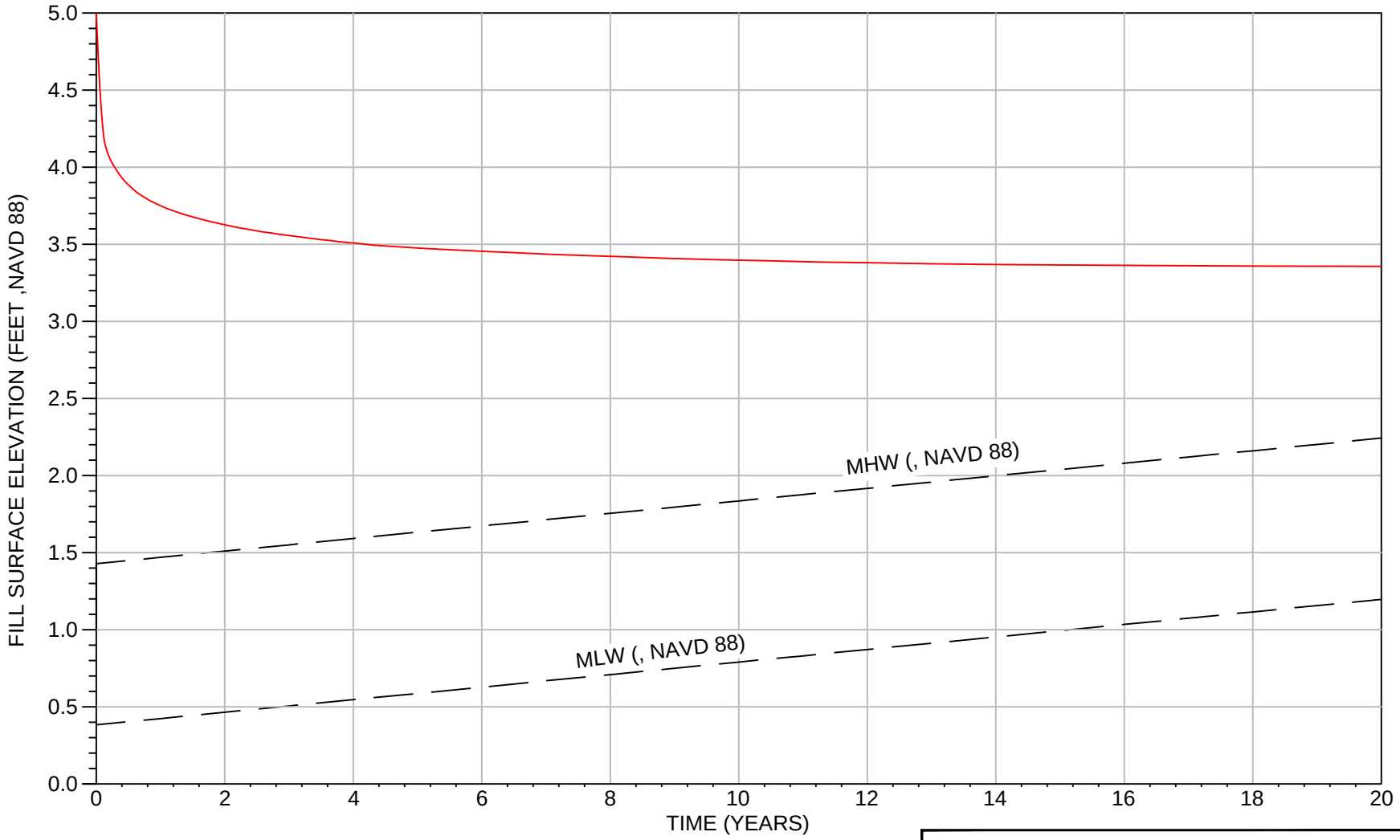
NOTE: Ridge constructed using combined material from bayou and existing marsh.

RIDGE SETTLEMENT VS. TIME B-2 & B-5

Grand Liard Marsh and Ridge Restoration Project
(BA-68)-Structures
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure F-2



TIME	END OF CONSTRUCTION	6 MONTHS	1 YEAR	2 YEAR	3 YEAR	5 YEAR	10 YEAR	20 YEAR
ELEV. (FEET)	5.0	3.9	3.7	3.6	3.6	3.5	3.4	3.4

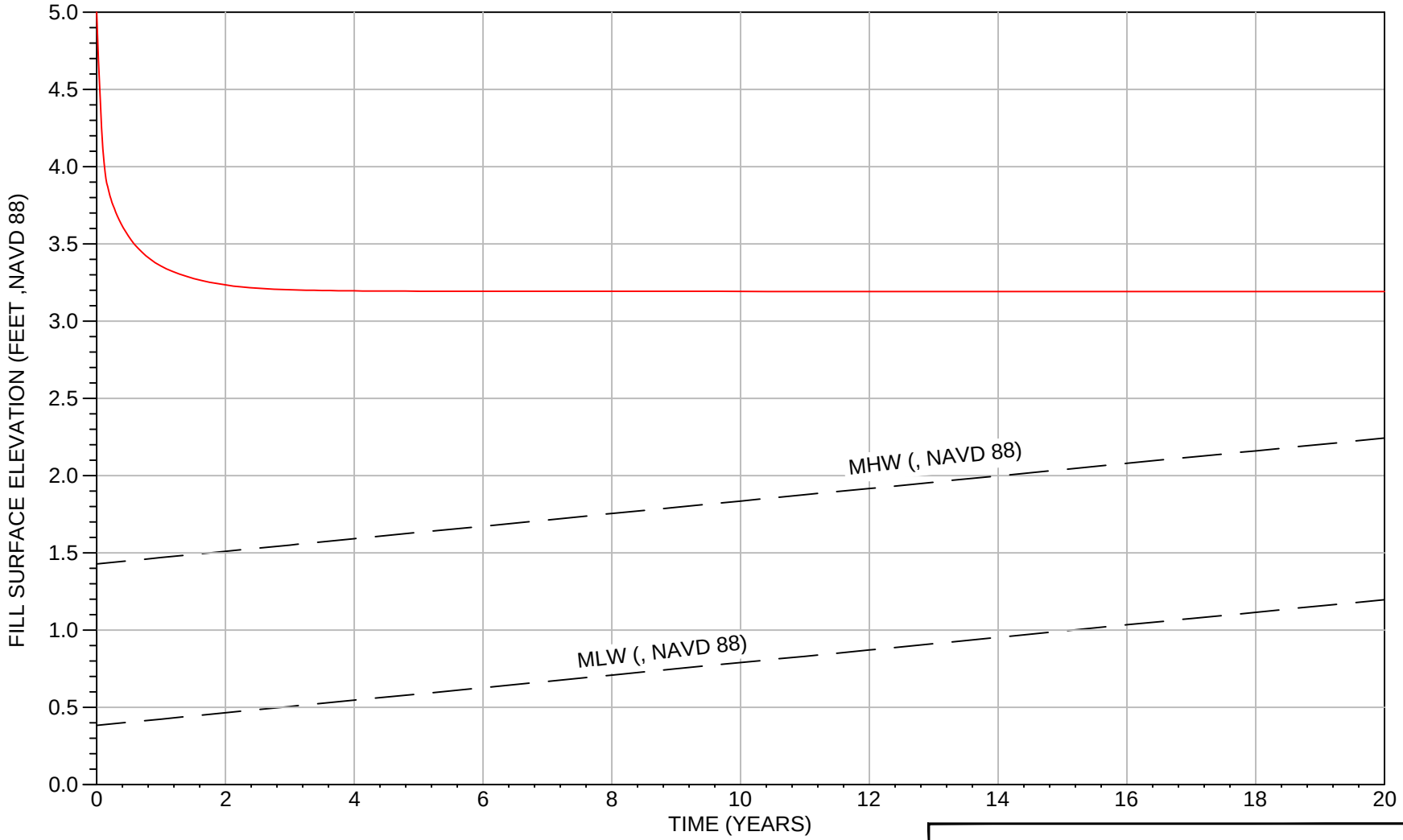
NOTE: Ridge constructed using combined material from bayou and existing marsh.

RIDGE SETTLEMENT VS. TIME B-3

Grand Liard Marsh and Ridge Restoration Project
(BA-68)-Structures
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure F-3



TIME	END OF CONSTRUCTION	6 MONTHS	1 YEAR	2 YEAR	3 YEAR	5 YEAR	10 YEAR	20 YEAR
ELEV. (FEET)	5.0	3.5	3.3	3.2	3.2	3.2	3.2	3.2

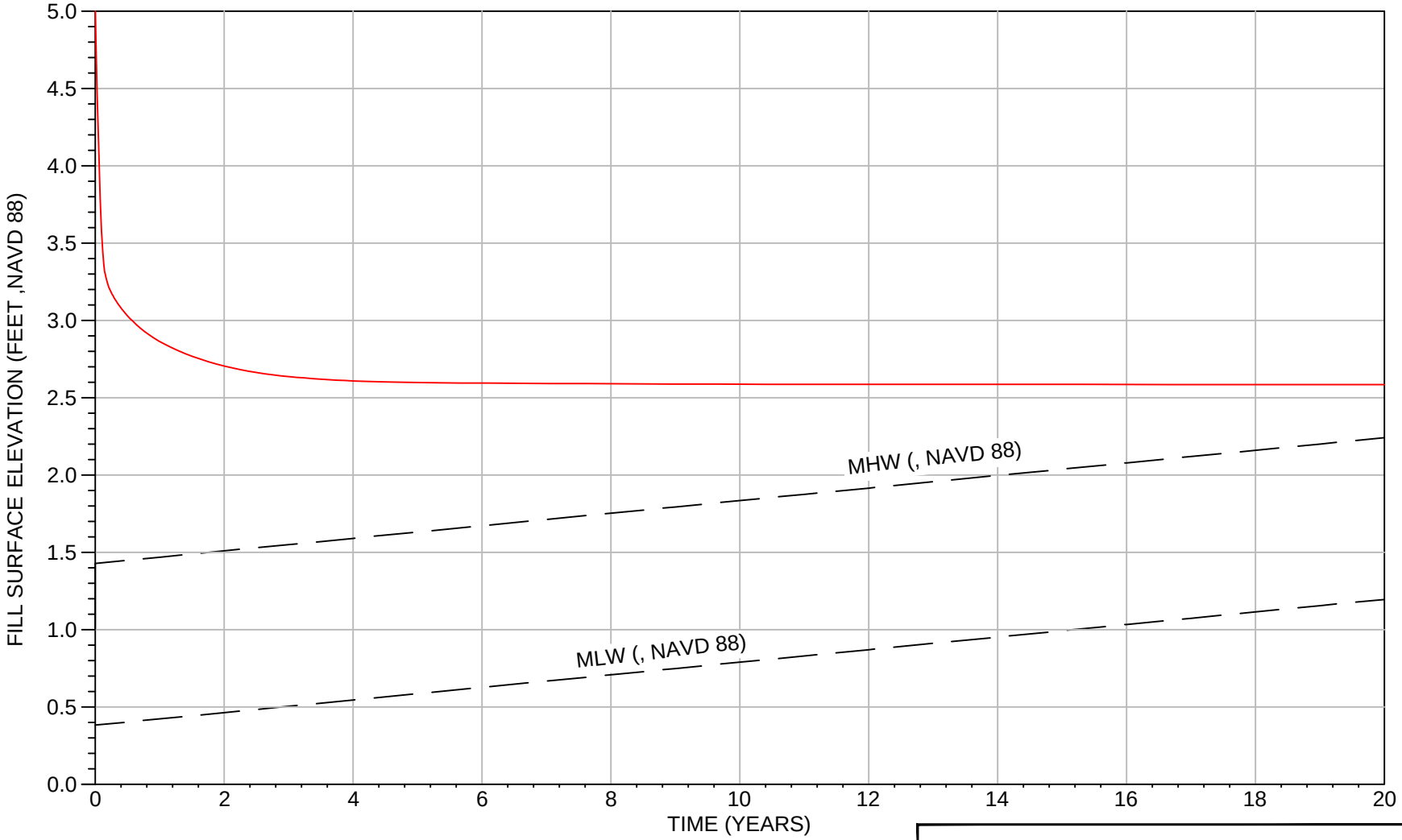
NOTE: Ridge constructed using combined material from bayou and existing marsh.

RIDGE SETTLEMENT VS. TIME B-4

Grand Liard Marsh and Ridge Restoration Project
(BA-68)-Structures
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure F-4



TIME	END OF CONSTRUCTION	6 MONTHS	1 YEAR	2 YEAR	3 YEAR	5 YEAR	10 YEAR	20 YEAR
ELEV. (FEET)	5.0	3.0	2.8	2.7	2.6	2.6	2.6	2.6

NOTE: Ridge constructed using combined material from bayou and existing marsh.

RIDGE SETTLEMENT VS. TIME B-6

Grand Liard Marsh and Ridge Restoration Project
(BA-68)-Structures
Plaquemines Parish, Louisiana

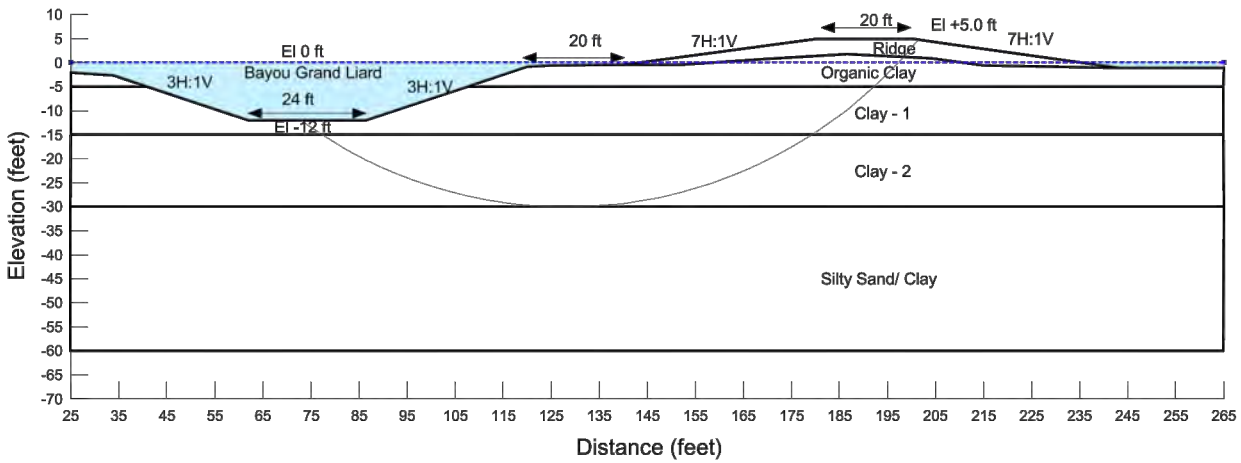
GEOENGINEERS

Figure F-5

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-1 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °

FOS: 1.183



SLO□E STABILITY
B-1 □FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

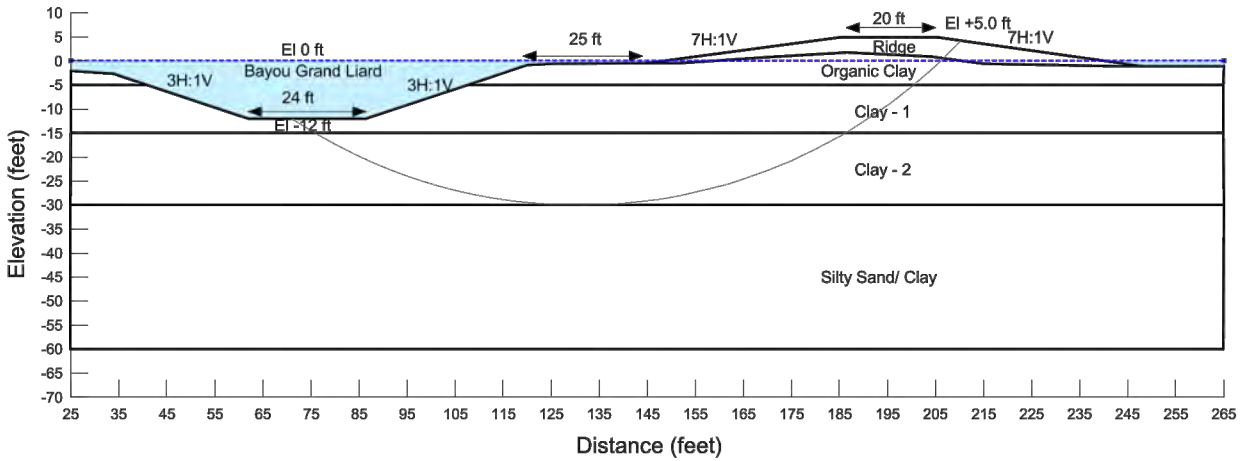
GEOENGINEERS

Figure E-1A

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-1 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °

FOS: 1.230



SLO E STABILITY
B-1 FAILURE INTO BAYOU WITH 25 FT. BENCH

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

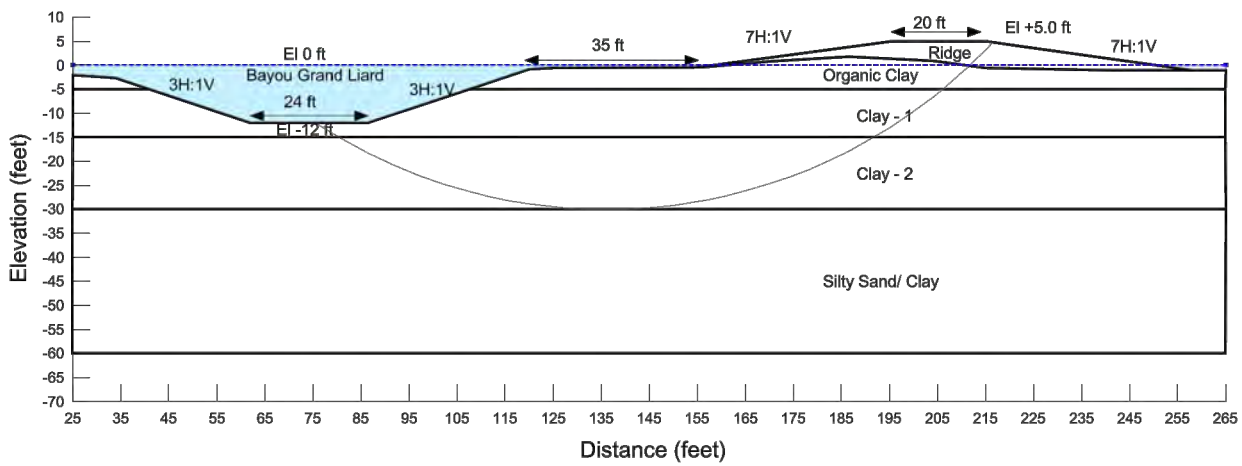
GEOENGINEERS

Figure E-1B

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-1 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °

FOS: 1.333



SLO□E STABILITY
B-1 □FAILURE INTO BAYOU WITH 35 FT. BENCH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

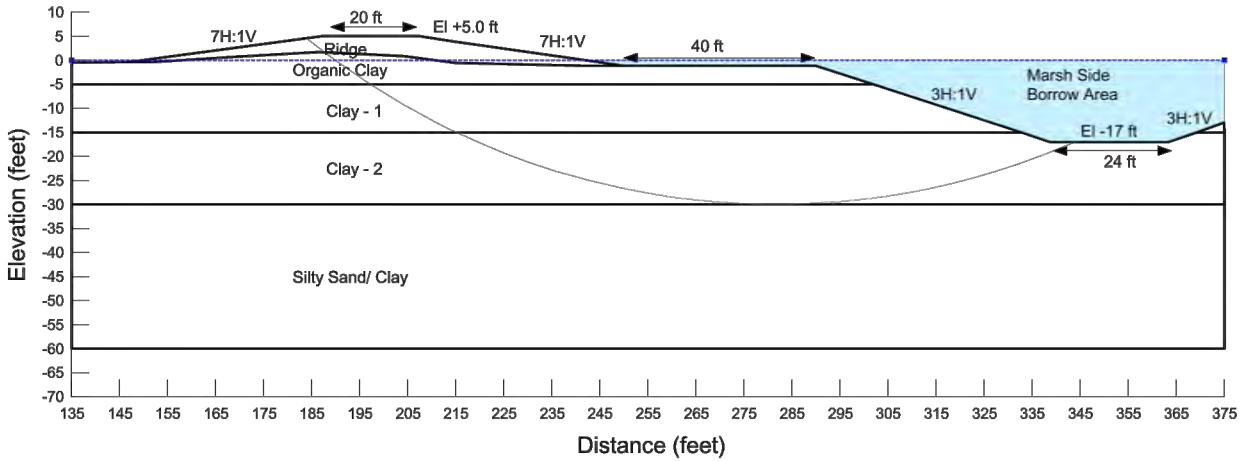
GEOENGINEERS

Figure E-1C

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-1 (Failure into Marsh Side)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °

FOS: 1.262



SLO□E STABILITY
B-1 □FAILURE INTO MARSH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

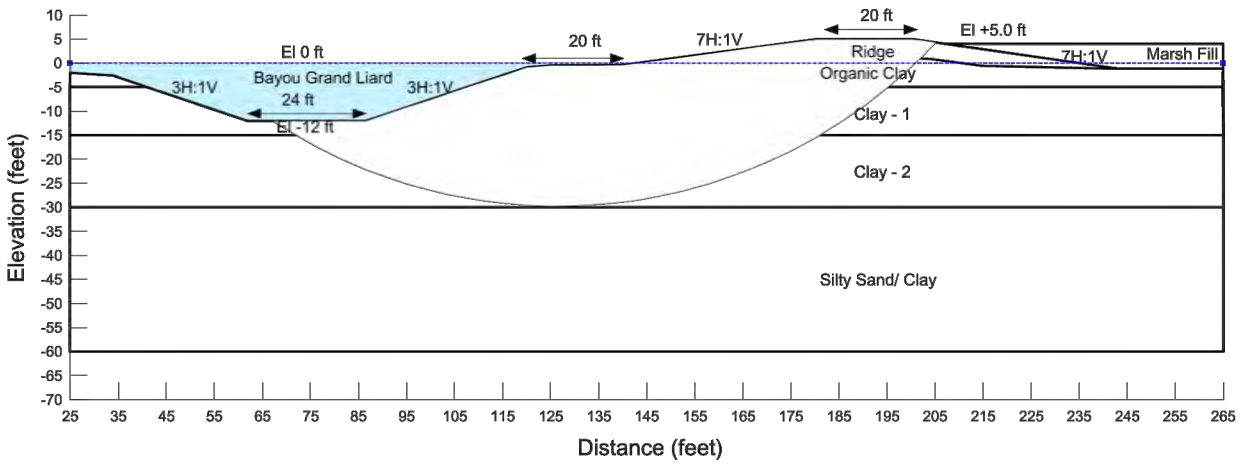
GEOENGINEERS

Figure E-1D

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-1 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.196



SLO□E STABILITY
B-1 □MARSH FILL AND FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

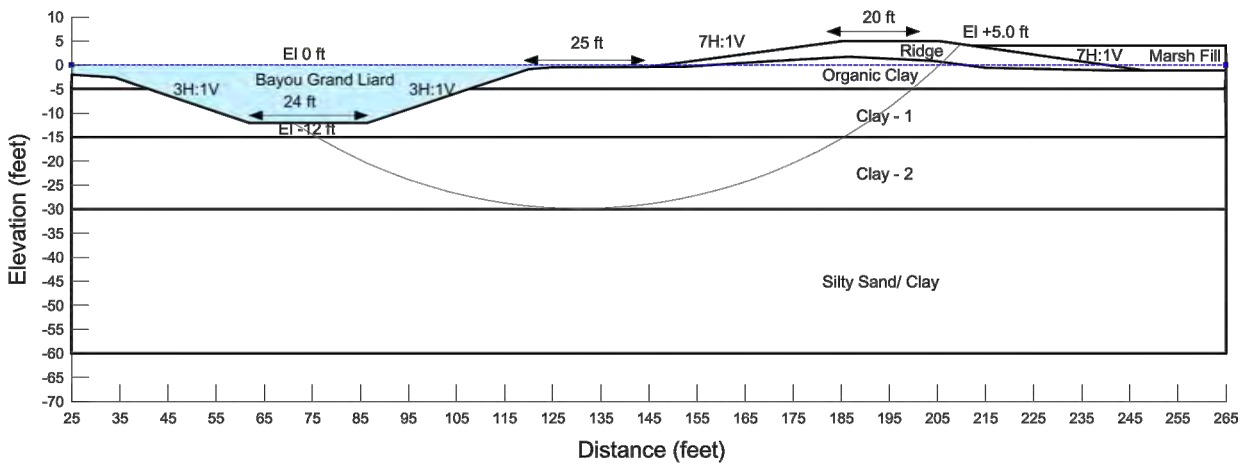
GEOENGINEERS

Figure E-1E

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-1 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.234



SLO□E STABILITY
B-1 □MARSH FILL AND FAILURE INTO BAYOU WITH 25 FT. BENCH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

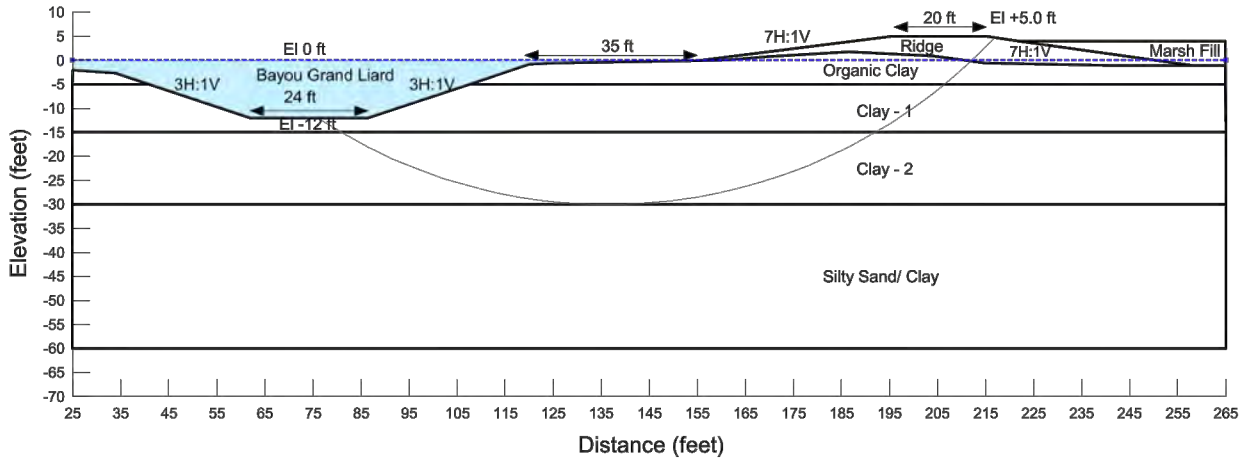
GEOENGINEERS

Figure E-1F

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-1 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.321



SLO□E STABILITY
B-1 □MARSH FILL AND FAILURE INTO BAYOU WITH 35 FT. BENCH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

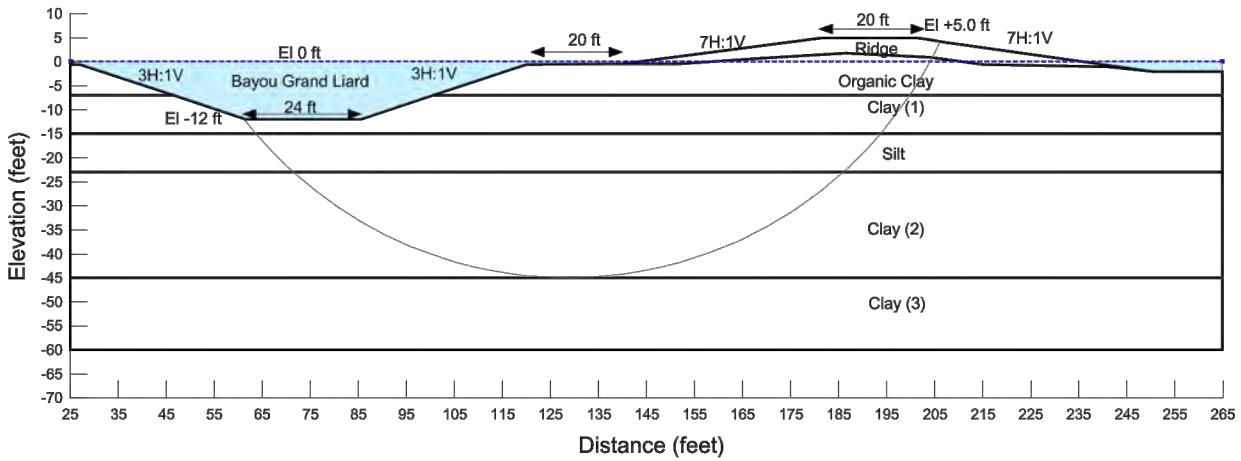
GEOENGINEERS

Figure E-1G

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-2&5 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °

FOS: 1.674



SLO□E STABILITY
B-2 & B-5 □FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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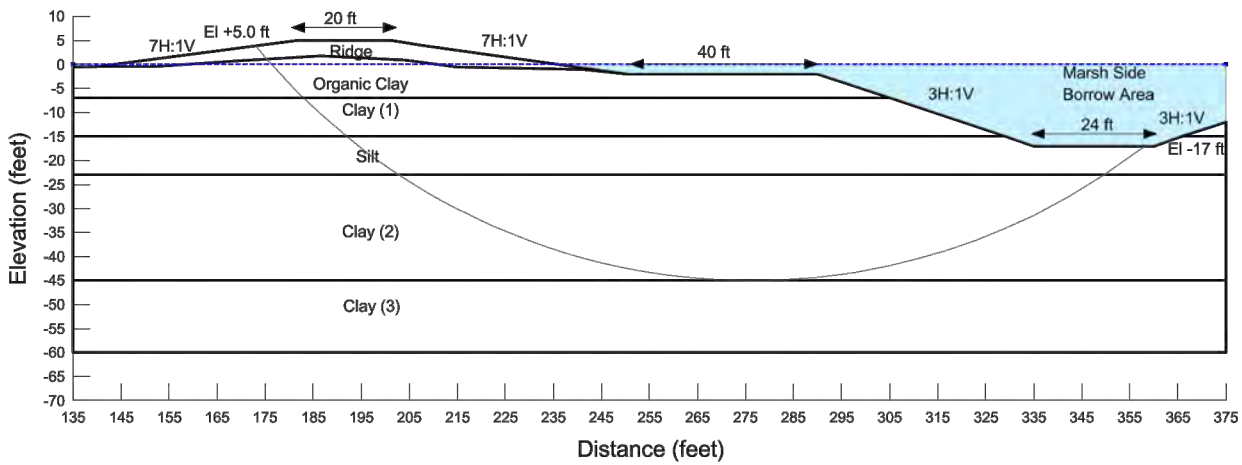
Figure E-2A

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-2&5 (Failure into Marsh Side)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °

FOS: 1.610



SLO□E STABILITY
B-2 & B-5 □FAILURE INTO MARSH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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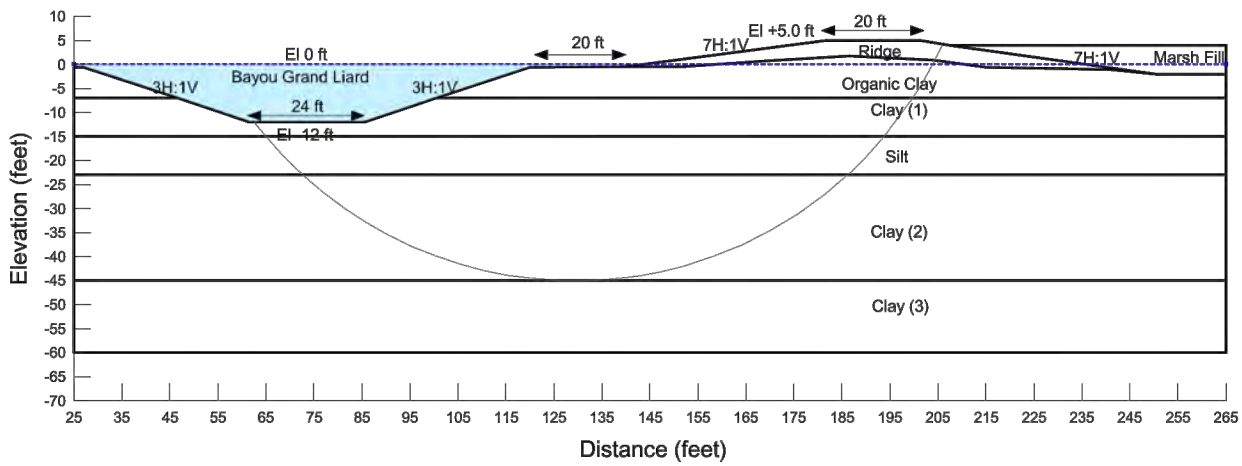
Figure E-2B

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-2&5 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °

FOS: 1.676



SLO□E STABILITY
B-2 & B-5 □MARSH FILL AND FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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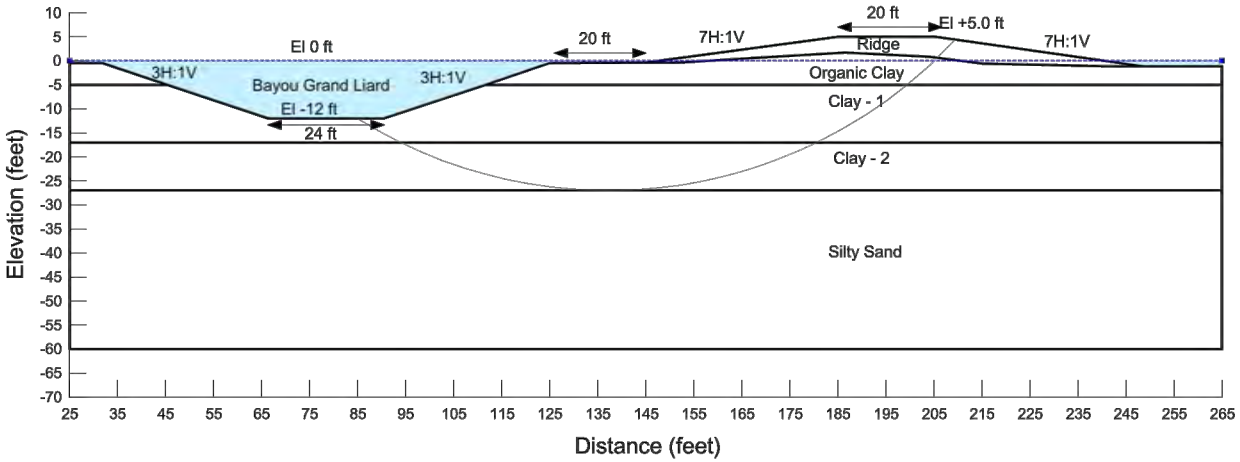
Figure E-2C

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-3 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °

FOS: 1.157



SLO□E STABILITY
B-3 □FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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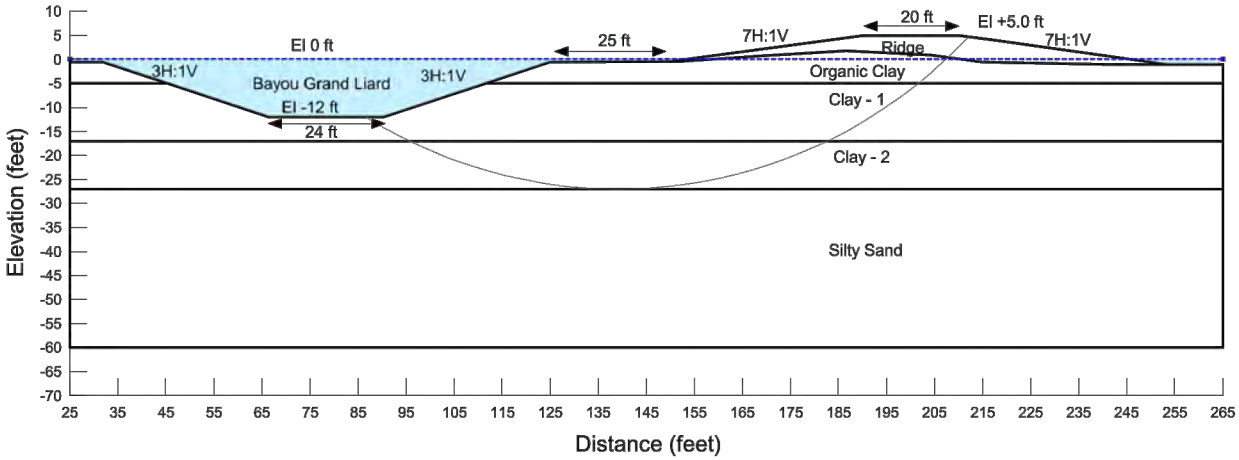
Figure E-3A

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-3 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °

FOS: 1.209



SLO□E STABILITY
B-3 □FAILURE INTO BAYOU WITH 25 FT. BENCH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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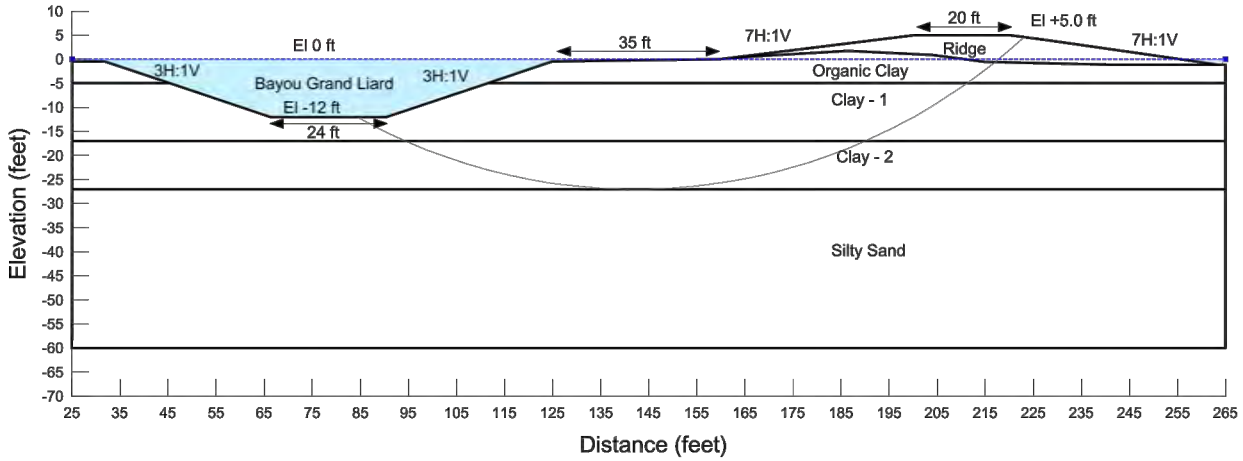
Figure E-3B

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-3 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °

FOS: 1.306



SLO□E STABILITY
B-3 □FAILURE INTO BAYOU WITH 35 FT. BENCH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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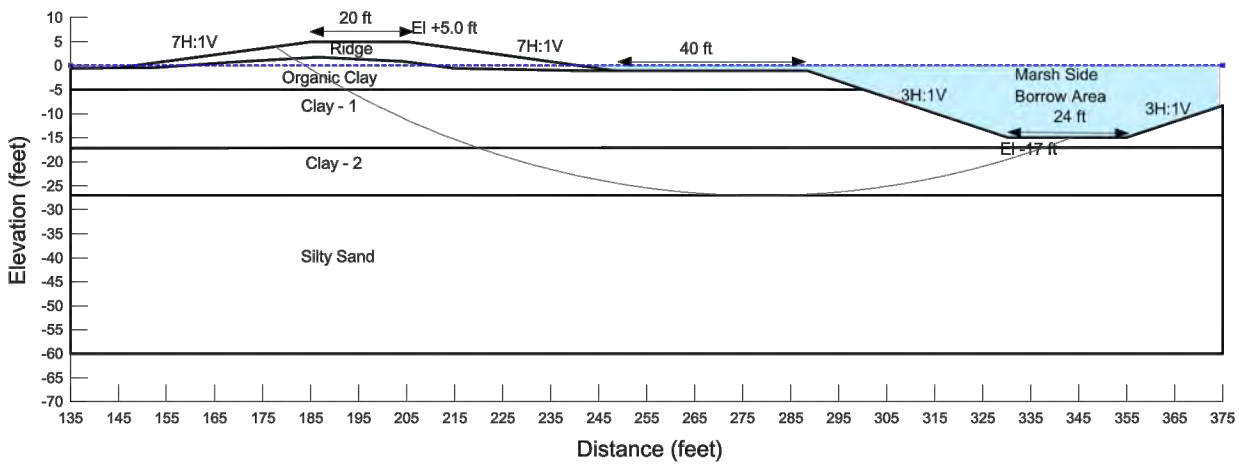
Figure E-3C

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-3 (Failure into Marsh Side)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °

FOS: 1.350



SLO□E STABILITY
B-3 □FAILURE INTO MARSH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

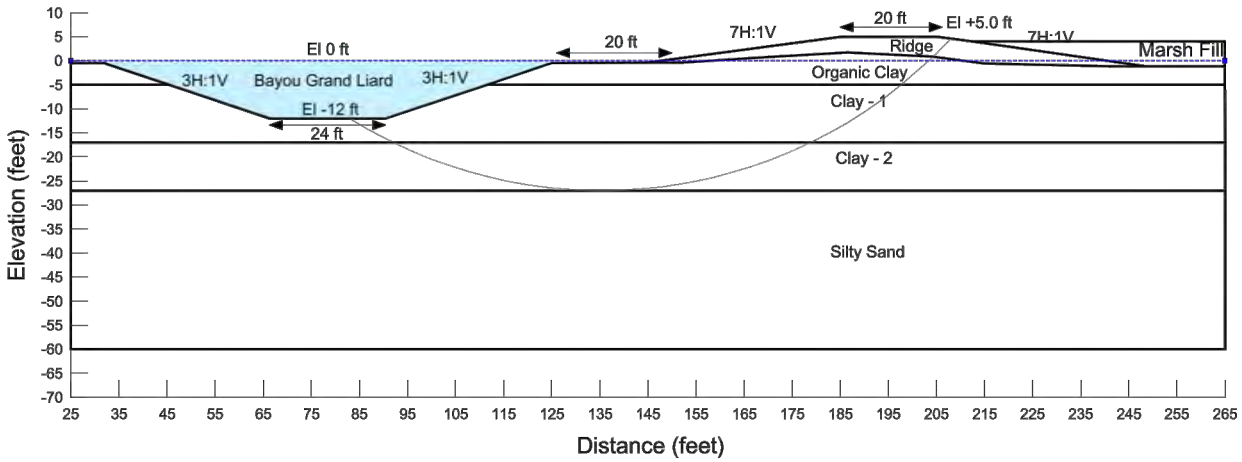
GEOENGINEERS

Figure E-3D

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-3 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.156



SLO□E STABILITY
B-3 □MARSH FILL AND FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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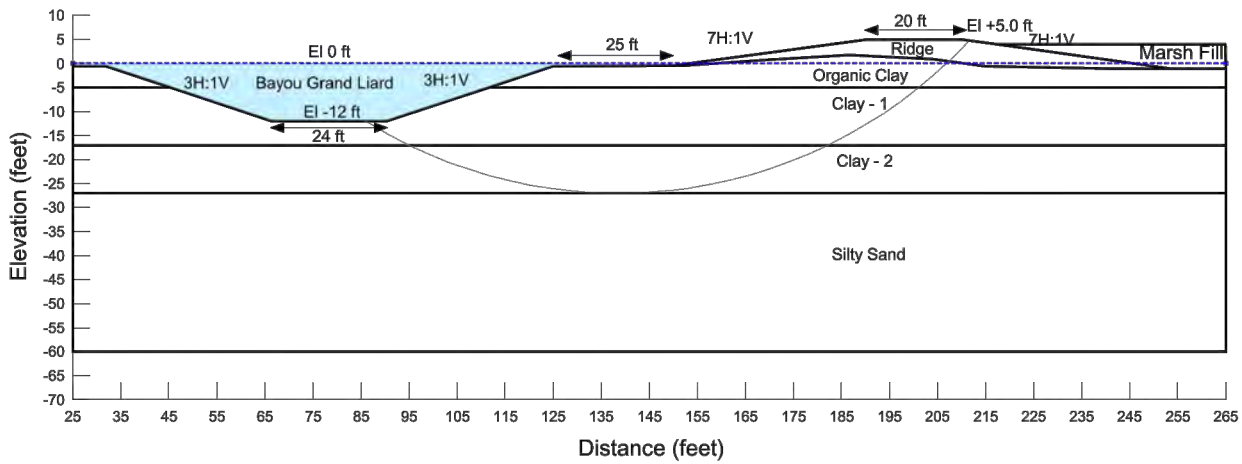
Figure E-3E

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-3 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.208



SLO□E STABILITY
B-3 □MARSH FILL AND FAILURE
INTO BAYOU WITH 25 FT. BENCH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

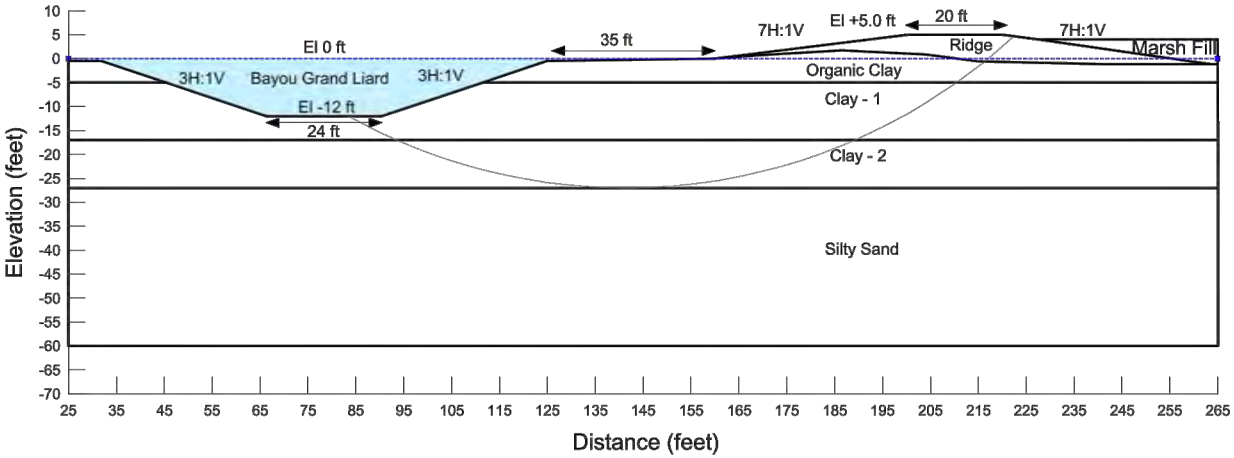
GEOENGINEERS

Figure
E-3F

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-3 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.306



SLO□E STABILITY
B-3 □MARSH FILL AND FAILURE
INTO BAYOU WITH 35 FT. BENCH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

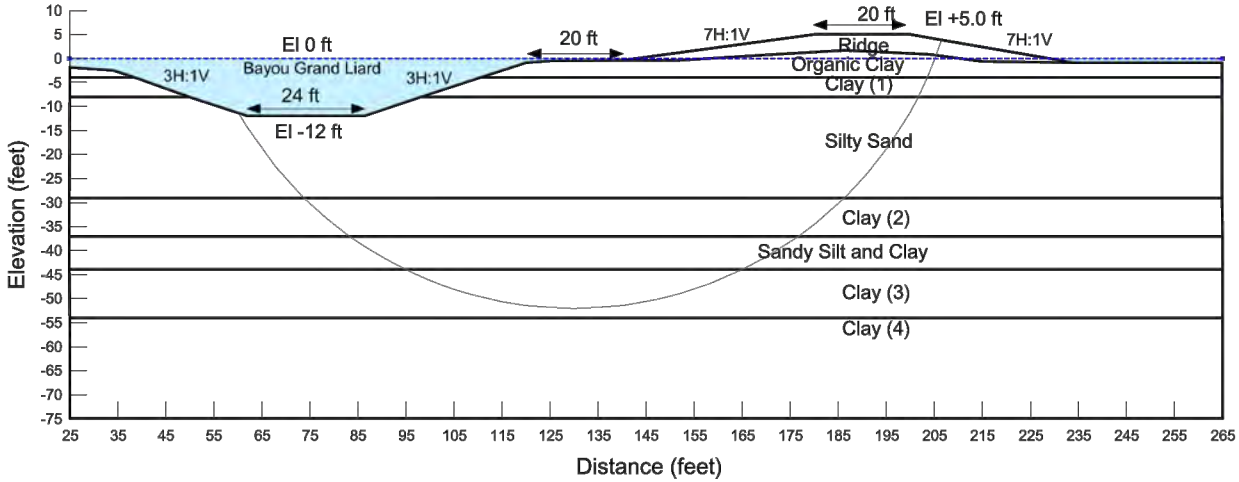
GEOENGINEERS

Figure E-3G

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-4 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 0 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °

FOS: 1.830



SLO□E STABILITY
B-4 □FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

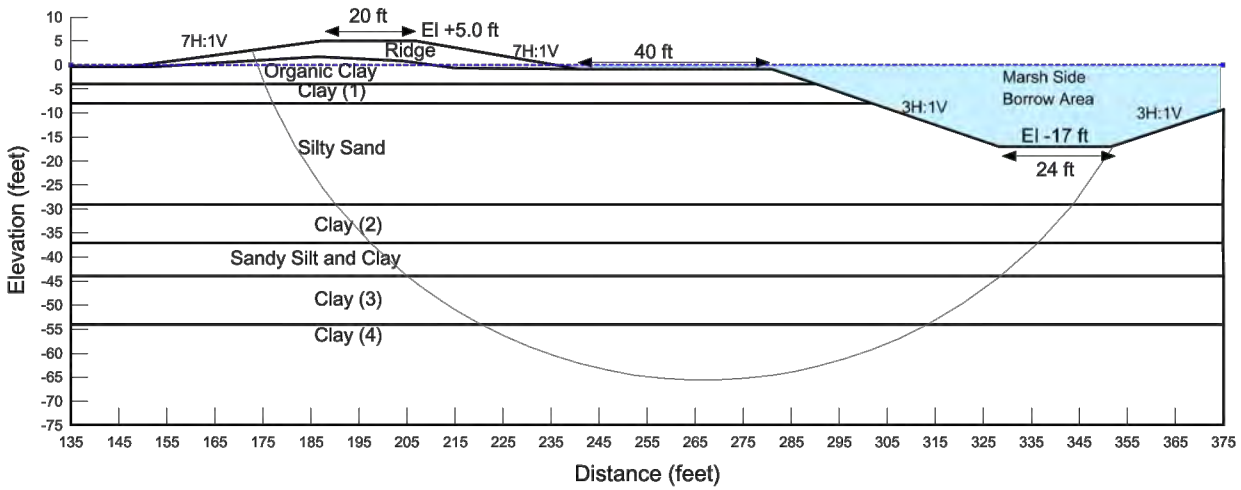
GEOENGINEERS

Figure E-4A

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-4 (Failure into Marsh Side)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 0 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °

FOS: 1.596



SLO□E STABILITY
B-4 □FAILURE INTO MARSH□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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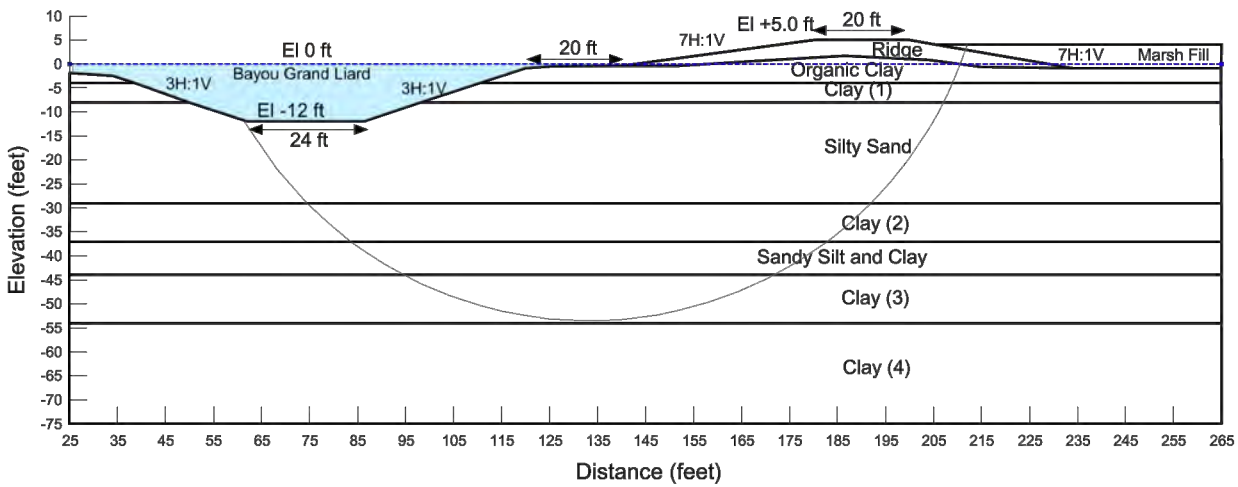
Figure E-4B

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-4 (Marsh Fill and Failure into Bayou)
Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 0 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.825



SLO□E STABILITY
B-4 □MARSH FILL AND FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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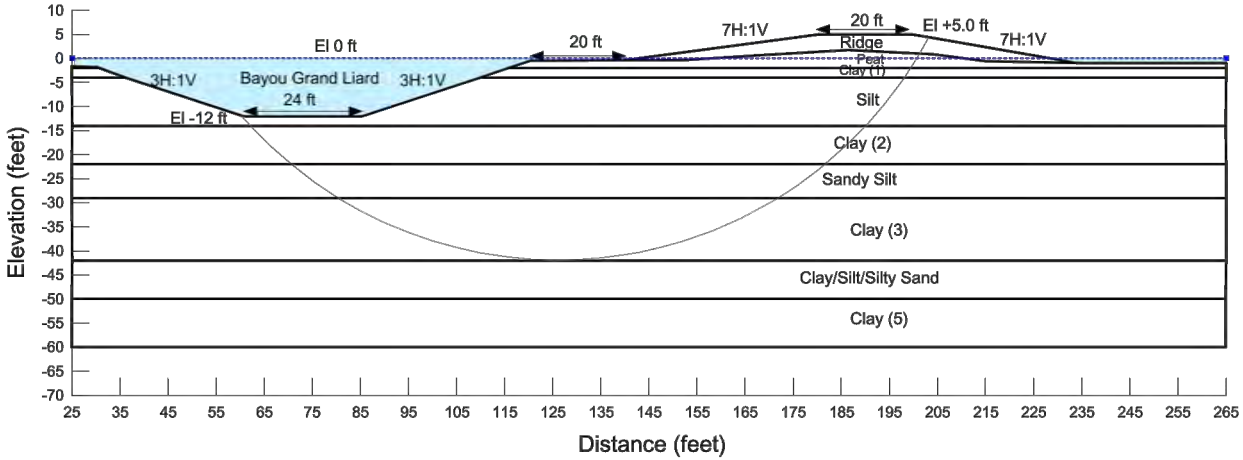
Figure E-4C

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-6 (Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay/Silt/Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °

FOS: 1.504



SLO□E STABILITY
B-6 □FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

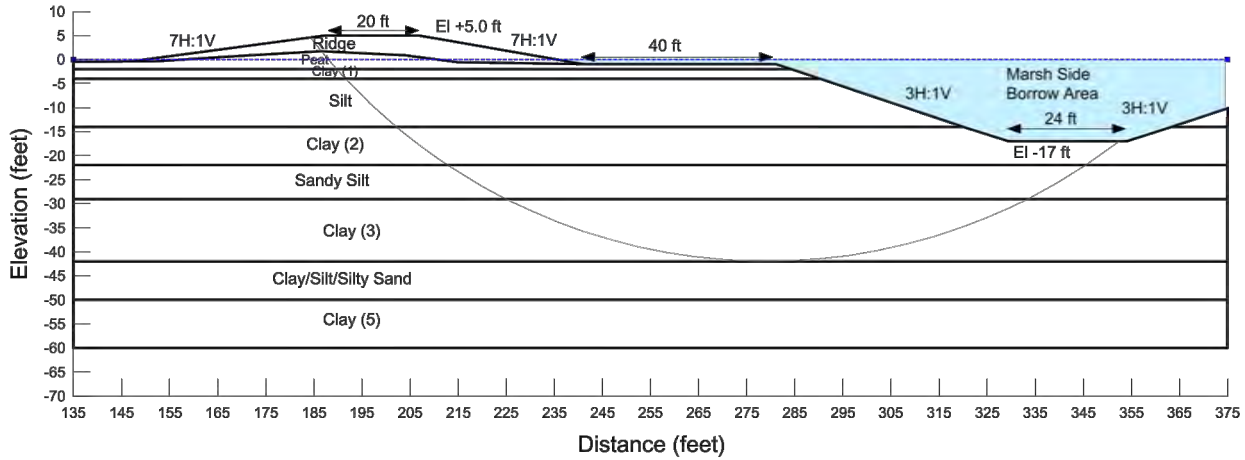
GEOENGINEERS

Figure E-5A

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-6 (Failure into Marsh Side)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay/Silt/Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °

FOS: 1.350



SLO□E STABILITY
B-6 □FAILURE INTO MARSH□

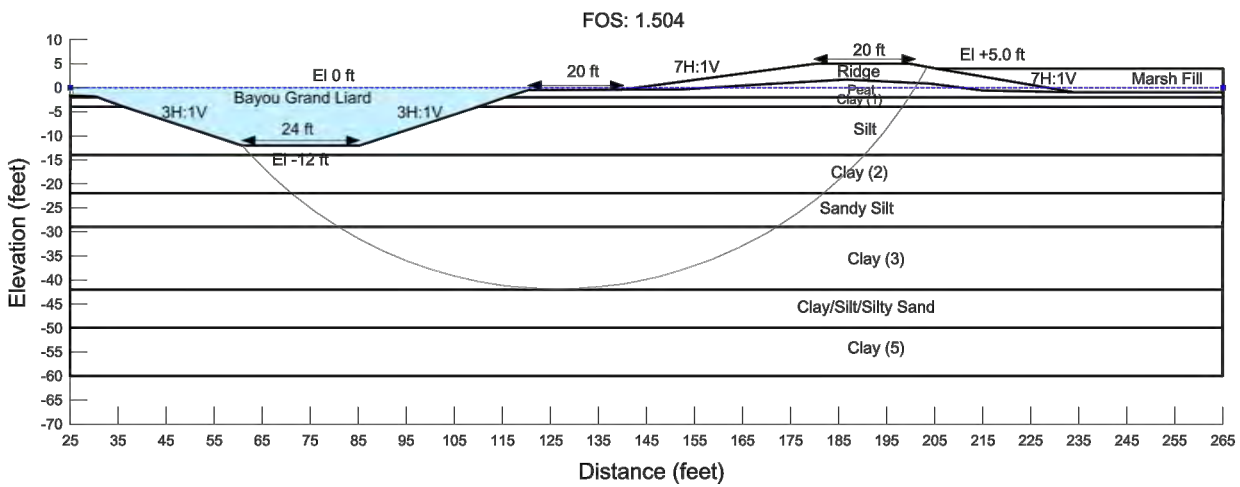
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure E-5b

Borrow Material From Bayou Grand Liard and Existing Marsh
Boring B-6 (Marsh Fill and Failure into Bayou)

Name: Ridge Unit Weight: 80 pcf Cohesion: 70 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay/Silt/Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °



SLO□E STABILITY
B-6 □MARSH FILL AND FAILURE INTO BAYOU□

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure E-5c

I. TIDAL DATUM

A. Given:

1. Control Station Gage Data: NOAA Station #8761724 at Grand Isle, LA.
   i. Coordinates: 29°15'48"N, 89°57'24"W
   ii. Observation Period (19 year tidal epoch): 06/25/1991 to 06/22/2010

2. Subordinate Station Gage Data: CRMS Station CRMS 0163-H01 southwest of Venice, LA
   i. Coordinates: 29° 13' 0.224"N 89° 25' 15.822"W
   ii. Observation Period: 06/25/07 to0 6/22/2010

B. Methodology/Calculations:

1. List of Variables:

   - MHW_{BA68} = observation period mean high water at subordinate station
   - MLW_{BA68} = observation period mean low water at subordinate station
   - MHW_{GI} = observation period mean high water at control station
   - MLW_{GI} = observation period mean low water at control station
   - MHW_C = 19 year mean high water at control station
   - MTL_C = 19 year mean tide level at control station
   - MLW_C= 19 year mean low water at control station
   - MR_C= 19 year mean tide range at control station
   - TL_C= mean tide level for the observation period at control station
   - R_C= mean tide range for the observation period at the control station
   - TL_S= mean tide level for the observation period at subordinate station
   - R_S= mean tide range for the observation period at subordinate station
   - MHW_S= 19 year mean high water at subordinate station
   - MTL_S= 19 year mean tide level at subordinate station
   - MLW_S= 19 year mean low water at subordinate station
   - MR_S= 19 year mean tide range at subordinate station

2. Calculations:

Variables Computed from Gage Data:

$MHW_{BA68} := 1.62 \cdot ft$ $\qquad$ $MHW_{GI} := 0.91593 \cdot ft$

$MLW_{BA68} := 0.46 ft$ $\qquad$ $MLW_{GI} := -0.247309 \cdot ft$

$MHW_C := 0.65 \cdot ft$

$MLW_C := -0.41 \cdot ft$

Calculated Tidal Datum:

$$TL_S := \frac{MHW_{BA68} + MLW_{BA68}}{2} \qquad \boxed{TL_S = 1.04\,ft}$$

$$R_S := MHW_{BA68} - MLW_{BA68} \qquad \boxed{R_S = 1.16\,ft}$$

$$TL_C := \frac{MHW_{GI} + MLW_{GI}}{2} \qquad \boxed{TL_C = 0.33\,ft}$$

$$R_C := MHW_{GI} - MLW_{GI} \qquad \boxed{R_C = 1.16\,ft}$$

$$MTL_C := \frac{MHW_C + MLW_C}{2} \qquad \boxed{MTL_C = 0.12\,ft}$$

$$MR_C := MHW_C - MLW_C \qquad \boxed{MR_C = 1.06\,ft}$$

$$MR_S := \frac{MR_C \cdot R_S}{R_C} \qquad \boxed{MR_S = 1.06\,ft}$$

$$MTL_S := TL_S + MTL_C - TL_C \qquad \boxed{MTL_S = 0.83\,ft}$$

$$MHW_S := MTL_S + \left(\frac{MR_S}{2}\right) \qquad \boxed{MHW_S = 1.35\,ft}$$

$$MLW_S := MTL_S - \left(\frac{MR_S}{2}\right) \qquad \boxed{MLW_S = 0.3\,ft}$$

II. FILL AREA DESIGN

A. Given:

1. Cross Sectional Survey Data of Marsh Fill Sites: XYZ data for each fill area cross section.

2. Target Fill Elevations:
   i. Settle to intertidal marsh within 3-4 years of construction.
   ii. Remain intertidal for the life of the project.

3. Containment Dike Parameters:
   i. Elevation = 1.5 ft. above target marsh creation elevation;
   ii. Side Slopes = 1(V):5(H) Containment Dikes

B. Methodology:

1. Area Calculations: The cross-sectional areas of each marsh fill transect were calculated using the XYZ data mentioned above. Due to the large number of points involved with each BA-68 cross-section, the following simplified example is used to show the method of calculating cross-sectional areas:

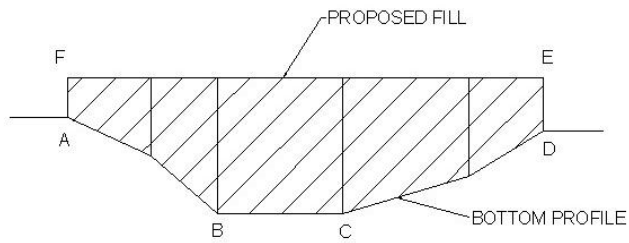


Figure 1

The area of this section can be obtained by incrementally computing the areas of each of the trapezoids that form the trapezoid ABCDEF shown in Figure 1. By treating the section as a traverse, fundamental survey methods can be utilized to calculate this area. These areas are calculated using the given data from the survey datasets with each point have a corresponding X, Y, and Z value. The incremental area calculations are carried out using the following formula:

$$A_i = \tfrac{1}{2} [D_i (Z_{i+1} - Z_{i-1})]$$

where: A_i = incremental area
D_i = cumulative distance from beginning of transect to point i
Z_{i+1} = elevation of previous point
Z_{i-1} = elevation of next point

The cumulative distance is computed by continuously summing the distance between each point, which is calculated with the distance formula:

$$L_i = [(X_2 - X_1)^2 + (Y_2 - Y_1)^2 + (Z_2 - Z_1)^2]^{1/2}$$

where: X = easting
Y = northing
Z = elevation

And

$$D_i = \sum L_i$$

The total area of the cross sections can then be obtained by summing each incremental area. Because these computations are so labor intensive, a spreadsheet was used for these area calculations.

2. Distance Between Cross Sections: Before the volume of the fill sites can be calculated, the distance between each cross section must be obtained. These distances represent the plan view area that each cross section will represent and were computed from the surveyor's CAD drawing.

3. Volume Calculations: The volume calculations for each cross section are computed by taking the product of the each cross-sectional area and its corresponding distance. The incremental volumes are then added together to get the total volume of the fill site. This is accomplished using the simple formulas shown below:

$$V_{xs} = (A_{xs})(d)$$

where: V_{xs} = Cross-sectional volume
A_{xs} = Cross-sectional area
d = Distance between cross-sections

$$V_{tot} = \sum V_{xs}$$

The volume calculations for each fill site are shown in Section B on the following pages:

A. Fill Area Design Volume Calculations:

1. Fill Cell A

i. Cross-Sectional Area(ft^2): Distance (ft.):

$A_{M05} := 2813.42ft^2$ $d_{M05} := 708ft$

$A_{M06} := 2918.18ft^2$ $d_{M06} := 483ft$

$A_{M07} := 2745.78ft^2$ $d_{M07} := 483ft$

$A_{M08} := 3286.44ft^2$ $d_{M08} := 416ft$

$A_{M09} := 3902.13ft^2$ $d_{M09} := 486ft$

$A_{M10} := 4729.43ft^2$ $d_{M10} := 582ft$

$A_{M11} := 4886.6ft^2$ $d_{M11} := 671ft$

$A_{M12} := 4436.81ft^2$ $d_{M12} := 330ft$

$A_{M13} := 5501.11ft^2$ $d_{M13} := 532ft$

$A_{M14} := 4161.47ft^2$ $d_{M14} := 419ft$

$A_{M15} := 3958.63ft^2$ $d_{M15} := 536ft$

$A_{M16} := 2851.03ft^2$ $d_{M16} := 552ft$

$A_{M17} := 1846.91ft^2$ $d_{M17} := 500ft$

ii. Calculated Volume (ft^3):

$V_{M05} := A_{M05} \cdot d_{M05}$ $\quad V_{M05} = 1991901.36\ ft^3$

$V_{M06} := A_{M06} \cdot d_{M06}$ $\quad V_{M06} = 1409480.94\ ft^3$

$V_{M07} := A_{M07} \cdot d_{M07}$ $\quad V_{M07} = 1326211.74\ ft^3$

$V_{M08} := A_{M08} \cdot d_{M08}$ $\quad V_{M08} = 1367159.04\ ft^3$

$V_{M09} := A_{M09} \cdot d_{M09}$ $\quad V_{M09} = 1896435.18\ ft^3$

$V_{M10} := A_{M10} \cdot d_{M10}$ $\quad V_{M10} = 2752528.26\ ft^3$

$V_{M11} := A_{M11} \cdot d_{M11}$ $\quad V_{M11} = 3278908.6\ ft^3$

$V_{M12} := A_{M12} \cdot d_{M12}$ $\quad V_{M12} = 1464147.3\ ft^3$

$V_{M13} := A_{M13} \cdot d_{M13}$ $\quad V_{M13} = 2926590.52\ ft^3$

$V_{M14} := A_{M14} \cdot d_{M14}$ $\quad V_{M14} = 1743655.93\ ft^3$

$V_{M15} := A_{M15} \cdot d_{M15}$ $\quad V_{M15} = 2121825.68\ ft^3$

$V_{M16} := A_{M16} \cdot d_{M16}$ $\quad V_{M16} = 1573768.56\ ft^3$

$V_{M17} := A_{M17} \cdot d_{M17}$ $\quad V_{M17} = 923455\ ft^3$

$$V_{MCA} := V_{M05} + V_{M06} + V_{M07} + V_{M08} + V_{M09} + V_{M10} + V_{M11} + V_{M12} + V_{M13} + V_{M14} + V_{M15} + V_{M16} \cdots + V_{M17}$$

Total Volume for Marsh Creation Cell A, $\boxed{V_{MCA} = 917632.15\ yd^3}$

2. Fill Cell B

i. Cross-Sectional Area(ft^2): Distance (ft.):

$A_{M16b} := 1399.68ft^2$ $d_{M16b} := 676ft$

$A_{M17b} := 1809.52ft^2$ $d_{M17b} := 390ft$

$A_{M18} := 2456.15ft^2$ $d_{M18} := 374ft$

$A_{M20} := 3498.39ft^2$ $d_{M20} := 488ft$

$A_{M21} := 4472.91ft^2$ $d_{M21} := 501ft$

$A_{M22} := 4456.30ft^2$ $d_{M22} := 529ft$

$A_{M23} := 4994.00ft^2$ $d_{M23} := 608ft$

$A_{M24} := 3902.34ft^2$ $d_{M24} := 572ft$

$A_{M25} := 5726.30ft^2$ $d_{M25} := 418ft$

$A_{M26} := 5855.5ft^2$ $d_{M26} := 368ft$

$A_{M27} := 2820.5ft^2$ $d_{M27} := 853ft$

ii. Calculated Volume (ft^3):

$V_{M16b} := A_{M16b} \cdot d_{M16b}$ $\quad V_{M16b} = 946183.68\ ft^3$

$V_{M17b} := A_{M17b} \cdot d_{M17b}$ $\quad V_{M17b} = 705712.80\ ft^3$

$V_{M18} := A_{M18} \cdot d_{M18}$ $\quad V_{M18} = 918600.10\ ft^3$

$V_{M20} := A_{M20} \cdot d_{M20}$ $\quad V_{M20} = 1707214.32\ ft^3$

$V_{M21} := A_{M21} \cdot d_{M21}$ $\quad V_{M21} = 2240927.91\ ft^3$

$V_{M22} := A_{M22} \cdot d_{M22}$ $\quad V_{M22} = 2357382.70\ ft^3$

$V_{M23} := A_{M23} \cdot d_{M23}$ $\quad V_{M23} = 3036352.00\ ft^3$

$V_{M24} := A_{M24} \cdot d_{M24}$ $\quad V_{M24} = 2232138.48\ ft^3$

$V_{M25} := A_{M25} \cdot d_{M25}$ $\quad V_{M25} = 2393593.40\ ft^3$

$V_{M26} := A_{M26} \cdot d_{M26}$ $\quad V_{M26} = 2154824.00\ ft^3$

$V_{M27} := A_{M27} \cdot d_{M27}$ $\quad V_{M27} = 2405886.50\ ft^3$

$$V_{MCB} := V_{M16b} + V_{M17b} + V_{M18} + V_{M20} + V_{M21} + V_{M22} + V_{M23} + V_{M24} + V_{M25} + V_{M26} + V_{M27}$$

Total Volume for Marsh Creation Cell B, $\boxed{V_{MCB} = 781437.63\ yd^3}$

3. Fill Cell C

i. Cross-Sectional Area(ft^2): Distance (ft.):

$A_{M29} := 829.28ft^2$ $d_{M29} := 575ft$

$A_{M30} := 2664.67ft^2$ $d_{M30} := 725ft$

$A_{M31} := 4420.01ft^2$ $d_{M31} := 275ft$

$A_{M32} := 5680.55ft^2$ $d_{M32} := 594ft$

$A_{M33} := 5452.69ft^2$ $d_{M33} := 462ft$

$A_{M34} := 5952.51ft^2$ $d_{M34} := 516ft$

$A_{M35} := 6606.57ft^2$ $d_{M35} := 645ft$

$A_{M36} := 5092.16ft^2$ $d_{M36} := 406ft$

ii. Calculated Volume (ft^3):

$V_{M29} := A_{M29} \cdot d_{M29}$ $V_{M29} = 476836.00\ ft^3$

$V_{M30} := A_{M30} \cdot d_{M30}$ $V_{M30} = 1931885.75\ ft^3$

$V_{M31} := A_{M31} \cdot d_{M31}$ $V_{M31} = 1215502.75\ ft^3$

$V_{M32} := A_{M32} \cdot d_{M32}$ $V_{M32} = 3374246.70\ ft^3$

$V_{M33} := A_{M33} \cdot d_{M33}$ $V_{M33} = 2519142.78\ ft^3$

$V_{M34} := A_{M34} \cdot d_{M34}$ $V_{M34} = 3071495.16\ ft^3$

$V_{M35} := A_{M35} \cdot d_{M35}$ $V_{M35} = 4261237.65\ ft^3$

$V_{M36} := A_{M36} \cdot d_{M36}$ $V_{M36} = 2067416.96\ ft^3$

$$V_{MCC} := V_{M29} + V_{M30} + V_{M31} + V_{M32} + V_{M33} + V_{M34} + V_{M35} + V_{M36}$$

Total Volume for Marsh Creation Cell C, $\boxed{V_{MCC} = 700657.92\ yd^3}$

4. Fill Cell D

i. Cross-Sectional Area(ft^2): Distance (ft.):

$A_{M37} := 3902.67 ft^2$ $d_{M37} := 670 ft$

$A_{M38} := 5844.39 ft^2$ $d_{M38} := 477 ft$

$A_{M39} := 4154.98 ft^2$ $d_{M39} := 439 ft$

ii. Calculated Volume (ft^3):

$V_{M37} := A_{M37} \cdot d_{M37}$ $V_{M37} = 2614788.90\ ft^3$

$V_{M38} := A_{M38} \cdot d_{M38}$ $V_{M38} = 2787774.03\ ft^3$

$V_{M39} := A_{M39} \cdot d_{M39}$ $V_{M39} = 1824036.22\ ft^3$

$V_{MCD} := V_{M37} + V_{M38} + V_{M39}$

Total Volume for Marsh Creation Cell D, $\boxed{V_{MCD} = 267651.82\ yd^3}$

TOTAL BA-68 MARSH FILL VOLUME, $V_{MC_TOT} := \left(V_{MCA} + V_{MCB} + V_{MCC} + V_{MCD}\right) \cdot 1.3$

$\boxed{V_{MC_TOT} = 3467593.37\ yd^3}$

Access dredged material will be used to constuct the containment dikes in Cell A. This volume is subtracted from the total marsh creation project.

$V_{BBA} := 78242 yd^3$

Reduced Total BA-68 Marsh Fill Volume, $V_{RMC_TOT} := V_{MC_TOT} - V_{BBA}$

$V_{RMC_TOT} = 3389351.37\ yd^3$

III. CONTAINMENT DIKE DESIGN

A. Given :

1. Crown Width: 5.0 ft.

2. Side Slope: 1(V):5(H)

3. Freeboard: 1.0 ft. above target marsh creation elevation

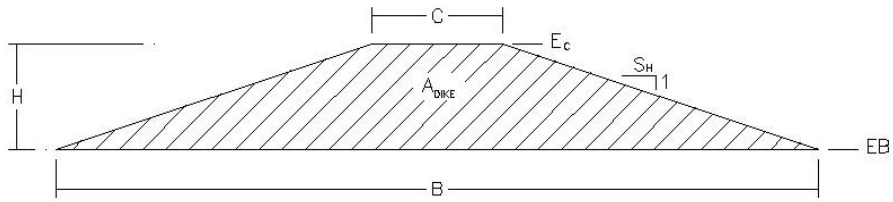
4. Containment Dike Crown Elevation:
   i. +5.0 ft. for each marsh creation cell

5. Containment Dike Length, L_{DIKE} (shown in table below; approximated with CAD):

	Segmetn Length	Avg. Base Elevation		Segmetn Length	Avg. Base Elevation		Segmetn Length	Avg. Base Elevation
A1	536	0.00	**A24**	90	-4.0	**C1**	925	1.5
A2	444	0.2	**A25**	90	0.5	**C2**	912	-0.25
A3	103	-2.0	**A26**	115	-1.5	**C3**	592	0.25
A4	451	-0.7	**A27**	315	1.5	**C4**	444	-0.65
A5	74	-2.0	**A28**	279	1.0	**C5**	577	-0.6
A6	570	0.0	**A29**	562	0.0	**C6**	422	-0.3
A7	65	-1.5	**A30**	497	1.0	**C7**	506	-1.0
A8	73	0.0	**A31**	646	0.5	**C8**	610	-1.0
A9	110	-2.1	**A32**	315	0.5	**C9**	1795	0.25
A10	205	0.0	**B1**	720	1.0	**D1**	1292	-0.8
A11	128	-3.0	**B2**	643	0.75	**D2**	685	-0.9
A12	406	0.5	**B3**	619	-0.9	**D3**	246	-0.9
A13	598	0.5	**B4**	248	0.75	**D4**	402	-1.2
A14	76	0.0	**B5**	544	-1.1	**D5**	219	1.0
A15	528	1.0	**B6**	528	-1.2	**D6**	247	-0.25
A16	113	-3.0	**B7**	620	-2.2	**D7**	592	1.0
A17	485	-0.7	**B8**	600	-2.5			
A18	99	-3.0	**B9**	505	-2.75			
A19	510	1.0	**B10**	535	-1.5			
A20	123	-3.0	**B11**	455	0.5			
A21	330	1.5	**B12**	177	1.25			
A22	112	-0.5	**B13**	380	1.0			
A23	275	0.5	**B14**	1257	-1.5			

6. Survey Data: XYZ points from profiles taken at proposed containment dike locations (also shown in the table above).

B. <u>Methodology</u>:



where: H = Dike height
B = Base width
C = Crown width (5.0 ft.)
EB = Base elevation
E_C = Crown elevation
A_{DIKE} = Cross-sectional area of dike

1. <u>Base Elevation</u>: The survey profiles mentioned above were used to determine the base elevation at each containment site. The base elevation at each site was determined by averaging the water-bottom elevations of each containment segment.

2. <u>Dike Height</u>: The height of the dike is computed by simply subtracting the base elevation from the crown elevation (+5.0 NAVD 88) as shown in the following formula:

$$H = E_{CROWN} - E_{BASE}$$

3. <u>Base Width</u>: The base width is governed by the dike height, the crown width, and the horizontal component of the side slope, S_H (5.0 throughout project area) and is computed using the following formula:

$$B = 2(S_H H)+C$$

4. <u>Cross-Sectional Area</u>: The cross-sectional area of each containment dike differs from site to site and is governed by the base elevation (given in the survey data), dike height, and base width at the proposed location. Once these variables are determined, the area can be easily calculated by treating the dike section as a trapezoid as shown in the formula below:

$$A_{DIKE} = ½ [H(C+B)]$$

5. <u>Containment Dike Volume</u>: The volume of material required to construct each containment is computed by multiplying each dike area by its corresponding length

$$V_{DIKE} = A_{DIKE} * L_{DIKE}$$

B. <u>Containment Dike Design Calculations</u>:

1. <u>Fill Site A</u>

i. <u>Fill Volume for Containment</u>:

<u>Constants</u>:

-Crown Width, $C := 5.0ft$

-Horizontal Side Slope, $S_H := 5.0$

-Target Marsh Creation Elevation, $E_{MC} := 2.0ft$

-Crown Elevation, $E_c := 5.0ft$

$$E_c = 5\ ft$$

a. <u>Containment Segment 1 (A1)</u>

-Segment Length (from CAD):

$$L_{A1} := 536ft$$

-Base Elevation (from survey data):

$$EB_{A1} := 0.0ft$$

-Segment Height:

$$H_{A1} := E_c - EB_{A1}$$

$$H_{A1} = 5\ ft$$

-Segment Base Width:

$$B_{A1} := 2\left(S_H \cdot H_{A1}\right) + C$$

$$B_{A1} = 55\ ft$$

-Cross Sectional Area:

$$A_{A1} := \frac{1}{2} H_{A1} \cdot \left(C + B_{A1}\right)$$

$$A_{A1} = 150\ ft^2$$

-Volume of Segment:

$$V_{A1} := A_{A1} \cdot L_{A1}$$

$$\boxed{V_{A1} = 2977.78\ yd^3}$$

b. <u>Containment Segment 2 (A2)</u>

-Segment Length (from CAD):

$$L_{A2} := 444ft$$

-Base Elevation (from survey data):

$$EB_{A2} := 0.2ft$$

-Segment Height:

$$H_{A2} := E_c - EB_{A2}$$

$$H_{A2} = 4.8\ ft$$

-Segment Base Width:

$$B_{A2} := 2\left(S_H \cdot H_{A2}\right) + C$$

$$B_{A2} = 53\ ft$$

-Cross Sectional Area:

$$A_{A2} := \frac{1}{2} H_{A2} \cdot \left(C + B_{A2}\right)$$

$$A_{A2} = 139.2\ ft^2$$

-Volume of Segment:

$$V_{A2} := A_{A2} \cdot L_{A2}$$

$$\boxed{V_{A2} = 2289.07\ yd^3}$$

c. <u>Containment Segment 3 (A3)</u>

-Segment Length (from CAD):

$$L_{A3} := 106ft$$

-Base Elevation (from survey data):

$$EB_{A3} := -2.0ft$$

-Segment Height:

$$H_{A3} := E_c - EB_{A3}$$

$$H_{A3} = 7\ ft$$

-Segment Base Width:

$$B_{A3} := 2\left(S_H \cdot H_{A3}\right) + C$$

$$B_{A3} = 75\ ft$$

-Cross Sectional Area:

$$A_{A3} := \frac{1}{2} H_{A3} \cdot \left(C + B_{A3}\right)$$

$$A_{A3} = 280\ ft^2$$

-Volume of Segment:

$$V_{A3} := A_{A3} \cdot L_{A3}$$

$$\boxed{V_{A3} = 1099.26\ yd^3}$$

d. <u>Containment Segment 4 (A4)</u>

-Segment Length (from CAD):

$$L_{A4} := 451ft$$

-Base Elevation (from survey data):

$$EB_{A4} := -0.7ft$$

-Segment Height:

$$H_{A4} := E_c - EB_{A4}$$

$$H_{A4} = 5.7\ ft$$

-Segment Base Width:

$$B_{A4} := 2\left(S_H \cdot H_{A4}\right) + C$$

$$B_{A4} = 62\ ft$$

-Cross Sectional Area:

$$A_{A4} := \frac{1}{2} H_{A4} \cdot \left(C + B_{A4}\right)$$

$$A_{A4} = 190.95\ ft^2$$

-Volume of Segment:

$$V_{A4} := A_{A4} \cdot L_{A4}$$

$$\boxed{V_{A4} = 3189.57\ yd^3}$$

e. <u>Containment Segment 5 (A5)</u>

-Segment Length (from CAD):

$$L_{A5} := 74ft$$

-Base Elevation (from survey data):

$$EB_{A5} := -2.0ft$$

-Segment Height:

$$H_{A5} := E_c - EB_{A5}$$

$$H_{A5} = 7\ ft$$

-Segment Base Width:

$$B_{A5} := 2\left(S_H \cdot H_{A5}\right) + C$$

$$B_{A5} = 75\ ft$$

-Cross Sectional Area:

$$A_{A5} := \frac{1}{2} H_{A5} \cdot \left(C + B_{A5}\right)$$

$$A_{A5} = 280\ ft^2$$

-Volume of Segment:

$$V_{A5} := A_{A5} \cdot L_{A5}$$

$$\boxed{V_{A5} = 767.41\ yd^3}$$

f. <u>Containment Segment 6 (A6)</u>

-Segment Length (from CAD):

$$L_{A6} := 570ft$$

-Base Elevation (from survey data):

$$EB_{A6} := 0.0ft$$

-Segment Height:

$$H_{A6} := E_c - EB_{A6}$$

$$H_{A6} = 5\ ft$$

-Segment Base Width:

$$B_{A6} := 2\left(S_H \cdot H_{A6}\right) + C$$

$$B_{A6} = 55\ ft$$

-Cross Sectional Area:

$$A_{A6} := \frac{1}{2} H_{A6} \cdot \left(C + B_{A6}\right)$$

$$A_{A6} = 150\ ft^2$$

-Volume of Segment:

$$V_{A6} := A_{A6} \cdot L_{A6}$$

$$\boxed{V_{A6} = 3166.67\ yd^3}$$

g. <u>Containment Segment 7 (A7)</u>

-Segment Length (from CAD):

$$L_{A7} := 65ft$$

-Base Elevation (from survey data):

$$EB_{A7} := -1.5ft$$

-Segment Height:

$$H_{A7} := E_c - EB_{A7}$$

$$H_{A7} = 6.5\ ft$$

-Segment Base Width:

$$B_{A7} := 2\left(S_H \cdot H_{A7}\right) + C$$

$$B_{A7} = 70\ ft$$

-Cross Sectional Area:

$$A_{A7} := \frac{1}{2} H_{A7} \cdot \left(C + B_{A7}\right)$$

$$A_{A7} = 243.75\ ft^2$$

-Volume of Segment:

$$V_{A7} := A_{A7} \cdot L_{A7}$$

$$\boxed{V_{A7} = 586.81\ yd^3}$$

h. <u>Containment Segment 8 (A8)</u>

-Segment Length (from CAD):

$$L_{A8} := 73ft$$

-Base Elevation (from survey data):

$$EB_{A8} := 0.0ft$$

-Segment Height:

$$H_{A8} := E_c - EB_{A8}$$

$$H_{A8} = 5\ ft$$

-Segment Base Width:

$$B_{A8} := 2\left(S_H \cdot H_{A8}\right) + C$$

$$B_{A8} = 55\ ft$$

-Cross Sectional Area:

$$A_{A8} := \frac{1}{2} H_{A8} \cdot \left(C + B_{A8}\right)$$

$$A_{A8} = 150\ ft^2$$

-Volume of Segment:

$$V_{A8} := A_{A8} \cdot L_{A8}$$

$$\boxed{V_{A8} = 405.56\ yd^3}$$

i. <u>Containment Segment 9 (A9)</u>

-Segment Length (from CAD):

$$L_{A9} := 110ft$$

-Base Elevation (from survey data):

$$EB_{A9} := -2.0ft$$

-Segment Height:

$$H_{A9} := E_c - EB_{A9}$$

$$H_{A9} = 7\ ft$$

-Segment Base Width:

$$B_{A9} := 2\left(S_H \cdot H_{A9}\right) + C$$

$$B_{A9} = 75\ ft$$

-Cross Sectional Area:

$$A_{A9} := \frac{1}{2} H_{A9} \cdot \left(C + B_{A9}\right)$$

$$A_{A9} = 280\ ft^2$$

-Volume of Segment:

$$V_{A9} := A_{A9} \cdot L_{A9}$$

$$\boxed{V_{A9} = 1140.74\ yd^3}$$

j. <u>Containment Segment 10 (A10)</u>

-Segment Length (from CAD):

$$L_{A10} := 205ft$$

-Base Elevation (from survey data):

$$EB_{A10} := 0ft$$

-Segment Height:

$$H_{A10} := E_c - EB_{A10}$$

$$H_{A10} = 5\ ft$$

-Segment Base Width:

$$B_{A10} := 2\left(S_H \cdot H_{A10}\right) + C$$

$$B_{A10} = 55\ ft$$

-Cross Sectional Area:

$$A_{A10} := \frac{1}{2} H_{A10} \cdot \left(C + B_{A10}\right)$$

$$A_{A10} = 150\ ft^2$$

-Volume of Segment:

$$V_{A10} := A_{A10} \cdot L_{A10}$$

$$\boxed{V_{A10} = 1138.89\ yd^3}$$

k. <u>Containment Segment 11 (A11)</u>

-Segment Length (from CAD):

$$L_{A11} := 128ft$$

-Base Elevation (from survey data):

$$EB_{A11} := -3.0ft$$

-Segment Height:

$$H_{A11} := E_c - EB_{A11}$$

$$H_{A11} = 8\ ft$$

-Segment Base Width:

$$B_{A11} := 2\left(S_H \cdot H_{A11}\right) + C$$

$$B_{A11} = 85\ ft$$

-Cross Sectional Area:

$$A_{A11} := \frac{1}{2} H_{A11} \cdot \left(C + B_{A11}\right)$$

$$A_{A11} = 360\ ft^2$$

-Volume of Segment:

$$V_{A11} := A_{A11} \cdot L_{A11}$$

$$\boxed{V_{A11} = 1706.67\ yd^3}$$

l. <u>Containment Segment 12 (A12)</u>

-Segment Length (from CAD):

$$L_{A12} := 406ft$$

-Base Elevation (from survey data):

$$EB_{A12} := 0.5ft$$

-Segment Height:

$$H_{A12} := E_c - EB_{A12}$$

$$H_{A12} = 4.5\ ft$$

-Segment Base Width:

$$B_{A12} := 2\left(S_H \cdot H_{A12}\right) + C$$

$$B_{A10} = 55\ ft$$

-Cross Sectional Area:

$$A_{A12} := \frac{1}{2} H_{A12} \cdot \left(C + B_{A12}\right)$$

$$A_{A12} = 123.75\ ft^2$$

-Volume of Segment:

$$V_{A12} := A_{A12} \cdot L_{A12}$$

$$\boxed{V_{A12} = 1860.83\ yd^3}$$

m. <u>Containment Segment 13 (A13)</u>

-Segment Length (from CAD):

$$L_{A13} := 598ft$$

-Base Elevation (from survey data):

$$EB_{A13} := 0.5ft$$

-Segment Height:

$$H_{A13} := E_c - EB_{A13}$$

$$H_{A13} = 4.5\ ft$$

-Segment Base Width:

$$B_{A13} := 2\left(S_H \cdot H_{A13}\right) + C$$

$$B_{A13} = 50\ ft$$

-Cross Sectional Area:

$$A_{A13} := \frac{1}{2} H_{A13} \cdot \left(C + B_{A13}\right)$$

$$A_{A13} = 123.75\ ft^2$$

-Volume of Segment:

$$V_{A13} := A_{A13} \cdot L_{A13}$$

$$\boxed{V_{A13} = 2740.83\ yd^3}$$

n. <u>Containment Segment 14 (A14)</u>

-Segment Length (from CAD):

$$L_{A14} := 76ft$$

-Base Elevation (from survey data):

$$EB_{A14} := 0.0ft$$

-Segment Height:

$$H_{A14} := E_c - EB_{A14}$$

$$H_{A14} = 5\ ft$$

-Segment Base Width:

$$B_{A14} := 2\left(S_H \cdot H_{A14}\right) + C$$

$$B_{A14} = 55\ ft$$

-Cross Sectional Area:

$$A_{A14} := \frac{1}{2} H_{A14} \cdot \left(C + B_{A14}\right)$$

$$A_{A14} = 150\ ft^2$$

-Volume of Segment:

$$V_{A14} := A_{A14} \cdot L_{A14}$$

$$\boxed{V_{A14} = 422.22\ yd^3}$$

o. <u>Containment Segment 15 (A15)</u>

-Segment Length (from CAD):

$$L_{A15} := 528ft$$

-Base Elevation (from survey data):

$$EB_{A15} := 1.0ft$$

-Segment Height:

$$H_{A15} := E_c - EB_{A15}$$

$$H_{A15} = 4\ ft$$

-Segment Base Width:

$$B_{A15} := 2\left(S_H \cdot H_{A15}\right) + C$$

$$B_{A15} = 45\ ft$$

-Cross Sectional Area:

$$A_{A15} := \frac{1}{2} H_{A15} \cdot \left(C + B_{A15}\right)$$

$$A_{A15} = 100\ ft^2$$

-Volume of Segment:

$$V_{A15} := A_{A15} \cdot L_{A15}$$

$$\boxed{V_{A15} = 1955.56\ yd^3}$$

p. <u>Containment Segment 16 (A16)</u>

-Segment Length (from CAD):

$$L_{A16} := 113ft$$

-Base Elevation (from survey data):

$$EB_{A16} := -3.0ft$$

-Segment Height:

$$H_{A16} := E_c - EB_{A16}$$

$$H_{A16} = 8\ ft$$

-Segment Base Width:

$$B_{A16} := 2\left(S_H \cdot H_{A16}\right) + C$$

$$B_{A16} = 85\ ft$$

-Cross Sectional Area:

$$A_{A16} := \frac{1}{2} H_{A16} \cdot \left(C + B_{A16}\right)$$

$$A_{A16} = 360\ ft^2$$

-Volume of Segment:

$$V_{A16} := A_{A16} \cdot L_{A16}$$

$$\boxed{V_{A16} = 1506.67\ yd^3}$$

q. <u>Containment Segment 17 (A17)</u>

-Segment Length (from CAD):

$$L_{A17} := 485ft$$

-Base Elevation (from survey data):

$$EB_{A17} := -0.7ft$$

-Segment Height:

$$H_{A17} := E_c - EB_{A17}$$

$$H_{A17} = 5.7\ ft$$

-Segment Base Width:

$$B_{A17} := 2\left(S_H \cdot H_{A17}\right) + C$$

$$B_{A17} = 62\ ft$$

-Cross Sectional Area:

$$A_{A17} := \frac{1}{2} H_{A17} \cdot \left(C + B_{A17}\right)$$

$$A_{A17} = 190.95\ ft^2$$

-Volume of Segment:

$$V_{A17} := A_{A17} \cdot L_{A17}$$

$$\boxed{V_{A17} = 3430.03\ yd^3}$$

r. <u>Containment Segment 18 (A18)</u>

-Segment Length (from CAD):

$$L_{A18} := 99ft$$

-Base Elevation (from survey data):

$$EB_{A18} := -3.0ft$$

-Segment Height:

$$H_{A18} := E_c - EB_{A18}$$

$$H_{A18} = 8\ ft$$

-Segment Base Width:

$$B_{A18} := 2\left(S_H \cdot H_{A18}\right) + C$$

$$B_{A18} = 85\ ft$$

-Cross Sectional Area:

$$A_{A18} := \frac{1}{2} H_{A18} \cdot \left(C + B_{A18}\right)$$

$$A_{A18} = 360\ ft^2$$

-Volume of Segment:

$$V_{A18} := A_{A18} \cdot L_{A18}$$

$$\boxed{V_{A18} = 1320\ yd^3}$$

s. <u>Containment Segment 19 (A19)</u>

-Segment Length (from CAD):

$$L_{A19} := 510ft$$

-Base Elevation (from survey data):

$$EB_{A19} := 1.0ft$$

-Segment Height:

$$H_{A19} := E_c - EB_{A19}$$

$$H_{A19} = 4\ ft$$

-Segment Base Width:

$$B_{A19} := 2\left(S_H \cdot H_{A19}\right) + C$$

$$B_{A19} = 45\ ft$$

-Cross Sectional Area:

$$A_{A19} := \frac{1}{2} H_{A19} \cdot \left(C + B_{A19}\right)$$

$$A_{A19} = 100\ ft^2$$

-Volume of Segment:

$$V_{A19} := A_{A19} \cdot L_{A19}$$

$$\boxed{V_{A19} = 1888.89\ yd^3}$$

t. <u>Containment Segment 20 (A20)</u>

-Segment Length (from CAD):

$$L_{A20} := 123\text{ft}$$

-Base Elevation (from survey data):

$$EB_{A20} := -3.0\text{ft}$$

-Segment Height:

$$H_{A20} := E_c - EB_{A20}$$

$$H_{A20} = 8\ \text{ft}$$

-Segment Base Width:

$$B_{A20} := 2\left(S_H \cdot H_{A20}\right) + C$$

$$B_{A20} = 85\ \text{ft}$$

-Cross Sectional Area:

$$A_{A20} := \frac{1}{2} H_{A20} \cdot \left(C + B_{A20}\right)$$

$$A_{A20} = 360\ \text{ft}^2$$

-Volume of Segment:

$$V_{A20} := A_{A20} \cdot L_{A20}$$

$$\boxed{V_{A20} = 1640\,\text{yd}^3}$$

u. <u>Containment Segment 21 (A21)</u>

-Segment Length (from CAD):

$$L_{A21} := 330\text{ft}$$

-Base Elevation (from survey data):

$$EB_{A21} := 1.5\text{ft}$$

-Segment Height:

$$H_{A21} := E_c - EB_{A21}$$

$$H_{A21} = 3.5\ \text{ft}$$

-Segment Base Width:

$$B_{A21} := 2\left(S_H \cdot H_{A21}\right) + C$$

$$B_{A21} = 40\ \text{ft}$$

-Cross Sectional Area:

$$A_{A21} := \frac{1}{2} H_{A21} \cdot \left(C + B_{A21}\right)$$

$$A_{A21} = 78.75\ \text{ft}^2$$

-Volume of Segment:

$$V_{A21} := A_{A21} \cdot L_{A21}$$

$$\boxed{V_{A21} = 962.5\ \text{yd}^3}$$

v. <u>Containment Segment 22 (A22)</u>

-Segment Length (from CAD):

$$L_{A22} := 112ft$$

-Base Elevation (from survey data):

$$EB_{A22} := -0.5ft$$

-Segment Height:

$$H_{A22} := E_c - EB_{A22}$$

$$H_{A21} = 3.5\ ft$$

-Segment Base Width:

$$B_{A22} := 2\left(S_H \cdot H_{A22}\right) + C$$

$$B_{A22} = 60\ ft$$

-Cross Sectional Area:

$$A_{A22} := \frac{1}{2} H_{A22} \cdot \left(C + B_{A22}\right)$$

$$A_{A22} = 178.75\ ft^2$$

-Volume of Segment:

$$V_{A22} := A_{A22} \cdot L_{A22}$$

$$\boxed{V_{A22} = 741.48\ yd^3}$$

w. <u>Containment Segment 23 (A23)</u>

-Segment Length (from CAD):

$$L_{A23} := 275ft$$

-Base Elevation (from survey data):

$$EB_{A23} := 0.5ft$$

-Segment Height:

$$H_{A23} := E_c - EB_{A23}$$

$$H_{A23} = 4.5\ ft$$

-Segment Base Width:

$$B_{A23} := 2\left(S_H \cdot H_{A23}\right) + C$$

$$B_{A23} = 50\ ft$$

-Cross Sectional Area:

$$A_{A23} := \frac{1}{2} H_{A23} \cdot \left(C + B_{A23}\right)$$

$$A_{A23} = 123.75\ ft^2$$

-Volume of Segment:

$$V_{A23} := A_{A23} \cdot L_{A23}$$

$$\boxed{V_{A23} = 1260.42\ yd^3}$$

x. <u>Containment Segment 24 (A24)</u>

-Segment Length (from CAD):

$$L_{A24} := 90ft$$

-Base Elevation (from survey data):

$$EB_{A24} := -4.0ft$$

-Segment Height:

$$H_{A24} := E_c - EB_{A24}$$

$$H_{A24} = 9\ ft$$

-Segment Base Width:

$$B_{A24} := 2\left(S_H \cdot H_{A24}\right) + C$$

$$B_{A24} = 95\ ft$$

-Cross Sectional Area:

$$A_{A24} := \frac{1}{2} H_{A24} \cdot \left(C + B_{A24}\right)$$

$$A_{A24} = 450\ ft^2$$

-Volume of Segment:

$$V_{A24} := A_{A24} \cdot L_{A24}$$

$$\boxed{V_{A24} = 1500\,yd^3}$$

y. <u>Containment Segment 25 (A25)</u>

-Segment Length (from CAD):

$$L_{A25} := 95ft$$

-Base Elevation (from survey data):

$$EB_{A25} := 0.5ft$$

-Segment Height:

$$H_{A25} := E_c - EB_{A25}$$

$$H_{A23} = 4.5\ ft$$

-Segment Base Width:

$$B_{A25} := 2\left(S_H \cdot H_{A25}\right) + C$$

$$B_{A25} = 50\ ft$$

-Cross Sectional Area:

$$A_{A25} := \frac{1}{2} H_{A25} \cdot \left(C + B_{A25}\right)$$

$$A_{A23} = 123.75\ ft^2$$

-Volume of Segment:

$$V_{A25} := A_{A25} \cdot L_{A25}$$

$$\boxed{V_{A25} = 435.42\ yd^3}$$

z. <u>Containment Segment 26 (A26)</u>

-Segment Length (from CAD):

$$L_{A26} := 115ft$$

-Base Elevation (from survey data):

$$EB_{A26} := -1.5ft$$

-Segment Height:

$$H_{A26} := E_c - EB_{A26}$$

$$H_{A23} = 4.5\ ft$$

-Segment Base Width:

$$B_{A26} := 2\left(S_H \cdot H_{A26}\right) + C$$

$$B_{A26} = 70\ ft$$

-Cross Sectional Area:

$$A_{A26} := \frac{1}{2} H_{A26} \cdot \left(C + B_{A26}\right)$$

$$A_{A26} = 243.75\ ft^2$$

-Volume of Segment:

$$V_{A26} := A_{A26} \cdot L_{A26}$$

$$\boxed{V_{A26} = 1038.19\ yd^3}$$

aa. <u>Containment Segment 27 (A27)</u>

-Segment Length (from CAD):

$$L_{A27} := 315ft$$

-Base Elevation (from survey data):

$$EB_{A27} := 1.5ft$$

-Segment Height:

$$H_{A27} := E_c - EB_{A27}$$

$$H_{A27} = 3.5\ ft$$

-Segment Base Width:

$$B_{A27} := 2\left(S_H \cdot H_{A27}\right) + C$$

$$B_{A27} = 40\ ft$$

-Cross Sectional Area:

$$A_{A27} := \frac{1}{2} H_{A27} \cdot \left(C + B_{A27}\right)$$

$$A_{A27} = 78.75\ ft^2$$

-Volume of Segment:

$$V_{A27} := A_{A23} \cdot L_{A23}$$

$$\boxed{V_{A27} = 1260.42\ yd^3}$$

bb. <u>Containment Segment 28 (A28)</u>

-Segment Length (from CAD):

$$L_{A28} := 279\text{ft}$$

-Base Elevation (from survey data):

$$EB_{A28} := -1.0\text{ft}$$

-Segment Height:

$$H_{A28} := E_c - EB_{A28}$$

$$H_{A28} = 6\ \text{ft}$$

-Segment Base Width:

$$B_{A28} := 2\left(S_H \cdot H_{A28}\right) + C$$

$$B_{A28} = 65\ \text{ft}$$

-Cross Sectional Area:

$$A_{A28} := \frac{1}{2} H_{A28} \cdot \left(C + B_{A28}\right)$$

$$A_{A28} = 210\ \text{ft}^2$$

-Volume of Segment:

$$V_{A28} := A_{A28} \cdot L_{A28}$$

$$\boxed{V_{A28} = 2170\,\text{yd}^3}$$

cc. <u>Containment Segment 29 (A29)</u>

-Segment Length (from CAD):

$$L_{A29} := 562\text{ft}$$

-Base Elevation (from survey data):

$$EB_{A29} := 0.0\text{ft}$$

-Segment Height:

$$H_{A29} := E_c - EB_{A29}$$

$$H_{A29} = 5\ \text{ft}$$

-Segment Base Width:

$$B_{A29} := 2\left(S_H \cdot H_{A29}\right) + C$$

$$B_{A29} = 55\ \text{ft}$$

-Cross Sectional Area:

$$A_{A29} := \frac{1}{2} H_{A29} \cdot \left(C + B_{A29}\right)$$

$$A_{A29} = 150\ \text{ft}^2$$

-Volume of Segment:

$$V_{A29} := A_{A29} \cdot L_{A29}$$

$$\boxed{V_{A29} = 3122.22\ \text{yd}^3}$$

dd. <u>Containment Segment 30 (A30)</u>

-Segment Length (from CAD):

$$L_{A30} := 497ft$$

-Base Elevation (from survey data):

$$EB_{A30} := 1.0ft$$

-Segment Height:

$$H_{A30} := E_c - EB_{A30}$$

$$H_{A30} = 4\ ft$$

-Segment Base Width:

$$B_{A30} := 2\left(S_H \cdot H_{A30}\right) + C$$

$$B_{A30} = 45\ ft$$

-Cross Sectional Area:

$$A_{A30} := \frac{1}{2} H_{A30} \cdot \left(C + B_{A30}\right)$$

$$A_{A30} = 100\ ft^2$$

-Volume of Segment:

$$V_{A30} := A_{A30} \cdot L_{A30}$$

$$\boxed{V_{A30} = 1840.74\ yd^3}$$

ee. <u>Containment Segment 31 (A31)</u>

-Segment Length (from CAD):

$$L_{A31} := 646ft$$

-Base Elevation (from survey data):

$$EB_{A31} := 0.5ft$$

-Segment Height:

$$H_{A31} := E_c - EB_{A31}$$

$$H_{A31} = 4.5\ ft$$

-Segment Base Width:

$$B_{A31} := 2\left(S_H \cdot H_{A31}\right) + C$$

$$B_{A31} = 50\ ft$$

-Cross Sectional Area:

$$A_{A31} := \frac{1}{2} H_{A31} \cdot \left(C + B_{A31}\right)$$

$$A_{A31} = 123.75\ ft^2$$

-Volume of Segment:

$$V_{A31} := A_{A31} \cdot L_{A31}$$

$$\boxed{V_{A31} = 2960.83\ yd^3}$$

ff. <u>Containment Segment 32 (A32)</u>

-Segment Length (from CAD):

$$L_{A32} := 315ft$$

-Base Elevation (from survey data):

$$EB_{A32} := 0.5ft$$

-Segment Height:

$$H_{A32} := E_c - EB_{A32}$$

$$H_{A32} = 4.5\ ft$$

-Segment Base Width:

$$B_{A32} := 2\left(S_H \cdot H_{A32}\right) + C$$

$$B_{A32} = 50\ ft$$

-Cross Sectional Area:

$$A_{A32} := \frac{1}{2} H_{A32} \cdot \left(C + B_{A32}\right)$$

$$A_{A32} = 123.75\ ft^2$$

-Volume of Segment:

$$V_{A32} := A_{A32} \cdot L_{A32}$$

$$\boxed{V_{A32} = 1443.75\ yd^3}$$

$$V_{DIKE_FILL_A} := V_{A1} + V_{A2} + V_{A3} + V_{A4} + V_{A5} + V_{A6} + V_{A7} + V_{A8} + V_{A9} + V_{A10} + V_{A11} + V_{A12} \cdots$$
$$+ V_{A13} + V_{A14} + V_{A15} + V_{A16} + V_{A17} + V_{A18} + V_{A19} + V_{A20} + V_{A21} + V_{A22} \cdots$$
$$+ V_{A23} + V_{A24} + V_{A25} + V_{A26} + V_{A27} + V_{A28} + V_{A29} + V_{A30} + V_{A31} + V_{A32}$$

$$V_{DIKE_FILL_A} = 53969.41\ yd^3$$

ii. Borrow Volume for Containment Dikes:

*A cut:fill ratio of 2.0:1 is used for mechanical dredging, CF_{MD}.
The borrow volume is computed by multiplying the fill volume by this value.

$$CF_{MD} := 2.0$$

$$V_{DIKE_BORROW_A} := V_{DIKE_FILL_A} \cdot CF_{MD}$$

$$V_{DIKE_BORROW_A} = 107938.81\ yd^3$$

This was used for backside containment in cell A

$$V_{DIKE_FILL_A2} := V_{A2} + V_{A3} + V_{A4} + V_{A5} + V_{A6} + V_{A7} + V_{A8} + V_{A9} + V_{A10} + V_{A11} + V_{A12} \cdots$$
$$+ V_{A13} + V_{A14} + V_{A15} + V_{A16} + V_{A17} + V_{A18} + V_{A19} + V_{A20} + V_{A21} + V_{A22} \cdots$$
$$+ V_{A23} + V_{A24} + V_{A25} + V_{A26} + V_{A27} + V_{A28}$$

$$V_{DIKE_FILL_A2} = 41624.08\ yd^3$$

2. Fill Site B

i. Fill Volume for Containment:

Constants:

-Crown Width, $C := 5.0ft$

-Horizontal Side Slope, $S_H := 5.0$

-Target Marsh Creation Elevation, $E_{MC} := 2.0ft$

-Crown Elevation, $E_c := 5.0ft$

$$E_c = 5\ ft$$

a. Containment Segment 1 (B1)

-Segment Length (from CAD):

$$L_{B1} := 720ft$$

-Base Elevation (from survey data):

$$EB_{B1} := 1.0ft$$

-Segment Height:

$$H_{B1} := E_c - EB_{B1}$$

$$H_{B1} = 4\ ft$$

-Segment Base Width:

$$B_{B1} := 2\left(S_H \cdot H_{B1}\right) + C$$

$$B_{B1} = 45\ ft$$

-Cross Sectional Area:

$$A_{B1} := \frac{1}{2} H_{B1} \cdot \left(C + B_{B1}\right)$$

$$A_{B1} = 100\ ft^2$$

-Volume of Segment:

$$V_{B1} := A_{B1} \cdot L_{B1}$$

$$\boxed{V_{B1} = 2666.67\ yd^3}$$

b. <u>Containment Segment 2 (B2)</u>

-Segment Length (from CAD):

$$L_{B2} := 643ft$$

-Base Elevation (from survey data):

$$EB_{B2} := 0.75ft$$

-Segment Height:

$$H_{B2} := E_c - EB_{B2}$$

$$H_{B2} = 4.25\ ft$$

-Segment Base Width:

$$B_{B2} := 2\left(S_H \cdot H_{B2}\right) + C$$

$$B_{B2} = 47.5\ ft$$

-Cross Sectional Area:

$$A_{B2} := \frac{1}{2} H_{B2} \cdot \left(C + B_{B2}\right)$$

$$A_{B2} = 111.56\ ft^2$$

-Volume of Segment:

$$V_{B2} := A_{B2} \cdot L_{B2}$$

$$\boxed{V_{B2} = 2656.84\ yd^3}$$

c. <u>Containment Segment 3 (B3)</u>

-Segment Length (from CAD):

$$L_{B3} := 619ft$$

-Base Elevation (from survey data):

$$EB_{B3} := -0.9ft$$

-Segment Height:

$$H_{B3} := E_c - EB_{B3}$$

$$H_{B3} = 5.9\ ft$$

-Segment Base Width:

$$B_{B3} := 2\left(S_H \cdot H_{B3}\right) + C$$

$$B_{B3} = 64\ ft$$

-Cross Sectional Area:

$$A_{B3} := \frac{1}{2} H_{B3} \cdot \left(C + B_{B3}\right)$$

$$A_{B3} = 203.55\ ft^2$$

-Volume of Segment:

$$V_{B3} := A_{B3} \cdot L_{B3}$$

$$\boxed{V_{B3} = 4666.57\ yd^3}$$

d. <u>Containment Segment 4 (B4)</u>

-Segment Length (from CAD):

$$L_{B4} := 248ft$$

-Base Elevation (from survey data):

$$EB_{B4} := 0.75ft$$

-Segment Height:

$$H_{B4} := E_c - EB_{B4}$$

$$H_{B4} = 4.25\ ft$$

-Segment Base Width:

$$B_{B4} := 2\left(S_H \cdot H_{B4}\right) + C$$

$$B_{B4} = 47.5\ ft$$

-Cross Sectional Area:

$$A_{B4} := \frac{1}{2} H_{B4} \cdot \left(C + B_{B4}\right)$$

$$A_{B4} = 111.56\ ft^2$$

-Volume of Segment:

$$V_{B4} := A_{B4} \cdot L_{B4}$$

$$\boxed{V_{B4} = 1024.72\ yd^3}$$

e. <u>Containment Segment 5 (B5)</u>

-Segment Length (from CAD):

$$L_{B5} := 544ft$$

-Base Elevation (from survey data):

$$EB_{B5} := -1.1ft$$

-Segment Height:

$$H_{B5} := E_c - EB_{B5}$$

$$H_{B5} = 6.1\ ft$$

-Segment Base Width:

$$B_{B5} := 2\left(S_H \cdot H_{B5}\right) + C$$

$$B_{B5} = 66\ ft$$

-Cross Sectional Area:

$$A_{B5} := \frac{1}{2} H_{B5} \cdot \left(C + B_{B5}\right)$$

$$A_{B5} = 216.55\ ft^2$$

-Volume of Segment:

$$V_{B5} := A_{B5} \cdot L_{B5}$$

$$\boxed{V_{B5} = 4363.08\ yd^3}$$

f. <u>Containment Segment 6 (B6)</u>

-Segment Length (from CAD):

$$L_{B6} := 528ft$$

-Base Elevation (from survey data):

$$EB_{B6} := -1.2ft$$

-Segment Height:

$$H_{B6} := E_c - EB_{B6}$$

$$H_{B6} = 6.2\ ft$$

-Segment Base Width:

$$B_{B6} := 2\left(S_H \cdot H_{B6}\right) + C$$

$$B_{B6} = 67\ ft$$

-Cross Sectional Area:

$$A_{B6} := \frac{1}{2} H_{B6} \cdot \left(C + B_{B6}\right)$$

$$A_{B6} = 223.2\ ft^2$$

-Volume of Segment:

$$V_{B6} := A_{B6} \cdot L_{B6}$$

$$\boxed{V_{B6} = 4364.8\ yd^3}$$

g. <u>Containment Segment 7 (B7)</u>

-Segment Length (from CAD):

$$L_{B7} := 620ft$$

-Base Elevation (from survey data):

$$EB_{B7} := -2.2ft$$

-Segment Height:

$$H_{B7} := E_c - EB_{B7}$$

$$H_{B7} = 7.2\ ft$$

-Segment Base Width:

$$B_{B7} := 2\left(S_H \cdot H_{B7}\right) + C$$

$$B_{B7} = 77\ ft$$

-Cross Sectional Area:

$$A_{B7} := \frac{1}{2} H_{B7} \cdot \left(C + B_{B7}\right)$$

$$A_{B7} = 295.2\ ft^2$$

-Volume of Segment:

$$V_{B7} := A_{B7} \cdot L_{B7}$$

$$\boxed{V_{B7} = 6778.67\ yd^3}$$

h. <u>Containment Segment 8 (B8)</u>

-Segment Length (from CAD):

$$L_{B8} := 600\text{ft}$$

-Base Elevation (from survey data):

$$EB_{B8} := -2.55\text{ft}$$

-Segment Height:

$$H_{B8} := E_c - EB_{B8}$$

$$H_{B8} = 7.55\ \text{ft}$$

-Segment Base Width:

$$B_{B8} := 2\left(S_H \cdot H_{B8}\right) + C$$

$$B_{B8} = 80.5\ \text{ft}$$

-Cross Sectional Area:

$$A_{B8} := \frac{1}{2} H_{B8} \cdot \left(C + B_{B8}\right)$$

$$A_{B8} = 322.76\ \text{ft}^2$$

-Volume of Segment:

$$V_{B8} := A_{B8} \cdot L_{B8}$$

$$\boxed{V_{B8} = 7172.5\ \text{yd}^3}$$

i. <u>Containment Segment 9 (B9)</u>

-Segment Length (from CAD):

$$L_{B9} := 505ft$$

-Base Elevation (from survey data):

$$EB_{B9} := -2.75ft$$

-Segment Height:

$$H_{B9} := E_c - EB_{B9}$$

$$H_{B9} = 7.75\ ft$$

-Segment Base Width:

$$B_{B9} := 2\left(S_H \cdot H_{B9}\right) + C$$

$$B_{B9} = 82.5\ ft$$

-Cross Sectional Area:

$$A_{B9} := \frac{1}{2} H_{B9} \cdot \left(C + B_{B9}\right)$$

$$A_{B9} = 339.06\ ft^2$$

-Volume of Segment:

$$V_{B9} := A_{B9} \cdot L_{B9}$$

$$\boxed{V_{B9} = 6341.72\ yd^3}$$

j. <u>Containment Segment 10 (B10)</u>

-Segment Length (from CAD):

$$L_{B10} := 535ft$$

-Base Elevation (from survey data):

$$EB_{B10} := -1.5ft$$

-Segment Height:

$$H_{B10} := E_c - EB_{B10}$$

$$H_{B10} = 6.5\ ft$$

-Segment Base Width:

$$B_{B10} := 2\left(S_H \cdot H_{B10}\right) + C$$

$$B_{B10} = 70\ ft$$

-Cross Sectional Area:

$$A_{B10} := \frac{1}{2} H_{B10} \cdot \left(C + B_{B10}\right)$$

$$A_{B10} = 243.75\ ft^2$$

-Volume of Segment:

$$V_{B10} := A_{B10} \cdot L_{B10}$$

$$\boxed{V_{B10} = 4829.86\ yd^3}$$

k. <u>Containment Segment 11 (B11)</u>

-Segment Length (from CAD):

$$L_{B11} := 455ft$$

-Base Elevation (from survey data):

$$EB_{B11} := 0.5ft$$

-Segment Height:

$$H_{B11} := E_c - EB_{B11}$$

$$H_{B10} = 6.5\ ft$$

-Segment Base Width:

$$B_{B11} := 2\left(S_H \cdot H_{B11}\right) + C$$

$$B_{B11} = 50\ ft$$

-Cross Sectional Area:

$$A_{B11} := \frac{1}{2} H_{B10} \cdot \left(C + B_{B11}\right)$$

$$A_{B11} = 178.75\ ft^2$$

-Volume of Segment:

$$V_{B11} := A_{B11} \cdot L_{B11}$$

$$\boxed{V_{B11} = 3012.27\ yd^3}$$

l. <u>Containment Segment 12 (B12)</u>

-Segment Length (from CAD):

$$L_{B12} := 177ft$$

-Base Elevation (from survey data):

$$EB_{B12} := 1.25ft$$

-Segment Height:

$$H_{B12} := E_c - EB_{B12}$$

$$H_{B12} = 3.75\ ft$$

-Segment Base Width:

$$B_{B12} := 2\left(S_H \cdot H_{B12}\right) + C$$

$$B_{B12} = 42.5\ ft$$

-Cross Sectional Area:

$$A_{B12} := \frac{1}{2} H_{B12} \cdot \left(C + B_{B12}\right)$$

$$A_{B12} = 89.06\ ft^2$$

-Volume of Segment:

$$V_{B12} := A_{B12} \cdot L_{B12}$$

$$\boxed{V_{B12} = 583.85\ yd^3}$$

m. <u>Containment Segment 13 (B13)</u>

-Segment Length (from CAD):

$$L_{B13} := 380ft$$

-Base Elevation (from survey data):

$$EB_{B13} := 1.0ft$$

-Segment Height:

$$H_{B13} := E_c - EB_{B13}$$

$$H_{B13} = 4\ ft$$

-Segment Base Width:

$$B_{B13} := 2\left(S_H \cdot H_{B13}\right) + C$$

$$B_{B13} = 45\ ft$$

-Cross Sectional Area:

$$A_{B13} := \frac{1}{2} H_{B13} \cdot \left(C + B_{B13}\right)$$

$$A_{B13} = 100\ ft^2$$

-Volume of Segment:

$$V_{B13} := A_{B13} \cdot L_{B13}$$

$$\boxed{V_{B13} = 1407.41\ yd^3}$$

n. <u>Containment Segment 14 (B14)</u>

-Segment Length (from CAD):

$$L_{B14} := 1257ft$$

-Base Elevation (from survey data):

$$EB_{B14} := -1.5ft$$

-Segment Height:

$$H_{B14} := E_c - EB_{B14}$$

$$H_{B14} = 6.5\ ft$$

-Segment Base Width:

$$B_{B14} := 2\left(S_H \cdot H_{B14}\right) + C$$

$$B_{B10} = 70\ ft$$

-Cross Sectional Area:

$$A_{B14} := \frac{1}{2} H_{B14} \cdot \left(C + B_{B14}\right)$$

$$A_{B14} = 243.75\ ft^2$$

-Volume of Segment:

$$V_{B14} := A_{B14} \cdot L_{B14}$$

$$\boxed{V_{B14} = 11347.92\ yd^3}$$

$$V_{DIKE_FILL_B} := V_{B1} + V_{B2} + V_{B3} + V_{B4} + V_{B5} + V_{B6} + V_{B7} + V_{B8} + V_{B9} \cdots + V_{B10} + V_{B11} + V_{B12} + V_{B13} + V_{B14}$$

$$V_{DIKE_FILL_B} = 61216.88\ yd^3$$

ii. <u>Borrow Volume for Containment Dikes:</u>

*A cut:fill ratio of 2.0:1 is used for mechanical dredging, CF_{MD}.
The borrow volume is computed by multiplying the fill volume by this value.

$$CF_{MD} := 2.0$$

$$V_{DIKE_BORROW_B} := V_{DIKE_FILL_B} \cdot CF_{MD}$$

$$V_{DIKE_BORROW_B} = 122433.76\ yd^3$$

3. Fill Site C

i. Fill Volume for Containment:

Constants:

-Crown Width, $C := 5.0ft$

-Horizontal Side Slope, $S_H := 5.0$

-Target Marsh Creation Elevation, $E_{MC} := 2.0ft$

-Crown Elevation, $E_c := 5.0ft$

$$E_c = 5\ ft$$

a. Containment Segment 1 (C1)

-Segment Length (from CAD):

$$L_{C1} := 925ft$$

-Base Elevation (from survey data):

$$EB_{C1} := 1.5ft$$

-Segment Height:

$$H_{C1} := E_c - EB_{C1}$$

$$H_{C1} = 3.5\ ft$$

-Segment Base Width:

$$B_{C1} := 2\left(S_H \cdot H_{C1}\right) + C$$

$$B_{C1} = 40\ ft$$

-Cross Sectional Area:

$$A_{C1} := \frac{1}{2} H_{C1} \cdot \left(C + B_{C1}\right)$$

$$A_{C1} = 78.75\ ft^2$$

-Volume of Segment:

$$V_{C1} := A_{C1} \cdot L_{C1}$$

$$\boxed{V_{C1} = 2697.92\ yd^3}$$

b. <u>Containment Segment 2 (C2)</u>

-Segment Length (from CAD):

$$L_{C2} := 912ft$$

-Base Elevation (from survey data):

$$EB_{C2} := -0.25ft$$

-Segment Height:

$$H_{C2} := E_c - EB_{C2}$$

$$H_{C2} = 5.25\ ft$$

-Segment Base Width:

$$B_{C2} := 2\left(S_H \cdot H_{C2}\right) + C$$

$$B_{C2} = 57.5\ ft$$

-Cross Sectional Area:

$$A_{C2} := \frac{1}{2} H_{C2} \cdot \left(C + B_{C2}\right)$$

$$A_{C2} = 164.06\ ft^2$$

-Volume of Segment:

$$V_{C2} := A_{C2} \cdot L_{C2}$$

$$\boxed{V_{C2} = 5541.67\ yd^3}$$

c. <u>Containment Segment 3 (C3)</u>

-Segment Length (from CAD):

$$L_{C3} := 592ft$$

-Base Elevation (from survey data):

$$EB_{C3} := 0.25ft$$

-Segment Height:

$$H_{C3} := E_c - EB_{C3}$$

$$H_{C3} = 4.75\ ft$$

-Segment Base Width:

$$B_{C3} := 2\left(S_H \cdot H_{C3}\right) + C$$

$$B_{C3} = 52.5\ ft$$

-Cross Sectional Area:

$$A_{C3} := \frac{1}{2} H_{C3} \cdot \left(C + B_{C3}\right)$$

$$A_{C3} = 136.56\ ft^2$$

-Volume of Segment:

$$V_{C3} := A_{C3} \cdot L_{C3}$$

$$\boxed{V_{C3} = 2994.26\ yd^3}$$

d. <u>Containment Segment 4 (C4)</u>

-Segment Length (from CAD):

$$L_{C4} := 444ft$$

-Base Elevation (from survey data):

$$EB_{C4} := -0.65ft$$

-Segment Height:

$$H_{C4} := E_c - EB_{C4}$$

$$H_{C4} = 5.65\ ft$$

-Segment Base Width:

$$B_{C4} := 2\left(S_H \cdot H_{C4}\right) + C$$

$$B_{C4} = 61.5\ ft$$

-Cross Sectional Area:

$$A_{C4} := \frac{1}{2} H_{C4} \cdot \left(C + B_{C4}\right)$$

$$A_{C4} = 187.86\ ft^2$$

-Volume of Segment:

$$V_{C4} := A_{C4} \cdot L_{C4}$$

$$\boxed{V_{C4} = 3089.29\ yd^3}$$

e. <u>Containment Segment 5 (C5)</u>

-Segment Length (from CAD):

$$L_{C5} := 577ft$$

-Base Elevation (from survey data):

$$EB_{C5} := -0.6ft$$

-Segment Height:

$$H_{C5} := E_c - EB_{C5}$$

$$H_{C5} = 5.6\ ft$$

-Segment Base Width:

$$B_{C5} := 2\left(S_H \cdot H_{C5}\right) + C$$

$$B_{C5} = 61\ ft$$

-Cross Sectional Area:

$$A_{C5} := \frac{1}{2} H_{C5} \cdot \left(C + B_{C5}\right)$$

$$A_{C5} = 184.8\ ft^2$$

-Volume of Segment:

$$V_{C5} := A_{C5} \cdot L_{C5}$$

$$\boxed{V_{C5} = 3949.24\ yd^3}$$

f. <u>Containment Segment 6 (C6)</u>

-Segment Length (from CAD):

$$L_{C6} := 422\text{ft}$$

-Base Elevation (from survey data):

$$EB_{C6} := -0.3\text{ft}$$

-Segment Height:

$$H_{C6} := E_c - EB_{C6}$$

$$H_{C6} = 5.3\ \text{ft}$$

-Segment Base Width:

$$B_{C6} := 2\left(S_H \cdot H_{C6}\right) + C$$

$$B_{C6} = 58\ \text{ft}$$

-Cross Sectional Area:

$$A_{C6} := \frac{1}{2} H_{C6} \cdot \left(C + B_{C6}\right)$$

$$A_{C6} = 166.95\ \text{ft}^2$$

-Volume of Segment:

$$V_{C6} := A_{C6} \cdot L_{C6}$$

$$\boxed{V_{C6} = 2609.37\ \text{yd}^3}$$

g. <u>Containment Segment 7 (C7)</u>

-Segment Length (from CAD):

$$L_{C7} := 506ft$$

-Base Elevation (from survey data):

$$EB_{C7} := -1.0ft$$

-Segment Height:

$$H_{C7} := E_c - EB_{C7}$$

$$H_{C7} = 6\ ft$$

-Segment Base Width:

$$B_{C7} := 2\left(S_H \cdot H_{C7}\right) + C$$

$$B_{C7} = 65\ ft$$

-Cross Sectional Area:

$$A_{C7} := \frac{1}{2} H_{C7} \cdot \left(C + B_{C4}\right)$$

$$A_{C7} = 199.5\ ft^2$$

-Volume of Segment:

$$V_{C7} := A_{C7} \cdot L_{C7}$$

$$\boxed{V_{C7} = 3738.78\ yd^3}$$

h. <u>Containment Segment 8 (C8)</u>

-Segment Length (from CAD):

$$L_{C8} := 610ft$$

-Base Elevation (from survey data):

$$EB_{C8} := -1.0ft$$

-Segment Height:

$$H_{C8} := E_c - EB_{C8}$$

$$H_{C8} = 6\ ft$$

-Segment Base Width:

$$B_{C8} := 2\left(S_H \cdot H_{C8}\right) + C$$

$$B_{C8} = 65\ ft$$

-Cross Sectional Area:

$$A_{C8} := \frac{1}{2} H_{C8} \cdot \left(C + B_{C8}\right)$$

$$A_{C8} = 210\ ft^2$$

-Volume of Segment:

$$V_{C8} := A_{C8} \cdot L_{C8}$$

$$\boxed{V_{C8} = 4744.44\ yd^3}$$

i. <u>Containment Segment 9 (C9)</u>

-Segment Length (from CAD):

$$L_{C9} := 1795ft$$

-Base Elevation (from survey data):

$$EB_{C9} := 0.25ft$$

-Segment Height:

$$H_{C9} := E_c - EB_{C9}$$

$$H_{C9} = 4.75\ ft$$

-Segment Base Width:

$$B_{C9} := 2\left(S_H \cdot H_{C9}\right) + C$$

$$B_{C9} = 52.5\ ft$$

-Cross Sectional Area:

$$A_{C9} := \frac{1}{2} H_{C9} \cdot \left(C + B_{C9}\right)$$

$$A_{C9} = 136.56\ ft^2$$

-Volume of Segment:

$$V_{C9} := A_{C4} \cdot L_{C9}$$

$$\boxed{V_{C9} = 12489.38\ yd^3}$$

$$V_{DIKE_FILL_C} := V_{C1} + V_{C2} + V_{C3} + V_{C4} + V_{C5} + V_{C6} + V_{C7} + V_{C8} + V_{C9}$$

$$V_{DIKE_FILL_C} = 41854.35\ yd^3$$

ii. Borrow Volume for Containment Dikes:

*A cut:fill ratio of 2.0:1 is used for mechanical dredging, CF_{MD}.
The borrow volume is computed by multiplying the fill volume by this value.

$$CF_{MD} := 2.0$$

$$V_{DIKE_BORROW_C} := V_{DIKE_FILL_C} \cdot CF_{MD}$$

$$V_{DIKE_BORROW_C} = 83708.7\ yd^3$$

4. Fill Site D

i. Fill Volume for Containment:

Constants:

-Crown Width, $C := 5.0ft$

-Horizontal Side Slope, $S_H := 5.0$

-Target Marsh Creation Elevation, $E_{MC} := 2.0ft$

-Crown Elevation, $E_c := 5.0ft$

$$E_c = 5\ ft$$

a. Containment Segment 1 (D1)

-Segment Length (from CAD):

$$L_{D1} := 1292ft$$

-Base Elevation (from survey data):

$$EB_{D1} := -0.8ft$$

-Segment Height:

$$H_{D1} := E_c - EB_{D1}$$

$$H_{D1} = 5.8\ ft$$

-Segment Base Width:

$$B_{D1} := 2\left(S_H \cdot H_{D1}\right) + C$$

$$B_{D1} = 63\ ft$$

-Cross Sectional Area:

$$A_{D1} := \frac{1}{2} H_{D1} \cdot \left(C + B_{D1}\right)$$

$$A_{D1} = 197.2\ ft^2$$

-Volume of Segment:

$$V_{D1} := A_{D1} \cdot L_{D1}$$

$$\boxed{V_{D1} = 9436.39\ yd^3}$$

b. <u>Containment Segment 2 (D2)</u>

-Segment Length (from CAD):

$$L_{D2} := 685ft$$

-Base Elevation (from survey data):

$$EB_{D2} := -0.9ft$$

-Segment Height:

$$H_{D2} := E_c - EB_{D2}$$

$$H_{D2} = 5.9\ ft$$

-Segment Base Width:

$$B_{D2} := 2\left(S_H \cdot H_{D2}\right) + C$$

$$B_{D2} = 64\ ft$$

-Cross Sectional Area:

$$A_{D2} := \frac{1}{2} H_{D2} \cdot \left(C + B_{D2}\right)$$

$$A_{D2} = 203.55\ ft^2$$

-Volume of Segment:

$$V_{D2} := A_{D2} \cdot L_{D2}$$

$$\boxed{V_{D2} = 5164.14\ yd^3}$$

c. <u>Containment Segment 3 (D3)</u>

-Segment Length (from CAD):

$$L_{D3} := 246ft$$

-Base Elevation (from survey data):

$$EB_{D3} := -0.9ft$$

-Segment Height:

$$H_{D3} := E_c - EB_{D3}$$

$$H_{D3} = 5.9\ ft$$

-Segment Base Width:

$$B_{D3} := 2\left(S_H \cdot H_{D3}\right) + C$$

$$B_{D3} = 64\ ft$$

-Cross Sectional Area:

$$A_{D3} := \frac{1}{2} H_{D3} \cdot \left(C + B_{D3}\right)$$

$$A_{D3} = 203.55\ ft^2$$

-Volume of Segment:

$$V_{D3} := A_{D3} \cdot L_{D3}$$

$$\boxed{V_{D3} = 1854.57\ yd^3}$$

d. <u>Containment Segment 4 (D4)</u>

-Segment Length (from CAD):

$$L_{D4} := 402\,ft$$

-Base Elevation (from survey data):

$$EB_{D4} := -1.2\,ft$$

-Segment Height:

$$H_{D4} := E_c - EB_{D4}$$

$$H_{D4} = 6.2\ ft$$

-Segment Base Width:

$$B_{D4} := 2\left(S_H \cdot H_{D4}\right) + C$$

$$B_{D4} = 67\ ft$$

-Cross Sectional Area:

$$A_{D4} := \frac{1}{2} H_{D4} \cdot \left(C + B_{D4}\right)$$

$$A_{D4} = 223.2\ ft^2$$

-Volume of Segment:

$$V_{D4} := A_{D4} \cdot L_{D4}$$

$$\boxed{V_{D4} = 3323.2\,yd^3}$$

e. <u>Containment Segment 5 (D5)</u>

-Segment Length (from CAD):

$$L_{D5} := 219ft$$

-Base Elevation (from survey data):

$$EB_{D5} := 1.0ft$$

-Segment Height:

$$H_{D5} := E_c - EB_{D5}$$

$$H_{D5} = 4\ ft$$

-Segment Base Width:

$$B_{D5} := 2\left(S_H \cdot H_{D5}\right) + C$$

$$B_{D5} = 45\ ft$$

-Cross Sectional Area:

$$A_{D5} := \frac{1}{2} H_{D5} \cdot \left(C + B_{D5}\right)$$

$$A_{D5} = 100\ ft^2$$

-Volume of Segment:

$$V_{D5} := A_{D5} \cdot L_{D5}$$

$$\boxed{V_{D5} = 811.11\ yd^3}$$

f. <u>Containment Segment 6 (D6)</u>

-Segment Length (from CAD):

$$L_{D6} := 247ft$$

-Base Elevation (from survey data):

$$EB_{D6} := -0.25ft$$

-Segment Height:

$$H_{D6} := E_c - EB_{D6}$$

$$H_{D6} = 5.25\ ft$$

-Segment Base Width:

$$B_{D6} := 2\left(S_H \cdot H_{D6}\right) + C$$

$$B_{D6} = 57.5\ ft$$

-Cross Sectional Area:

$$A_{D6} := \frac{1}{2} H_{D6} \cdot \left(C + B_{D6}\right)$$

$$A_{D6} = 164.06\ ft^2$$

-Volume of Segment:

$$V_{D6} := A_{D6} \cdot L_{D6}$$

$$\boxed{V_{D6} = 1500.87\ yd^3}$$

g. <u>Containment Segment 7 (D7)</u>

-Segment Length (from CAD):

$$L_{D7} := 592ft$$

-Base Elevation (from survey data):

$$EB_{D7} := 1.0ft$$

-Segment Height:

$$H_{D7} := E_c - EB_{D7}$$

$$H_{D7} = 4\ ft$$

-Segment Base Width:

$$B_{D7} := 2\left(S_H \cdot H_{D7}\right) + C$$

$$B_{D7} = 45\ ft$$

-Cross Sectional Area:

$$A_{D7} := \frac{1}{2} H_{D7} \cdot \left(C + B_{D7}\right)$$

$$A_{D7} = 100\ ft^2$$

-Volume of Segment:

$$V_{D7} := A_{D7} \cdot L_{D7}$$

$$\boxed{V_{D7} = 2192.59\ yd^3}$$

$$V_{DIKE_FILL_D} := V_{D1} + V_{D2} + V_{D3} + V_{D4} + V_{D5} + V_{D6} + V_{D7}$$

$$V_{DIKE_FILL_D} = 24282.86\ yd^3$$

ii. Borrow Volume for Containment Dikes:

*A cut:fill ratio of 2.0:1 is used for mechanical dredging, CF_{MD}.
The borrow volume is computed by multiplying the fill volume by this value.

$$CF_{MD} := 2.0$$

$$V_{DIKE_BORROW_D} := V_{DIKE_FILL_D} \cdot CF_{MD}$$

$$V_{DIKE_BORROW_D} = 48565.73\ yd^3$$

IV. BORROW SITE DESIGN

A. Given:

1. Fill Volume for Marsh Creation: V_{MC} = 3,389,352 yd^3

2. Cut:Fill Ratios:

   i. For Marsh Creation, CF_{MC} = 1.3

3. Elevation Cuts from Off Shore Borrow Sites:

   i. Grand Liard East, V_{GLEB}=5,280457 yd^3
   ii. Grand Liard West, V_{GLWB}=4,680,280 yd^3

4. Cross Sectional Survey Data of Borrow Sites: XYZ data for each fill borrow site cross section.

5. The following table lists the areas of each river section and the length that each section represents. This data was computed with CAD and used to calculate the Available Volume in the Permitted Borrow Sites for comparison with the volumes found in CAD.

Grand Liard West Borrow Site		
Transect	Length	Area
1	638	9,275.9
2	775	41,671.0
3	775	47,135.0
4	775	45,130.4
5	775	30,052.7
Grand Liard East Borrow Site		
Transect	Length	Area
6	775	40,345.4
7	775	40,141.6
8	775	33,539.3
9	775	17,991.4
10	775	26,159.3

B. Methodology:

1. Required Borrow Volume, VI: The borrow volume needed to fill the marsh creation/nourishment sites to the target elevation was computed by simply taking the product of the Fill Volume and the Cut:Fill Ratio:

$$VI = VF * CF$$

2. Available Volume in Permitted Borrow Site: To ensure that the permitted borrow site will produce enough material to fill the marsh creation/nourishment sites to the target fill elevations (a volume greater than (or equal to) the Required Borrow Volume), the volume of the Permitted Borrow Site was calculated. The cross-sectional area of each borrow site transect was computed with a similar method as the fill area cross-sectional areas using the XYZ survey data for the borrow sites (see Section II, "Area Calculations"). Once each cross-sectional area was computed, the volume was calculated using the formulas below:

$$V_{xs} = (A_{xs})(d)$$

where: V_{xs} = Cross-sectional volume
A_{xs} = Cross-sectional area
d = Distance between cross-sections

$$V_{GLXB} = \sum V_{xs}$$

This volume was then compared to the Required Borrow Volume to ensure that the Permitted Borrow site contains a sufficient quantity of borrow material.

C. **Earthen Ridge Design:**

1. Survey Data

i. Cross-Sectional Area(ft^2): Distance (ft.):

$A_{20} := 271.91ft^2$ $d_{20} := 613.86ft$

$A_{25} := 324.46ft^2$ $d_{25} := 497.67ft$

$A_{30} := 339.17ft^2$ $d_{30} := 589.73ft$

$A_{35} := 362.69ft^2$ $d_{35} := 280.91ft$

$A_{40} := 226.98ft^2$ $d_{40} := 398.88ft$

$A_{45} := 320.12ft^2$ $d_{45} := 607.49ft$

$A_{50} := 394.75ft^2$ $d_{50} := 794.09ft$

$A_{55} := 308.08ft^2$ $d_{55} := 527.75ft$

$A_{60} := 2404.34ft^2$ $d_{60} := 305.76ft$

$A_{65} := 244.27ft^2$ $d_{65} := 573.49ft$

$A_{75} := 218.05ft^2$ $d_{75} := 814.15ft$

$A_{80} := 365.67ft^2$ $d_{80} := 662ft$

$A_{85} := 174.76ft^2$ $d_{85} := 0ft$

$A_{95.50} := 208.78ft^2$ $d_{95.50} := 373.11ft$

$A_{100} := 337.39ft^2$ $d_{100} := 389.55ft$

$A_{105.50} := 337.39ft^2$ $d_{105.50} := 735.98ft$

$A_{110.50} := 300.50ft^2$ $d_{110.50} := 504.07ft$

$A_{115.50} := 300.50ft^2$ $d_{115.50} := 1137.16ft$

$A_{130.50} := 180.12ft^2$ $d_{130.50} := 0ft$

$A_{140.50} := 165.28ft^2$ $d_{140.50} := 600.93ft$

$A_{145.50} := 134.25ft^2$ $d_{145.50} := 312.83ft$

$A_{150.50} := 242.25ft^2$ $d_{150.50} := 457.03ft$

$A_{155.50} := 205.02ft^2$ $d_{155.50} := 703.37ft$

$A_{160.50} := 162.33ft^2$ $d_{160.50} := 557.11ft$

$A_{165.50} := 169.59ft^2$ $d_{165.50} := 487.34ft$

$A_{170.50} := 171.60ft^2$ $d_{170.50} := 562.91ft$

$A_{180.50} := 244.34ft^2$ $d_{180.50} := 938.34ft$

$A_{185.50} := 169.64ft^2$ $d_{185.50} := 364.56ft$

$A_{190.50} := 176.81ft^2$ $d_{190.50} := 656.42ft$

ii. Calculated Volume (ft^3):

$V_{20} := A_{20} \cdot d_{20}$ $V_{20} = 6182.025\ yd^3$

$V_{25} := A_{25} \cdot d_{25}$ $V_{25} = 5980.519\ yd^3$

$V_{30} := A_{30} \cdot d_{30}$ $V_{30} = 7408.101\ yd^3$

$V_{35} := A_{35} \cdot d_{35}$ $V_{35} = 3773.454\ yd^3$

$V_{40} := A_{40} \cdot d_{40}$ $V_{40} = 3353.251\ yd^3$

$V_{45} := A_{45} \cdot d_{45}$ $V_{45} = 7202.581\ yd^3$

$V_{50} := A_{50} \cdot d_{50}$ $V_{50} = 11609.89\ yd^3$

$V_{55} := A_{55} \cdot d_{55}$ $V_{55} = 6021.823\ yd^3$

$V_{60} := A_{60} \cdot d_{60}$ $V_{60} = 27227.815\ yd^3$

$V_{65} := A_{65} \cdot d_{65}$ $V_{65} = 5188.385\ yd^3$

$V_{75} := A_{75} \cdot d_{75}$ $V_{75} = 6575.015\ yd^3$

$V_{80} := A_{80} \cdot d_{80}$ $V_{80} = 8965.687\ yd^3$

$V_{85} := A_{85} \cdot d_{85}$ $V_{85} = 0\ yd^3$

$V_{95.50} := A_{95.50} \cdot d_{95.50}$ $V_{95.50} = 2885.108\ yd^3$

$V_{100} := A_{100} \cdot d_{100}$ $V_{100} = 4867.788\ yd^3$

$V_{105.50} := A_{105.50} \cdot d_{105.50}$ $V_{105.50} = 9196.752\ yd^3$

$V_{110.50} := A_{110.50} \cdot d_{110.50}$ $V_{110.50} = 5610.112\ yd^3$

$V_{115.50} := A_{115.50} \cdot d_{115.50}$ $V_{115.50} = 12656.17\ yd^3$

$V_{130.50} := A_{130.50} \cdot d_{130.50}$ $V_{130.50} = 0\ yd^3$

$V_{140.50} := A_{140.50} \cdot d_{140.50}$ $\quad V_{140.50} = 3678.582\ yd^3$

$V_{145.50} := A_{145.50} \cdot d_{145.50}$ $\quad V_{145.50} = 1555.46\ yd^3$

$V_{150.50} := A_{150.50} \cdot d_{150.50}$ $\quad V_{150.50} = 4100.575\ yd^3$

$V_{155.50} := A_{155.50} \cdot d_{155.50}$ $\quad V_{155.50} = 5340.923\ yd^3$

$V_{160.50} := A_{160.50} \cdot d_{160.50}$ $\quad V_{160.50} = 3349.469\ yd^3$

$V_{165.50} := A_{165.50} \cdot d_{165.50}$ $\quad V_{165.50} = 3061.037\ yd^3$

$V_{170.50} := A_{170.50} \cdot d_{170.50}$ $\quad V_{170.50} = 3577.606\ yd^3$

$V_{180.50} := A_{180.50} \cdot d_{180.50}$ $\quad V_{180.50} = 8491.629\ yd^3$

$V_{185.50} := A_{185.50} \cdot d_{185.50}$ $\quad V_{185.50} = 2290.517\ yd^3$

$V_{190.50} := A_{190.50} \cdot d_{190.50}$ $\quad V_{190.50} = 4298.579\ yd^3$

$$V_{RR} := V_{20} + V_{25} + V_{30} + V_{35} + V_{40} + V_{45} + V_{50} + V_{55} + V_{60} + V_{65} + V_{75} + V_{80} \cdots$$
$$+ V_{85} + V_{95.50} + V_{100} + V_{105.50} + V_{110.50} + V_{115.50} + V_{130.50} + V_{140.50} + V_{145.50} \cdots$$
$$+ V_{150.50} + V_{155.50} + V_{160.50} + V_{165.50} + V_{170.50} + V_{180.50} + V_{185.50} + V_{190.50}$$

Total Volume for Ridge Restoration, $\boxed{V_{RR} = 174448.85\ yd^3}$

The volume of sand fill used in the gap closure constuction should be removed from V_{RR}

$$V_{RRS} := V_{RR} - 1206 yd^3$$

$$V_{RRS} = 173242.85\ yd^3$$

Total Volume for ridge w/ 2:1 Cut to Fill

$$V_{RRC} := V_{RRS} \cdot 2$$

$$V_{RRC} = 346485.70\ yd^3$$

D. Bayou Borrow Design:

1. Survey Data

i. Cross-Sectional Area(ft^2): Distance (ft.):

$A_{20} := 1.8ft^2$ $d_{20} := 636.4ft$

$A_{25} := 107.1ft^2$ $d_{25} := 461.4ft$

$A_{30} := 117.9ft^2$ $d_{30} := 652.8ft$

$A_{35} := 151.6ft^2$ $d_{35} := 322.1ft$

$A_{40} := 109.1ft^2$ $d_{40} := 486.5ft$

$A_{45} := 470.3ft^2$ $d_{45} := 639.8ft$

$A1_{50} := 591.1ft^2$ $d1_{50} := 365.5ft$

$A2_{50} := 372.3ft^2$ $d2_{50} := 731.3ft$

$A_{55} := 342.2ft^2$ $d_{55} := 496.0ft$

$A_{60} := 0.0ft^2$ $d_{60} := 305.76ft$

$A_{65} := 0.0ft^2$ $d_{65} := 573.49ft$

$A1_{75} := 353.6ft^2$ $d1_{75} := 355.6ft$

$A2_{75} := 447.9ft^2$ $d2_{75} := 685.0ft$

$A_{80} := 322ft^2$ $d_{80} := 130ft$

$A_{85} := 214.7ft^2$ $d_{85} := 307ft$

$A_{95.50} := 678.0ft^2$ $d_{95.50} := 210ft$

$A_{100} := 457.2ft^2$ $d_{100} := 419ft$

$A_{105.50} := 589.6ft^2$ $d_{105.50} := 750ft$

$A_{110.50} := 525.3ft^2$ $d_{110.50} := 522ft$

$A1_{115.50} := 425.6ft^2$ $d1_{115.50} := 930ft$

$A2_{115.50} := 68.3ft^2$ $d2_{115.50} := 260ft$

$A3_{115.50} := 259.3ft^2$ $d3_{115.50} := 370.0ft$

$A_{130.50} := 0ft^2$ $d_{130.50} := 0ft$

$A1_{140.50} := 409.2ft^2$ $d1_{140.50} := 250ft$

$A2_{140.50} := 253.4ft^2$ $d2_{140.50} := 406ft$

$A_{145.50} := 253.4ft^2$ $d_{145.50} := 340ft$

$A_{150.50} := 478.7ft^2$ $d_{150.50} := 490ft$

$A_{155.50} := 315ft^2$ $d_{155.50} := 705ft$

$A1_{160.50} := 350.6ft^2$ $d_{160.50} := 244ft$

$A2_{160.50} := 155.5ft^2$ $d_{165.50} := 335ft$

$A_{165.50} := 111.7ft^2$ $d1_{170.50} := 488ft$

$A1_{170.50} := 111.7ft^2$ $d2_{170.50} := 255ft$

$A2_{170.50} := 498.4ft^2$ $d2_{170.50} := 280ft$

$A1_{180.50} := 580.1ft^2$ $d1_{180.50} := 323ft$

$A2_{180.50} := 0ft^2$ $d2_{180.50} := 0ft$

$A_{185.50} := 577.1ft^2$ $d_{185.50} := 365ft$

$A_{190.50} := 367.9ft^2$ $d_{190.50} := 750ft$

ii. Calculated Volume (ft^3):

$V_{20} := A_{20} \cdot d_{20}$ $\quad V_{20} = 42.427\ yd^3$

$V_{25} := A_{25} \cdot d_{25}$ $\quad V_{25} = 1830.22\ yd^3$

$V_{30} := A_{30} \cdot d_{30}$ $\quad V_{30} = 2850.56\ yd^3$

$V_{35} := A_{35} \cdot d_{35}$ $\quad V_{35} = 1808.532\ yd^3$

$V_{40} := A_{40} \cdot d_{40}$ $\quad V_{40} = 1965.82\ yd^3$

$V_{45} := A_{45} \cdot d_{45}$ $\quad V_{45} = 11144.368\ yd^3$

$V1_{50} := A1_{50} \cdot d1_{50}$ $\quad V1_{50} = 8001.743\ yd^3$

$V2_{50} := A2_{50} \cdot d2_{50}$ $\quad V2_{50} = 10083.814\ yd^3$

$V_{55} := A_{55} \cdot d_{55}$ $\quad V_{55} = 6286.341\ yd^3$

$V_{60} := A_{60} \cdot d_{60}$ $\quad V_{60} = 0$

$V_{65} := A_{65} \cdot d_{65}$ $\quad V_{65} = 0$

$$V_{BBA} := V_{20} + V_{25} + V_{30} + V_{35} + V_{40} + V_{45} + V1_{50} + V2_{50} + V_{55} + V_{60} + V_{65}$$

$$V_{BBA} = 44013.82\ yd^3$$

$V1_{75} := A1_{75} \cdot d1_{75}$ $\quad V1_{75} = 4657.043\ yd^3$

$V2_{75} := A2_{75} \cdot d2_{75}$ $\quad V2_{75} = 11363.389\ yd^3$

$V_{80} := A_{80} \cdot d_{80}$ $\quad V_{80} = 1550.37\ yd^3$

$V_{85} := A_{85} \cdot d_{85}$ $\quad V_{85} = 2441.219\ yd^3$

$V_{95.50} := A_{95.50} \cdot d_{95.50}$ $\quad V_{95.50} = 5273.333\ yd^3$

$V_{100} := A_{100} \cdot d_{100}$ $\quad V_{100} = 7095.067\ yd^3$

$V_{105.50} := A_{105.50} \cdot d_{105.50}$ $\quad V_{105.50} = 16377.778\ yd^3$

$V_{110.50} := A_{110.50} \cdot d_{110.50}$ $\quad V_{110.50} = 10155.8\ yd^3$

$V1_{115.50} := A1_{115.50} \cdot d1_{115.50}$ $\quad V1_{115.50} = 14659.556\ yd^3$

$V2_{115.50} := A2_{115.50} \cdot d2_{115.50}$ $\quad V2_{115.50} = 657.704\ yd^3$

$V3_{115.50} := A3_{115.50} \cdot d3_{115.50}$ $\quad V3_{115.50} = 3553.37\ yd^3$

$V_{130.50} := A_{130.50} \cdot d_{130.50}$ $\quad V_{130.50} = 0\ yd^3$

$V_{BBB} := V1_{75} + V2_{75} + V_{80} + V_{85} + V_{95.50} + V_{100} + V_{105.50} + V_{110.50} + V1_{115.50} + V2_{115.50} + V3_{115.50} + V_{130}$

$V_{BBB} = 77784.63\ yd^3$

$V1_{140.50} := A1_{140.50} \cdot d1_{140.50}$ $V1_{140.50} = 3788.889\ yd^3$

$V2_{140.50} := A2_{140.50} \cdot d2_{140.50}$ $V2_{140.50} = 3810.385\ yd^3$

$V_{145.50} := A_{145.50} \cdot d_{145.50}$ $V_{145.50} = 3190.963\ yd^3$

$V_{150.50} := A_{150.50} \cdot d_{150.50}$ $V_{150.50} = 8687.519\ yd^3$

$V_{155.50} := A_{155.50} \cdot d_{155.50}$ $V_{155.50} = 8225\ yd^3$

$V1_{160.50} := A1_{160.50} \cdot d_{160.50}$ $V1_{160.50} = 3168.385\ yd^3$

$V2_{160.50} := A2_{160.50} \cdot d_{160.50}$ $V2_{160.50} = 1405.259\ yd^3$

$V_{165.50} := A_{165.50} \cdot d_{165.50}$ $V_{165.50} = 1385.907\ yd^3$

$V1_{170.50} := A1_{170.50} \cdot d1_{170.50}$ $V1_{170.50} = 2018.874\ yd^3$

$V2_{170.50} := A2_{170.50} \cdot d2_{170.50}$ $V2_{170.50} = 5168.593\ yd^3$

$$V_{BBC} := V1_{140.50} + V2_{140.50} + V_{145.50} + V_{150.50} + V_{155.50} + V1_{160.50} + V2_{160.50} + V_{165.50} + V1_{170.50} + V2_{170.50}$$

$V_{BBC} = 40849.77\ yd^3$

$V1_{180.50} := A1_{180.50} \cdot d1_{180.50}$ $V1_{180.50} = 6939.715\ yd^3$

$V2_{180.50} := A2_{180.50} \cdot d2_{180.50}$ $V2_{180.50} = 0\ yd^3$

$V_{185.50} := A_{185.50} \cdot d_{185.50}$ $V_{185.50} = 7801.537\ yd^3$

$V_{190.50} := A_{190.50} \cdot d_{190.50}$ $V_{190.50} = 10219.444\ yd^3$

$$V_{BBD} := V1_{180.50} + V2_{180.50} + V_{185.50} + V_{190.50}$$

$V_{BBD} = 24960.70\ yd^3$

Total Volume for Bayou Borrow,

$$V_{BB} := V_{20} + V_{25} + V_{30} + V_{35} + V_{40} + V_{45} + V1_{50} + V2_{50} + V_{55} + V_{60} + V_{65} + V1_{75} + V2_{75} + V_{80} \cdots$$
$$+ V_{85} + V_{95.50} + V_{100} + V_{105.50} + V_{110.50} + V1_{115.50} + V2_{115.50} + V3_{115.50} + V_{130.50} + V1_{140.50} \cdots$$
$$+ V2_{140.50} + V_{145.50} \cdots$$
$$+ V_{150.50} + V_{155.50} + V1_{160.50} + V2_{160.50} + V_{165.50} + V1_{170.50} + V2_{170.50} + V1_{180.50} + V2_{180.50} + V_{185.50} + V_{190.5}$$

$$\boxed{V_{BB} = 187608.92\ yd^3}$$

STATE OF LOUISIANA
COASTAL PROTECTION AND RESTORATION AUTHORITY

GRAND LIARD MARSH AND RIDGE RESTORATION
BA-68
PLAQUEMINES PARISH

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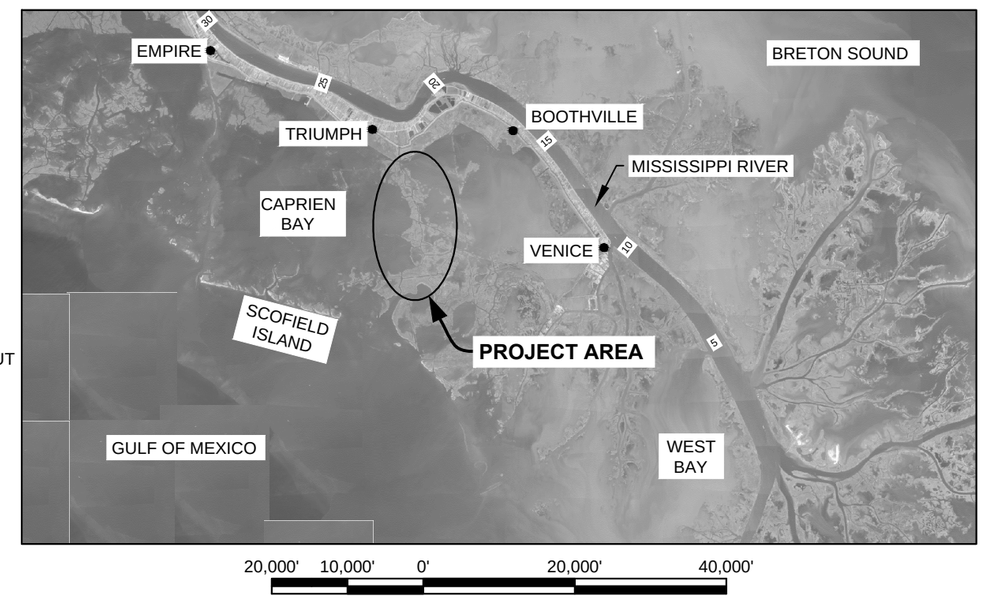


PRELIMINARY

DOCUMENTS ARE NOT TO BE USED FOR CONSTRUCTION, BIDDING, RECORDATION, CONVEYANCE, SALES, OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT.

CHIEF, ENGINEERING DIVISION

ENGINEER MANAGER

PROJECT ENGINEER

LICENSURE CLASSIFICATION REQUIREMENTS
MAJOR CLASSIFICATION: HEAVY CONSTRUCTION

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

TITLE SHEET

DATE: SEPTEMBER 2013

SHEET 1 OF 54

G:\Users\Autocad\BASINS\BA\BA-68 Grand Liard Marsh and Ridge Restoration\Plan Drawings\01 Title Sheet.dwg, 9/18/2013 1:01:43 PM

GENERAL NOTES

1. ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) GEOID 03 (2004.65), U.S. SURVEY FEET. ALL HORIZONTAL COORDINATES ARE GIVEN IN THE NORTH AMERICAN DATUM OF 1983 (NAD 83, LOUISIANA STATE PLANE SOUTH ZONE U.S. FEET). ELEVATIONS ARE BASED ON THE FOLLOWING SECONDARY MONUMENTS:

SECONDARY MONUMENT	ELEVATION	NORTHING	EASTING
CRMS BA-SM-14	2.27'	275,747.40	3,881,961.78
N 367	0.97'	314,850.54	3,878,540.64
C 279	-0.93'	318,589.90	3,846,907.90
J370	-4.20'	302,488.49	3,900,689.99

2. MEAN HIGH WATER (MHW) AND MEAN LOW WATER (MLW) WERE CALCULATED FROM THE GAGE CRMS0163 LOCATED 4 MILES SOUTH OF VENICE. DATA FROM JUNE 25, 2007 TO JUNE 22, 2010 WAS USED. ELEVATIONS ARE REFERENCED TO NAVD 88, US FEET. MHW=1.35' AND MLW =0.30'.

3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR IDENTIFYING SAFE ACCESS TO THE PROJECT AND FOR NAVIGATING WITHIN THE LIMITS OF THE PROJECT AREA. ALL EQUIPMENT SHALL BE FLOATING AT ALL TIMES DURING TRANSIT TO AND FROM THE PROJECT SITE. THE CPRA CONSTRUCTION ENGINEER OR THEIR REPRESENTATIVE SHALL MONITOR THE LOCATION OF EQUIPMENT DURING CONSTRUCTION.

4. THE CONTRACTOR SHALL NOT, AT ANYTIME, TRAVERSE EXISTING MARSH OR VEGETATIVE WETLANDS OUTSIDE FILL AREAS UNLESS OTHERWISE DIRECTED BY THE CPRA CONSTRUCTION ENGINEER.

5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR NOTIFYING PIPELINE OPERATORS THREE (3) WORKING DAYS IN ADVANCE OF THE WORK. ALL PIPELINES SHALL BE MARKED BY THE CONTRACTOR. THE CONTRACTOR SHALL MAINTAIN BUOYS DURING CONSTRUCTION AND HAVE ADEQUATE NAVIGATIONAL EQUIPMENT ON THE DREDGE TO AVOID DREDGING IN RESTRICTED AREAS. IT IS THE CONTRACTOR'S RESPONSIBILITY TO MAINTAIN THE CLEARANCES FROM THE PIPELINES SET FORTH IN THE PLANS AND SPECIFICATIONS. SEE SP-11 OF THE SPECIFICATIONS FOR ADDITIONAL INFORMATION. THE CONTRACTOR SHALL NOT ANCHOR OR EXCAVATE WITHIN 50 FEET OF ANY PIPELINE. **CALL LOUISIANA ONE CALL AT 1-800-272-3020 48 HOURS PRIOR TO ANY EXCAVATION AND/OR DREDGING TO LOCATE ALL PIPELINES OR UTILITIES.**

GULF SOUTH PIPELINE
HAROLD SILL
(504) 415-1864

TEXAS EASTERN TRANSMISSION
JEROME SNYDER
(985) 876-6761 EXT. 6851

TENNESSEE GAS PIPELINE
PAT ADAMS
(985) 223-6139

CHEVRON PIPELINE
KEITH SCHAUBHUT
PARADIS DIVISION
(507) 415-0593

COLUMBIA GULF TRANSMISSION
DARREN DUHON
INTEGRITY MANAGEMENT
(337) 266-4672

LOUISIANA STATE GAS CORP.
MORRIS P. HEBERT
(985) 879-2731

SOUTHERN NATURAL GAS
KURT CHERAMIE
EMPIRE DIVISION
(985) 233-6417

HILCORP ENERGY COMPANY
GEORGE MOSS
(985) 397-1325

6. PLANS AND SPECIFICATIONS ARE COMPLEMENTARY; WHAT IS REQUIRED BY ONE IS BINDING AS IF REQUIRED BY ALL. CLARIFICATIONS AND INTERPRETATIONS OF, OR NOTIFICATIONS OF MINOR VARIATIONS AND DEVIATIONS IN THE CONTRACT DOCUMENTS, WILL BE ISSUED IN WRITING BY THE ENGINEER.

7. ANY DAMAGE TO EXISTING U.S. COAST GUARD NAVIGATION AIDS OR PRIVATE NAVIGATION AIDS SHALL BE REPAIRED BY THE CONTRACTOR TO U.S. COAST GUARD STANDARDS AT THE EXPENSE OF THE CONTRACTOR.

8. MARSH CREATION AREA ELEVATIONS SHOWN ON THE PLANS ARE BASED ON THE SURVEYS PERFORMED BETWEEN AUGUST 05, 2010 AND SEPTEMBER 23, 2010 BY SIGMA CONSULTING GROUP, INC. FOR THE CPRA. BORROW AREA ELEVATIONS SHOWN ON THE PLANS ARE BASED ON THE SURVEYS PERFORMED BETWEEN FEBRUARY 2, 2010 AND FEBRUARY 4, 2010 BY COASTAL PLANNING & ENGINEERING, INC. FOR THE CPRA. AN UPDATED PRE-CONSTRUCTION SURVEY SHALL BE PERFORMED AS PART OF THIS CONTRACT PER TS-2.3 OF THE SPECIFICATIONS.

9. THE EARTHEN RIDGE, EARTHEN CONTAINMENT DIKES, MARSH CREATION AREAS, OFFSHORE BORROW AREAS, AND SHEET PILE CLOSURE STRUCTURES MAY BE REVISED BY THE CPRA CONSTRUCTION ENGINEER AT THE TIME OF CONSTRUCTION TO REFLECT CHANGES IN FIELD CONDITIONS.

10. ESTIMATED HYDRAULIC DREDGING QUANTITIES SHOWN ARE FOR BIDDING PURPOSES ONLY AND WERE CALCULATED ACCORDING TO CONDITIONS SURVEYED FROM 08-05-2010 TO 09-23-2010. QUANTITIES WERE CALCULATED USING AUTOCAD AND AERIAL PHOTOGRAPHY FOR SECTIONS 20+00 THROUGH 190+50.

11. THE CONTRACTOR SHALL PERFORM A MAGNETOMETER SURVEY OF THE BORROW AREAS AND ALL PROPOSED ACCESS CORRIDORS PRIOR TO MOBILIZATION FOR CONSTRUCTION. DRAWINGS SHOWING THE TRACK LINES, ANY MAGNETOMETER HITS, COORDINATES, AMPLITUDE, SIGNATURE TYPE, AND SIGNATURE WIDTH OF ALL MAGNETOMETER HITS SHALL BE SUBMITTED TO THE ENGINEER PRIOR TO MOBILIZATION. ADDITIONAL TRACK LINES SHALL BE RUN IN ACCORDANCE WITH TS-2.3.9 OF THE SPECIFICATIONS.

12. THE GEOTECHNICAL INVESTIGATION AND ANALYSES WERE PERFORMED FROM JANUARY 2010 THROUGH SEPTEMBER 2011 BY GEOENGINEERS, INC. AND COASTAL PLANNING AND ENGINEERING, INC. THE LOCATIONS OF THE SOIL BORINGS ARE SHOWN ON SHEET 28. THE GEOTECHNICAL BORING LOGS CAN BE FOUND IN APPENDIX H OF THE SPECIFICATIONS.

13. THE CONTRACTOR IS RESPONSIBLE FOR CONTAINING ALL DREDGED MATERIAL WITHIN THE BOUNDARIES OF THE PROPOSED MARSH CREATION AREAS.

SUMMARY OF ESTIMATED QUANTITIES

ITEM No.	DESCRIPTION	UNIT	ESTIMATED[3] QUANTITY
1	MOBILIZATION AND DEMOBILIZATION	LUMP SUM	1
2	CLEARING AND GRUBBING	LUMP SUM	1
3	MARSH CREATION HYDRAULIC DREDGING (BORROW CUT VOLUME)[2]	CUBIC YARDS	3,442,824
4	EARTHEN CONTAINMENT DIKES[1]	LINEAR FOOT	29,275
5	EARTHEN RIDGE	LINEAR FOOT	16,780
6	CONSTRUCTION SURVEYS	LUMP SUM	1
7	STEEL SHEET PILING	SQUARE FOOT	45,626
8	SAND FILL	CUBIC YARDS	22,569
9	SETTLEMENT PLATES	EACH	11
10	ACCESS DREDGING	LUMP SUM	1
11	PIPELINE REMOVAL	LUMP SUM	1

1. THE LINEAR FOOTAGE OF EARTHEN CONTAINMENT DIKES AND EARTHEN RIDGE WAS ESTIMATED FOR CONSTRUCTION USING AERIAL PHOTOGRAPHY, FIELD SURVEYS, AND AUTOCAD. THE OWNER RESERVES THE RIGHT TO REQUEST THAT ADDITIONAL EARTHEN CONTAINMENT DIKES AND EARTHEN RIDGE BE BUILT FOR CONSTRUCTION AT THE CONTRACTOR'S BID PRICE/LINEAR FOOT.
2. THE HYDRAULIC DREDGING QUANTITIES FOR THE MARSH CREATION AREAS ARE BASED ON THE OFFSHORE BORROW AREA CUT VOLUME. ACTUAL QUANTITIES FOR PAYMENT WILL BE BASED ON SURVEYS PERFORMED AS PART OF THIS CONTRACT AS REQUIRED IN TS-2 "CONSTRUCTION SURVEYS" OF THE SPECIFICATIONS.
3. WHERE THE QUANTITY OF WORK WITH RESPECT TO ANY ITEM IS COVERED BY A UNIT PRICE, SUCH QUANTITIES ARE ESTIMATED QUANTITIES TO BE USED WHEN COMPARING BIDS AND THE RIGHT IS RESERVED BY THE OWNER TO INCREASE/DECREASE SUCH QUANTITIES AS MAY BE NECESSARY TO COMPLETE THE WORK AND/OR REMAIN WITHIN FUNDING LIMITS.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

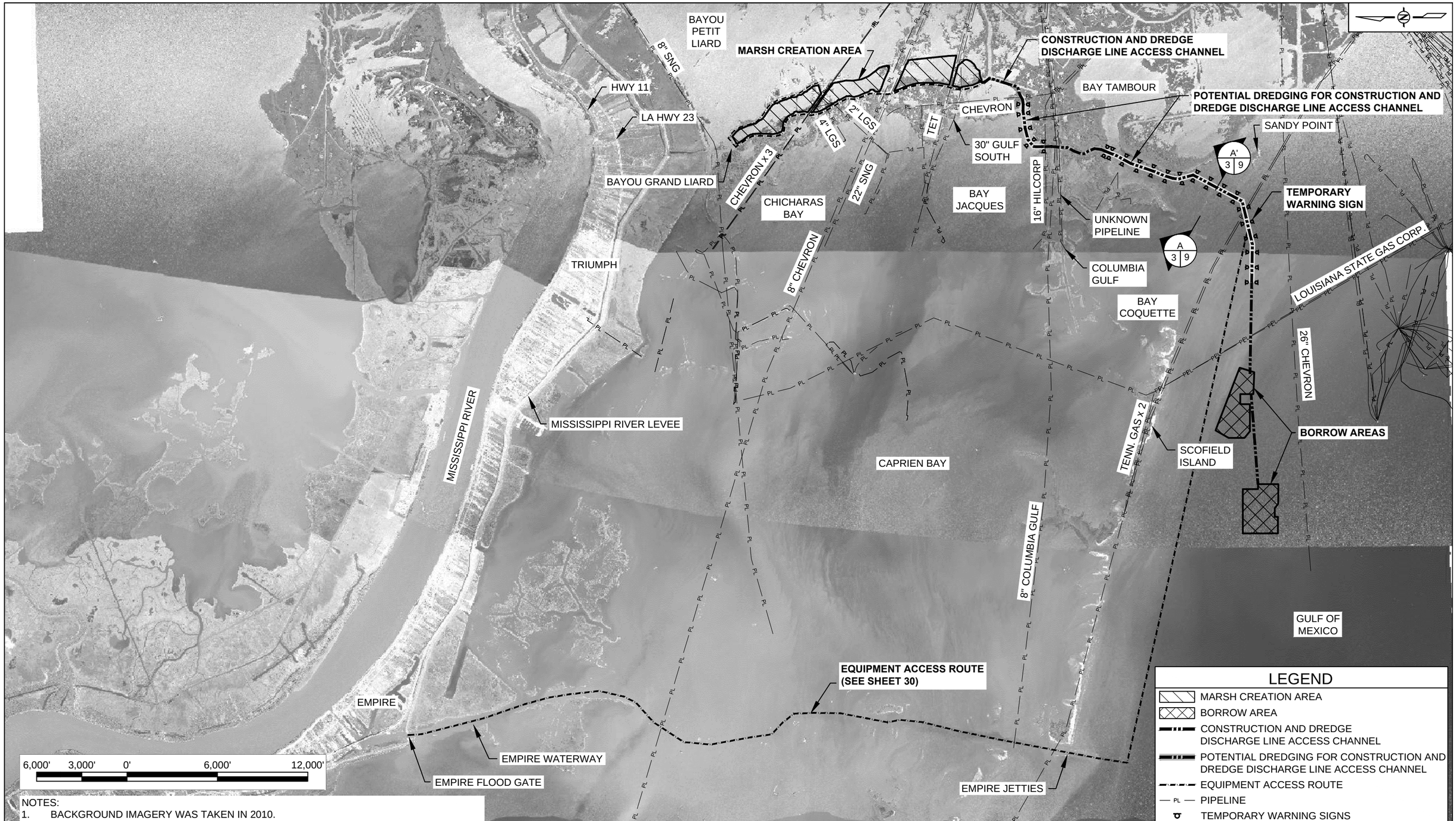
GENERAL NOTES

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.



NOTES:

1. BACKGROUND IMAGERY WAS TAKEN IN 2010.
2. PIPELINE INFORMATION SHOWN ON PLANS IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY EXACT LOCATIONS PRIOR TO BEGINNING CONSTRUCTION.
3. PIPELINE LOCATIONS ARE BASED ON USGS DATABASE AND IS NOT GUARANTEED TO BE ACCURATE.
4. ALL PIPELINES LOCATED WITHIN 150' OF THE EARTHEN RIDGE AND DIKE ALIGNMENTS, MARSH CREATION AREAS, BORROW AREAS, AND SHEET PILE CLOSURES SHALL BE PROBED AND THEIR LOCATIONS MARKED FOR THE DURATION OF CONSTRUCTION ACTIVITIES. SEE SP-11 OF THE SPECIFICATIONS FOR ADDITIONAL DETAILS.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY: RUDOLPH SIMONEAUX, P.E.

ACCESS ROUTE

DATE: SEPTEMBER 2013
SHEET 3 OF 54

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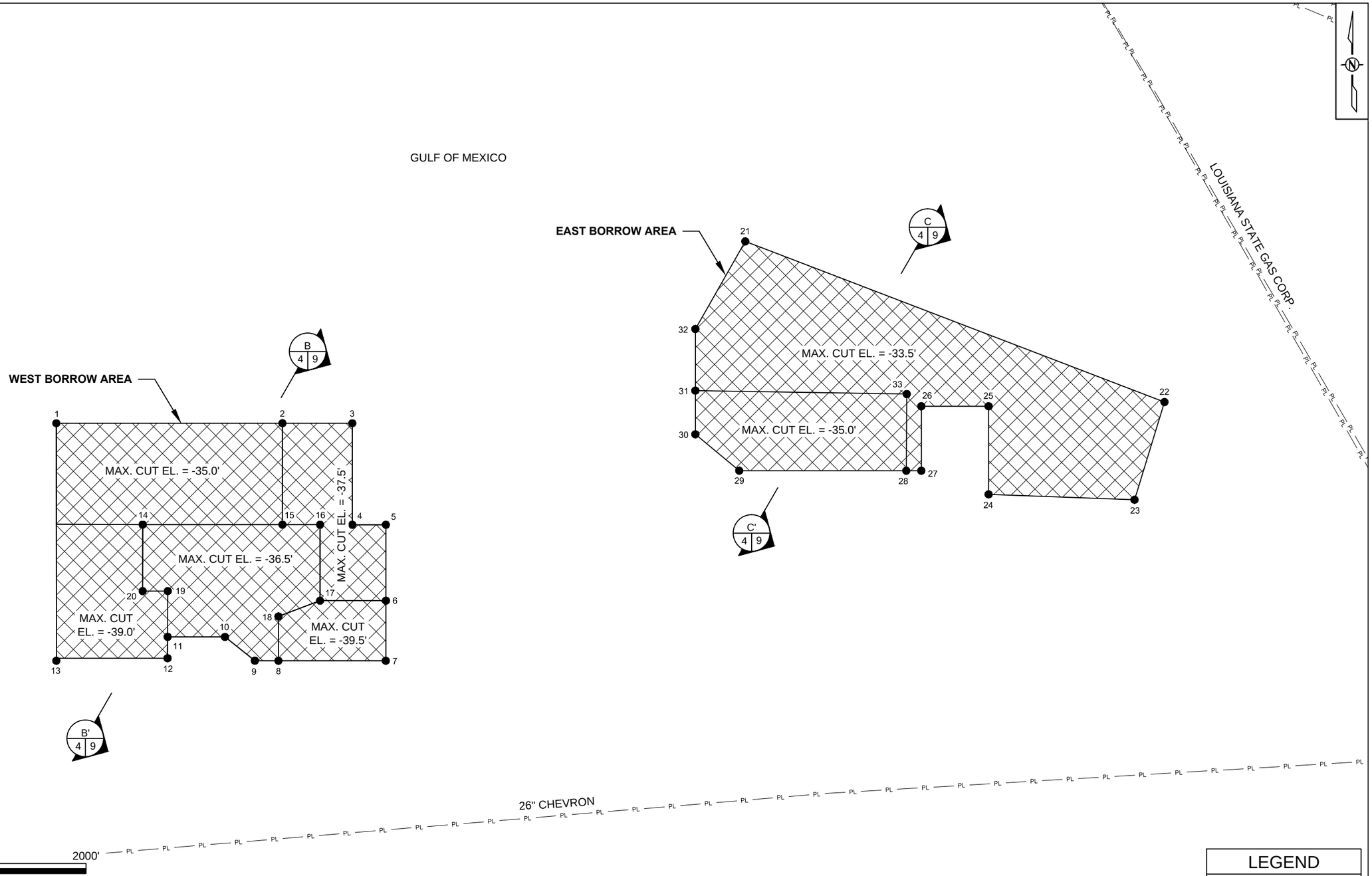
WEST BORROW AREA		
	NORTHING	EASTING
1	267,055.94	3,845,785.04
2	267,055.96	3,848,029.68
3	267,055.94	3,848,723.04
4	266,048.61	3,848,723.04
5	266,048.61	3,849,056.64
6	265,294.95	3,849,056.83
7	264,698.11	3,849,055.36
8	264,698.11	3,847,989.13
9	264,698.77	3,847,755.37
10	264,934.53	3,847,458.71
11	264,935.39	3,846,889.33
12	264,723.34	3,846,888.60
13	264,698.16	3,845,785.04
14	266,050.28	3,846,642.26
15	266,049.27	3,848,029.68
16	266,048.91	3,848,402.96
17	265,294.95	3,848,403.01
18	265,138.60	3,847,990.03
19	265,389.54	3,846,890.88
20	265,389.61	3,846,641.27

EAST BORROW AREA		
	NORTHING	EASTING
21	268,861.16	3,852,624.70
22	267,266.13	3,856,785.51
23	266,296.16	3,856,488.54
24	266,349.82	3,855,039.86
25	267,224.70	3,855,039.86
26	267,224.70	3,854,371.88
27	266,584.86	3,854,371.88
28	266,584.86	3,854,222.63
29	266,584.86	3,852,564.14
30	266,946.00	3,852,128.69
31	267,379.60	3,852,128.69
32	267,991.93	3,852,128.69
33	267,345.73	3,854,227.40



LEGEND

BORROW AREA

PL PIPELINE

NOTES:

1. PIPELINE INFORMATION SHOWN ON PLANS IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY EXACT LOCATIONS PRIOR TO BEGINNING CONSTRUCTION.
2. ALL PIPELINES LOCATED WITHIN 150' OF THE BORROW AREAS SHALL BE PROBED AND THEIR LOCATIONS MARKED FOR THE DURATION OF CONSTRUCTION ACTIVITIES. SEE SP-11 OF THE SPECIFICATIONS FOR DETAILS.
3. THE WEST BORROW AREA CONTAINS APPROXIMATELY 4.01 M CUBIC YARDS OF MATERIAL.
4. THE EAST BORROW AREA CONTAINS APPROXIMATELY 4.31 M CUBIC YARDS OF MATERIAL.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

BORROW AREA LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 4 OF 54

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SHEET PILE CLOSURE
2" GULF
CHEVRON x 2
EARTHEN CONTAINMENT DIKE
TET
30" GULFSOUTH
MARSH CREATION AREA A
MARSH CREATION AREA B
MARSH CREATION AREA C
MARSH CREATION AREA D
2" LGS
4" LGS
CONSTRUCTION AND DREDGE DISCHARGE LINE ACCESS CHANNEL (SEE NOTE 5)
BAYOU GRAND LIARD
EARTHEN RIDGE RESTORATION
CHEVRON
8" SNG
8" CHEVRON
22" SNG
POTENTIAL DREDGING FOR CONSTRUCTION AND DREDGE DISCHARGE LINE ACCESS CHANNEL
COLUMBIA GULF
16" HILCORP
COLUMBIA GULF
CHICHARAS BAY
BAY JACQUES
TEMPORARY WARNING SIGN

2000' 1000' 0' 2000' 4000'

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- CONSTRUCTION AND DREDGE DISCHARGE LINE ACCESS CHANNEL
- POTENTIAL DREDGING FOR CONSTRUCTION AND DREDGE DISCHARGE LINE ACCESS CHANNEL
- EQUIPMENT ACCESS ROUTE
- PL — PIPELINE
- SHEET PILE CLOSURE
- TEMPORARY WARNING SIGN

NOTES:

1. PIPELINE INFORMATION SHOWN ON PLANS IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY EXACT LOCATIONS PRIOR TO BEGINNING CONSTRUCTION.
2. ALL PIPELINES LOCATED WITHIN 150' OF THE EARTHEN RIDGE AND DIKE ALIGNMENTS, FILL AREAS, BORROW AREA, OR SHEET PILE CLOSURES SHALL BE PROBED AND THEIR LOCATIONS MARKED FOR THE DURATION OF CONSTRUCTION ACTIVITIES. SEE SP-11 OF THE SPECIFICATIONS FOR DETAILS.
3. NO EXCAVATION SHALL OCCUR WITHIN 50.0' OF A PIPELINE.
4. THE CONTRACTOR SHALL CONSTRUCT THE MARSH CREATION AREAS IN A TWO CONSTRUCTION LIFT SEQUENCE AS SPECIFIED IN TS-8.5.
5. THE DREDGE DISCHARGE LINE MAY BE LAID WITHIN THE EQUIPMENT ACCESS ROUTE.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREA LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 5 OF 54

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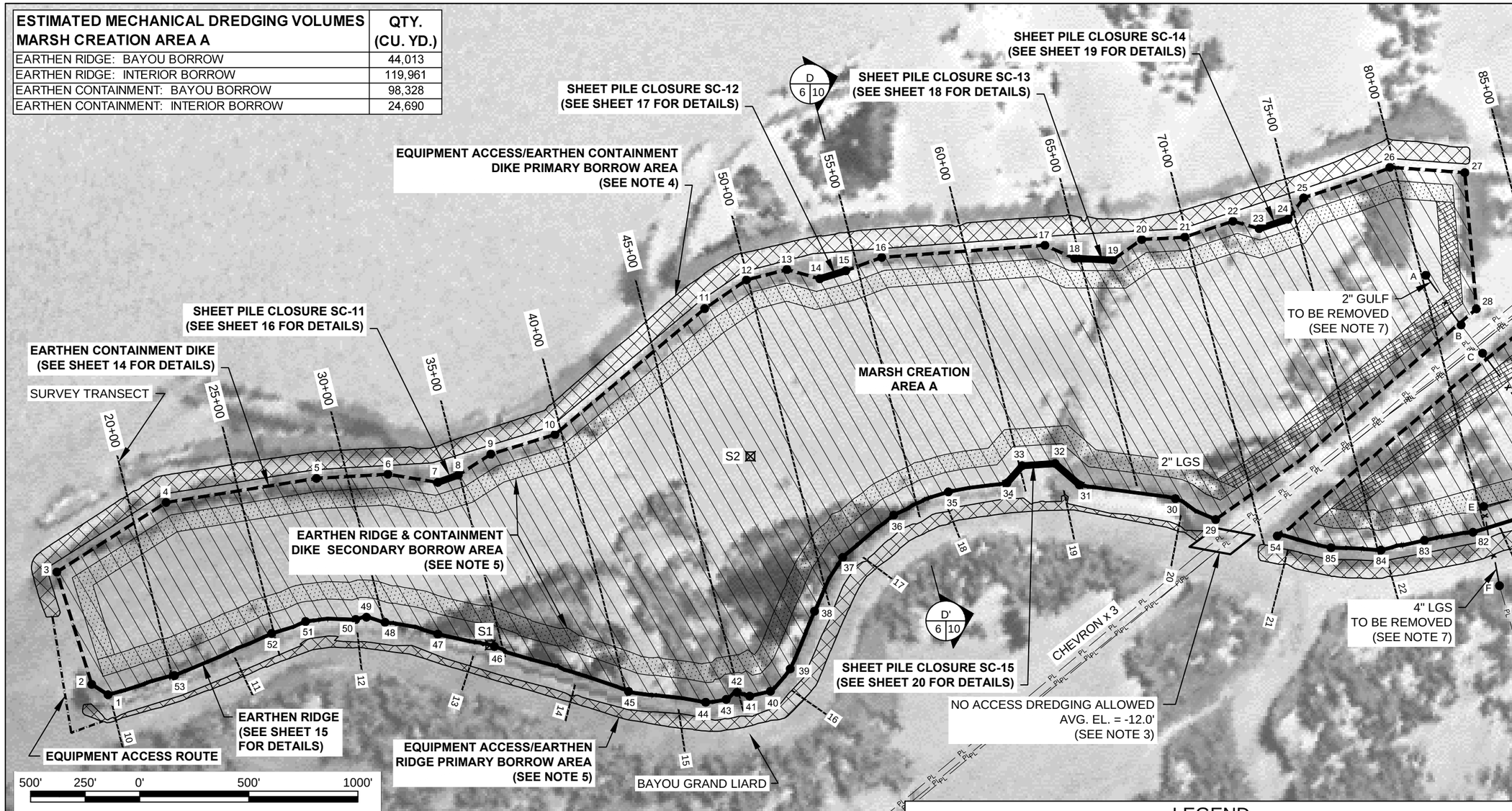
ESTIMATED MECHANICAL DREDGING VOLUMES MARSH CREATION AREA A	QTY. (CU. YD.)
EARTHEN RIDGE: BAYOU BORROW	44,013
EARTHEN RIDGE: INTERIOR BORROW	119,961
EARTHEN CONTAINMENT: BAYOU BORROW	98,328
EARTHEN CONTAINMENT: INTERIOR BORROW	24,690



SETTLEMENT PLATES	NORTHING	EASTING
S1	298,974.97	3,872,339.85
S2	298,047.05	3,873,483.87

MARSH CREATION AREA A	NORTHING	EASTING
1	300,607.96	3,871,666.97
2	300,692.41	3,871,693.73
3	300,979.87	3,872,149.14
4	300,578.71	3,872,586.41
5	299,941.66	3,872,871.51
6	299,630.15	3,872,974.80
7	299,399.97	3,872,997.41
9	299,198.56	3,873,185.45
10	298,937.62	3,873,348.63
11	298,424.84	3,874,083.00
12	298,273.57	3,874,259.16
13	298,106.81	3,874,353.66
14	297,950.57	3,874,351.46
15	297,844.63	3,874,417.81
16	297,701.34	3,874,520.02
17	296,993.55	3,874,766.83
18	296,846.09	3,874,743.42
19	296,675.57	3,874,782.73
20	296,571.86	3,874,906.99
21	296,383.78	3,874,969.64
22	296,189.97	3,875,096.54
23	296,064.92	3,875,094.45
24	295,947.73	3,875,171.05
25	295,904.60	3,875,283.38
26	295,559.33	3,875,521.02
27	295,220.75	3,875,586.17
28	295,008.21	3,874,997.03
29	295,912.71	3,873,756.03
30	296,115.71	3,873,800.93
31	296,557.26	3,873,748.15
32	296,689.23	3,873,813.30
33	296,832.75	3,873,764.66
34	296,879.68	3,873,670.03
35	297,128.65	3,873,560.96
36	297,343.14	3,873,393.69
37	297,518.34	3,873,146.05
38	297,579.46	3,872,874.44
39	297,618.75	3,872,590.51
40	297,679.76	3,872,467.80
41	297,765.95	3,872,421.68
42	297,826.20	3,872,423.32
43	297,865.77	3,872,378.98
44	297,953.37	3,872,342.50
45	298,308.22	3,872,298.96
46	298,954.32	3,872,338.49
47	299,219.90	3,872,326.14
48	299,467.75	3,872,315.65
49	299,555.85	3,872,316.49
50	299,600.47	3,872,293.63
51	299,820.68	3,872,225.11
52	299,955.97	3,872,132.42
53	300,336.11	3,871,830.71

NOTES:

1. PIPELINE INFORMATION SHOWN ON PLANS IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY EXACT LOCATIONS PRIOR TO BEGINNING CONSTRUCTION.
2. ALL PIPELINES LOCATED WITHIN 150' OF THE EARTHEN RIDGE AND DIKE ALIGNMENTS, FILL AREAS, BORROW AREA, OR SHEET PILE CLOSURES SHALL BE PROBED AND THEIR LOCATIONS MARKED FOR THE DURATION OF CONSTRUCTION ACTIVITIES. SEE SP-11 OF THE SPECIFICATIONS FOR ADDITIONAL INFORMATION.
3. NO EXCAVATION SHALL OCCUR WITHIN 50.0' OF A PIPELINE.
4. DREDGING OF EQUIPMENT ACCESS/BORROW CHANNEL EAST OF FILL AREA A WILL BE PERFORMED FOR EQUIPMENT ACCESS AND SHALL NOT EXCEED THE TEMPLATE SHOWN ON SHEET 14. SPOIL SHALL BE USED TO CONSTRUCT THE EASTERN EARTHEN CONTAINMENT DIKE ALIGNMENT OF MARSH CREATION FILL AREA A.
5. THE CONTRACTOR SHALL CONSTRUCT THE EARTHEN RIDGE AND EARTHEN CONTAINMENT DIKES BY DREDGING FROM BOTH PRIMARY AND SECONDARY BORROW AREAS. SEE TS-6.2 AND TS-7.2 OF THE SPECIFICATIONS FOR MORE DETAILS.
6. ESTIMATED BORROW VOLUMES SHOWN FOR THE EARTHEN RIDGE AND EARTHEN CONTAINMENT DIKES ARE FOR INFORMATIONAL PURPOSES ONLY.
7. THE 2" GULF SOUTH AND 4" LOUISIANA STATE GAS CORPORATION PIPELINES SHALL BE CUT AND REMOVED BY THE CONTRACTOR. SEE TS-3 OF THE SPECIFICATION AND SHEET 7 FOR MORE DETAILS.

LEGEND

- MARSH CREATION AREA
- EQUIPMENT ACCESS/PRIMARY BORROW AREA FOR EARTHEN RIDGE & CONTAINMENT DIKE
- SECONDARY BORROW AREA FOR EARTHEN RIDGE & EARTHEN CONTAINMENT DIKE
- SOLE BORROW AREA FOR CONTAINMENT DIKE
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- SHEET PILE CLOSURE
- EQUIPMENT ACCESS ROUTE
- PIPELINE
- PIPELINE REMOVAL
- SURVEY TRANSECT
- SETTLEMENT PLATE

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREA A LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E. | SHEET 6 OF 54

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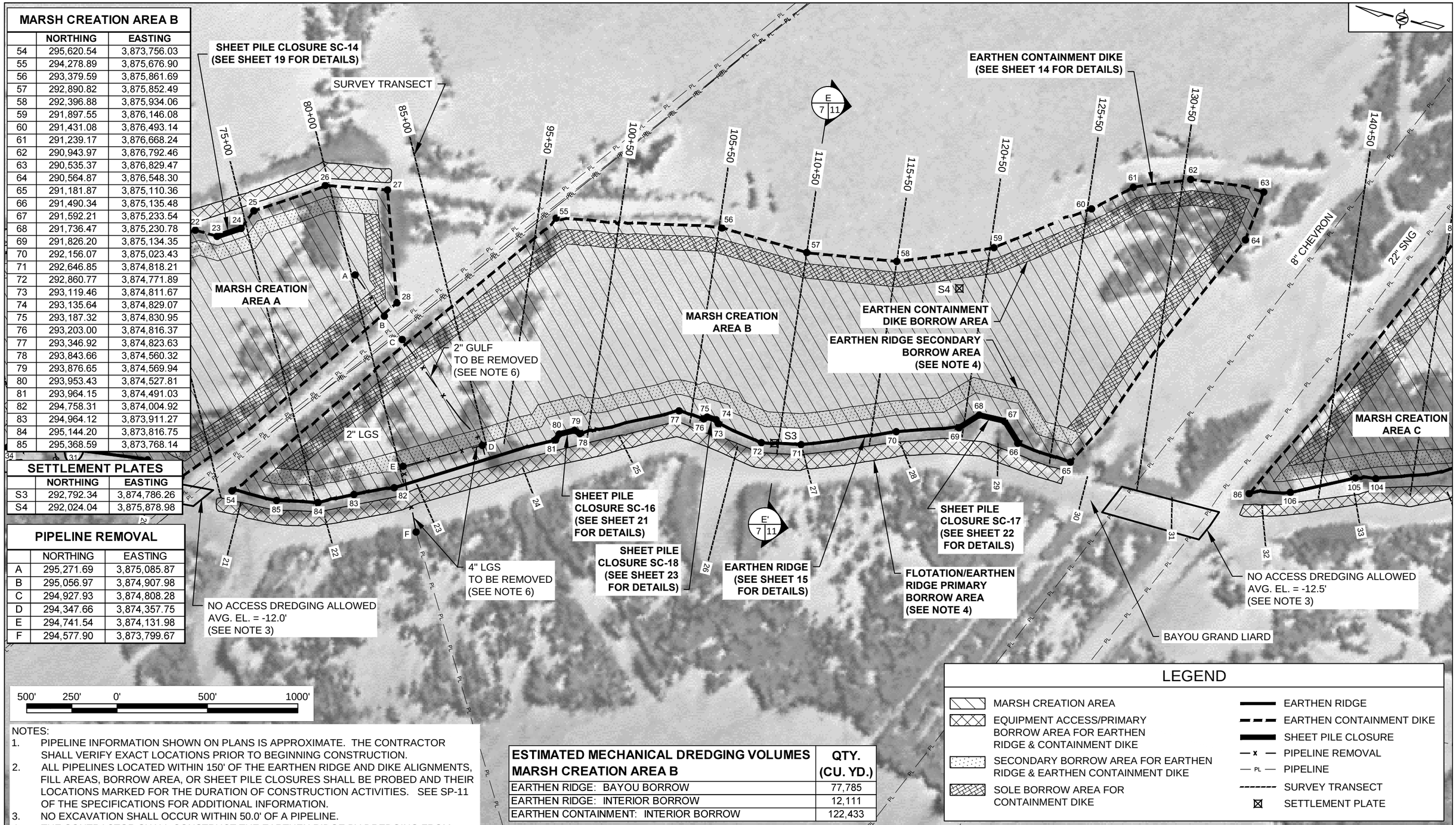

MARSH CREATION AREA B

	NORTHING	EASTING
54	295,620.54	3,873,756.03
55	294,278.89	3,875,676.90
56	293,379.59	3,875,861.69
57	292,890.82	3,875,852.49
58	292,396.88	3,875,934.06
59	291,897.55	3,876,146.08
60	291,431.08	3,876,493.14
61	291,239.17	3,876,668.24
62	290,943.97	3,876,792.46
63	290,535.37	3,876,829.47
64	290,564.87	3,876,548.30
65	291,181.87	3,875,110.36
66	291,490.34	3,875,135.48
67	291,592.21	3,875,233.54
68	291,736.47	3,875,230.78
69	291,826.20	3,875,134.35
70	292,156.07	3,875,023.43
71	292,646.85	3,874,818.21
72	292,860.77	3,874,771.89
73	293,119.46	3,874,811.67
74	293,135.64	3,874,829.07
75	293,187.32	3,874,830.95
76	293,203.00	3,874,816.37
77	293,346.92	3,874,823.63
78	293,843.66	3,874,560.32
79	293,876.65	3,874,569.94
80	293,953.43	3,874,527.81
81	293,964.15	3,874,491.03
82	294,758.31	3,874,004.92
83	294,964.12	3,873,911.27
84	295,144.20	3,873,816.75
85	295,368.59	3,873,768.14

SETTLEMENT PLATES

	NORTHING	EASTING
S3	292,792.34	3,874,786.26
S4	292,024.04	3,875,878.98

PIPELINE REMOVAL

	NORTHING	EASTING
A	295,271.69	3,875,085.87
B	295,056.97	3,874,907.98
C	294,927.93	3,874,808.28
D	294,347.66	3,874,357.75
E	294,741.54	3,874,131.98
F	294,577.90	3,873,799.67

NOTES:

1. PIPELINE INFORMATION SHOWN ON PLANS IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY EXACT LOCATIONS PRIOR TO BEGINNING CONSTRUCTION.
2. ALL PIPELINES LOCATED WITHIN 150' OF THE EARTHEN RIDGE AND DIKE ALIGNMENTS, FILL AREAS, BORROW AREA, OR SHEET PILE CLOSURES SHALL BE PROBED AND THEIR LOCATIONS MARKED FOR THE DURATION OF CONSTRUCTION ACTIVITIES. SEE SP-11 OF THE SPECIFICATIONS FOR ADDITIONAL INFORMATION.
3. NO EXCAVATION SHALL OCCUR WITHIN 50.0' OF A PIPELINE.
4. THE CONTRACTOR SHALL CONSTRUCT THE EARTHEN RIDGE BY DREDGING FROM BOTH PRIMARY AND SECONDARY BORROW AREAS. SEE TS-7.2 OF THE SPECIFICATIONS FOR MORE DETAILS.
5. ESTIMATED BORROW VOLUMES SHOWN FOR THE EARTHEN RIDGE AND EARTHEN CONTAINMENT DIKES ARE FOR INFORMATIONAL PURPOSES ONLY.
6. THE 2" GULF SOUTH AND 4" LOUISIANA STATE GAS CORPORATION PIPELINES SHALL BE CUT AND REMOVED BY THE CONTRACTOR. SEE TS-3 OF THE SPECIFICATIONS FOR MORE DETAILS.

ESTIMATED MECHANICAL DREDGING VOLUMES MARSH CREATION AREA B	QTY. (CU. YD.)
EARTHEN RIDGE: BAYOU BORROW	77,785
EARTHEN RIDGE: INTERIOR BORROW	12,111
EARTHEN CONTAINMENT: INTERIOR BORROW	122,433

LEGEND

- MARSH CREATION AREA
- EQUIPMENT ACCESS/PRIMARY BORROW AREA FOR EARTHEN RIDGE & CONTAINMENT DIKE
- SECONDARY BORROW AREA FOR EARTHEN RIDGE & EARTHEN CONTAINMENT DIKE
- SOLE BORROW AREA FOR CONTAINMENT DIKE
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- SHEET PILE CLOSURE
- PIPELINE REMOVAL
- PIPELINE
- SURVEY TRANSECT
- SETTLEMENT PLATE

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREA B LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E. | SHEET 7 OF 54

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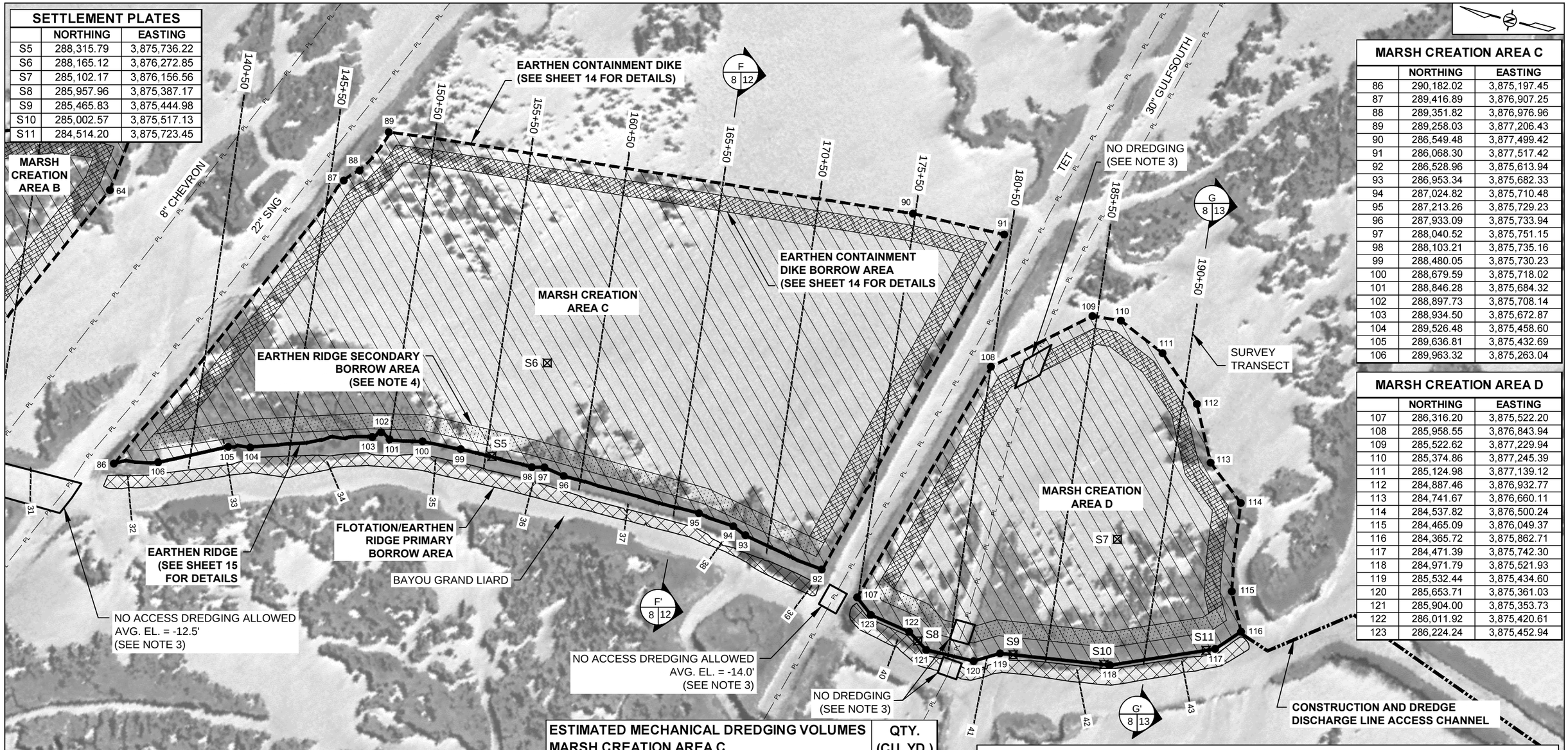
SETTLEMENT PLATES		
	NORTHING	EASTING
S5	288,315.79	3,875,736.22
S6	288,165.12	3,876,272.85
S7	285,102.17	3,876,156.56
S8	285,957.96	3,875,387.17
S9	285,465.83	3,875,444.98
S10	285,002.57	3,875,517.13
S11	284,514.20	3,875,723.45



MARSH CREATION AREA C		
	NORTHING	EASTING
86	290,182.02	3,875,197.45
87	289,416.89	3,876,907.25
88	289,351.82	3,876,976.96
89	289,258.03	3,877,206.43
90	286,549.48	3,877,499.42
91	286,068.30	3,877,517.42
92	286,528.96	3,875,613.94
93	286,953.34	3,875,682.33
94	287,024.82	3,875,710.48
95	287,213.26	3,875,729.23
96	287,933.09	3,875,733.94
97	288,040.52	3,875,751.15
98	288,103.21	3,875,735.16
99	288,480.05	3,875,730.23
100	288,679.59	3,875,718.02
101	288,846.28	3,875,684.32
102	288,897.73	3,875,708.14
103	288,934.50	3,875,672.87
104	289,526.48	3,875,458.60
105	289,636.81	3,875,432.69
106	289,963.32	3,875,263.04

MARSH CREATION AREA D		
	NORTHING	EASTING
107	286,316.20	3,875,522.20
108	285,958.55	3,876,843.94
109	285,522.62	3,877,229.94
110	285,374.86	3,877,245.39
111	285,124.98	3,877,139.12
112	284,887.46	3,876,932.77
113	284,741.67	3,876,660.11
114	284,537.82	3,876,500.24
115	284,465.09	3,876,049.37
116	284,365.72	3,875,862.71
117	284,471.39	3,875,742.30
118	284,971.79	3,875,521.93
119	285,532.44	3,875,434.60
120	285,653.71	3,875,361.03
121	285,904.00	3,875,353.73
122	286,011.92	3,875,420.61
123	286,224.24	3,875,452.94

ESTIMATED MECHANICAL DREDGING VOLUMES MARSH CREATION AREA C	QTY. (CU. YD.)
EARTHEN RIDGE: BAYOU BORROW	40,850
EARTHEN RIDGE: INTERIOR BORROW	8,475
EARTHEN CONTAINMENT: INTERIOR BORROW	83,708

ESTIMATED MECHANICAL DREDGING VOLUMES MARSH CREATION AREA D	QTY. (CU. YD.)
EARTHEN RIDGE: BAYOU BORROW	24,961
EARTHEN RIDGE: INTERIOR BORROW	5,201
EARTHEN CONTAINMENT: INTERIOR BORROW	48,565

LEGEND

- MARSH CREATION AREA
- EQUIPMENT ACCESS/PRIMARY BORROW AREA FOR EARTHEN RIDGE
- SECONDARY BORROW AREA FOR EARTHEN RIDGE & EARTHEN CONTAINMENT DIKE
- SOLE BORROW AREA FOR CONTAINMENT DIKE
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- CONSTRUCTION AND DREDGE DISCHARGE LINE ACCESS CHANNEL
- PL PIPELINE
- SURVEY TRANSECT
- SETTLEMENT PLATE

NOTES:

1. PIPELINE INFORMATION SHOWN ON PLANS IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY EXACT LOCATIONS PRIOR TO BEGINNING CONSTRUCTION.
2. ALL PIPELINES LOCATED WITHIN 150' OF THE EARTHEN RIDGE AND DIKE ALIGNMENTS, FILL AREAS, BORROW AREAS, OR SHEET PILE CLOSURES SHALL BE PROBED AND THEIR LOCATIONS MARKED FOR THE DURATION OF CONSTRUCTION ACTIVITIES. SEE SP-11 OF THE SPECIFICATIONS FOR ADDITIONAL INFORMATION.
3. NO EXCAVATION SHALL OCCUR WITHIN 50.0' OF A PIPELINE.
4. THE CONTRACTOR SHALL CONSTRUCT THE EARTHEN RIDGE BY DREDGING FROM BOTH PRIMARY AND SECONDARY BORROW AREAS. SEE TS-7.2 FOR MORE DETAILS.
5. ESTIMATED BORROW VOLUMES SHOWN FOR THE EARTHEN RIDGE AND EARTHEN CONTAINMENT DIKES ARE FOR INFORMATIONAL PURPOSES ONLY.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREA C & D LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 8 OF 54

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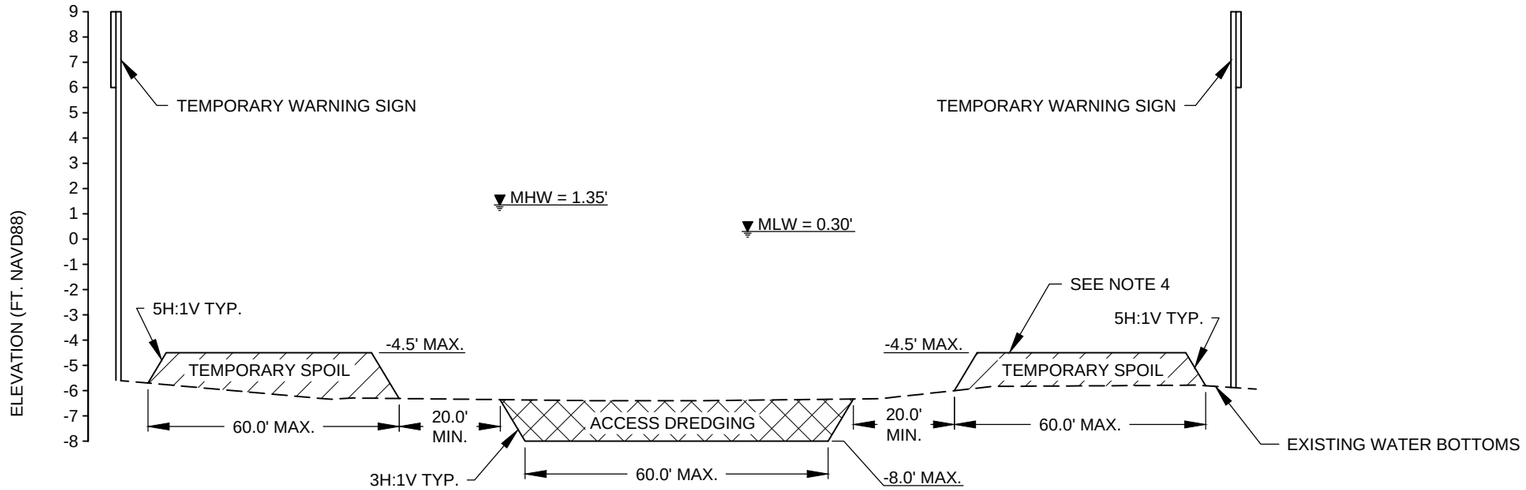
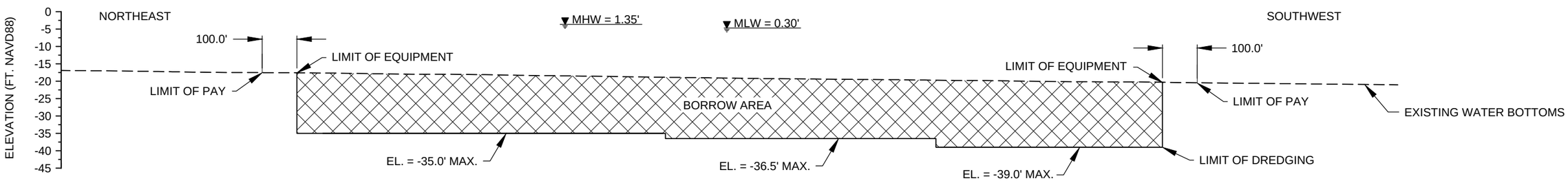
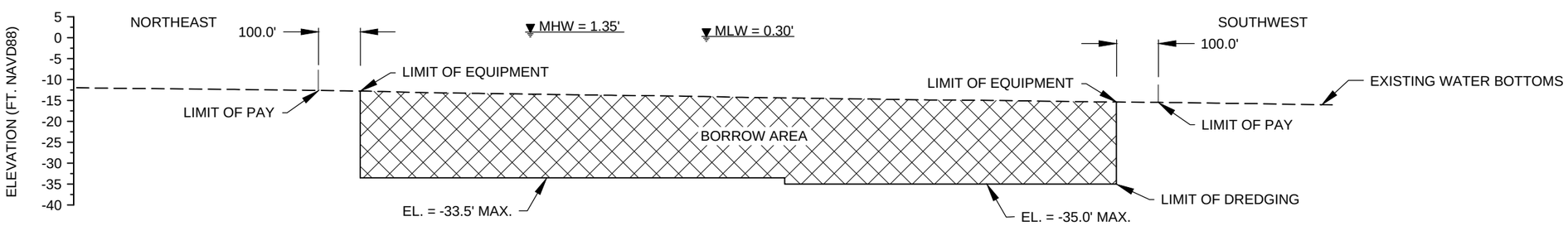


A-A' 9 3 **TYPICAL SECTION - POTENTIAL DREDGING FOR CONSTRUCTION AND DREDGE DISCHARGE LINE ACCESS CHANNEL**

HORIZONTAL GRAPHIC SCALE
30' 15' 0 30' 60'
6' 3' 0 6' 12'
VERTICAL GRAPHIC SCALE



B-B' 9 4 **TYPICAL SECTION - WEST BORROW AREA**
TRANSECT WEST 3



C-C' 9 4 **TYPICAL SECTION - EAST BORROW AREA**
TRANSECT EAST 7

HORIZONTAL GRAPHIC SCALE
300' 150' 0 300' 600'
30' 15' 0 30' 60'
VERTICAL GRAPHIC SCALE

NOTES:

1. THE WEST BORROW AREA CONTAINS APPROXIMATELY 4.01 M. CUBIC YARDS OF MATERIAL.
2. THE EAST BORROW AREA CONTAINS APPROXIMATELY 4.31 M. CUBIC YARDS OF MATERIAL.
3. SEE SHEETS 4, 25, 26, AND 27 FOR PLAN VIEWS OF BORROW AREA LAYOUT.
4. ACCESS CHANNEL SHALL BE BACKFILLED IN ACCORDANCE WITH TS-5 AND MARKED IN ACCORDANCE WITH TS-16 OF THE SPECIFICATIONS.
5. DEPENDING ON DRAFT REQUIREMENTS OF THE CONTRACTOR'S EQUIPMENT, ACCESS DREDGING MAY NOT BE REQUIRED AT ALL LOCATIONS SHOWN. PERMITTED DEPTHS AND WIDTHS ARE AS SHOWN. IT IS NOT MANDATORY THAT THE CONTRACTOR DREDGE OR EXCAVATE TO THE FULL DEPTHS AND WIDTHS.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

BORROW AREA & CONSTRUCTION DREDGING TYPICAL SECTIONS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 9 OF 54

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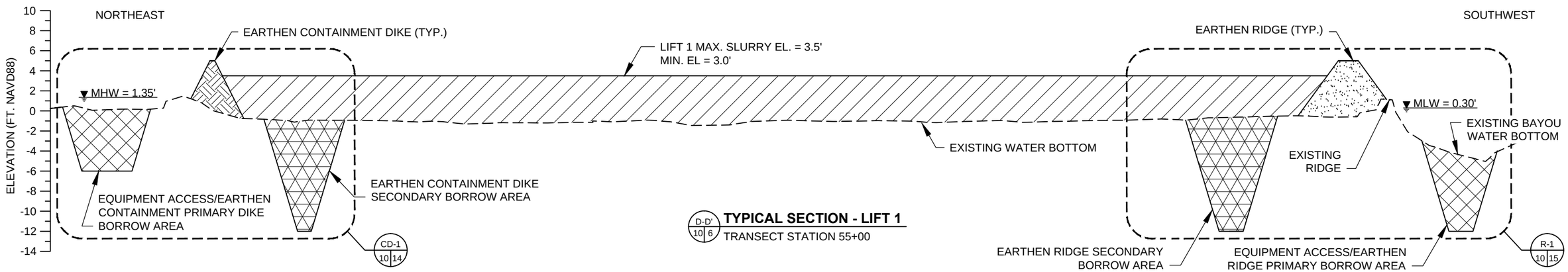
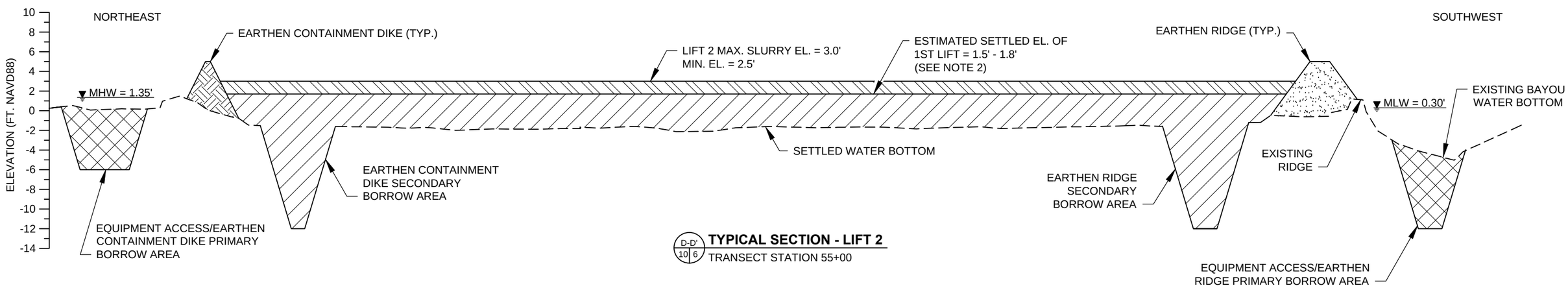


D-D' 10 6 **TYPICAL SECTION - LIFT 1**
TRANSECT STATION 55+00



D-D' 10 6 **TYPICAL SECTION - LIFT 2**
TRANSECT STATION 55+00

HORIZONTAL GRAPHIC SCALE
100' 50' 0 100' 200'
10' 5' 0 10' 20'
VERTICAL GRAPHIC SCALE

LEGEND

- EARTHEN CONTAINMENT DIKE
- EARTHEN RIDGE
- BORROW AREA
- SECONDARY BORROW AREA
- MARSH FILL - LIFT 1
- MARSH FILL - LIFT 2
- EXISTING WATER BOTTOM

NOTES:
1. BASED ON RECOMMENDATIONS FROM THE GEOTECHNICAL ANALYSIS A TWO LIFT SYSTEM IS REQUIRED TO MEET THE LONG TERM TARGET ELEVATIONS.
2. THE CONTRACTOR SHALL CONSTRUCT THE MARSH CREATION AREAS IN THE TWO CONSTRUCTION LIFT SEQUENCE AS SPECIFIED IN TS-8.5 OF THE SPECIFICATIONS.
3. ALL MARSH CREATION AREAS SHALL BE DEWATERED IN ACCORDANCE WITH TS-13 OF THE SPECIFICATIONS.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION
STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREA A
TYPICAL SECTION D-D'
DATE: SEPTEMBER 2013
SHEET 10 OF 54

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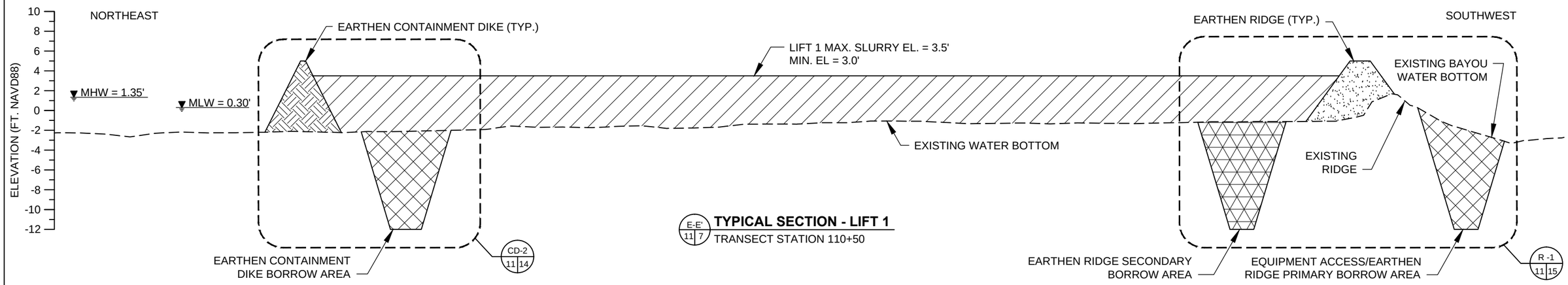
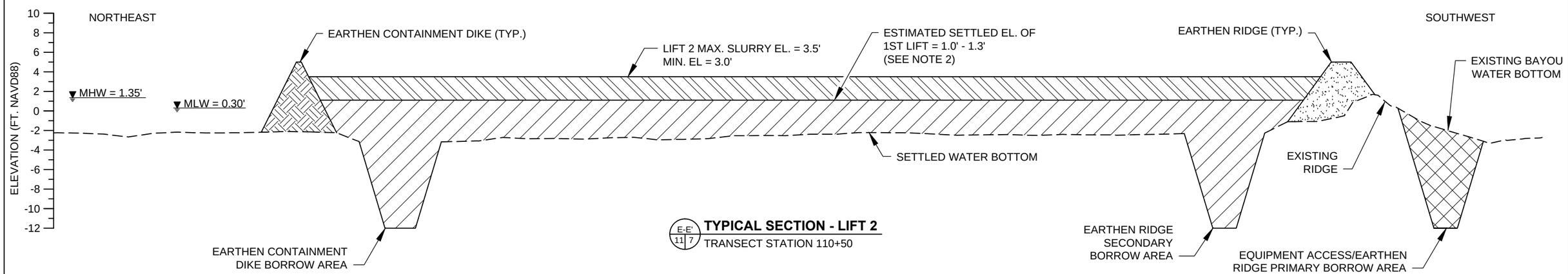


E-E' 11 7 **TYPICAL SECTION - LIFT 1**
TRANSECT STATION 110+50



E-E' 11 7 **TYPICAL SECTION - LIFT 2**
TRANSECT STATION 110+50

HORIZONTAL GRAPHIC SCALE
100' 50' 0 100' 200'
10' 5' 0 10' 20'
VERTICAL GRAPHIC SCALE

LEGEND

- EARTHEN CONTAINMENT DIKE
- EARTHEN RIDGE
- BORROW AREA
- SECONDARY BORROW AREA
- MARSH FILL - LIFT 1
- MARSH FILL - LIFT 2
- EXISTING WATER BOTTOM

NOTES:
1. BASED ON RECOMMENDATIONS FROM THE GEOTECHNICAL ANALYSIS A TWO LIFT SYSTEM IS REQUIRED TO MEET THE LONG TERM TARGET ELEVATIONS.
2. THE CONTRACTOR SHALL CONSTRUCT THE MARSH CREATION AREAS IN THE TWO CONSTRUCTION LIFT SEQUENCE AS SPECIFIED IN TS-8.5 OF THE SPECIFICATIONS.
3. ALL MARSH CREATION AREAS SHALL BE DEWATERED IN ACCORDANCE WITH TS-13 OF THE SPECIFICATIONS.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREA B
TYPICAL SECTION E-E'

STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.
APPROVED BY: RUDOLPH SIMONEAUX, P.E.
SHEET 11 OF 54

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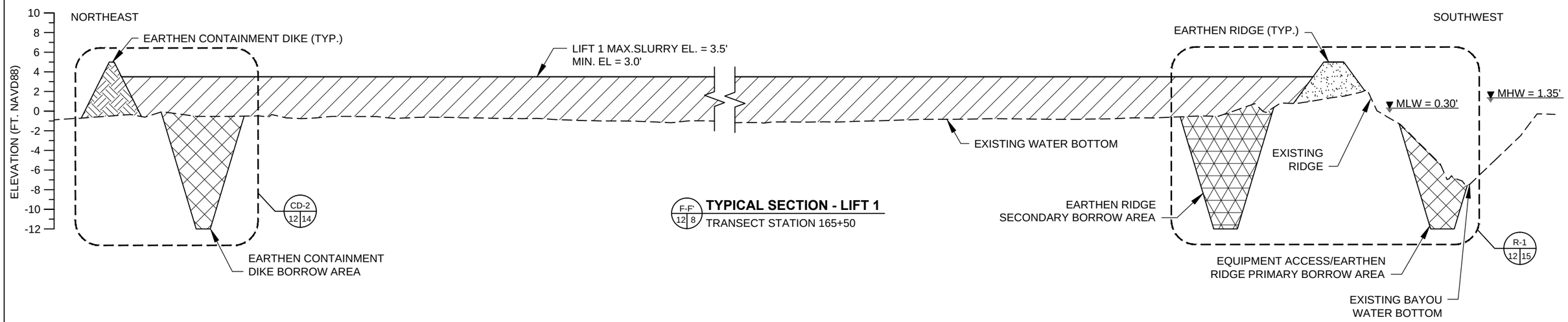
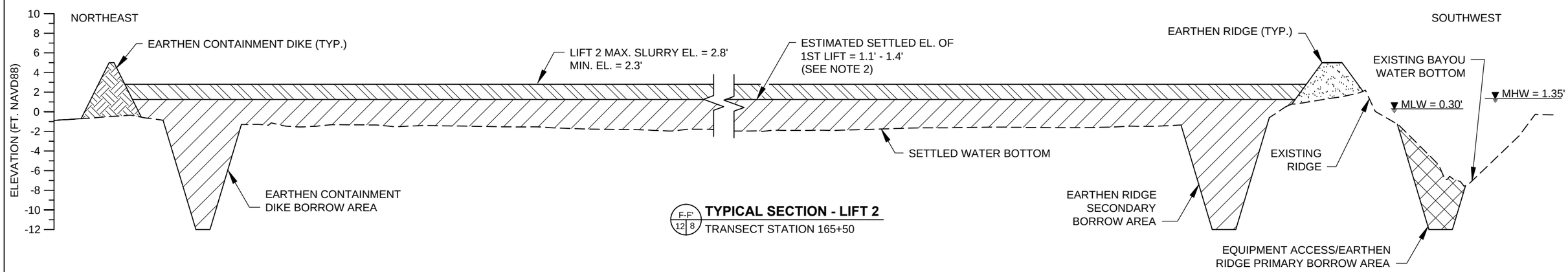


F-F' 12 8 **TYPICAL SECTION - LIFT 1**
TRANSECT STATION 165+50



F-F' 12 8 **TYPICAL SECTION - LIFT 2**
TRANSECT STATION 165+50

HORIZONTAL GRAPHIC SCALE
100' 50' 0 100' 200'
10' 5' 0 10' 20'
VERTICAL GRAPHIC SCALE

LEGEND

- EARTHEN CONTAINMENT DIKE
- EARTHEN RIDGE
- BORROW AREA
- SECONDARY BORROW AREA
- MARSH FILL - LIFT 1
- MARSH FILL - LIFT 2
- EXISTING WATER BOTTOM

NOTES:
1. BASED ON RECOMMENDATIONS FROM THE GEOTECHNICAL ANALYSIS A TWO LIFT SYSTEM IS REQUIRED TO MEET THE LONG TERM TARGET ELEVATIONS.
2. THE CONTRACTOR SHALL CONSTRUCT THE MARSH CREATION AREAS IN THE TWO CONSTRUCTION LIFT SEQUENCE AS SPECIFIED IN TS-8.5 OF THE SPECIFICATIONS.
3. ALL MARSH CREATION AREAS SHALL BE DEWATERED IN ACCORDANCE WITH TS-13 OF THE SPECIFICATIONS.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION
STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREA C
TYPICAL SECTION F-F'
DATE: SEPTEMBER 2013
SHEET 12 OF 54

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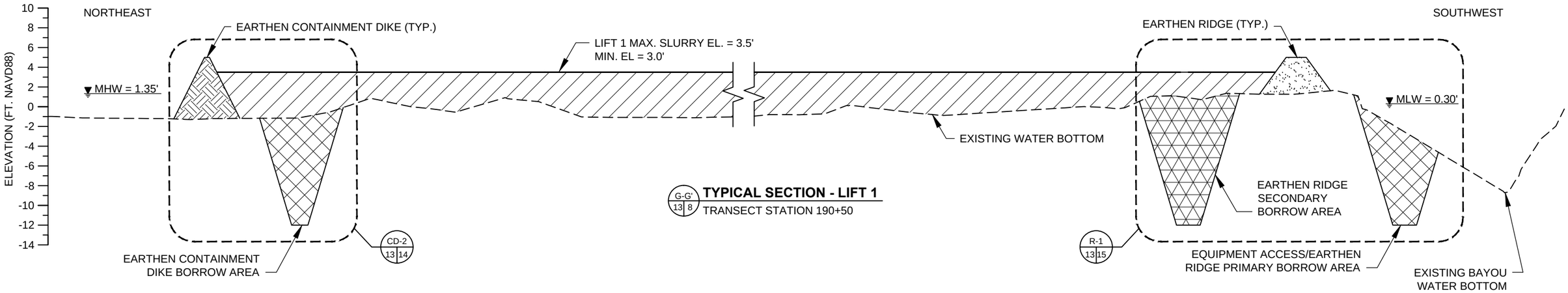
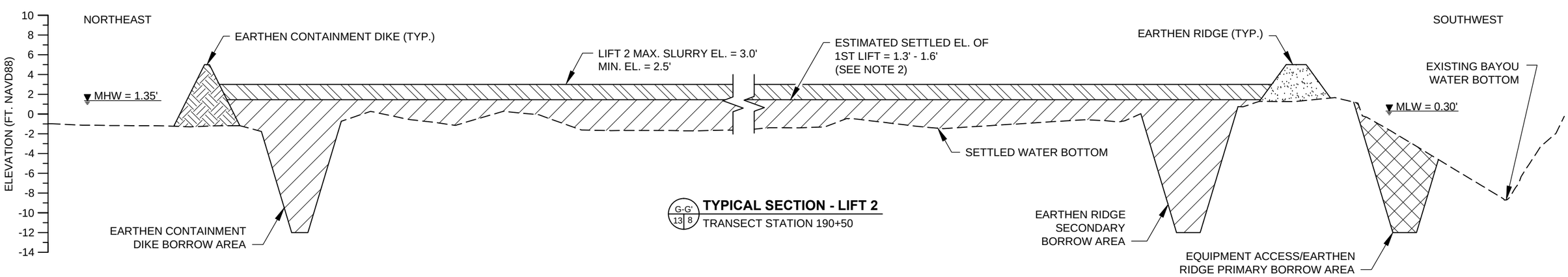


G-G'
13 8
TYPICAL SECTION - LIFT 1
TRANSECT STATION 190+50



G-G'
13 8
TYPICAL SECTION - LIFT 2
TRANSECT STATION 190+50

HORIZONTAL GRAPHIC SCALE
100' 50' 0 100' 200'
10' 5' 0 10' 20'
VERTICAL GRAPHIC SCALE

LEGEND

- EARTHEN CONTAINMENT DIKE
- EARTHEN RIDGE
- BORROW AREA
- SECONDARY BORROW AREA
- MARSH FILL - LIFT 1
- MARSH FILL - LIFT 2
- EXISTING WATER BOTTOM

NOTES:
1. BASED ON RECOMMENDATIONS FROM THE GEOTECHNICAL ANALYSIS A TWO LIFT SYSTEM IS REQUIRED TO MEET THE LONG TERM TARGET ELEVATIONS.
2. THE CONTRACTOR SHALL CONSTRUCT THE MARSH CREATION AREAS IN THE TWO CONSTRUCTION LIFT SEQUENCE AS SPECIFIED IN TS-8.5 OF THE SPECIFICATIONS.
3. ALL MARSH CREATION AREAS SHALL BE DEWATERED IN ACCORDANCE WITH TS-13 OF THE SPECIFICATIONS.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREA D
TYPICAL SECTION G-G'

STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.
APPROVED BY: RUDOLPH SIMONEAUX, P.E.
SHEET 13 OF 54

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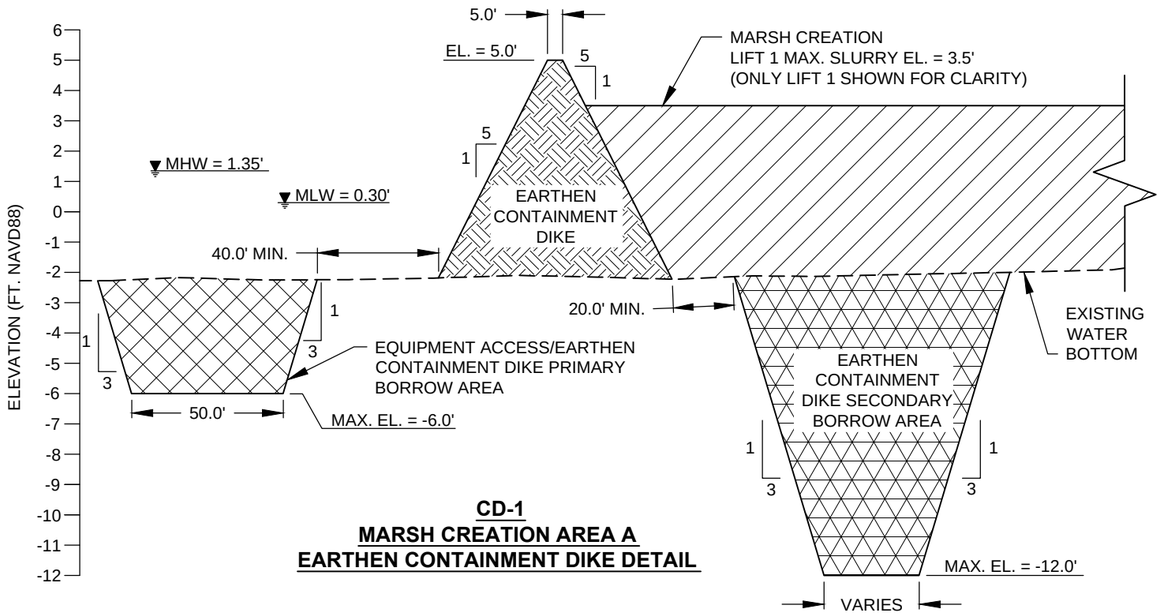
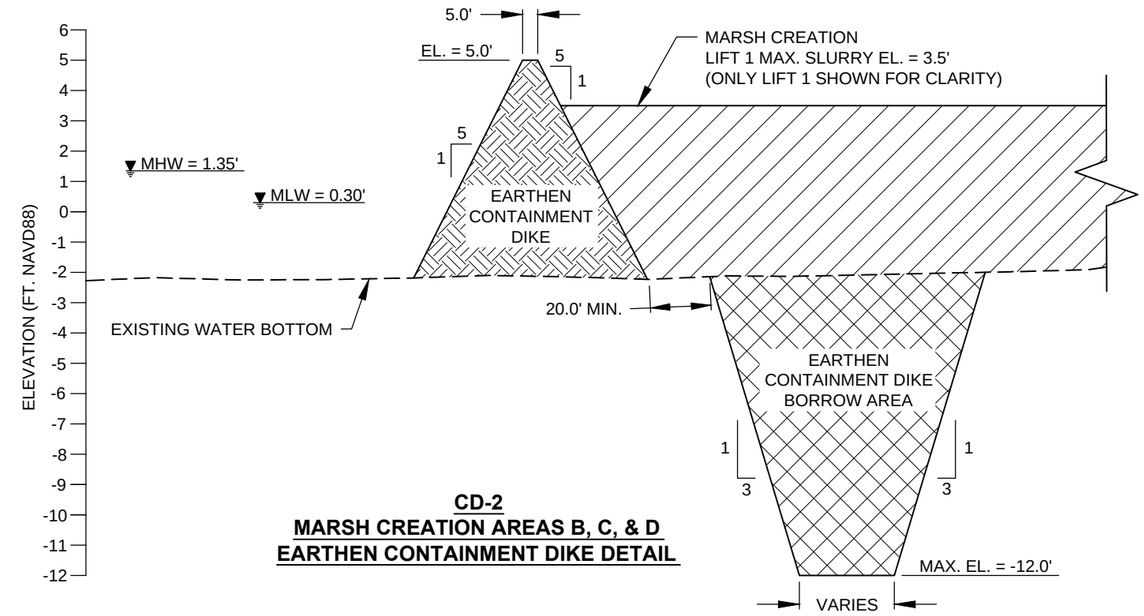


CD-1
MARSH CREATION AREA A
EARTHEN CONTAINMENT DIKE DETAIL



CD-2
MARSH CREATION AREAS B, C, & D
EARTHEN CONTAINMENT DIKE DETAIL

HORIZONTAL GRAPHIC SCALE
50' 25' 0 50' 100'
5' 2.5' 0 5' 10'
VERTICAL GRAPHIC SCALE

LEGEND

- EARTHEN CONTAINMENT DIKE
- BORROW AREA
- SECONDARY BORROW AREA
- MARSH FILL - LIFT 1
- EXISTING WATER BOTTOM

NOTES:
1. THE EARTHEN CONTAINMENT DIKES SHALL BE CONSTRUCTED USING IN-SITU MATERIAL. SEE SHEETS 6-8 FOR EARTHEN CONTAINMENT DIKE LOCATIONS.
2. THE LENGTHS OF EACH EARTHEN CONTAINMENT DIKE WERE ESTIMATED USING AUTOCAD AND AERIAL PHOTOGRAPHY.
3. THE OWNER RESERVES THE RIGHT TO REQUEST ADDITIONAL LINEAR FEET OF EARTHEN CONTAINMENT DIKE FOR CONSTRUCTION AT THE CONTRACTOR'S UNIT BID PRICE.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY: RUDOLPH SIMONEAUX, P.E.

EARTHEN CONTAINMENT DIKE DETAILS

DATE: SEPTEMBER 2013
SHEET 14 OF 54

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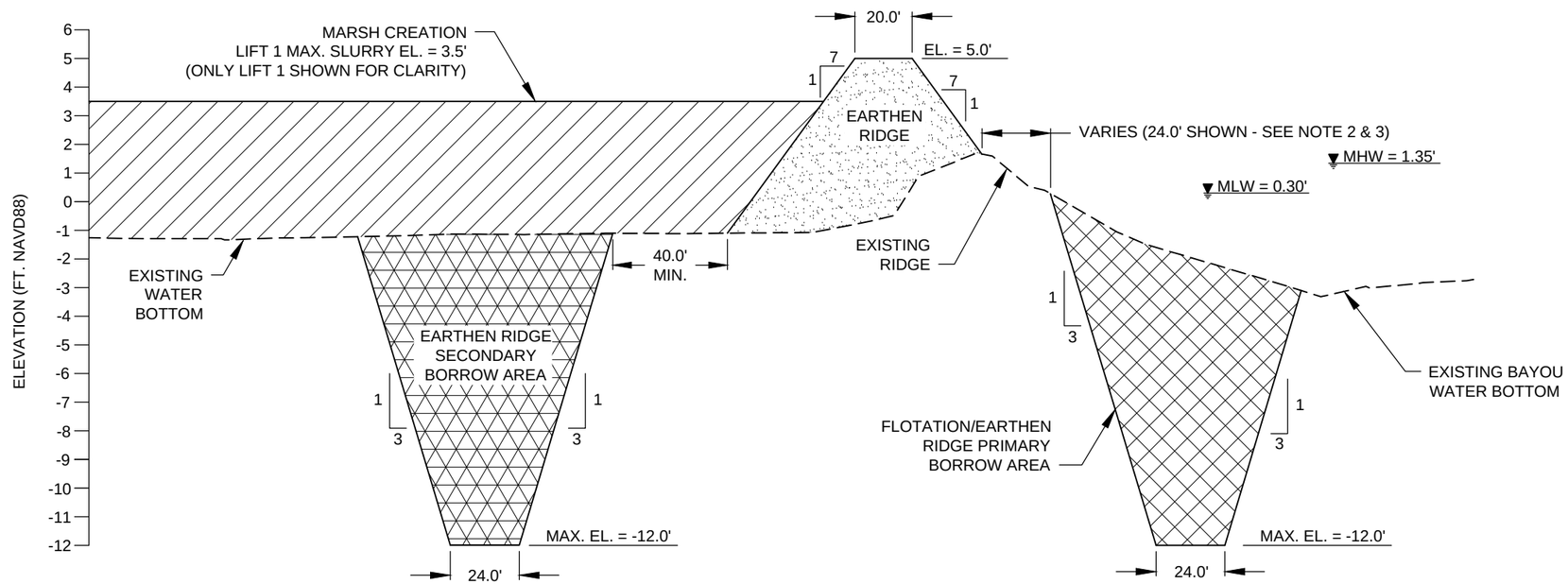

R-1
EARTHEN RIDGE DETAIL

HORIZONTAL GRAPHIC SCALE
50' 25' 0 50' 100'
5' 2.5' 0 5' 10'
VERTICAL GRAPHIC SCALE

NOTES:
1. THE EARTHEN RIDGE SHALL BE CONSTRUCTED USING IN-SITU MATERIAL. SEE SHEETS 6-8 FOR EARTHEN RIDGE LOCATIONS.
2. THE MINIMUM DISTANCE FROM THE EARTHEN RIDGE TOE TO THE FLOTATION/EARTHEN RIDGE PRIMARY BORROW AREA IS 20.0' FOR MARSH CREATION AREAS A AND C.
3. THE MINIMUM DISTANCE FROM THE EARTHEN RIDGE TOE TO THE FLOTATION/EARTHEN RIDGE PRIMARY BORROW AREA IS 35.0' FOR MARSH CREATION AREAS B AND D.
4. THE LENGTHS OF EACH EARTHEN RIDGE WERE ESTIMATED USING AUTOCAD AND AERIAL PHOTOGRAPHY.
5. THE OWNER RESERVES THE RIGHT TO REQUEST ADDITIONAL EARTHEN RIDGE MATERIAL BE PLACED FOR CONSTRUCTION AT THE CONTRACTOR'S UNIT BID PRICE.

LEGEND
- EARTHEN RIDGE
- BORROW AREA
- SECONDARY BORROW AREA
- MARSH FILL - LIFT 1
- EXISTING WATER BOTTOM

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

EARTHEN RIDGE DETAILS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 15 OF 54

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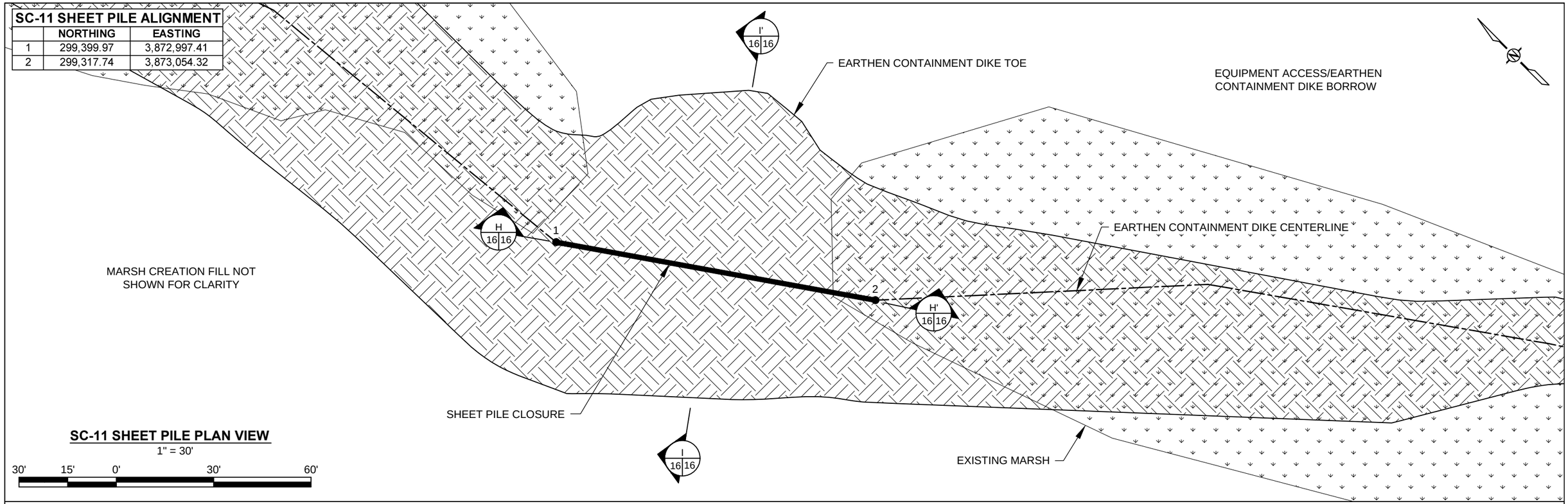
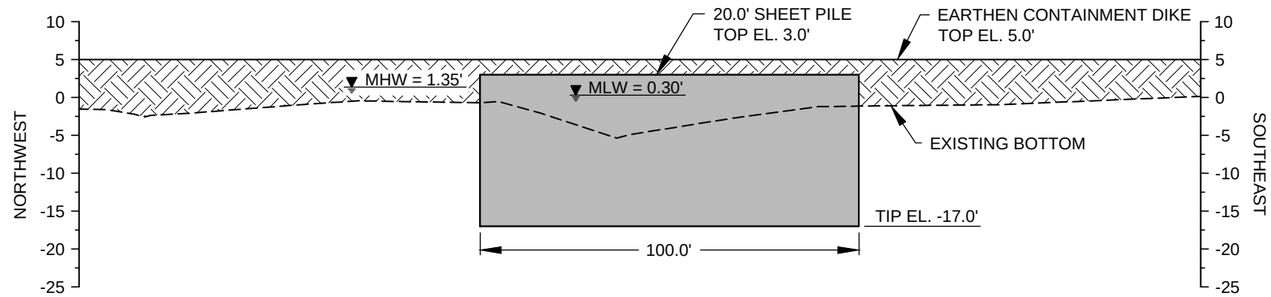
SC-11 SHEET PILE ALIGNMENT		
	NORTHING	EASTING
1	299,399.97	3,872,997.41
2	299,317.74	3,873,054.32



SC-11 SHEET PILE PLAN VIEW

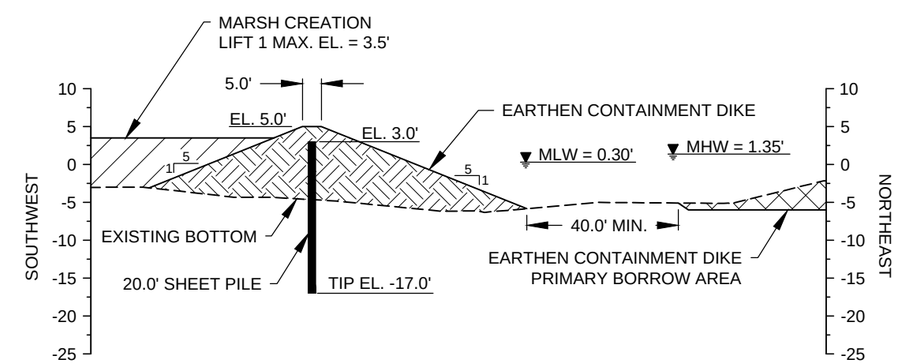
1" = 30'

30' 15' 0' 30' 60'



H-H' 16 16 SC-11 SHEET PILE PROFILE

1" = 40' HORIZONTAL
1" = 20' VERTICAL



I-I' 16 16 SC-11 SHEET PILE SECTION

1" = 40' HORIZONTAL
1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE

40' 20' 0 40' 80'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTES:

1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 IN^3/FT., MOMENT OF INERTIA: 184.20 IN^4/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SEE SHEET 6 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

SC-11 SHEET PILE CLOSURE DETAILS

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 16 OF 54

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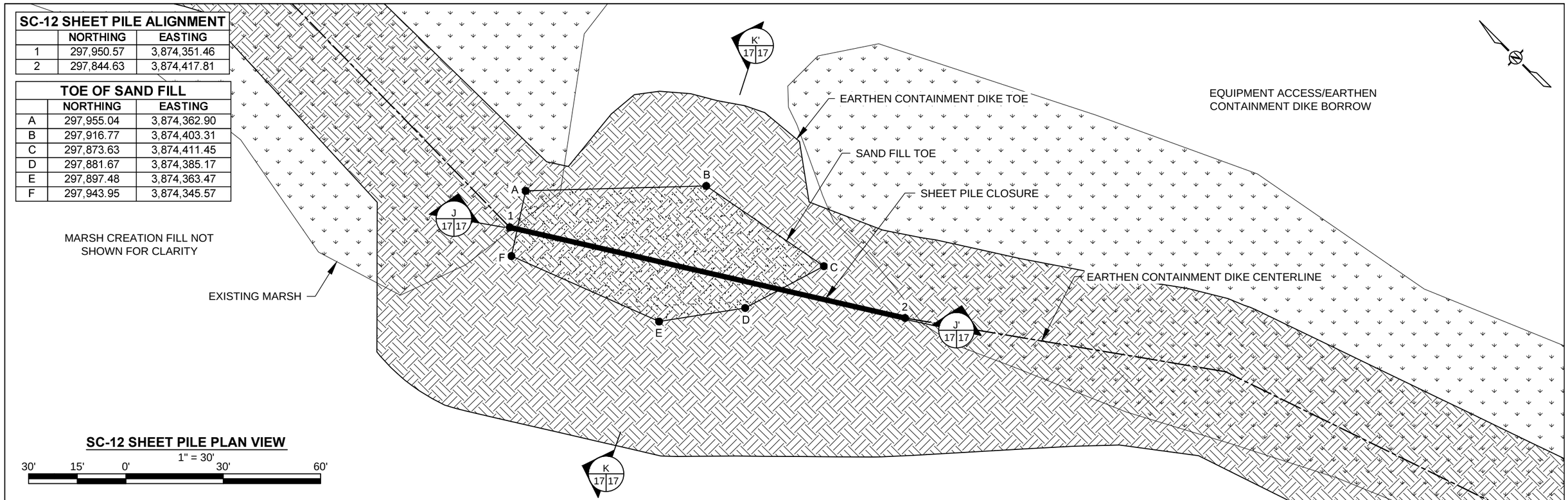
SC-12 SHEET PILE ALIGNMENT		
	NORTHING	EASTING
1	297,950.57	3,874,351.46
2	297,844.63	3,874,417.81

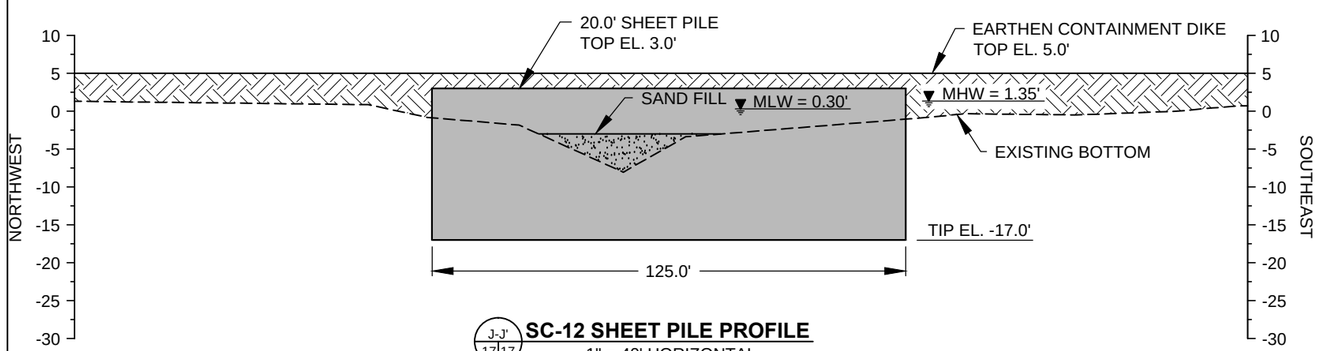
TOE OF SAND FILL		
	NORTHING	EASTING
A	297,955.04	3,874,362.90
B	297,916.77	3,874,403.31
C	297,873.63	3,874,411.45
D	297,881.67	3,874,385.17
E	297,897.48	3,874,363.47
F	297,943.95	3,874,345.57



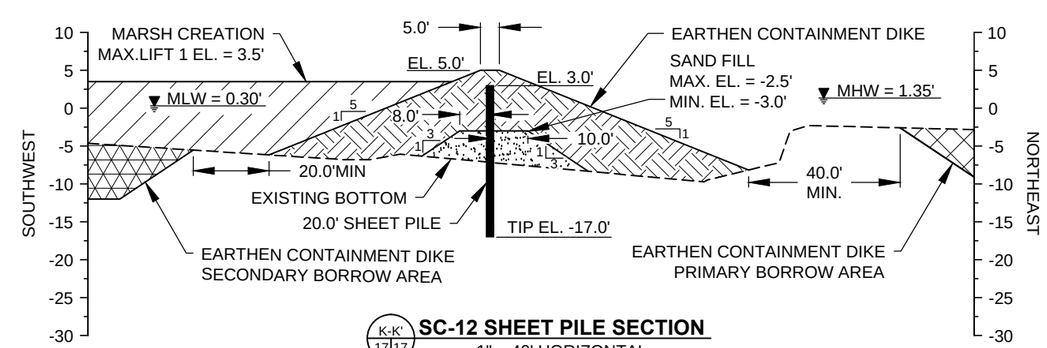
SC-12 SHEET PILE PLAN VIEW

1" = 30'

30' 15' 0' 30' 60'



SC-12 SHEET PILE PROFILE
J-J' 17 17
1" = 40' HORIZONTAL
1" = 20' VERTICAL



SC-12 SHEET PILE SECTION
K-K' 17 17
1" = 40' HORIZONTAL
1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE

40' 20' 0 40' 80'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTES:

1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 $IN.^3$/FT., MOMENT OF INERTIA: 184.20 $IN.^4$/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SAND FILL SHALL BE BARGED IN FROM AN OFFSITE BORROW SOURCE. SEE TS-9 OF THE SPECIFICATIONS FOR MORE INFORMATION.
4. SEE SHEET 6 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

SC-12 SHEET PILE CLOSURE DETAILS

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 17 OF 54

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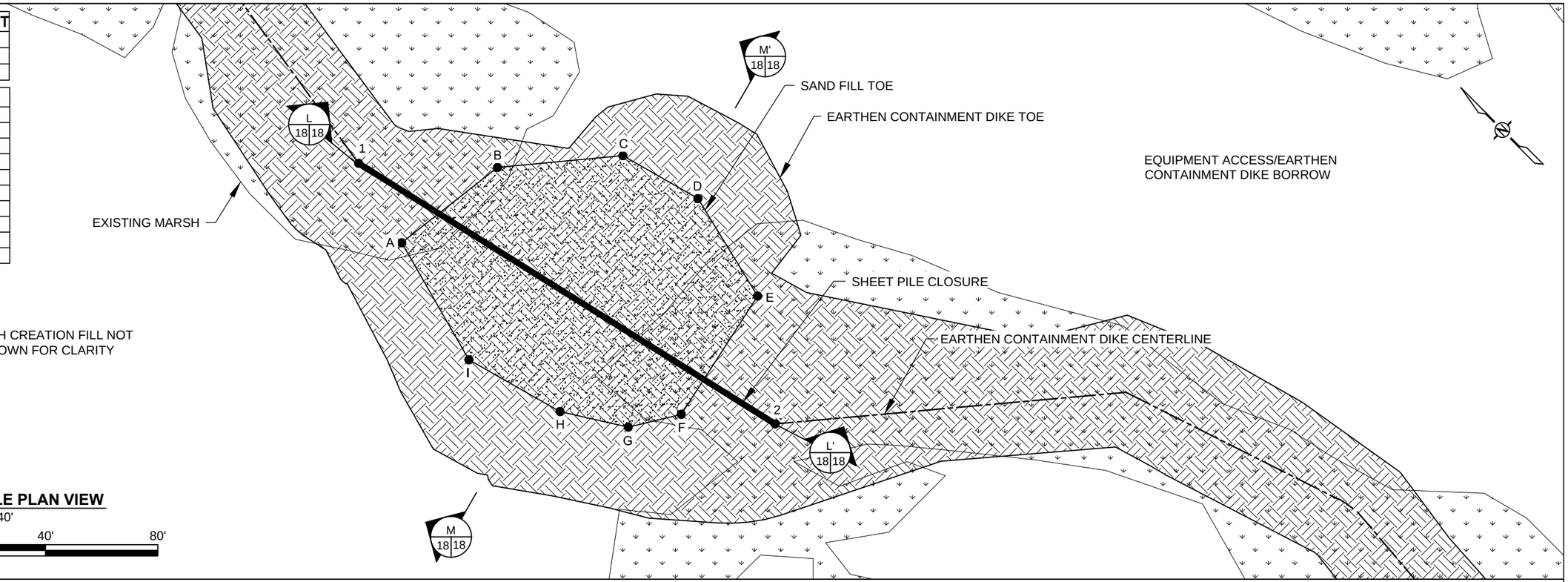
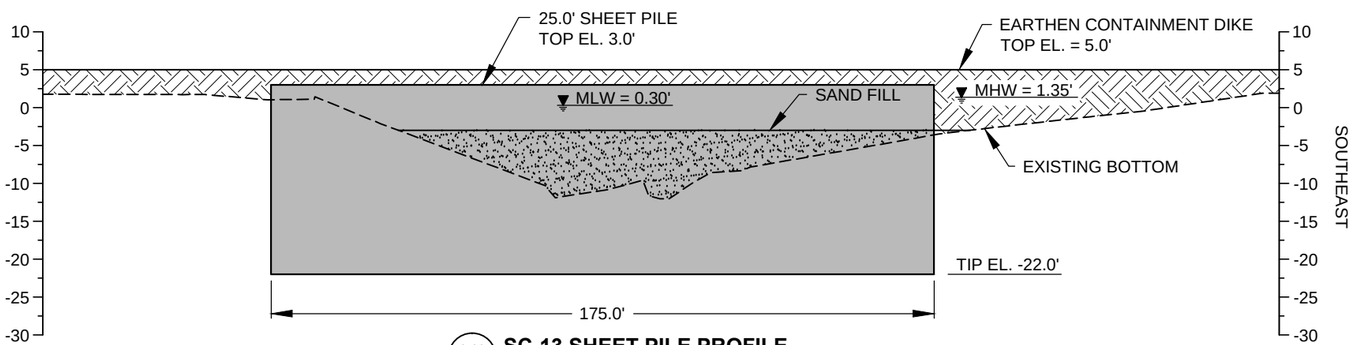
SC-13 SHEET PILE ALIGNMENT		
	NORTHING	EASTING
1	296,846.09	3,874,743.42
2	296,675.57	3,874,782.73

TOE OF SAND FILL		
	NORTHING	EASTING
A	296,815.19	3,874,734.30
B	296,810.02	3,874,777.39
C	296,781.40	3,874,811.92
D	296,751.73	3,874,820.05
E	296,712.11	3,874,810.53
F	296,701.60	3,874,761.52
G	296,711.73	3,874,744.93
H	296,732.86	3,874,731.68
I	296,768.82	3,874,721.74

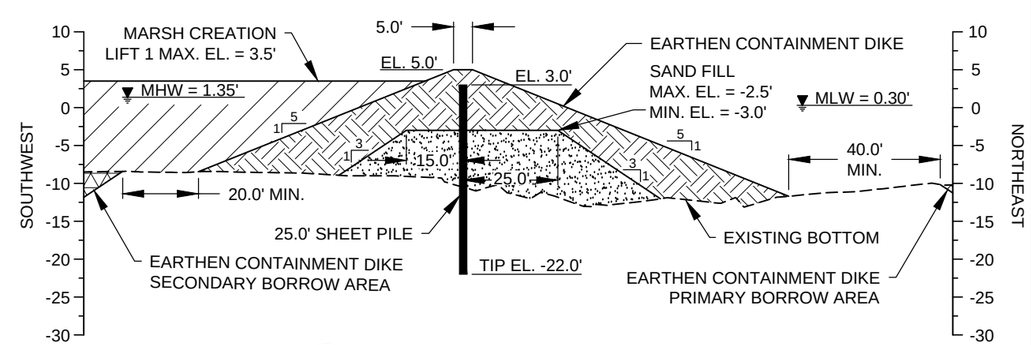


SC-13 SHEET PILE PLAN VIEW
1" = 40'

40' 20' 0' 40' 80'



L-L' 18 18 **SC-13 SHEET PILE PROFILE**
1" = 40' HORIZONTAL
1" = 20' VERTICAL



M-M' 18 18 **SC-13 SHEET PILE SECTION**
1" = 40' HORIZONTAL
1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE
40' 20' 0 40' 80'
20' 10' 0 20' 40'
VERTICAL GRAPHIC SCALE

NOTES:
1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 $IN.^3$/FT., MOMENT OF INERTIA: 184.20 $IN.^4$/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SAND FILL SHALL BE BARGED IN FROM AN OFFSITE BORROW SOURCE. SEE TS-9 OF THE SPECIFICATIONS FOR MORE INFORMATION.
4. SEE SHEET 6 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

SC-13 SHEET PILE CLOSURE DETAILS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 18 OF 54

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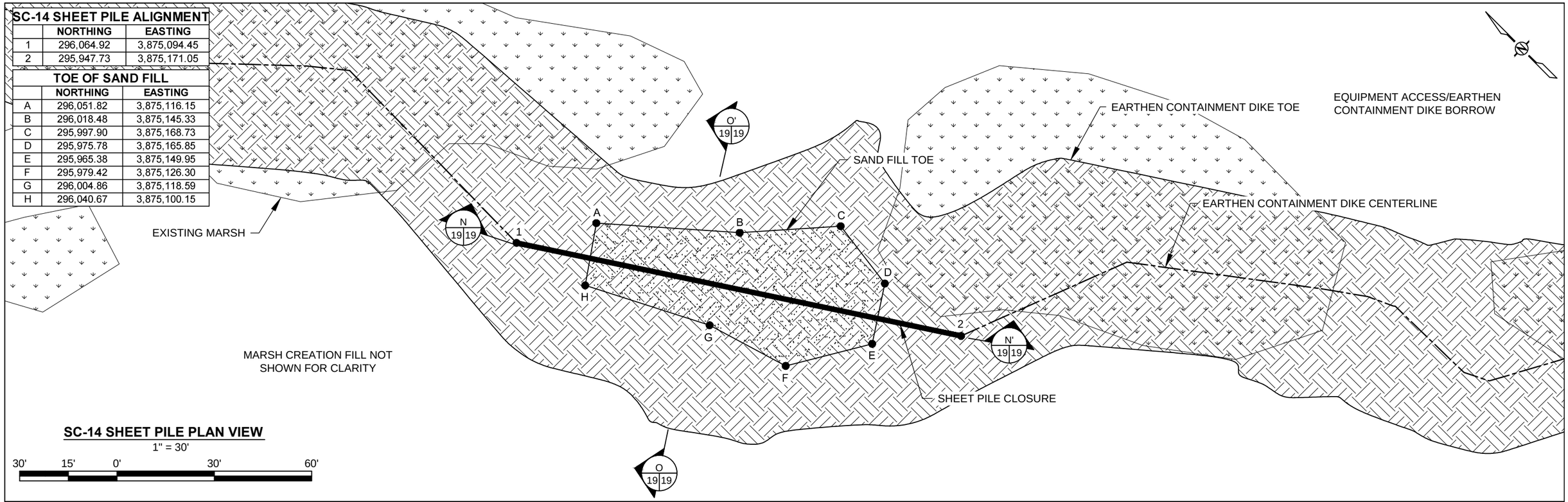
SC-14 SHEET PILE ALIGNMENT		
	NORTHING	EASTING
1	296,064.92	3,875,094.45
2	295,947.73	3,875,171.05

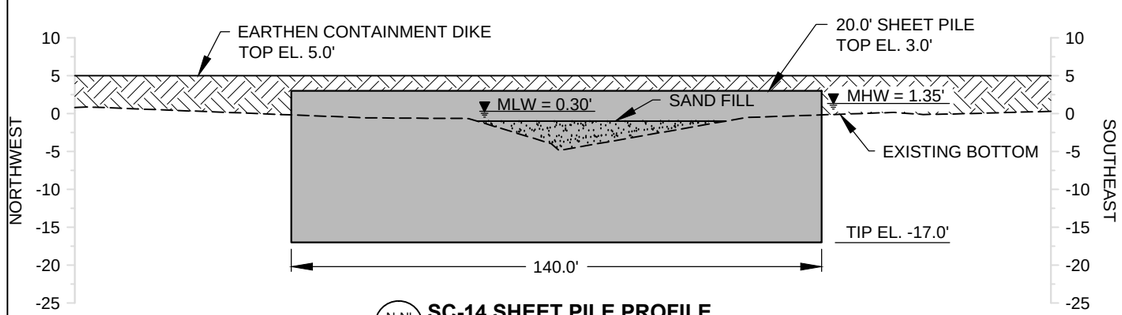
TOE OF SAND FILL		
	NORTHING	EASTING
A	296,051.82	3,875,116.15
B	296,018.48	3,875,145.33
C	295,997.90	3,875,168.73
D	295,975.78	3,875,165.85
E	295,965.38	3,875,149.95
F	295,979.42	3,875,126.30
G	296,004.86	3,875,118.59
H	296,040.67	3,875,100.15



SC-14 SHEET PILE PLAN VIEW

1" = 30'

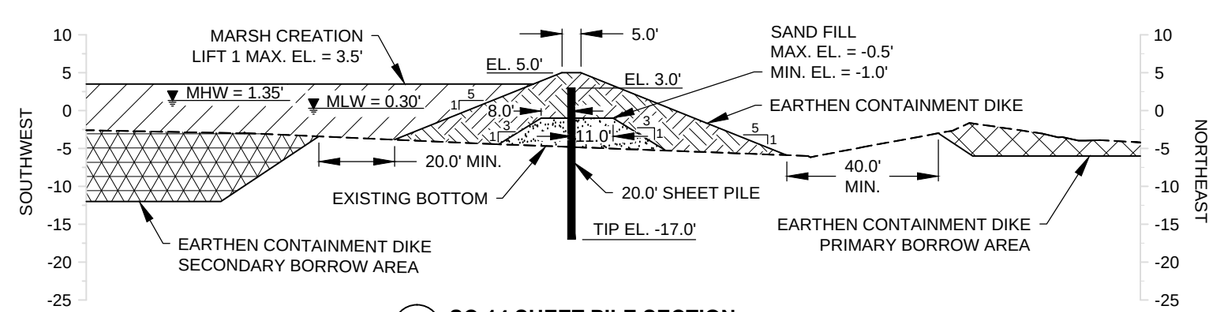
30' 15' 0' 30' 60'



N-N' 19 19 **SC-14 SHEET PILE PROFILE**

1" = 40' HORIZONTAL

1" = 20' VERTICAL



O-O' 19 19 **SC-14 SHEET PILE SECTION**

1" = 40' HORIZONTAL

1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE

40' 20' 0 40' 80'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTES:

1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 $IN.^3$/FT., MOMENT OF INERTIA: 184.20 $IN.^4$/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SAND FILL SHALL BE BARGED IN FROM AN OFFSITE BORROW SOURCE. SEE TS-9 OF THE SPECIFICATIONS FOR MORE INFORMATION.
4. SEE SHEET 6 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

SC-14 SHEET PILE CLOSURE DETAILS

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 19 OF 54

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SC-15 SHEET PILE ALIGNMENT

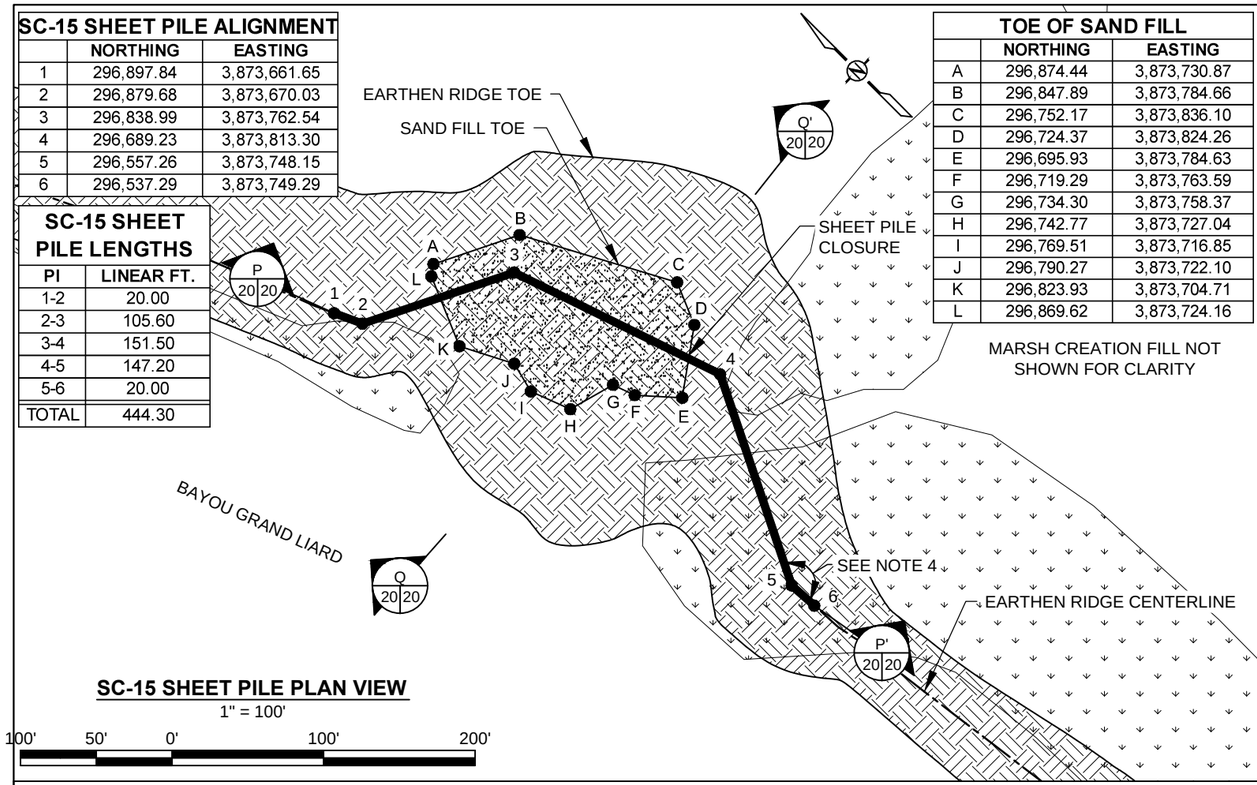
	NORTHING	EASTING
1	296,897.84	3,873,661.65
2	296,879.68	3,873,670.03
3	296,838.99	3,873,762.54
4	296,689.23	3,873,813.30
5	296,557.26	3,873,748.15
6	296,537.29	3,873,749.29

SC-15 SHEET PILE LENGTHS

PI	LINEAR FT.
1-2	20.00
2-3	105.60
3-4	151.50
4-5	147.20
5-6	20.00
TOTAL	444.30

TOE OF SAND FILL

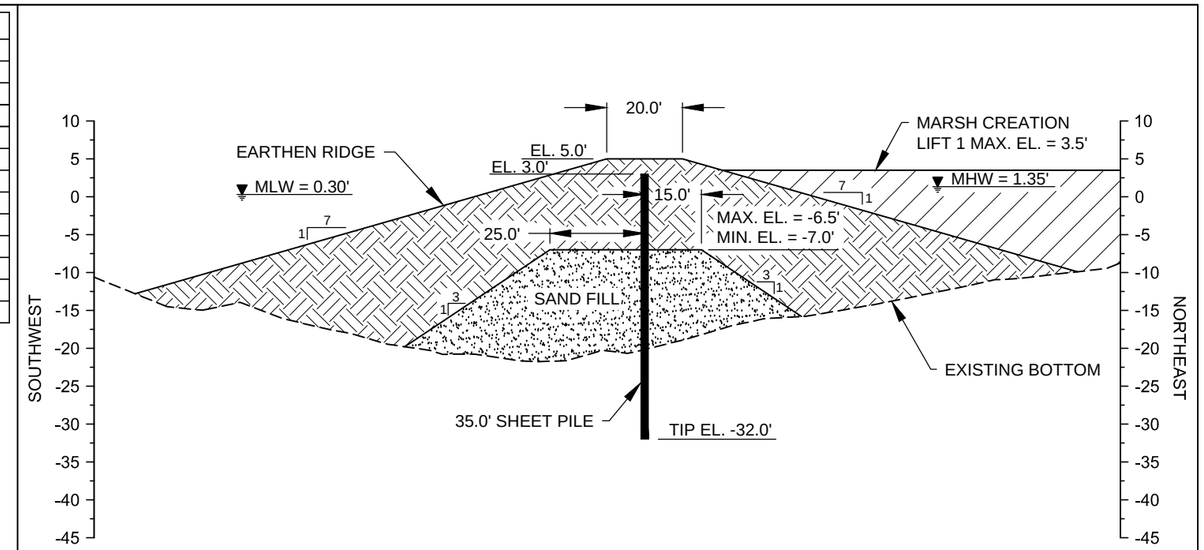
	NORTHING	EASTING
A	296,874.44	3,873,730.87
B	296,847.89	3,873,784.66
C	296,752.17	3,873,836.10
D	296,724.37	3,873,824.26
E	296,695.93	3,873,784.63
F	296,719.29	3,873,763.59
G	296,734.30	3,873,758.37
H	296,742.77	3,873,727.04
I	296,769.51	3,873,716.85
J	296,790.27	3,873,722.10
K	296,823.93	3,873,704.71
L	296,869.62	3,873,724.16



SC-15 SHEET PILE PLAN VIEW

1" = 100'

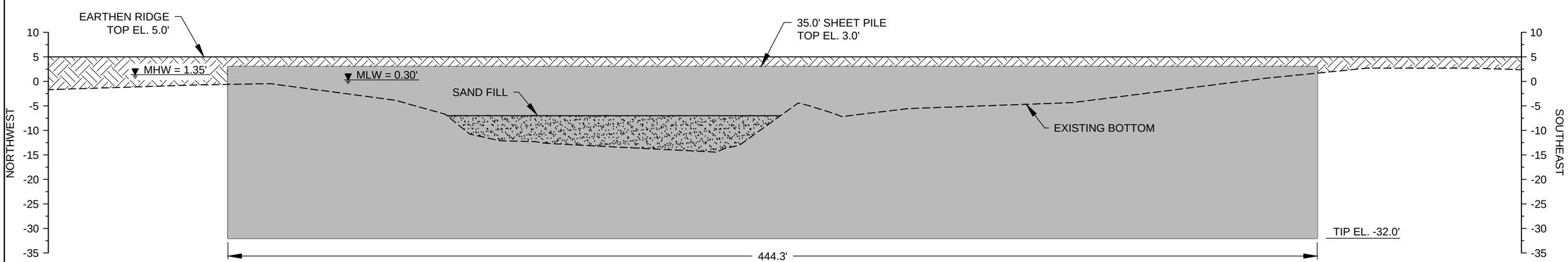
100' 50' 0' 100' 200'



SC-15 SHEET PILE SECTION

Q-Q' 20 20

1" = 40' HORIZONTAL
1" = 20' VERTICAL



SC-15 SHEET PILE PROFILE

P-P' 20 20

1" = 40' HORIZONTAL
1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE

40' 20' 0 40' 80'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTES:

1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 $IN.^3$/FT., MOMENT OF INERTIA: 184.20 $IN.^4$/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SAND FILL SHALL BE BARGED IN FROM AN OFFSITE BORROW SOURCE. SEE TS-9 OF THE SPECIFICATIONS FOR MORE INFORMATION.
4. ALL INTERIOR SHEET PILE ANGLES ARE 135°.
5. SEE SHEET 6 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

SC-15 SHEET PILE CLOSURE DETAILS

DATE: SEPTEMBER 2013

SHEET 20 OF 54

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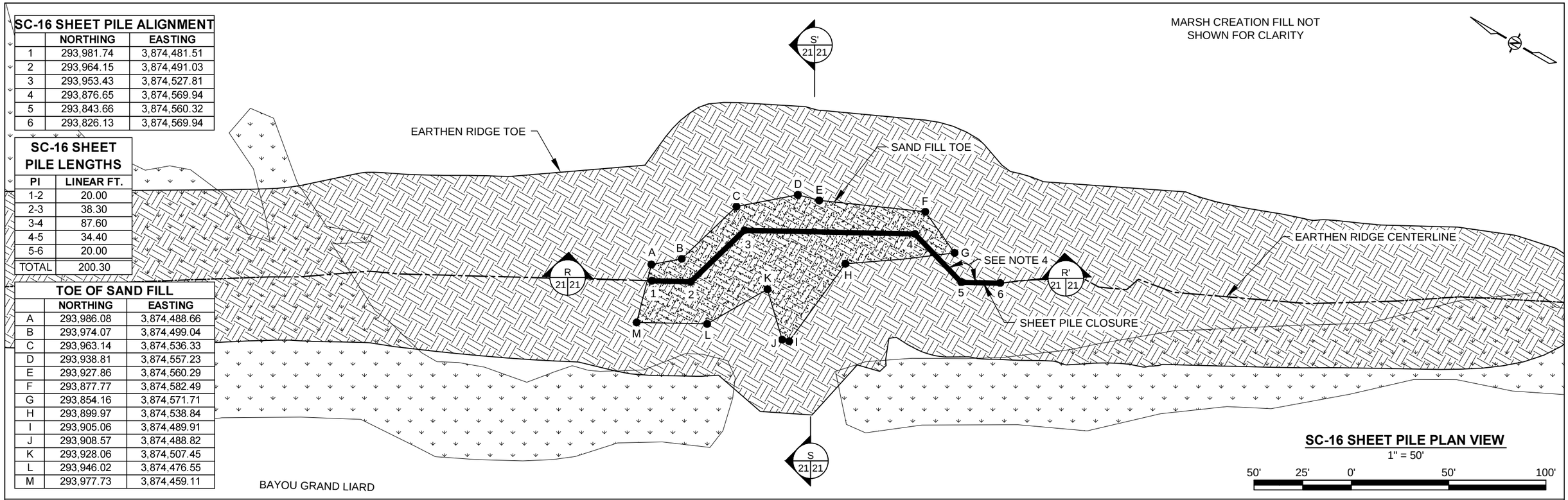
SC-16 SHEET PILE ALIGNMENT		
	NORTHING	EASTING
1	293,981.74	3,874,481.51
2	293,964.15	3,874,491.03
3	293,953.43	3,874,527.81
4	293,876.65	3,874,569.94
5	293,843.66	3,874,560.32
6	293,826.13	3,874,569.94

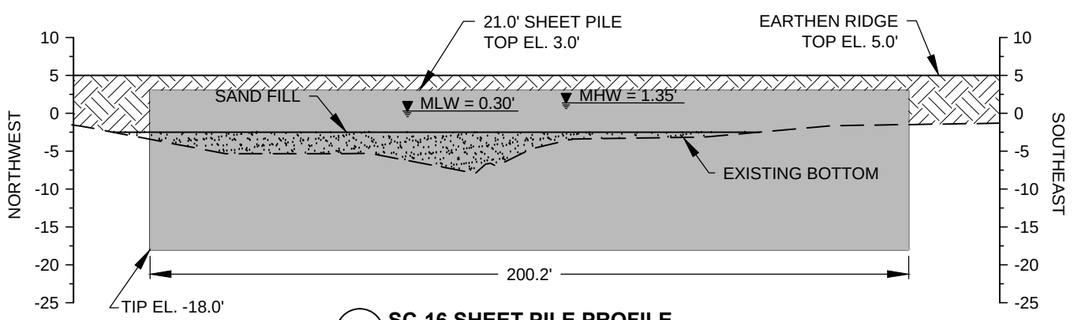
SC-16 SHEET PILE LENGTHS	
PI	LINEAR FT.
1-2	20.00
2-3	38.30
3-4	87.60
4-5	34.40
5-6	20.00
TOTAL	200.30

TOE OF SAND FILL		
	NORTHING	EASTING
A	293,986.08	3,874,488.66
B	293,974.07	3,874,499.04
C	293,963.14	3,874,536.33
D	293,938.81	3,874,557.23
E	293,927.86	3,874,560.29
F	293,877.77	3,874,582.49
G	293,854.16	3,874,571.71
H	293,899.97	3,874,538.84
I	293,905.06	3,874,489.91
J	293,908.57	3,874,488.82
K	293,928.06	3,874,507.45
L	293,946.02	3,874,476.55
M	293,977.73	3,874,459.11



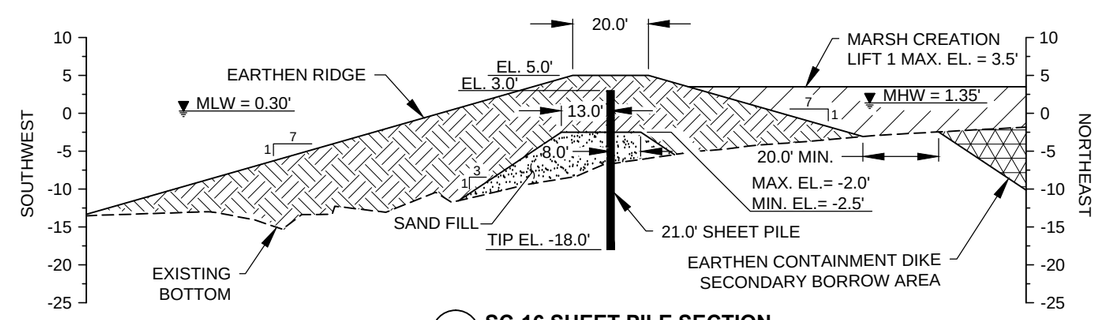
SC-16 SHEET PILE PLAN VIEW

1" = 50'



R-R' 21 21 **SC-16 SHEET PILE PROFILE**

1" = 40' HORIZONTAL
1" = 20' VERTICAL



S-S' 21 21 **SC-16 SHEET PILE SECTION**

1" = 40' HORIZONTAL
1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE

40' 20' 0 40' 80'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTES:

1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 $IN.^3$/FT., MOMENT OF INERTIA: 184.20 $IN.^4$/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SAND FILL SHALL BE BARGED IN FROM AN OFFSITE BORROW SOURCE. SEE TS-9 OF THE SPECIFICATIONS FOR MORE INFORMATION.
4. ALL INTERIOR SHEET PILE ANGLES ARE 135°.
5. SEE SHEET 7 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

SC-16 SHEET PILE CLOSURE DETAILS

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 21 OF 54

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SC-17SHEET PILE LENGTHS

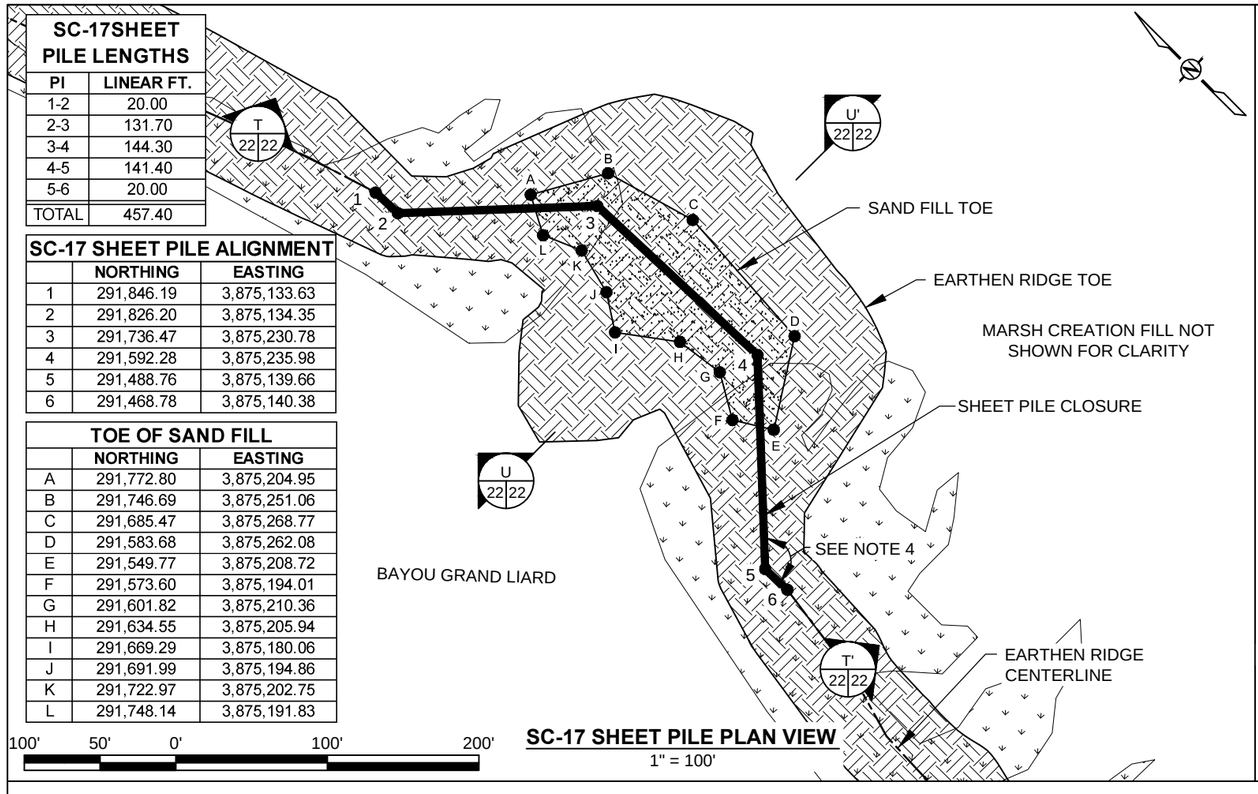
PI	LINEAR FT.
1-2	20.00
2-3	131.70
3-4	144.30
4-5	141.40
5-6	20.00
TOTAL	457.40

SC-17 SHEET PILE ALIGNMENT

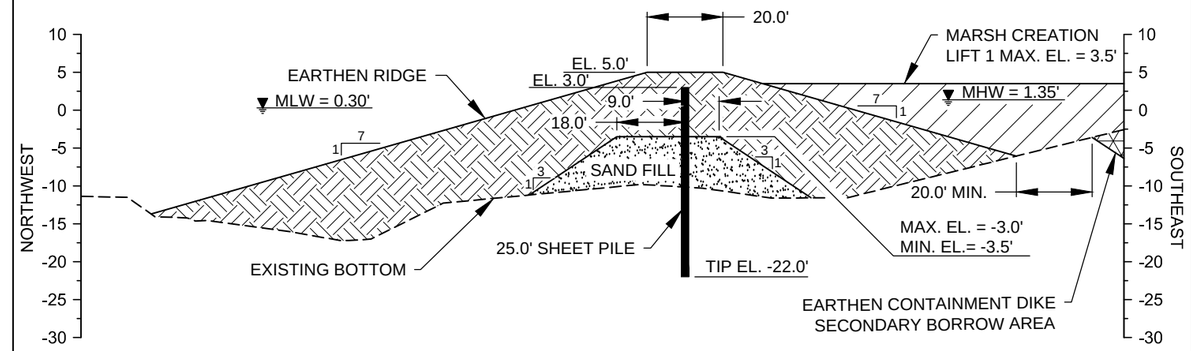
	NORTHING	EASTING
1	291,846.19	3,875,133.63
2	291,826.20	3,875,134.35
3	291,736.47	3,875,230.78
4	291,592.28	3,875,235.98
5	291,488.76	3,875,139.66
6	291,468.78	3,875,140.38

TOE OF SAND FILL

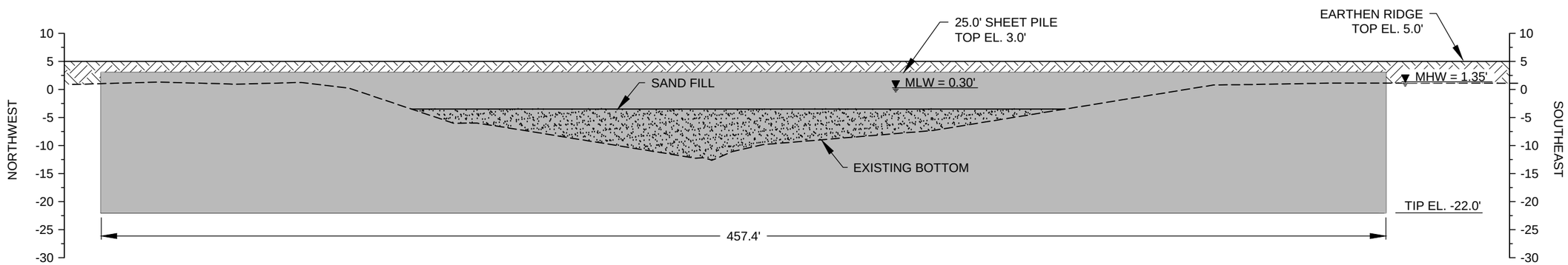
	NORTHING	EASTING
A	291,772.80	3,875,204.95
B	291,746.69	3,875,251.06
C	291,685.47	3,875,268.77
D	291,583.68	3,875,262.08
E	291,549.77	3,875,208.72
F	291,573.60	3,875,194.01
G	291,601.82	3,875,210.36
H	291,634.55	3,875,205.94
I	291,669.29	3,875,180.06
J	291,691.99	3,875,194.86
K	291,722.97	3,875,202.75
L	291,748.14	3,875,191.83



SC-17 SHEET PILE PLAN VIEW
1" = 100'



U-U' 22 22 **SC-17 SHEET PILE SECTION**
1" = 40' HORIZONTAL
1" = 20' VERTICAL



T-T' 22 22 **SC-17 SHEET PILE PROFILE**
1" = 40' HORIZONTAL
1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE
40' 20' 0 40' 80'
20' 10' 0 20' 40'
VERTICAL GRAPHIC SCALE

NOTES:
1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 $IN.^3$/FT., MOMENT OF INERTIA: 184.20 $IN.^4$/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SAND FILL SHALL BE BARGED IN FROM AN OFFSITE BORROW SOURCE. SEE TS-9 OF THE SPECIFICATIONS FOR MORE INFORMATION.
4. ALL INTERIOR SHEET PILE ANGLES ARE 135°.
5. SEE SHEET 7 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

SC-17 SHEET PILE CLOSURE DETAILS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 22 OF 54

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SC-18 SHEET PILE ALIGNMENT

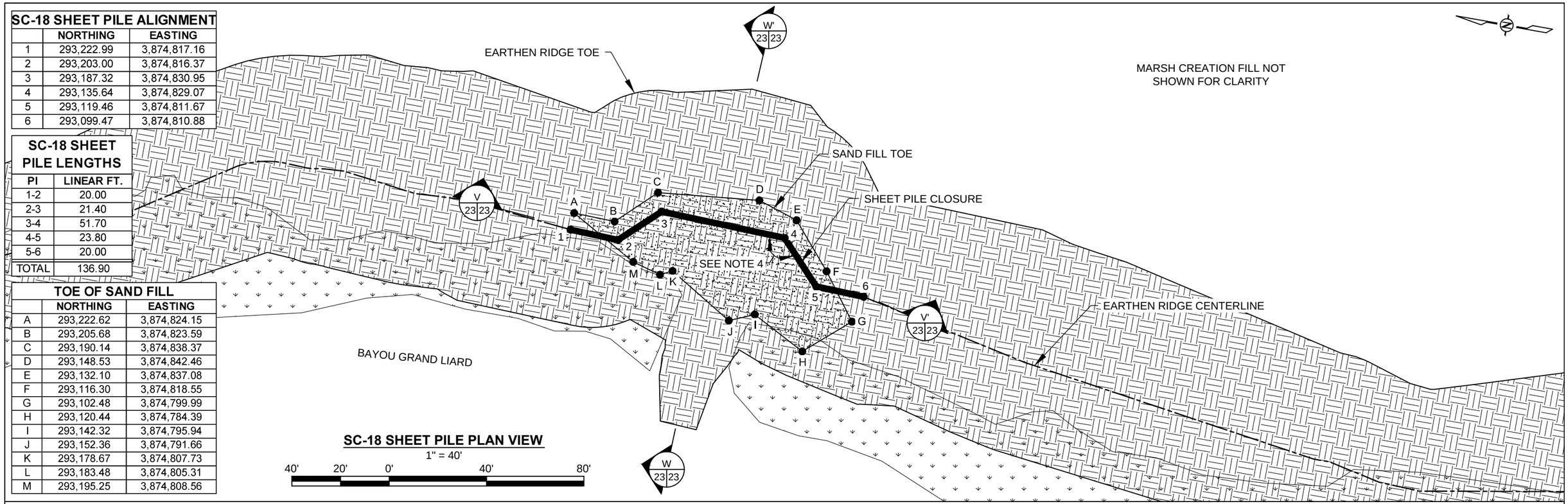
	NORTHING	EASTING
1	293,222.99	3,874,817.16
2	293,203.00	3,874,816.37
3	293,187.32	3,874,830.95
4	293,135.64	3,874,829.07
5	293,119.46	3,874,811.67
6	293,099.47	3,874,810.88

SC-18 SHEET PILE LENGTHS

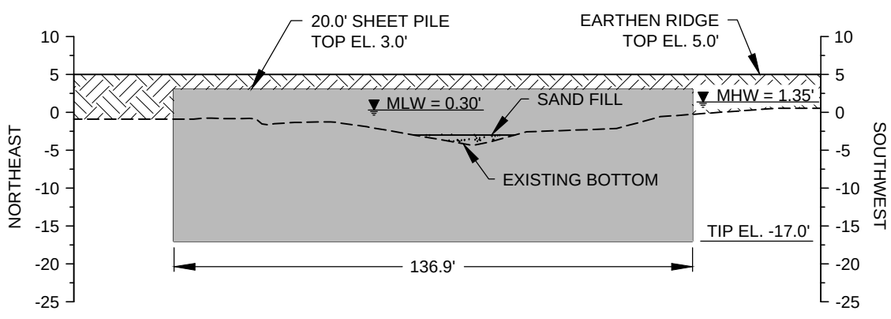
PI	LINEAR FT.
1-2	20.00
2-3	21.40
3-4	51.70
4-5	23.80
5-6	20.00
TOTAL	136.90

TOE OF SAND FILL

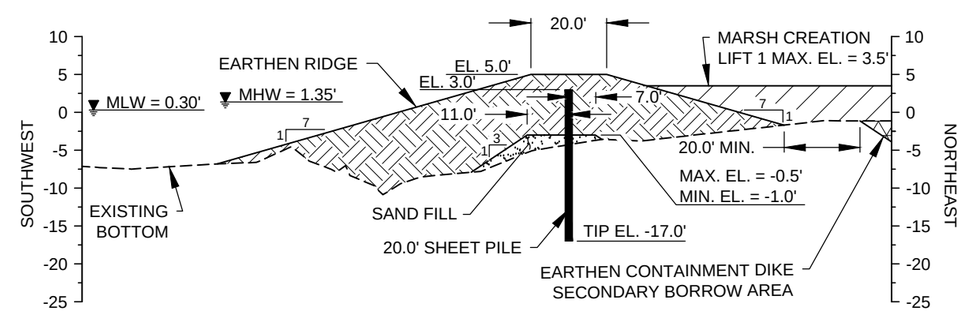
	NORTHING	EASTING
A	293,222.62	3,874,824.15
B	293,205.68	3,874,823.59
C	293,190.14	3,874,838.37
D	293,148.53	3,874,842.46
E	293,132.10	3,874,837.08
F	293,116.30	3,874,818.55
G	293,102.48	3,874,799.99
H	293,120.44	3,874,784.39
I	293,142.32	3,874,795.94
J	293,152.36	3,874,791.66
K	293,178.67	3,874,807.73
L	293,183.48	3,874,805.31
M	293,195.25	3,874,808.56



SC-18 SHEET PILE PLAN VIEW
1" = 40'
40' 20' 0' 40' 80'



V-V' 23 23 SC-18 SHEET PILE PROFILE
1" = 40' HORIZONTAL
1" = 20' VERTICAL



W-W' 23 23 SC-18 SHEET PILE SECTION
1" = 40' HORIZONTAL
1" = 20' VERTICAL

HORIZONTAL GRAPHIC SCALE
40' 20' 0 40' 80'
20' 10' 0 20' 40'
VERTICAL GRAPHIC SCALE

NOTES:
1. ALL STEEL SHEET PILES SHALL BE PZ-27 (MINIMUM SECTION MODULUS: 30.20 $IN.^3$/FT., MOMENT OF INERTIA: 184.20 $IN.^4$/FT.) OR ENGINEER APPROVED EQUIVALENT.
2. STEEL SHEET PILES SHALL BE ENCAPSULATED WITH IN-SITU MATERIAL AS SPECIFIED IN TS-10.7 OF THE SPECIFICATIONS.
3. SAND FILL SHALL BE BARGED IN FROM AN OFFSITE BORROW SOURCE. SEE TS-9 OF THE SPECIFICATIONS FOR MORE INFORMATION.
4. ALL INTERIOR SHEET PILE ANGLES ARE 135°.
5. SEE SHEET 6 FOR SHEET PILE LOCATION.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

SC-18 SHEET PILE CLOSURE DETAILS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 23 OF 54

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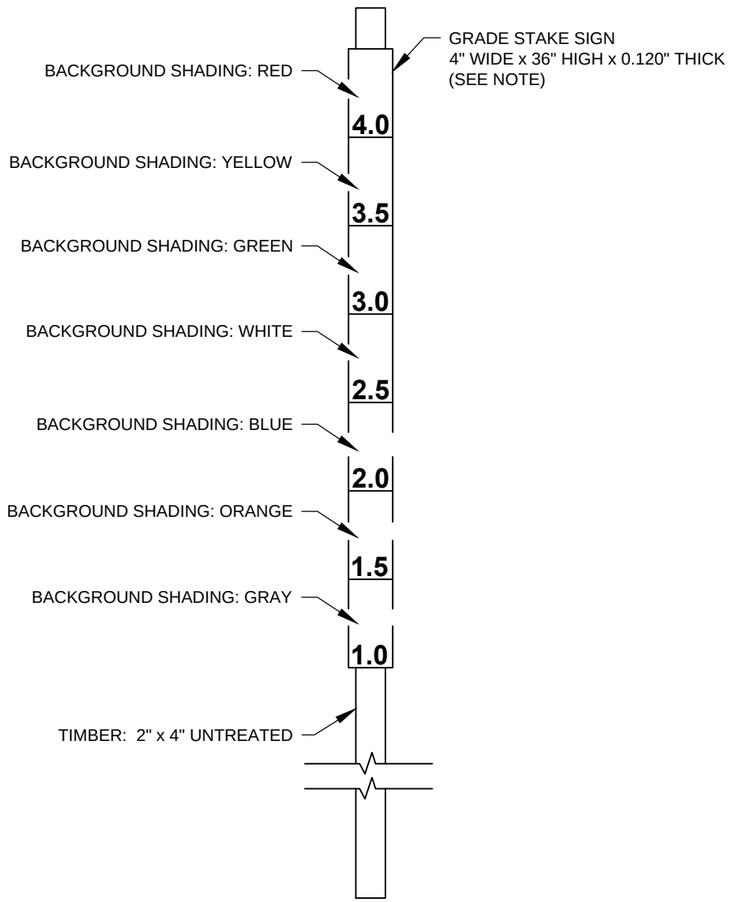
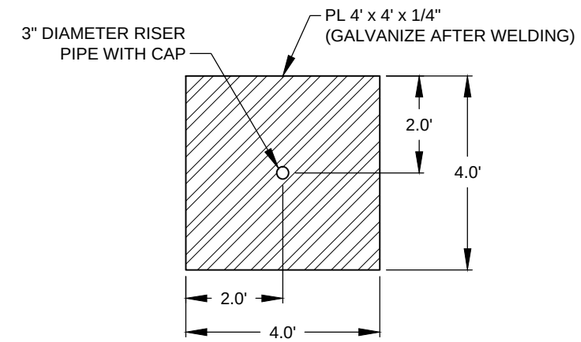
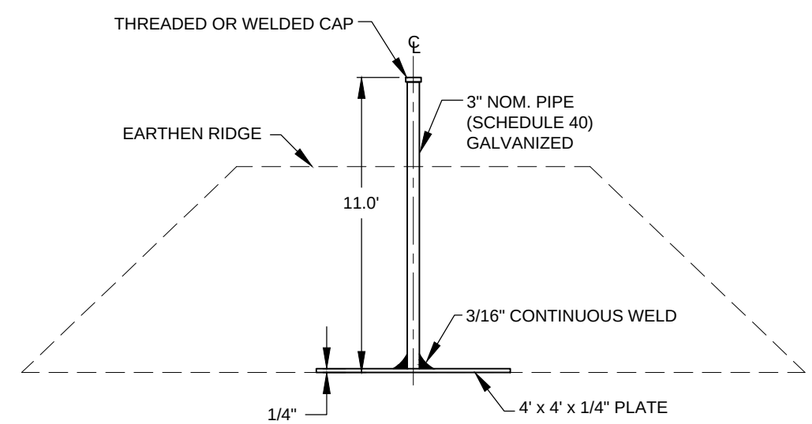
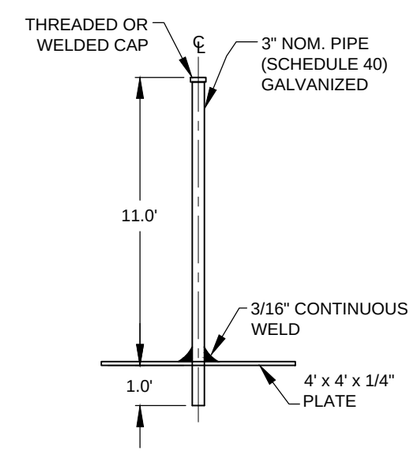


MARSH CREATION AREA GRADE STAKE DETAIL
NOT TO SCALE





EARTHEN RIDGE SETTLEMENT PLATE
(SEE NOTE 2)
NOT TO SCALE



MARSH CREATION SETTLEMENT PLATE
NOT TO SCALE

GRADE STAKE SIGN NOTE:
THE GRADE STAKE SIGN SHALL BE CONSTRUCTED USING A RIGID SUBSTRATE WITH ENGINEER-GRADE REFLECTIVE SHEETING.
SEE TS-8.9 OF THE SPECIFICATIONS FOR ADDITIONAL DETAILS.

SETTLEMENT PLATE NOTES:
1. SETTLEMENT PLATES SHALL BE HOT DIPPED GALVANIZED AFTER FABRICATION.
2. LOCATION AND ELEVATION WILL BE RECORDED AS SPECIFIED IN TS-2.0.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION
STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY: RUDOLPH SIMONEAUX, P.E.

GRADE STAKE AND SETTLEMENT PLATE DETAIL
DATE: SEPTEMBER 2013
SHEET 24 OF 54

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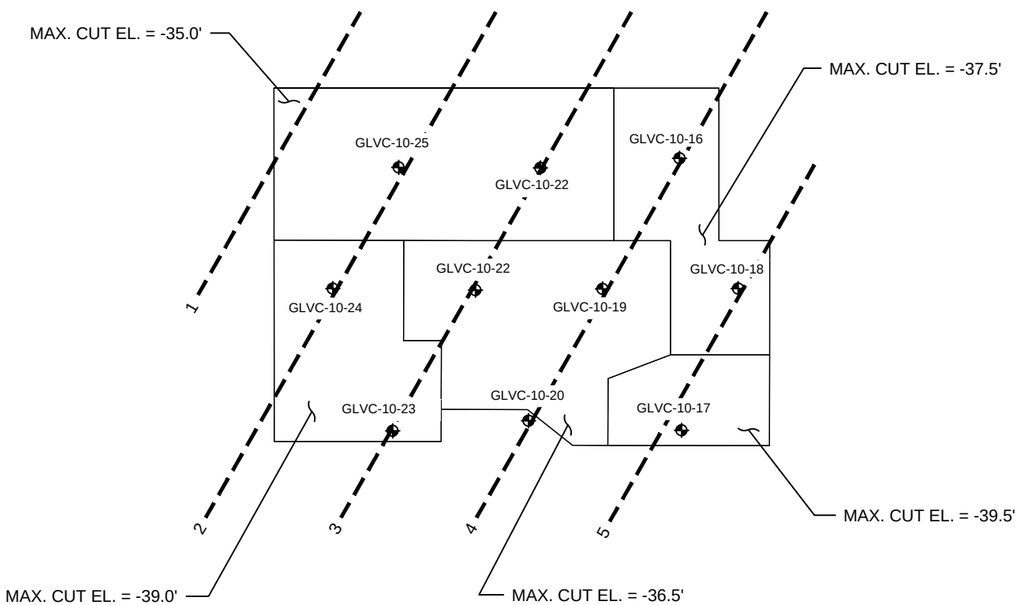
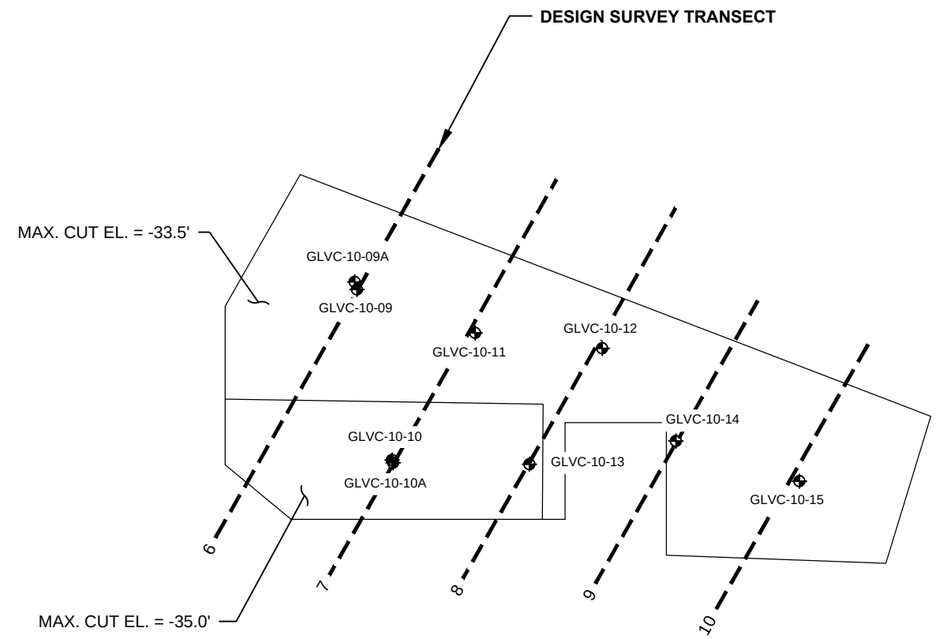
SOIL BORINGS					
WEST BORROW AREA			EAST BORROW AREA		
BORING	NORTHING	EASTING	BORING	NORTHING	EASTING
GLVC-10-16	266,592	3,848,463	GLVC-10-09	268,102	3,852,999
GLVC-10-17	264,798	3,848,476	GLVC-10-09A	268,152	3,852,984
GLVC-10-18	265,732	3,848,849	GLVC-10-10	266,978	3,853,230
GLVC-10-19	265,731	3,847,954	GLVC-10-10A	266,959	3,853,238
GLVC-10-20	264,860	3,847,466	GLVC-10-11	267,816	3,853,779
GLVC-10-21	265,722	3,847,116	GLVC-10-12	267,714	3,854,618
GLVC-10-22	266,529	3,847,544	GLVC-10-13	266,949	3,854,137
GLVC-10-23	264,794	3,846,569	GLVC-10-14	267,103	3,855,103
GLVC-10-24	265,733	3,846,174	GLVC-10-15	266,837	3,855,919
GLVC-10-25	266,533	3,846,609			

WEST BORROW AREA





EAST BORROW AREA

1000' 500' 0' 1000' 2000'

DESIGN SURVEY TRANSECTS				
	BEGINNING		ENDING	
	NORTHING	EASTING	NORTHING	EASTING
1	267,555.90	3,846,355.58	265,693.59	3,845,286.17
2	267,555.98	3,847,249.21	264,223.49	3,845,335.70
3	267,555.94	3,848,142.91	264,223.40	3,846,229.33
4	267,555.94	3,849,036.59	264,223.32	3,847,122.96
5	266,548.56	3,849,351.85	264,198.64	3,848,002.47
6	269,030.81	3,853,538.13	266,465.48	3,852,065.09
7	268,826.59	3,854,314.55	266,220.01	3,852,817.82
8	268,639.62	3,855,100.87	266,196.88	3,853,698.22
9	268,027.53	3,855,643.08	266,164.15	3,854,573.10
10	267,739.12	3,856,371.15	265,996.20	3,855,370.34

LEGEND

- DESIGN SURVEY TRANSECTS
- SOIL BORING

NOTES:
1. SURVEY CROSS-SECTIONS POINT FILES ARE AVAILABLE UPON REQUEST.
2. SEE APPENDIX H OF THE SPECIFICATIONS FOR BORING LOG INFORMATION.
3. TRANSECTS 1 THROUGH 10 REPRESENT DATA FROM THE DESIGN SURVEY TAKEN IN FEBRUARY 2010 BY CP&E.
4. SEE SHEETS 31 - 33 FOR CROSS-SECTIONS 1 THROUGH 10.
5. ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) U.S. SURVEY FEET.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

BORROW AREA DESIGN SURVEY & BORING LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E. | SHEET 25 OF 54

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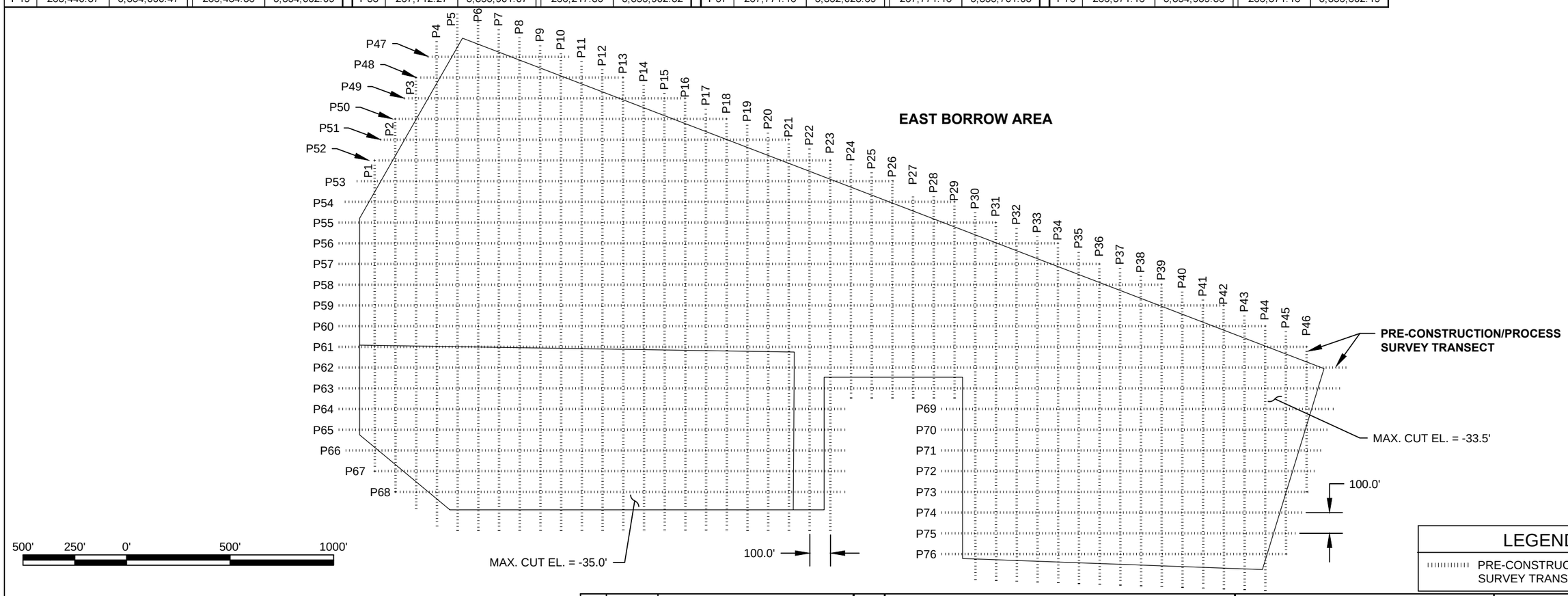
PROCESS SURVEY TRANSECTS

	BEGINNING		ENDING			BEGINNING		ENDING			BEGINNING		ENDING			BEGINNING		ENDING	
	NORTHING	EASTING	NORTHING	EASTING		NORTHING	EASTING	NORTHING	EASTING		NORTHING	EASTING	NORTHING	EASTING		NORTHING	EASTING	NORTHING	EASTING
P1	268,271.16	3,852,200.61	266,771.16	3,852,201.86	P20	268,402.52	3,854,100.50	266,484.94	3,854,102.09	P39	267,673.92	3,856,001.11	266,214.10	3,856,002.32	P58	267,671.16	3,852,028.69	267,673.92	3,856,001.11
P2	268,471.16	3,852,300.44	266,671.16	3,852,301.94	P21	268,371.16	3,854,200.53	266,485.03	3,854,202.09	P40	267,635.58	3,856,101.14	266,210.40	3,856,102.32	P59	267,571.16	3,852,028.69	267,571.16	3,856,301.19
P3	268,671.16	3,852,400.28	266,589.41	3,852,402.01	P22	268,325.82	3,854,300.56	266,484.86	3,854,302.09	P41	267,597.23	3,856,201.17	266,206.69	3,856,202.33	P60	267,471.16	3,852,028.69	267,471.16	3,856,501.27
P4	268,844.60	3,852,500.13	266,506.41	3,852,502.08	P23	268,271.16	3,854,400.61	266,484.94	3,854,402.09	P42	267,571.16	3,856,301.19	266,202.99	3,856,302.33	P61	267,371.16	3,852,028.69	267,371.16	3,856,701.36
P5	268,977.72	3,852,600.02	266,484.86	3,852,602.09	P24	268,249.13	3,854,500.63	267,124.70	3,854,501.56	P43	267,520.54	3,856,401.23	266,199.28	3,856,402.33	P62	267,271.16	3,852,028.69	267,271.16	3,856,891.63
P6	268,939.38	3,852,700.05	266,484.86	3,852,702.09	P25	268,210.78	3,854,600.66	267,124.87	3,854,601.56	P44	267,471.16	3,856,501.27	266,195.58	3,856,502.34	P63	267,171.16	3,852,028.69	267,171.16	3,856,861.02
P7	268,901.03	3,852,800.08	266,484.86	3,852,802.09	P26	268,172.44	3,854,700.69	267,124.78	3,854,701.56	P45	267,443.84	3,856,601.30	266,371.16	3,856,602.19	P64	267,071.16	3,852,028.69	267,071.16	3,854,471.88
P8	268,862.68	3,852,900.12	266,484.94	3,852,902.09	P27	268,134.09	3,854,800.72	267,124.62	3,854,801.56	P46	267,371.16	3,856,701.36	266,671.16	3,856,701.94	P65	266,971.16	3,852,028.69	266,971.16	3,854,471.88
P9	268,824.34	3,853,000.15	266,485.03	3,853,002.09	P28	268,095.74	3,854,900.75	267,124.70	3,854,901.56	P47	268,771.16	3,852,458.22	268,771.16	3,853,138.86	P66	266,871.16	3,852,062.28	266,871.16	3,854,471.88
P10	268,785.99	3,853,100.18	266,484.86	3,853,102.09	P29	268,071.16	3,855,000.78	267,124.78	3,855,001.56	P48	268,671.16	3,852,400.28	268,671.16	3,853,399.72	P67	266,771.16	3,852,201.86	266,771.16	3,854,471.88
P11	268,747.64	3,853,200.21	266,484.94	3,853,202.09	P30	268,019.05	3,855,100.82	266,247.43	3,855,102.29	P49	268,571.16	3,852,344.09	268,571.16	3,853,700.36	P68	266,671.16	3,852,301.94	266,671.16	3,854,471.88
P12	268,709.29	3,853,300.24	266,485.03	3,853,302.09	P31	267,971.16	3,855,200.86	266,243.73	3,855,202.29	P50	268,471.16	3,852,300.44	268,471.16	3,853,900.44	P69	267,071.16	3,854,939.86	267,071.16	3,856,830.40
P13	268,671.16	3,853,399.72	266,487.72	3,853,402.09	P32	267,942.35	3,855,300.88	266,240.03	3,855,302.30	P51	268,371.16	3,852,229.96	268,371.16	3,854,200.53	P70	266,971.16	3,854,939.86	266,971.16	3,856,799.78
P14	268,632.60	3,853,500.31	266,487.80	3,853,502.09	P33	267,904.01	3,855,400.91	266,236.32	3,855,402.30	P52	268,271.16	3,852,200.61	268,271.16	3,854,400.61	P71	266,871.16	3,854,939.86	266,871.16	3,856,769.17
P15	268,594.25	3,853,600.34	266,487.89	3,853,602.09	P34	267,871.16	3,855,500.94	266,232.62	3,855,502.30	P53	268,171.16	3,852,115.83	268,172.44	3,854,700.69	P72	266,771.16	3,854,939.86	266,771.16	3,856,738.55
P16	268,571.16	3,853,700.36	266,487.27	3,853,702.09	P35	267,827.31	3,855,600.98	266,228.92	3,855,602.31	P54	268,071.16	3,852,058.77	268,071.16	3,855,000.78	P73	266,671.16	3,854,939.86	266,671.16	3,856,701.94
P17	268,517.56	3,853,800.40	266,487.35	3,853,802.09	P36	267,771.16	3,855,701.03	266,225.21	3,855,702.31	P55	267,971.16	3,852,028.69	267,971.16	3,855,200.86	P74	266,571.16	3,854,939.86	266,571.16	3,856,677.31
P18	268,471.16	3,853,900.44	266,487.43	3,853,902.09	P37	267,750.62	3,855,801.04	266,221.51	3,855,802.31	P56	267,871.16	3,852,028.69	267,871.16	3,855,500.94	P75	266,471.16	3,854,939.86	266,471.16	3,856,646.70
P19	268,440.87	3,854,000.47	266,484.86	3,854,002.09	P38	267,712.27	3,855,901.07	266,217.80	3,855,902.32	P57	267,771.16	3,852,028.69	267,771.16	3,855,701.03	P76	266,371.16	3,854,939.86	266,371.16	3,856,602.19



NOTES:

1. PRE-CONSTRUCTION/PROCESS SURVEY TRANSECTS P1 THROUGH P76, PROVIDE MORE ACCURATE VOLUME ESTIMATES THAN THE DESIGN SURVEY LAYOUT SHOWN ON SHEET 25.
2. THE PRE-CONSTRUCTION PROCESS SURVEY TRANSECTS SHALL EXTEND A MINIMUM OF A 100.0' PAST THE LIMITS OF PAY.
3. ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) U.S. SURVEY FEET.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

BORROW AREA PRE-CONSTRUCTION/ PROCESS SURVEY LAYOUT

DATE: SEPTEMBER 2013

SHEET 26 OF 54

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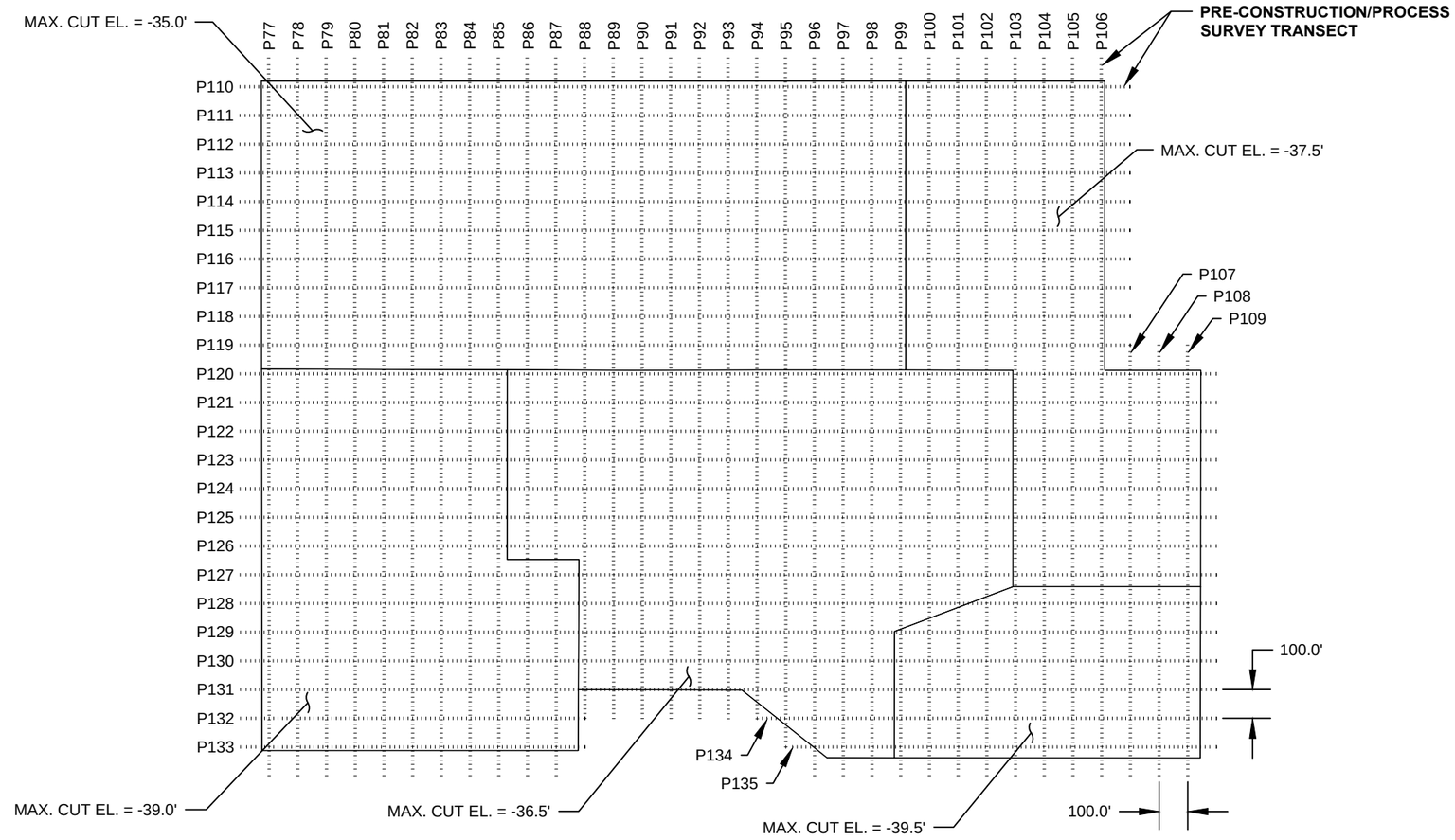
PROCESS SURVEY TRANSECTS

	BEGINNING		ENDING	
	NORTHING	EASTING	NORTHING	EASTING
P77	267,135.94	3,845,809.97	264,635.94	3,845,812.05
P78	267,135.94	3,845,909.97	264,635.94	3,845,912.05
P79	267,135.94	3,846,009.97	264,635.94	3,846,012.05
P80	267,135.94	3,846,109.97	264,635.94	3,846,112.05
P81	267,135.94	3,846,209.97	264,635.94	3,846,212.05
P82	267,135.94	3,846,309.97	264,635.94	3,846,312.05
P83	267,135.94	3,846,409.97	264,635.94	3,846,412.05
P84	267,135.94	3,846,509.97	264,635.94	3,846,512.05
P85	267,135.94	3,846,609.97	264,635.94	3,846,612.05
P86	267,135.94	3,846,709.97	264,635.94	3,846,712.05
P87	267,135.94	3,846,809.97	264,635.94	3,846,812.05
P88	267,135.94	3,846,909.97	264,835.94	3,846,911.88
P89	267,135.94	3,847,009.97	264,835.50	3,847,011.88
P90	267,135.94	3,847,109.97	264,835.06	3,847,111.88
P91	267,135.94	3,847,209.97	264,835.14	3,847,211.88
P92	267,135.94	3,847,309.97	264,835.22	3,847,311.88
P93	267,135.94	3,847,409.97	264,834.60	3,847,411.89
P94	267,135.94	3,847,509.97	264,834.69	3,847,511.88
P95	267,135.94	3,847,609.97	264,735.94	3,847,611.97
P96	267,135.94	3,847,709.97	264,635.94	3,847,712.05
P97	267,135.94	3,847,809.97	264,635.94	3,847,812.05
P98	267,135.94	3,847,909.97	264,635.94	3,847,912.05
P99	267,135.94	3,848,009.97	264,635.94	3,848,012.05
P100	267,135.94	3,848,109.97	264,635.94	3,848,112.05
P101	267,135.94	3,848,209.97	264,635.94	3,848,212.05
P102	267,135.94	3,848,309.97	264,635.94	3,848,312.05
P103	267,135.94	3,848,409.97	264,635.94	3,848,412.05
P104	267,135.94	3,848,509.97	264,635.94	3,848,512.05
P105	267,135.94	3,848,609.97	264,635.94	3,848,612.05
P106	267,135.94	3,848,709.97	264,635.94	3,848,712.05
P107	266,135.94	3,848,810.80	264,635.94	3,848,812.05
P108	266,135.94	3,848,910.80	264,635.94	3,848,912.05
P109	266,135.94	3,849,010.80	264,635.94	3,849,012.05
P110	267,035.94	3,845,710.05	267,035.94	3,848,810.06
P111	266,935.94	3,845,710.14	266,935.94	3,848,810.14
P112	266,835.94	3,845,710.22	266,835.94	3,848,810.22
P113	266,735.94	3,845,710.30	266,735.94	3,848,810.30
P114	266,635.94	3,845,710.39	266,635.94	3,848,810.39
P115	266,535.94	3,845,710.47	266,535.94	3,848,810.47
P116	266,435.94	3,845,710.55	266,435.94	3,848,810.55
P117	266,335.94	3,845,710.64	266,335.94	3,848,810.64
P118	266,235.94	3,845,710.72	266,235.94	3,848,810.72
P119	266,135.94	3,845,710.80	266,135.94	3,848,810.80
P120	266,035.94	3,845,710.89	266,035.94	3,849,110.89
P121	265,935.94	3,845,710.97	265,935.94	3,849,110.97
P122	265,835.94	3,845,711.05	265,835.94	3,849,111.05
P123	265,735.94	3,845,711.13	265,735.94	3,849,111.14
P124	265,635.94	3,845,711.22	265,635.94	3,849,111.22
P125	265,535.94	3,845,711.30	265,535.94	3,849,111.30
P126	265,435.94	3,845,711.38	265,435.94	3,849,111.39
P127	265,335.94	3,845,711.47	265,335.94	3,849,111.47
P128	265,235.94	3,845,711.55	265,235.94	3,849,111.55
P129	265,135.94	3,845,711.63	265,135.94	3,849,111.64
P130	265,035.94	3,845,711.72	265,035.94	3,849,111.72
P131	264,935.94	3,845,711.80	264,935.94	3,849,111.80
P132	264,835.94	3,845,711.88	264,835.94	3,846,911.88
P133	264,735.94	3,845,711.97	264,735.94	3,846,911.97
P134	264,834.69	3,847,511.88	264,835.94	3,849,111.88
P135	264,735.94	3,847,611.97	264,735.94	3,849,111.97

WEST BORROW AREA



1000' 500' 0' 1000' 2000'

LEGEND
PRE-CONSTUCTION/PROCESS SURVEY TRANSECTS

NOTES:

1. PRE-CONSTRUCTION/PROCESS SURVEY TRANSECTS P77 THROUGH P135, PROVIDE MORE ACCURATE VOLUME ESTIMATES THAN THE DESIGN SURVEY LAYOUT SHOWN ON SHEET 25.
2. THE PRE-CONSTRUCTION PROCESS SURVEY TRANSECTS SHALL EXTEND A MINIMUM OF A 100.0' PAST THE LIMITS OF PAY.
3. ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) U.S. SURVEY FEET.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

BORROW AREA PRE-CONSTRUCTION/ PROCESS SURVEY LAYOUT

DATE: SEPTEMBER 2013

SHEET 27 OF 54

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SOIL BORING

BORING	NORTHING	EASTING
B1	297,634.93	3,872,405.57
B2	294,063.77	3,874,155.11
B3	289,356.78	3,875,232.29
B4	298,977.66	3,872,300.06
B5	292,785.03	3,874,750.65
B6	288,315.79	3,875,686.22
B7	298,047.05	3,873,483.87
B8	292,097.00	3,876,023.00
B9	288,165.12	3,876,272.85
B10	285,102.17	3,876,156.56
B11	299,355.21	3,873,081.04
B12	297,922.80	3,874,459.07
B13	296,817.70	3,874,840.10
B14	296,107.65	3,875,285.56
B15	296,798.56	3,873,662.67
B16	293,902.11	3,874,471.29
B17	291,700.86	3,875,162.45
B18	293,159.46	3,874,775.61

MARSH CREATION TRANSECTS

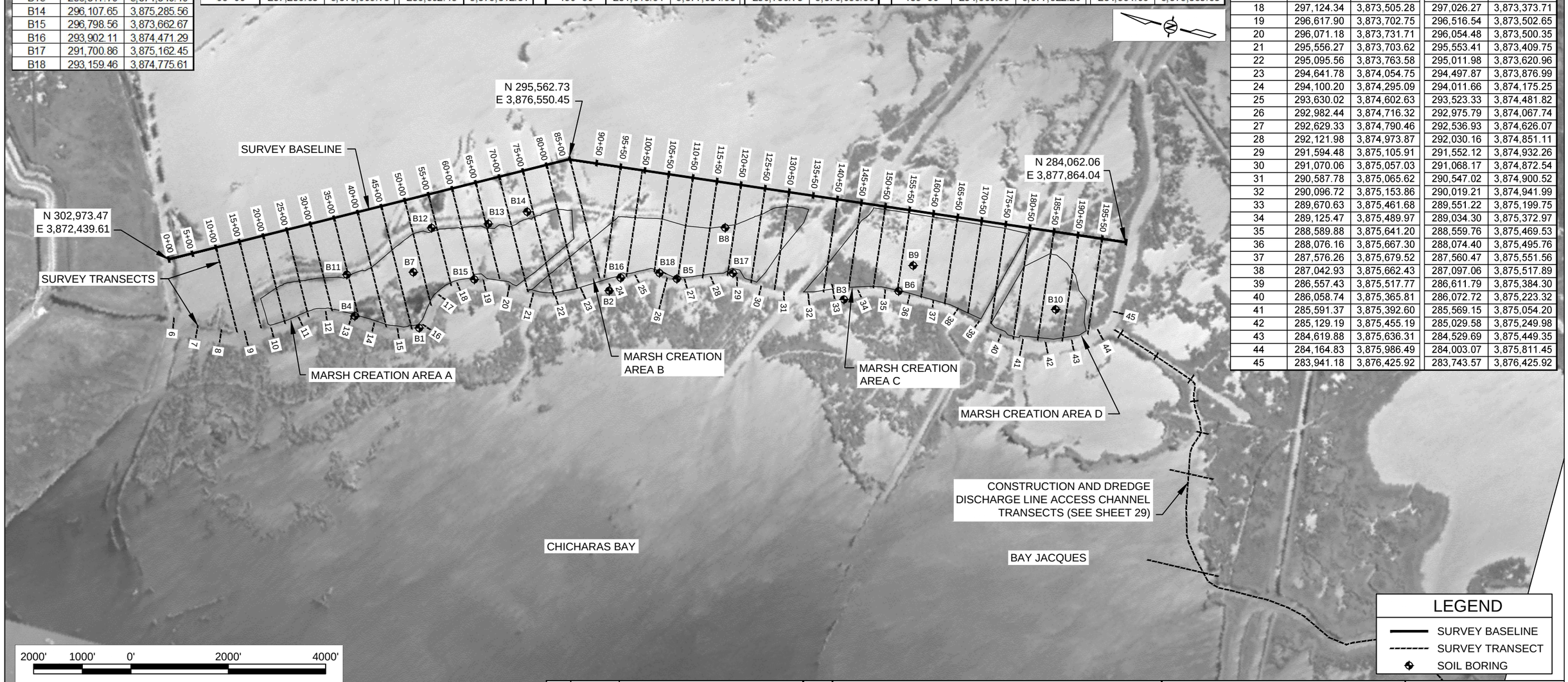
TRANSECT	BEGINNING NORTHING	BEGINNING EASTING	ENDING NORTHING	ENDING EASTING
10+00	302,098.83	3,872,924.90	301,229.68	3,871,357.53
15+00	301,661.77	3,873,167.23	300,774.90	3,871,568.44
20+00	301,231.81	3,873,422.89	300,322.96	3,871,784.48
25+00	300,750.62	3,873,586.19	299,895.19	3,872,044.07
30+00	300,357.34	3,873,907.97	299,456.93	3,872,284.76
35+00	299,920.10	3,874,150.51	298,896.81	3,872,305.78
40+00	299,482.87	3,874,393.05	298,297.06	3,872,255.36
45+00	299,045.63	3,874,635.59	297,777.15	3,872,348.85
50+00	298,608.40	3,874,878.13	297,522.36	3,872,920.29
55+00	298,171.16	3,875,120.67	297,226.51	3,873,417.70
60+00	297,733.93	3,875,363.21	296,787.22	3,873,656.54
65+00	297,296.69	3,875,605.75	296,302.13	3,873,812.81

TRANSECT	BEGINNING NORTHING	BEGINNING EASTING	ENDING NORTHING	ENDING EASTING
70+00	296,859.46	3,875,848.29	295,671.04	3,873,705.89
75+00	296,422.22	3,876,090.83	295,136.89	3,873,774.35
80+00	295,984.99	3,876,333.37	294,716.50	3,874,046.63
85+00	295,539.15	3,876,568.24	294,328.08	3,874,366.14
95+50	294,495.93	3,876,687.39	294,234.57	3,874,399.16
100+50	294,048.84	3,876,738.46	293,796.87	3,874,532.70
105+50	293,502.39	3,876,800.87	293,271.08	3,874,775.66
110+50	293,005.62	3,876,857.61	292,762.89	3,874,732.45
115+50	292,508.85	3,876,914.35	292,279.91	3,874,909.90
120+50	292,012.08	3,876,971.09	291,797.17	3,875,089.47
125+50	291,515.31	3,877,027.84	291,292.04	3,875,073.06
130+50	291,018.54	3,877,084.58	290,786.79	3,875,055.56

TRANSECT	BEGINNING NORTHING	BEGINNING EASTING	ENDING NORTHING	ENDING EASTING
140+50	290,025.00	3,877,198.06	289,805.30	3,875,272.69
145+50	289,528.23	3,877,254.80	289,318.71	3,875,420.45
150+50	289,031.46	3,877,311.54	288,838.22	3,875,619.67
155+50	288,534.69	3,877,368.28	288,340.15	3,875,665.00
160+50	288,037.92	3,877,425.02	287,839.19	3,875,685.10
165+50	287,541.15	3,877,481.76	287,335.56	3,875,681.77
170+50	287,044.38	3,877,538.50	286,825.37	3,875,621.01
175+50	286,547.61	3,877,595.24	286,312.80	3,875,539.45
180+50	286,050.84	3,877,651.98	285,787.66	3,875,347.83
185+50	285,554.07	3,877,708.72	285,296.82	3,875,456.46
190+50	285,057.30	3,877,765.46	284,806.48	3,875,569.48
195+50	284,560.53	3,877,822.20	284,334.06	3,875,839.38

BAYOU TRANSECTS

TRANSECT	BEGINNING NORTHING	BEGINNING EASTING	ENDING NORTHING	ENDING EASTING
6	302,556.85	3,871,299.68	302,523.06	3,871,099.96
7	302,043.07	3,871,278.96	302,020.70	3,871,024.94
8	301,550.40	3,871,322.16	301,523.18	3,871,064.48
9	301,084.56	3,871,414.61	300,944.99	3,871,154.29
10	300,574.04	3,871,621.32	300,482.04	3,871,453.30
11	300,088.95	3,871,980.23	299,968.63	3,871,838.37
12	299,576.77	3,872,236.14	299,516.21	3,872,080.29
13	299,036.97	3,872,269.93	299,046.31	3,872,109.26
14	298,552.27	3,872,263.67	298,552.25	3,872,095.77
15	298,064.43	3,872,277.52	297,988.22	3,872,100.98
16	297,582.95	3,872,495.96	297,407.46	3,872,432.83
17	297,426.75	3,873,170.01	297,277.71	3,873,110.46
18	297,124.34	3,873,505.28	297,026.27	3,873,373.71
19	296,617.90	3,873,702.75	296,516.54	3,873,502.65
20	296,071.18	3,873,731.71	296,054.48	3,873,500.35
21	295,556.27	3,873,703.62	295,553.41	3,873,409.75
22	295,095.56	3,873,763.58	295,011.98	3,873,620.96
23	294,641.78	3,874,054.75	294,497.87	3,873,876.99
24	294,100.20	3,874,295.09	294,011.66	3,874,175.25
25	293,630.02	3,874,602.63	293,523.33	3,874,481.82
26	292,982.44	3,874,716.32	292,975.79	3,874,067.74
27	292,629.33	3,874,790.46	292,536.93	3,874,626.07
28	292,121.98	3,874,973.87	292,030.16	3,874,851.11
29	291,594.48	3,875,105.91	291,552.12	3,874,932.26
30	291,070.06	3,875,057.03	291,068.17	3,874,872.54
31	290,587.78	3,875,065.62	290,547.02	3,874,900.52
32	290,096.72	3,875,153.86	290,019.21	3,874,941.99
33	289,670.63	3,875,461.68	289,551.22	3,875,199.75
34	289,125.47	3,875,489.97	289,034.30	3,875,372.97
35	288,589.88	3,875,641.20	288,559.76	3,875,469.53
36	288,076.16	3,875,667.30	288,074.40	3,875,495.76
37	287,576.26	3,875,679.52	287,560.47	3,875,551.56
38	287,042.93	3,875,662.43	287,097.06	3,875,517.89
39	286,557.43	3,875,517.77	286,611.79	3,875,384.30
40	286,058.74	3,875,365.81	286,072.72	3,875,223.32
41	285,591.37	3,875,392.60	285,569.15	3,875,054.20
42	285,129.19	3,875,455.19	285,029.58	3,875,249.98
43	284,619.88	3,875,636.31	284,529.69	3,875,449.35
44	284,164.83	3,875,986.49	284,003.07	3,875,811.45
45	283,941.18	3,876,425.92	283,743.57	3,876,425.92



NOTES:
1. SURVEY CROSS-SECTION POINT FILES ARE AVAILABLE UPON REQUEST.
2. SEE APPENDIX H OF THE SPECIFICATIONS FOR BORING LOG INFORMATION.
3. SEE APPENDIX F OF THE SPECIFICATIONS FOR BENCHMARK DATA SHEETS.
4. SEE SHEETS 34-42 FOR MARSH CREATION CROSS-SECTIONS 10+00 THROUGH 190+50 AND SHEETS 43-46 FOR BAYOU CROSS-SECTIONS 6 THROUGH 45.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION SURVEY & BORING LAYOUT

DATE: SEPTEMBER 2013
SHEET 28 OF 54

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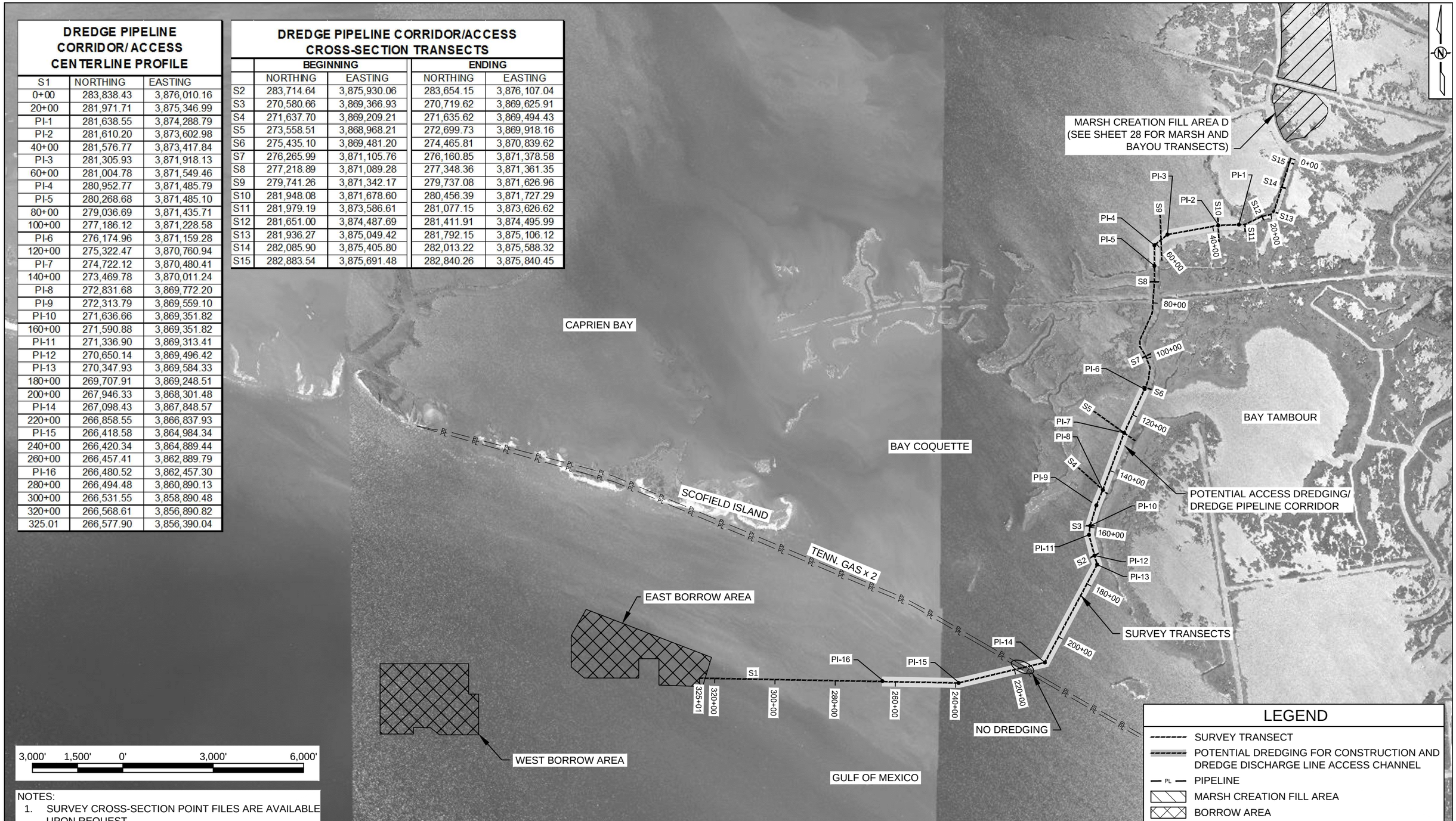
DREDGE PIPELINE CORRIDOR/ ACCESS CENTERLINE PROFILE

S1	NORTHING	EASTING
0+00	283,838.43	3,876,010.16
20+00	281,971.71	3,875,346.99
PI-1	281,638.55	3,874,288.79
PI-2	281,610.20	3,873,602.98
40+00	281,576.77	3,873,417.84
PI-3	281,305.93	3,871,918.13
60+00	281,004.78	3,871,549.46
PI-4	280,952.77	3,871,485.79
PI-5	280,268.68	3,871,485.10
80+00	279,036.69	3,871,435.71
100+00	277,186.12	3,871,228.58
PI-6	276,174.96	3,871,159.28
120+00	275,322.47	3,870,760.94
PI-7	274,722.12	3,870,480.41
140+00	273,469.78	3,870,011.24
PI-8	272,831.68	3,869,772.20
PI-9	272,313.79	3,869,559.10
PI-10	271,636.66	3,869,351.82
160+00	271,590.88	3,869,351.82
PI-11	271,336.90	3,869,313.41
PI-12	270,650.14	3,869,496.42
PI-13	270,347.93	3,869,584.33
180+00	269,707.91	3,869,248.51
200+00	267,946.33	3,868,301.48
PI-14	267,098.43	3,867,848.57
220+00	266,858.55	3,866,837.93
PI-15	266,418.58	3,864,984.34
240+00	266,420.34	3,864,889.44
260+00	266,457.41	3,862,889.79
PI-16	266,480.52	3,862,457.30
280+00	266,494.48	3,860,890.13
300+00	266,531.55	3,858,890.48
320+00	266,568.61	3,856,890.82
325.01	266,577.90	3,856,390.04

DREDGE PIPELINE CORRIDOR/ACCESS CROSS-SECTION TRANSECTS

	BEGINNING		ENDING	
	NORTHING	EASTING	NORTHING	EASTING
S2	283,714.64	3,875,930.06	283,654.15	3,876,107.04
S3	270,580.66	3,869,366.93	270,719.62	3,869,625.91
S4	271,637.70	3,869,209.21	271,635.62	3,869,494.43
S5	273,558.51	3,868,968.21	272,699.73	3,869,918.16
S6	275,435.10	3,869,481.20	274,465.81	3,870,839.62
S7	276,265.99	3,871,105.76	276,160.85	3,871,378.58
S8	277,218.89	3,871,089.28	277,348.36	3,871,361.35
S9	279,741.26	3,871,342.17	279,737.08	3,871,626.96
S10	281,948.08	3,871,678.60	280,456.39	3,871,727.29
S11	281,979.19	3,873,586.61	281,077.15	3,873,626.62
S12	281,651.00	3,874,487.69	281,411.91	3,874,495.99
S13	281,936.27	3,875,049.42	281,792.15	3,875,106.12
S14	282,085.90	3,875,405.80	282,013.22	3,875,588.32
S15	282,883.54	3,875,691.48	282,840.26	3,875,840.45



NOTES:
1. SURVEY CROSS-SECTION POINT FILES ARE AVAILABLE UPON REQUEST.
2. SEE SHEETS 47-50 FOR ACCESS CENTER LINE PROFILE, S1, AND CROSS-SECTIONS S2 THROUGH S15.
3. THE CONTRACTOR WILL HAVE SUFFICIENT DEPTH TO TRAVERSE FROM EAST TO WEST BORROW AREA.
4. SEE OYSTER ACQUISITION MAP IN APPENDIX I FOR ADDITIONAL DETAILS ON ACQUIRED AND EXTINGUISHED OYSTER LEASES.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

CONSTRUCTION & DREDGE DISCHARGE LINE ACCESS CHANNEL SURVEY LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E. | SHEET 29 OF 54

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EMPIRE WATERWAY EQUIPMENT ACCESS ROUTE

	NORTHING	EASTING
0+00	322,485.18	3,832,401.76
20+00	320,515.51	3,832,748.75
40+00	318,577.95	3,833,233.33
60+00	316,658.14	3,833,793.97
80+00	314,767.35	3,834,436.24
100+00	312,848.74	3,834,966.71
120+00	310,867.93	3,835,243.12
140+00	308,871.55	3,835,189.69
160+00	307,044.97	3,834,496.69
180+00	305,658.92	3,833,055.61
200+00	303,961.10	3,832,018.64
220+00	302,026.25	3,831,816.75
240+00	300,062.37	3,832,195.11
260+00	298,129.04	3,832,647.85
280+00	296,580.21	3,833,898.36
300+00	294,597.84	3,833,736.28
320+00	292,612.79	3,833,578.16
340+00	290,628.99	3,833,379.30
360+00	288,661.94	3,833,118.78
380+00	286,719.58	3,832,720.00
400+00	284,754.29	3,832,272.40
420+00	282,807.14	3,831,877.50
440+00	280,813.64	3,831,607.99
460+00	278,839.23	3,831,299.85
478+96	276,978.19	3,830,935.96

LEGEND

- SURVEY TRANSECT
- PL — PIPELINE

NOTES:
1. BACKGROUND IMAGERY WAS TAKEN IN 2010.
2. PIPELINE INFORMATION SHOWN ON PLANS IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY EXACT LOCATIONS PRIOR TO BEGINNING CONSTRUCTION.
3. PIPELINE LOCATIONS ARE BASED ON USGS DATABASE AND IS NOT GUARANTEED TO BE ACCURATE.
4. SURVEY POINT FILES ARE AVAILABLE UPON REQUEST.
5. SEE SHEETS 51 - 54 FOR THE PROFILE OF THE EMPIRE WATERWAY EQUIPMENT ACCESS ROUTE.

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

EMPIRE WATERWAY ACCESS SURVEY LAYOUT

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 30 OF 54

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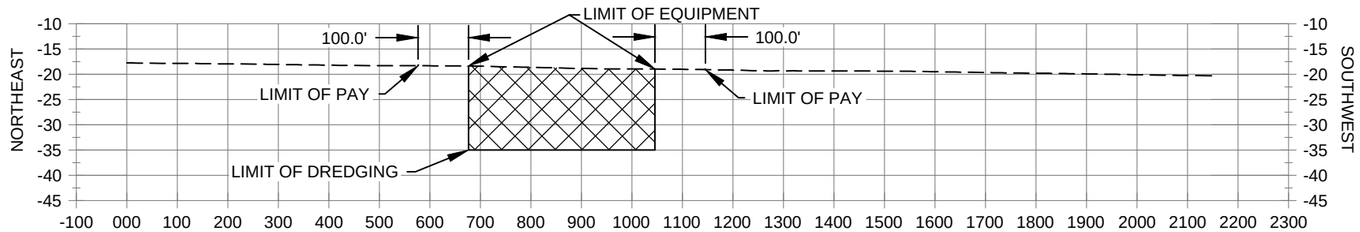
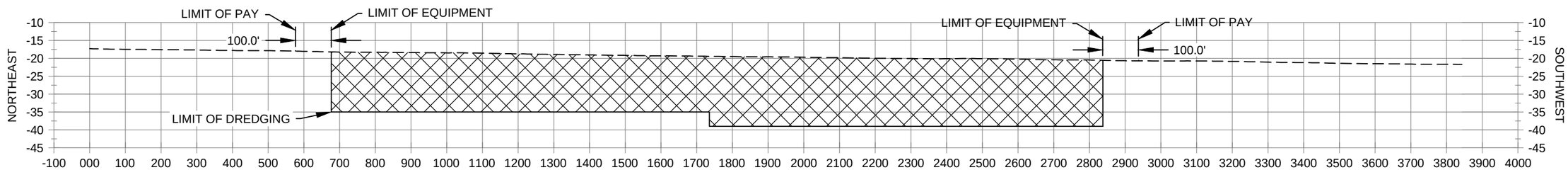
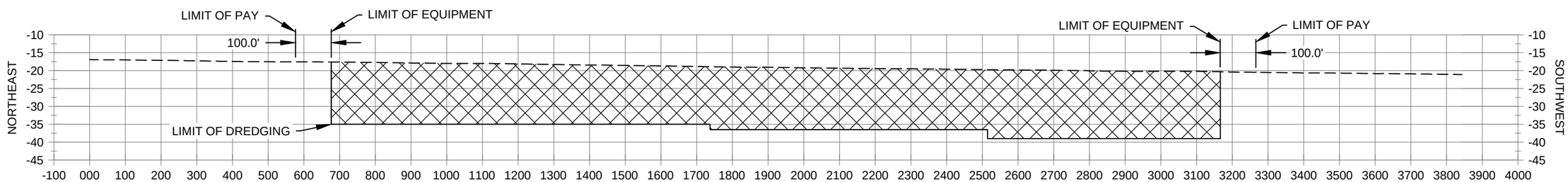


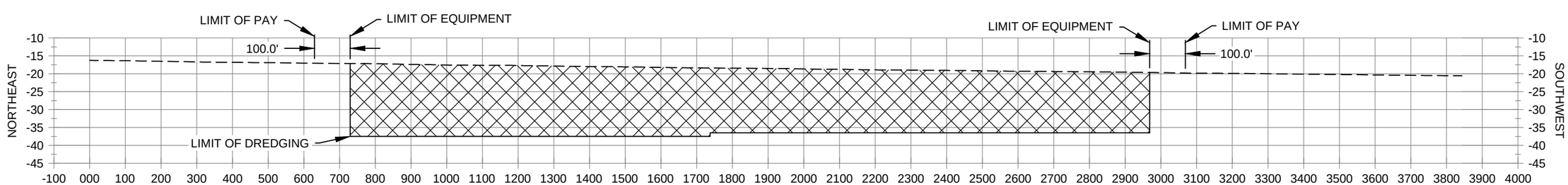
BORROW TRANSECT 1



BORROW TRANSECT 2



BORROW TRANSECT 3



BORROW TRANSECT 4

LEGEND

- BORROW AREA
- EXISTING WATER BOTTOM

HORIZONTAL GRAPHIC SCALE

300' 150' 0 300' 600'

30' 15' 0 30' 60'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

BORROW AREA SECTIONS

DATE: SEPTEMBER 2013

SHEET 31 OF 54

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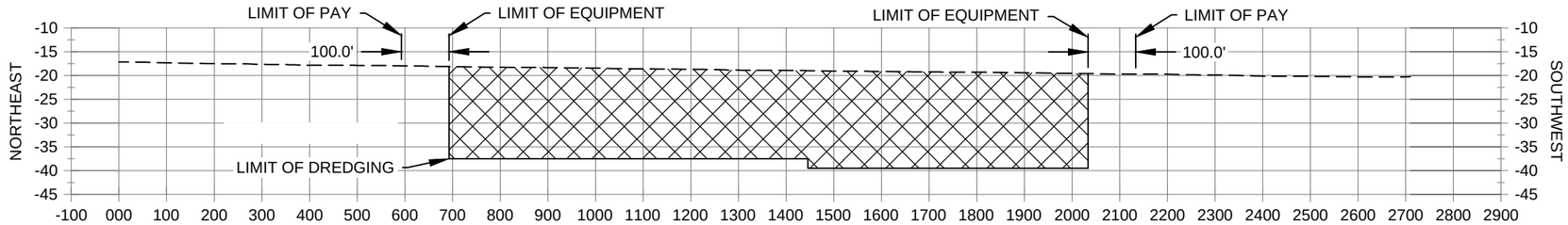
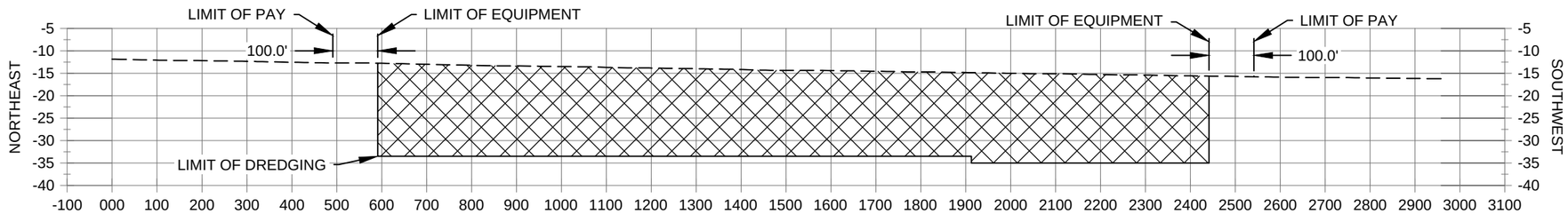
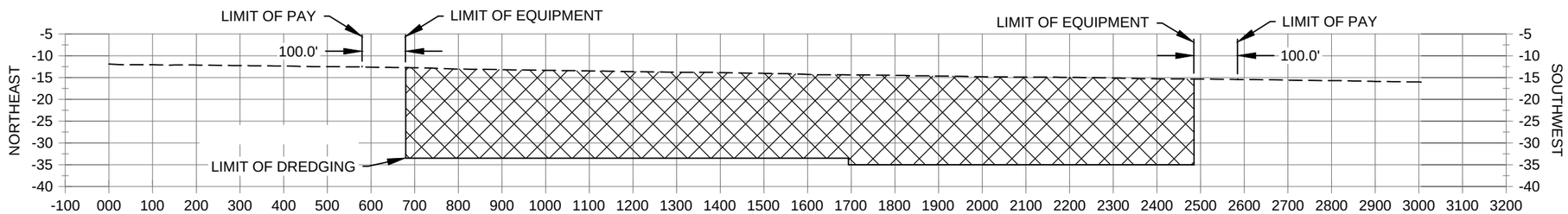


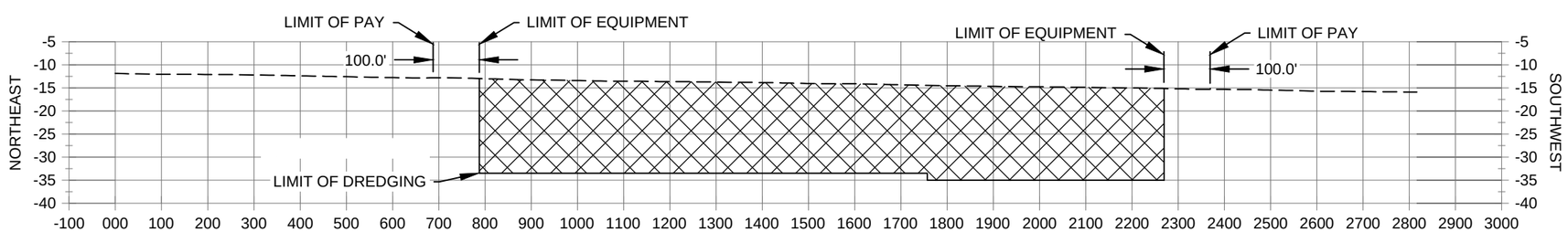
BORROW TRANSECT 5



BORROW TRANSECT 6



BORROW TRANSECT 7



BORROW TRANSECT 8

LEGEND	
	BORROW AREA
	EXISTING WATER BOTTOM

HORIZONTAL GRAPHIC SCALE

300' 150' 0 300' 600'

30' 15' 0 30' 60'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

BORROW AREA SECTIONS

DATE: SEPTEMBER 2013

SHEET 32 OF 54

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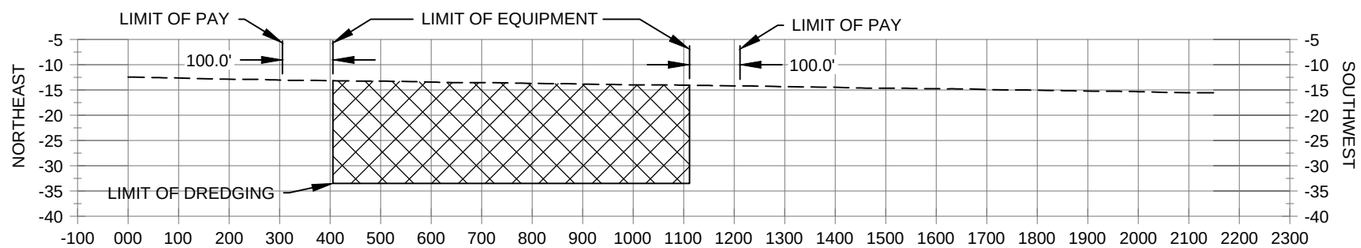
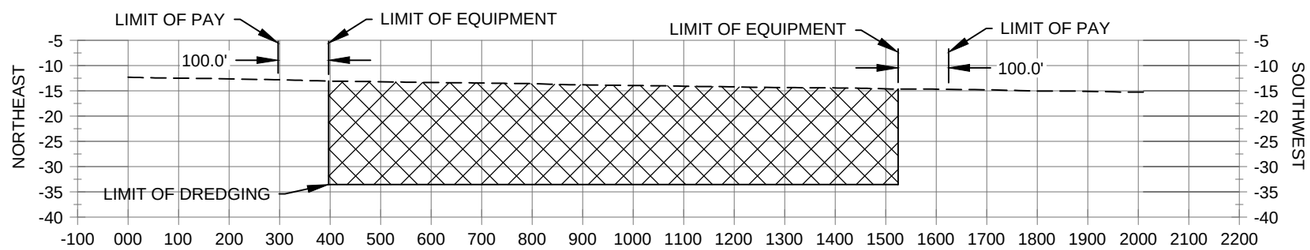


BORROW TRANSECT 9



BORROW TRANSECT 10

LEGEND	
	BORROW AREA
	EXISTING WATER BOTTOM

HORIZONTAL GRAPHIC SCALE

300' 150' 0 300' 600'

30' 15' 0 30' 60'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

BORROW AREA SECTIONS

DATE: SEPTEMBER 2013

SHEET 33 OF 54

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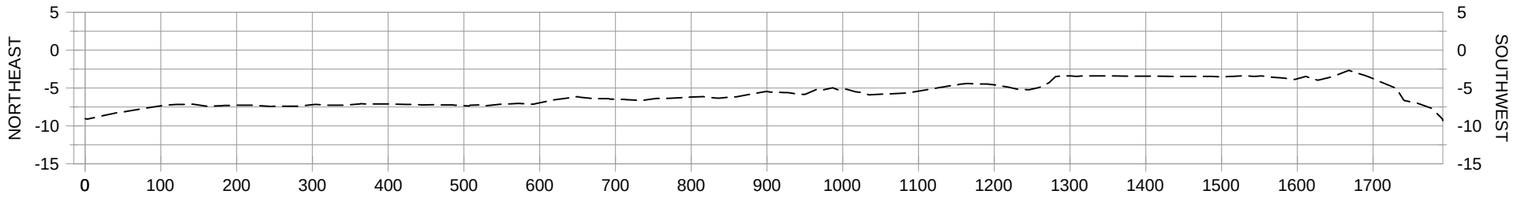

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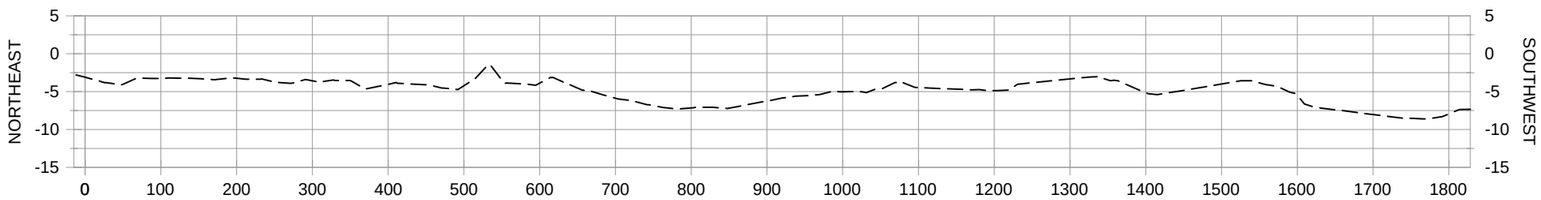

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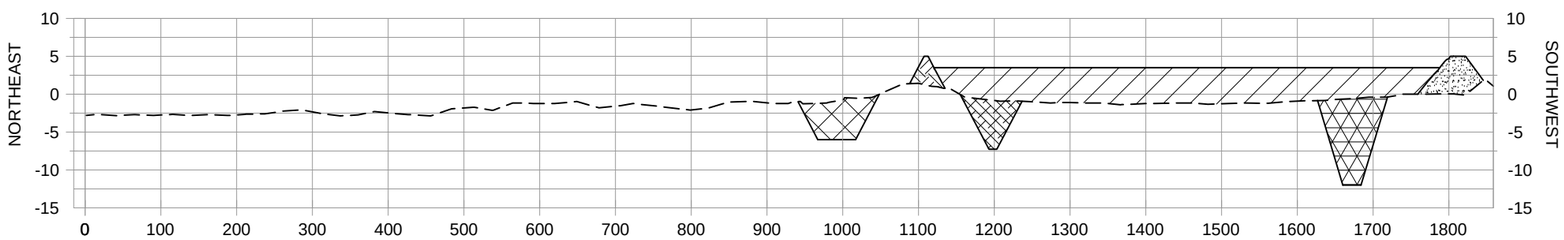

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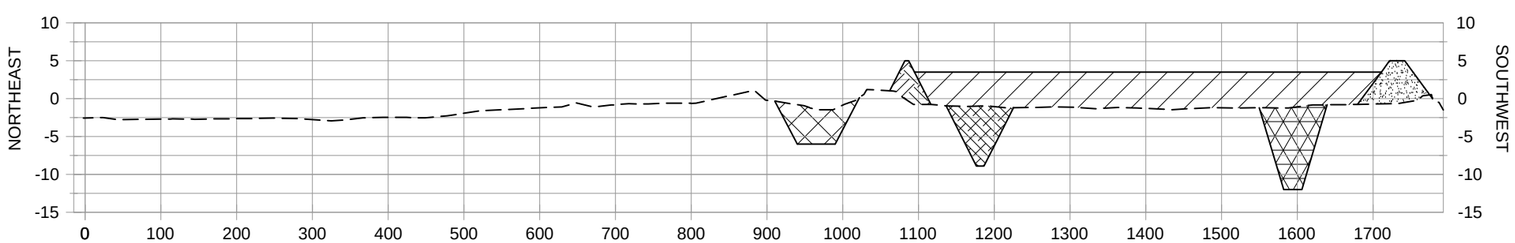

25+00

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE PRIMARY BORROW AREA
- EARTHEN CONTAINMENT DIKE SECONDARY BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREAS SECTIONS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU | DESIGNED BY: TYE FITZGERALD, P.E. | APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 34 OF 54

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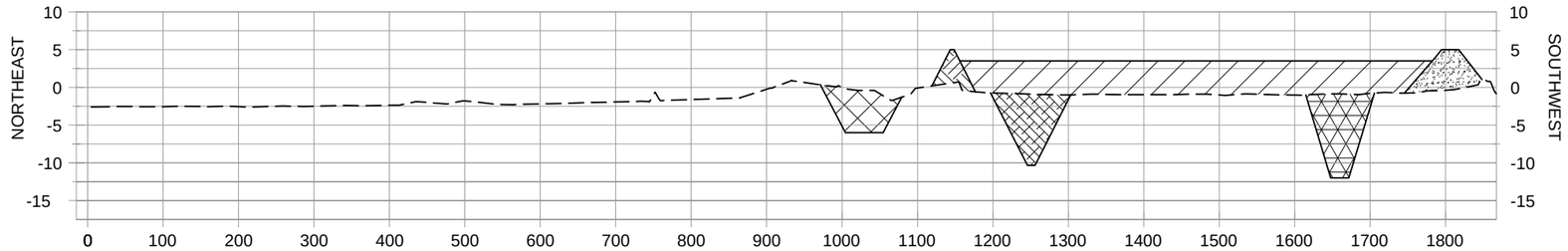

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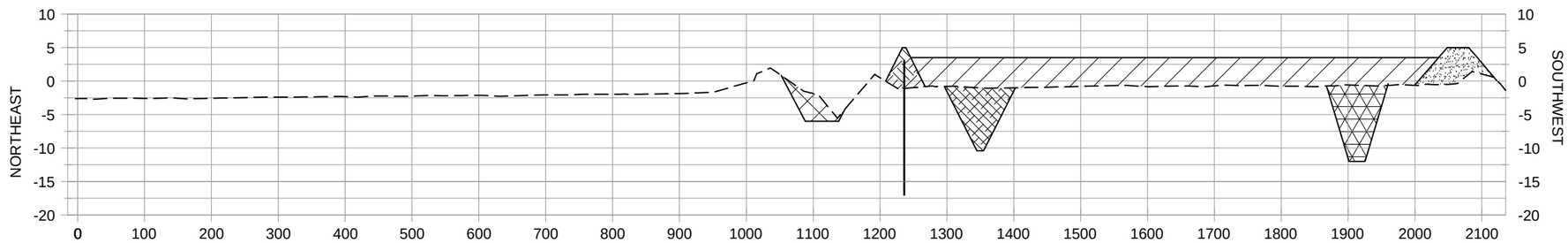

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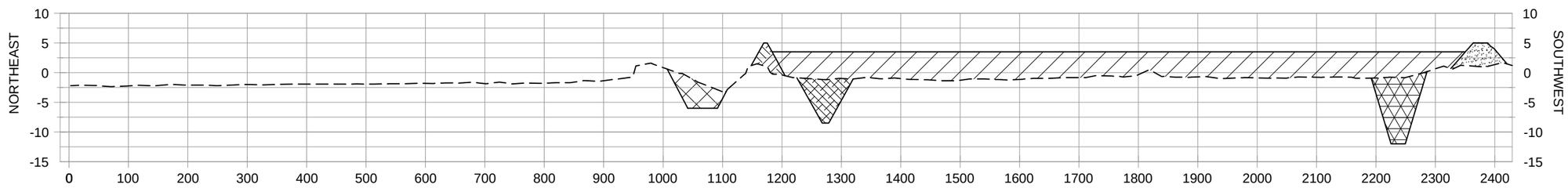

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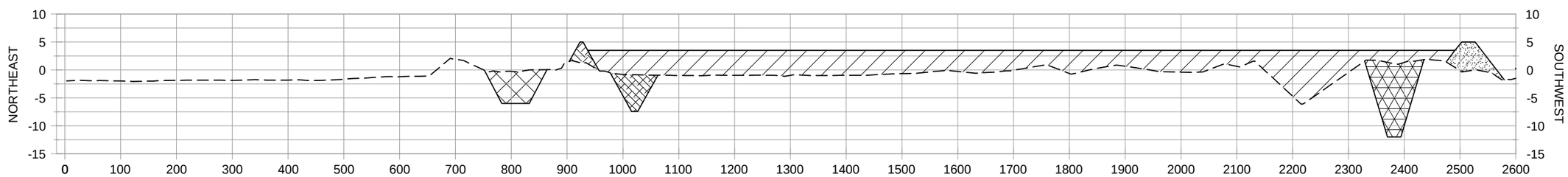

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LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE PRIMARY BORROW AREA
- EARTHEN CONTAINMENT DIKE SECONDARY BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND
- SHEET PILE CLOSURE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

HORIZONTAL GRAPHIC SCALE
200' 100' 0 200' 400'
20' 10' 0 20' 40'
VERTICAL GRAPHIC SCALE

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREAS SECTIONS

DATE: SEPTEMBER 2013

SHEET 35 OF 54

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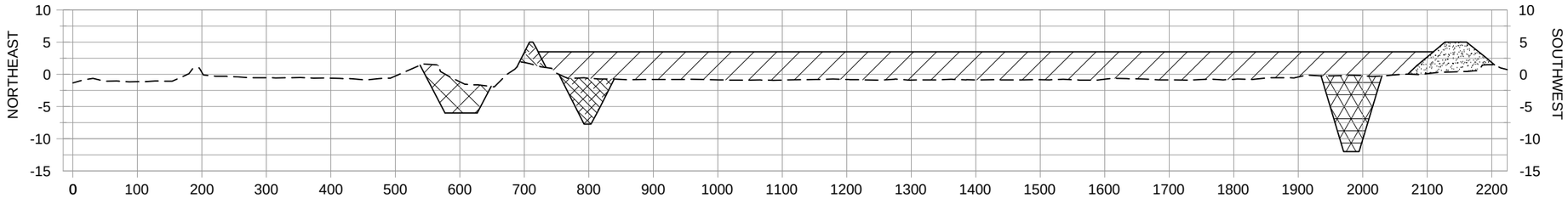

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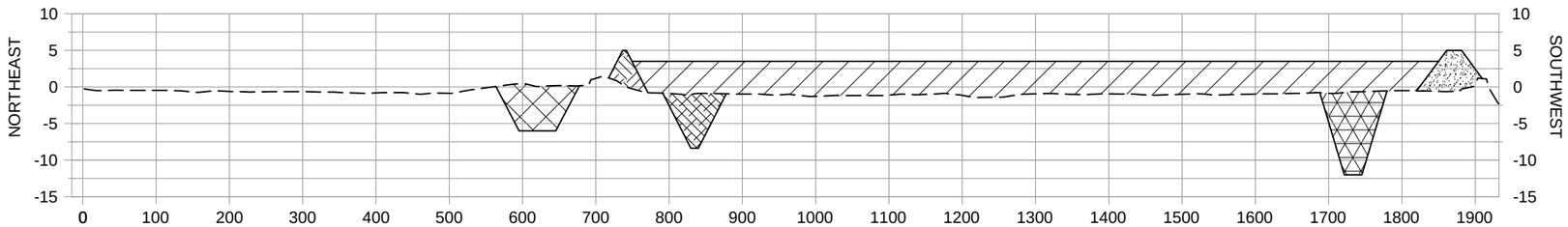

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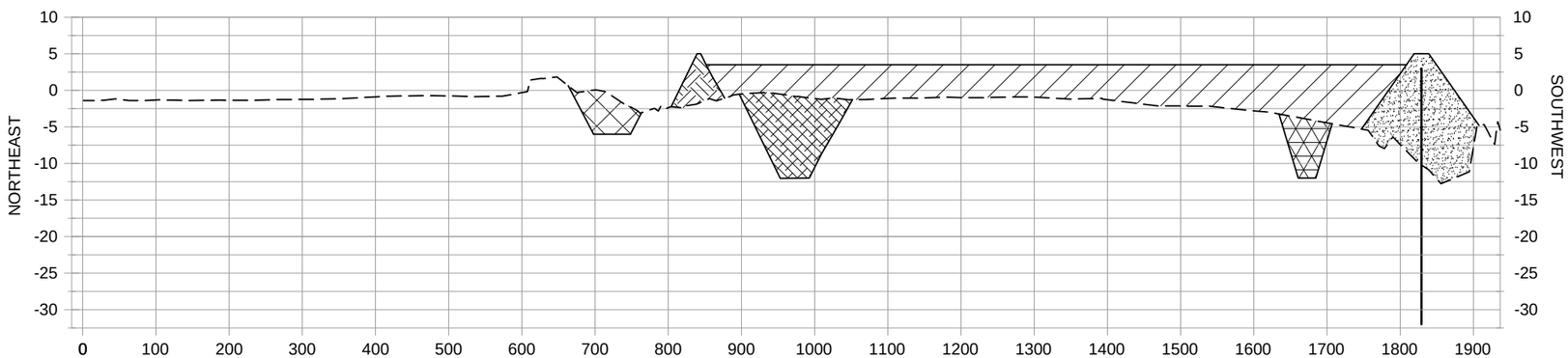

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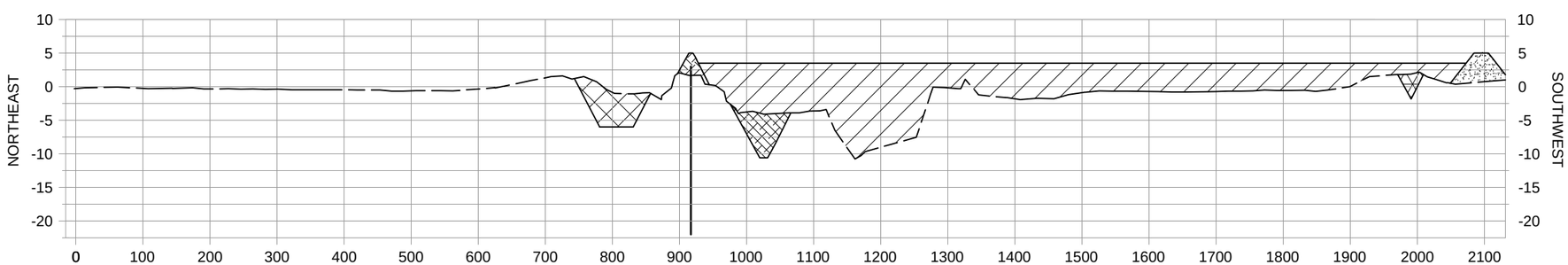

65+00

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE PRIMARY BORROW AREA
- EARTHEN CONTAINMENT DIKE SECONDARY BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND
- SHEET PILE CLOSURE

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREAS SECTIONS

DATE: SEPTEMBER 2013

SHEET 36 OF 54

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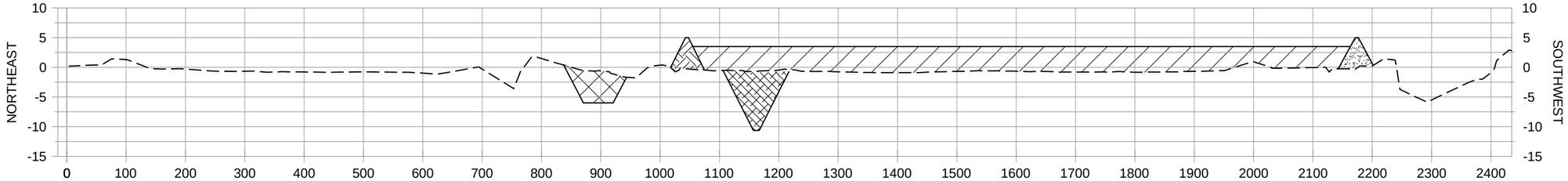

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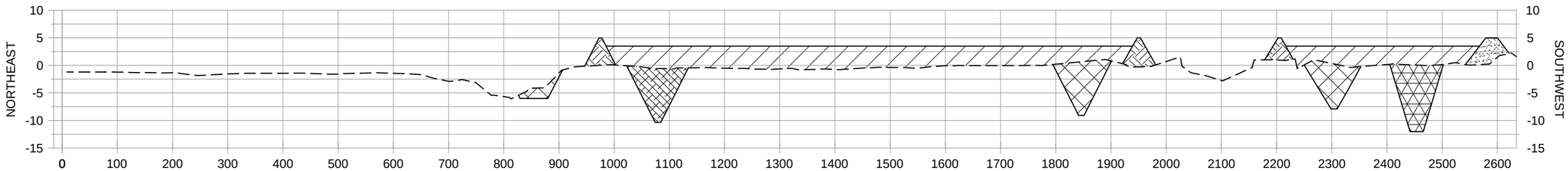

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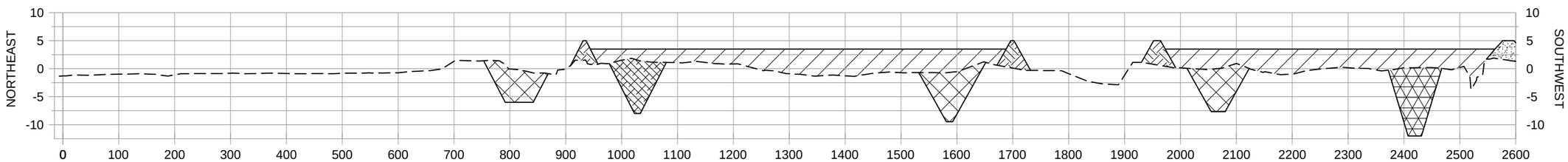

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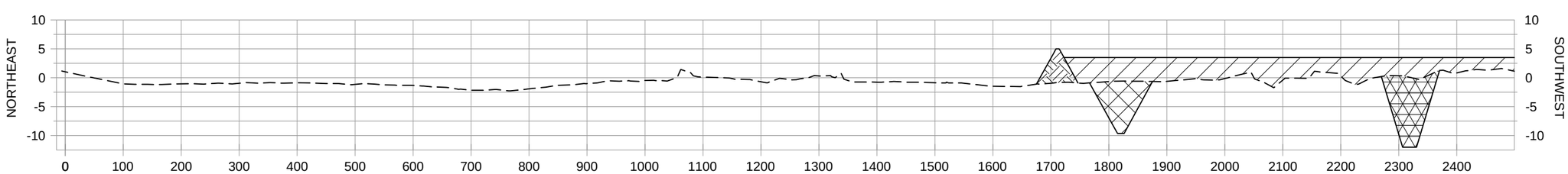

85+00

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE PRIMARY BORROW AREA
- EARTHEN CONTAINMENT DIKE SECONDARY BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

HORIZONTAL GRAPHIC SCALE
200' 100' 0 200' 400'
20' 10' 0 20' 40'
VERTICAL GRAPHIC SCALE

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION
STATE PROJECT NUMBER: BA-68
FEDERAL PROJECT NUMBER:
APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREAS SECTIONS
DATE: SEPTEMBER 2013
SHEET 37 OF 54

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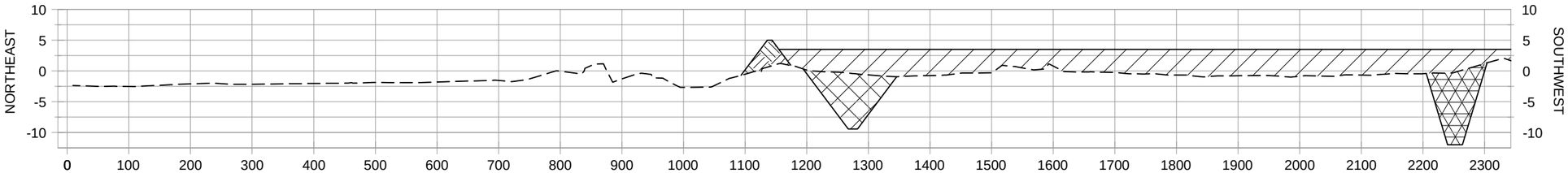

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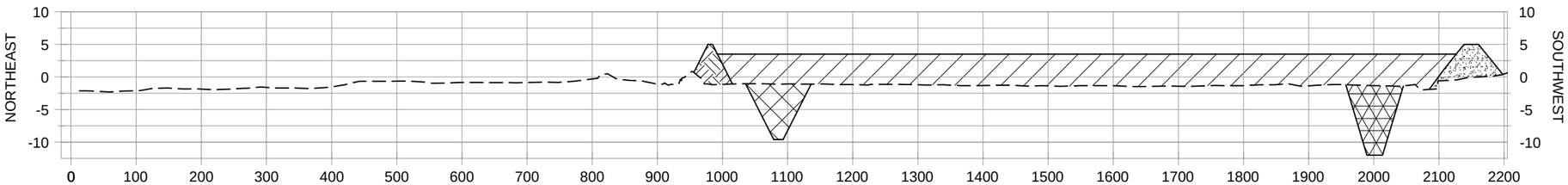

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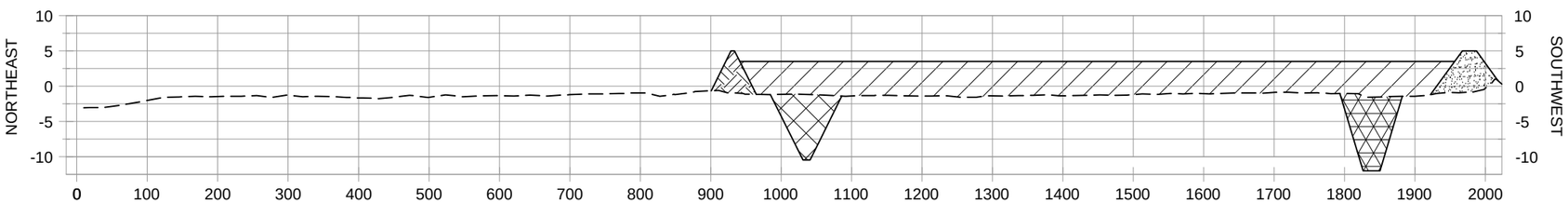

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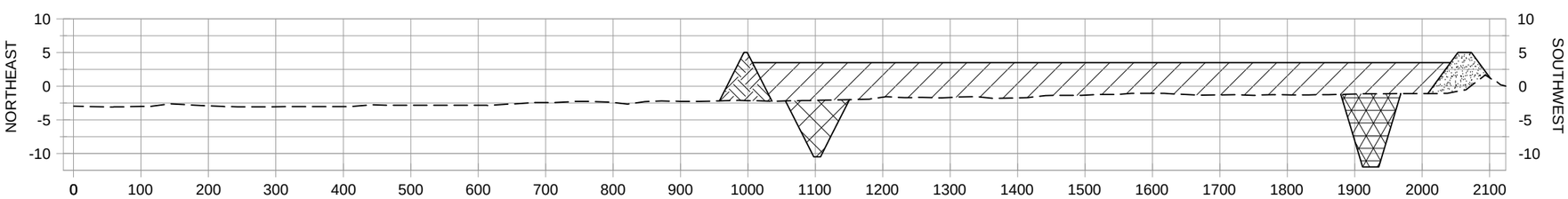

110+50

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREAS SECTIONS

DATE: SEPTEMBER 2013

SHEET 38 OF 54

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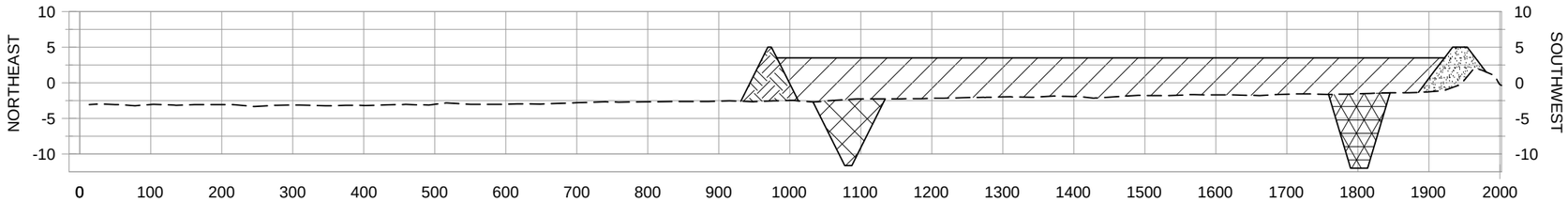

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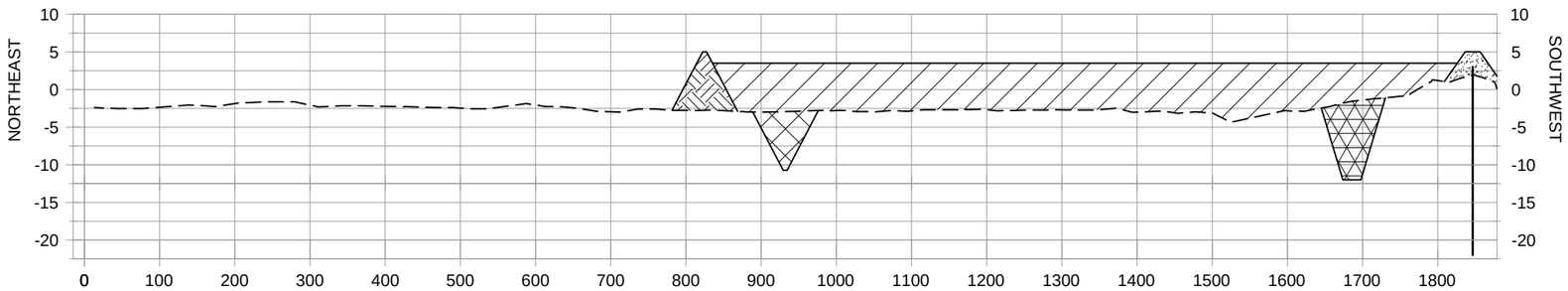

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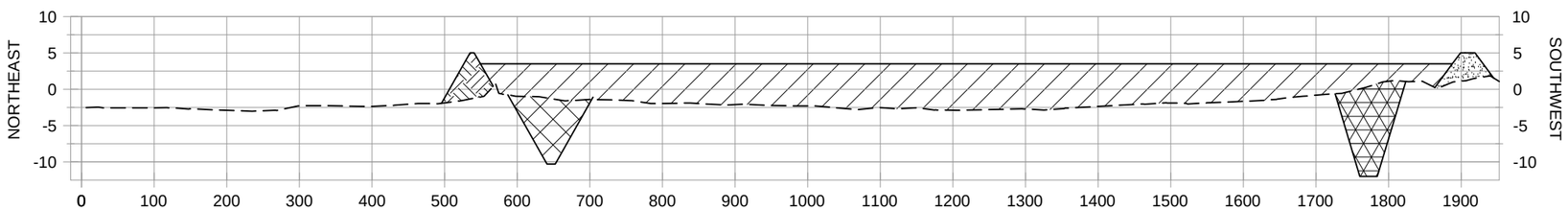

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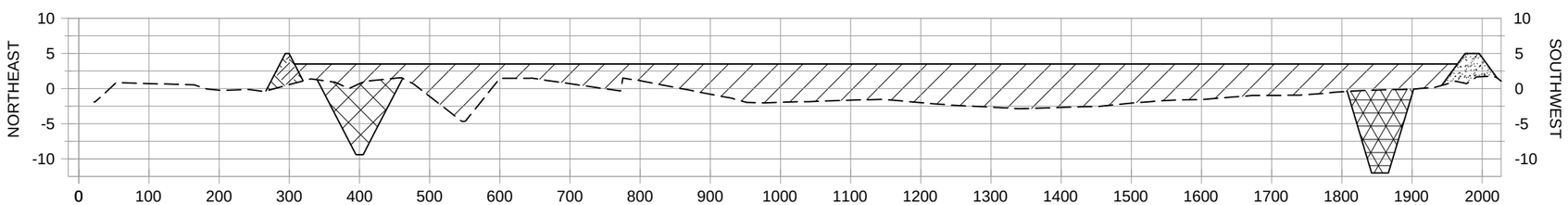

130+50

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND
- SHEET PILE CLOSURE

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREAS SECTIONS

DATE: SEPTEMBER 2013

SHEET 39 OF 54

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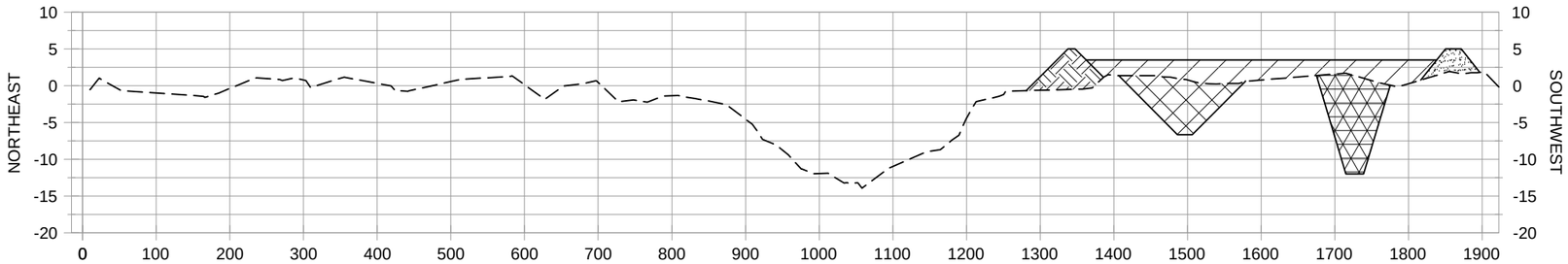

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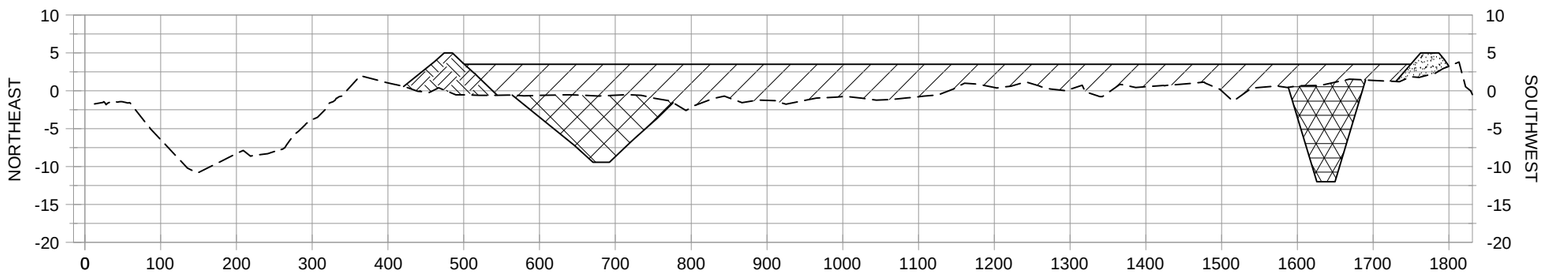

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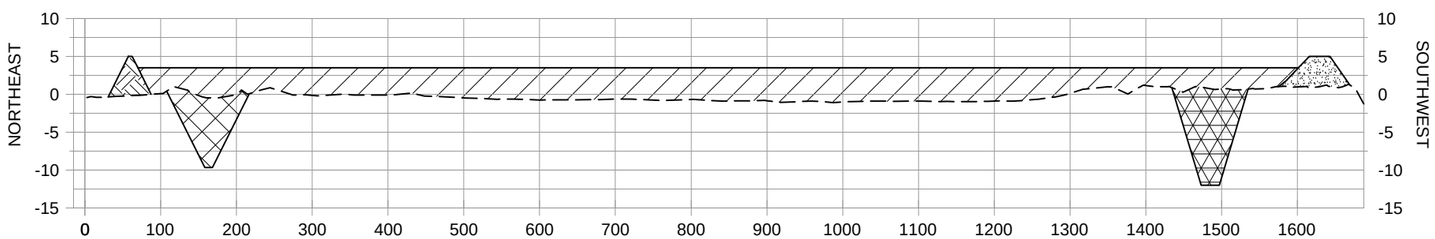

150+50

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREAS SECTIONS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU

DESIGNED BY: TYE FITZGERALD, P.E.

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 40 OF 54

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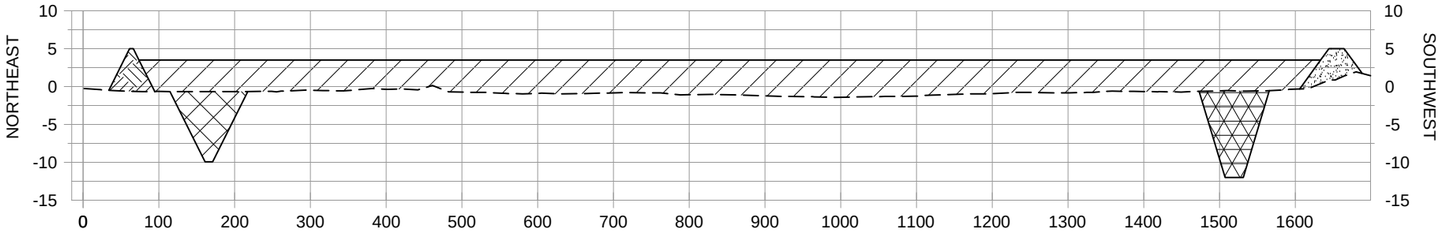

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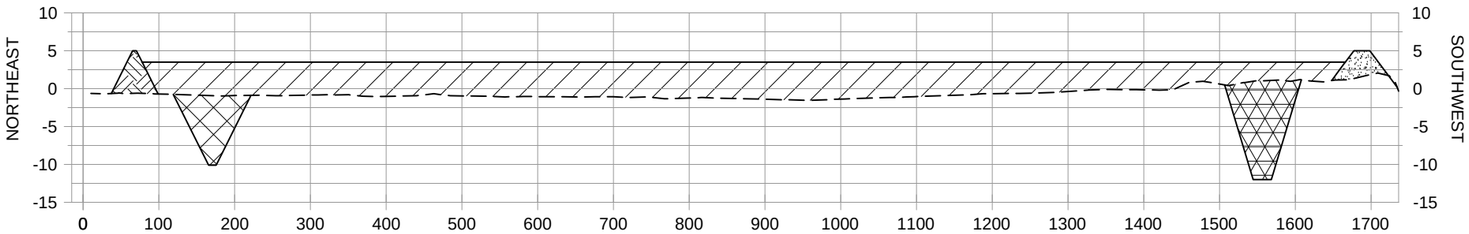

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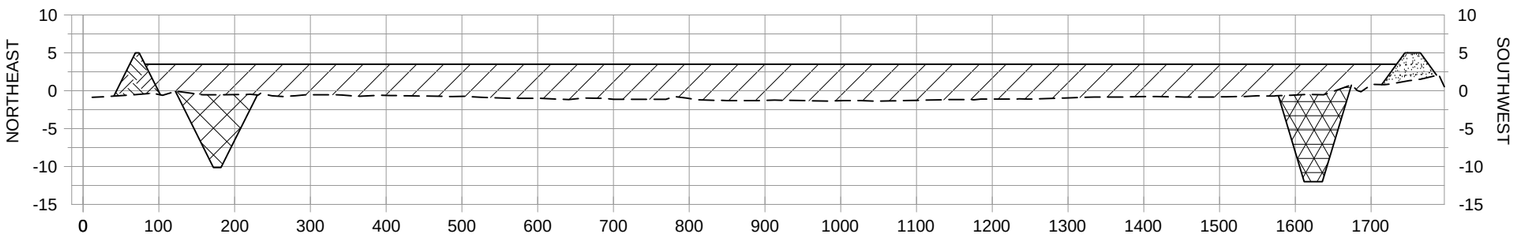

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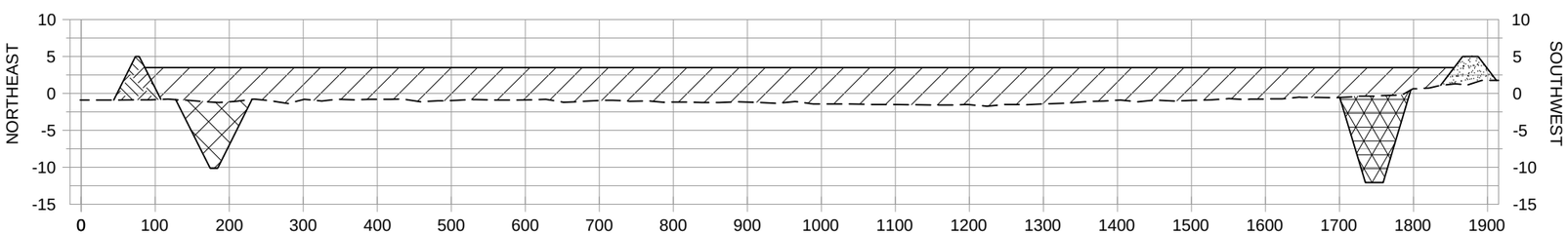

170+50

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

MARSH CREATION AREAS SECTIONS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU

DESIGNED BY: TYE FITZGERALD, P.E.

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 41 OF 54

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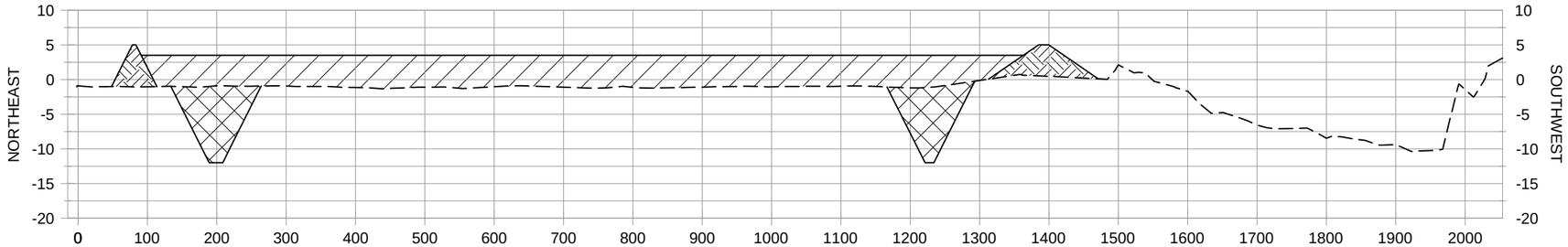

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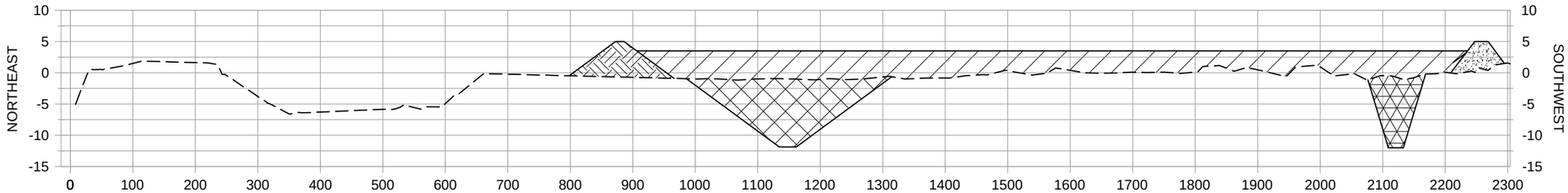

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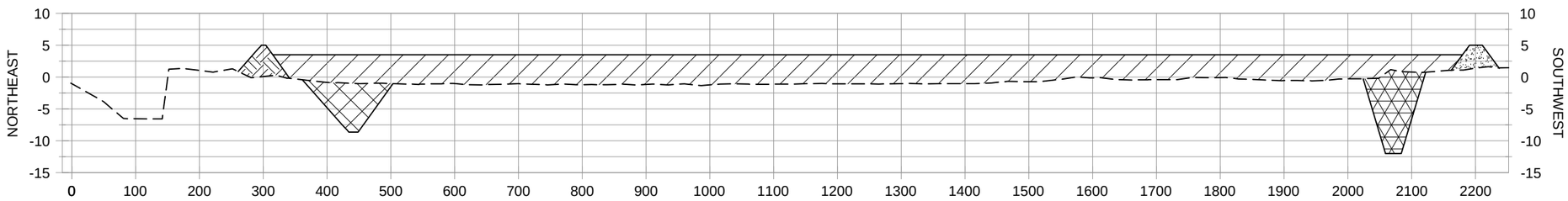

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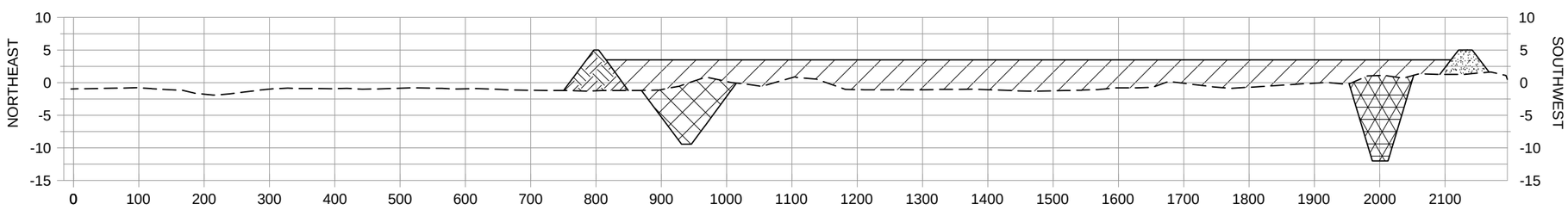

190+50

LEGEND

- MARSH CREATION AREA
- EARTHEN RIDGE
- EARTHEN CONTAINMENT DIKE
- EARTHEN CONTAINMENT DIKE BORROW AREA
- EARTHEN RIDGE SECONDARY BORROW AREA
- EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

MARSH CREATION AREAS SECTIONS

DATE: SEPTEMBER 2013

SHEET 42 OF 54

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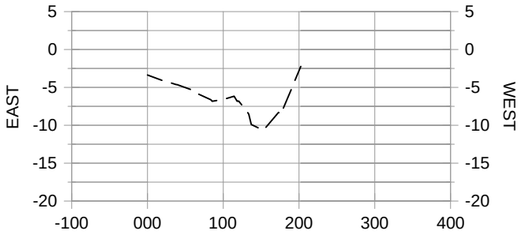

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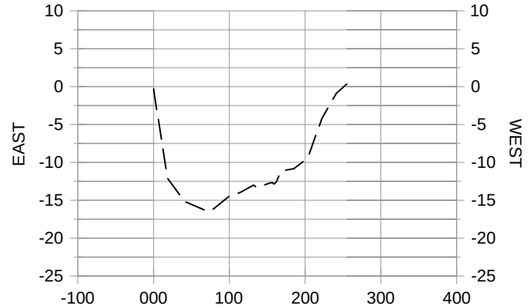

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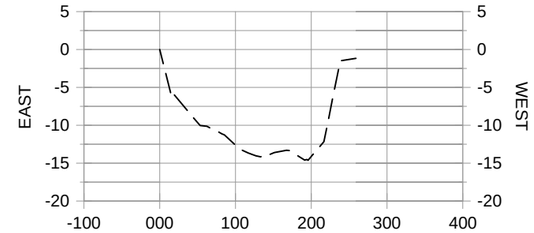

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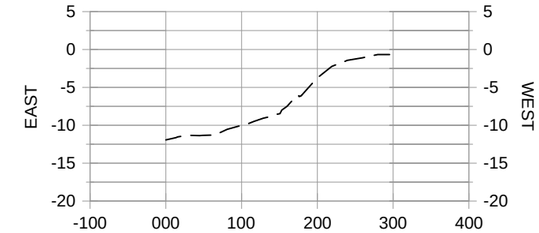

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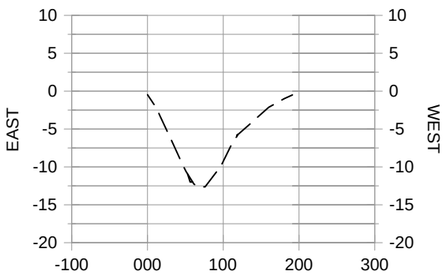

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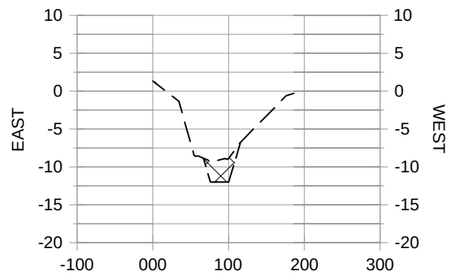

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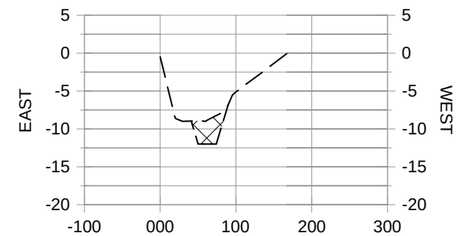

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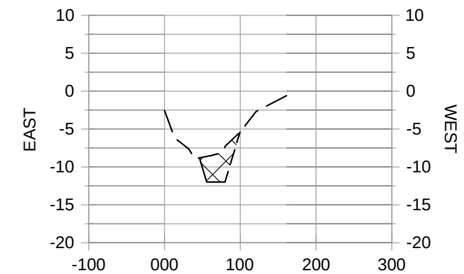

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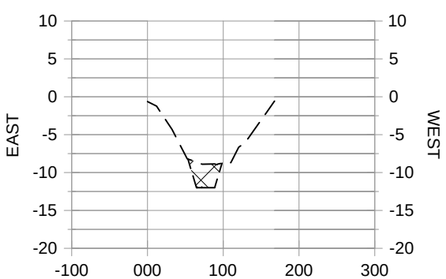

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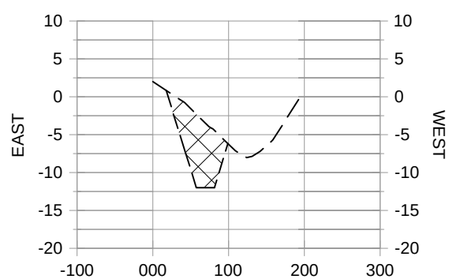

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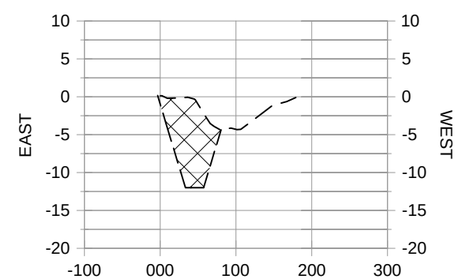

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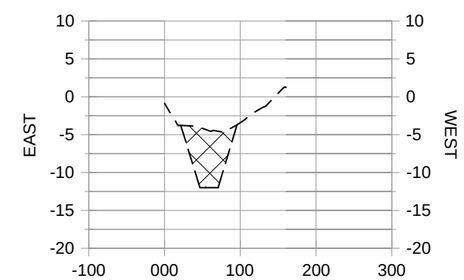

BAYOU TRANSECT 17

LEGEND

FLOTATION/BORROW AREA

EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

BAYOU SECTIONS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU

DESIGNED BY: TYE FITZGERALD, P.E.

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 43 OF 54

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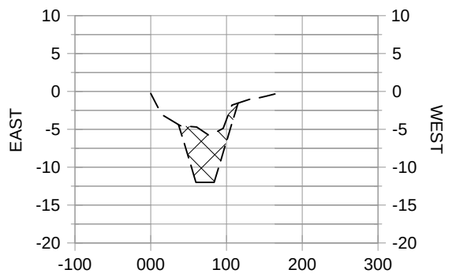

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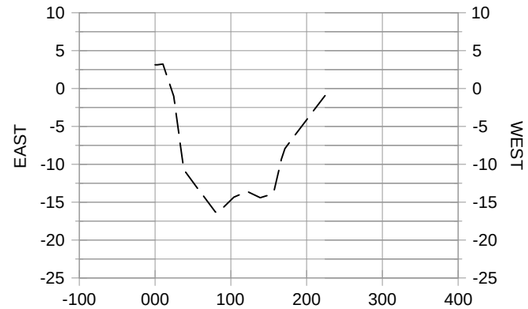

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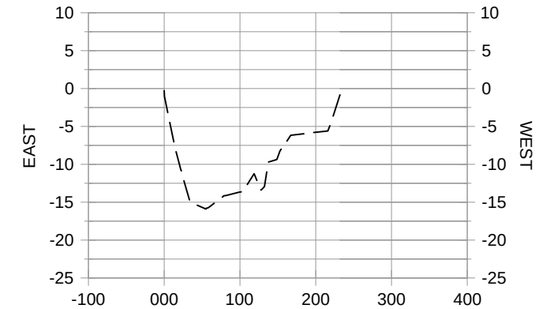

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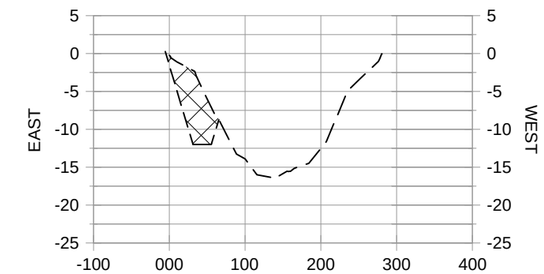

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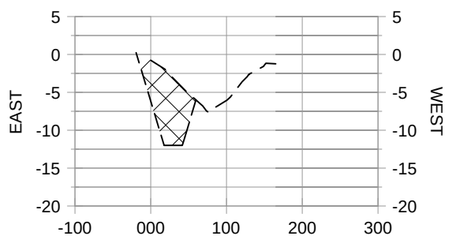

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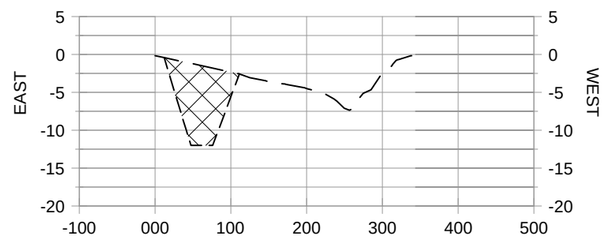

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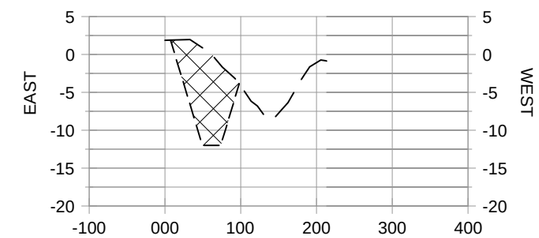

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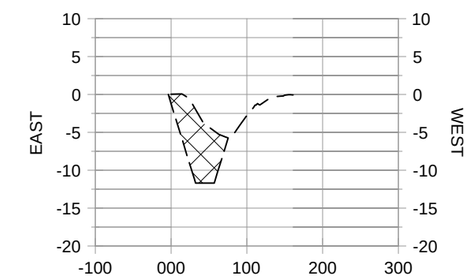

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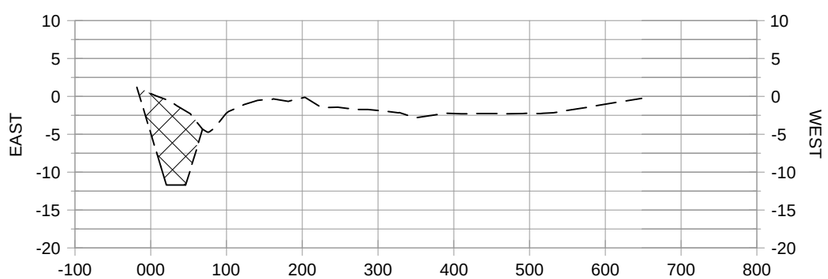

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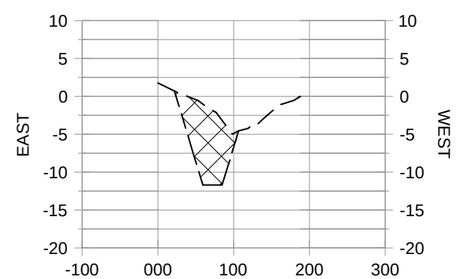

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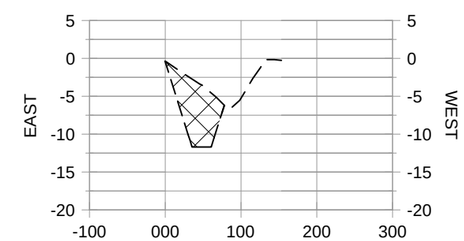

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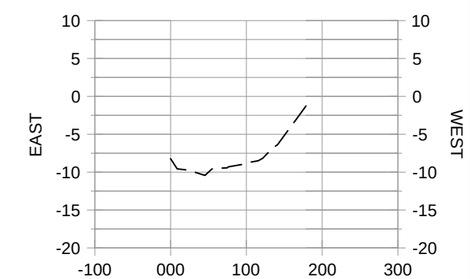

BAYOU TRANSECT 29

LEGEND	
	FLOTATION/BORROW AREA
	EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

BAYOU SECTIONS

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU

DESIGNED BY: TYE FITZGERALD, P.E.

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 44 OF 54

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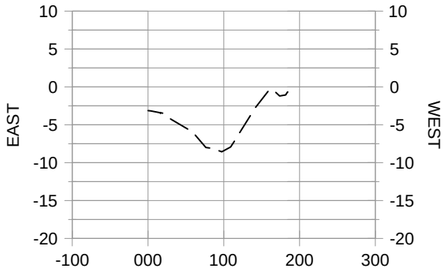

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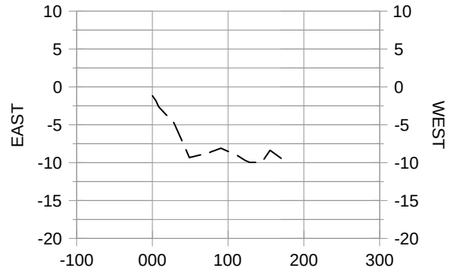

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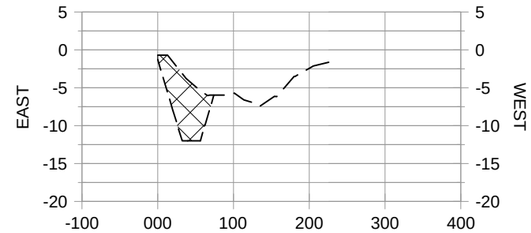

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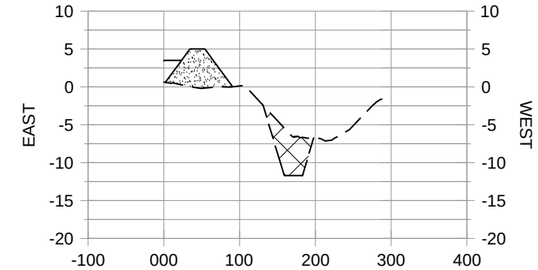

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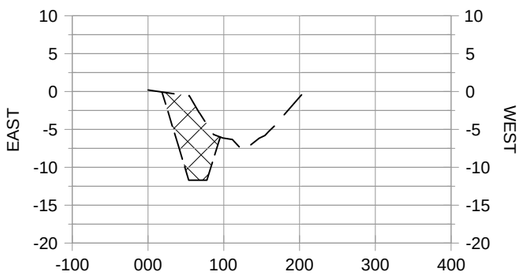

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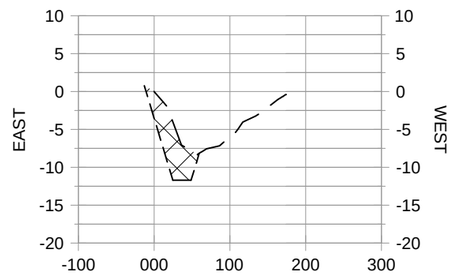

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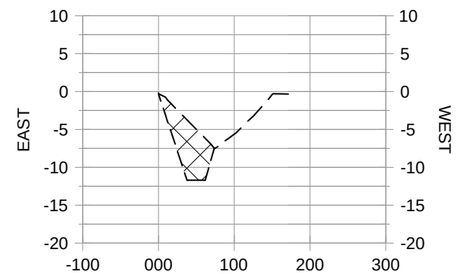

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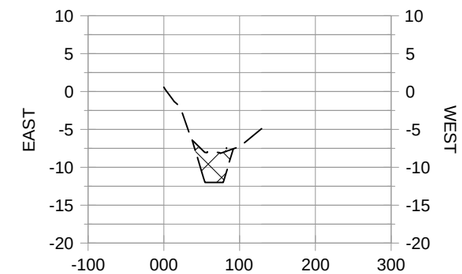

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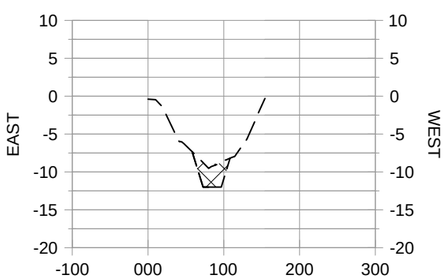

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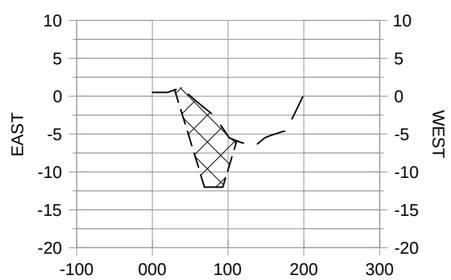

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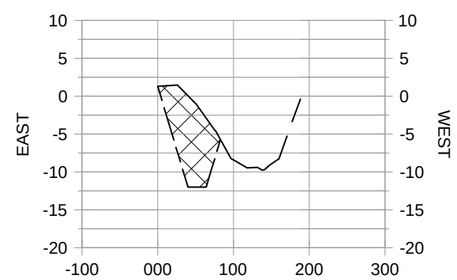

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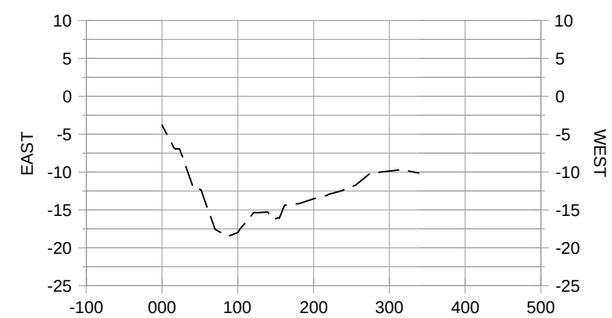

BAYOU TRANSECT 41

LEGEND

FLOTATION/BORROW AREA

EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

BAYOU SECTIONS

DATE: SEPTEMBER 2013

SHEET 45 OF 54

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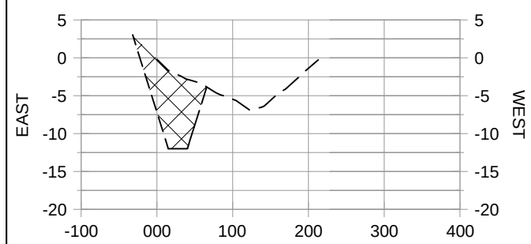

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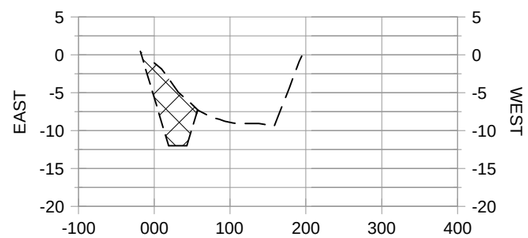

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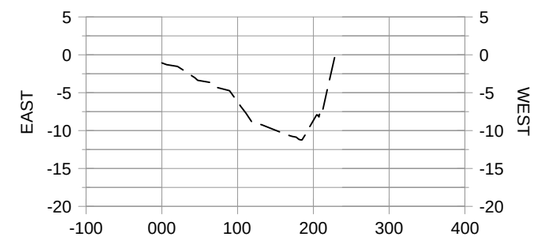

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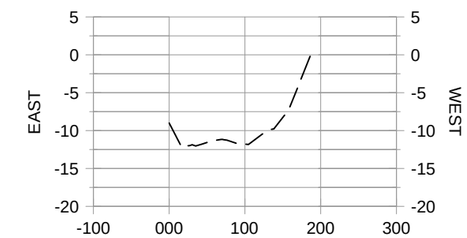

BAYOU TRANSECT 45

LEGEND

FLOTATION/BORROW AREA

EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU

DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

BAYOU SECTIONS

DATE: SEPTEMBER 2013

SHEET 46 OF 54

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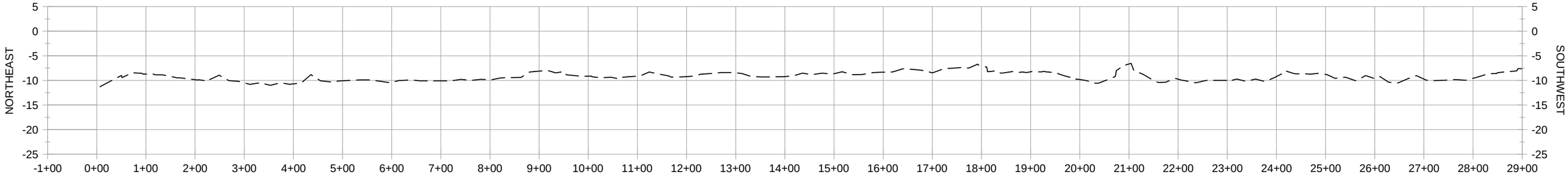

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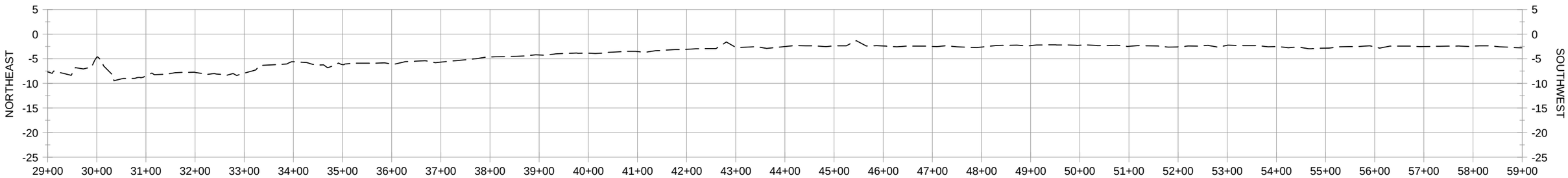

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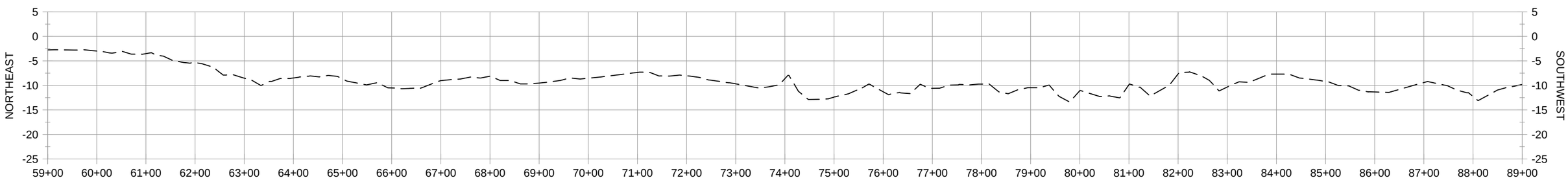

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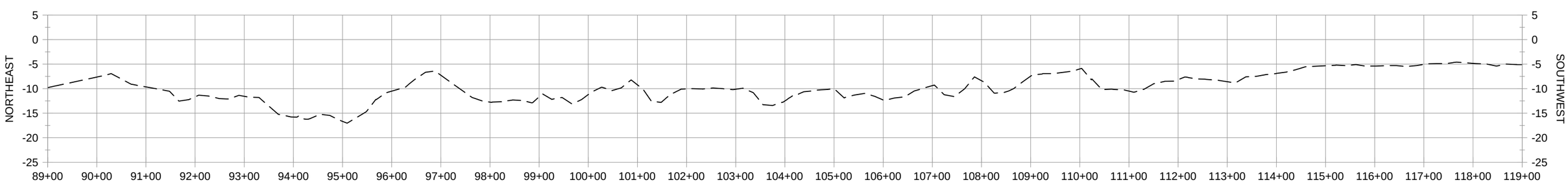

ACCESS PROFILE S1 CONTINUED

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

LEGEND

— — — EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

CONSTRUCTION & DREDGE DISCHARGE LINE ACCESS CHANNEL SECTIONS

DATE: SEPTEMBER 2013

DRAWN BY: KRISTI CANTU

DESIGNED BY: TYE FITZGERALD, P.E.

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

SHEET 47 OF 54

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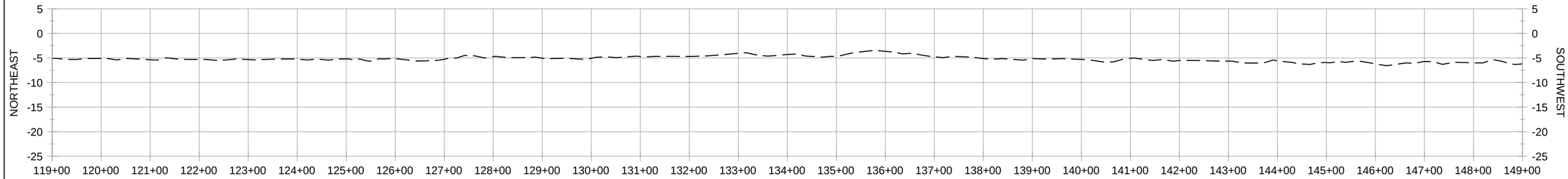

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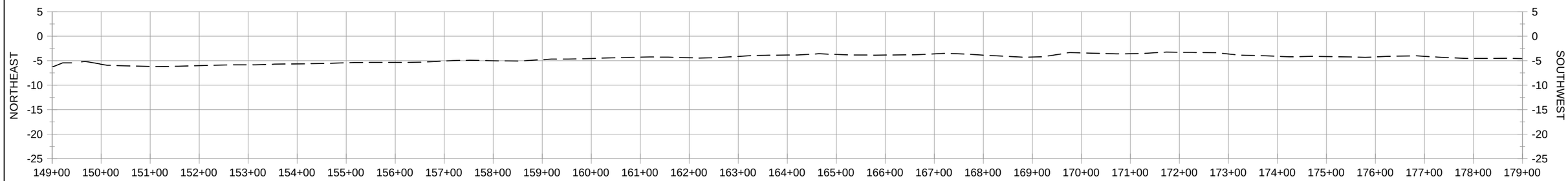

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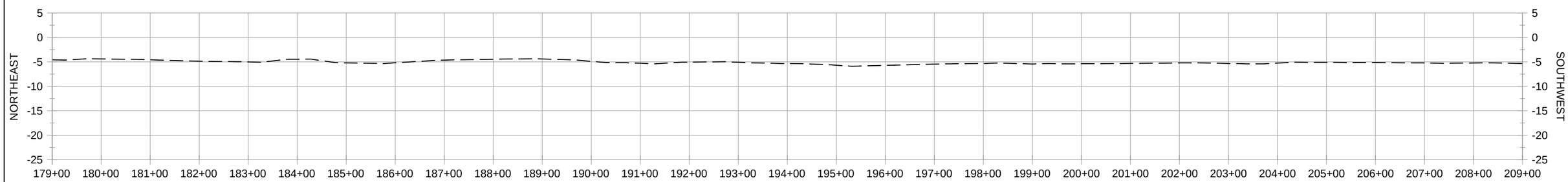

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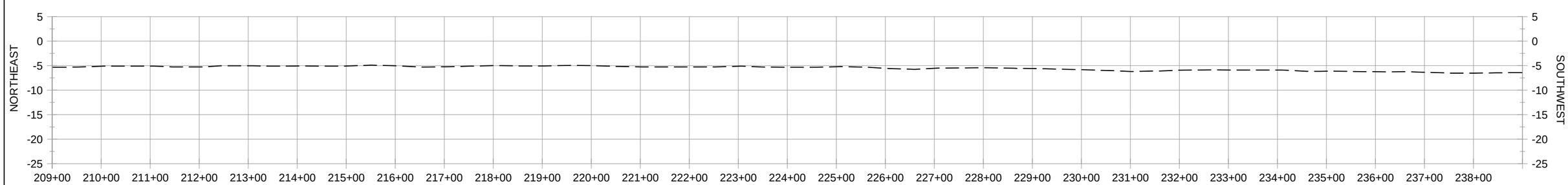

ACCESS PROFILE S1 CONTINUED

NOTE:
ALL ELEVATIONS ARE GIVEN IN THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

LEGEND
— — — EXISTING GROUND

HORIZONTAL GRAPHIC SCALE

200' 100' 0 200' 400'

20' 10' 0 20' 40'

VERTICAL GRAPHIC SCALE

REV.	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

DRAWN BY: KRISTI CANTU
DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

STATE PROJECT NUMBER: BA-68

FEDERAL PROJECT NUMBER:

APPROVED BY: RUDOLPH SIMONEAUX, P.E.

CONSTRUCTION & DREDGE DISCHARGE LINE ACCESS CHANNEL SECTIONS

DATE: SEPTEMBER 2013

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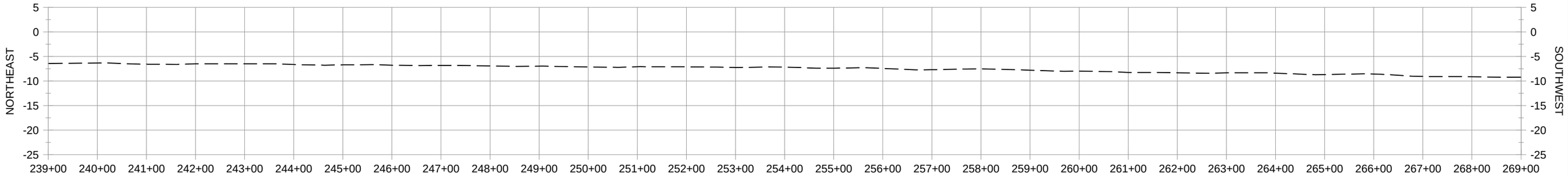

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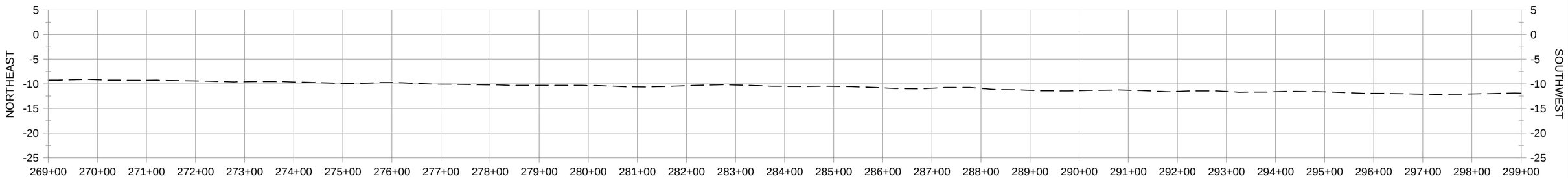

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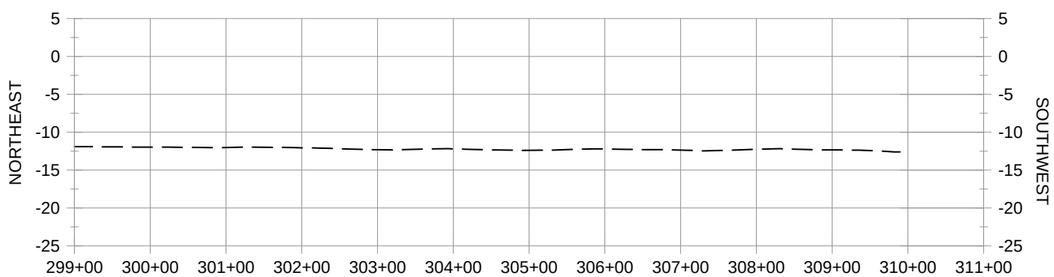

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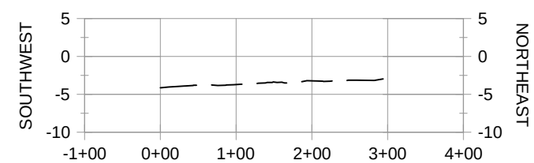

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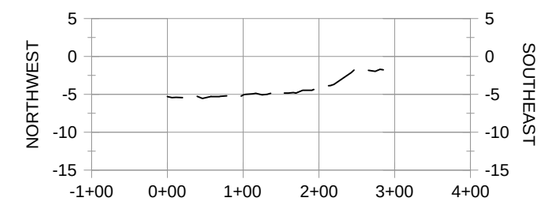

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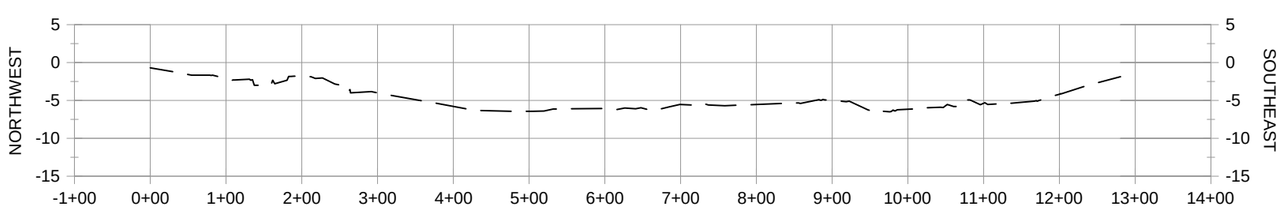

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HORIZONTAL GRAPHIC SCALE

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DESIGNED BY: TYE FITZGERALD, P.E.

GRAND LIARD MARSH AND RIDGE RESTORATION

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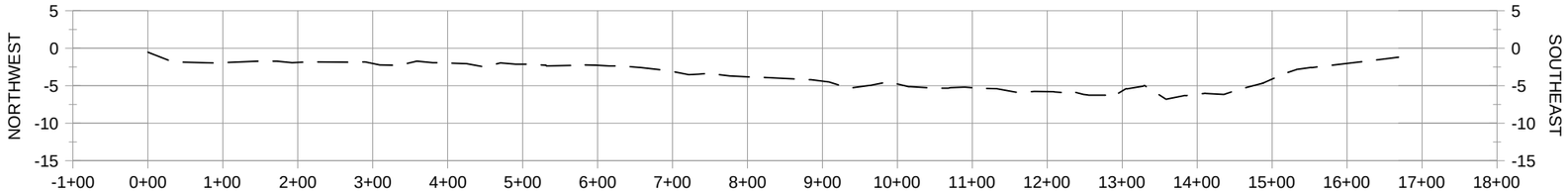

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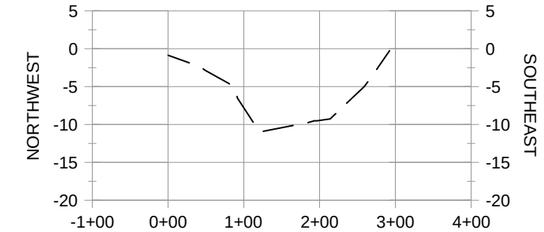

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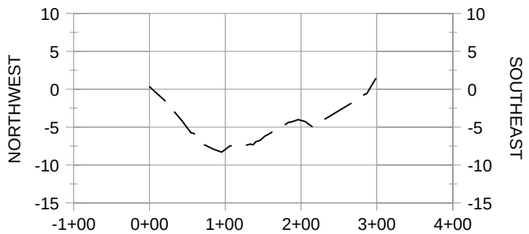

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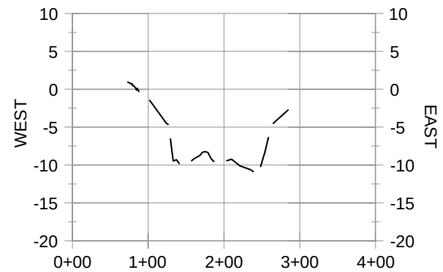

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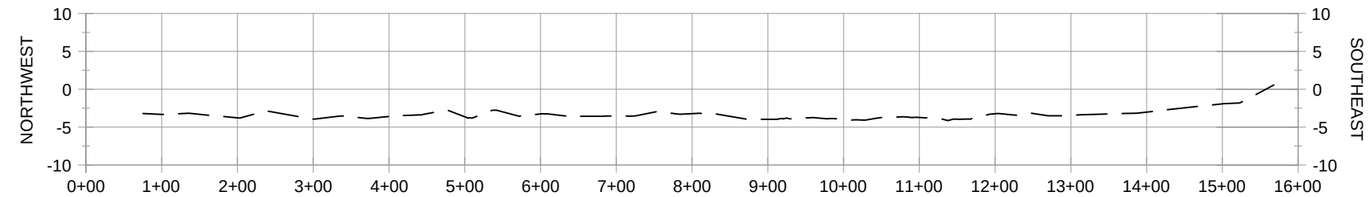

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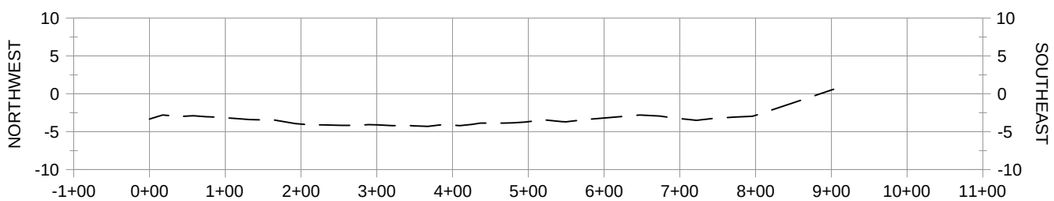

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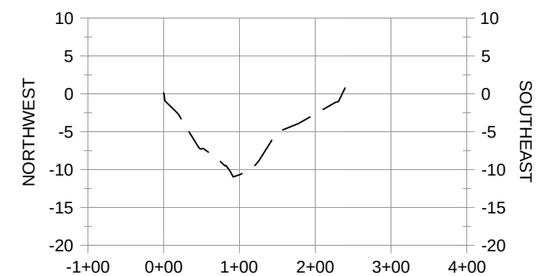

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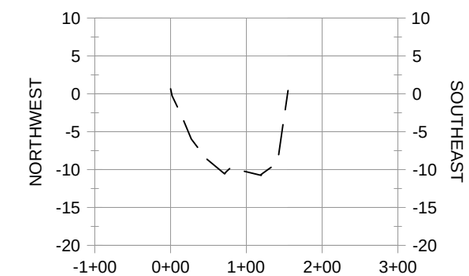

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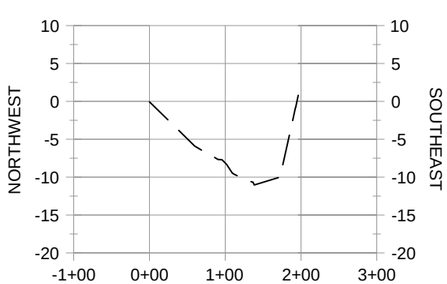

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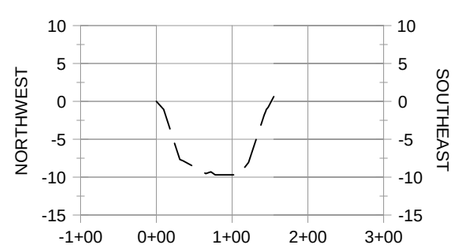

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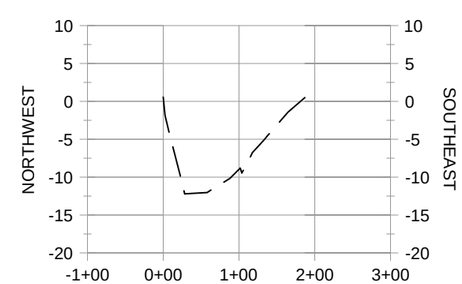

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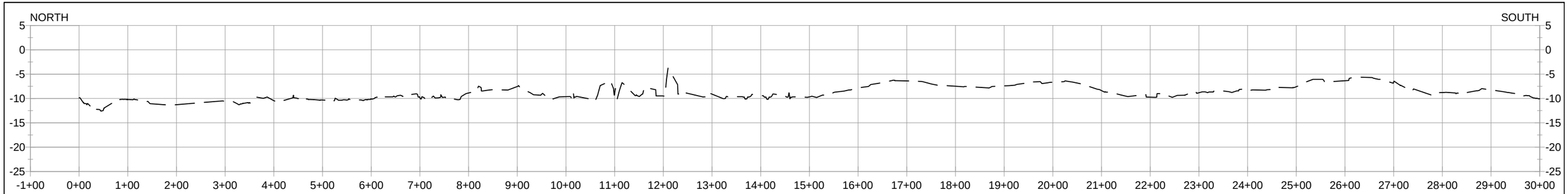

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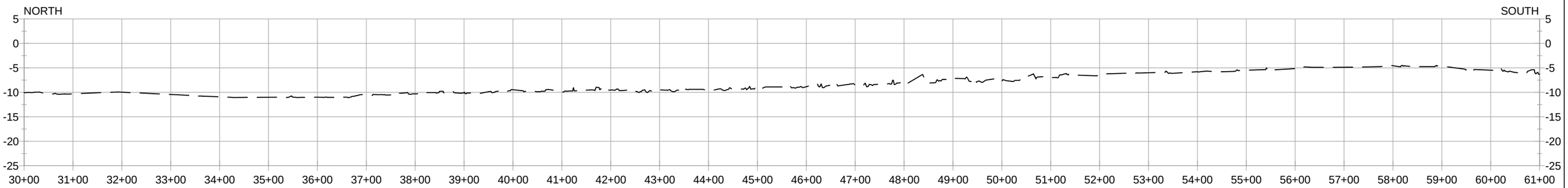

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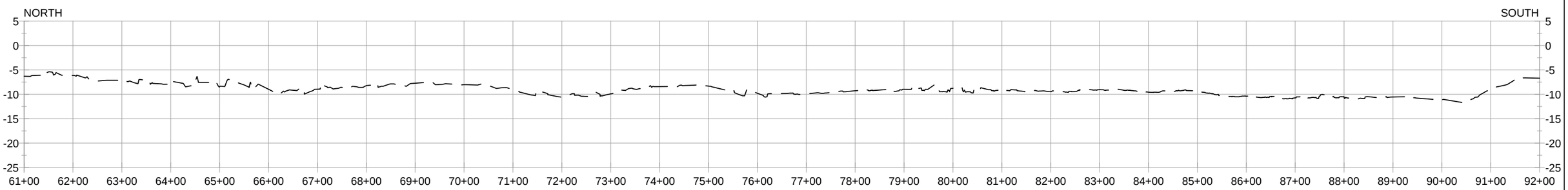

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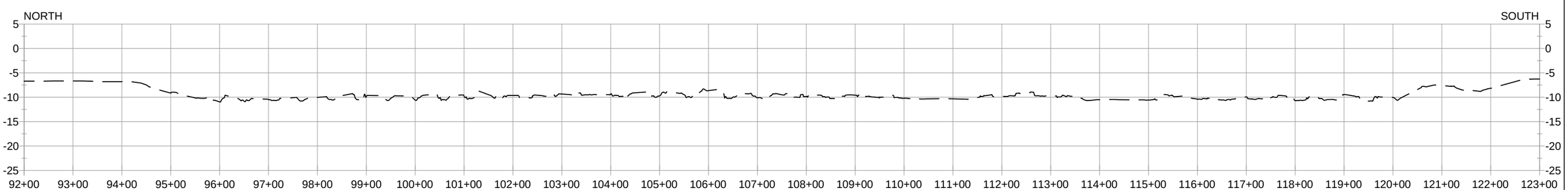

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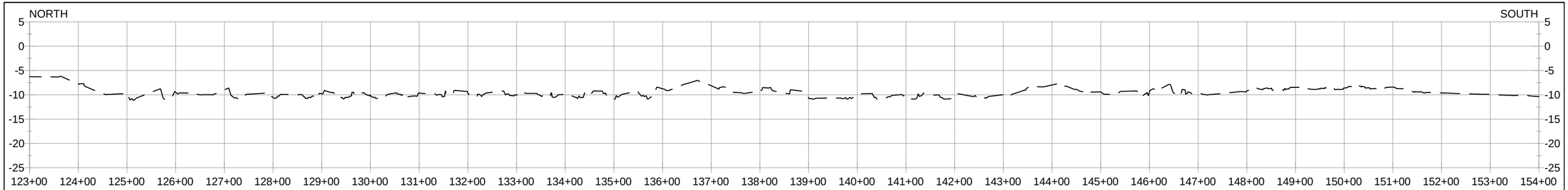

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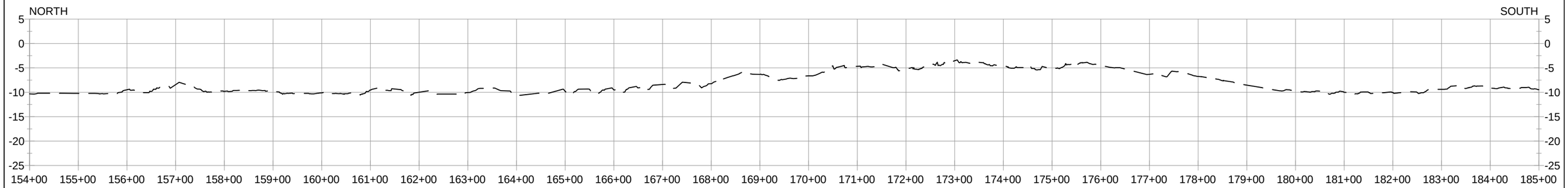

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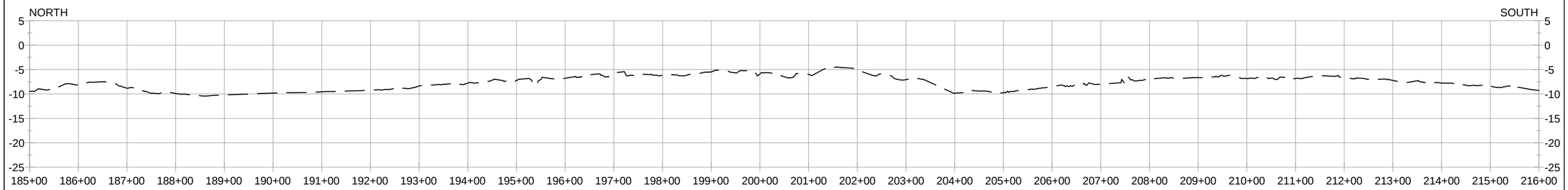

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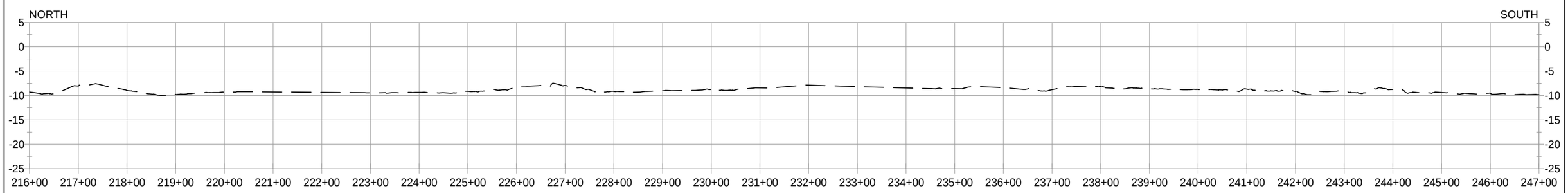

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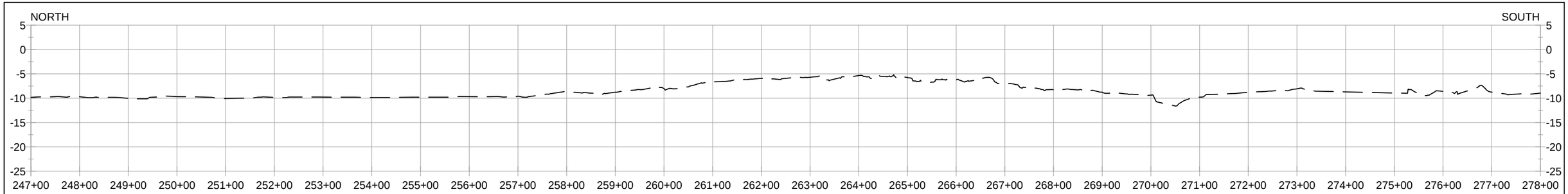

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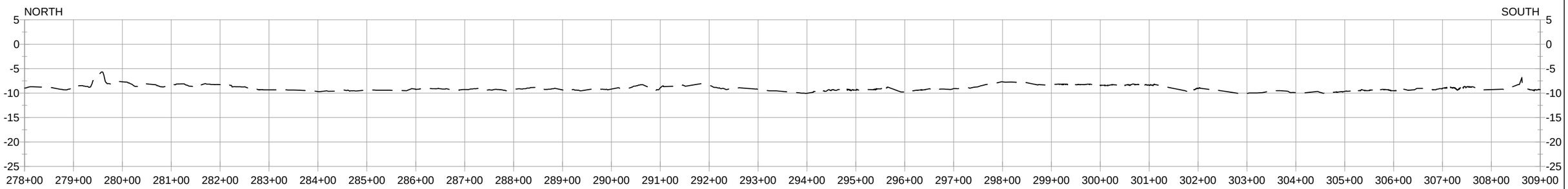

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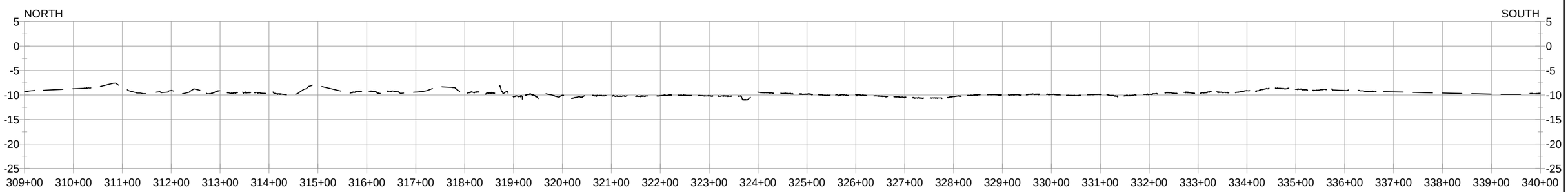

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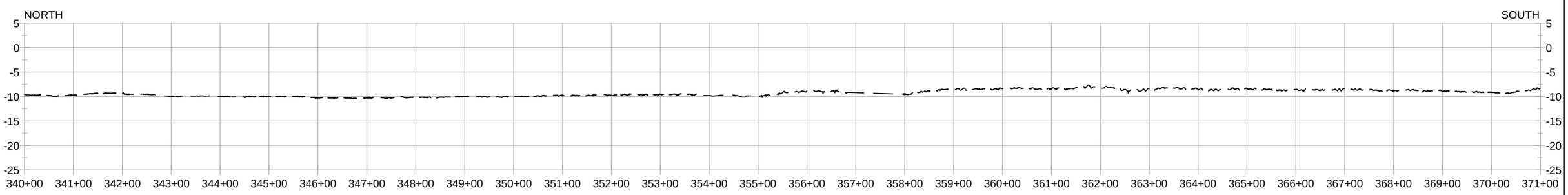

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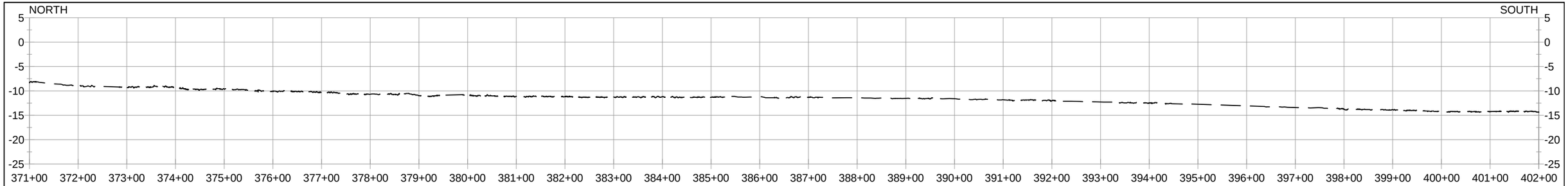

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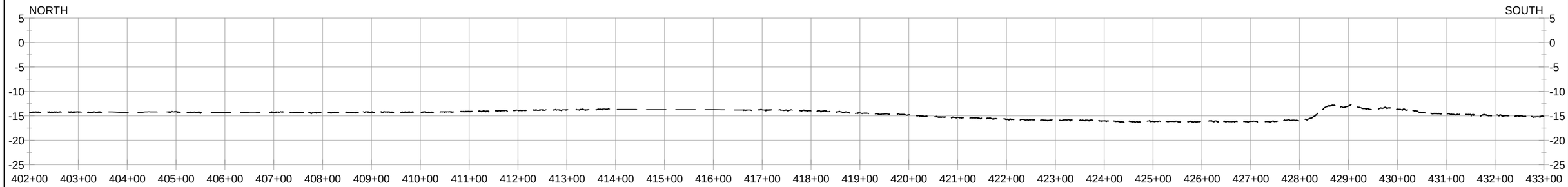

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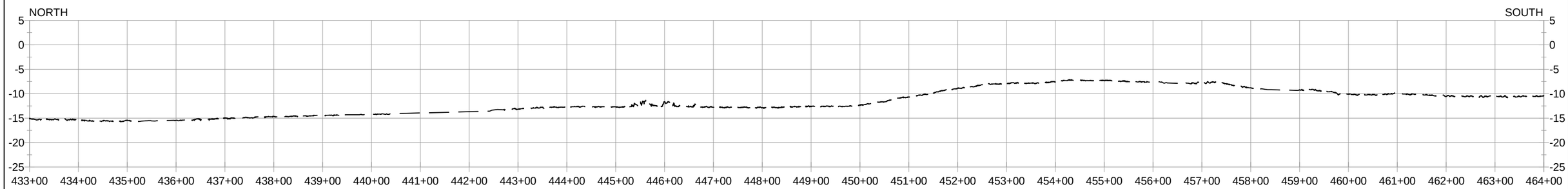

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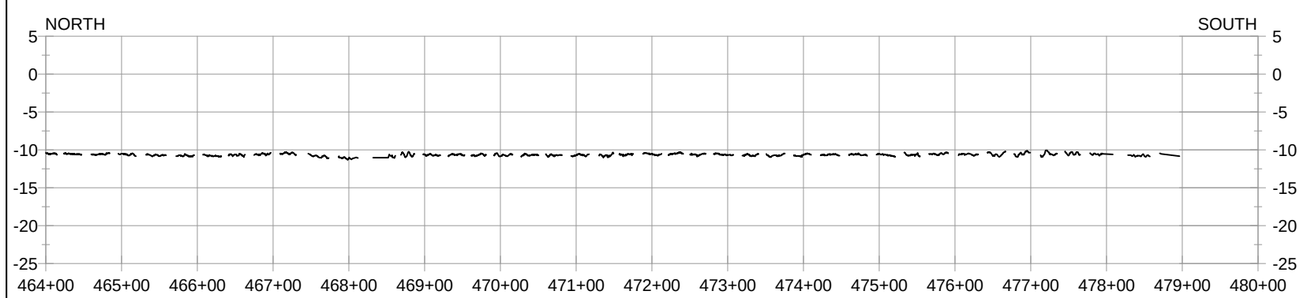

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Appendix J

Inshore Geotechnical Report

(Complete Report with Appendices available upon request)

Volume II: Geotechnical Engineering Report

Grand Liard Marsh and Ridge Restoration Project (BA-68)
Plaquemines Parish, Louisiana

for
Sigma Consulting Group, Inc.

March 21, 2011

GeoEngineers
Earth Science + Technology

Volume II: Geotechnical Engineering Report

Grand Liard Marsh and Ridge Restoration Project (BA-68)
Plaquemines Parish, Louisiana

for
Sigma Consulting Group, Inc.

March 21, 2011

GeoEngineers

11955 Lakeland Park Boulevard, Suite 100
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225.293.2460

Volume II: Geotechnical Engineering Report

Grand Liard Marsh and Ridge Restoration Project (BA-68)
Plaquemines Parish, Louisiana

LDNR Contract No. 2503-10-46

File No. 16715-018-00

March 21, 2011

Prepared for:

Sigma Consulting Group, Inc.
10305 Airline Highway
Baton Rouge, Louisiana 70816

Attention: Robbie Lear

Prepared by:

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INTRODUCTION

This report provides geotechnical engineering recommendations for the Grand Liard Marsh and Ridge Restoration project (BA-68) in accordance with the scope of services presented in the Louisiana Office of Coastal Protection and Restoration (OCPR) request dated May 2010, and our proposal dated June 16, 2010. The site location and a site map are shown in Figures II-1 and II-2 respectively. The main body of the engineering report contains interpreted geotechnical subsurface profiles and engineering recommendations. A summary of our slope stability and settlement calculations for marsh, containment dike and earthen ridge are provided in Appendix II-A, Appendix II-B and Appendix II-C, respectively. All elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88).

PROJECT UNDERSTANDING

Our understanding of the project is based on the information provided in our proposal dated June 16, 2010, and subsequent communications with OCPR and Sigma Consulting Group, Inc. (Sigma) during meetings on October 12, 2010, December 6, 2010, January 24, 2011 and February 22, 2011.

The project is estimated to create/restore about 500 acres of marsh and ridge habitat along the eastern bank of Bayou Grand Liard in Plaquemines Parish, Louisiana. As shown on Figure II-2, the project features include:

- Earthen Containment Dike: Construction of earthen dikes to contain approximately 328 acres for marsh creation.
- Marsh: Creation of approximately 328 acres of marsh habitat and nourishment of approximately 140 acres of existing marsh that will be done using hydraulic dredge and pumped sediment from the Gulf of Mexico East Borrow Site as shown on Figure II-2.
- Earthen Ridge: Creation of approximately 20,000 linear feet (34 acres) of maritime ridge along the eastern bank of Bayou Grand Liard.

PURPOSE AND SCOPE OF SERVICES

The purpose of our services was to collect geotechnical data and perform geotechnical analyses to develop recommendations for marsh and ridge restoration. Our specific scope of services included the following:

1. Visited the site to observe field conditions and better understand the project conditions.
2. Contacted Louisiana "One-Call" to notify them of our intent to perform soil borings at this site and to clear the boring locations of potential underground utilities.
3. Performed field exploration and laboratory analyses as provided in Volume I- Geotechnical Data Collection report.

4. Evaluated subsurface data and identified appropriate design profiles representing different sections along the project alignment.
5. Completed the following evaluations for each design profile as requested by OCPR:
    a. Marsh Creation (Design profiles 7, 8, 9 and 10):
        i. Settlement analyses to determine the initial marsh elevation required to reach intertidal, between MHW and MLW, around three years after placement of second lift of dredged fill.
        ii. Marsh settlement versus time over a 20-year period was checked for a range of initial fill elevations from elevation +2.0 to +4.5 feet NAVD 88 for a single lift scenario and from elevation +2.8 to +4.0 feet NAVD 88 for a two lift scenario.
    b. Containment Dike (Design profiles 7, 8, 9 and 10):
        i. Stability analyses to determine stable side slopes and minimum berm width between the containment dike toe and access channel excavation.
        ii. Settlement analyses for the stable configuration at the end of construction (assumed 30 days), 1 year, 5 years, 10 years, and 20 years.
    c. Earthen Ridge (Design profiles 1, 3, 4, 6 and combined 2 & 5):
        i. Analyses to determine the stability of the ridge section provided by OCPR with base width of 100 feet and crown width of 20 feet for three different scenarios given below:
            1. Ridge constructed with material from the Bayou Grand Liard.
            2. Ridge constructed with material from the Gulf of Mexico east borrow site.
            3. Ridge constructed with material from the proposed marsh creation area.
        ii. Analyses were also performed to determine the minimum berm required between the ridge toe and excavation channel in Bayou Grand Liard and existing marsh where applicable.
        iii. Settlement analyses for the stable configuration at the end of construction (assumed 30 days), 1 year, 5 years, 10 years, and 20 years.
6. Provided general construction recommendations.
7. Prepared this geotechnical engineering report, a geotechnical data collection report, and calculations package for this project.

SUBSURFACE CONDITIONS

Based on the field exploration data and subsequent laboratory testing, nine design soil profiles were developed (combined soil profiles 2 and 5). A subsurface soil section based on soil borings is shown in Figure II-4. Due to significant variation in soil borings, grouping of soil borings could not be performed, except for soil borings 2 and 5 which were combined into one design profile. In

general, except for soil boring B-1, all borings encountered high organic content soil and/or cohesive soil in the upper 6-14 feet. These soils predominantly consisted of peat, organic clay, silty clay and clay. The consistency of these soils based on laboratory tests was determined to be very soft.

Beneath the high organic content soil and/or cohesive soil, semi-cohesive soil and/or non-cohesive soil were encountered beneath which cohesive soil (except soil boring B-9) was encountered. Intermittent layers of granular soils were also encountered in most of the borings. The semi-cohesive and non-cohesive soils predominantly consisted of silt, sandy silt, silty sand, and sand. The cohesive soil underneath the semi-cohesive and/or non-cohesive soils predominantly consisted of clay and sandy clay. In general, the consistency of the soils improved by depth.

For additional information, please refer to the detailed soil boring logs provided in the geotechnical data report for this project.

Borrow Area Stratigraphy

Based on the information provided by OCPR, the borrow area materials in the Gulf of Mexico east borrow site were predominantly fine grained cohesive and semi-cohesive soils. These soils predominantly consisted of clay, sandy clay, clayey silt, and silt. Intermittent granular soil layers and pockets were encountered in some borings performed in the borrow area. These granular soils consisted predominantly of silty sand, clayey sand, and sand.

For details and additional information, please refer to soil boring data provided in the geotechnical data report.

CONCLUSIONS AND RECOMMENDATIONS

General

Based on the investigation results, the proposed improvement area is generally suitable for the proposed containment dike and shoreline earthen ridge construction, and marsh creation. The summary results of the slope stability and settlement analyses are presented in Tables 1 through 5. Details of the analysis methods are presented in Appendices II-A through II-C for slope stability and settlement.

GeoEngineers performed stability analyses using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory to evaluate the stability of earth slopes. Subsurface soil properties were estimated using the results of subsurface explorations and associated laboratory testing. The soil units and soil properties used in the stability model are included in the geotechnical data report.

Identifying the critical slip surface with the lowest factor of safety was accomplished by an iterative process by which the program calculated the factor of safety for a large number of potential slip surfaces. A minimum required factor of safety of 1.3 against failure was used for this project.

GeoEngineers performed settlement analyses for the containment dike, earthen ridge and marsh fill sections based on Terzaghi's one-dimensional linear consolidation theory. Settlement parameters were developed using consolidation test results. Published correlations and correlations based on test data from this project and similar projects were used to develop settlement parameters for soil without a consolidation test.

In addition to consolidation settlement, there will be elastic settlement. Estimates of elastic settlement, which occurs during earth fill placement, are about 20 percent of the long-term consolidation settlement. The total settlement will be the consolidation settlement plus the construction (immediate elastic) settlement. However, the construction settlement will not be recognized because more earthen fill will be placed to achieve the required end-of-construction elevation during construction.

Another component of settlement for this project is settlement within fill placed at the site. For dredged fill, a computer program model was used as discussed below. For mechanically placed fill for the earthen ridge and containment dike, a settlement of six inches was assumed within the fill. There are many factors that will affect this number including organic content, disturbance, and placement methods. Six inches was assumed as a reasonable estimate, and has been incorporated into all the tables and figures showing settlement estimates in this report.

Settlement figures presented in this report show the estimated mean high water (MHW) and mean low water (MLW) levels for the next 20 years based on data provided by the OCPR. This information was provided by and included at the request of the OCPR. GeoEngineers is not aware of the source of these projected water levels.

Marsh Creation

Settlement (Design profiles 7, 8, 9 and 10)

The average existing marsh mudline surface was determined based on the survey information provided by Sigma (presented in the geotechnical data report). The water level was assumed to be at elevation 0.0 feet NAVD 88. The proposed marsh creation target elevation is +1.4 feet NAVD 88 twenty years after construction. However, during the meeting with OCPR on January 24, 2011, OCPR determined that the target elevation of +1.4 feet after 20 years was not mandatory so long that the estimated marsh settlement is between the projected MHW and MLW for the design period.

The height of dredged material in a contained area is reduced by primary consolidation, secondary consolidation, and desiccation within the dredged fill, as well as settlement of soil beneath the fill. The consolidation settlement and time rate of settlement analyses within the dredged fill for the marsh creation area were performed using the Primary consolidation, Secondary compression, and Desiccation of Dredged Fill (PSDDF) program. Laboratory tests performed on composite samples prepared from the proposed borrow area were used to establish the input parameters for the dredged fill materials. The borrow area soil samples were provided by the OCPR.

In addition to the dredged material settlement, the existing soil beneath the dredge fill areas will experience consolidation settlement from the additional fill overburden placed during dredging.

This settlement was determined using the procedures described previously using the load area dimensions and pressure consistent with the dredged fill.

The sum of the dredged fill settlement and the underlying soil settlement was used to determine the total settlement that will be realized at the surface of the dredged fill area after filling is complete. Dredged fill settlement evaluations were initially performed for single lift scenario with projected fill placed to an elevation of +2.0 and +4.5 feet. In both cases, the final elevation of dredged fill over a 20-year design life was estimated to be below elevation of +1.4 feet and below the MLW for most of the design life. Hence, the settlement for dredged fill was estimated over a 20-year design life for a two-lift scenario where dredged fill is placed to an initial elevation of +4.0 feet and re-filled back to elevation +4.0 feet 60 days after placement of initial fill. In other words, the time gap between the end of initial lift to the beginning of placing the second lift is 60 days.

Figures II-A1 through II-A4 in Appendix II-A provide both graphical and tabular summaries of marsh elevation versus time for a 20-year period for single and two-lift scenarios for an initial marsh fill elevation of +4.0 feet NAVD 88 based on the combined settlement of the dredged fill and underlying soil. These results were not acceptable to OCPR due to the following reasons:

1. The settlement curves for Groups B-7 through B-10 did not reach intertidal, between Mean High Water (MHW) and Mean Low Water (MLW), around three years after placement of the second lift of dredged fill. This was determined to be essential during the meeting on January 24, 2011. It was also determined during this meeting that the target elevation of +1.4 feet after 20 years was not mandatory so long that the estimated marsh settlement is between the projected MHW and MLW for the design period.

2. The marsh elevation at Group 7 and Group 9 was at or above +1.9 feet after 20 years which was not acceptable based on the meeting on January 24, 2011.

3. Time gap between the end of initial lift to beginning of placing second lift was revised on January 24, 2011 for each cell as shown below:

TABLE 1: TIME GAP BETWEEN LIFT 1 AND LIFT 2

Cell	Boring in the Area	Initial Time Gap (End of lift 1 to beginning of lift 2) (days)	Revised Time Gap (End of lift 1 to beginning of lift 2) (days)
A	B-7	60	80
B	B-8	60	75
C	B-9	60	85
D	B-10	60	85

Based on information provided on January 24, 2011 and February 22, 2011, GeoEngineers performed settlement analysis for various dredged fill elevations given below:

TABLE 2: DREDGED FILL ELEVATION AT EACH CELL

Cell	Fill Elevation (January 24, 2011)		Fill Elevation (February 22, 2011)	
	Lift 1	Lift 2	Lift 1	Lift 2
7	3.5	3.0	3.5	3.5
8	4.0	3.0	3.5	3.5
9	3.5	3.0	3.5	2.8
10	3.5	3.5	3.5	3.0

Figures II-A5 through II-A12 in Appendix II-A provide both graphical and tabular summaries of marsh elevation versus time for a 20-year period for single and two-lift scenarios for an initial marsh fill elevation as shown in Table 2. Based on the combined settlement of the dredged fill and underlying soil, the estimated elastic settlement for each marsh fill scenario is provided in Table 3 below. The elastic construction settlement should be added to the total dredged fill height for purposes of quantity estimates.

TABLE 3. ELASTIC CONSTRUCTION SETTLEMENT OF FOUNDATION SOILS IN MARSH FILL AREA

Design Profile	Initial Marsh Fill Elevation (Feet NAVD 88)	Time Gap (End of lift 1 to beginning of lift 2) (days)	Estimated Elastic Construction Settlement (inches)	
			Lift 1	Lift 2
7	Lift 1@ 4 / Lift 2 @ 4	60	4	1
	Lift 1@ 3.5 / Lift 2 @ 3.5	80	4	1
	Lift 1@ 3.5 / Lift 2 @ 3.0	80	4	1
8	Lift 1@ 4 / Lift 2 @ 4	60	3	1
	Lift 1@ 4.0 / Lift 2 @ 3.0	75	3	1
	Lift 1@ 3.5 / Lift 2 @ 3.5	75	3	1
9	Lift 1@ 4 / Lift 2 @ 4	60	3	1
	Lift 1@ 3.5 / Lift 2 @ 3.0	85	3	1
	Lift 1@ 3.5 / Lift 2 @ 2.8	85	3	1
10	Lift 1@ 4 / Lift 2 @ 4	60	5	1
	Lift 1@ 3.5 / Lift 2 @ 3.5	85	4	1
	Lift 1@ 3.5 / Lift 2 @ 3.0	85	4	1

Containment Dike

Slope Stability (Design profiles 7, 8, 9 and 10)

Slope stability analyses were performed for a typical containment dike section with an adjacent excavation access channel to determine the minimum required horizontal distance from the

excavation access channel to the containment dike, and verify side slope requirements, as shown in Figure II-5.

The analysis results indicate that side slopes of 5H:1V for the containment dike will provide a 1.3 factor of safety or greater on the excavation access channel side of the embankment for all sections. The containment dike sections were analyzed with a 20-foot berm from the dike toe to the excavation access channel bank. The excavation access channel was assumed to be excavated to a maximum depth of 5 feet below the existing mudline and with a 3H:1V bank slope. Results are summarized in Table 4 below.

The OCPR requires a freeboard of at least one foot on the marsh side during placement of dredged fill. Based on this, marsh fill containment requirements, and a 6-inch allowance for settlement within the containment dike fill, an initial completed containment dike elevation of +5.5 feet, NAVD 88 is recommended.

Figures II-B1 through II-B4 in Appendix II-B show the critical failure surface in the containment dike section for design profiles 7, 8, 9 and 10.

TABLE 4. CONTAINMENT DIKE SLOPE STABILITY ANALYSIS RESULTS

Design Profile	Location	Side slopes (H:V)	Factor of Safety
7	Marsh Side	5:1	1.54
8	Marsh Side	5:1	1.30
9	Marsh Side	5:1	1.40
10	Marsh Side	5:1	1.37

Settlement (Design profiles 7, 8, 9 and 10)

All settlements were based on side slopes of 5H:1V with a 5-foot crown width and earthen fill to elevation +5.5 feet, NAVD 88. Table 5 provides a summary of settlement estimates for both construction activities and consolidation settlement for the containment dike. Time rate of settlement versus elevation over a 20-year period is shown for each of the design profiles in Figures II-B5 through II-B8 in Appendix II-B. We assumed consolidation within the containment dike to be approximately 6 inches.

TABLE 5. CONTAINMENT DIKE SETTLEMENT ESTIMATES

Design Profile	Initial Fill Elevation (feet)	Estimated Settlement (inches)					
		Construction Settlement	Consolidation Settlement(1)				
		Elastic	6 months	1 Year	5 Years	10 Years	Long-term (20 Years)
7	5.5	5	17	19	23	23	23
8	5.5	5	15	16	19	21	23
9	5.5	5	19	22	25	25	25
10	5.5	5	16	18	22	24	25

Estimated construction settlement is not included in the estimated consolidation settlement.

The peat and/or organic clay identified in the top 7-8 feet of the soil profile in almost every soil boring completed for this project has the potential to shrink significantly when removed from a submerged condition and placed above water. For this reason, a containment dike constructed from these materials may experience more than 6 inches of internal settlement/shrinkage in the dike as assumed in the calculated numbers and may need to be re-dressed before installation of dredged fill to maintain the required freeboard.

Earthen Ridge

General ***(Design profiles 1, 3, 4, 6 and combined 2 & 5)***

Based on information provided by OCPR, analyses to determine the stability of the ridge section with a base width of 100 feet and a crown width of 20 feet was performed for three different scenarios given below:

- Ridge constructed with material from Bayou Grand Liard.
- Ridge constructed with material from Gulf of Mexico East Borrow Site.
- Ridge constructed with material from proposed marsh creation area.

For the scenarios where borrow material is obtained from Bayou Grand Liard and Gulf of Mexico East Borrow Site, the stability of the ridge on the Bayou side was most critical. The “a” and “b” series slope stability figures in Appendix II-C show the critical failure surface for the above scenarios. For the scenario where borrow material is obtained from the marsh creation area, the critical failure surface was on the marsh side of the ridge. The “c” series slope stability figures in Appendix II-C show the critical failure surface on the marsh side of the earthen ridge.

Settlement calculations were also performed for the earthen ridge based on the material used to construct the ridge. Settlement is presented after slope stability section below.

Slope Stability (Design profiles 1, 3, 4, 6 and combined 2 & 5)

Slope stability analyses were performed for a typical earthen ridge section and an adjacent excavation access channel to determine the minimum required horizontal distance from the excavation access channel to the ridge embankment, and verify side slope requirements, as shown in Figures II-6a and II-6b.

Based on the typical ridge section provided by OCPR with a crown width of 20 feet and base width of 100 feet, a factor of safety greater than 1.3 was achieved on both the Bayou Grand Liard side and the marsh side of the earthen ridge. In the scenario where earthen ridge is built from the existing marsh, the ridge is stable provided the dredging depth is less than 15 feet and the berm between the toe of the ridge and the excavation channel bank is between 30 and 40 feet depending on the design profile used. However, for ease of construction, it is recommended that the berm width be at least 40 feet.

All evaluations were based on the appropriate geometry with earthen ridge fill to elevation +5.5 feet, NAVD 88. Table 6 provides a summary of slope stability analyses results. Figures in Appendix II-C show the critical failure surfaces in the earthen ridge section for each of the design profiles.

TABLE 6. EARTHEN RIDGE SLOPE STABILITY ANALYSIS RESULTS

Design Profile	Borrow Material Source	Factor of Safety
1	Bayou Grand Liard (Figure II-C1a)	1.43
	Gulf of Mexico Grand Liard East Borrow Site (Figure II-C1b)	1.65
	Existing marsh (Figure II-C1c)	1.31
2 & 5	Bayou Grand Liard (Figure II-C2a)	1.61
	Gulf of Mexico Grand Liard East Borrow Site (Figure II-C2b)	1.61
	Existing marsh (Figure II-C2c)	1.45
3	Bayou Grand Liard (Figure II-C3a)	1.32
	Gulf of Mexico Grand Liard East Borrow Site (Figure II-C3b)	1.42
	Existing marsh Figure II-C3c)	1.34
4	Bayou Grand Liard (Figure II-C4a)	2.10
	Gulf of Mexico Grand Liard East Borrow Site (Figure II-C4b)	2.12
	Existing marsh (Figure II-C4c)	2.03
6	Bayou Grand Liard (Figure II-C5a)	1.87
	Gulf of Mexico Grand Liard East Borrow Site (Figure II-C5b)	2.11
	Existing marsh (Figure II-C5c)	1.69

The slope stability factor of safety of the earthen ridge will increase as the crown elevation is reduced from +5.5 feet to +5.0 feet for the given geometry keeping side slopes constant.

Settlement (Design profiles 1, 3, 4, 6 and combined 2 & 5)

Settlement calculations were completed for the earthen ridge using the three different fill sources. Influence of the adjacent marsh fill was evaluated with respect to earthen ridge settlement estimates. The marsh fill will have some influence on the marsh side of the ridge fill; however, from the center of the ridge to the edge farthest from the marsh fill, the marsh fill will cause little to no additional settlement of the earthen ridge fill. A narrower ridge will be influenced more by the marsh fill than the proposed 100-foot wide ridge.

Time rate of settlement versus elevation over a 20-year period is shown for each of the design profiles in Appendix II-C, including an estimated six inches of settlement within the ridge embankment.

The peat and/or organic clay identified in the top 4-7 feet of the soil profile in some of the soil borings completed for the earthen ridge has the potential to shrink significantly when removed from a submerged condition and placed above water. For this reason, an earthen ridge embankment constructed from these materials may experience more than 6 inches of internal settlement/shrinkage in the ridge as assumed in the calculated numbers and may need to be re-dressed before installation of dredged fill to maintain the required freeboard.

TABLE 7. EARTHEN RIDGE SETTLEMENT ESTIMATES

Design Profile	Borrow Material Source	Initial Fill Elevation (feet)	Estimated Settlement (inches)					
			Construction Settlement	Consolidation Settlement(1)				
			Elastic	6 months	1 Year	5 Years	10 Years	Long-term (20 Years)
1	Bayou Grand Liard	5.5	4	19	20	21	21	21
	Gulf of Mexico Grand Liard East Borrow Site	5.5	4	18	19	20	20	20
	Existing marsh	5.5	4	18	18	19	19	20
2 & 5	Bayou Grand Liard	5.5	4	12	13	17	19	21
	Gulf of Mexico Grand Liard East Borrow Site	5.5	4	12	13	16	18	20
	Existing marsh	5.5	4	12	12	15	17	19
3	Bayou Grand Liard	5.5	5	16	18	23	24	24
	Gulf of Mexico Grand Liard East Borrow Site	5.5	5	16	18	22	23	23
	Existing marsh	5.5	4	15	17	21	22	22
4	Bayou Grand Liard	5.5	6	22	25	27	27	27
	Gulf of Mexico Grand Liard East Borrow Site	5.5	5	22	24	26	26	26
	Existing marsh	5.5	5	21	24	25	25	25
6	Bayou Grand Liard	5.5	7	25	27	32	33	33

Design Profile	Borrow Material Source	Initial Fill Elevation (feet)	Estimated Settlement (inches)					
			Construction Settlement	Consolidation Settlement(1)				
			Elastic	6 months	1 Year	5 Years	10 Years	Long-term (20 Years)
	Gulf of Mexico Grand Liard East Borrow Site	5.5	6	24	27	31	31	31
	Existing marsh	5.5	6	23	26	30	30	30

(1) Estimated construction settlement is not included in the estimated consolidation settlement.

Both construction and consolidation settlement of the earthen ridge will be less than those estimates provided in Table 7 when the crown elevation of the ridge is reduced from +5.5 feet to +5.0 feet for the given geometry keeping side slopes constant.

CONSTRUCTION CONSIDERATIONS

Based on the site work and evaluations completed for this project, the following considerations are offered with respect to construction.

- As stated previously, six inches of settlement was assumed within the fill for the containment dike and earthen ridge embankment; however, this settlement will largely be a function of fill materials used for construction and handling of the fill materials. Organic materials handled in a manner that causes more disturbance (i.e. a small excavator bucket) are likely to have substantially more settlement, while granular materials such as silt and sand that are placed with minimal handling/disturbance are likely to have less settlement. In addition to settlement, organic materials excavated from a submerged condition and placed as fill above the water level, are likely to experience significant shrinkage as they dry.
- Slope stability evaluations only considered static conditions. Equipment working from a berm between adjacent borrow trench and embankment fill areas, may create stability issues from repeated motions such as fill excavation and placement.
- In places where the earthen ridge and containment dikes are placed over pipelines, there is the potential for the pipeline to be damaged not only from impact loading associated with construction, but also potentially from deflection associated with settlement.
- Calculations indicate that a geotextile is not necessary to construct a stable shoreline embankment. If the OCPR elects to place a geotextile beneath the ridge, debris including branches and wood debris may interfere. Removal of this debris should be accomplished in a manner that minimizes disturbance of underlying soil, otherwise the benefits of the geotextile may be lost by the reduction in strength of the underlying soil.

LIMITATIONS

The information presented in this report is based on the soil borings and soil testing completed for this study, and judgments made by the certifying engineers. This report is specific to this site and

should not be used other than for the design of the Grand Liard Marsh and Ridge Restoration (BA-68) project located in Plaquemines Parish, Louisiana. We have provided the requested information for the geotechnical investigation data report. Additional geotechnical data and calculations are in Volumes I and III.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions express or implied should be understood.

Any electronic form or hard copy of this document (email, text, table, and/or figure), if provided, and any attachments are only a copy of a master document. The master hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to Appendix II-D titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

FIGURES

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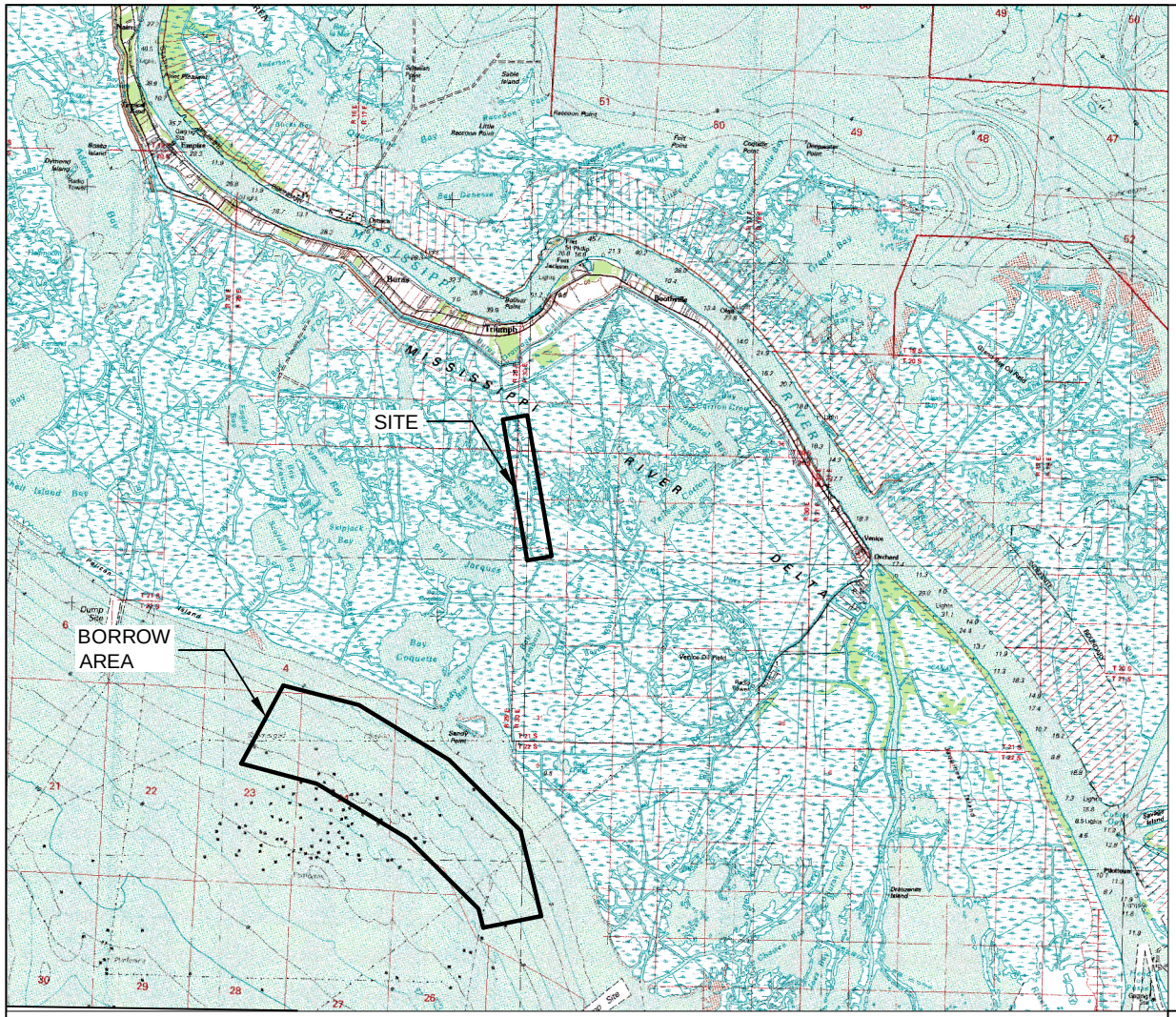

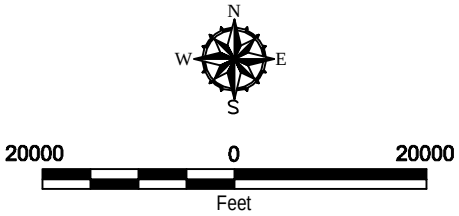

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: 1) Topographic map taken from USGS, 100K Template, Quad Plaquemines, Dated 10/2008
2) Borrow area information based on American Vibracore Services, Coastal Planning & Engineering, September 2010 Report provided to GeoEngineers by OCPR.

VICINITY MAP

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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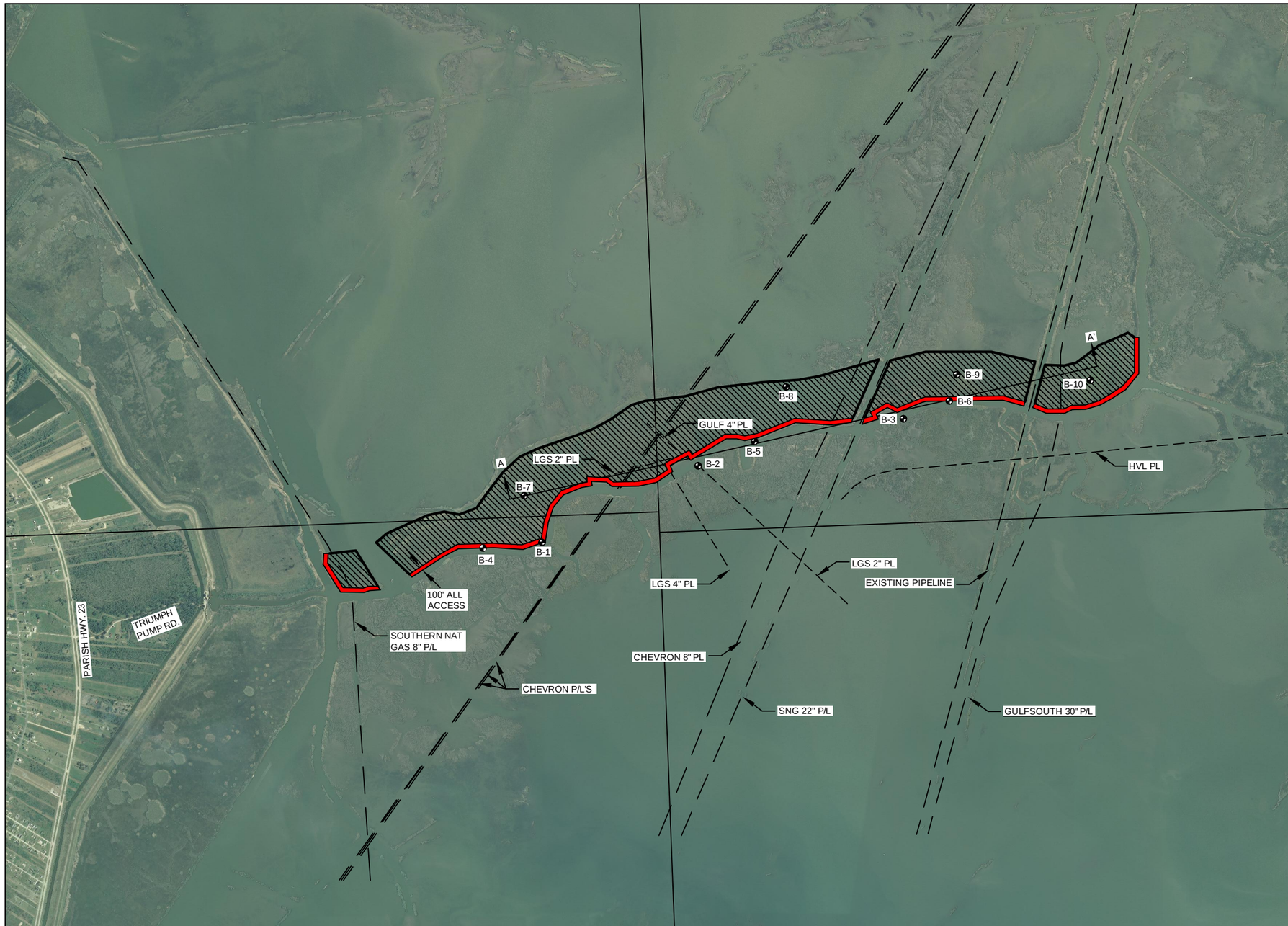
Figure II-1



BOREHOLE LOCATION

B-1	N29 18' 18.90"	W89 28' 38.17"
B-2	N29 17' 43.25",	W89 28' 19.04"
B-3	N29 16' 56.53",	W89 28' 07.76"
B-4	N29 18' 32.19"	W89 28 39.09"
B-5	N29 17' 30.50"	W89 28 12.55"
B-6	N29 16' 46.16"	W89 28 02.83"
B-7	N29 18' 22.81"	W89 28 25.89"
B-8	N29 17' 23.49"	W89 27 58.30"
B-9	N29 16' 44.59"	W89 27 56.26"
B-10	N29 16' 14.25"	W89 27 58.11"

LEGEND

- B-1 Borehole Location
- Proposed Ridge Restoration
- Proposed Marsh Creation
- Proposed Earthen Containment Dike

N W E S

2500 0 2500
FEET

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: 1. Aerial image taken from USGS, USGS High Resolution State Orthoimagery for the Louisiana Coastal Area, Dated 10/18/2008
2. Ridge Restoration and Marsh Creation Outlines provided by USGS, Grand Liard Marsh and Restoration (PPI18 Candidate), Dated 9/18/2008
3. Approximate location of existing pipelines taken from information provided by Sigma Consulting Group, Magnetometer Survey, Bayou Grand Liard Field, Plaquemines Paris, Dated 8/27/2010

SITE PLAN WITH SOIL BORING LOCATIONS

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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Figure II-2

DPS : KMC

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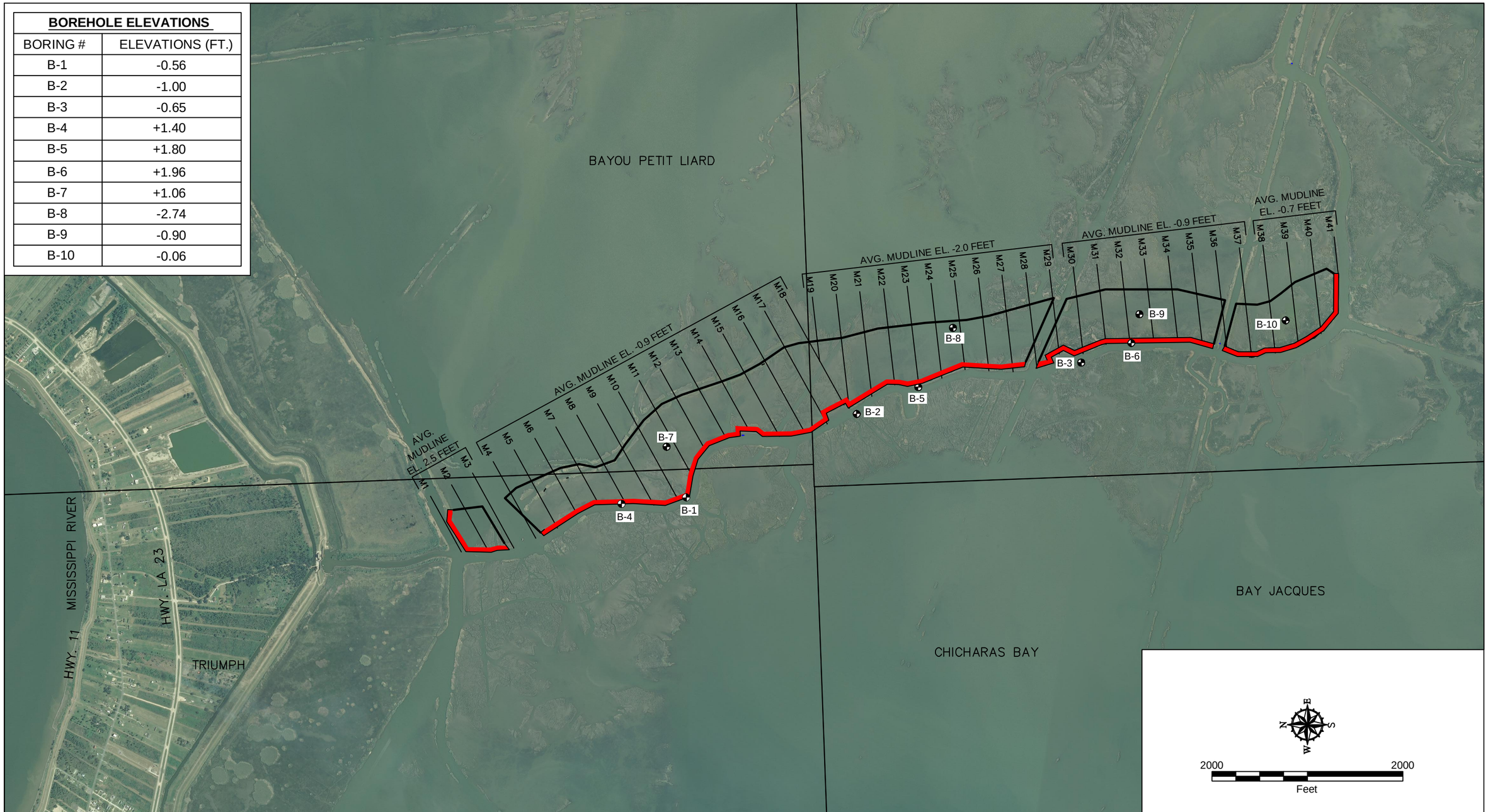
BOREHOLE ELEVATIONS	
BORING #	ELEVATIONS (FT.)
B-1	-0.56
B-2	-1.00
B-3	-0.65
B-4	+1.40
B-5	+1.80
B-6	+1.96
B-7	+1.06
B-8	-2.74
B-9	-0.90
B-10	-0.06



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: 1) Aerial image taken from USGS, USGS High Resolution State Orthoimagery for the Louisiana Coastal Area, Dated 10/18/2008
2) Survey lines and drawing information provided by Sigma Consulting Group, In., Grand Liard Marsh and Ridge Restoration (BA-68) Transect Layout Map, Dated Oct 2010. (Partial information reproduced in Appendix A of this report).
3) Average mudline elevations in the marsh area estimated from survey data provided by OCPR on 12/6/2010

LEGEND

B-1 Borehole Location

Proposed Ridge Restoration

Proposed Earthen Containment Dike

M1 Cross Section Line

SITE PLAN WITH TRANSECT LAYOUT MAP

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

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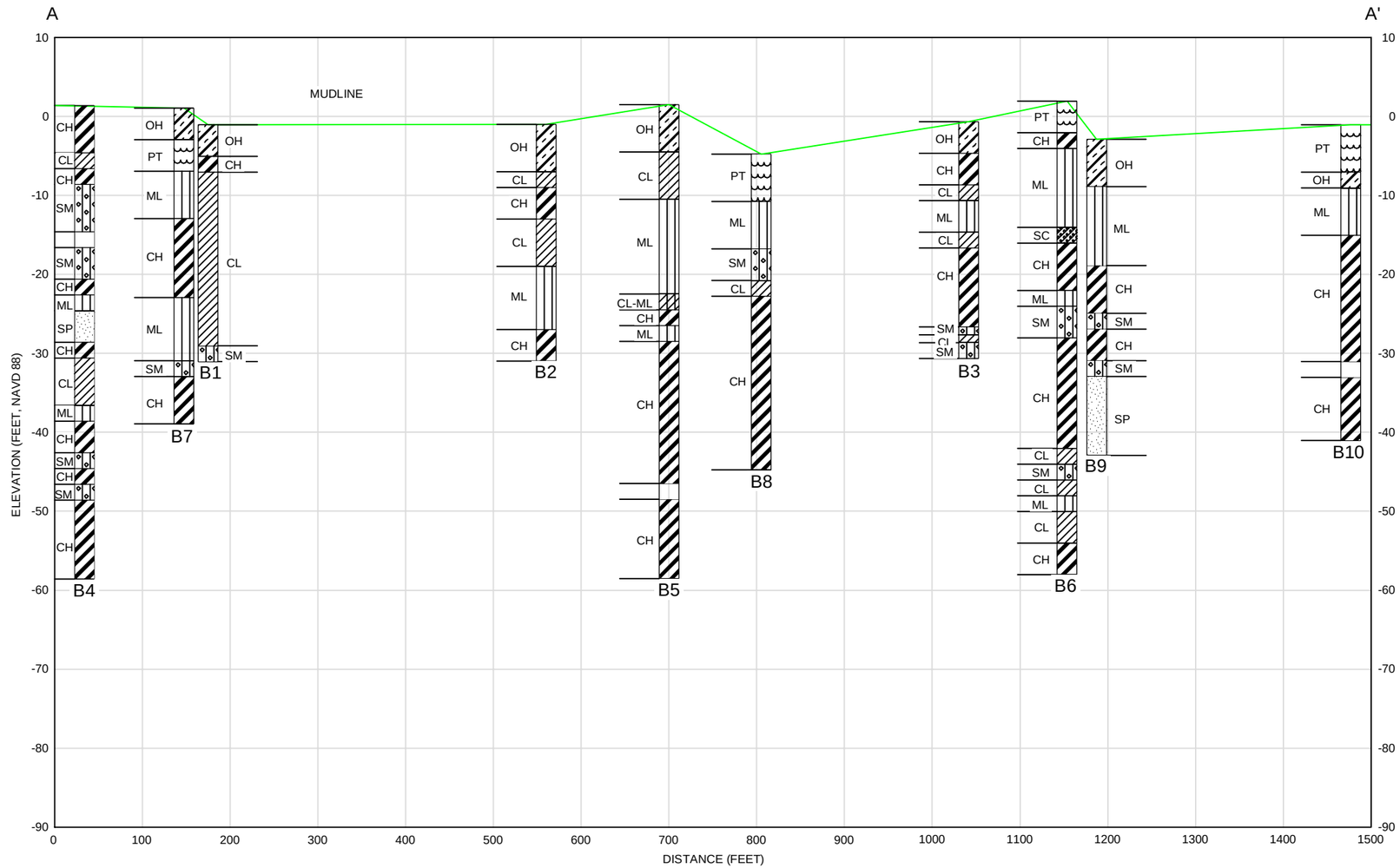
Figure II-3

VT : KMC

P:\16\16715018\00\CAD\100519 Layout.dwg\TAB:Layout3 modified on Jan 05, 2011 - 9:54am



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

SUBSURFACE SOIL PROFILE A - A'

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

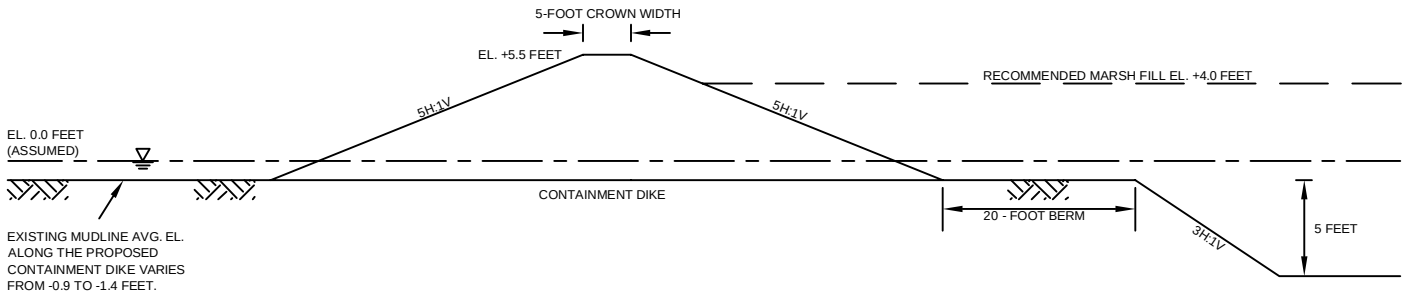
GEOENGINEERS

Figure II-4

VT : KMC

P:\16\1671501800\CAD\SUBSURFACE PROFILE1.dwg\TAB:Layout2 modified on Jan 06, 2011 - 10:46am

DESIGN SECTION : CONTAINMENT DIKE



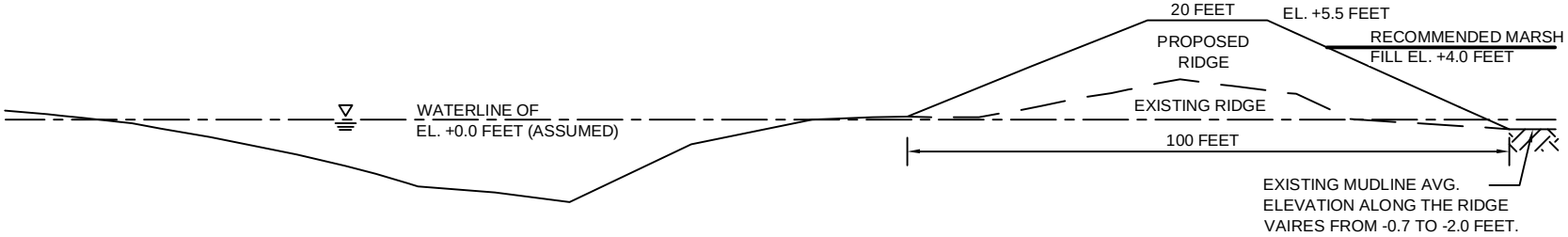
Notes:
1. Assumed settlement of 6 inches within the containment dike during construction (0-30 days).
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

RECOMMENDED CONTAINMENT DIKE SECTION

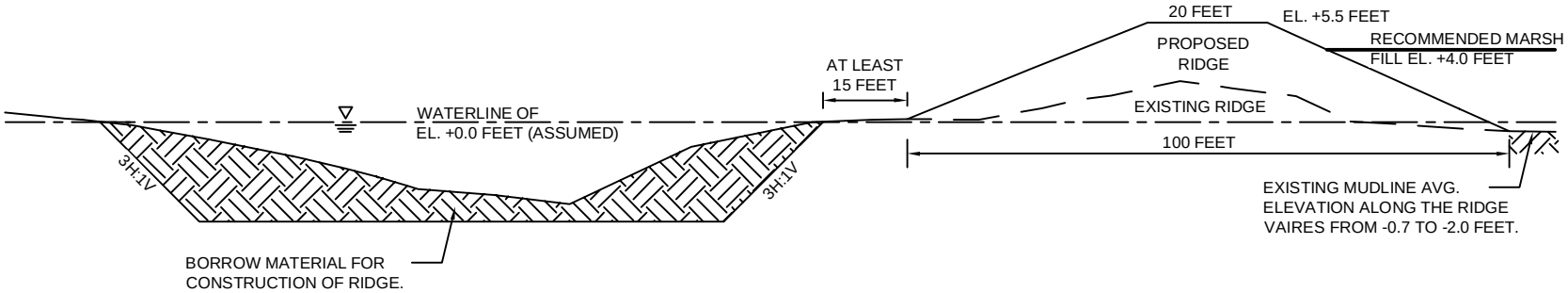
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-5



BORROW MATERIAL FROM BORROW AREA



BORROW MATERIAL FROM BAYOU GRAND LIARD

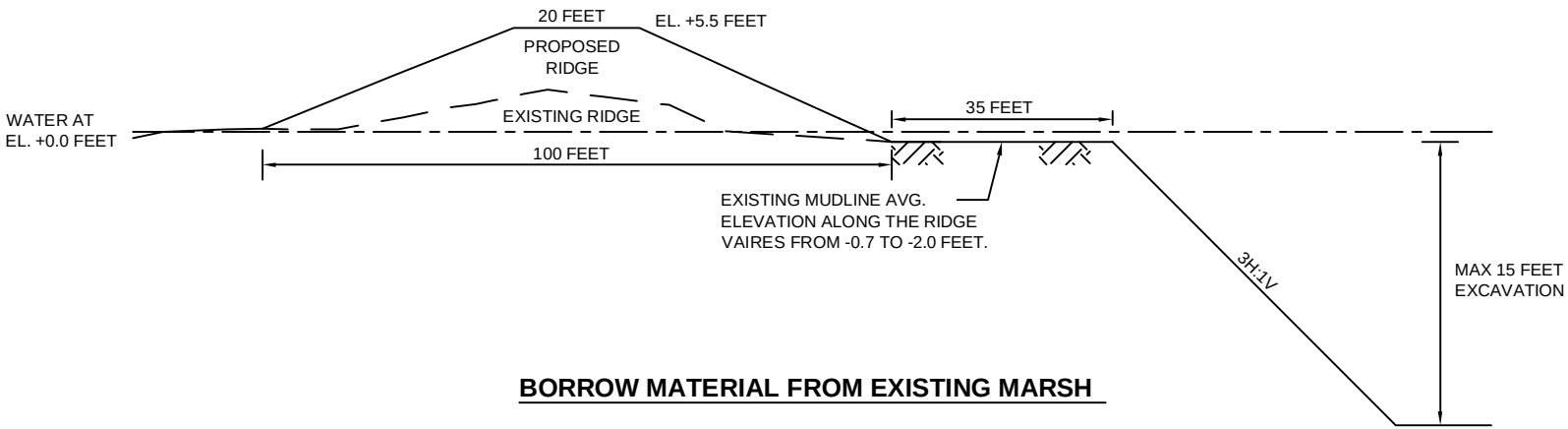
Notes:
1. Assumed settlement of 6 inches within the earthen ridge during construction (0-30 days).
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

RECOMMENDED RIDGE SECTION

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-6a



BORROW MATERIAL FROM EXISTING MARSH

Notes:
1. Assumed settlement of 6 inches within the earthen ridge during construction (0-30 days).
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

RECOMMENDED RIDGE SECTION

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-6b

APPENDICES

GeoEngineers

APPENDIX II-A
Settlement Analysis for Marsh Fill and Foundation Soils

Settlement Calculation Approach for the Dredged Fill Marsh Creation Area
Grand Liard Marsh and Ridge Restoration (BA-68)

1. Settlement parameters were developed for each soil layer for all borings as shown in the spreadsheets provided in Appendix I-E. Settlement parameters for Borings B-7 through B-10 were used for settlement estimates for the marsh creation area. The following description explains how the parameters were developed.
    (a) One consolidation test was done for each soil boring and the samples for the consolidation test were selected from varying depths and materials.
    (b) Four consolidation test results were analyzed and graphs were reconstructed to determine compression (C_c), recompression (C_r), and vertical consolidation (C_v) coefficients, initial void ratios (e_0) and maximum past pressures (P_c).
    (c) Correlations presented in equations 1 through 3 (shown in the attached spreadsheets) were used to calculate e_0 and C_c for all the soil layers.
    (d) GeoEngineers developed different correlations based on the analyses of the consolidation test results as follows:
        (i) Moisture Content (w) Vs. C_v: A best fit curve was drawn through the plotted points from this and other coastal projects and C_v for the soil layers were obtained depending upon the moisture content.
        (ii) w Vs. C_c: C_c=0.0054*((w*S.G.)-35) was found to provide sufficient accuracy based on the test data for this and other projects for all compressible soil types; C_c was obtained for the soil layers based on the moisture content.
        (iii) C_r was taken to be 15% of C_c for peat and 10% of C_c for all other cohesive and semi-cohesive soils.
    (e) For the soil layers without a representative consolidation test, the above mentioned correlations were used to estimate C_c, C_r , C_v, and e_0.
    (f) Past previous pressure (P_c) were obtained from the consolidation test curves for the soil layers with a representative consolidation test. For other soil layers, the overconsolidation ratio (OCR) was estimated from the equation OCR = (c/(P_0' * 0.22))^(1/0.8). This equation was taken from Figure 7.1 of "Recommended practice for soft ground site characterization," by Charles Ladd and Don DeGroot. P_c was estimated by multiplying the overburden pressure (P_0) by OCR.
    (g) In some cases where P_0 was greater than P_c, P_0 was used as the maximum past pressure instead of P_c for the settlement analysis assuming the layers to be normally consolidated.
2. In this area, clay shear strength for a normally consolidated soil profile will be approximately 22% of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles. Based on this relationship, it appears that the top 12-25 feet of the soil profile is slightly over-consolidated in all the design groups. This affects the settlement parameters selected for design within this zone.
3. Due to the broad fill area, the drainage is vertical for all the soil layers. Drainage to the phreatic surface or to the nearest granular soil layer has been considered for these soil layers. The presence of small sand and silt layers within clay was considered in the drainage path evaluation.

Settlement of the marsh creation area consists primarily of two separate processes: consolidation of the dredged fill and consolidation of the foundation soils. Consolidation of the dredged fill was modeled using PSDDF (Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill), a program created for the United States Army Corps of Engineers to simulate finite strain consolidation in dredged fill materials. Consolidation of the foundations soils was modeled iteratively using a one-dimensional consolidation program.

To account for the effects of progressive dredged fill densification and submergence below the waterline caused by foundation soil settlement, we re-computed effective vertical stress and corresponding settlement at various time intervals after fill placement. The typical steps at some time = t were as follows:

1. Calculate settlement for soil beneath the fill based on the elapsed time and the effective stress calculated for the previous time t and determine the new mudline elevation.
2. From PSDDF determine the change in the thickness of the fill computed by PSDDF to determine the fill material density, and the new fill surface elevation. The new fill surface elevation will be reduced by both the foundation settlement and the change in fill thickness from PSDDF.
3. Re-compute the effective vertical stress based on the new elevations of the fill surface and mudline, and a constant water elevation of 0.0 feet NAVD 88.
4. Use the new lower effective stress to re-compute settlement

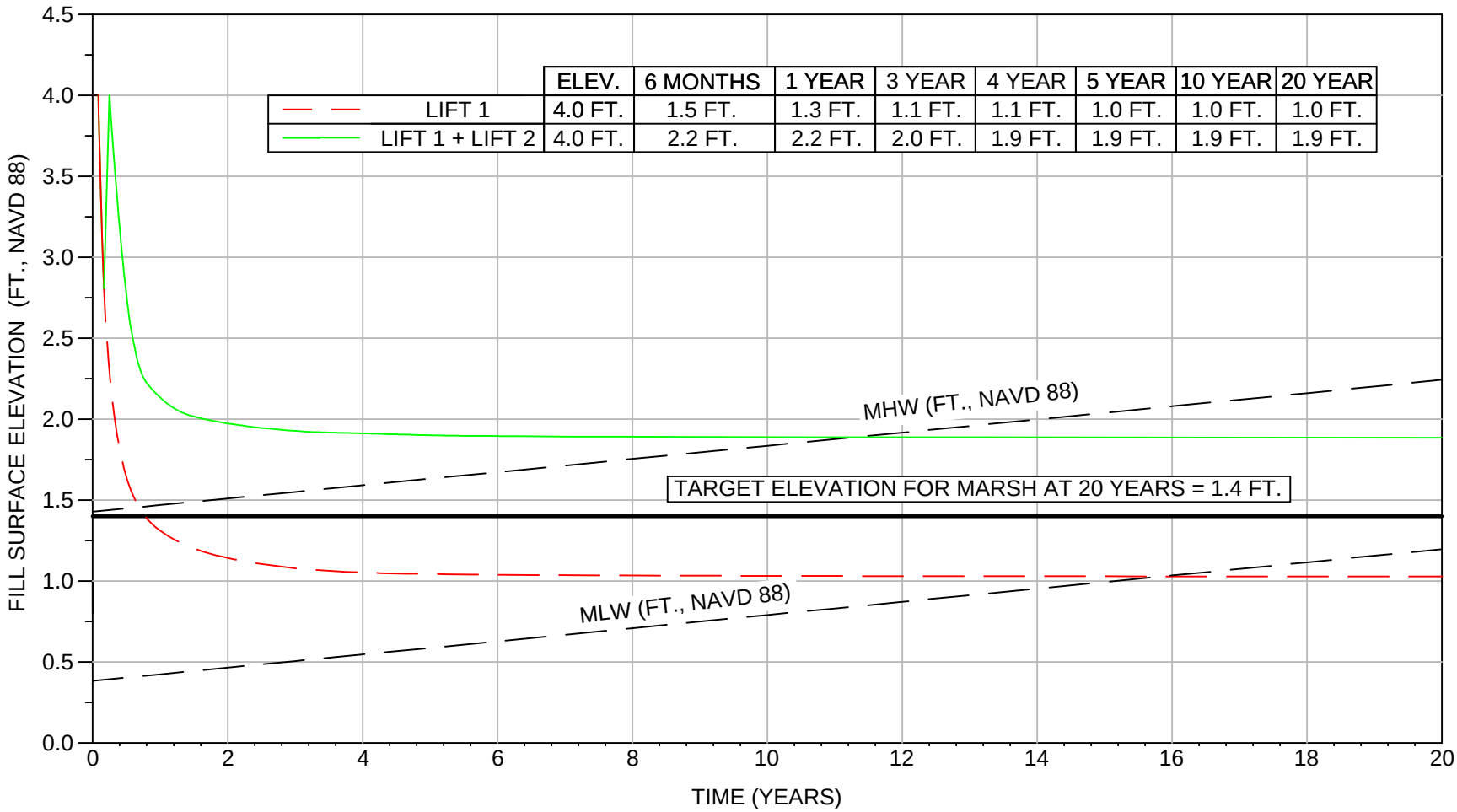
This was repeated for 45, 60, 90, 180, 365, 1095 (3 years), 1825 (5 years), 3650 (10 years), and 7300 days (20 yrs). Day 1 of the PSDDF calculation was taken as 30 days after the start of filling, allowing 30 days to complete placing hydraulic fill. Therefore day 30 for foundation soil settlement calculations equals day 1 for PSDDF calculations.

The sum of the dredge fill settlement and the underlying soil settlement was used to determine the total settlement that will be realized at the surface of the dredge fill area after filling is complete. Settlement of dredged fill evaluations were initially performed for single lift scenario with fill placed to an elevation of +2.0 and +4.5 feet. In both cases, the final elevation of dredged fill over a 20-year design life was estimated to be less than the required elevation +1.4 feet. Hence, the settlement for dredged fill was estimated over a 20-year design life for a two lift scenario. Figures II-A1 through A4 in Appendix II-A summarize our evaluation for dredged fill placed to an initial elevation of +4.0 feet and re-filled back to elevation +4.0 feet after 60 days from placement of initial fill. In other words, the time gap between the end of initial lift to the beginning of placing second lift is 60 days. Figures II-A5 through II-A12 summarize our evaluation for dredged fill placed to an elevation as provided in Table 2 for a two lift scenario.

The assumptions made for the staged-construction settlement analysis are as follows:

- A single mobilization for both lifts,
- Time gap between end of first lift and beginning of second lift is as provided in Table 3.
- Initial fill elevation as provided in Table 3.
- Water elevation at 0.0 feet NAVD88.

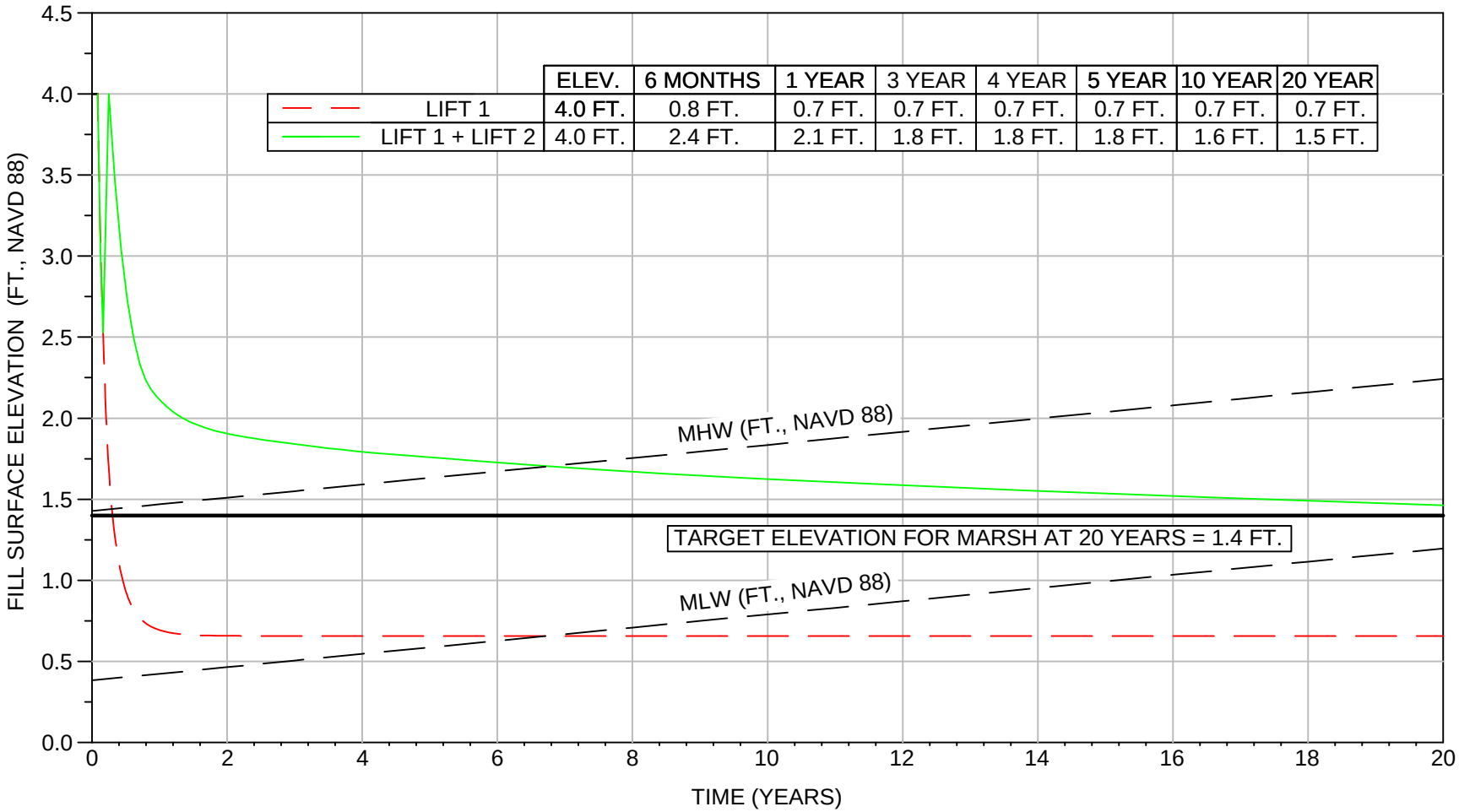
Computations for staged-construction settlement are similar to those for single-stage construction. The staged-construction calculations assumed that the properties computed in the evaluation of one lift carry over to the evaluation of subsequent lifts. Density, in particular, was a key component in computing the pressure on top of the foundation soils. The density used in the two lift analysis was a weighted average of the densities from both lifts, assuming that the densities computed in the one-lift analysis were held constant after the placement of additional material.



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	1.5 FT.	1.3 FT.	1.1 FT.	1.1 FT.	1.0 FT.	1.0 FT.	1.0 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.2 FT.	2.2 FT.	2.0 FT.	1.9 FT.	1.9 FT.	1.9 FT.	1.9 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

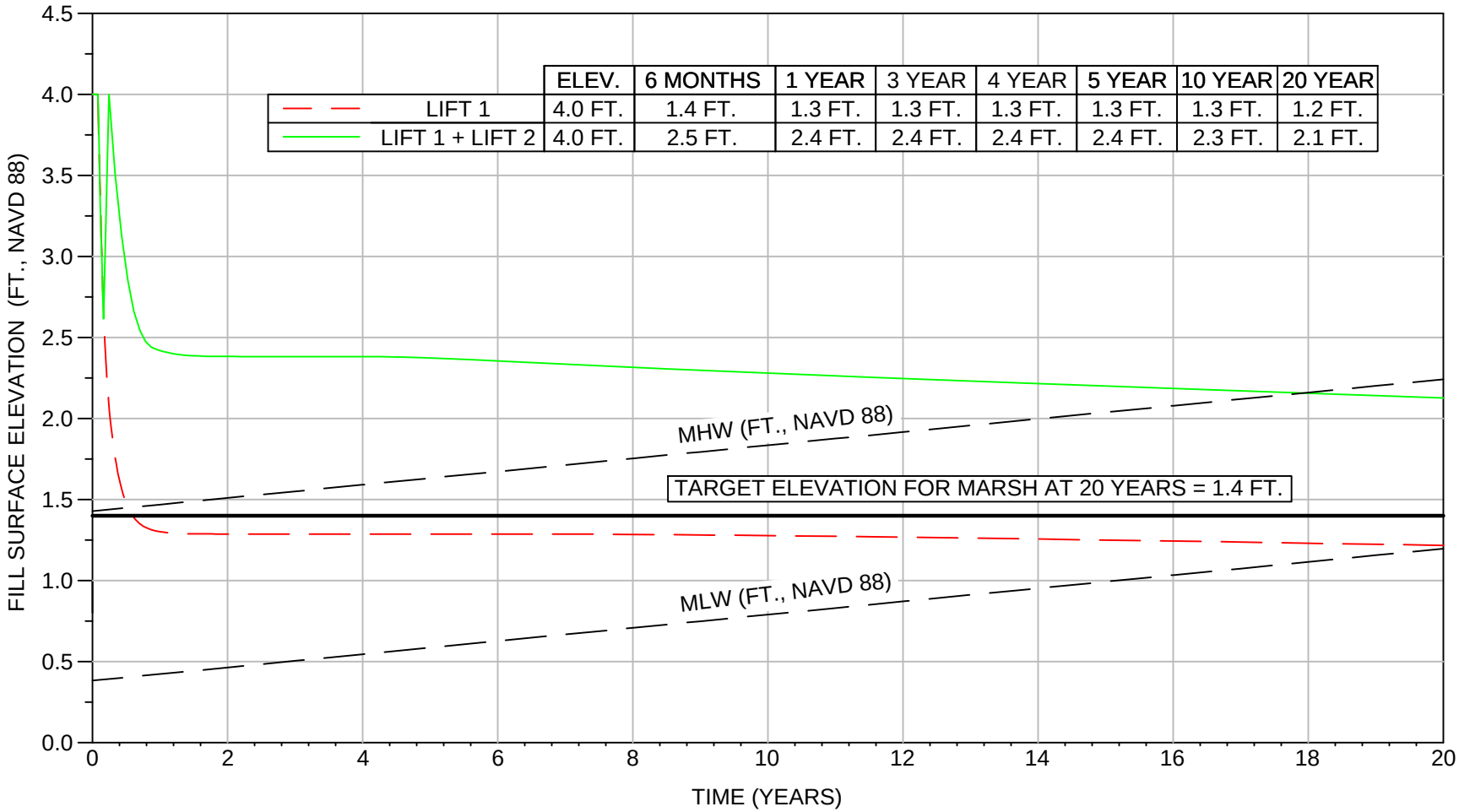
MARSH FILL SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A1**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	0.8 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.4 FT.	2.1 FT.	1.8 FT.	1.8 FT.	1.8 FT.	1.6 FT.	1.5 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

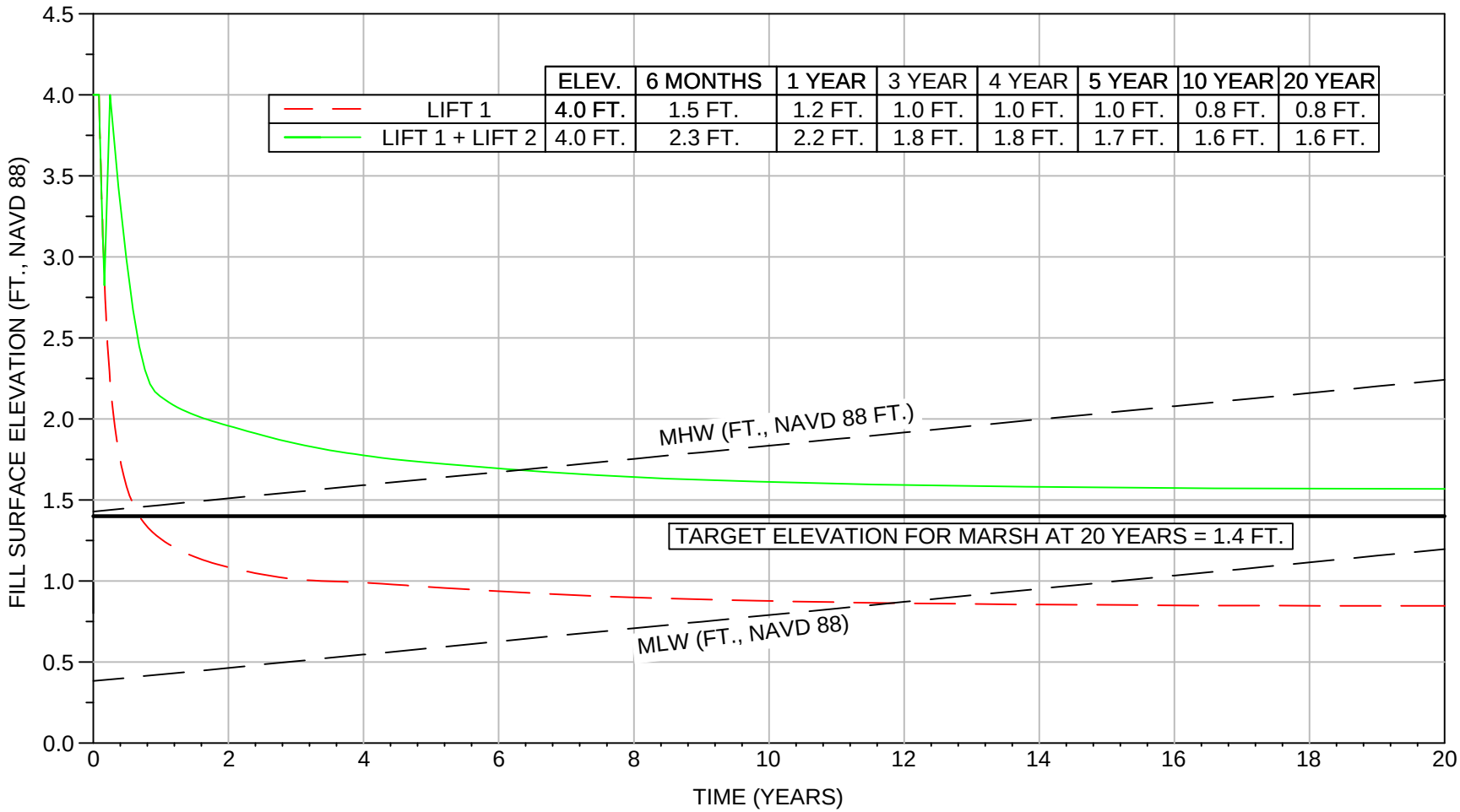
MARSH FILL SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A2**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	1.4 FT.	1.3 FT.	1.3 FT.	1.3 FT.	1.3 FT.	1.3 FT.	1.2 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.5 FT.	2.4 FT.	2.4 FT.	2.4 FT.	2.4 FT.	2.3 FT.	2.1 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

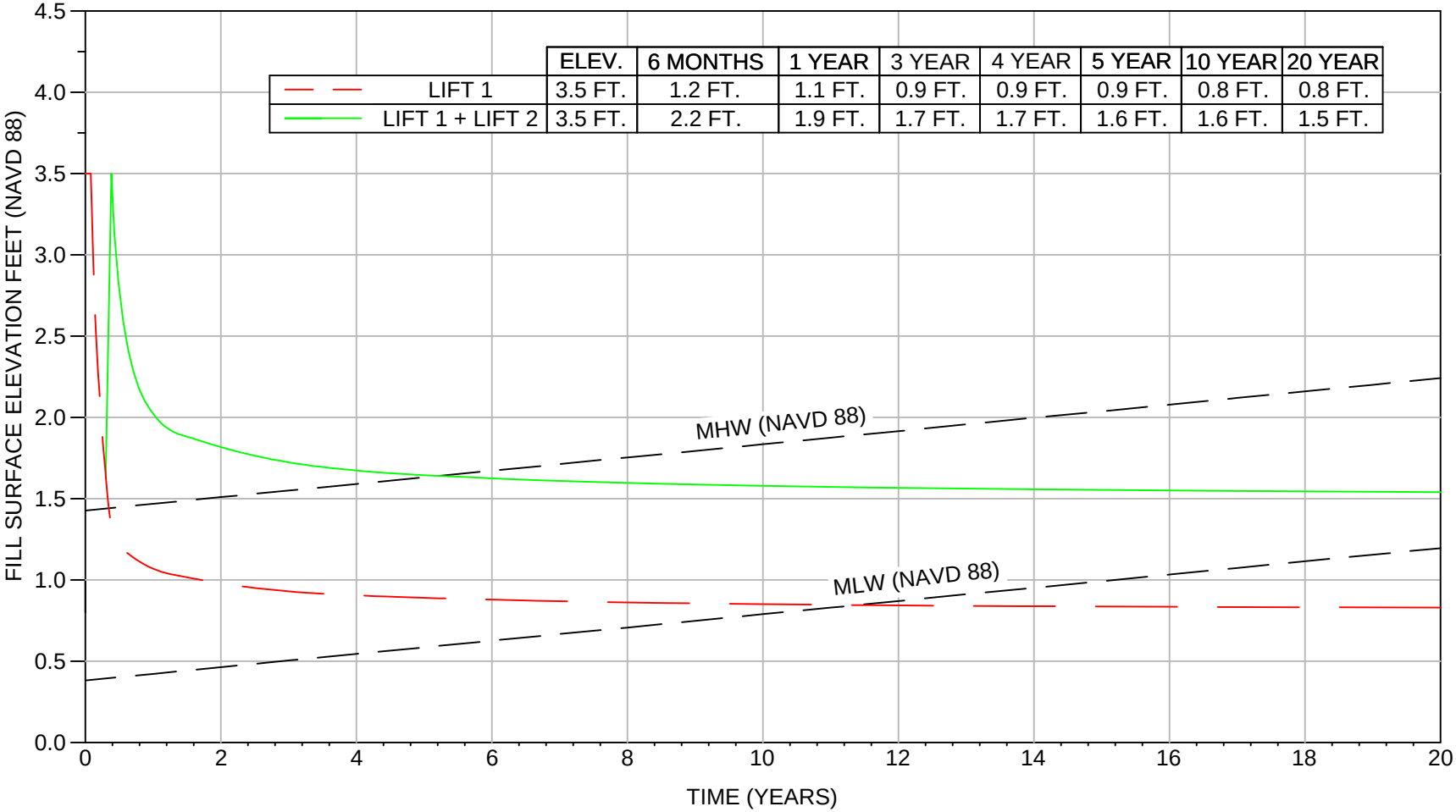
MARSH FILL SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A3**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	1.5 FT.	1.2 FT.	1.0 FT.	1.0 FT.	1.0 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	4.0 FT.	2.3 FT.	2.2 FT.	1.8 FT.	1.8 FT.	1.7 FT.	1.6 FT.	1.6 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 60 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

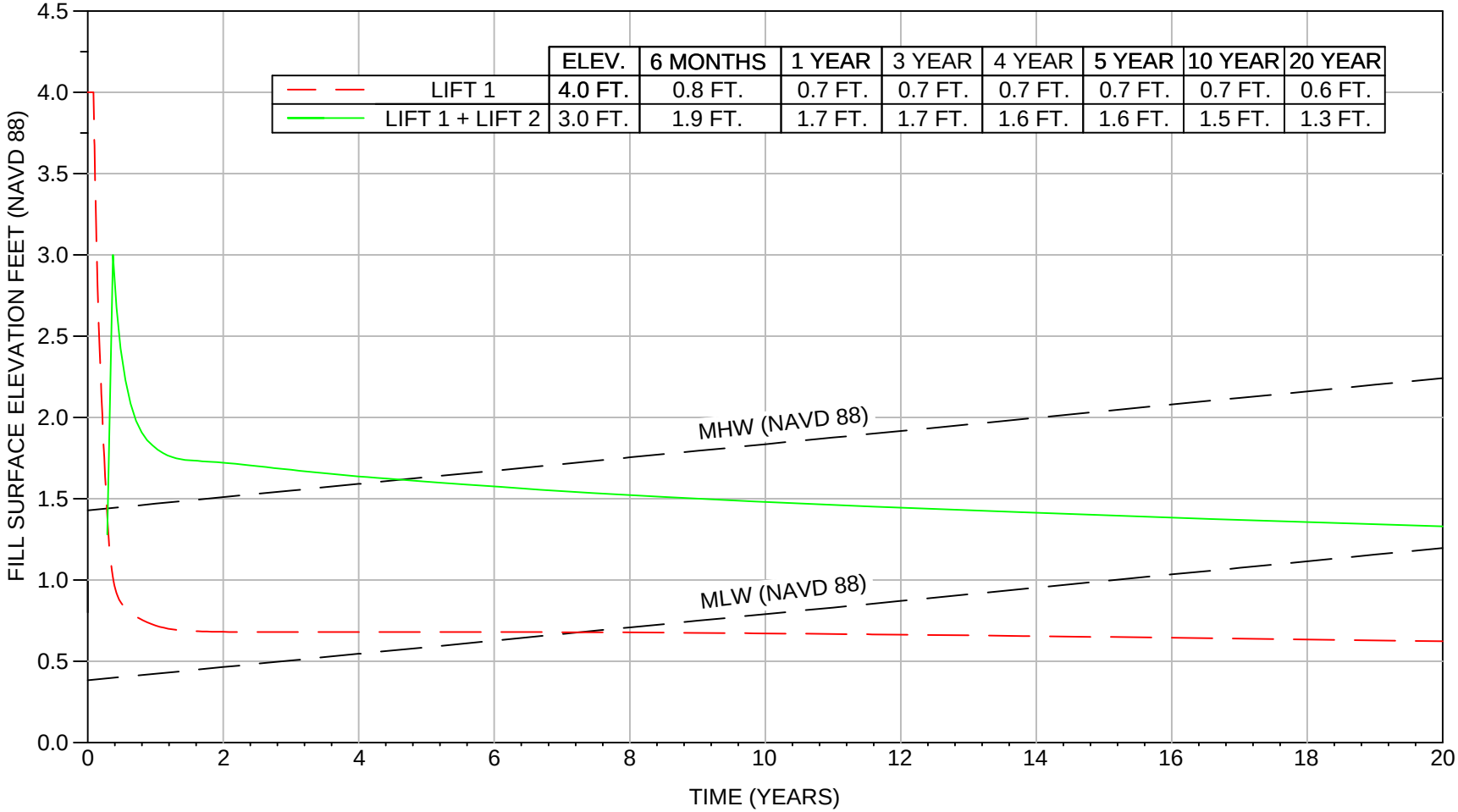
MARSH FILL SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A4**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.5 FT.	2.2 FT.	1.9 FT.	1.7 FT.	1.7 FT.	1.6 FT.	1.6 FT.	1.5 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 80 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

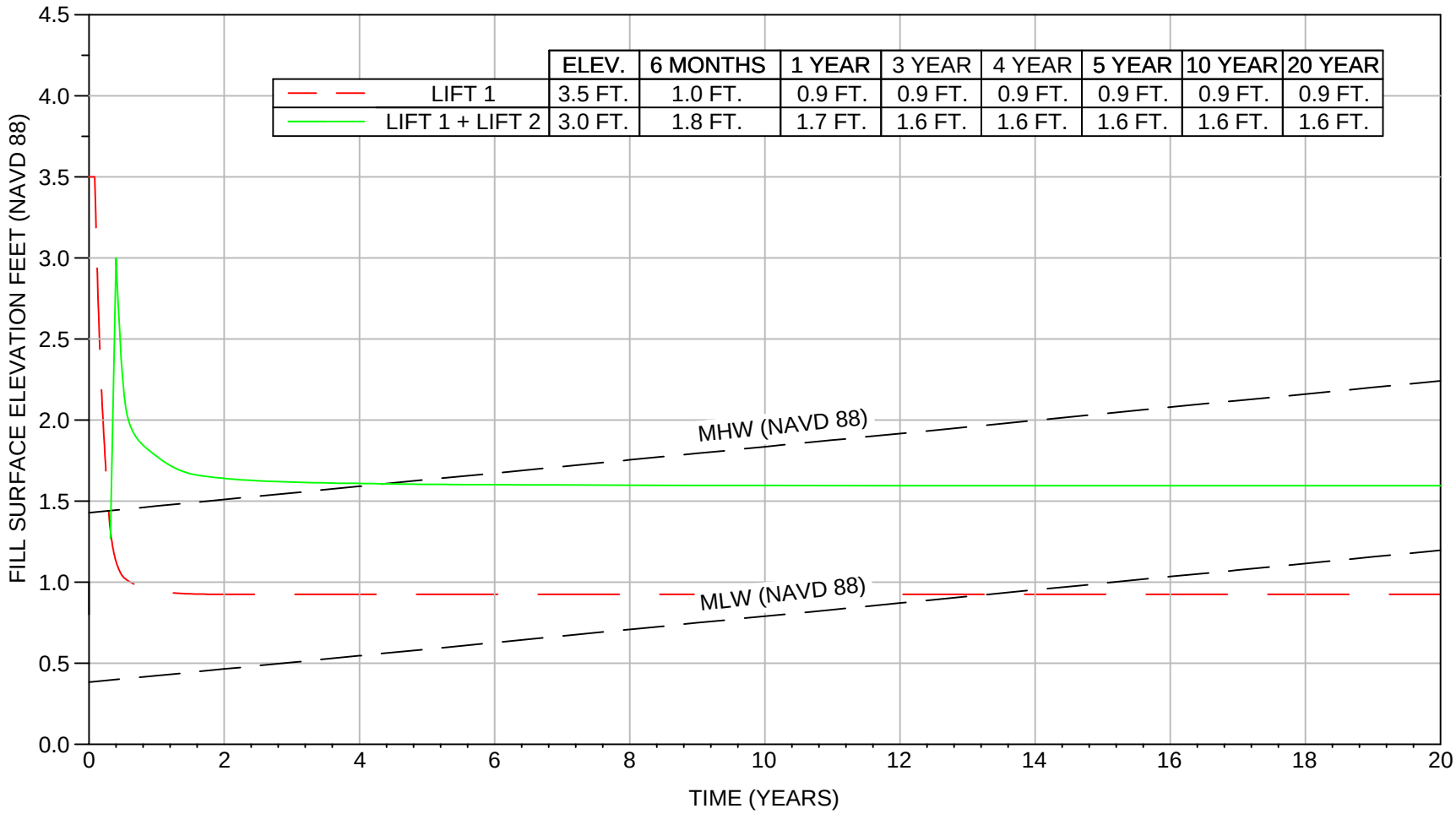
MARSH FILL SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A5**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	4.0 FT.	0.8 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.7 FT.	0.6 FT.
LIFT 1 + LIFT 2	3.0 FT.	1.9 FT.	1.7 FT.	1.7 FT.	1.6 FT.	1.6 FT.	1.5 FT.	1.3 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 75 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

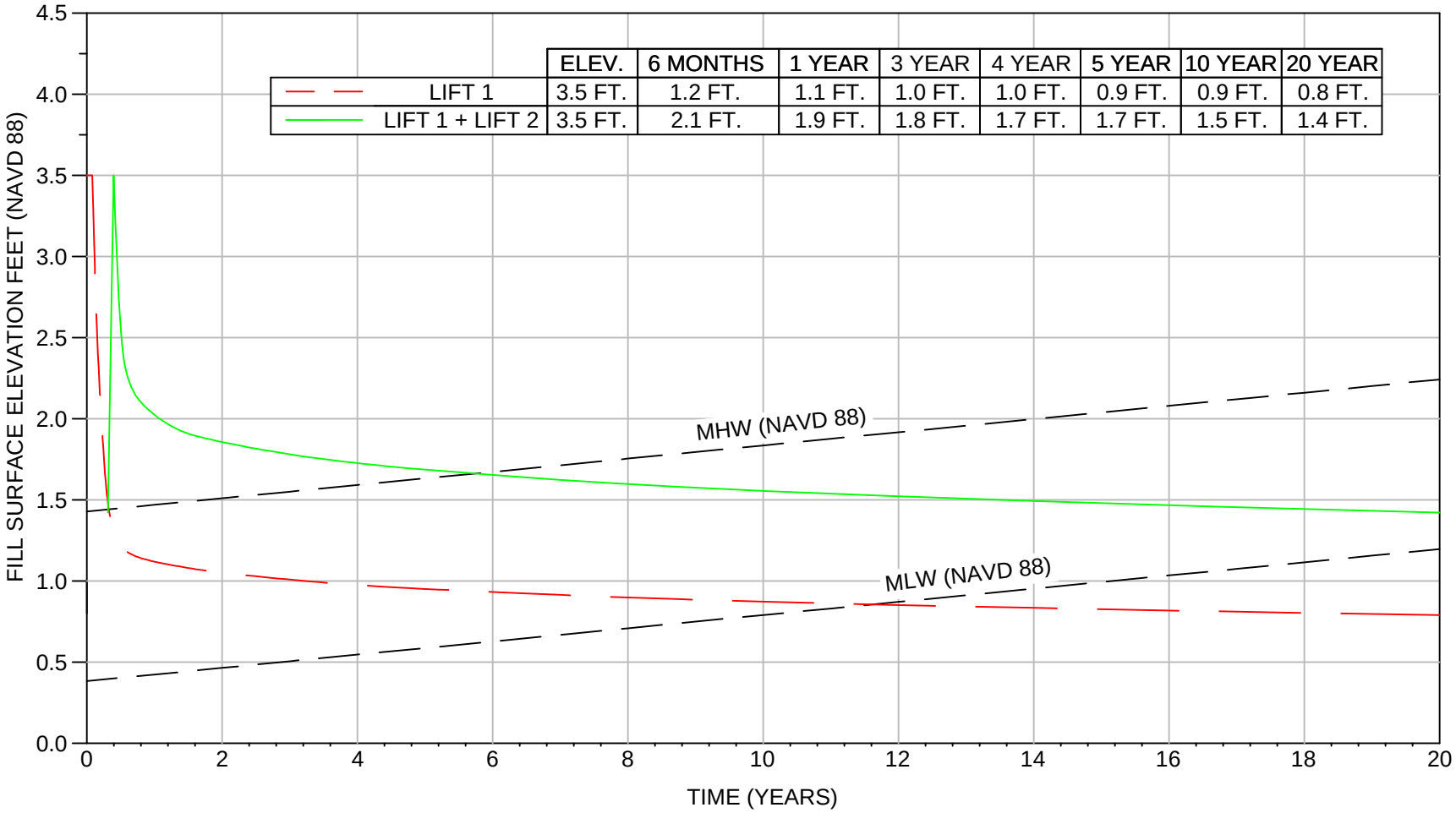
MARSH FILL SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A6**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.0 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.
LIFT 1 + LIFT 2	3.0 FT.	1.8 FT.	1.7 FT.	1.6 FT.	1.6 FT.	1.6 FT.	1.6 FT.	1.6 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

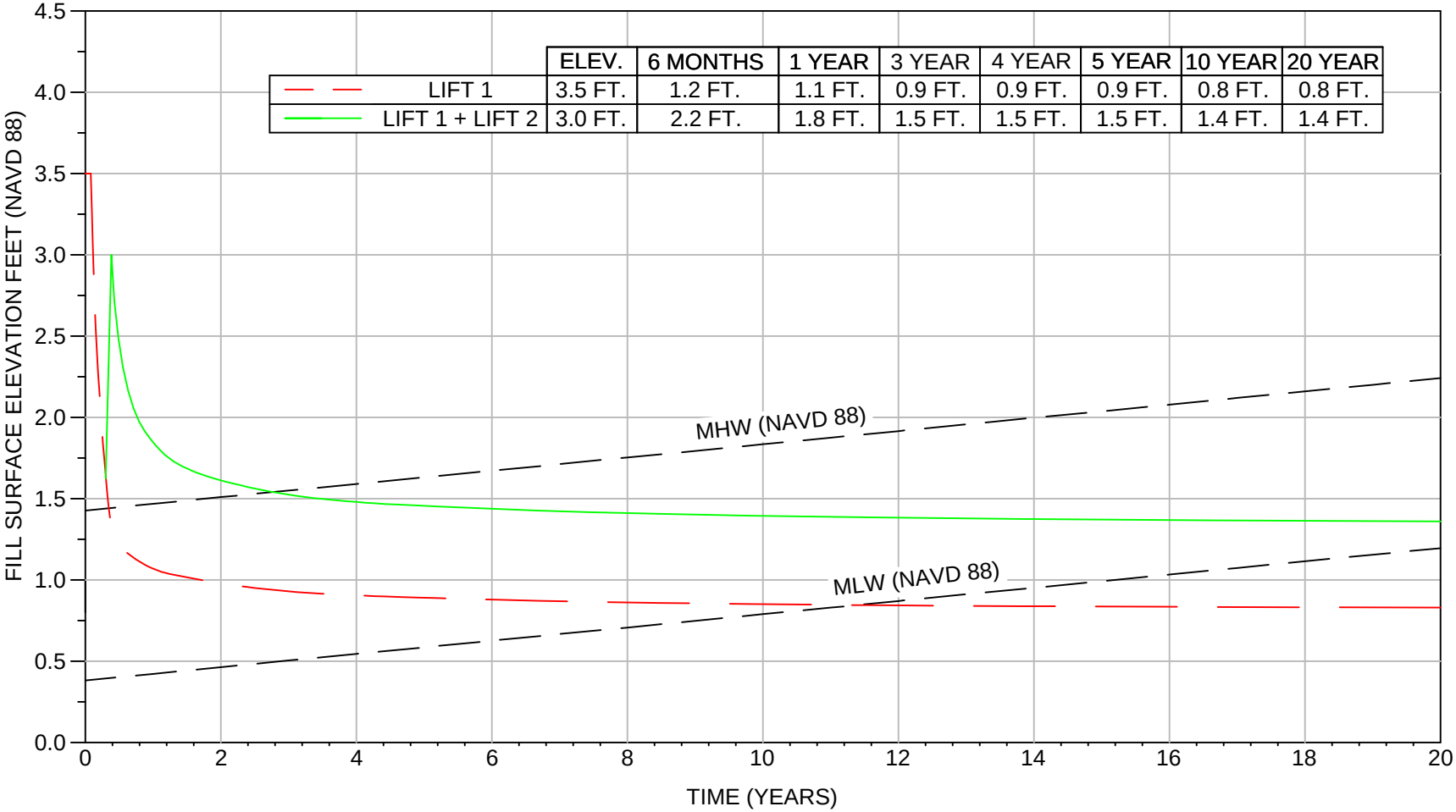
MARSH FILL SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A7**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	1.0 FT.	1.0 FT.	0.9 FT.	0.9 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.5 FT.	2.1 FT.	1.9 FT.	1.8 FT.	1.7 FT.	1.7 FT.	1.5 FT.	1.4 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

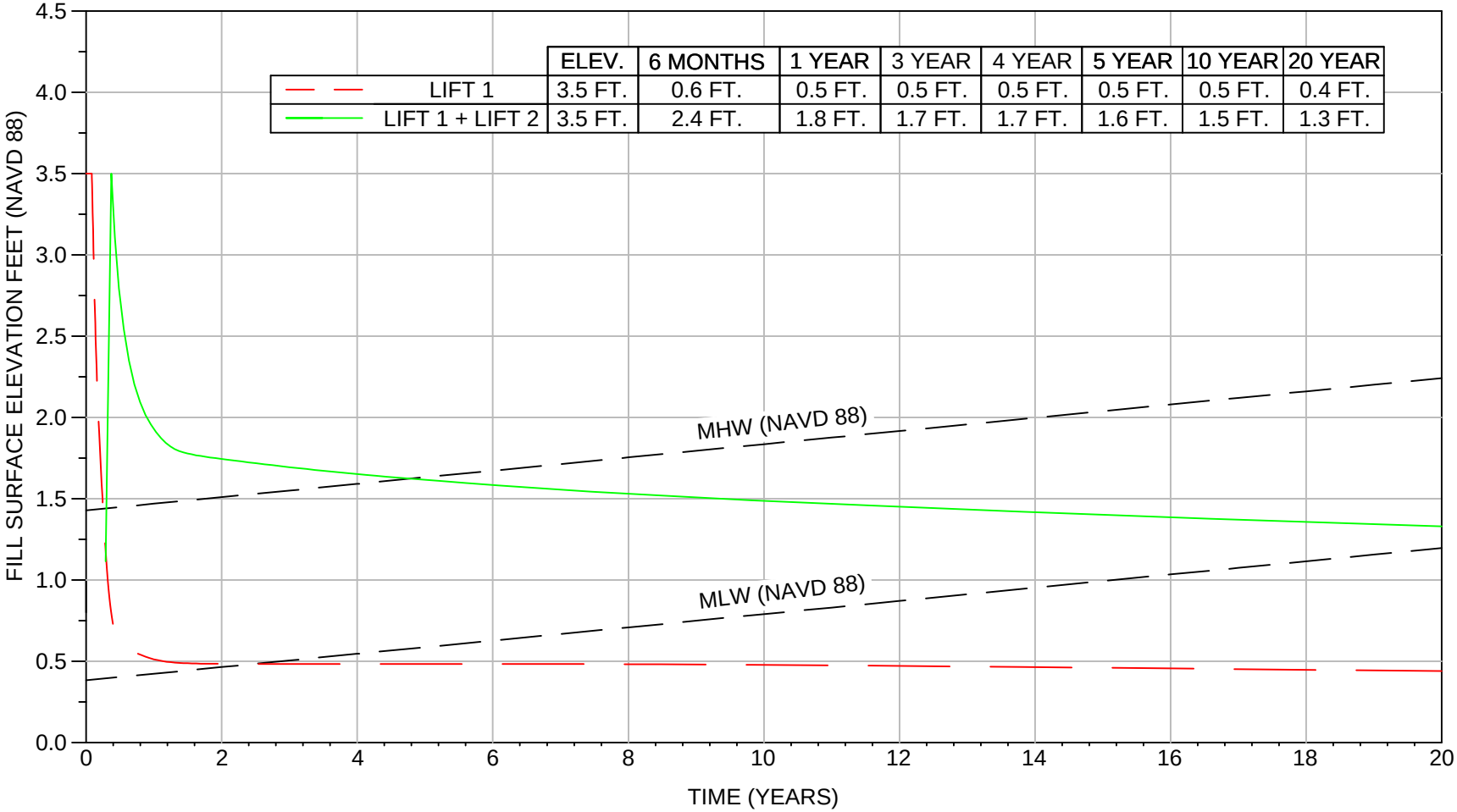
MARSH FILL SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A8**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.0 FT.	2.2 FT.	1.8 FT.	1.5 FT.	1.5 FT.	1.5 FT.	1.4 FT.	1.4 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 80 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

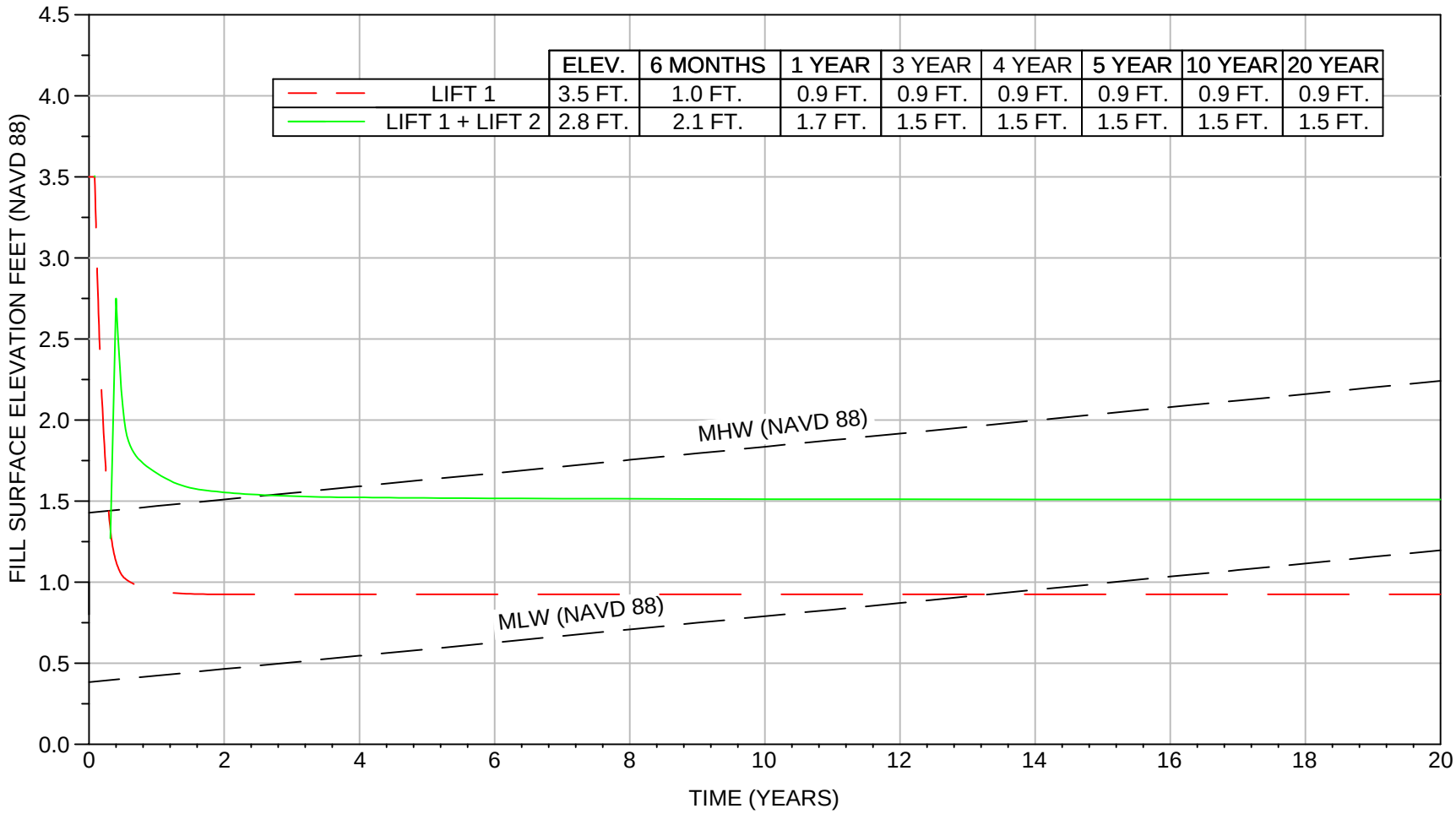
MARSH FILL SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A9**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	0.6 FT.	0.5 FT.	0.5 FT.	0.5 FT.	0.5 FT.	0.5 FT.	0.4 FT.
LIFT 1 + LIFT 2	3.5 FT.	2.4 FT.	1.8 FT.	1.7 FT.	1.7 FT.	1.6 FT.	1.5 FT.	1.3 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 75 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

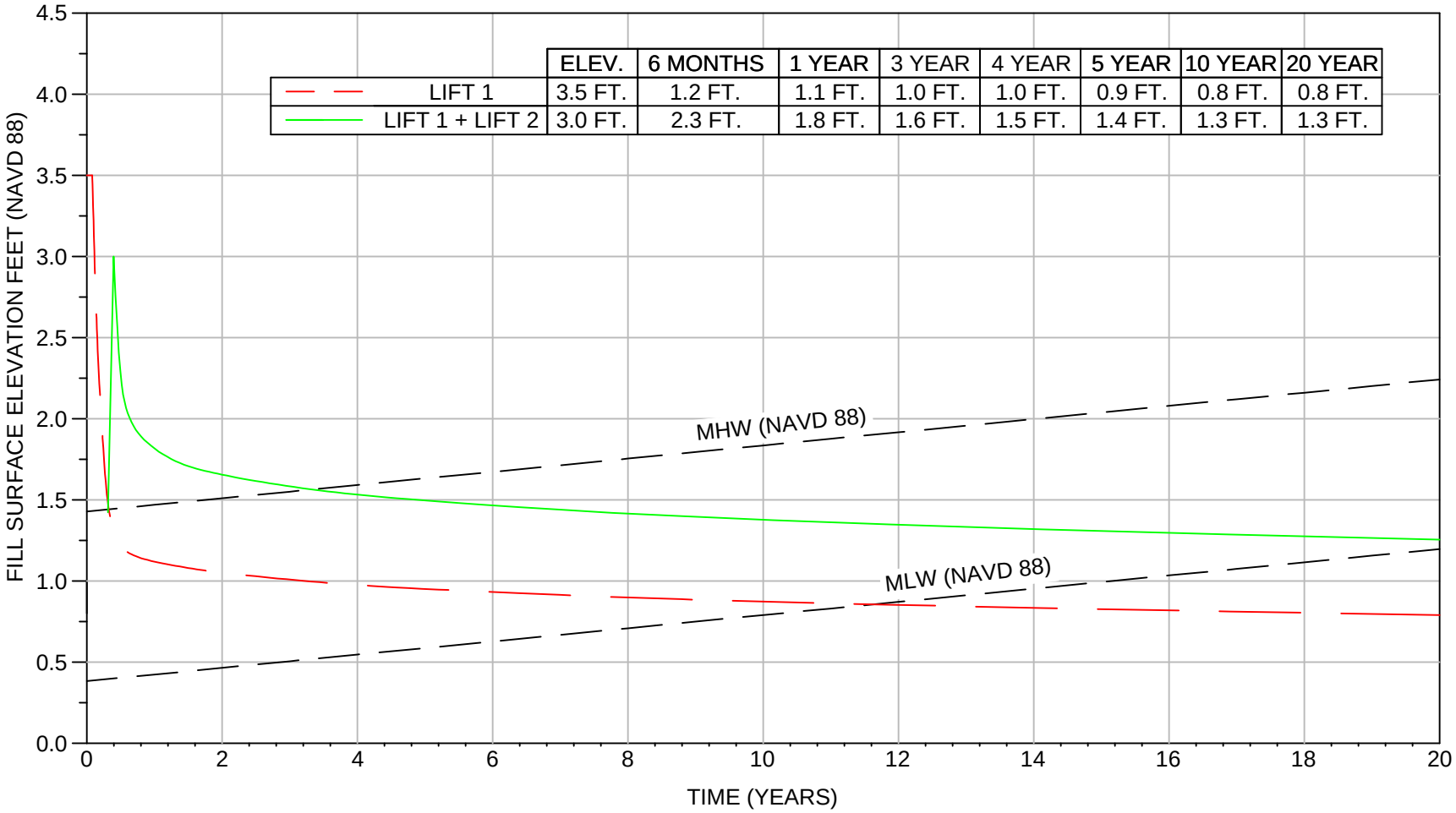
MARSH FILL SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A10**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.0 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.	0.9 FT.
LIFT 1 + LIFT 2	2.8 FT.	2.1 FT.	1.7 FT.	1.5 FT.	1.5 FT.	1.5 FT.	1.5 FT.	1.5 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

MARSH FILL SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A11**



	ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
LIFT 1	3.5 FT.	1.2 FT.	1.1 FT.	1.0 FT.	1.0 FT.	0.9 FT.	0.8 FT.	0.8 FT.
LIFT 1 + LIFT 2	3.0 FT.	2.3 FT.	1.8 FT.	1.6 FT.	1.5 FT.	1.4 FT.	1.3 FT.	1.3 FT.

Notes: 1) Time gap between the end of first lift (lift 1) and beginning of second lift (lift 2) is 85 days.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

MARSH FILL SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-A12**

APPENDIX II-B
Slope Stability and Settlement Analyses for Containment Dike

Slope Stability Calculation Approach for the Containment Dike
Grand Liard Marsh and Ridge Restoration (BA-68)

1. A total of 4 design profiles were prepared after analyzing shear strength profile of Borings B-7, B-8, B-9 and B-10 for the containment dike as requested by OCPR.
2. Subsurface profiles for each design profile were developed by shear strength, unit weight, and moisture content.
3. Based on our proposal sated June 16, 2010 and information provided by OCPR and Sigma Consulting Group, Inc . during meetings on October 12, 2010 and December 6, 2010
    a. Earthen Containment Dike
        i. Establish crown elevation to contain marsh creation dredge slurry and maintain at least 1-foot of freeboard during construction.
4. Results
    a. Earthen Containment Dike
        i. Based on results obtained, the containment dike is stable with a crown width of 5 feet and side slopes at 5H:1V at the edge of the earthen embankment on the marsh side when the crown elevation is less than or equal to +5.5 feet.
        ii. The excavation access channel was assumed to be excavated to a maximum depth of 5 feet below existing mudline and with a 3H:1V bank slope.

GeoEngineers performed stability analyses for the containment dike using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory to evaluate the stability of earth slopes. Subsurface soil properties were estimated using the results of subsurface explorations and associated laboratory testing. The factor of safety for the containment dike for various slopes was analyzed using the Spencer method. The Spencer method considers both shear and normal interslice forces. The method involves a circular search and takes into account both moment and force equilibrium.

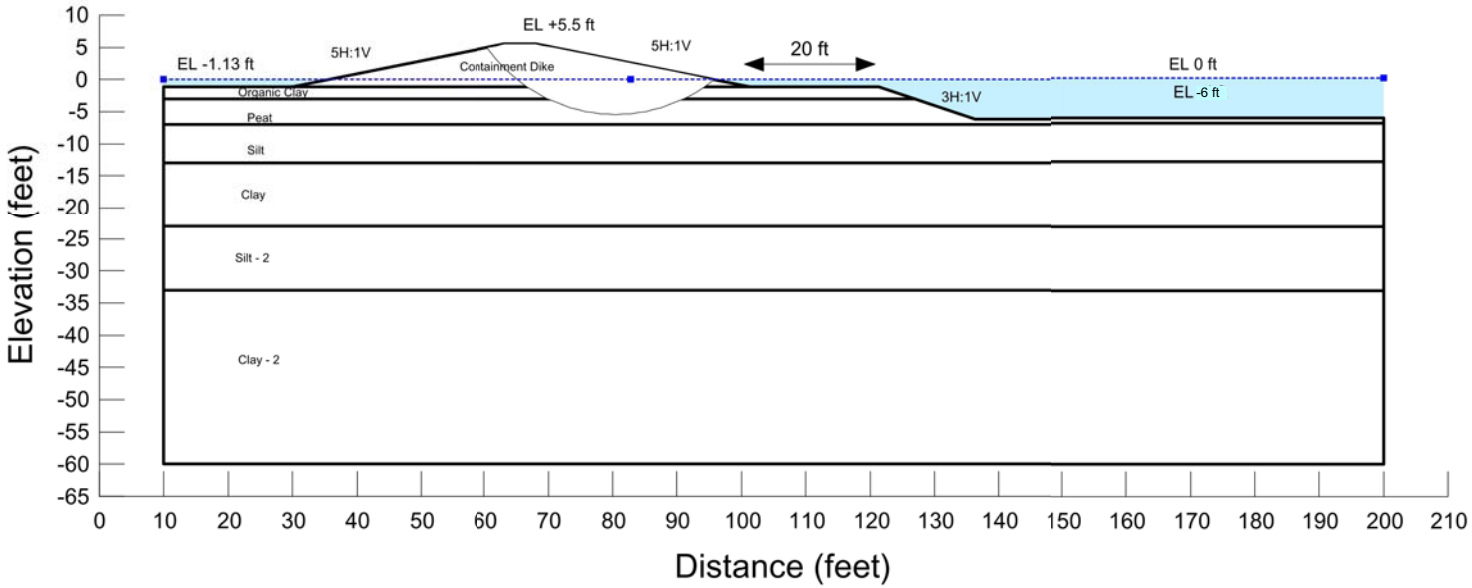
The stability analyses for the containment dike was initially performed for side slopes at 3H:1V and 4H:1V. Based on the required freeboard of at least 1-foot and marsh fill containment requirements, an initial completed containment dike elevation of +5.5 feet NAVD 88 was used. The containment dike was stable with a crown width of 5 feet and side slopes at 5H:1V at the edge of the earthen embankment on the marsh side when the crown elevation is less than or equal to +5.5 feet. The containment dike stability was reevaluated for various berm widths between the toe of the containment dike and the excavation access channel. A berm width of at least 20 feet was required for all design profiles for factor of safety to be greater than 1.3.

Settlement Calculation Approach for the Containment Dike
Grand Liard Marsh and Ridge Restoration (BA-68)

1. Settlement parameters were developed for each soil layer for all borings as shown in the spreadsheets provided in Appendix I-E. Settlement parameters for Borings B-7 through B-10 were used for settlement estimates for the containment dike. The following description explains how the parameters were developed.
    (a) One consolidation test was done for each soil boring and the samples for the consolidation test were selected from varying depths and materials.
    (b) Four consolidation test results were analyzed and graphs were reconstructed to determine compression (C_c), recompression (C_r) and vertical consolidation (C_v) coefficients, initial void ratios (e_0) and maximum past pressures (P_c).
    (c) Correlations presented in equations 1 through 3 (shown in the spreadsheets) were used to calculate e_0 and C_c for all the soil layers.
    (d) GeoEngineers developed different correlations based on the analyses of the consolidation test results as follows:
        (i) Moisture Content (w) Vs. C_v: A best fit curve was drawn through the plotted points from this and other coastal projects and C_v for the soil layers were obtained depending upon the moisture content.
        (ii) w Vs. C_c: C_c=0.0054*((w*S.G.)-35 was found to provide sufficient accuracy based on the test data for this and other projects for all compressible soil types; C_c was obtained for the soil layers based on the moisture content.
        (iii) C_r was taken to be 15% of C_c for peat and 10% of C_c for all other cohesive and semi-cohesive soils.
    (e) For the soil layers without a representative consolidation test, the above mentioned correlations were used to estimate C_c, C_r and C_v.
    (f) Past previous pressure (P_c) were obtained from the consolidation test curves for the soil layers with a representative consolidation test. For other soil layers, the overconsolidation ratio (OCR) was estimated from the equation OCR = (c/(P_0' * 0.22))^(1/0.8). This equation was taken from Figure 7.1 of "Recommended practice for soft ground site characterization," by Charles Ladd and Don DeGroot. P_c was estimated by multiplying the overburden pressure (P_0) by OCR.
    (g) In some cases where P_0 was greater than P_c, P_0 was used as the maximum past pressure instead of P_c for the settlement analysis assuming the layers to be normally consolidated.
2. In this area, clay shear strength for a normally consolidated soil profile will be approximately 22% of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles. Based on this relationship, it appears that the top 8-17 feet of the soil profile is slightly over-consolidated in all the design profiles. This affects the settlement parameters selected for design within this zone.
3. Due to the broad fill area, the drainage is vertical for all the soil layers. Drainage to the phreatic surface or to the nearest granular soil layer has been considered for these soil layers. The presence of small sand and silt layers within clay was considered in the drainage path evaluation.
4. Consolidation of the foundations soils was modeled iteratively using a one-dimensional consolidation program.

Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Silt Unit Weight: 112 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 95 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt - 2 Unit Weight: 104 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay - 2 Unit Weight: 104 pcf Cohesion: 200 psf Phi: 0 °

FOS: 1.54



Notes:
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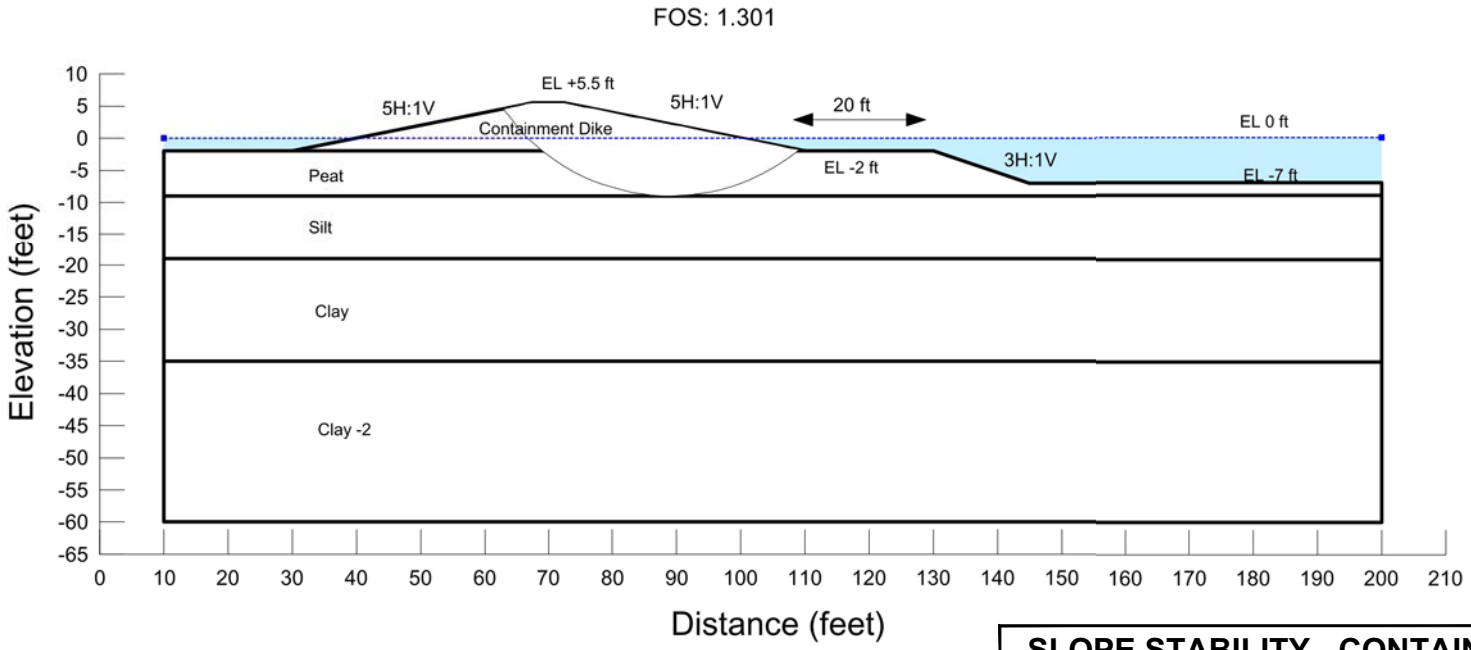
SLOPE STABILITY - CONTAINMENT DIKE - B-7

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-B1

Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Silt Unit Weight: 110 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Clay - 2 Unit Weight: 100 pcf Cohesion: 160 psf Phi: 0 °



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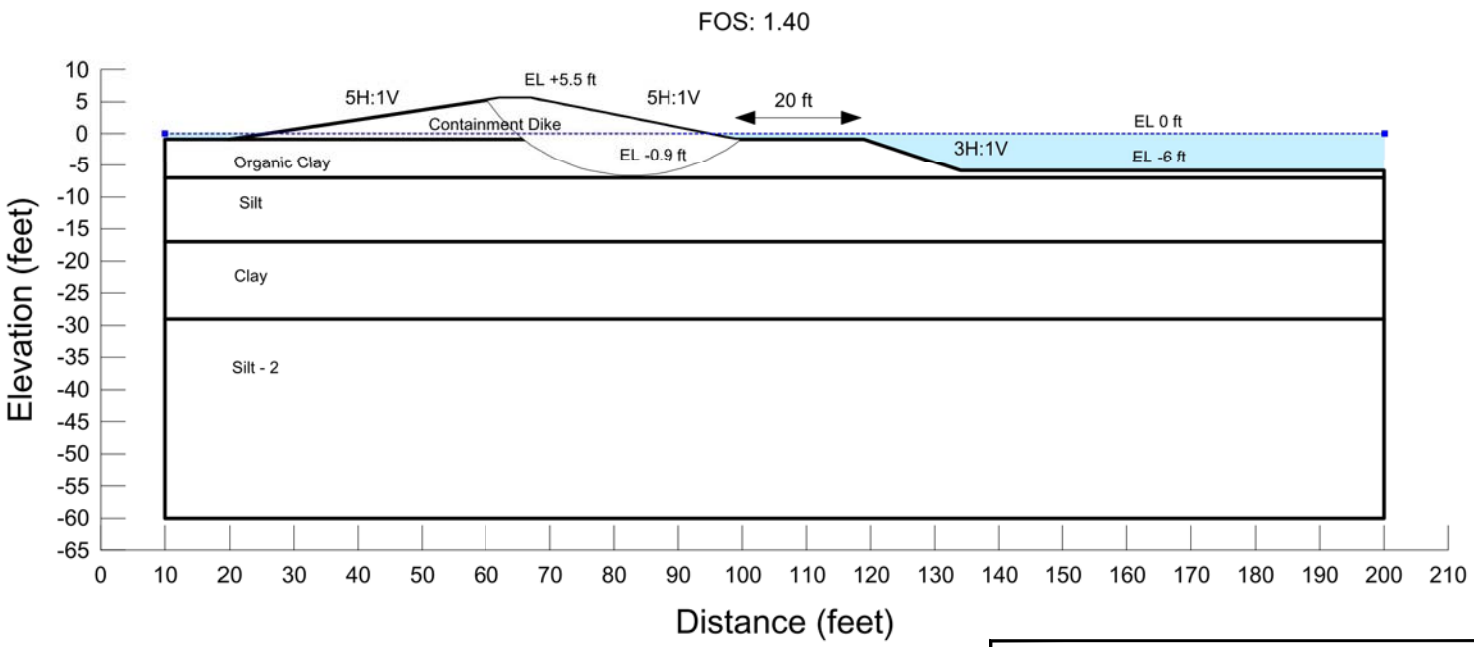
SLOPE STABILITY - CONTAINMENT DIKE - B-8

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-B2

Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 91 pcf Cohesion: 140 psf Phi: 0 °
Name: Silt - 2 Unit Weight: 115 pcf Cohesion: 100 psf Phi: 20 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 90 psf Phi: 0 °



SLOPE STABILITY - CONTAINMENT DIKE - B-9

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-B3

Notes:
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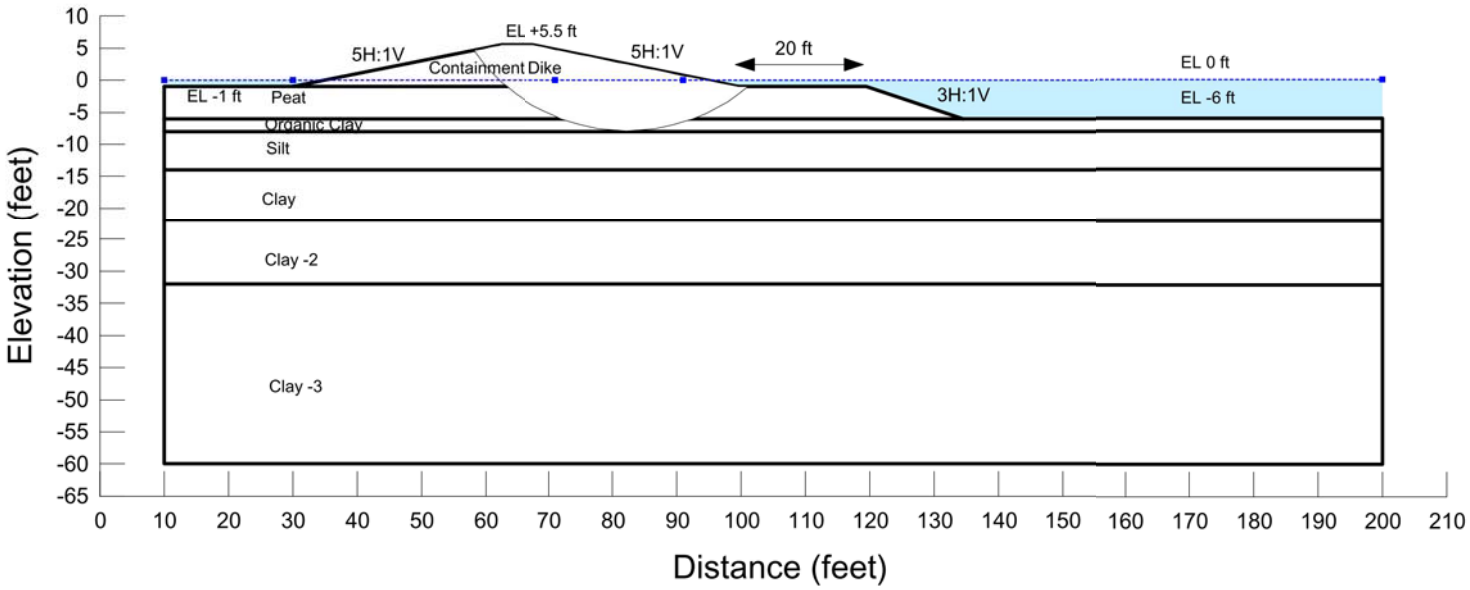
Name: Containment Dike Fill Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Organic Clay Unit Weight: 83 pcf Cohesion: 90 psf Phi: 0 °
Name: Silt Unit Weight: 119 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay Unit Weight: 103 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay - 2 Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay - 3 Unit Weight: 102 pcf Cohesion: 170 psf Phi: 0 °

FOS: 1.37



SLOPE STABILITY - CONTAINMENT DIKE - B-10

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-B4

Notes:
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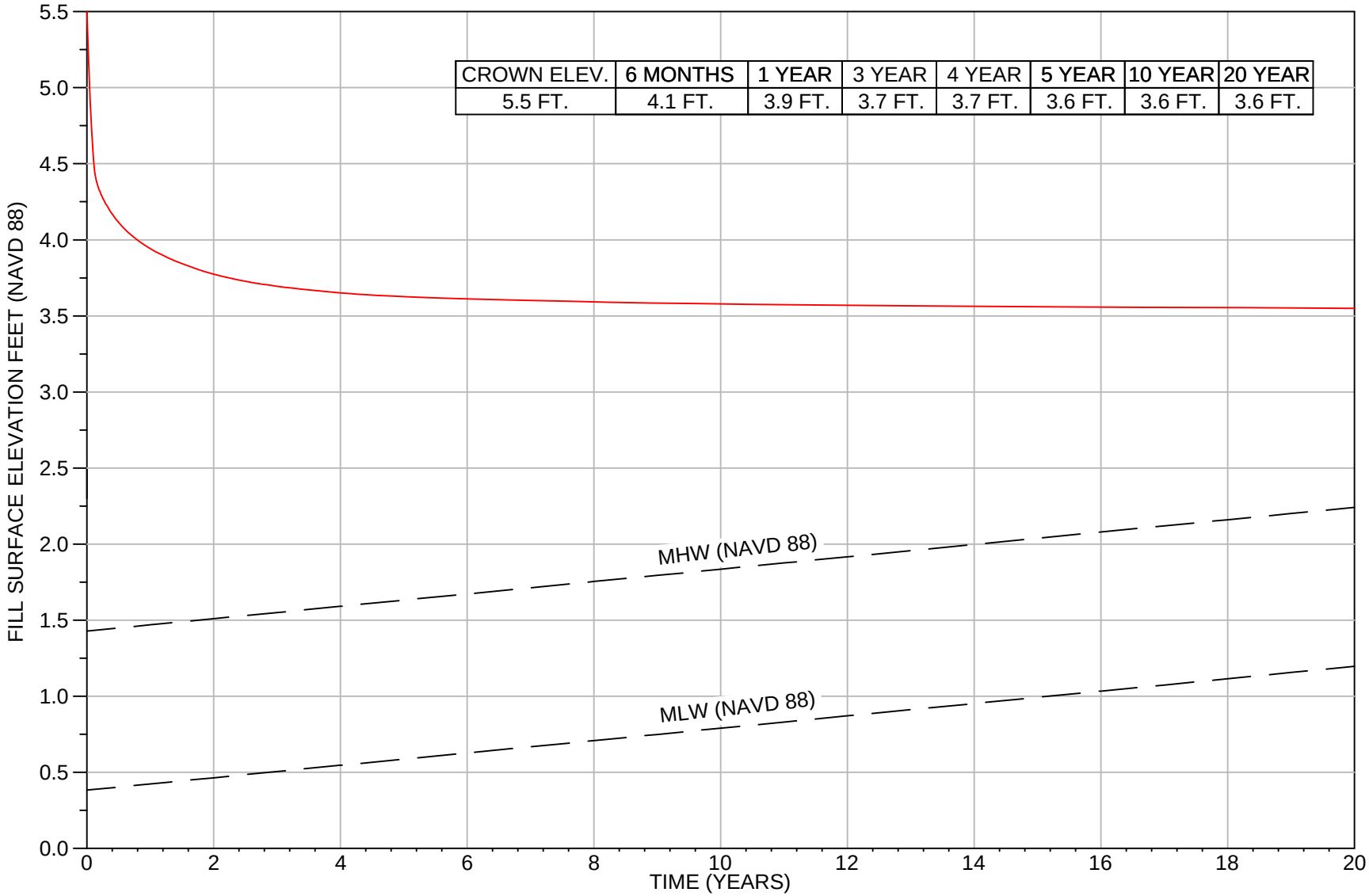
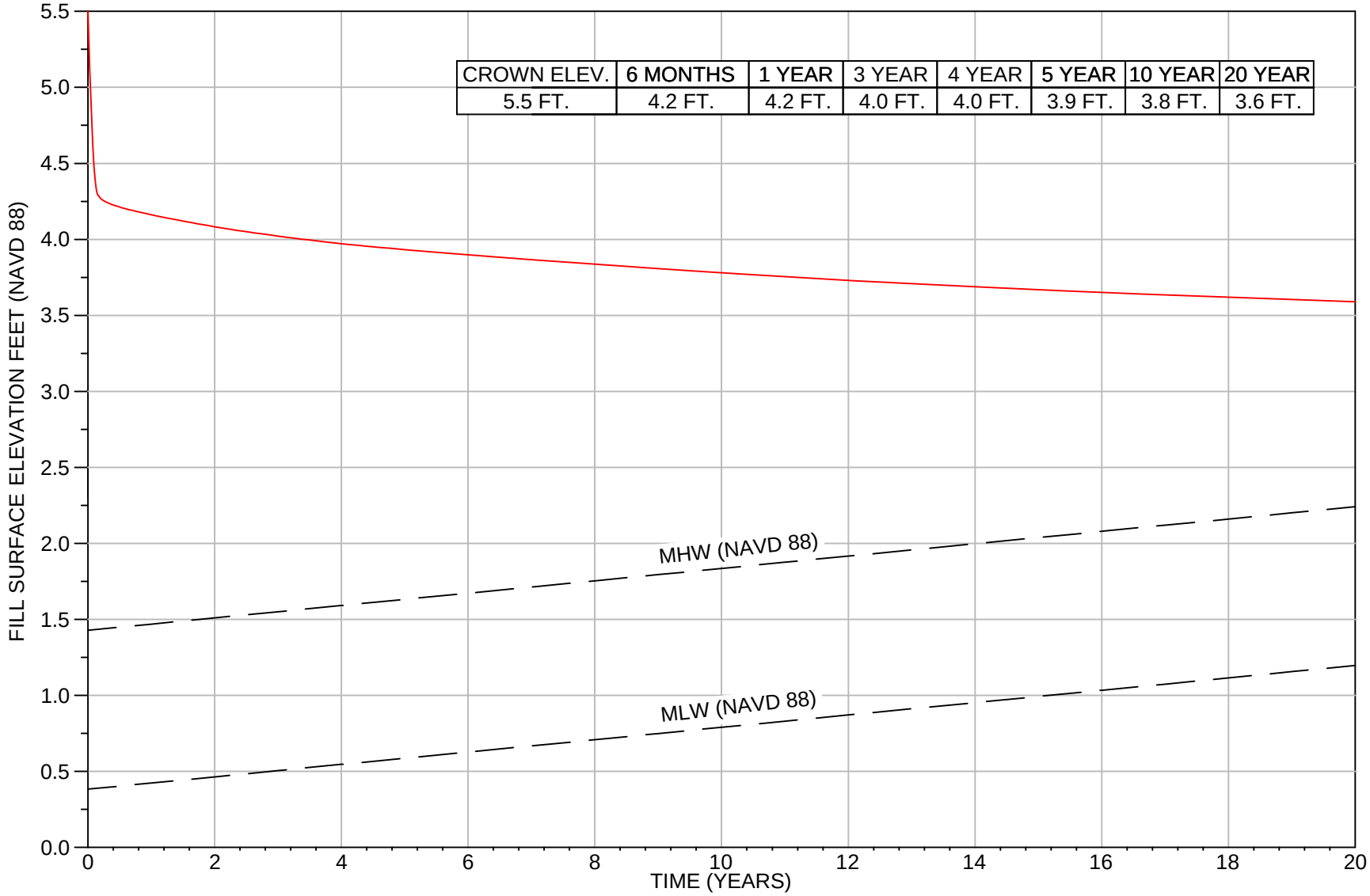


Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

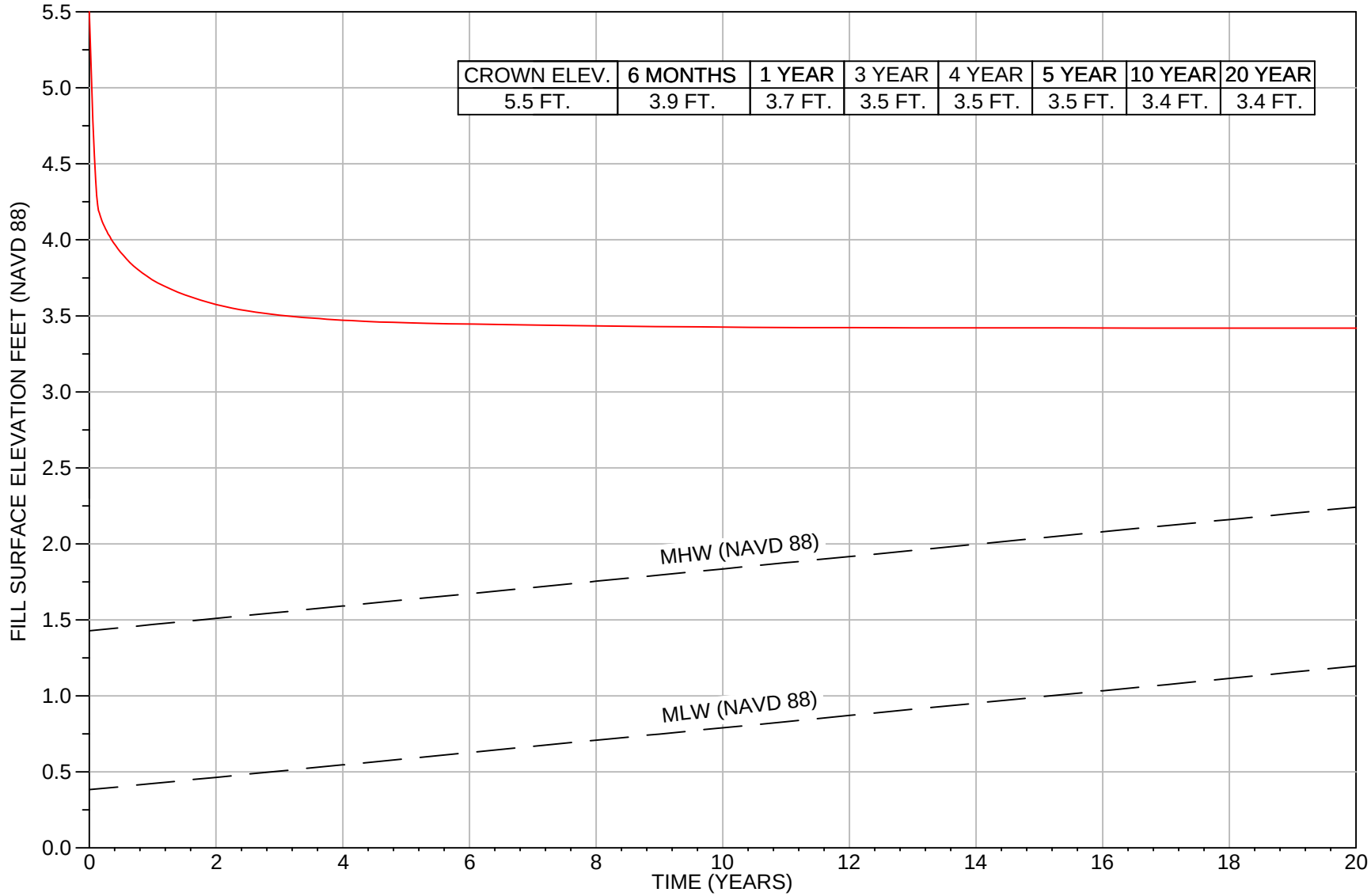
CONTAINMENT DIKE SETTLEMENT VS. TIME (B-7)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B5**



CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.2 FT.	4.2 FT.	4.0 FT.	4.0 FT.	3.9 FT.	3.8 FT.	3.6 FT.

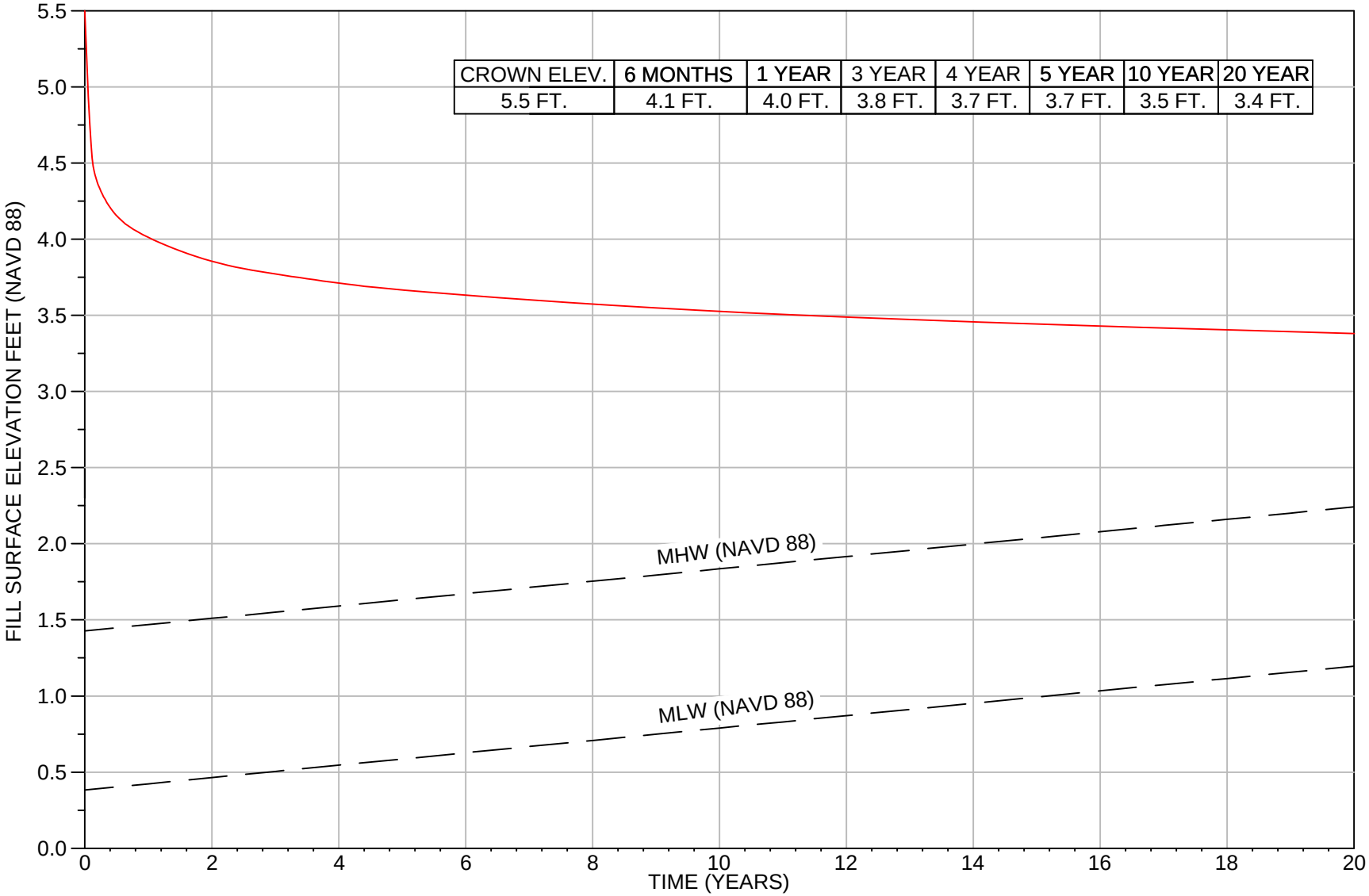
Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

CONTAINMENT DIKE SETTLEMENT VS. TIME (B-8)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B6**



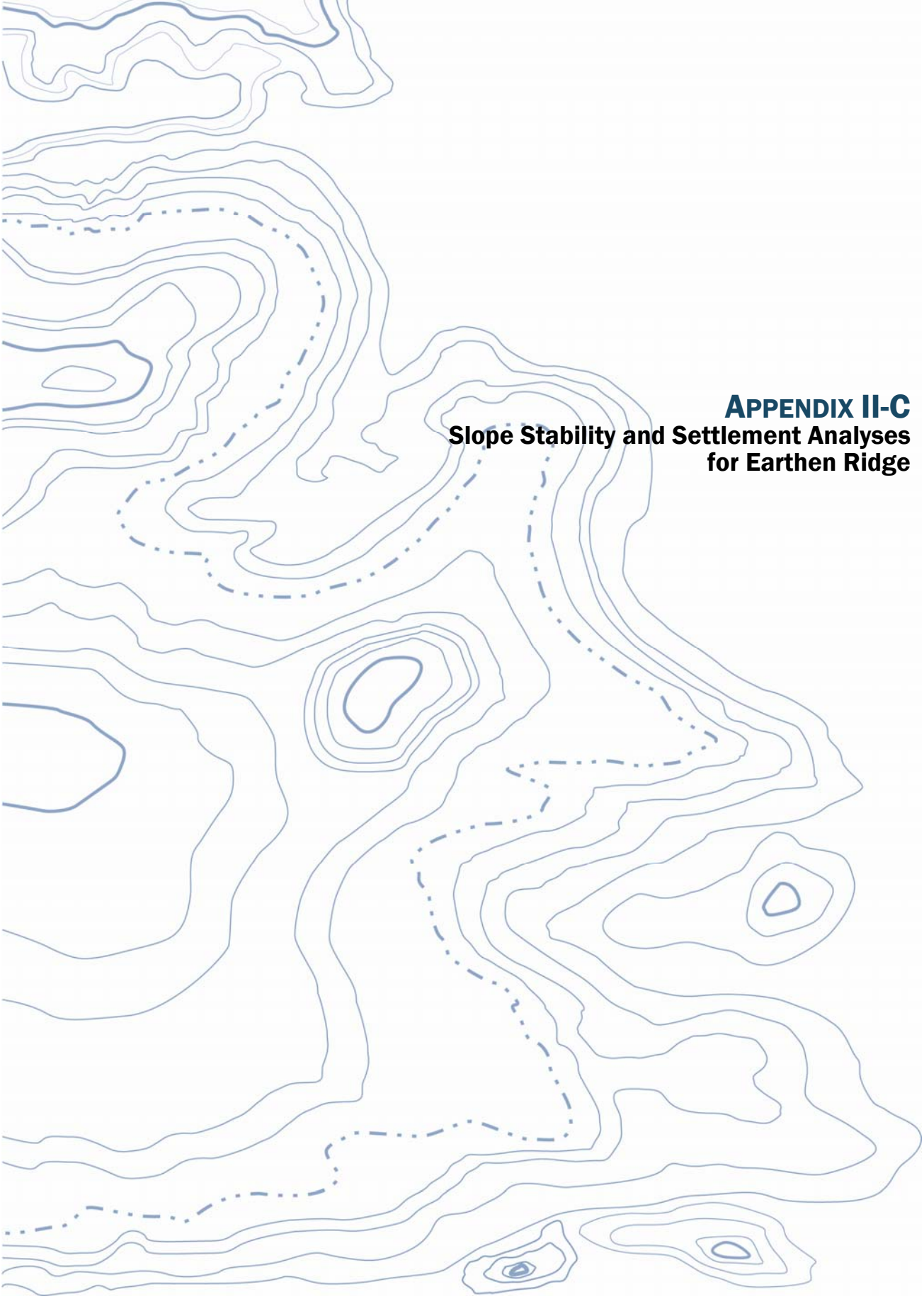
Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

CONTAINMENT DIKE SETTLEMENT VS. TIME (B-9)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B7**



Notes:1) Initial crown elevation of the containment dike during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

CONTAINMENT DIKE SETTLEMENT VS. TIME (B-10)	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-B8**



APPENDIX II-C

Slope Stability and Settlement Analyses for Earthen Ridge

Slope Stability Calculation Approach for the Earthen Ridge
Grand Liard Marsh and Ridge Restoration (BA-68)

1. A total of 5 design profiles were prepared after analyzing shear strength profile of Borings B-1 through B-6 for the earthen ridge as requested by OCPR.
2. Subsurface profiles for each design profile were developed by shear strength, unit weight, and moisture content.
3. Based on information provided by OCPR, stability analyses to determine the stability of the ridge section with base width of 100 feet and crown width of 20 feet was performed for three different scenarios given below:
    i. Ridge constructed with material from Bayou Grand Liard.
    ii. Ridge constructed with material from Gulf of Mexico East Borrow Site (CPR cores GLVC-10-09, GLVC-10-10, GLVC-10-11, GLVC-10-12, GLVC-10-14, and GLVC-10-15).
    iii. Ridge constructed with material from proposed marsh creation area.

GeoEngineers performed stability analyses for the earthen ridge using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory to evaluate the stability of earth slopes. Subsurface soil properties were estimated using the results of subsurface explorations and associated laboratory testing. The factor of safety for the earthen ridge for various slopes was analyzed using the Spencer method. The Spencer method considers both shear and normal interslice forces. The method involves a circular search and takes into account both moment and force equilibrium.

The average mudline elevations for the slope stability calculations at each design profile were determined from the survey information provided by Sigma Consulting Group, Inc (Sigma). Initially stability of the earthen ridge was checked on both the bayou side and the marsh side of the ridge for various berm widths. Based on our analyses, for the scenarios where borrow material is obtained from Bayou Grand Liard and Gulf of Mexico East Borrow Site, the stability of the ridge on the Bayou side was estimated to be the most critical. A minimum of 15 feet berm is required on the Bayou side of the ridge between the toe of the earthen ridge and the bank of the excavation in Bayou Grand Liard for the factor of safety to be above 1.3. Figures II-C1a, C1b through II-C6a, C6b show the critical failure surface for the above scenarios.

For the scenario where borrow material is obtained from the marsh creation area, the critical failure surface was estimated to be on the marsh side of the ridge. Initially evaluations were performed to check if dredging depth of 20 feet was feasible. The results indicated that the earthen ridge would be stable in this case only if the berm width is at least 80 feet. The other option might be to use geotextile underneath the proposed ridge. The ridge was found stable provided the dredging depth is less than 15 feet and the berm between the toe of the ridge and the excavation channel bank varies between 30 and 35 feet depending on the design profile. For ease of construction, it is recommended that the berm width be at least 35 feet. Figures II-C1c through C6c show the critical failure surface on the marsh side of the earthen ridge.

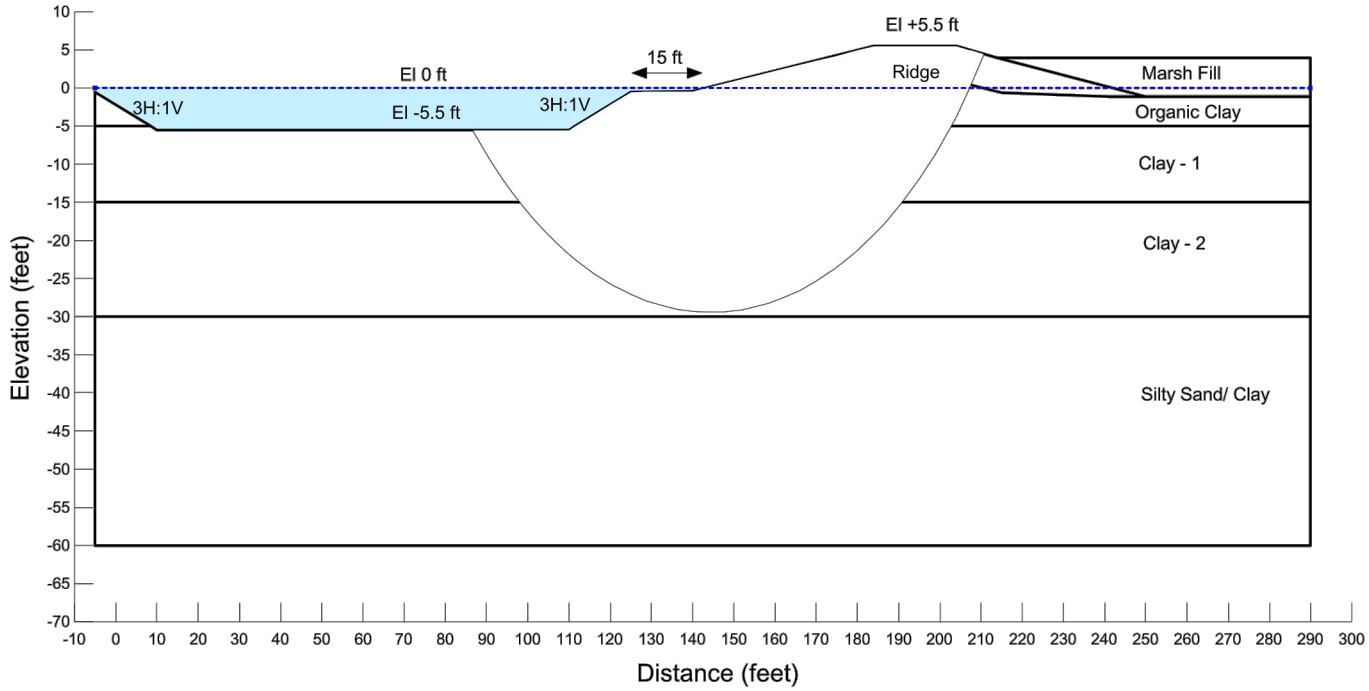
Settlement Calculation Approach for the Earthen Ridge
Grand Liard Marsh and Ridge Restoration (BA-68)

1. Settlement parameters were developed for each soil layer for all borings as shown in the spreadsheets provided in Appendix I-E. Settlement parameters for Borings B-1 through B-6 were used for settlement estaimates for the earthen ridge. The following description explains how the parameters were developed.
    (a) One consolidation test was done for each soil boring and the samples for the consolidation test were selected from varying depths and materials.
    (b) Six consolidation test results were analyzed and graphs were reconstructed to determine compression (C_c), recompression (C_r) and vertical consolidation (C_v) coefficients, initial void ratios (e_0) and maximum past pressures (P_c).
    (c) Correlations presented in equations 1 through 3 (shown in the spreadsheets) were used to calculate e_0 and C_c for all the soil layers.
    (d) GeoEngineers developed different correlations based on the analyses of the consolidation test results as follows:
        (i) Moisture Content (w) Vs. C_v: A best fit curve was drawn through the plotted points from this and other coastal projects and C_v for the soil layers were obtained depending upon the moisture content.
        (ii) w Vs. C_c: C_c=0.0054*((w*S.G.)-35 was found to provide sufficient accuracy based on the test data for this and other projects for all compressible soil types; C_c was obtained for the soil layers based on the moisture content.
        (iii) C_r was taken to be 15% of C_c for peat and 10% of C_c for all other cohesive and semi-cohesive soils.
    (e) For the soil layers without a representative consolidation test, the above mentioned correlations were used to estimate C_c, C_r and C_v.
    (f) Past previous pressure (P_c) were obtained from the consolidation test curves for the soil layers with a representative consolidation test. For other soil layers, the overconsolidation ratio (OCR) was estimated from the equation OCR = (c/(P_0' * 0.22))^(1/0.8). This equation was taken from Figure 7.1 of "Recommended practice for soft ground site characterization," by Charles Ladd and Don DeGroot. P_c was estimated by multiplying the overburden pressure (P_0) by OCR.
    (g) In some cases where P_0 was greater than P_c, P_0 was used as the maximum past pressure instead of P_c for the settlement analysis assuming the layers to be normally consolidated.
2. In this area, clay shear strength for a normally consolidated soil profile will be approximately 22% of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles. Based on this relationship, it appears that the top 8-17 feet of the soil profile is slightly over-consolidated in all the design profiles. This affects the settlement parameters selected for design within this zone.
3. Due to the broad fill area, the drainage is vertical for all the soil layers. Drainage to the phreatic surface or to the nearest granular soil layer has been considered for these soil layers. The presence of small sand and silt layers within clay was considered in the drainage path evaluation.
4. Consolidation of the foundations soils was modeled iteratively using a one-dimensional consolidation program.
5. The evaluations for settlement were performed for three scenarios where the source of the borrow material changed. Thus the properties of the material used to construct the earthen ridge were taken into account during the evaluation of the settlement caused due to construction of the ridge.

Borrow Material From Bayou Grand Liard
Boring B-1

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.428



SLOPE STABILITY - EARTHEN RIDGE
BORROW MATERIAL FROM BAYOU GRAND LIARD - B-1

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C1a

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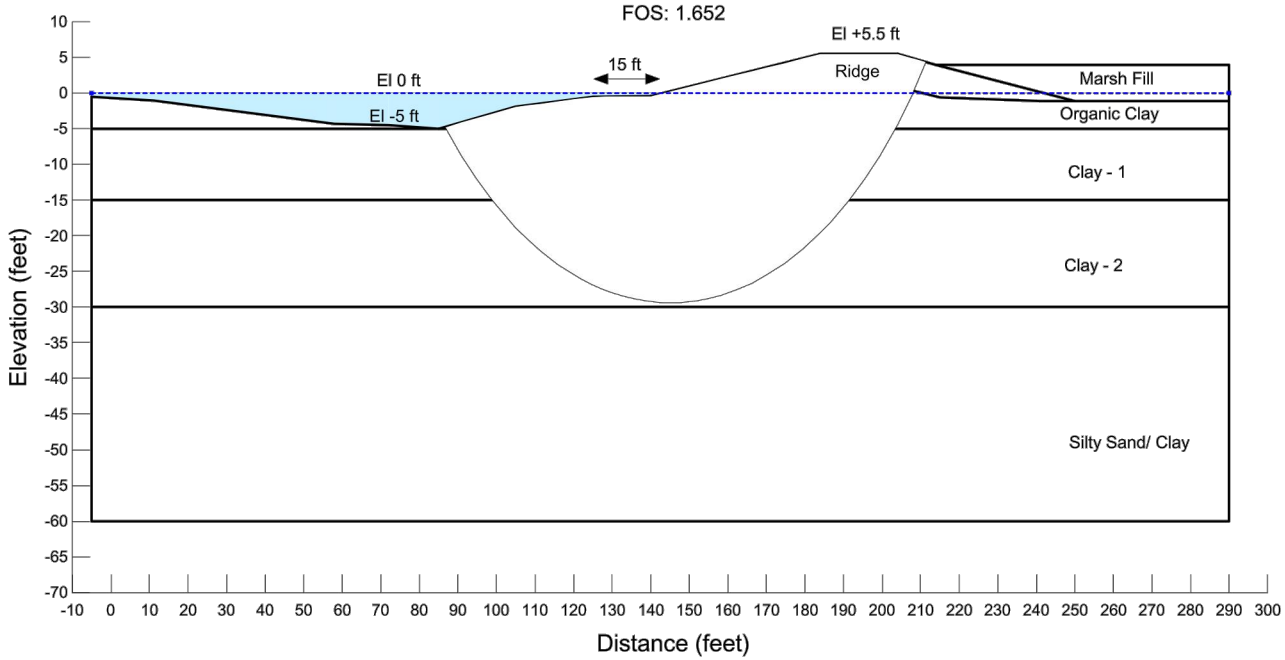
Borrow Material From Borrow Area
Boring B-1

Name: Ridge (Borrow Area) Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °



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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BORROW AREAS - B-1

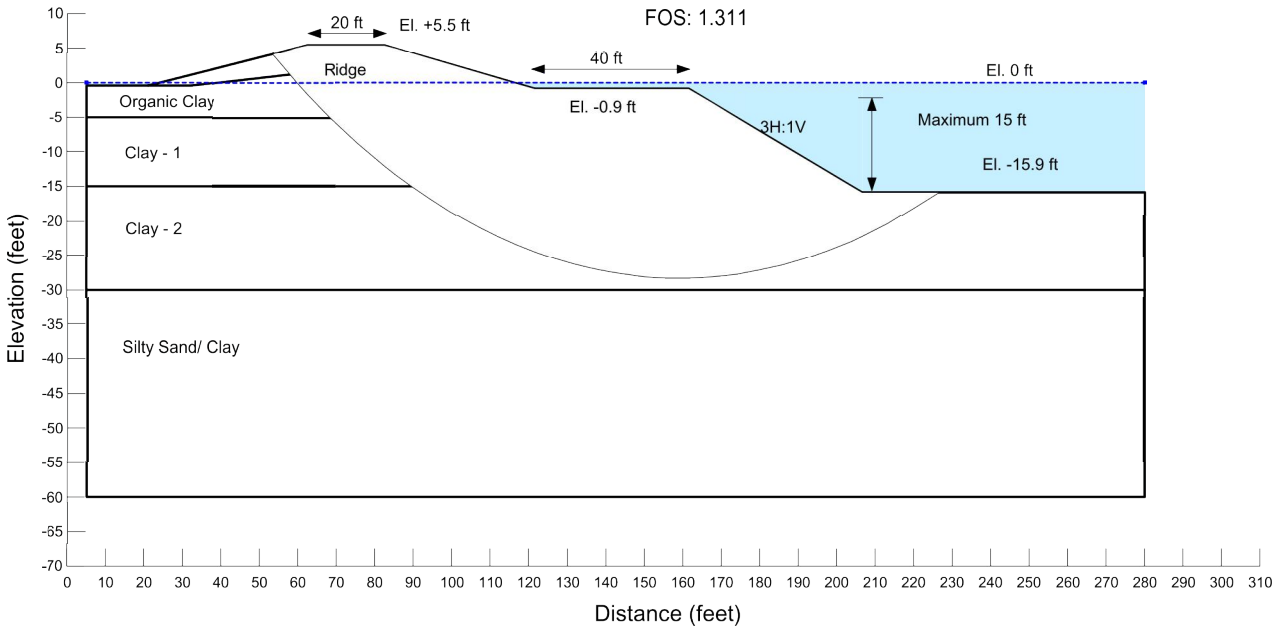
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C1b

Borrow Material From Existing Marsh
Boring B-1

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 110 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay-2 Unit Weight: 100 pcf Cohesion: 130 psf Phi: 0 °
Name: Silty Sand/ Clay Unit Weight: 100 pcf Cohesion: 130 psf Phi: 10 °



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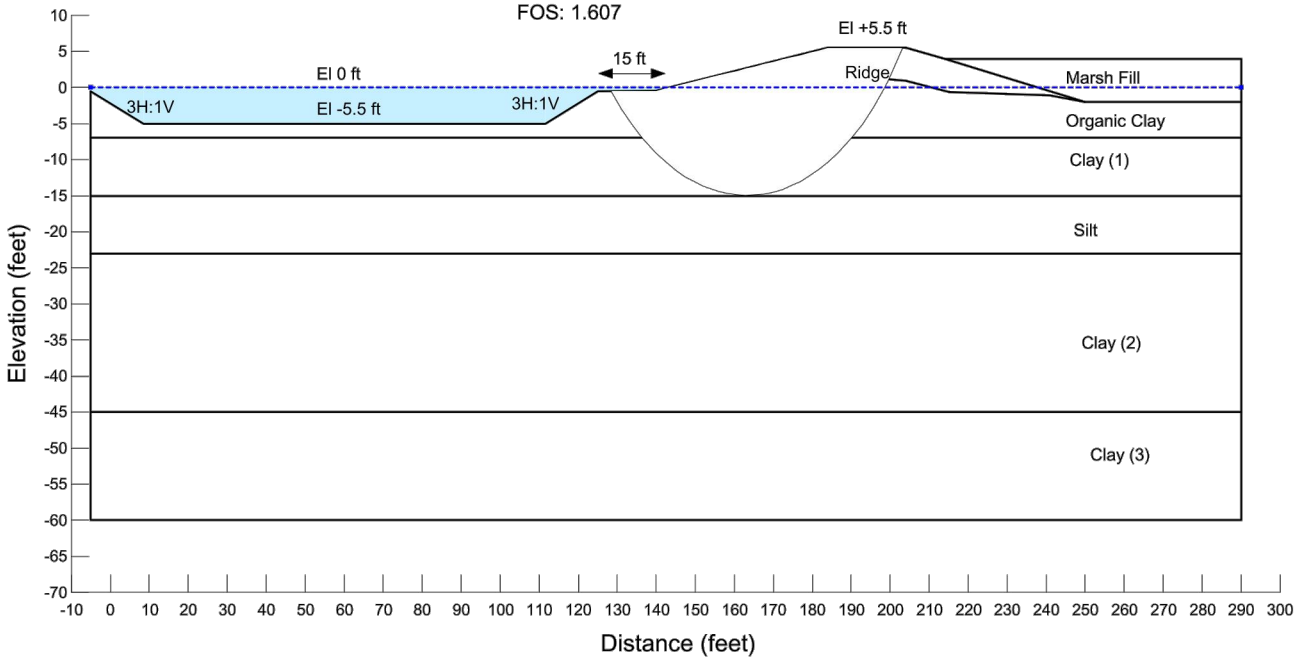
SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM EXISTING MARSH - B-1

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C1c

Borrow Material From Bayou Grand Liard
Boring B-2&5
Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °



Notes:
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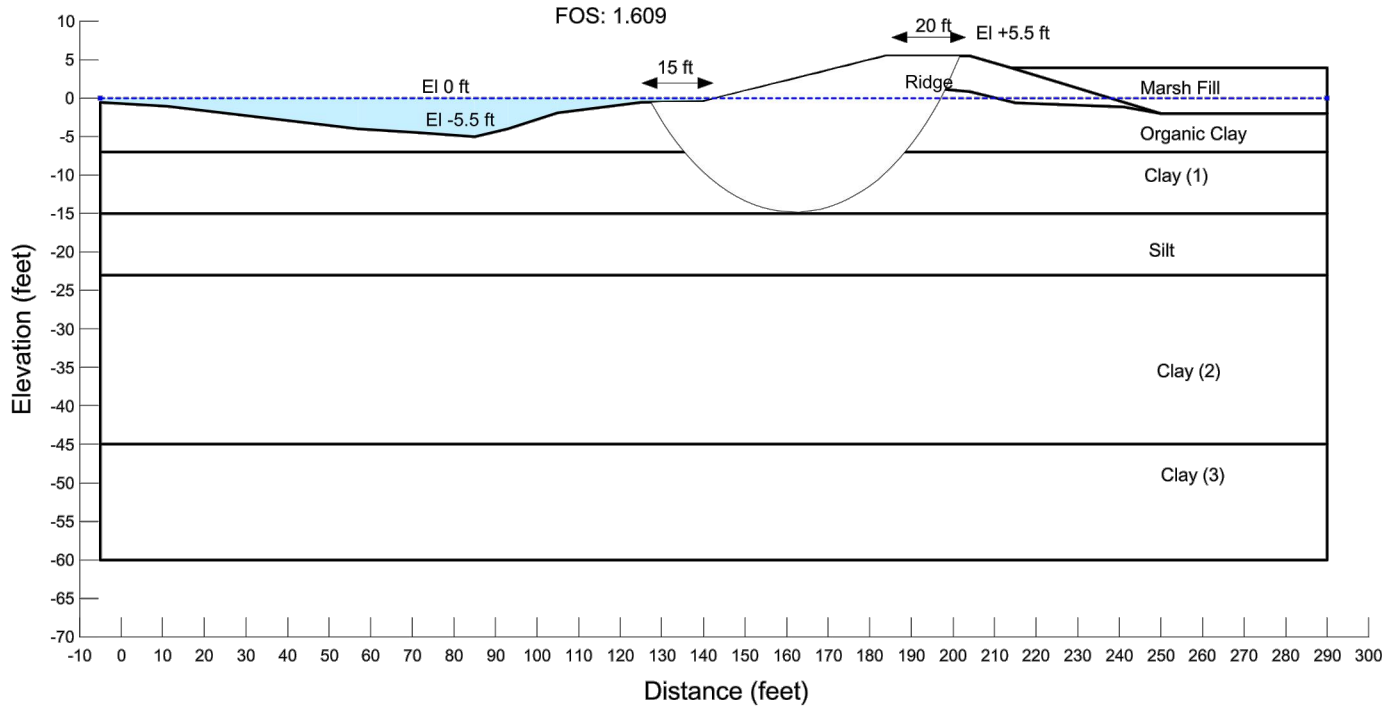
SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-2 & B-5

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C2a

Borrow Material From Borrow Area
Boring B-2&5
Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °



SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BORROW AREAS - B-2 & B-5

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C2b

Notes:
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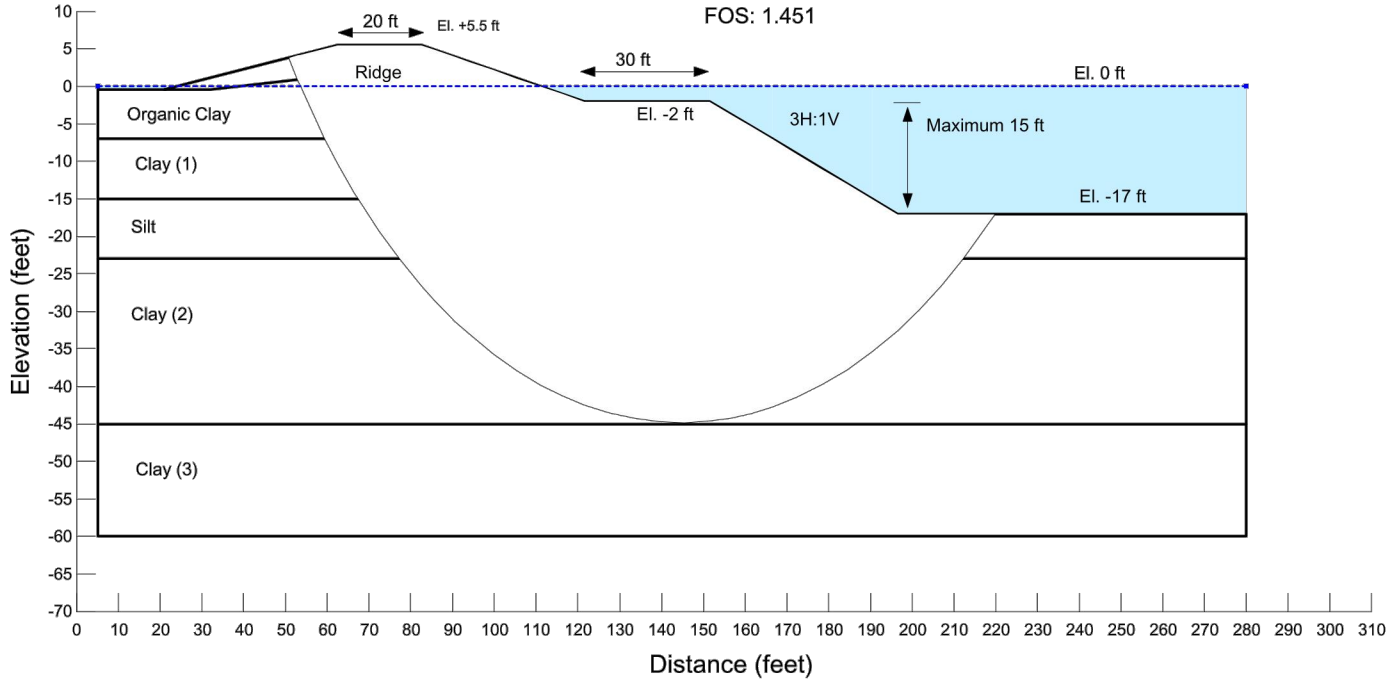
Borrow Material From Existing Marsh
Boring B-2&5

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 130 psf Phi: 0 °
Name: Silt Unit Weight: 108 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 100 pcf Cohesion: 200 psf Phi: 0 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 271 psf Phi: 0 °



Notes:
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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM EXISTING MARSH - B-2 & B-5

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

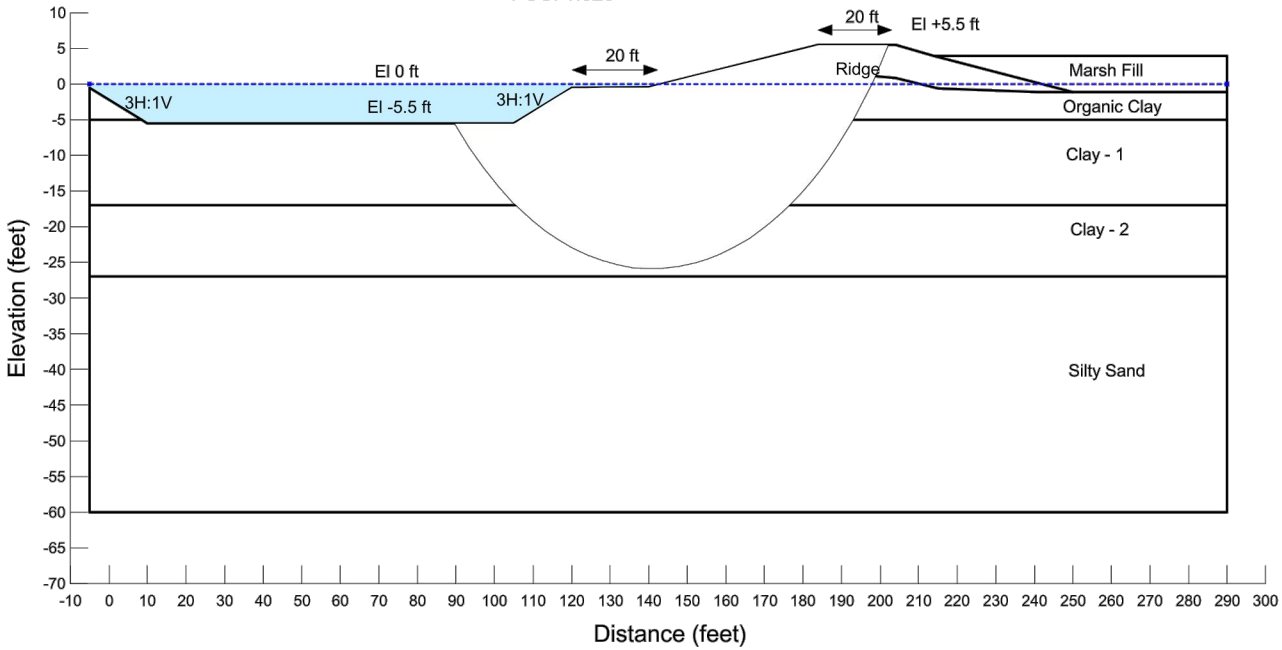
GEOENGINEERS

Figure II-C2c

Borrow Material From Bayou Grand Liard
Boring B-3

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.323



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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BAYOU GRAND LIARD - B-3

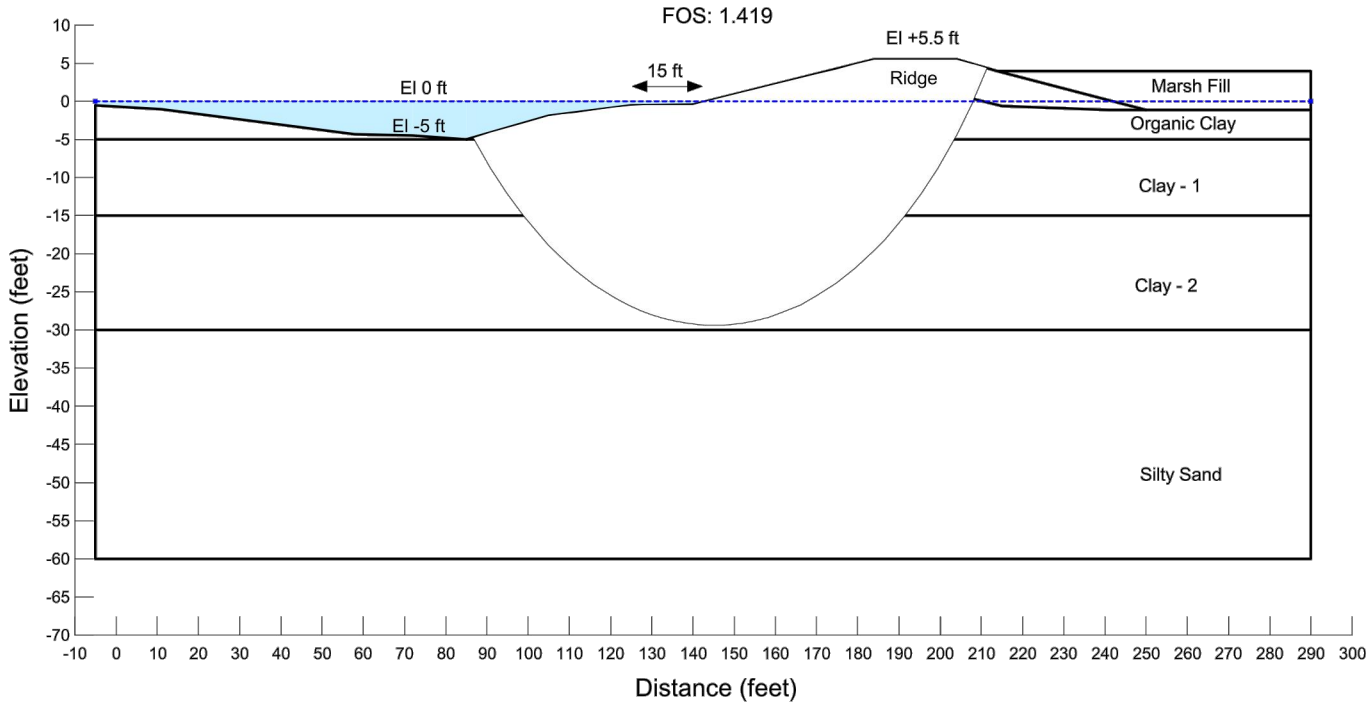
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C3a

Borrow Material From Borrow Area
Boring B-3

Name: Ridge (Borrow Area) Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay-1 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay-2 Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °



SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BORROW AREAS - B-3

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C3b

Notes:
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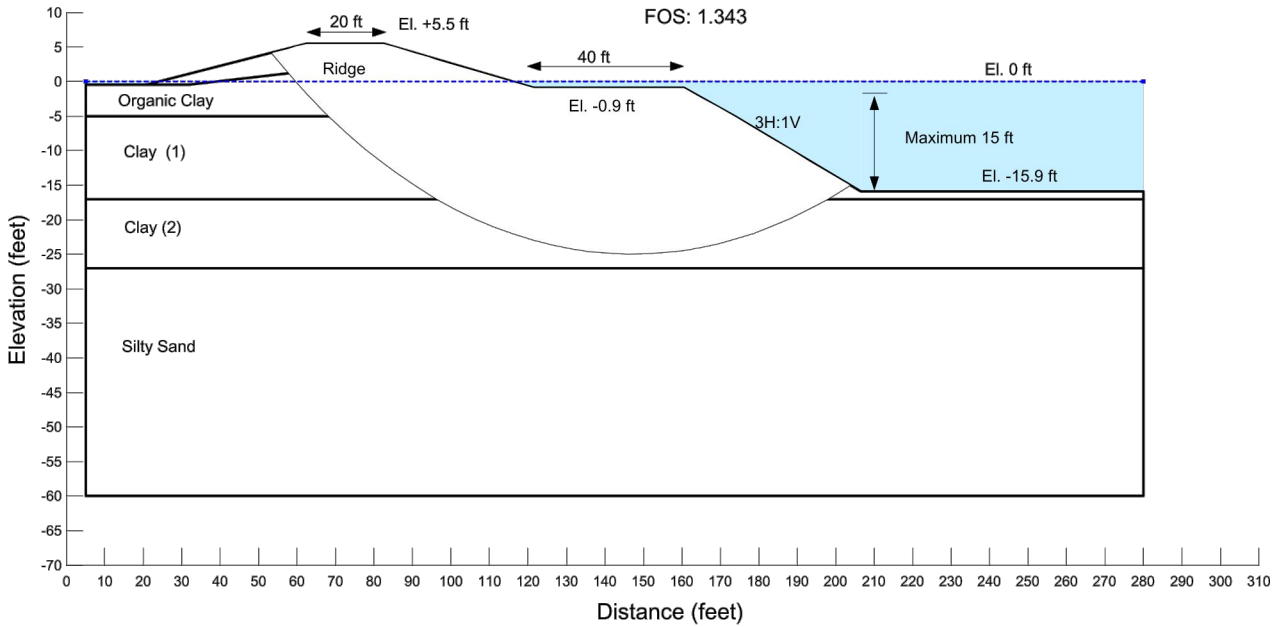
Borrow Material From Existing Marsh
Boring B-3

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 90 pcf Cohesion: 80 psf Phi: 0 °
Name: Clay (1) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 120 psf Phi: 15 °



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM EXISTING MARSH - B-3

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

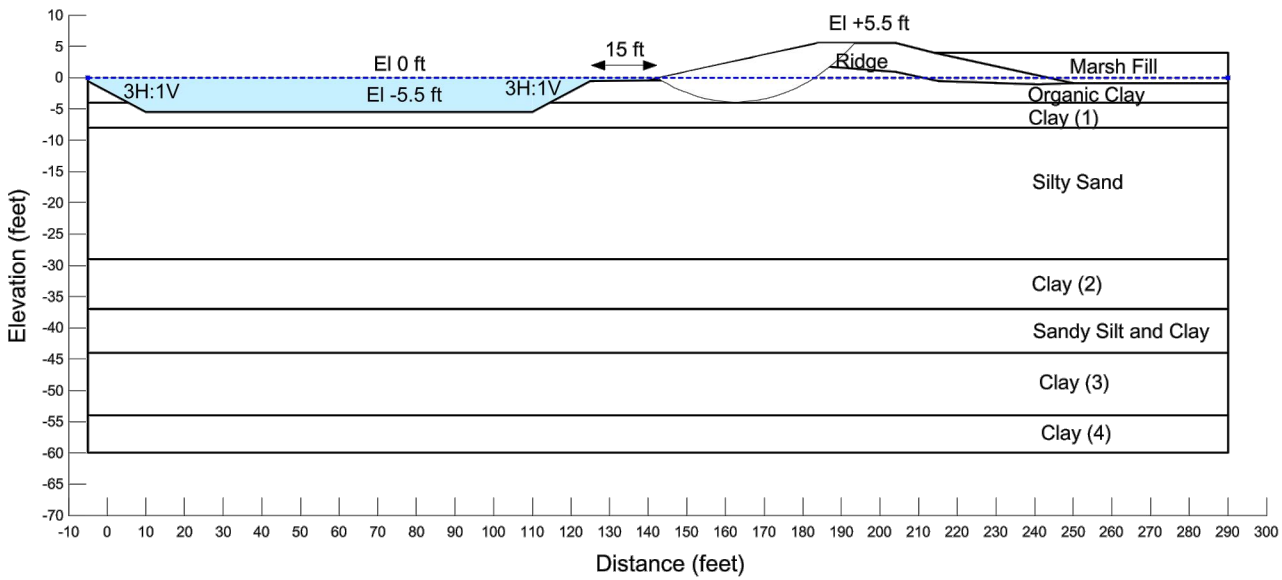
GEOENGINEERS

Figure II-C3c

Borrow Material From Bayou Grand Liard
Boring B-4

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay-1 Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 0 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 2.096



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SLOPE STABILITY - EARTHEN RIDGE
- BORROW MATERIAL FROM BAYOU GRAND LIARD - B-4

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

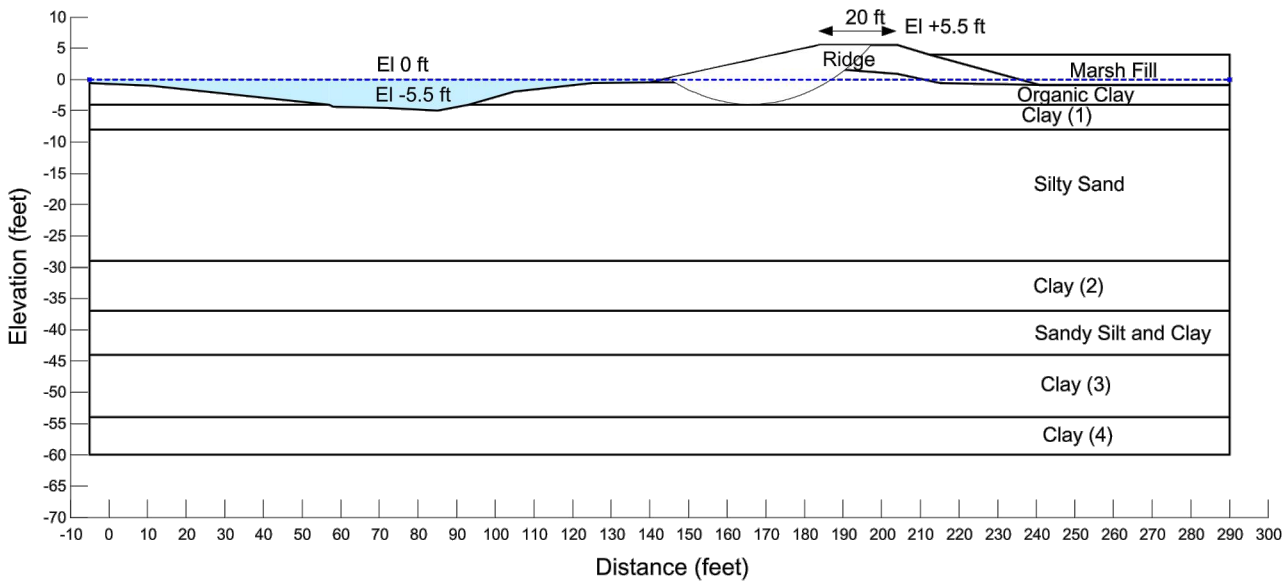
GEOENGINEERS

Figure II-C4a

Borrow Material From Borrow Area
Boring B-4

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 0 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 2.118



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BORROW AREAS - B-4

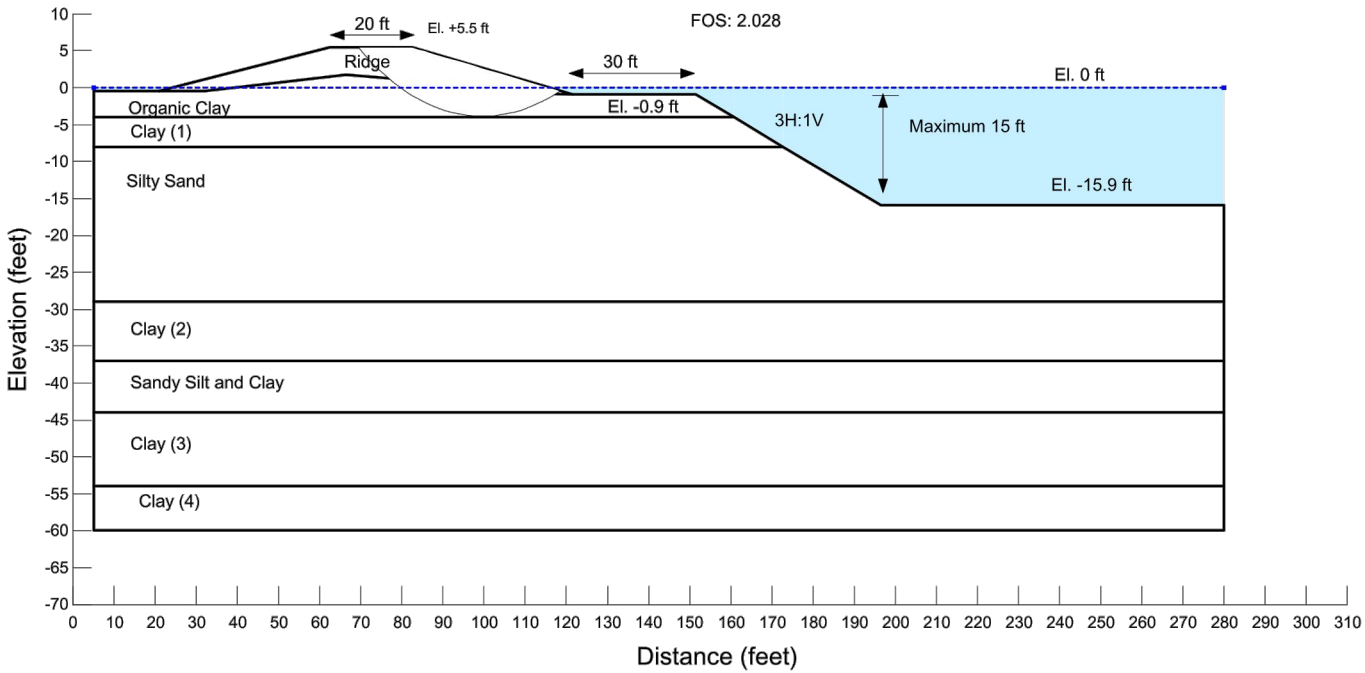
Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C4b

Borrow Material From Existing Marsh
Boring B-4

Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Organic Clay Unit Weight: 105 pcf Cohesion: 100 psf Phi: 0 °
Name: Clay (1) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Silty Sand Unit Weight: 101 pcf Cohesion: 140 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 200 psf Phi: 10 °
Name: Sandy Silt and Clay Unit Weight: 101 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (3) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °
Name: Clay (4) Unit Weight: 100 pcf Cohesion: 250 psf Phi: 0 °



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM EXISTING MARSH - B-4

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

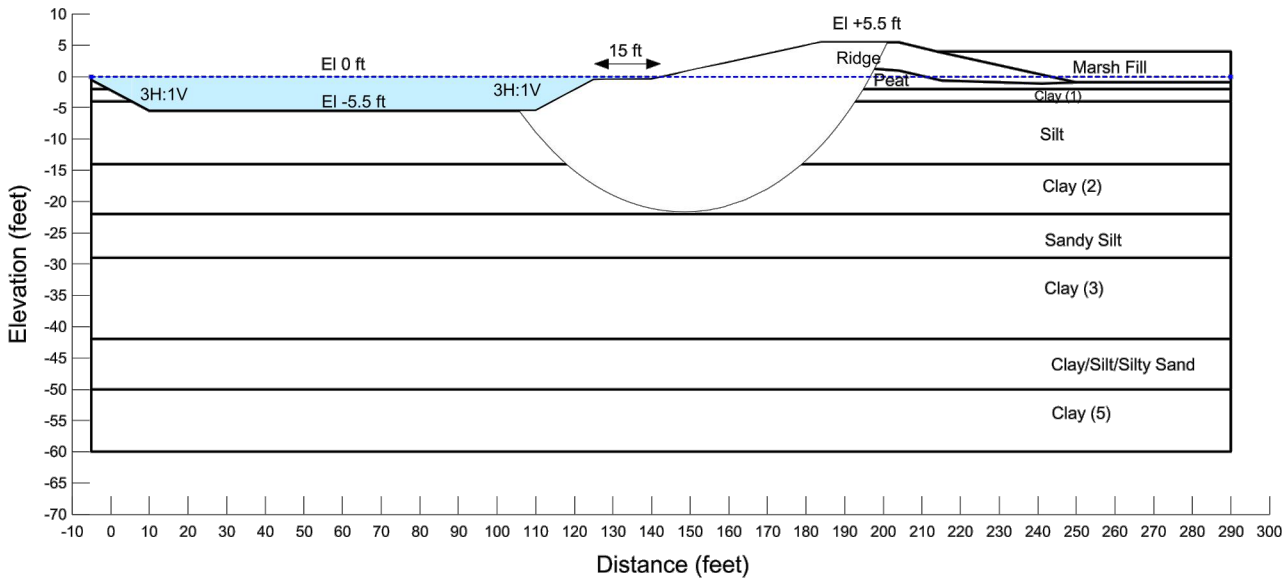
GEOENGINEERS

Figure II-C4c

Borrow Material From Bayou Grand Liard
Boring B-6

Name: Ridge (Bayou) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay / Silt/ Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 1.873



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SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-6

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

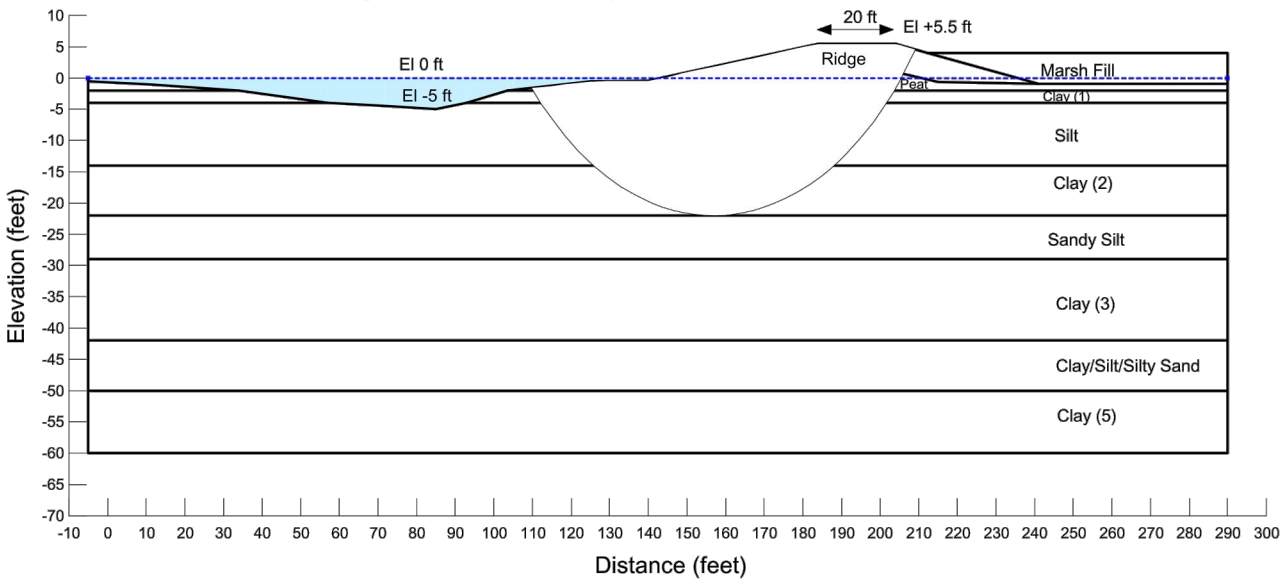
GEOENGINEERS

Figure II-C5a

Borrow Material From Borrow Area
Boring B-6

Name: Ridge (Borrow) Unit Weight: 85 pcf Cohesion: 75 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay/Silt/Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °
Name: Marsh Fill Unit Weight: 80 pcf Cohesion: 50 psf Phi: 0 °

FOS: 2.105



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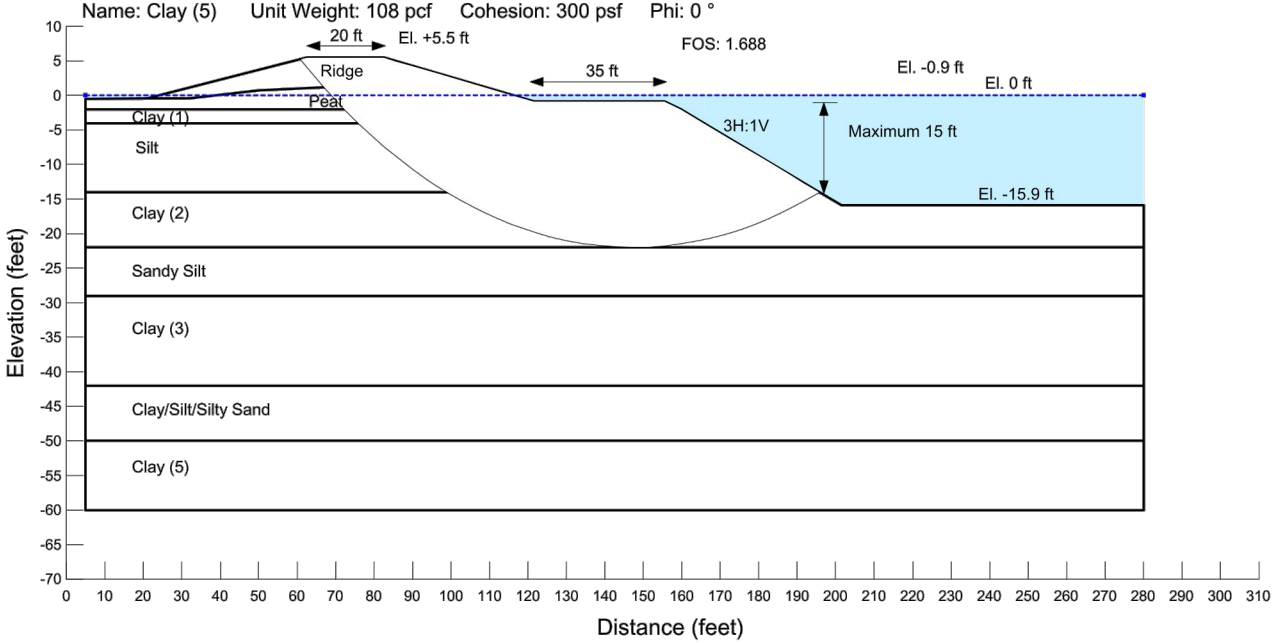
SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM BORROW AREAS - B-6

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure II-C5b

Borrow Material From Existing Marsh
Boring B-6
Name: Ridge (Existing Marsh) Unit Weight: 75 pcf Cohesion: 60 psf Phi: 0 °
Name: Peat Unit Weight: 75 pcf Cohesion: 90 psf Phi: 0 °
Name: Clay (1) Unit Weight: 89 pcf Cohesion: 120 psf Phi: 0 °
Name: Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (2) Unit Weight: 101 pcf Cohesion: 120 psf Phi: 0 °
Name: Sandy Silt Unit Weight: 115 pcf Cohesion: 100 psf Phi: 15 °
Name: Clay (3) Unit Weight: 105 pcf Cohesion: 170 psf Phi: 0 °
Name: Clay/Silt/Silty Sand Unit Weight: 119 pcf Cohesion: 200 psf Phi: 15 °
Name: Clay (5) Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °



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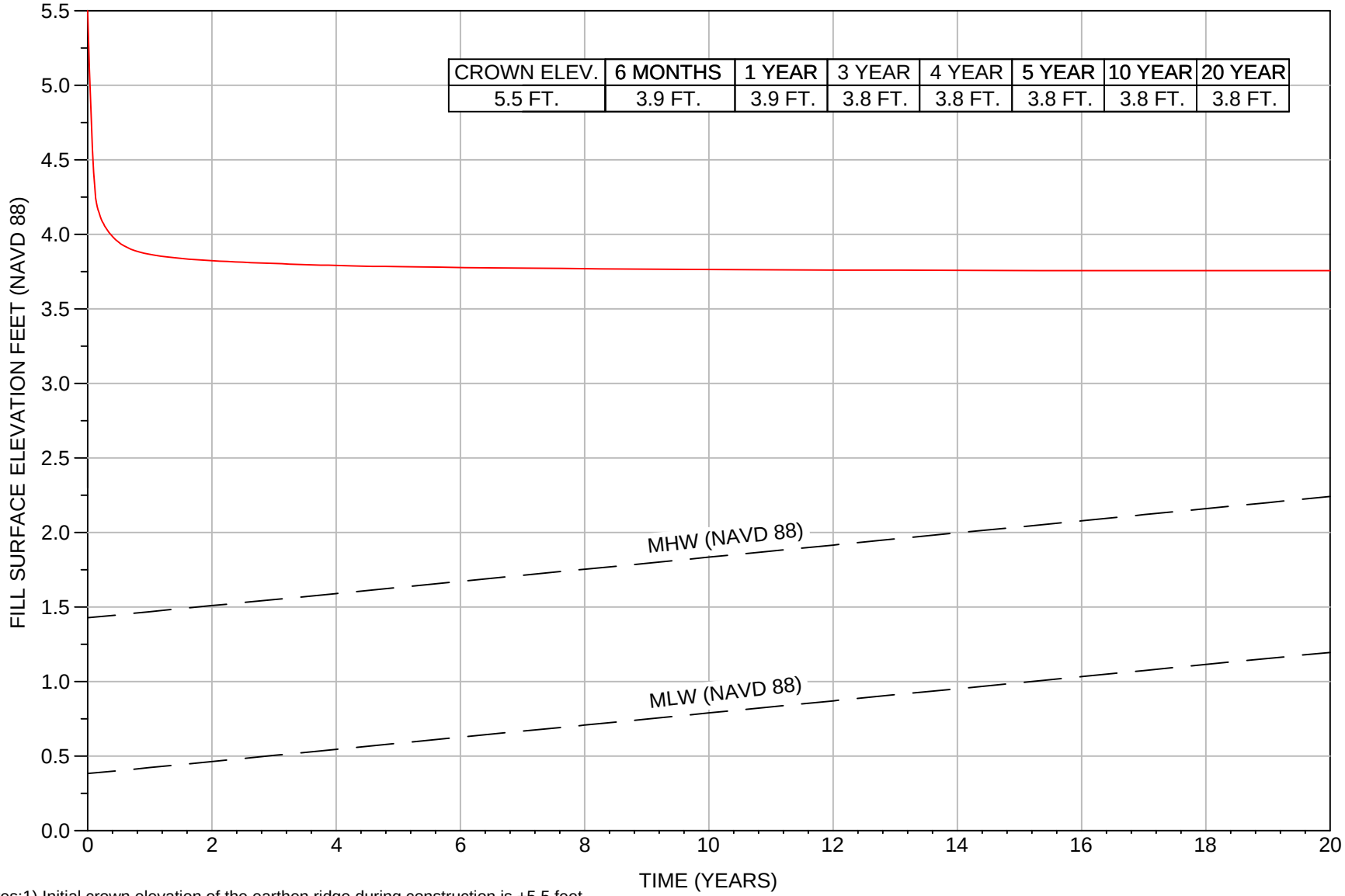
SLOPE STABILITY - EARTHEN RIDGE - BORROW MATERIAL FROM EXISTING MARSH - B-6

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

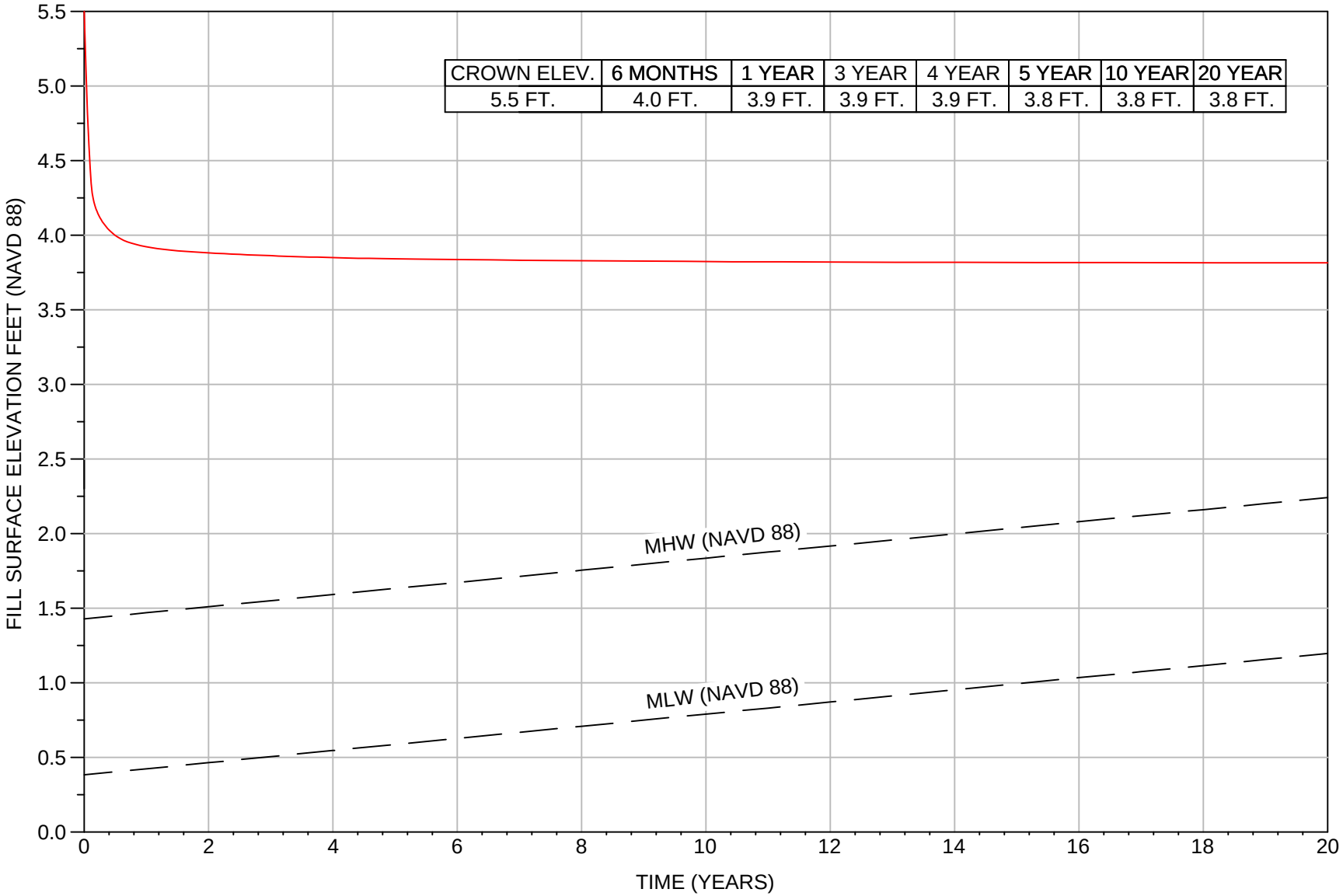
GEOENGINEERS

Figure II-C5c



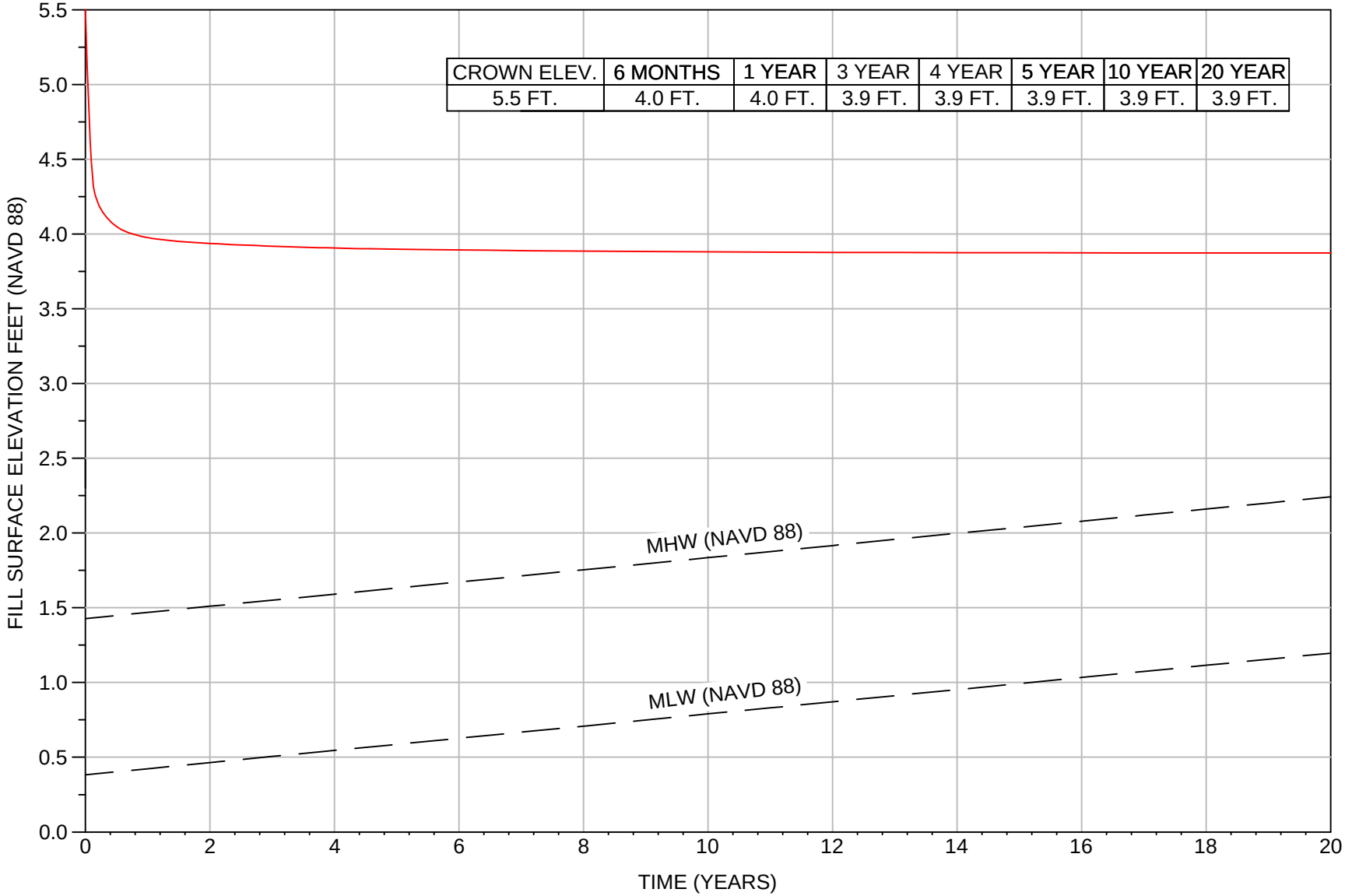
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-1	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C6a**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-1	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C6b**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-1	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C6c**

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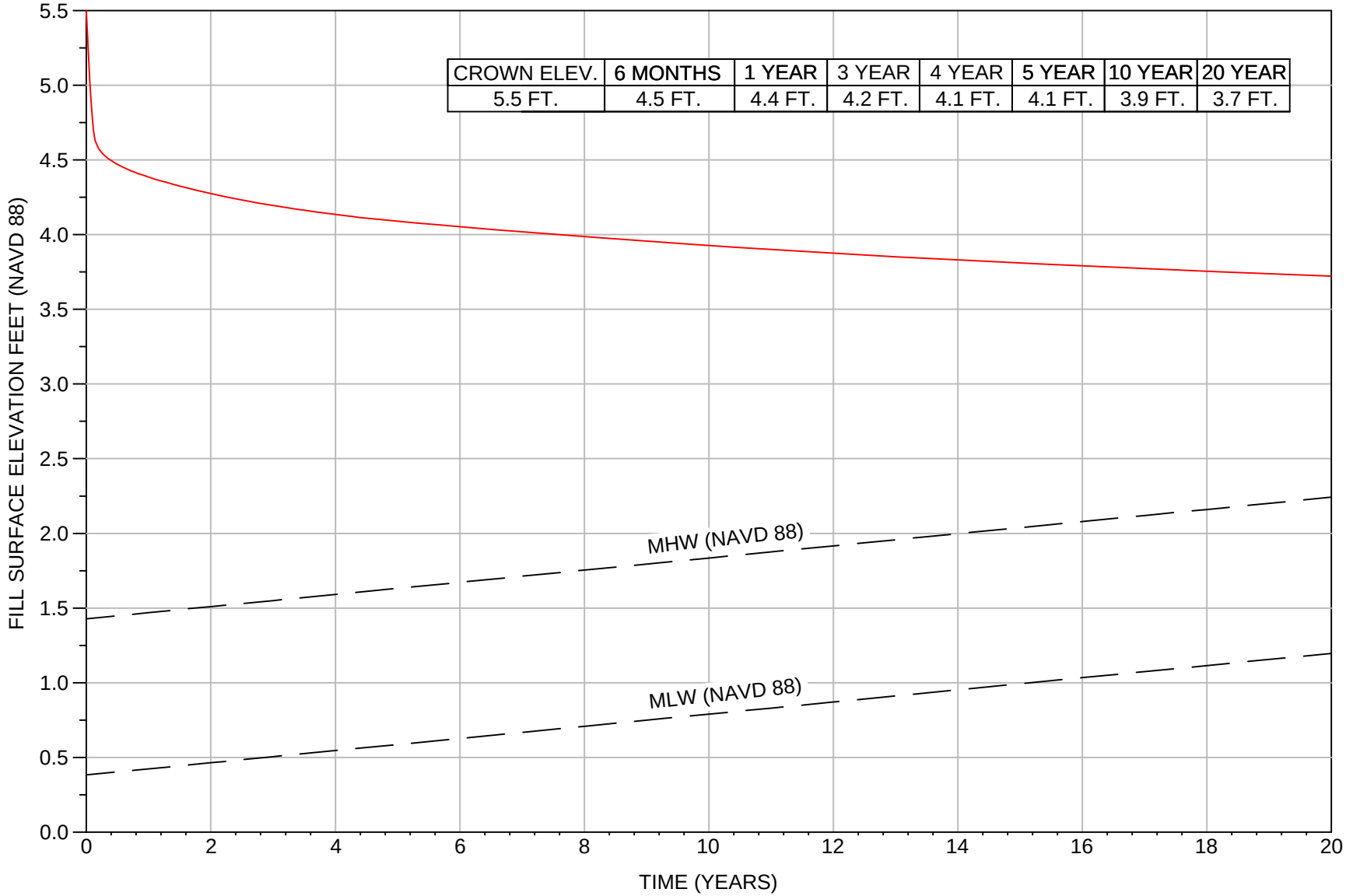
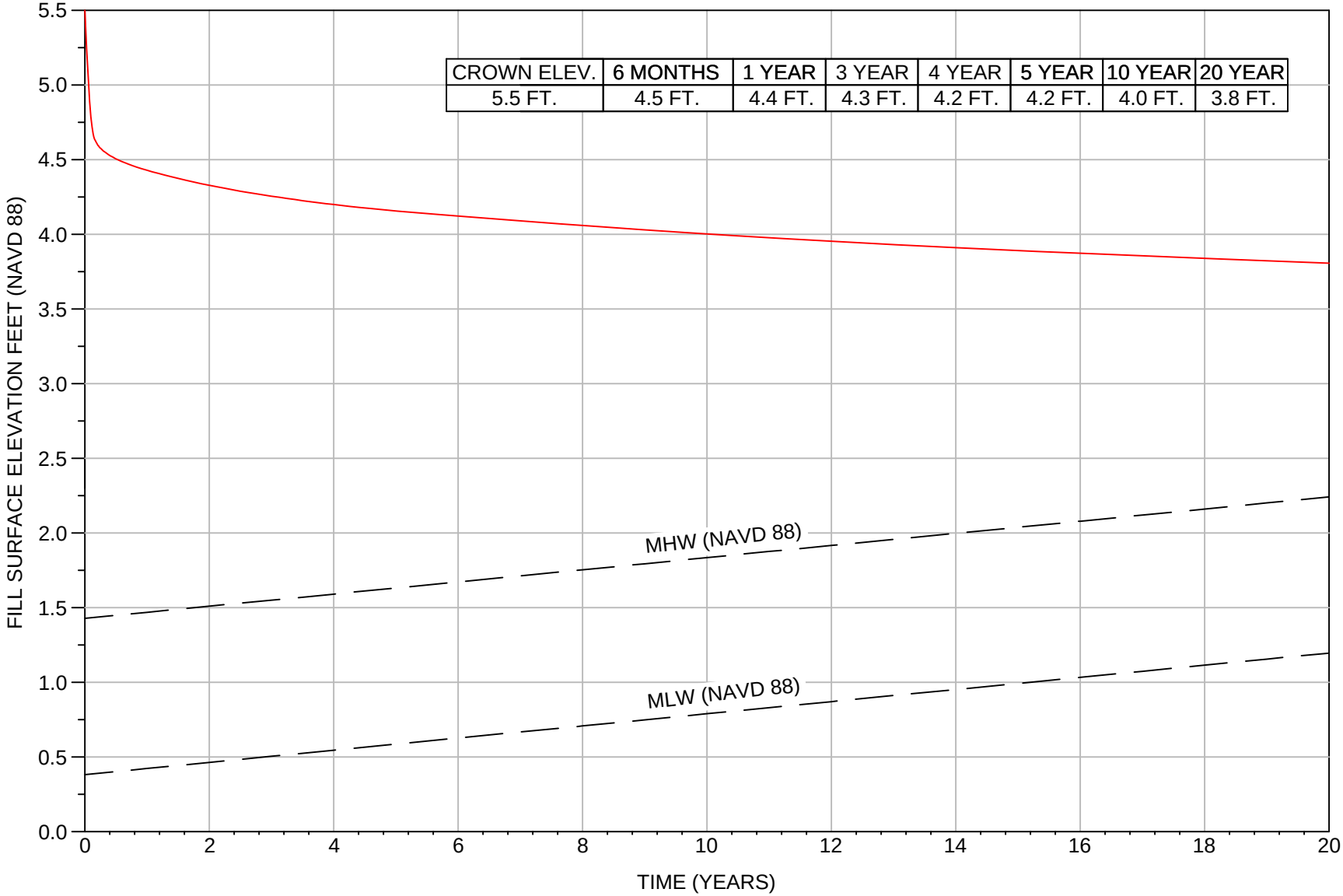


CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.5 FT.	4.4 FT.	4.2 FT.	4.1 FT.	4.1 FT.	3.9 FT.	3.7 FT.

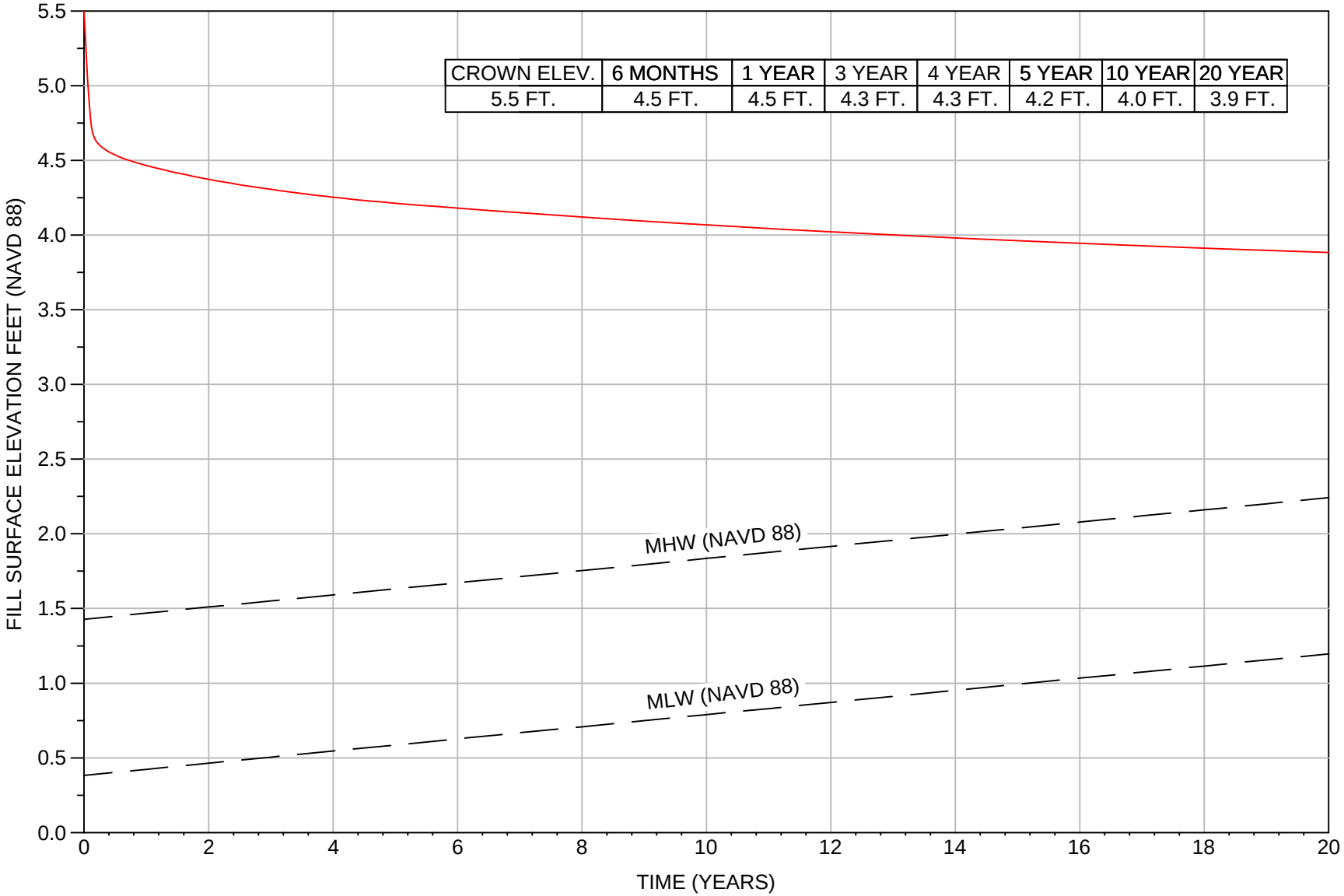
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-2 & B-5	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C7a**



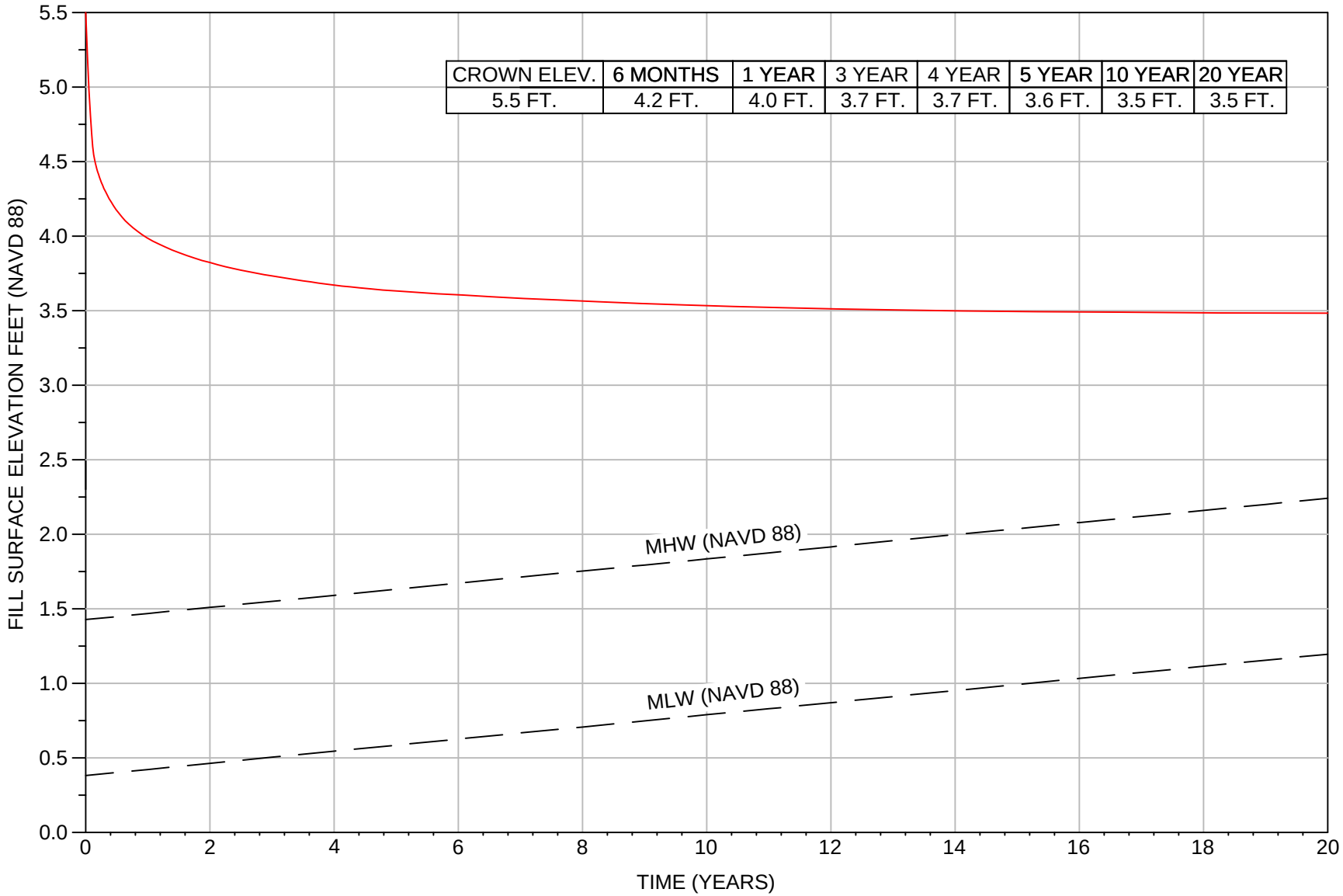
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-2 & B-5	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C7b**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-2 & B-5	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C7c**



CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.2 FT.	4.0 FT.	3.7 FT.	3.7 FT.	3.6 FT.	3.5 FT.	3.5 FT.

Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-3	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C8a**

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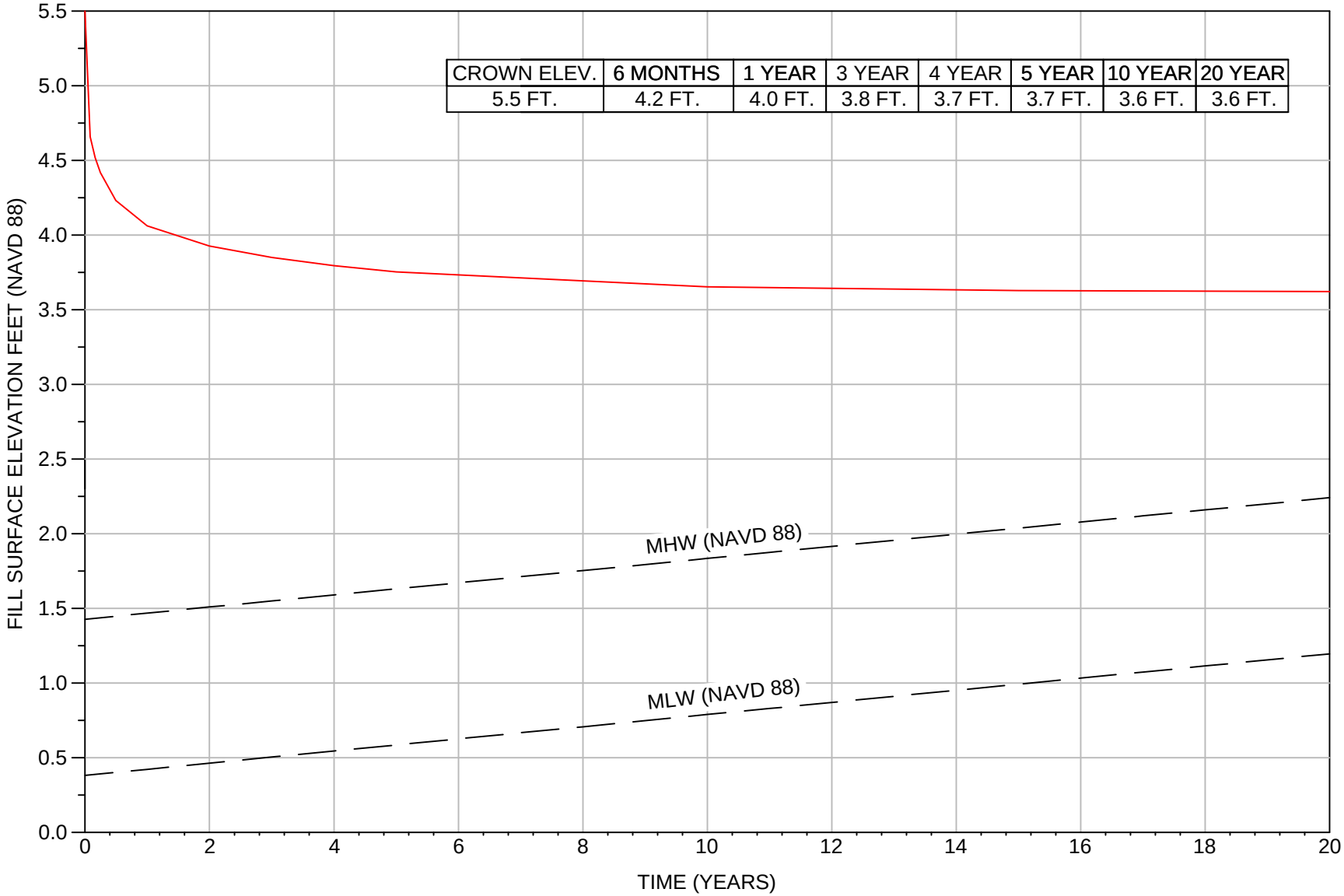

CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.2 FT.	4.0 FT.	3.8 FT.	3.7 FT.	3.7 FT.	3.6 FT.	3.6 FT.

Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-3	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C8b**

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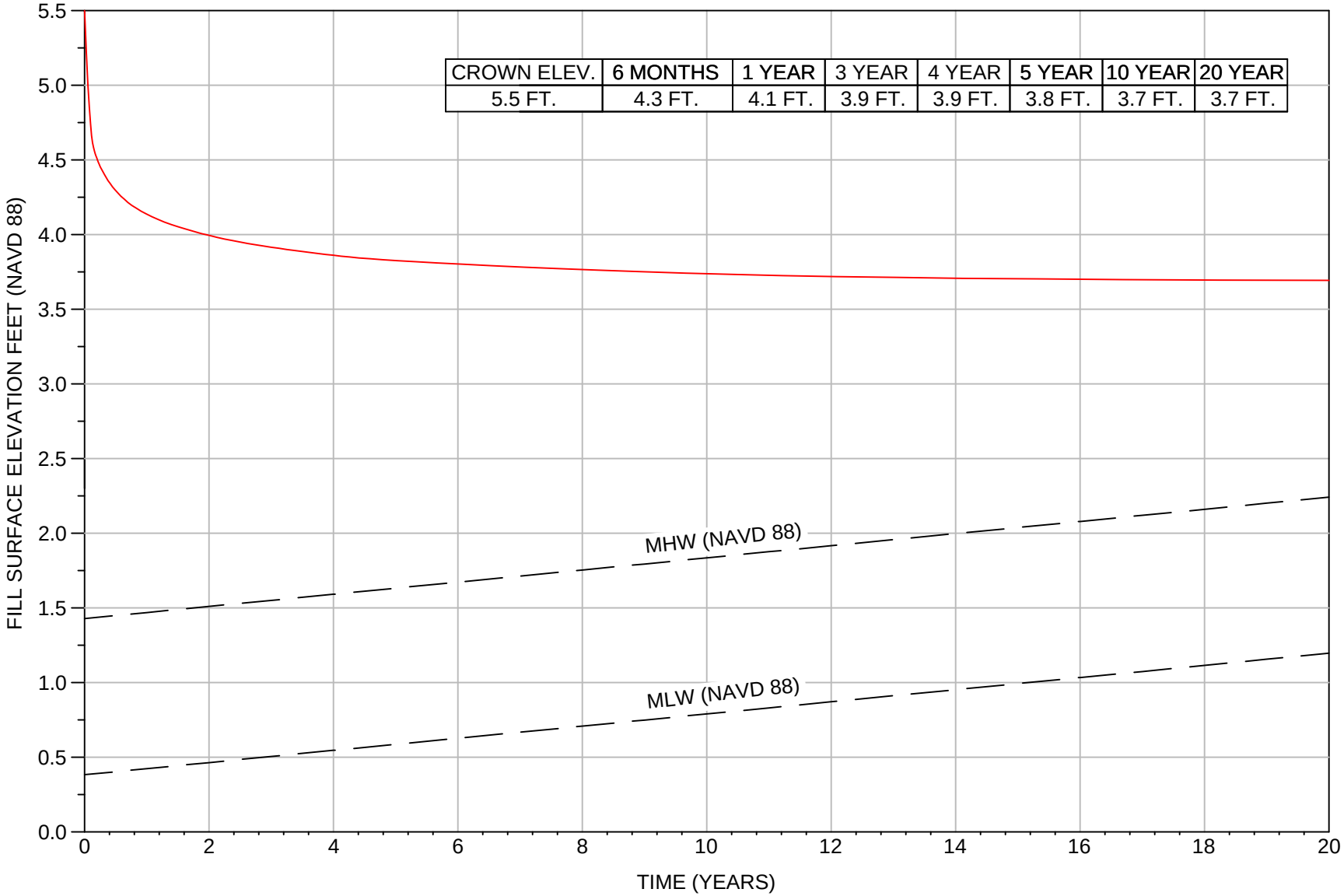

CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	4.3 FT.	4.1 FT.	3.9 FT.	3.9 FT.	3.8 FT.	3.7 FT.	3.7 FT.

Notes: 1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-3	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C8c**

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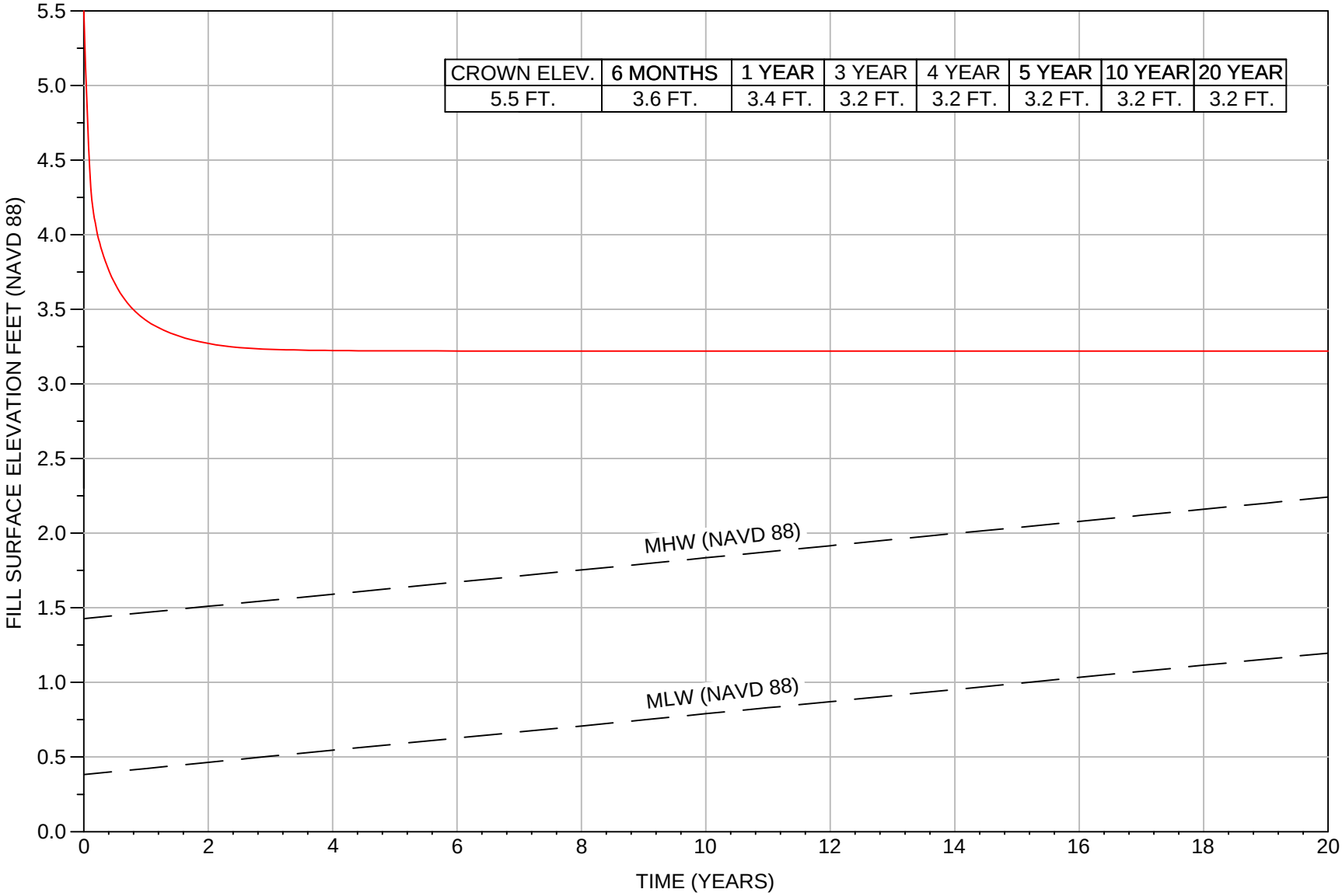
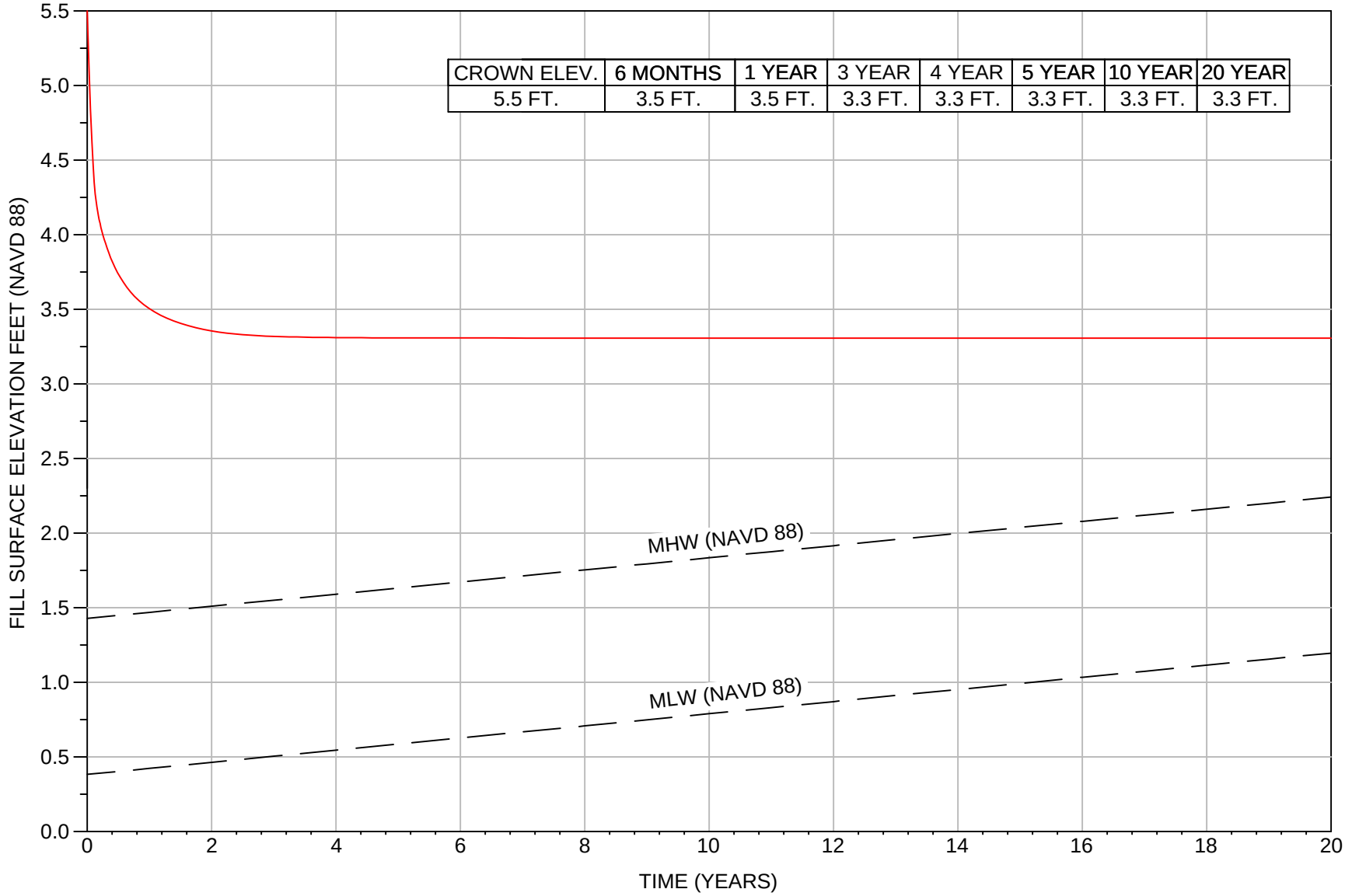


CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	3.6 FT.	3.4 FT.	3.2 FT.	3.2 FT.	3.2 FT.	3.2 FT.	3.2 FT.

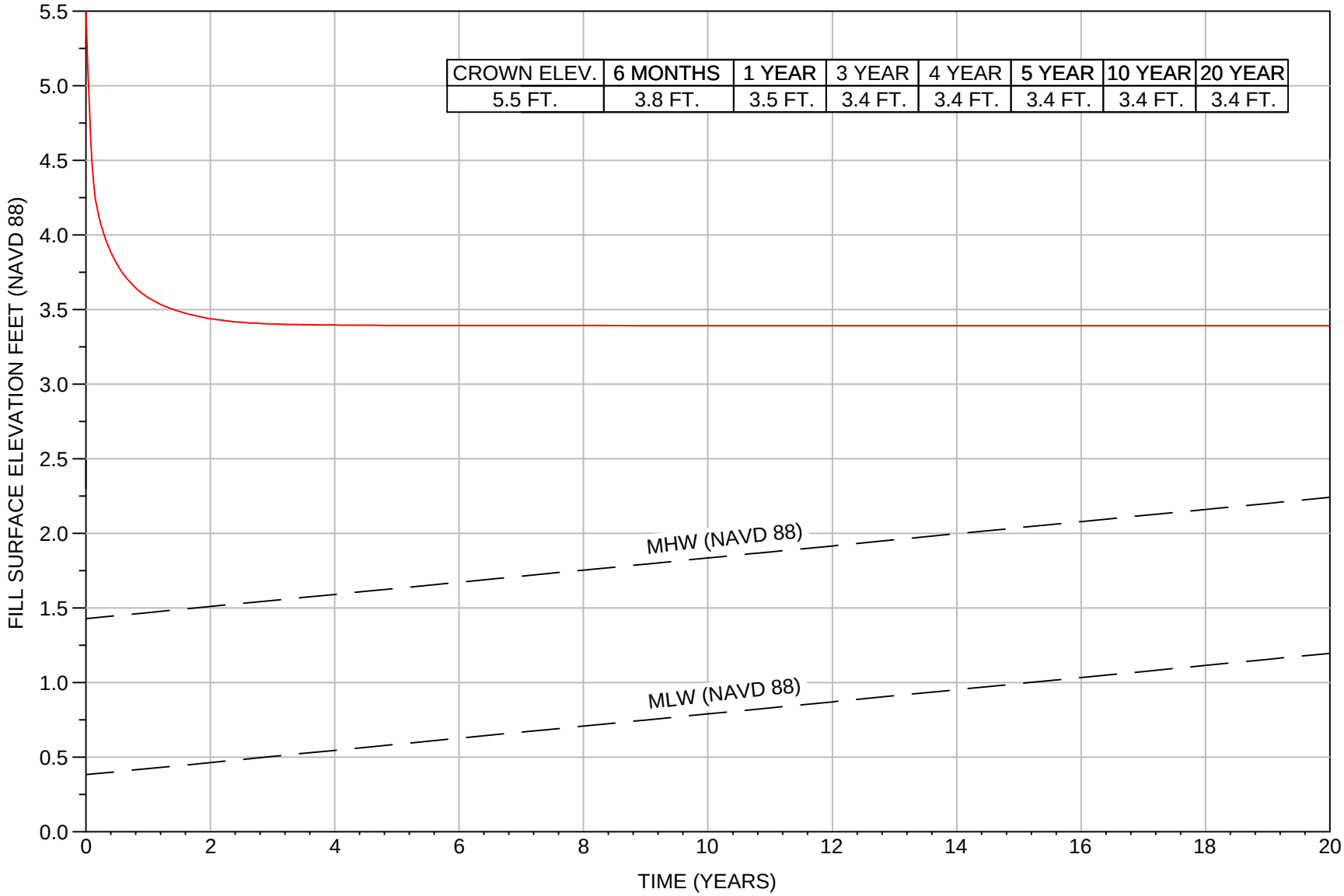
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-4	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C9a**



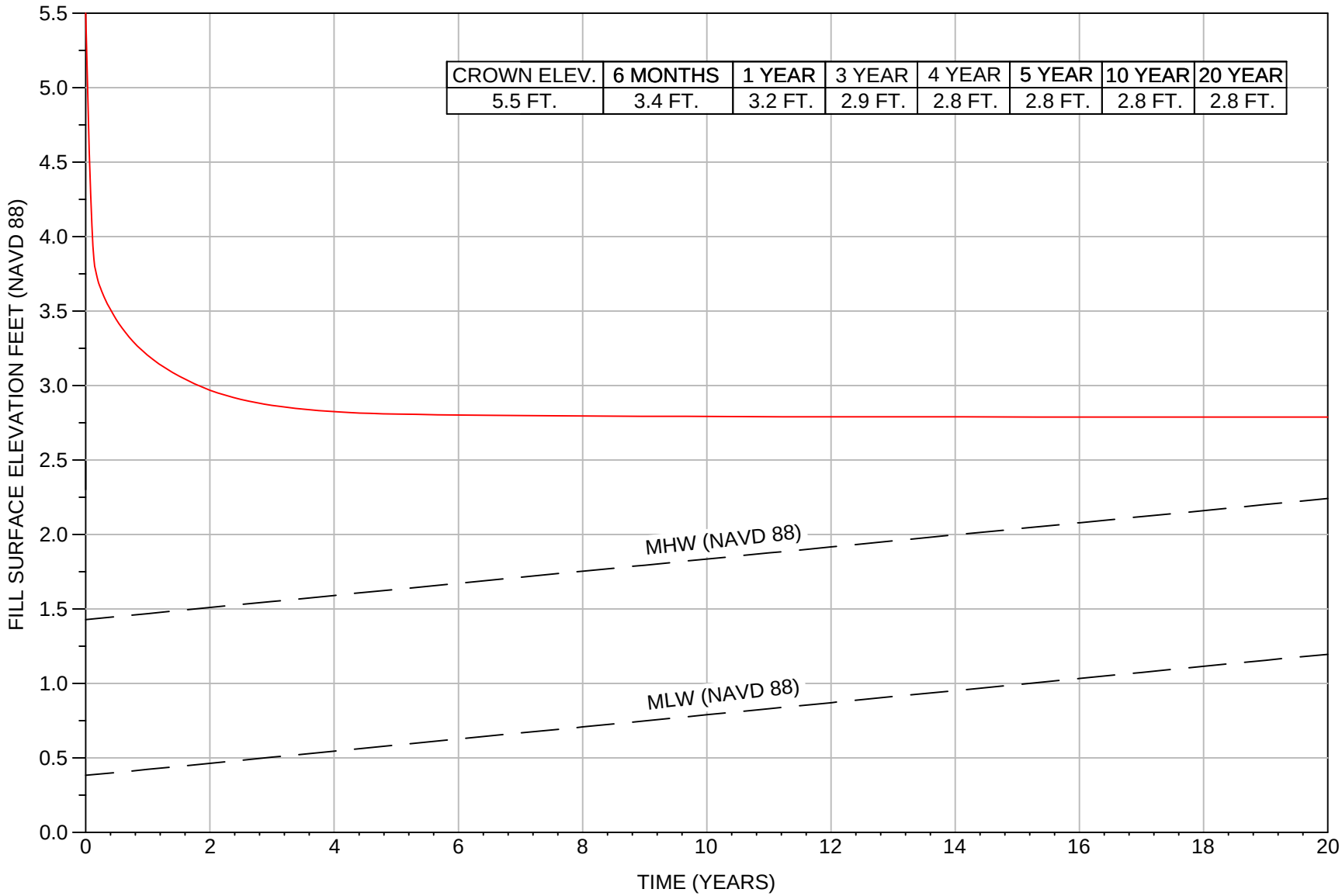
Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-4	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C9b**



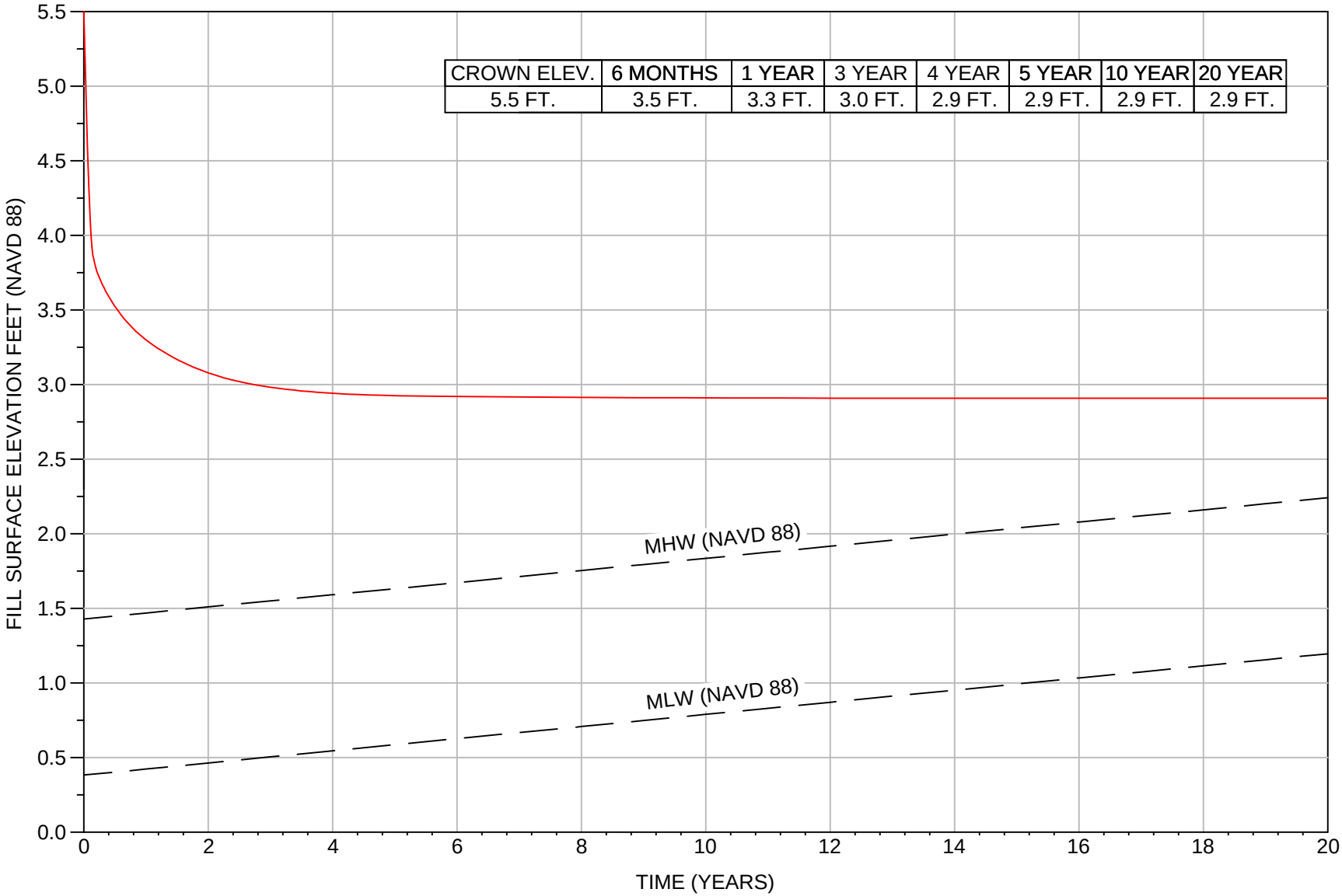
Notes: 1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-4	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C9c**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

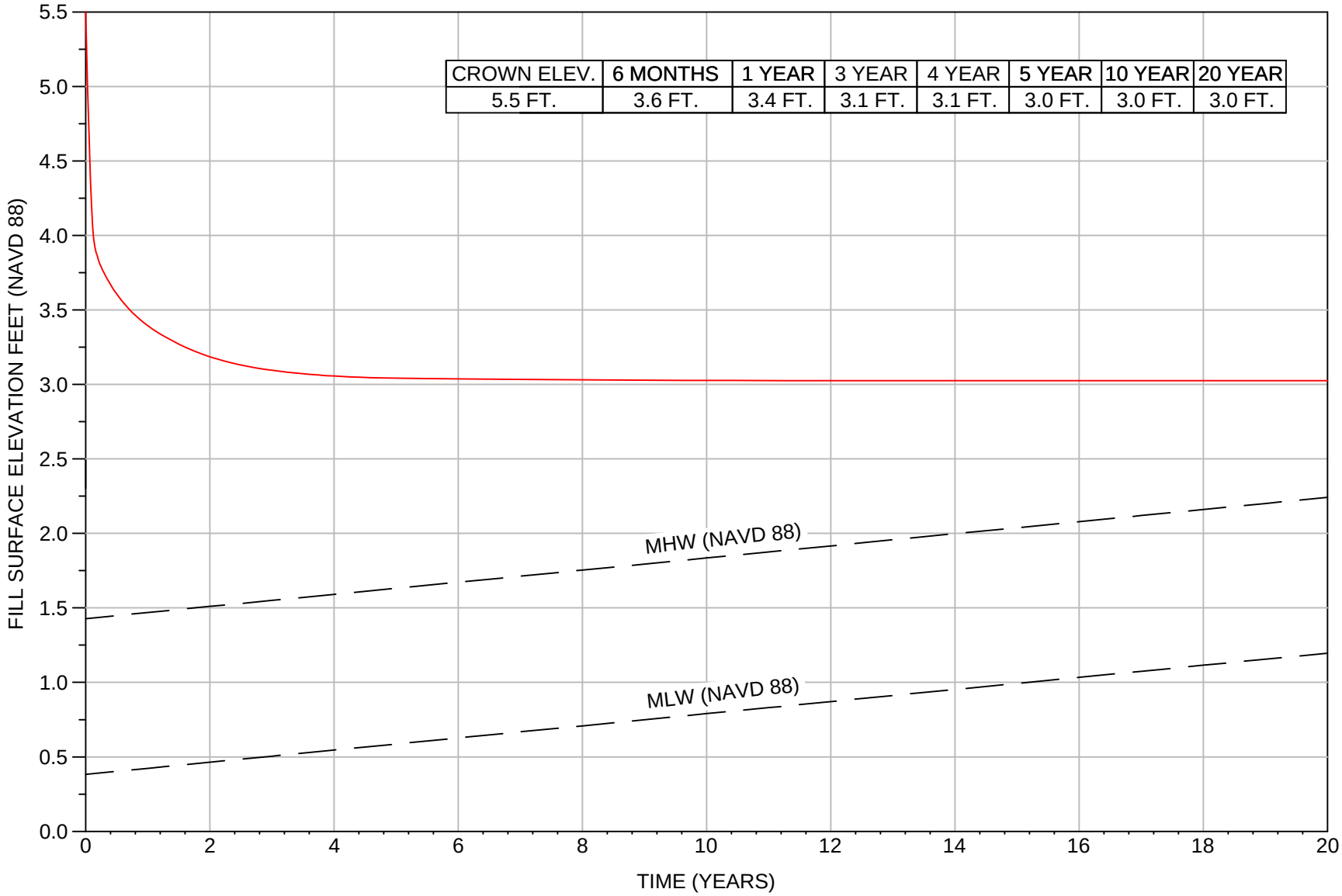
EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BAYOU GRAND LIARD - B-6	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C10a**



Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM BORROW AREAS - B-6	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C10b**

P:\16\16715018\00\CAD\RIDGE SETTLEMENT.dwg\TAB:C-30 modified on Jan 06, 2011 - 10:58am VT : KMC



CROWN ELEV.	6 MONTHS	1 YEAR	3 YEAR	4 YEAR	5 YEAR	10 YEAR	20 YEAR
5.5 FT.	3.6 FT.	3.4 FT.	3.1 FT.	3.1 FT.	3.0 FT.	3.0 FT.	3.0 FT.

Notes:1) Initial crown elevation of the earthen ridge during construction is +5.5 feet.
2) Mean high water (MHW) and mean low water (MLW) elevations projected over 20 year period, provided by OCPR on 12/13/2010.

EARTHEN RIDGE SETTLEMENT VS. TIME - BORROW MATERIAL FROM EXISTING MARSH - B-6	Grand Liard Marsh and Ridge Restoration Project Plaquemines Parish, Louisiana	GEOENGINEERS	**Figure II-C10c**

APPENDIX II-D
Report Limitations and Guidelines for Use

APPENDIX D
REPORT LIMITATIONS AND GUIDELINES FOR USE

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Sigma Consulting Group, Inc. and their authorized agents and regulatory agencies. The information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. No party other than Sigma Consulting Group, Inc. may rely on the product of our services unless we agree to such reliance in advance and in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. Use of this report is not recommended for any purpose or project except the one originally contemplated.

A Geotechnical Engineering or Geologic Report Is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the Grand Liard Marsh and Ridge Restoration Project in Plaquemine Parish, Louisiana. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, we recommend that GeoEngineers be given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Most Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an informed opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

The construction recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers is unable to assume responsibility for the recommendations in this report without performing construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings.

Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help prevent costly problems associated with unanticipated subsurface conditions, we recommend giving contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report's accuracy is limited. In addition, encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) are less exact than other engineering and natural science disciplines. Without this understanding, there may be expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

Geotechnical Engineering Report - Addendum

Grand Liard Marsh and Ridge Restoration Project (BA-68) - Structures
Plaquemines Parish, Louisiana

for

Louisiana Office of Coastal Protection and Restoration

October 11, 2011

GeoEngineers
Earth Science + Technology

Geotechnical Engineering Report - Addendum

Grand Liard Marsh and Ridge Restoration Project (BA-68) - Structures
Plaquemines Parish, Louisiana

for
Louisiana Office of Coastal Protection and Restoration

October 11, 2011

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Geotechnical Engineering Report - Addendum

Grand Liard Marsh and Ridge Restoration Project (BA-68) - Structures
Plaquemines Parish, Louisiana

LDNR Contract No. 2503-11-67

File No. 16715-018-01

October 11, 2011

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GEOENGINEERS

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INTRODUCTION

This report provides geotechnical engineering recommendations for the Grand Liard Marsh and Ridge Restoration project (BA-68) - Structures in accordance with information provided by the Louisiana Office of Coastal Protection and Restoration (CPRA) during the meeting on July 19, 2011, and our proposal dated July 28, 2011. This geotechnical report should be considered as an addendum to the existing Geotechnical Report dated March 21, 2010, prepared by GeoEngineers, Inc. for the current project. The site location and a site map are shown in Figures 1 and 2, respectively. The main body of the engineering report contains our interpreted geotechnical subsurface conditions and engineering recommendations. A summary of our slope stability and settlement calculations for earthen ridge constructed from combined material from the Bayou and the marsh are provided in Appendix E and Appendix F, respectively. Sheetpile structure calculations are provided in Appendix G. All elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88).

PROJECT UNDERSTANDING

Our understanding of the project is based on the information provided in our proposal dated July 28, 2011, and subsequent communications with CPRA.

The project is estimated to create/restore about 500 acres of marsh and ridge habitat along the eastern bank of Bayou Grand Liard in Plaquemines Parish, Louisiana. As shown on Figure 2, the project features include:

- Earthen Containment Dike: Construction of earthen dikes to contain approximately 328 acres for marsh creation.
- Marsh: Creation of approximately 328 acres of marsh habitat and nourishment of approximately 140 acres of existing marsh that will be done using hydraulically dredged sediment from the Gulf of Mexico East Borrow Site as shown on Figure II-2.
- Earthen Ridge: Creation of approximately 18,000 linear feet (34 acres) of maritime ridge along the eastern bank of Bayou Grand Liard.
- Sheetpile Structures: Structures to stop water flow in the east-west direction through the marsh creation area. This will allow for construction of the earthen ridge along the eastern bank of Bayou Grand Liard and containment dikes on the east side of Cell A.

Recommendations for earthen containment dike, marsh creation and earthen ridge are provided in the Geotechnical Report Dated March 21, 2010 prepared by GeoEngineers for the Grand Liard marsh and Ridge Restoration Project (BA-68). Additional analysis was requested by CPRA for the earthen ridge which is covered in this report.

PURPOSE AND SCOPE OF SERVICES

The purpose of our services was to collect geotechnical data and perform geotechnical analyses to develop recommendations for structures to stop water flowing across the marsh in the channels. Our specific scope of services included the following:

1. Visited the site to observe field conditions and better understand the project conditions.
2. Contacted Louisiana "One-Call" to notify them of our intent to perform soil borings at this site and to clear the boring locations of potential underground utilities.
3. Performed field exploration and laboratory analyses.
4. Evaluated subsurface data at the structure locations and developed appropriate strength profiles.
5. Completed the following evaluations for each soil boring as requested by CPRA:
    a. Earthen Ridge (Design profiles/soil borings 1, 3, 4, 6 and combined 2 & 5 provided in Geotechnical Report dated March 21, 2010):
        i. Determined the stability of the earthen ridge section provided by CPRA with crown width of 20 feet and constructed using combined material from the Bayou and the marsh.
        ii. Determined the minimum berm width between the earthen ridge toe and excavation channel in Bayou Grand Liard and existing marsh required for stability.
        iii. Provided time rate settlement curves showing estimates at the end of construction (assumed 30 days), 1 year, 5 years, 10 years, and 20 years.
    b. Structures to stop water flow through the marsh creation area (Soil Borings B-11 through B-18)
        i. Analyzed steel sheetpiles to determine the minimum depth of embedment and sheetpile section modulus with and without sand backfill.
        ii. Provided recommendations for construction of sheetpiles.
6. Provided general construction recommendations.
7. Prepared this geotechnical engineering report as an addendum to the existing Geotechnical Report prepared by GeoEngineers dated March 21, 2010.

SUBSURFACE CONDITIONS

Based on the field exploration data and subsequent laboratory testing, eight soil profiles were developed. In general, all borings except B-15 and B-16 encountered organic soil in the upper soil profile followed by cohesive soil. Boring B-11 encountered a layer of organic soil at an elevation of El -23 feet, NAVD 88. The organic soil encountered predominantly consisted of very soft peat, and organic clay.

At Borings B-15 and B-16, cohesive soil was encountered the entire depth of the boring. The cohesive soil predominantly consisted of silty clay and clay with very soft consistency. Occasionally semi-cohesive or granular soil layers were encountered in borings B-11, B-12, B-14, and B-16. The semi-cohesive and non-cohesive soil predominantly consisted of silt, sandy silt, silty sand, and sand.

For additional information, please refer to the detailed soil boring logs provided in the appendix of this geotechnical report.

CONCLUSIONS AND RECOMMENDATIONS

General

Based on the investigation results, the proposed improvement area is generally suitable for the proposed earthen ridge construction. The summary results of the slope stability and settlement analyses are presented in Tables 1 and 2. Details of the analysis methods are presented in Appendices D and E for slope stability and settlement, respectively.

GeoEngineers performed stability analyses using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory to evaluate the stability of earth slopes. Subsurface soil properties were estimated using the results of subsurface explorations and associated laboratory testing. The soil units and soil properties used in the stability model are included in Appendix B.

Identifying the critical slip surface with the lowest factor of safety was accomplished by an iterative process by which the program calculated the factor of safety for a large number of potential slip surfaces. A minimum required factor of safety of 1.3 against failure on the bayou side and 1.2 on the marsh side of the earthen ridge was used for this project. Based on the relatively short duration between construction of the earthen ridge and placing of marsh fill, and GeoEngineers experience on coastal projects, we believe a safety factor of 1.2 on the marsh side would suffice for the current project.

GeoEngineers performed settlement analyses for the earthen ridge sections based on Terzaghi's one-dimensional linear consolidation theory. Settlement parameters were developed using consolidation test results. Published correlations and correlations based on test data from this project and similar projects were used to develop settlement parameters where soil consolidation test results were not available.

In addition to consolidation settlement, there will be elastic settlement. Estimates of elastic settlement, which occurs during earth fill placement, are about 20 percent of the long-term consolidation settlement. The total settlement will be the consolidation settlement plus the construction (immediate elastic) settlement. However, the construction settlement will not be recognized because more earthen fill will be placed to achieve the required end-of-construction elevation during construction.

Another component of settlement for this project is settlement within fill placed at the site. For mechanically placed fill for the earthen ridge, a settlement of six inches was assumed within the fill. There are many factors that will affect this number including organic content, disturbance, and placement methods. Six inches was assumed as a reasonable estimate, and has been incorporated into all the tables and figures showing settlement estimates in this report.

Settlement figures presented in this report show the estimated MHW and MLW levels for the next 20 years. This information was provided by and included at the request of CPRA.

Earthen Ridge

General *(Design profiles 1, 3, 4, 6 and combined 2 & 5)*

Based on information provided by CPRA, analyses to determine the stability of the earthen ridge section with a base width of approximately 100 feet and a crown width of 20 feet was performed for earthen ridge constructed with combined material from Bayou Grand Liard and marsh creation area. As requested by CPRA, the crown elevation of the earthen ridge was taken as El +5 feet.

Settlement calculations were also performed for the earthen ridge with crown elevation at +5 feet and combined material from Bayou Grand Liard and marsh creation area used to construct the ridge. Settlement is presented after slope stability section below.

Slope Stability (Design profiles 1, 3, 4, 6 and combined 2 & 5)

Slope stability analyses were performed for a typical earthen ridge section and an adjacent excavation access channel to determine the minimum required horizontal distance from the excavation access channel to the earthen ridge embankment, and verify side slope requirements, as shown in Figure 4.

Based on the typical earthen ridge section provided by CPRA, a factor of safety greater than 1.3 and 1.2 were achieved on the Bayou Grand Liard side and the marsh side of the earthen ridge, respectively. The berm width was increased from 20 to 35 feet on the Bayou side of the earthen ridge at borings B-1 and B-3 to achieve a factor of safety of 1.3. A berm width of 40 feet on the marsh side of the earthen ridge was sufficient to achieve a factor of safety greater than 1.2.

All evaluations were based on the appropriate geometry with earthen ridge fill to elevation +5 feet, NAVD 88. Table 1 provides a summary of slope stability analyses results. Figures in Appendix E show the critical failure surfaces in the earthen ridge section for each of the design profiles.

TABLE 1. EARTHEN RIDGE SLOPE STABILITY ANALYSIS RESULTS

Design Profile/Soil Borings	Borrow Material Source*	Bench Width Between Ridge Toe and Excavation Channel		Factor of Safety	
		Towards Bayou(without/with marsh fill)	Towards Marsh	Bayou**	Marsh
1	Bayou Grand Liard and existing marsh	35/35		1.33/1.32	-
			40	-	1.26
2 & 5	Bayou Grand Liard and existing marsh	20/20	-	1.67/1.67	-
			40	-	1.61
3	Bayou Grand Liard and existing marsh	35/35		1.31/1.31	-
			40	-	1.35
4	Bayou Grand Liard and existing marsh	20/20		1.83/1.83	-
			40	-	1.60
6	Bayou Grand Liard and existing marsh	20/20		1.50/1.50	-
			40	-	1.35

* Borrow material from Bayou Grand Liard and existing marsh will be combined to construct the earthen ridge

**Installation of the marsh fill does not have significant influence on the stability of the earthen ridge.

Settlement (Design profiles 1, 3, 4, 6 and combined 2 & 5)

Settlement calculations were completed for the earthen ridge constructed from material combined from Bayou Grand Liard and existing marsh. Influence of the adjacent marsh fill was evaluated with respect to earthen ridge settlement estimates. The marsh fill will have some influence on the marsh side of the ridge fill; however, from the center of the ridge to the edge farthest from the marsh fill, the marsh fill will cause little to no additional settlement of the earthen ridge fill. A narrower ridge will be influenced more by the marsh fill than the proposed 90-foot wide ridge.

Time rate of settlement versus elevation over a 20-year period is shown for each of the design profiles in Appendix F, including an estimated six inches of settlement within the earthen ridge embankment.

The peat and/or organic clay identified in the top 4-7 feet of the soil profile in some of the soil borings completed for the earthen ridge has the potential to shrink significantly when removed from a submerged condition and placed above water. For this reason, an earthen ridge embankment constructed from these materials may experience more than 6 inches of internal settlement/shrinkage in the ridge as assumed in the calculated numbers and may need to be re-dressed before installation of dredged fill to maintain the required freeboard.

TABLE 2. EARTHEN RIDGE SETTLEMENT ESTIMATES

Design Profile	Borrow Material Source	Initial Fill Elevation (feet)	Estimated Settlement (inches)					
			Construction Settlement	Consolidation Settlement[1]				
			Elastic	6 months	1 Year	5 Years	10 Years	Long-term (20 Years)
1	Bayou Grand Liard and existing marsh	5	3	15	15	17	17	17
2 & 5	Bayou Grand Liard and existing marsh	5	3	11	12	14	16	17
3	Bayou Grand Liard and existing marsh	5	4	14	15	18	19	20
4	Bayou Grand Liard and existing marsh	5	4	18	20	22	22	22
6	Bayou Grand Liard and existing marsh	5	6	24	26	29	29	29

1. Estimated construction settlement is not included in the estimated consolidation settlement.

Construction, or elastic, settlement is the result of immediate compression of the underlying soils during placement of fill (i.e. during construction). Elastic settlement has been estimated as 20% of the long term consolidation settlement. Construction settlement will not be recognized over time because more fill is placed during construction as the elastic settlement occurs to achieve the target elevation. This settlement will result in increased construction fill quantities, compared to a site where construction is on a base that does not deflect at all.

Structures

Based on our understanding of the project, CPRA proposes to install eight structures at the project site at locations shown in Figure 3. The purpose of the structures is to stop the flow of water in the channels in the east-west direction through the marsh creation area. Construction of a ridge or containment dike is not feasible at the location where proposed earthen ridge crosses the channels in the marsh due to the depth of existing mudline in the channels and significant tidal action occurring at those locations. A soil boring was performed for each structure location as shown on Figure 3 and testing was performed to obtain soil properties. Based on the soil testing results, soil profiles were developed which were used to evaluate the foundations for the proposed structures.

GeoEngineers recommends steel sheetpile wall structures at the eight locations to minimize the flow of water through the marsh. Table 3 below lists the boring performed at each structure location and the design mudline elevation selected for analyses. For the purpose of analyses, design mudline was selected at the deepest elevation based on information provided by CPRA (Appendix A).

TABLE 3. BORING PERFORMED AT STRUCTURES

Boring No.	Mudline Elevation Considered for Analyses (feet, NAVD 88)
B-11	-6.5
B-12	-12
B-13	-13
B-14	-6.5
B-15 (Side wall)	-13
B-15 (Channel wall)	-17
B-16	-15.5
B-17	-17.5
B-18	-8

Cantilever sheetpiles were analyzed for the project. Based on information provided by CPRA, sand will be installed on either side of the sheetpile wall as show in Figures 5A and 5B. Due to the uncertainty of installing sand before or after driving the sheetpiles, we have performed analyses for both cases as shown in Tables 4 and 5, respectively.

TABLE 4. SUMMARY OF SHEETPILE ANALYSES (WITHOUT SAND FILL)

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile *(feet)	Recommended Minimum Section Modulus** (cubic Inch/feet)
B-11	4.5	3.5	-6.5	30	5
B-12	4.5	3.5	-12	35	11
B-13	4.5	3.5	-13	50	14.5
B-14	4.5	3.5	-6.5	25	4.5
B-15 (Side wall)	4.5	3.5	-13	35	12
B-15 (Channel wall)	4.5	3.5	-17	45	19
B-16	4.5	3.5	-15.5	35	16
B-17	4.5	3.5	-17.5	55	22.5

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile *(feet)	Recommended Minimum Section Modulus** (cubic Inch/feet)
B-18	4.5	3.5	-8	25	5.5

*Length includes sheetpile length above and below the mudline. Length of sheetpile as measured from Elevation +4.5 feet, NAVD 88. We estimate that the settlement induced from sand fill will be less than 6 inches.

**CPRA proposes to use PZ 27 steel sheetpiles for the project which meets the requirement for minimum required section modulus based on our estimate.

TABLE 5. SUMMARY OF SHEETPILE ANALYSES (WITH SAND FILL)

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Recommended Elevation of Top of Sand (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile *(feet)
B-11	4.5	3.5	-1.5	-6.5	25
B-12	4.5	3.5	-2	-12	25
B-13	4.5	3.5	-3	-13	25
B-14	4.5	3.5	-1.5	-6.5	25
B-15 (Side wall)	4.5	3.5	-7	-13	35
B-15 (Channel wall)	4.5	3.5	-7	-17	35
B-16	4.5	3.5	-5.5	-15.5	30
B-17	4.5	3.5	-7.5	-17.5	35
B-18	4.5	3.5	-3	-8	25

*Length includes sheetpile length above and below the mudline

At Borings B-14 and B-18, the estimated total length of sheetpile was less than 25 feet. However, taking into account the consistency of in-situ soil (very soft) and GeoEngineers experience on coastal projects, we recommend a minimum length of 25 feet at Borings B-14 and B-18 for scenarios with and without sand.

Analysis was performed for the side wall at Boring B-15 based on the mudline information provided by CPRA. As can be seen in Table 5 above, the total length of sheetpile remained the same at Boring B-15 for both the channel wall and the side wall. This can be attributed to decreasing sand thickness which is replaced by very soft in-situ soils. Based on this, for same length of cantilever wall standing above the sand fill layer, it is recommended that the length of sheetpile wall

embedment remains the same for the side wall and the wall in the channel. Limited mudline elevation data was available at structures B-16, 17 and 18 due to which additional analyses for the side wall could not be performed at those locations.

The sand fill berm width on either side of the sheetpile wall was estimated based on the embedment depth of the sheetpile and the estimated failure plane. Due to sand fill over clay soil, the failure plane in the sand layer makes a higher angle with the vertical on the passive side of the structure than the active side. This translates into having different berm dimensions on the active and passive side of the structure. The side slopes of the sand fill are recommended to be at 3H:1V as shown in Figures 5A and 5B. Given below is a summary of the berm width estimated at each structure.

TABLE 6. SUMMARY OF RECOMMENDED SAND FILL

Boring No.	Elevation of Top of Marsh Fill (feet, NAVD 88)	Recommended Elevation of Top of Sand Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Recommended Thickness of Sand Fill (feet)	Recommended Crown Width of Sand* (feet)	
					Marsh	Open Water
B-11	3.5	-1.5	-6.5	5	15	20
B-12	3.5	-2	-12	10	15	25
B-13	3.5	-3	-13	10	15	25
B-14	3.5	-1.5	-6.5	5	15	20
B-15 (Side wall)	3.5	-7	-13	6	15	25
B-15 (Channel wall)	3.5	-7	-17	10	15	25
B-16	3.5	-5.5	-15.5	10	15	25
B-17	3.5	-7.5	-17.5	10	15	25
B-18	3.5	-3	-8	5	15	20

* Crown width as measured perpendicular to the sheetpile alignment on either side of sheetpile wall; Recommended side slope of sand fill embankment of 3H:1V.

For calculations for sheetpile wall structures, please refer to Appendix G. Structure evaluations only considered static conditions. Based on discussion with CPRA, the tidal action influence on the structures was neglected. We estimate that the settlement induced from sand fill causing downdrag on the sheetpile wall will be less than 6 inches. It is recommended that the sand be installed prior to the installation of the sheetpile as this will increase the stability of the sheetpiles. The lengths of sheetpile shown in the tables above include a factor of safety of 1.5 and 2 for

sheetpile wall driven without sand fill and with sand fill, respectively. Based on the information provided by CPRA, the time between installing sheetpile and placing sand will be less than 60 days if it is decided to have sheetpile wall installed prior to sand fill.

CONSTRUCTION CONSIDERATIONS

Based on the site work and evaluations completed for this project, the following considerations are offered with respect to construction.

- The mudline at Borings B-15 through B-17 is relatively deeper than the mudline at Borings B-11 through B14 and B-18. To reduce the flow in the existing channels, we concur with CPRA in installing the structures at Borings B-11 through 14 prior to installation at Borings B-15 through B-18. We also recommend installing sand prior to installation of the structures where possible.
- As stated previously, six inches of settlement was assumed within the fill for the earthen ridge embankment; however, this settlement will largely be a function of fill materials used for construction and handling of the fill materials. Organic materials handled in a manner that causes more disturbance (i.e. a small excavator bucket) are likely to have substantially more settlement, while granular materials such as silt and sand that are placed with minimal handling/disturbance are likely to have less settlement. In addition to settlement, organic materials excavated from a submerged condition and placed as fill above the water level, are likely to experience significant shrinkage as they dry.
- Slope stability evaluations for earthen ridge only considered static conditions. Equipment working from a berm between adjacent borrow trench and embankment fill areas, may create stability issues from repeated motions such as fill excavation and placement.
- In places where the earthen ridge and containment dikes are placed over pipelines, there is the potential for the pipeline to be damaged not only from impact loading associated with construction, but also from deflection associated with settlement.

LIMITATIONS

The information presented in this report is based on the soil borings and soil testing completed for this study, and judgments made by the certifying engineers. This report is specific to this site and should not be used other than for the design of the Grand Liard Marsh and Ridge Restoration (BA-68) project located in Plaquemines Parish, Louisiana. This geotechnical report should be considered as an addendum to the existing Geotechnical Report dated March 21, 2010, prepared by GeoEngineers, Inc. for the project.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions express or implied should be understood.

Any electronic form or hard copy of this document (email, text, table, and/or figure), if provided, and any attachments are only a copy of a master document. The master hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to Appendix H titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

FIGURES

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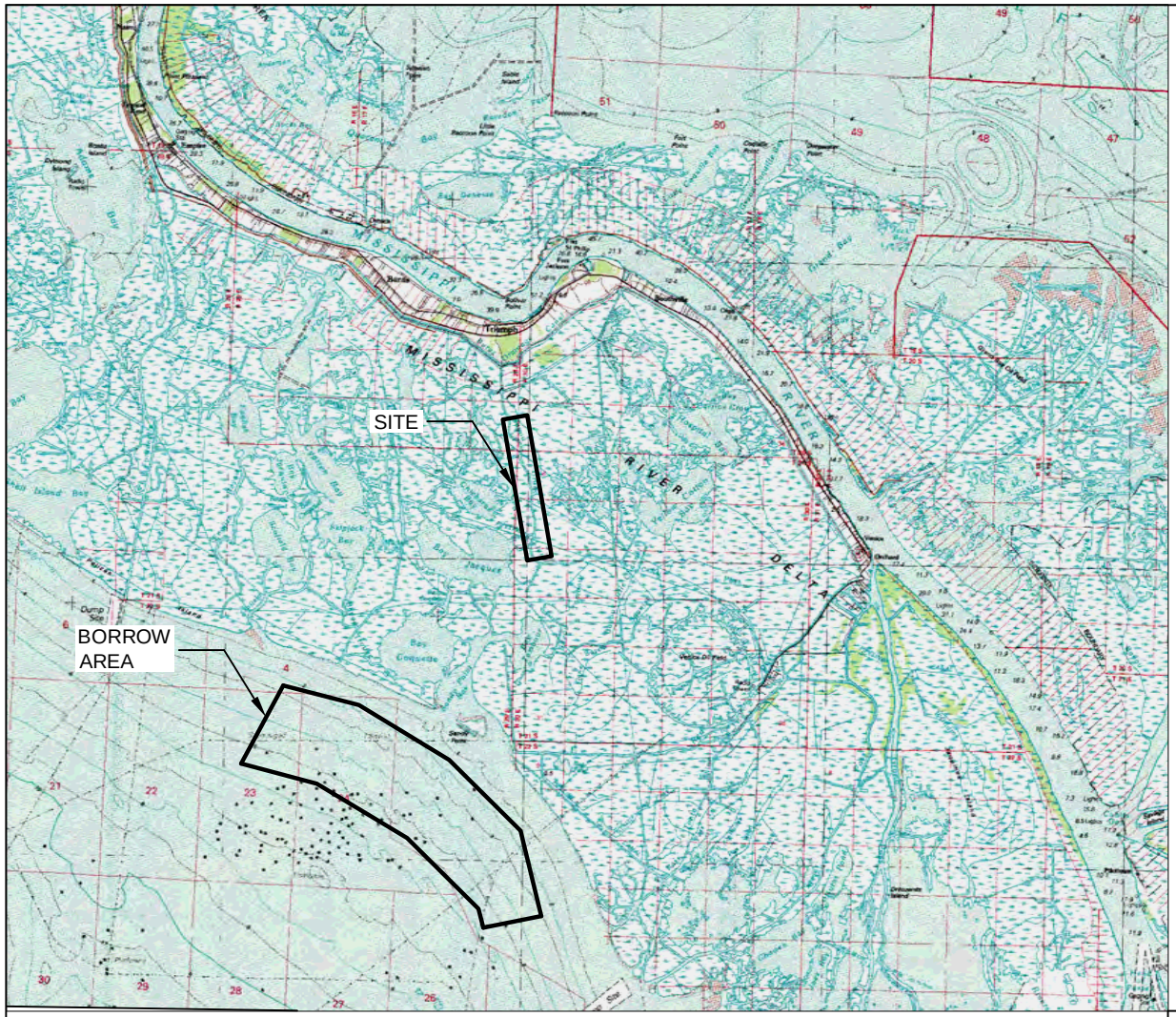
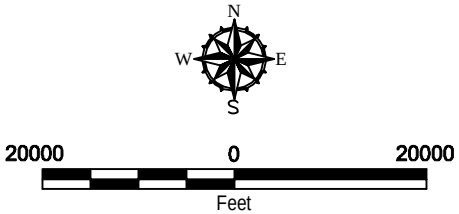




Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

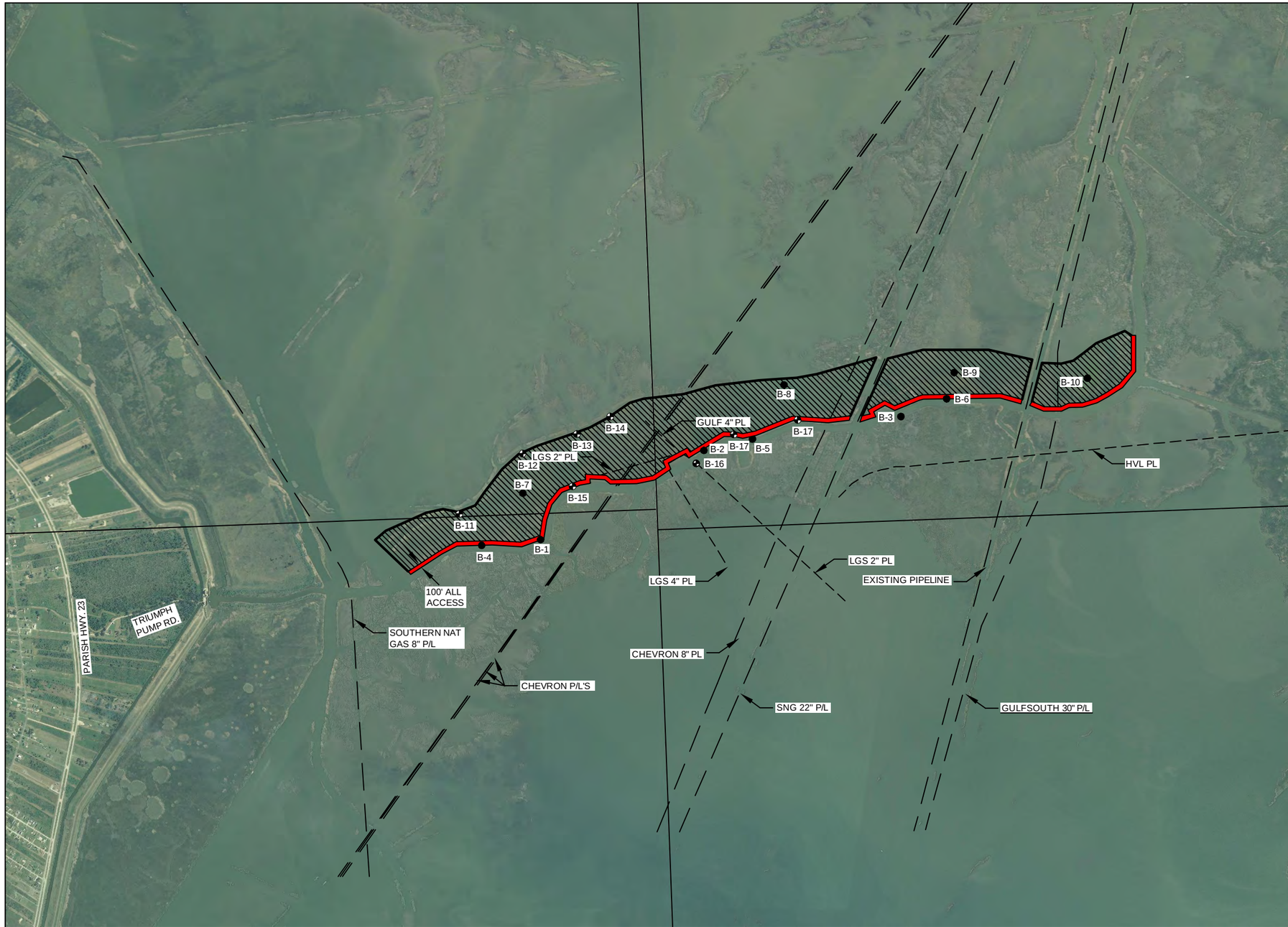
Reference: 1) Topographic map taken from USGS, 100K Template, Quad Plaquemines, Dated 10/2008
2) Borrow area information based on American Vibracore Services, Coastal Planning & Engineering, September 2010 Report provided to GeoEngineers by OCPR.

VICINITY MAP

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 1



BOREHOLE LOCATION

B-11	N29 18' 35.8"	W89 28' 30.2"
B-12	N29 18' 21.4"	W89 28' 14.9"
B-13	N29 18' 10.4"	W89 28' 10.8"
B-14	N29 18' 03.3"	W89 28' 05.9"
B-15	N29 18' 10.4"	W89 28' 24.1"
B-16	N29 17' 41.6"	W89 28' 15.5"
B-17	N29 17' 19.7"	W89 28' 08.1"
B-18	N29 17' 34.2"	W89 28' 12.2"

LEGEND

- B-1 — Borehole Location (From Previous Report)
- B-11 — Borehole Location (Proposed Location of Structures)
- Proposed Ridge Restoration
- Proposed Marsh Creation
- Proposed Earthen Containment Dike

N W E S

2500 0 2500
FEET

Notes:
1. The locations of all features shown are approximate.

Reference: 1. Aerial image taken from USGS, USGS High Resolution State Orthoimagery for the Louisiana Coastal Area, Dated 10/18/2008
2. Ridge Restoration and Marsh Creation Outlines provided by USGS, Grand Liard Marsh and Restoration (PPl18 Candidate), Dated 9/18/2008
3. Approximate location of existing pipelines taken from information provided by Sigma Consulting Group, Magnetometer Survey, Bayou Grand Liard Field, Plaquemines Paris, Dated 8/27/2010

SITE PLAN WITH SOIL BORING LOCATIONS

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 2

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LEGEND

B-11 Borehole Location

B-1 Borehole Location (From Previous Report)

A11 —— Cross Section Line

Notes:
1. The locations of all features shown are approximate.

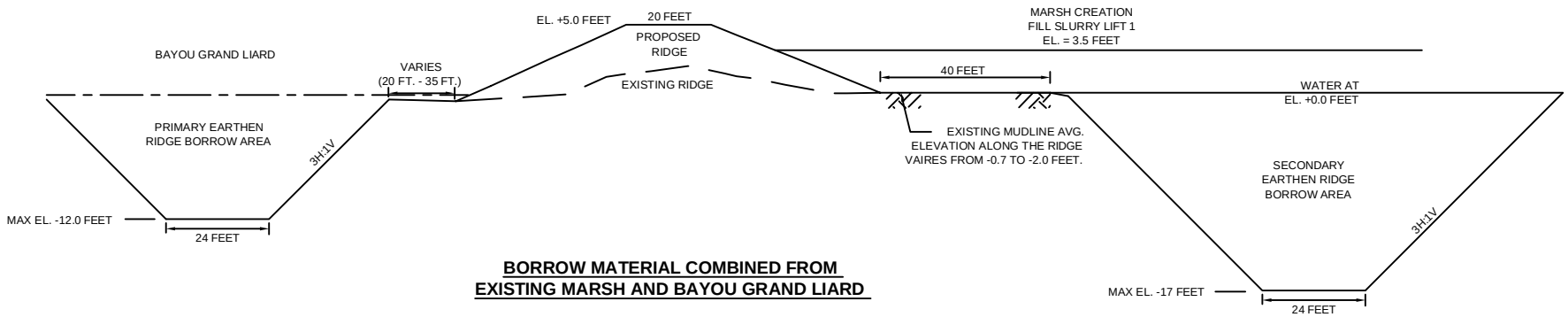
Reference: 1) Aerial image taken from USGS, USGS High Resolution State Orthoimagery for the Louisiana Coastal Area, Dated 10/18/2008
2) Survey lines and drawing information provided by Sigma Consulting Group, In., Grand Liard Marsh and Ridge CPRA on July 19, 2011

SITE PLAN WITH TRANSECT LAYOUT MAP

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 3



BORROW MATERIAL COMBINED FROM EXISTING MARSH AND BAYOU GRAND LIARD

Notes:
1. Assumed settlement of 6 inches within the earthen ridge during construction (0-30 days).
2. All elevations are referenced to the North American Vertical Datum of 1988 (NAVD88).
3. Ridge dimensions and Borrow Area bottom elevation provided by CPRA on July 19, 2011.

RECOMMENDED EARTHEN RIDGE SECTION

Grand Liard Marsh and Ridge Restoration Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 4

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile (feet)	Recommended Minimum Section Modulus (cubic Inch/feet)
B-11	4.5	3.5	-6.5	30	5
B-12	4.5	3.5	-12	35	11
B-13	4.5	3.5	-13	50	14.5
B-14	4.5	3.5	-6.5	25	4.5

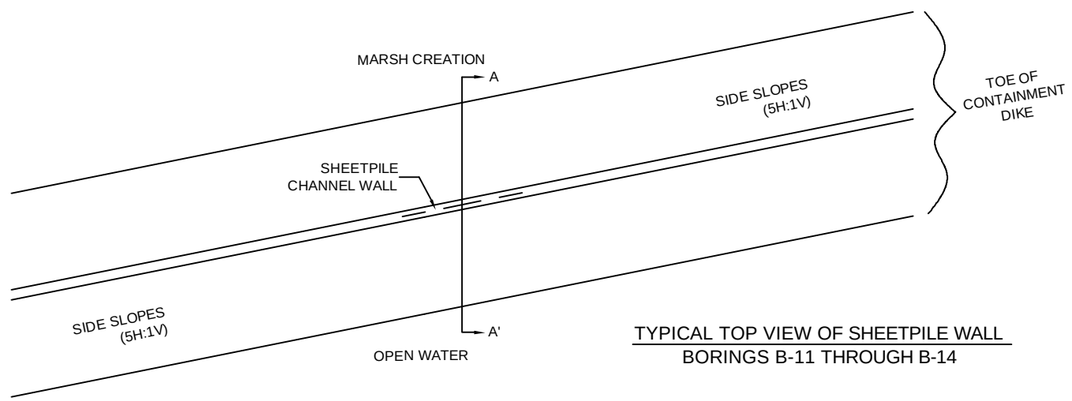
SUMMARY OF SHEETPILE ANALYSES (WITHOUT SAND FILL)

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Recommended Elevation of Top of Sand (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile (feet)
B-11	4.5	3.5	-1.5	-6.5	25
B-12	4.5	3.5	-2	-12	25
B-13	4.5	3.5	-3	-13	25
B-14	4.5	3.5	-1.5	-6.5	25

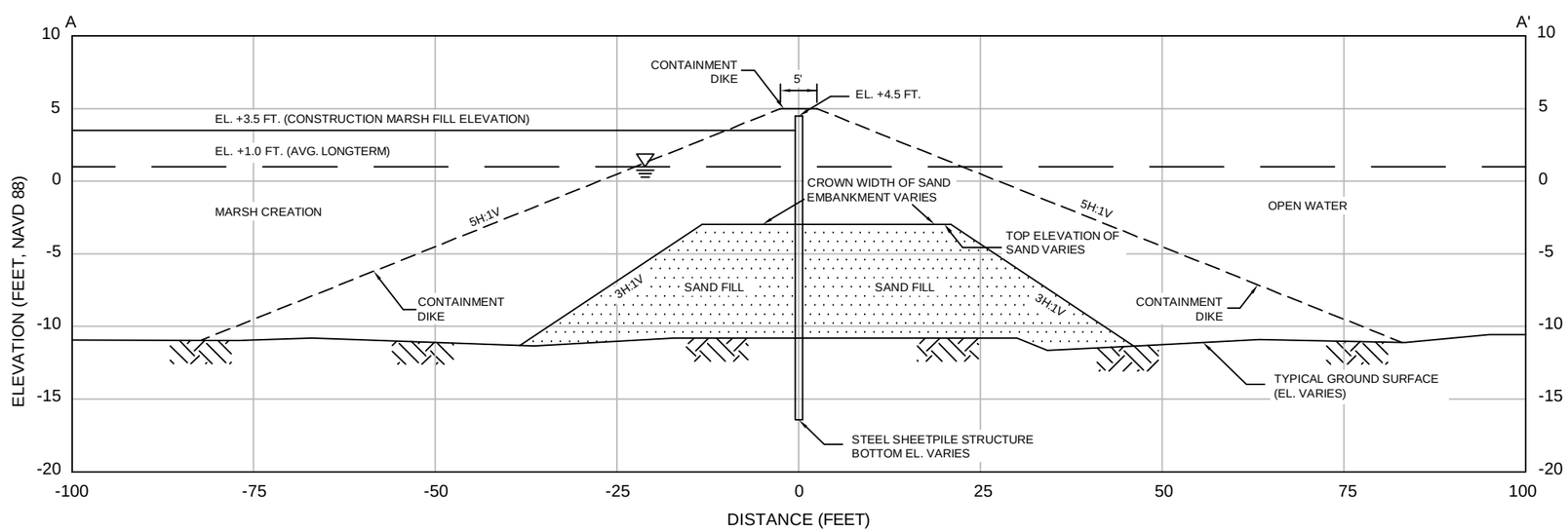
SUMMARY OF SHEETPILE ANALYSES (WITH SAND FILL)

Boring No.	Elevation of Top of Marsh Fill (feet, NAVD 88)	Recommended Elevation of Top of Sand Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Recommended Thickness of Sand Fill (feet)	Recommended Crown Width of Sand (feet)	
					Marsh	Open Water
B-11	3.5	-1.5	-6.5	5	15	20
B-12	3.5	-2	-12	10	15	25
B-13	3.5	-3	-13	10	15	25
B-14	3.5	-1.5	-6.5	5	15	20

SUMMARY OF RECOMMENDED SAND FILL



TYPICAL TOP VIEW OF SHEETPILE WALL
BORINGS B-11 THROUGH B-14



TYPICAL CROSS SECTION (A-A') OF CANTILEVER STEEL SHEETPILE
BORINGS B-11 THROUGH B-14

NOTES:

1. ALL LENGTHS FOR STEEL SHEETPILES ARE PROVIDED BASED ON TOP ELEVATION OF SHEETPILE AT EL. +4.5 FT.
2. THE STEEL SHEETPILE MUST HAVE SECTION MODULUS THAT MEETS OR EXCEEDS THE RESPECTIVE MINIMUM VALUES PROVIDED ABOVE.
3. STEEL SHEETPILES ARE RECOMMENED TO BE INSTALLED AFTER THE INSTALLATION OF SAND.
4. MARSH FILL WILL BE PLACED AFTER CONSTRUCTION OF CONTAINMENT DIKE OVER THE STEEL SHEET PILES ENCOMPASSING THE SAND FILL.
5. ELEVATION OF SAND MUST BE CHECKED PRIOR TO THE INSTALLATION OF CONTAINMENT DIKE AT THE STRUCTURE LOCATIONS.

REFERENCE: MUDLINE PROFILE IN THE CHANNELS PROVIDED BY CPRA ON SEPTEMBER 13, 2011

TYPICAL CROSS SECTION OF SHEETPILE WALL AT B-11 THROUGH B-14

Grand Liard Marsh and Ridge Restoration Project
(BA-68)-Structures
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 5A

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Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile (feet)	Recommended Minimum Section Modulus (cubic Inch/feet)
B-15 (Side wall)	4.5	3.5	-13	35	12
B-15 (Channel wall)	4.5	3.5	-17	45	19
B-16	4.5	3.5	-15.5	35	16
B-17	4.5	3.5	-17.5	55	22.5
B-18	4.5	3.5	-8	25	5.5

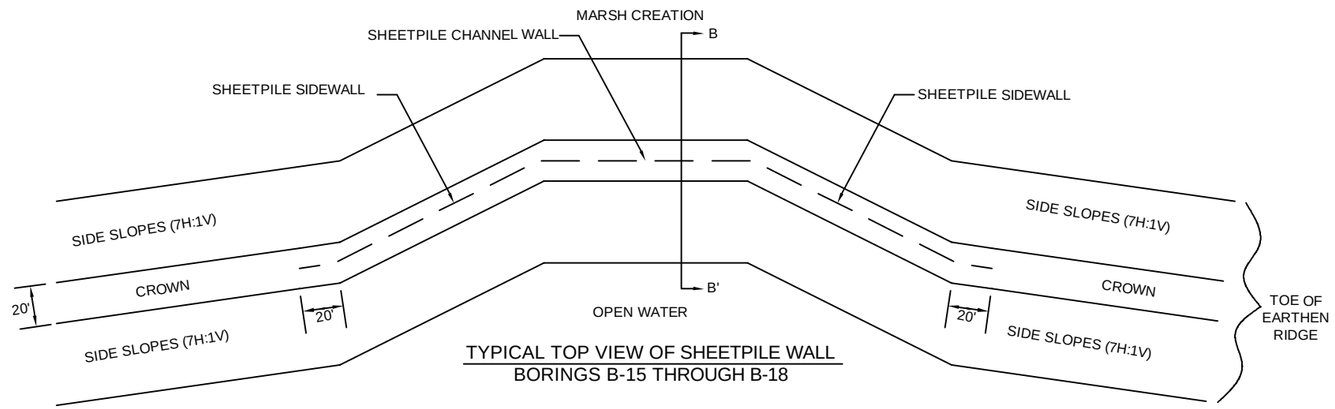
SUMMARY OF SHEETPILE ANALYSES (WITHOUT SAND FILL)

Boring No.	Elevation of Top of Sheetpile (feet, NAVD 88)	Elevation of Top of Marsh Fill (feet, NAVD 88)	Recommended Elevation of Top of Sand (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Total Length of Sheetpile (feet)
B-15 (Side wall)	4.5	3.5	-7	-13	35
B-15 (Channel wall)	4.5	3.5	-7	-17	35
B-16	4.5	3.5	-5.5	-15.5	30
B-17	4.5	3.5	-7.5	-17.5	35
B-18	4.5	3.5	-3	-8	25

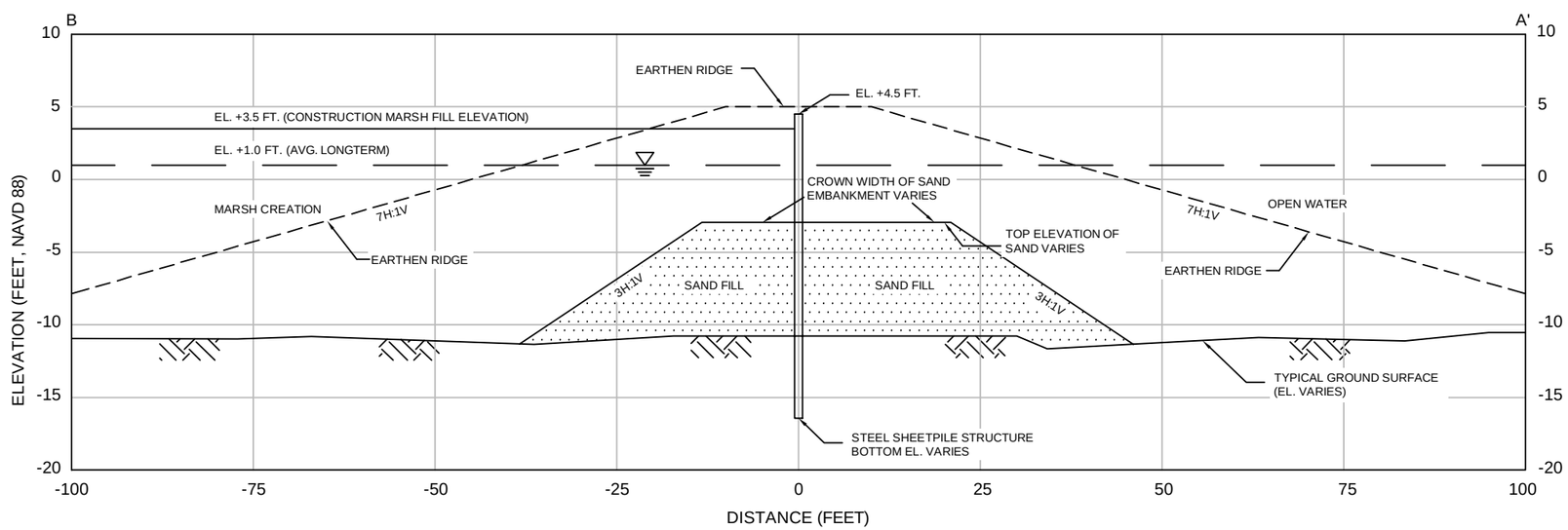
SUMMARY OF SHEETPILE ANALYSES (WITH SAND FILL)

Boring No.	Elevation of Top of Marsh Fill (feet, NAVD 88)	Recommended Elevation of Top of Sand Fill (feet, NAVD 88)	Elevation of Natural Mudline (feet, NAVD 88)	Recommended Thickness of Sand Fill (feet)	Recommended Crown Width of Sand (feet)	
					Marsh	Open Water
B-15 (Side wall)	3.5	-7	-13	6	15	25
B-15 (Channel wall)	3.5	-7	-17	10	15	25
B-16	3.5	-5.5	-15.5	10	15	25
B-17	3.5	-7.5	-17.5	10	15	25
B-18	3.5	-3	-8	5	15	20

SUMMARY OF RECOMMENDED SAND FILL



TYPICAL TOP VIEW OF SHEETPILE WALL
BORINGS B-15 THROUGH B-18



TYPICAL CROSS SECTION (B-B') OF CANTILEVER STEEL SHEETPILE
BORINGS B-15 THROUGH B-18

NOTES:

1. ALL LENGTHS FOR STEEL SHEETPILES ARE PROVIDED BASED ON TOP ELEVATION OF SHEETPILE AT EL. +4.5 FT.
2. THE STEEL SHEETPILE MUST HAVE SECTION MODULUS THAT MEETS OR EXCEEDS THE RESPECTIVE MINIMUM VALUES PROVIDED ABOVE.
3. STEEL SHEETPILES ARE RECOMMENED TO BE INSTALLED AFTER THE INSTALLATION OF SAND.
4. MARSH FILL WILL BE PLACED AFTER CONSTRUCTION OF EARTHEN RIDGE OVER THE STEEL SHEET PILES ENCOMPASSING THE SAND FILL.
5. ELEVATION OF SAND MUST BE CHECKED PRIOR TO THE INSTALLATION OF EARTHEN RIDGE AT THE STRUCTURE LOCATIONS.

REFERENCE: MUDLINE PROFILE IN THE CHANNELS PROVIDED BY CPRA ON SEPTEMBER 13, 2011

TYPICAL CROSS SECTION OF SHEETPILE WALL AT B-15 THROUGH B-18

Grand Liard Marsh and Ridge Restoration Project
(BA-68)-Structures
Plaquemines Parish, Louisiana

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Figure 5B

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Appendix K

Offshore Borrow Report

(Appendices available upon request)

GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68)

Prepared by:

American Vibracore Services

Coastal Planning & Engineering, Inc.

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Prepared for:

Louisiana Office of Coastal Protection and Restoration
Baton Rouge, Louisiana

Recommended Citation: Forrest-Vandera, B.M.; Larenas, M. and Andrews, J.L., 2010. *Grand Liard Marsh and Ridge Restoration (BA-68).* Boca Raton, Florida: Coastal Planning & Engineering, Inc. 28p. (Prepared for Louisiana Office of Coastal Protection and Restoration, Baton Rouge, Louisiana).

September 2010

Abstract

The Louisiana Office of Coastal Protection and Restoration (OCPR) authorized American Vibracore Services (AVS) and Coastal Planning & Engineering, Inc. (CPE) to conduct a marine sediment search investigation to identify approximately 3,500,000 cubic yards of suitable material to re-establish some ridge and marsh function in the Bayou Grand Liard vicinity for the Grand Liard Marsh and Ridge Restoration Project (BA-68). Investigations included reconnaissance and design level geophysical and geotechnical surveys, a cultural resource investigation, data processing and interpretation and borrow area design.

Two (2) borrow areas, designated Grand Liard East and Grand Liard West were designed. The total dredgeable volume in the Grand Liard East borrow area was calculated to be approximately 3,015,000 cy. The total dredgeable volume in the Grand Liard West borrow area was calculated to be approximately 4,765,000 cy. The volume of suitable material identified during this marine sediment search investigation exceeded the project's needs.

GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68)

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GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68)

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Appendix 7	2010 CPE Seismic Data (Digital Copy Only)
Appendix 8	Cultural Resource Report
Appendix 9	Borrow Area Impact Analysis

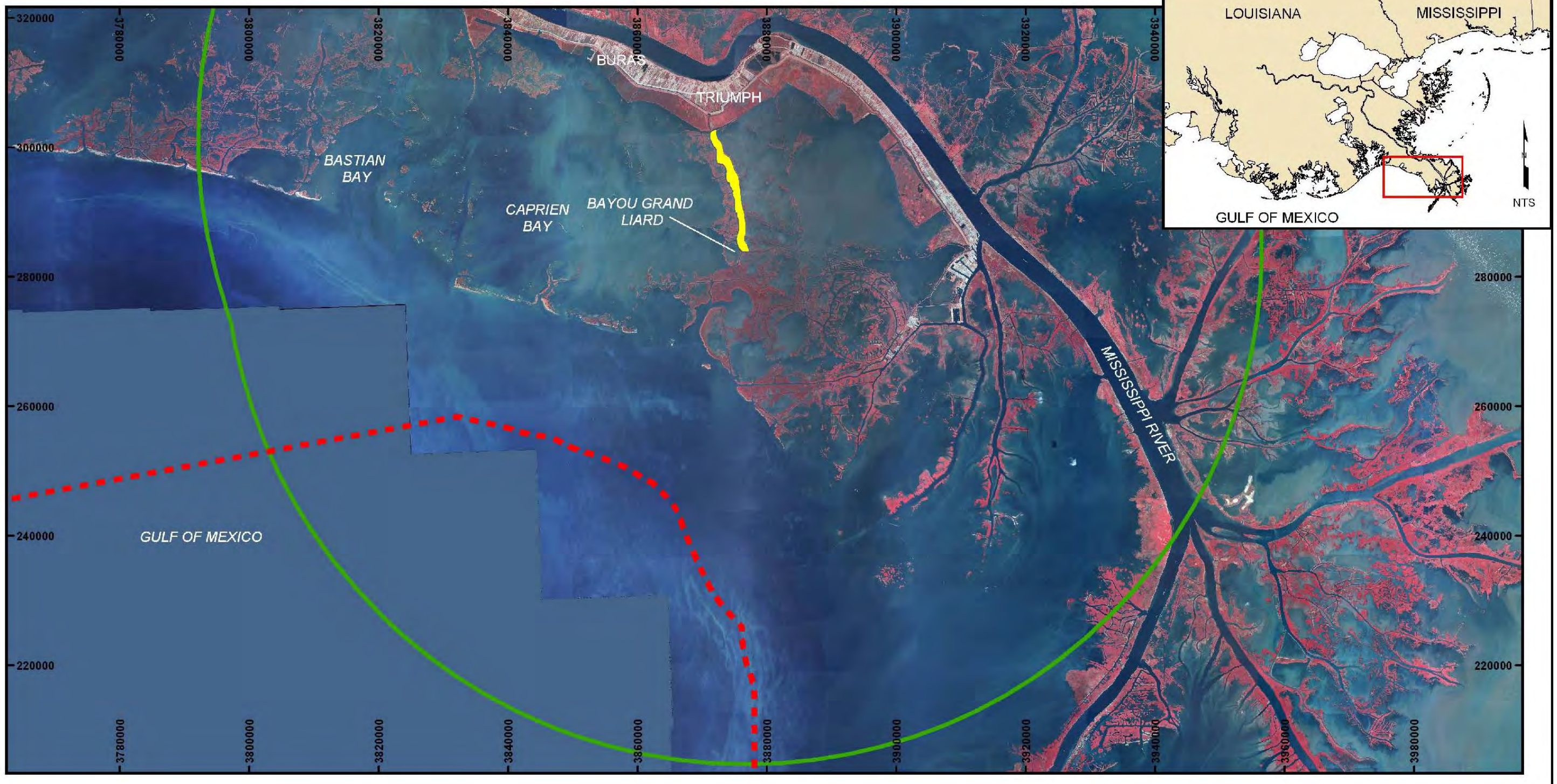
INTRODUCTION

Bayou Grand Liard was formerly a distributary of the Mississippi River that flowed into the Gulf of Mexico. The area has experienced tremendous wetland loss due to a variety of forces including subsidence, saltwater intrusion, a lack of sediment supply and oil and gas activities. The Bastian Bay and Grand Liard mapping units were historically structured by a series of north-south bayous and associated ridges. Over time, the majority of these bayou ridges and the marshes flanking them have disappeared. Ridge loss combined with interior wetland loss has resulted in large expanses of open water. The Grand Liard ridge is the most prominent remaining ridge and separates the open bays of the Bastian Bay and Grand Liard mapping units. If the ridges continue to degrade, the wetlands that are protected by the ridges will be subject to much more severe daily abuse from increased shoreline, wind and tidal erosion. Land loss projections suggest that remaining bayou bank wetlands will be completely converted to open water by the year 2050.

The Grand Liard Marsh and Ridge Restoration (BA-68) Project site is located in Plaquemines Parish, Louisiana, just south of the communities of Buras and Triumph (Figure 1). The project site is located along the western bank of the Mississippi River, within the Bastian Bay and Grand Liard mapping units. The goal of this project is to re-establish some ridge and marsh function in the Bayou Grand Liard vicinity. The project will create approximately 328 acres of marsh habitat, nourish approximately 140 acres of existing marsh and create approximately 20,000 linear ft. (34 acres) of maritime ridge habitat along the eastern bank of Bayou Grand Liard.

The Louisiana Office of Coastal Protection and Restoration (OCPR) authorized American Vibracore Services (AVS) and Coastal Planning & Engineering, Inc. (CPE) to conduct a marine sediment search investigation to identify approximately 3,500,000 cubic yards of suitable material for the Grand Liard project (Appendix 1). Investigations included reconnaissance and design level geophysical and geotechnical surveys, a cultural resource investigation, data processing and interpretation and borrow area design.

This sediment search investigation followed sequential survey procedures developed by CPE that maximize resources and effectively characterize offshore sediment deposits. Prior to the collection of any new data, existing data was compiled and reviewed during a Phase I investigation. Reconnaissance level geophysical and geotechnical data was then collected during a Phase II investigation. Upon review of the reconnaissance data, additional remotely sensed data (*i.e.* seismic reflection profiles, sidescan sonar imagery and magnetometer surveys) and vibracores were collected in smaller target areas during a Phase III investigation. Reconnaissance-level surveys that cover large areas of the seafloor provide useful information that helps define smaller targets (areas with higher potential for containing materials that are suitable for beach nourishment) where more intensive sediment and cultural resource investigations are then conducted.



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).
2. AERIAL PHOTOGRAPHY DATED 2005 FROM USGS.

LEGEND

- FEDERAL STATE BOUNDARY
- GRAND LIARD MARSH AND RIDGE RESTORATION PROJECT (BA-68)
- INVESTIGATION AREA

0 8,000 16,000 Feet

1 inch = 16,000 feet

N

TITLE:

FIGURE 1. MAP SHOWING THE PROJECT LOCATION AND THE AREA OF INVESTIGATION.

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 03/03/10	BY: BF	COMM NO: 7900.26	FIGURE 1

This report briefly discusses the results of the Phase I investigation, which were presented to the OCPR in February 2010 at the OCPR office in Baton Rouge, Louisiana. This report also presents the results of the Phase II reconnaissance and Phase III design level geophysical and geotechnical investigations that led to the identification of two (2) sediment resources. General investigation sequencing is discussed first, followed by a brief discussion of the Phase I investigations, a description of Phase II, III and cultural resource field activities, analysis of results from the Phase II, III and cultural resource field measurements and finally definition of the characteristics of the identified sediment resources and borrow area development.

INVESTIGATION SEQUENCING

A systematic approach to marine sediment searches has been developed over the years by the CPE Coastal Geology and Geomatics team (*e.g.* Finkl, Khalil and Andrews, 1997; Finkl, Andrews and Benedet, 2003; Finkl, Benedet and Andrews, 2005; Finkl and Khalil, 2005; Khalil, 2008). In a comprehensive marine sediment search, CPE typically divides the investigation into three (3) sequential phases (Figure 2). This phased approach can be modified to meet the scope of the investigation and accommodate the level of work previously performed. Regardless of the phases executed during a sediment search, the CPE investigation sequencing is preserved in order to maintain efficiency and completeness to provide confident results.

Phase I investigations typically consist of a comprehensive review of the project area and sediment resources offshore of the project area. This desktop study examines previously collected information within the geologic context of the search area in order to identify features having the highest potential of containing project-compatible sediment. The geological background of the area is assessed to identify the geomorphic features that may contain material suitable for the project. Information related to previously investigated areas, potential sediment resources and borrow areas, is compiled and related back to the geomorphic features. Geophysical and geotechnical data previously collected within these areas, as well as any reports discussing the findings, are then reviewed. Based on this analysis, deposits potentially containing project-compatible material are identified. The results of Phase I are used to define the areas that will be surveyed during Phase II investigations.

Phase II investigations usually consist of reconnaissance level geophysical and geotechnical surveys. A joint geophysical investigation (typically collecting seismic reflection profiles, sidescan sonar images, magnetometer and bathymetric data) is conducted at reconnaissance line spacing to assess the thickness of potential sediment resources. The wide reconnaissance line spacing is designed to cover large expanses of seafloor. Therefore, the data coverage achieved during Phase II investigations may not be sufficient to develop a detailed sediment thickness (isopachous) map. The geophysical data collected during this phase is used to design a vibracore investigation plan. Vibracores are collected to determine the sediment characteristics within the areas identified through remote sensing. Typically a limited number of cores are collected to groundtruth each potential sediment resource. Sediment resources within the investigation area are then analyzed using GIS procedures that integrate the seismic reflection profile and vibracore data to provide an estimate of deposit thickness and sedimentary characteristics. Samples may also be collected from the project area during this phase to characterize the project area in terms of grain size, color and composition (*i.e.* how well the

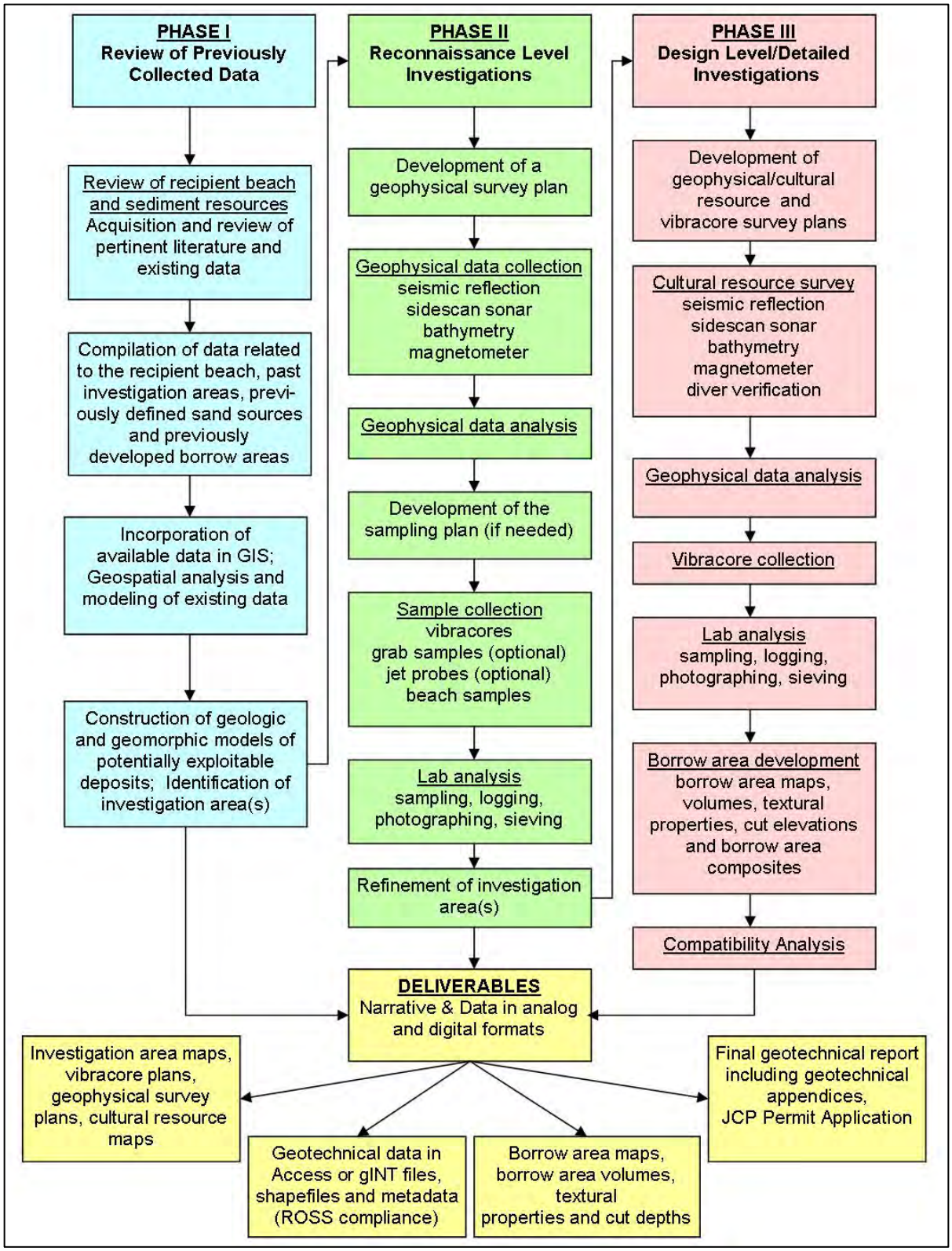


Figure 2. Flow diagram showing the general investigation sequence followed by CPE during a typical marine sediment search investigation.

potential borrow area sediment matches the existing material in the project area). The Phase II results are reviewed within the context of project compatibility to identify potential resource areas that will undergo design level investigations during Phase III.

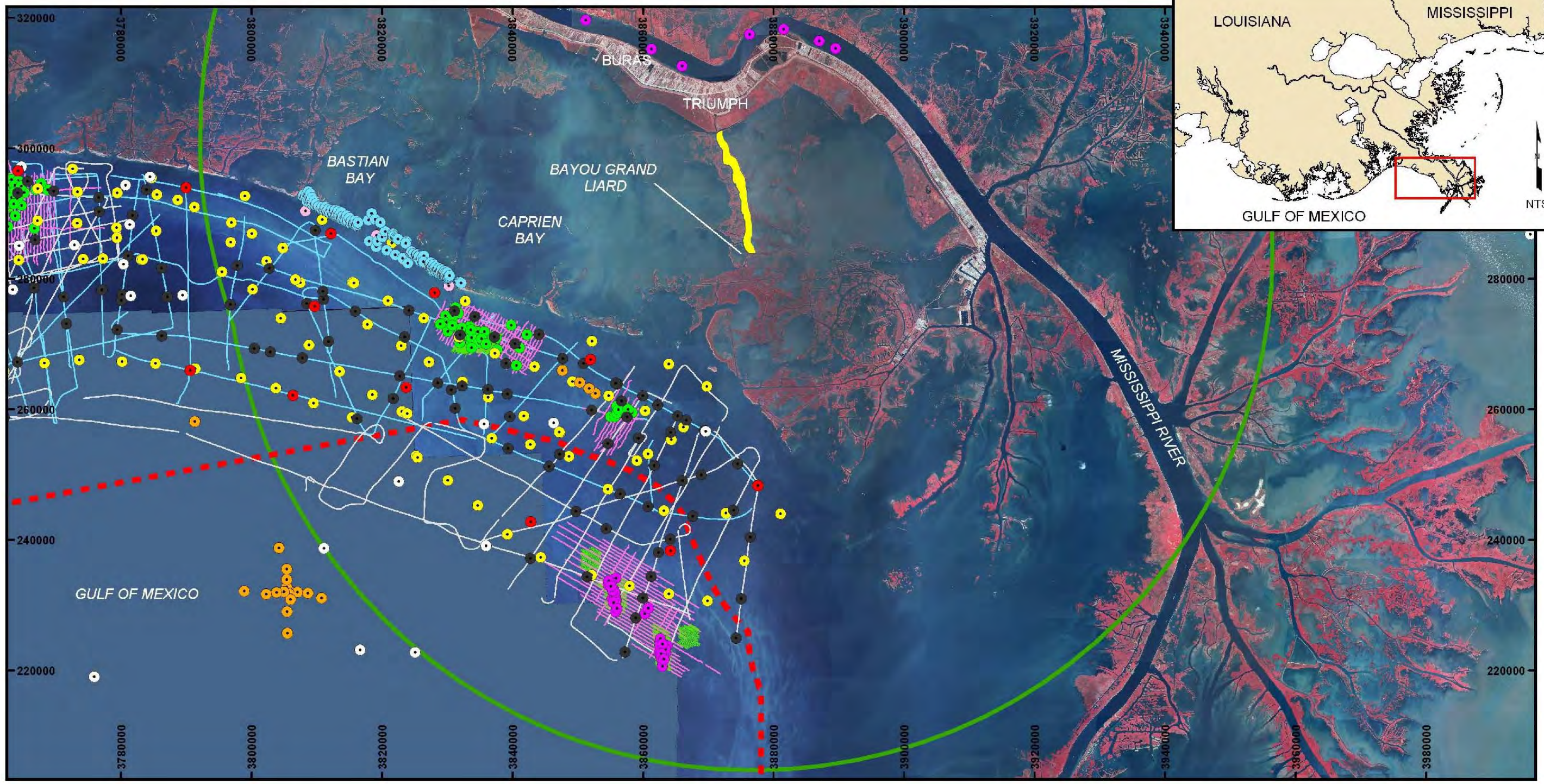
Phase III typically consists of design level geotechnical and geophysical investigations, a cultural resource investigation, and borrow area design. A joint seismic, sidescan sonar, magnetometer and bathymetric survey is conducted within the potential sediment resource area(s). The data collected is used to identify possible cultural or environmental resources for avoidance and to develop isopach (sediment thickness) maps for borrow area design. These results are also used to target areas for additional vibracoring. In order to conform to standard geological and engineering practice, fulfill permitting requirements, and conduct geophysical and geotechnical surveys in an expeditious manner, vibracores are collected to provide a maximum spacing of 1000 ft. (industry standard spacing) within the potential resource area. Preliminary borrow area boundaries and excavation depths are developed from the data collected during the Phase I, II and III investigations.

A final cultural resource investigation is required to permit borrow areas for use. During this investigation, additional geophysical data is collected within the borrow area to achieve a total combined line spacing of 30 m (approximately 98 ft.). A qualified marine archaeologist is required to be on the survey vessel at all times during the cultural resource investigation. The geophysical data is used to identify any cultural resources, submerged hazards or any other features that would affect borrow area delineation and dredging activities. Based on the results of the cultural resource investigation, the marine archaeologist compiles a report that includes recommendations for buffers around any potentially significant magnetic anomalies. The final borrow area design is then modified to take the recommended buffers into account.

This report summarizes the results of the Phase I, II, III and cultural resource investigations that were conducted in support of the Grand Liard Marsh and Ridge Restoration Project. These investigations led to the identification and development of two (2) borrow areas.

PHASE I INVESTIGATIONS

During the Phase I investigation, CPE conducted archival literature studies of the inner continental shelf area within a 15 mile radius of the project area. Available data pertaining to sediment deposits, previously identified borrow areas, oil and gas infrastructure, environmental avoidance areas and existing geological and geophysical data was compiled. This data was obtained from a variety of sources including the United States Geological Survey (USGS), Minerals Management Service (MMS), Louisiana State University (LSU), University of New Orleans (UNO), Louisiana Office of Coastal Protection and Restoration (OCPR), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), the Louisiana Department of Natural Resources SONRIS database and the National Pipeline Mapping System (NPMS). The data that was compiled during the Phase I investigation is shown in Figure 3.



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).
2. AERIAL PHOTOGRAPHY DATED 2005 FROM USGS.

LEGEND

- TEXAS A M (1978)
- MCCLELLAND (1987)
- UNO (2003)
- LGS/USGS (1983-1992)
- USGS (2000)
- HASTINGS ET AL (2000)
- CPE 2002 VIBRACORES
- CPE 2003 VIBRACORES
- ACOE VIBRACORES (DATE UNKNOWN)
- USGS CRUISE 00SCC04 (2004) GEOPHYSICAL TRACKLINES
- CPE (2003) GEOPHYSICAL TRACKLINES
- CPE (2002) GEOPHYSICAL TRACKLINES
- USGS CRUISE 00SCC02 (2002) GEOPHYSICAL TRACKLINES
- FEDERAL STATE BOUNDARY
- GRAND LIARD MARSH AND RIDGE RESTORATION PROJECT (BA-68)
- INVESTIGATION AREA

0 8,000 16,000 Feet

1 inch = 16,000 feet

N

TITLE:

FIGURE 3. GEOPHYSICAL AND GEOTECHNICAL DATA COMPILED DURING THE PHASE I INVESTIGATION

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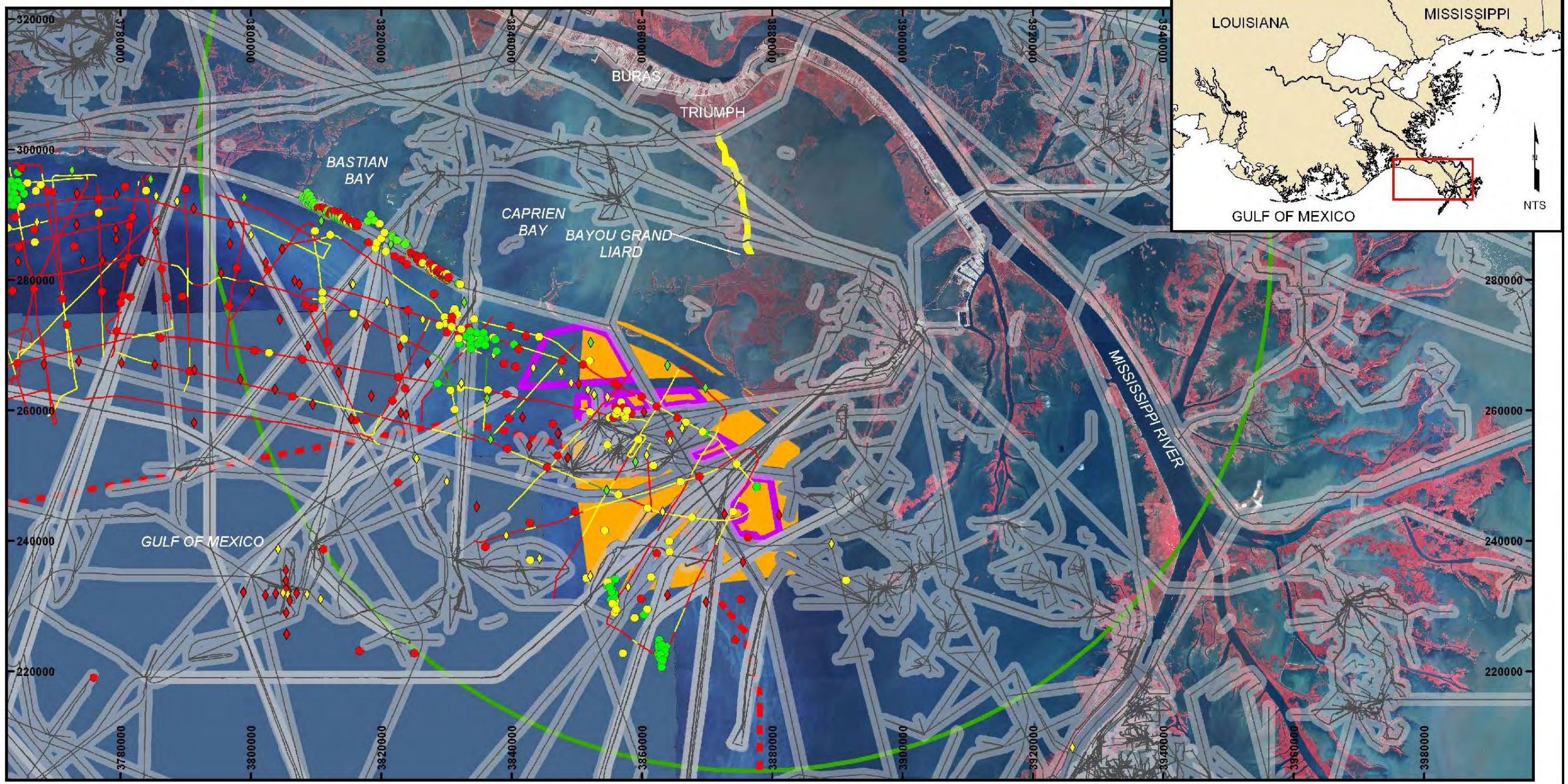
Results of Phase I Investigations

The data compiled during the Phase I review was evaluated and incorporated into a central Geographic Information System (GIS) database and subsequently used to develop a reconnaissance survey plan. CPE reviewed the vibracore logs and grab samples. The vibracore logs and grab samples were color coded according to sediment type where green, yellow and red represent sand, mixed sediment and clay, respectively (Figure 4).

The seismic data that was compiled during the Phase I investigation was also reviewed and color coded according to sediment type to identify potential sediment resources (Figure 4). Red represents clay, green represents sand and yellow represents mixed sediment. The majority of seismic data available for review had been collected and archived by the USGS or by CPE. Where possible, existing vibracore information was correlated to the seismic profiles to map the sedimentary units in the sub-bottom data.

The OCPR provided AVS and CPE with a number of proposed borrow areas (shown in orange in Figure 4). These proposed borrow areas incorporated the location of known oil and gas infrastructure, environmental avoidance areas and cultural resources. These areas were based on a 1000 ft. buffer, based on previously permitted Federal buffers, placed around the pipelines. However, it should be noted that smaller buffers are typically used in State waters.

Based on the results of the Phase I investigations, CPE recommended six (6) of these areas for further investigation. The areas recommended for further investigation are outlined in purple in Figure 4. A plan for a two (2) day reconnaissance survey (joint seismic reflection profiling, sidescan sonar, bathymetric and magnetometer) was developed based on the Phase I results. Following the reconnaissance geophysical survey, a plan was developed for the collection of ten (10) reconnaissance vibracores. Design level geophysical and geotechnical investigation plans were developed following the reconnaissance geophysical and geotechnical surveys.



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2. AERIAL PHOTOGRAPHY DATED 2005 FROM USGS.

LEGEND

VIBRACORE CLASSIFICATION
- CLAY
- SAND
- SANDY CLAY

GRAB SAMPLE CLASSIFICATION
- CLAY
- SAND
- SANDY CLAY

SEISMIC LINE CLASSIFICATION
- CLAY
- SAND
- MIXED SEDIMENT
- PIPELINES (LA OCM V7, MMS)
- 1000 FT PIPELINE BUFFER
- AREAS RECOMMENDED FOR FURTHER INVESTIGATION
- OCPR POTENTIAL BORROW AREAS

- GRAND LIARD MARSH AND RIDGE RESTORATION PROJECT
- FEDERAL STATE BOUNDARY
- INVESTIGATION AREA

0 8,000 16,000 Feet

1 inch = 16,000 feet

N

TITLE:

FIGURE 4. COLOR CODED GEOTECHNICAL AND GEOPHYSICAL DATA AND AREAS IDENTIFIED FOR FURTHER INVESTIGATION

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PHASE II AND III INVESTIGATIONS

Investigation Details

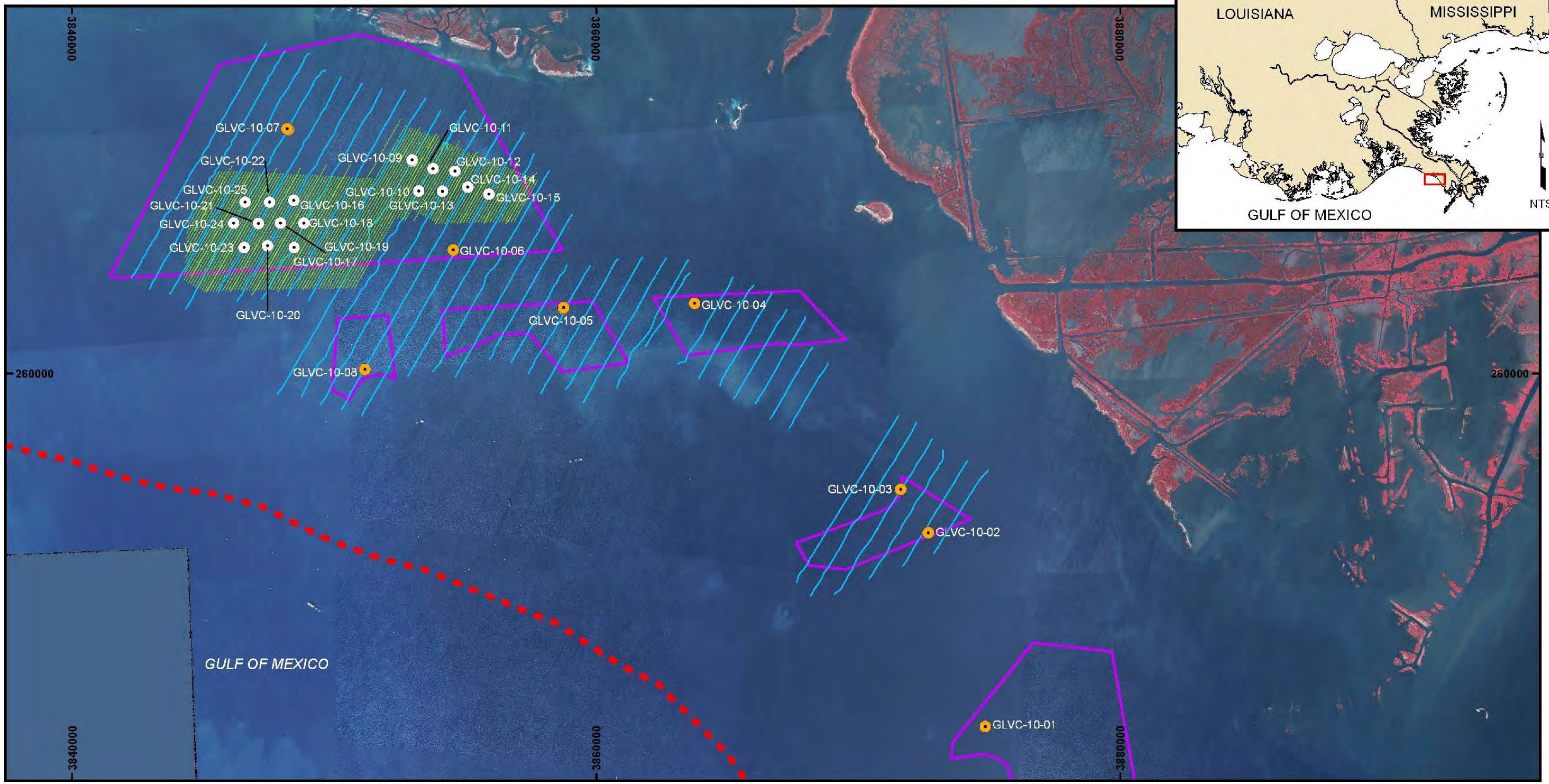
During Phase II investigations, CPE conducted reconnaissance level geophysical and vibracore surveys within six (6) of the areas identified by the OCPR as potential borrow areas. Between January 29 and January 31, 2010, eight (8) vibracores were collected from locations selected based on the analysis of historic data compiled during the Phase I investigation. On February 2 and February 4, 2010, a concurrent magnetometer, seismic reflection profiling, sidescan sonar and bathymetric survey was conducted off the *R/V Thunderforce.* A total of 47 nautical line miles of reconnaissance level geophysical data were collected. Figure 5 shows the location of the geophysical tracklines and vibracore locations. The geophysical data, coupled with analysis of the vibracores was used to determine sediment quality and to ascertain the presence of material suitable for dredging. Two (2) sediment resource areas were identified during the Phase II investigation. These two (2) areas were targeted during the Phase III investigation.

Phase III of the sediment search included design level geophysical and geotechnical investigations, a cultural resource investigation, and borrow area design. On February 10, 2010, sixteen (16) vibracores were collected to meet the maximum 1000 ft. industry standard spacing guidelines for permitting. Between February 10 and 15, 2010, a concurrent seismic reflection profiling, sidescan sonar and magnetometer survey was conducted. Approximately 82 nautical line miles of geophysical data was collected. During the geophysical survey, data was collected at approximately 30 m (approximately 100 ft.) line spacing to meet cultural resource investigation spacing requirements. The joint seismic reflection profiling, sidescan sonar and magnetometer survey was used to identify potential cultural resources such as artifacts, underwater wrecks, submerged hazards, significant relict landforms or any other features including modern debris that would affect borrow area delineation and dredging activities. A qualified marine archaeologist was onboard at all times during the cultural resource investigation. Based on the results of the cultural resource investigation, the marine archaeologist recommended the avoidance of several potentially significant magnetic anomalies by the creation of an avoidance buffer zone around each. Figure 5 shows the locations of the geophysical tracklines and vibracores. Based on the data that was collected up to this point, preliminary borrow area boundaries were developed.

The quantum of work undertaken during the Phase II and III investigations is summarized in Table 1.

Table 1. *Quantum of work summary.*

Total line miles surveyed (bathymetric, magnetometer, seismic and sidescan sonar)	129
Number of vibracores collected	24
Total number of subsamples (vibracore) generated and analyzed	144
Number of potential deposit sites investigated	6
Number of potential borrow areas identified	2



NOTES

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2. AERIAL PHOTOGRAPHY DATED 2005 FROM USGS.

LEGEND

- 2010 CPE RECONNAISSANCE VIBRACORES
- 2010 CPE DESIGN LEVEL VIBRACORES
- 2010 PHASE III & CULTURAL RESOURCE TRACKLINES
- 2010 CPE RECONNAISSANCE TRACKLINES
- POTENTIAL SURVEY AREAS
- FEDERAL STATE BOUNDARY
- INVESTIGATION AREA

0 2,000 4,000 Feet

1 inch = 4,000 feet

N

TITLE:

FIGURE 5. RECONNAISSANCE AND DESIGN LEVEL GEOPHYSICAL AND GEOTECHNICAL DATA

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Equipment and Methods

Due to the scope and precision required by modern sediment search protocols, a wide range of geophysical and geotechnical survey methods are required. The Phase II and III geophysical and geotechnical investigations included bathymetric, sidescan sonar, seismic reflection profiling and magnetometer surveys and determination of sediment composition and thickness via vibracoring. The bathymetric, sidescan sonar, seismic reflection profiling and magnetometer surveys were conducted concurrently using the setup illustrated in Figure 6. The collection and processing of this data is described below. The geophysical and geotechnical equipment is listed in Table 2 and described below.

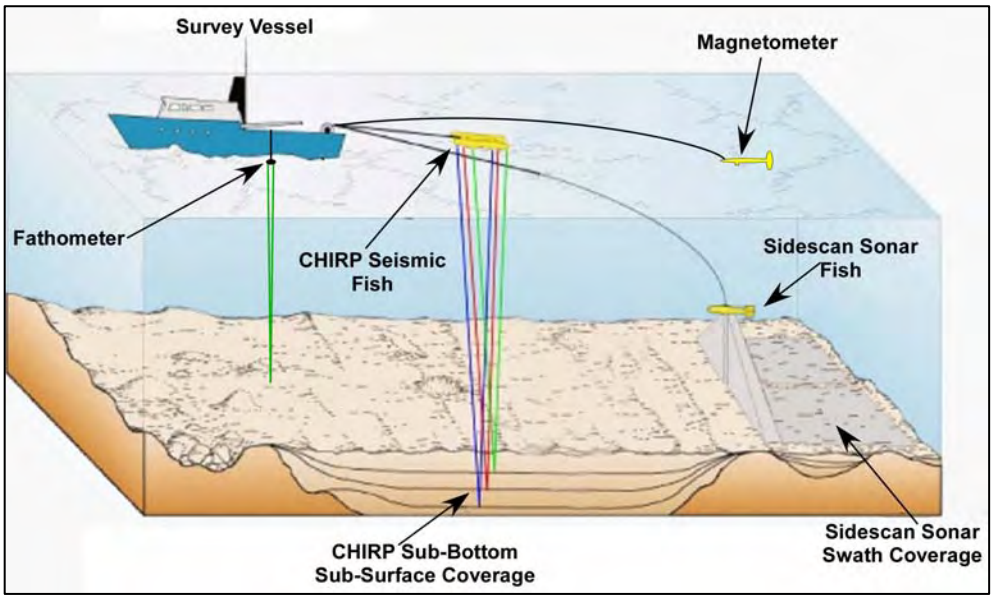


Figure 6. Schematic diagram showing the deployment of a joint seismic reflection profile, bathymetric, magnetometer and sidescan sonar survey.
(Modified from: http://woodshole.er.usgs.gov/operations/sfmapping/seismichist.htm)

Table 2. *Equipment used during Phase II and III of the sediment search investigation.*

Equipment Type	Description
Navigation	Trimble Differential Global Positioning System (DGPS) interfaced with Hypack Inc.'s Hypack 2009® software
Sounder (Bathymetry)	Odom Hydrographic Systems, Inc. "Hydrotrac" Hydrographic Echo Sounder
Sub-bottom Profiler (seismic reflection)	EdgeTech X-STAR SB-512i Sub-bottom Profiler
Sidescan Sonar	Edgetech 4200-HFL
Vibracores	AVS Pneumatic Vibracore System
Magnetometer	Geometrics G-882 Digital Cesium Marine Magnetometer interfaced with Hypack 2009® software

Navigation Systems

The navigation and positioning system deployed for the geophysical and geotechnical surveys was a Trimble Differential Global Positioning System (DGPS) interfaced to Hypack Inc.'s Hypack 2009®. A Pro Beacon receiver provided differential GPS correction from the U.S. Coast Guard Navigational Beacon located at English Turn, Louisiana. The DGPS initially receives the civilian signal from the global positioning system (GPS) NAVSTAR satellites. The locator automatically acquires and simultaneously tracks the NAVSTAR satellites, while receiving precisely measured code phase and Doppler phase shifts, which enables the receiver to compute the position and velocity of the vessel. The receiver then determines the time, latitude, longitude, height, and velocity once per second. Most of the time, the GPS accuracy with differential correction, provides for a position accuracy of one (1) to four (4) ft. This is within the accuracy needed for geotechnical investigations.

Hypack Inc.'s Hypack 2009® Data Collection and Processing Program

Navigational, magnetometer, and depth sounder systems were interfaced with an onboard computer, and the data was integrated in real time using Hypack Inc.'s Hypack 2009® software. Hypack 2009® is a state-of-the-art navigation and hydrographic surveying system. The location of the fish tow-point on the vessel in relation to the DGPS was measured, recorded and entered into the Hypack 2009® survey program. The length of cable deployed between the tow-point and each towfish was also measured and entered into Hypack 2009®. Hypack 2009® then takes these values and monitors the actual position of each towfish in real time. Online screen graphic displays include the pre-plotted survey lines, the updated boat track across the survey area, adjustable left/right indicator, as well as other positioning information such as boat speed, quality of fix measured by Position Dilution of Precision (PDOP), and line bearing. The digital data is merged with positioning data (DGPS), video displayed and recorded to the acquisition computers hard disk for post processing and/or replay.

Bathymetric Survey

The Odom Hydrographic Systems, Inc.'s Hydrotrac, a single frequency portable hydrographic echo sounder, was used to perform the bathymetric survey. The Hydrotrac operates at frequencies of 24, 33, 40, 200, 210, or 340 kHz and is a digital, survey-grade sounder. A 210 kHz transducer was used for the bathymetric survey.

Tide data for the cultural resource survey was obtained from a tide gauge set by CPE near the Empire Jetty. The tide gauge elevation was set by running an elevation bench loop from the monument set on the backside of the island to the tide gauge that was approximately 300 ft. offshore of the island and approximately 1000 ft. east of the Empire Jetty.

The sounder was calibrated via bar-checks and/or a sound velocity probe at the beginning and end of each survey day. The DIGIBAR PRO sound velocity meter offers a fast additional calibration for sound velocity in addition to the traditional bar check. Bar checks were performed from a depth of 5 ft. to a minimum depth of 25 ft. for a shallow water survey. Analog data showing the results of the bar check calibration was displayed on the sounder charts at 5 ft. increments during descent and ascent of the bar. Real-time navigation software, such as Hypack, was used to provide navigation to the helm to minimize deviation from the online azimuth. Soundings were collected at intervals sufficient to provide an accurate depiction of the seafloor.

Upon completion of the field work, data was edited and reduced with CPE's internal software programs and Hypack 2009®. The observed tide data was compared to local predictions and other regional gauges for verification purposes. The offshore raw digital data was viewed and edited in Hypack 2009®. Digitized data was scanned for noise and compared to the analog record. False soundings were removed and a comma delimited ACSII file was created and exported.

Magnetometer Survey

High-resolution magnetic remote sensing is needed to identify any metallic objects that could represent a potential cultural resource or hazard to construction. A Geometrics G-882 Digital Cesium Marine Magnetometer, capable of a plus or minus 0.1 gamma resolution, was used to perform a cursory investigation of magnetic anomalies within the potential sediment sources (Figure 7). The purpose of the magnetometer survey was to establish the presence, and subsequent exclusion zones around any potential underwater wrecks, submerged hazards, or any other features that would affect borrow area delineation and dredging activities.

To produce a magnetic record of sufficient resolution, the sensor was deployed and maintained in the water column at a depth of 3 to 7 ft. below the water surface. A computer recorder provided a continuous permanent record of the magnetic background and target signatures. Positioning data generated by the navigation system was tied to magnetometer records by regular annotations to facilitate target location and anomaly analysis. Annotations include line number, date and time of start and end of each line, and target identification.

Upon completion of the general magnetometer survey, the data was examined and magnetic anomalies were identified. Data from the survey area was contoured using Quicksurf (or equivalent) software to facilitate anomaly location and definition of target signature characteristics. All magnetic data was correlated with the acoustic remote sensing records.

Figure 7. Geometrics G-882 Digital Cesium Marine Magnetometer used to investigate magnetic anomalies within the potential sediment source.

Seismic Reflection Profile Surveys

"Chirp" sub-bottom seismic-reflection data is used to show sedimentary stratigraphy and identify potential project-compatible sediment resources. The use of chirp sub-bottom data allows common stratigraphic layers to be mapped throughout the study area while determining the thickness and extent of potential project compatible sediment.

An EdgeTech X-STAR SB-512i was used to conduct the seismic reflection profile surveys (Figure 8). The X-STAR Full Spectrum Sonar is a versatile wideband FM sub-bottom profiler that collects digital normal incidence reflection data over many frequency ranges. This instrumentation generates cross-sectional images of the seabed (to a depth of up to 50 ft. in this survey). The X-STAR SB-512i transmits an FM pulse that is linearly swept over a full spectrum frequency range (also called a "chirp pulse"). The tapered waveform spectrum results in images that have virtually constant resolution with depth. The Chirp systems have an advantage over 3.5 kHz and "boomer" systems in sediment delineation because the reflectors are more discrete and less susceptible to ringing from both vessel and ambient noise. The full-wave rectified reflection horizons are cleaner and more distinct than the half-wave rectified reflections produced by older analog systems.

The X-STAR SB-512i, the newest model in the EdgeTech suite of Chirp Full Spectrum Sub-bottom towfish, differs from the older X-STAR SB-512 (which had four (4) 6" diameter transducers) by having a single 13" diameter low frequency transducer and a single 6.5" diameter high frequency transducer. The new low frequency transducer provides more low frequency energy at all pulse settings, which allows deeper penetration of seafloor sediments while at the same time maintaining the high resolution of the original configuration.

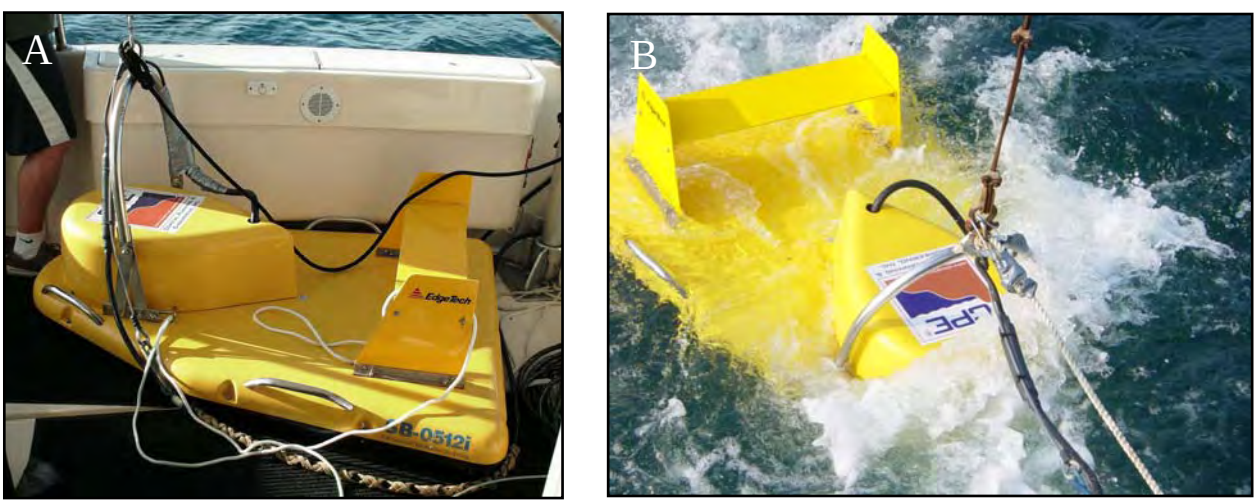


Figure 8. EdgeTech X-STAR SB-512i sub-bottom profiling system. (a) shows the sub-bottom profiling system prior to deployment. (b) shows the system after deployment.

In order to minimize noise related to the survey vessel and sea conditions, the seismic towfish (which operates as both the source and receiver for the sub-bottom system) was deployed and towed behind the research vessel. The sub-bottom system was interfaced with DGPS via Hypack 2009® navigational software. The location of the fish tow point (as referenced to the

DGPS antenna), together with the length of cable deployed from the tow point, were entered into Hypack 2009® in order to account for the fish layback and provide accurate positioning of the seismic fish during the survey. The sub-bottom system was operated by the Discover-SB® software program. At the start of the sub-bottom profiling survey, the sweep frequencies of the outgoing pulse together with the different gain settings available within Discover-SB® were adjusted to obtain the best possible resolution for the survey. The data was continuously bottom-tracked to allow for the application of real-time gain functions in order to have an optimal in-the-field view of the data. Automatic gain control (AGC) was used to normalize the data by strengthening quiet regions/soft returns while simultaneously reducing/eliminating overly strong returns by obtaining a local average at a given point. A time-varying gain (TVG) was used to increase the returning signal over time in order to reduce the effects of signal attenuation.

All sub-bottom data was recorded on the acquisition computer's hard disk and transferred to a USB memory stick and/or portable hard drive at the end of each survey day to back-up raw survey data. A printed hardcopy of the data was also produced as the data was collected. Notes regarding line name, time, event, and direction of collection were recorded for the beginning and end of each survey trackline. Post collection processing of the seismic data was completed using Chesapeake Technology, Inc's SonarWiz.MAP +SBP® software. This software allows the user to apply specific gains and settings in order to produce enhanced sub-bottom imagery that can then be interpreted and digitized for specific stratigraphic facies relevant to the project goals.

The first data processing step is to calculate the approximate depth of the reflector below the sound source by converting the two-way travel time (the time in milliseconds that it takes for the "chirp pulse" to leave the source, hit the reflector and return to the source) to feet by utilizing an approximate value for the speed of sound through both the water and underlying geology. For this survey, a detailed hydrographic and geologic sound velocity structure was not available, so CPE geophysicists used an estimated sound velocity of 1.6 meters per millisecond (m/ms) in order to convert two-way travel time to feet. This estimate of the composite sound velocity is based on several assumptions including the speed of sound through water which is typically 1.5 m/ms as well as on the speed of sound through the sediment which can vary from 1.6 m/ms for unconsolidated sediment to >1.7 m/ms for limestone.

CPE geophysicists then processed the imagery to reduce noise effects (commonly due to the vessel, sea state, or other natural and anthropogenic phenomenon) and enhance stratigraphy. This was done using the processing features available in SonarWiz.MAP +SBP®; AGC, swell filter, and a user-defined gain control (UGC). The SonarWiz.MAP +SBP® AGC is similar to the Discover-SB® AGC feature, where the data are normalized in order to remove the extreme high and low returns, while enhancing the contrast of the middle returns. In order to appropriately apply the swell filter and UGC functions, the sub-bottom data was bottom-tracked to produce an accurate baseline representation of the seafloor. Once this was done through a process of automatic bottom tracking (based on the high-amplitude signal associated with the seafloor) and manual digitization, the swell filter and UGC were applied to the data. The swell filter is based on a ping averaging function that removes vertical changes in the data due to towfish movement caused by the sea state. The swell filter was increased or decreased depending on the period and frequency of the sea surface wave conditions, however, special care was taken during this phase to not remove, or smooth over geologic features that are masked by the sea state noise. The final

step was to apply the UGC. The SonarWiz.MAP +SBP® UGC feature allows the user to define amplitude gains based on either the depth below the source, or the depth below the seafloor. For this survey, the UGC was adjusted so that the gain would increase with depth below the imaged seafloor (and not the source), mimicking a time-varying gain. The user was able to remove the noise within the water column, increase the contrast within the stratigraphy, and increase the amplitude of the stratigraphy with depth, accounting for some of the signal attenuation normally associated with sound penetration over time.

Sidescan Sonar Survey

Sidescan data is required to verify the location and extent of unconsolidated sediment and to map ocean bottom features such as benthic habitats, exposed pipelines, cables, underwater wrecks, potential cultural resources, *etc*. The sidescan survey was conducted to identify features that may affect borrow area delineation, introduce hazards to dredging, or adversely impact the environment.

During this sediment search investigation an EdgeTech 4200-HFL sidescan sonar system was used (Figure 9). This system uses full-spectrum chirp technology to deliver wide-band, high-energy pulses coupled with high resolution and good signal to noise ratio echo data. The sonar package included a portable configuration with a laptop computer running EdgeTech's Discover® acquisition software and a 300/600 kHz dual frequency towfish running in high definition mode. Dual frequency provides a more complete sidescan return that aids interpolation at the outer portions of the swath, which in turn provides a more complete data set.

Figure 9. EdgeTech 4200-HFL sidescan sonar system.

During the investigations, the sidescan was towed from the survey vessel at a position and depth that limited exposure to sources of interference and provided the best possible record quality. The survey was conducted in such a manner to achieve total bottom coverage within the survey area. The line spacing was set up so that we obtained 100% overlap (*i.e.* all areas of the

seafloor were covered twice). The digital sidescan data was merged with positioning data (DGPS via Hypack 2009®). Position data appeared in the video display and was logged to disk for post processing and/or replay. The acoustic data was recorded digitally.

Post collection processing of the sidescan data was completed using Chesapeake Technology, Inc's SonarWiz.MAP software. This software allows the user to apply specific gains and settings in order to produce enhanced sidescan imagery that can be interpreted and digitized for specific benthic habitat features and debris throughout the survey area. The first step in processing was to import the data into the software and bottom track the data. Bottom tracking is achieved using an automated bottom tracking routine and in some cases manual bottom tracking. This step provides the data with an accurate baseline representation of the seafloor and eliminates the water column from the data.

After bottom tracking, the data was processed to reduce noise effects (commonly due to the vessel, sea state, or other anthropogenic phenomenon) and enhance the seafloor definition. In most cases automatic time-varying gain (TVG) is sufficient to provide the best imagery. Time-varying gain divides the data into parallel swaths and equalizes backscatter of each swath to create a normalized image highlighting contrast change throughout the image, which creates a better mosaic and allows the processer to pick out areas with similar acoustic properties. In areas with high levels of noise in the data it was necessary to apply automatic gain control (AGC) which normalizes the data by strengthening quiet regions/soft returns while simultaneously reducing/eliminating overly strong returns by obtaining a local average at a given point. Once the data was sufficiently processed a mosaic was produced in the form of a geotiff.

Vibracore Survey

Vibracores were collected to obtain continuous physical samples of the material within the potential sediment resources. They are used to characterize the physical properties of the material and groundtruth the seismic data.

Vibracores were collected using an AVS Pneumatic Vibracore System (Figure 10). This self-contained, freestanding pneumatic vibracore unit contains an air-driven vibratory hammer assembly, an aluminum H-beam which acts as the vertical beam upright on the seafloor, 20-ft. long steel tubes measuring 4" in diameter, and a drilling bit with a cutting edge. An air hose array provides compressed air from the compressor on deck to drive the vibracore. The vibracore unit was deployed from the R/V *Thunderforce* using an A-frame.

Figure 10. A) *R/V Thunderforce*. B) Deployment of the AVS Pneumatic vibracore system off the *R/V Thunderforce.*

If recovery was less than 80% of the expected penetration, the pipe was removed, a new pipe inserted, and a jet pump hose was attached just below the vibracore head. The rig was, again, lowered to the bottom and jetted into the sediment just above refusal depth. The jet was then turned off and the vibrator resumed collecting the lower part of the core.

Upon removal of the vibracores, they were measured, marked and cut into 3-ft. sections. The cores were then labeled, and transported to CPE's office in Boca Raton, Florida. There, the vibracores were split and logged by describing sedimentary properties by layer in terms of layer thickness, color, texture (grain size), composition and presence of clay, silt, gravel, or shell and any other identifying features (Figure 11). Wet Munsell color was determined in accordance with American Society for Testing and Materials Standard Materials Designation D2488-00 for description and identification of soils (visual-manual procedure) (ASTM, 2009). The vibracores were digitally photographed against an 18% gray background. This is the standard reference value against which all camera light meters are calibrated. Use of an 18% gray background is preferred because it provides a known reference color. Sediment samples were obtained from irregular intervals based on distinct layers in the sediment sequence. The unsampled half of each core was then archived.

Figure 11. Vibracore logging, sub-sample collection and Munsell color determination being conducted at CPE's office in Boca Raton, Florida.

Sediment Grain Size (Mechanical) Analysis. During sieve analysis, dry and washed Munsell color were noted. Sieve analyses were conducted on all sediment samples in accordance with American Society for Testing and Materials Standard Materials Designation D422-63 for particle size analysis of soils (ASTM, 2007). This method covered the quantitative determination of the distribution of sediment size particles. For sediment finer than the No. 230 sieve (4.0 phi) the ASTM Standard Test Method, Designation D1140-00 was followed (ASTM, 2006). Mechanical sieving was accomplished using calibrated sieves with a gradation of half phi intervals. Additional sieves representing key ASTM sediment classification boundaries were also included. Weights retained on each sieve were recorded cumulatively.

Grain size data were entered into the gINT® software program, which computes the mean and median grain size, sorting, and silt/clay percentages for each sample using the moment method (Folk, 1974). Granularmetric reports and grain size distribution curves were compiled for each sample.

Field Vane Shear Tests. Field vane shear tests were conducted during vibracore logging in accordance with American Society for Testing and Materials Standard Methods Designation D2573 for field vane shear tests in cohesive soils. These tests were conducted to characterize the clay material.

Atterberg Limits Testing. Atterberg Limits were determined on eight (8) clay samples in accordance with AASHTO T89-02 & T90-00 and ASTM 4318 for determining the liquid, plastic limits and plasticity index of soils. These tests were also conducted to characterize the clay material.

Incremental Consolidation. Incremental consolidation tests were conducted on six (6) clay samples to determine the magnitude and rate of consolidation of the clay when restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. Testing was done in accordance with ASTM D2435 for one dimensional consolidation properties

of soils using incremental loading. Bulk unit weight was also determined during incremental consolidation testing.

Unconsolidated Undrained Triaxial. Unconsolidated-undrained triaxial compression tests were conducted on six (6) clay samples to determine the strength and stress-strain relationships of a cylindrical sample of either undisturbed or remolded clay. Samples were subjected to confining fluid pressure in a triaxial chamber. The samples were sheared in compression without drainage at a constant rate of axial deformation (strain controlled). Testing was done in accordance with ASTM D2850 for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils.

Consolidated Undrained Triaxial. Consolidated undrained triaxial compression tests were conducted on six (6) clay samples to measure the shear characteristics under undrained conditions. These tests were conducted to determine the strength and stress-strain relationships of a cylindrical specimen of either an undisturbed or remolded saturated cohesive sediment. Clay samples were isotropically consolidated and sheared in compression without drainage at a constant rate of axial deformation (strain controlled). Testing was done in accordance with ASTM D4767 for Consolidated Undrained Triaxial Compression Test for Cohesive Soils.

Permeability Testing. Hydraulic conductivity (permeability testing) was done on six (6) samples of water saturated porous materials using a flexible wall permeameter. Testing was done in accordance with ASTM D5084 for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

Results and Discussion

During this investigation, reconnaissance and design level geophysical and geotechnical investigations were conducted. A cultural resource investigation was also conducted. The results of these investigations are discussed below.

As part of the Phase I historic data collection and review, CPE obtained vibracore and subbottom profile data from a variety of sources including the USGS, MMS, LSU, UNO, OCPR, NASA, NOAA and NPMS. Based on this data and on the potential borrow areas provided by the OCPR, eight (8) reconnaissance vibracores were collected. Following the collection and analysis of the reconnaissance vibracores, seismic data was collected, analyzed and used to develop a detailed plan to collect the design level vibracores to target the most promising sediment resources, while avoiding potential natural resources and magnetic anomalies. Appendices 2 and 3 contain vibracore logs and photographs. The granularmetric reports and grain size curves/histograms for the samples collected from the vibracores are presented in Appendices 4 and 5, respectively.

Vibracores collected from the six (6) potential sediment resources are predominantly soft clay with trace sand, shell hash and organics. The wet Munsell color value ranges from 3 to 4. The uppermost 1 ft. or so of material in vibracores GLVC-10-01, 03, 05, 09, 10, 12, 13, 18, 21 and 22 is very soft clay. Vibracores GLVC-10-09 to 15, which is the easternmost cluster of design level vibracores are predominantly soft clay with trace sand, shell hash and organics. Wet Munsell color values range from 3 to 4. The results of permeability testing, incremental

consolidation, unconsolidated undrained triaxial, consolidated undrained Triaxial and Atterberg Limits Testing are provided in Appendix 6.

CPE reviewed the 2010 vibracore logs for sediment quality. The logs were color coded according to sand content, where green has the highest content, yellow contained moderate amounts of sand and red is predominantly clay. Table 3 lists the criteria for color coding the vibracores.

Table 3. *Vibracore color code scheme showing the range of sediment differentiation.*

Color Code	**Description**
Green	>60% sand, <40% fines
Yellow	<60% sand, 40-70% fines
Red	Clay, >70% fines

The seismic data that was collected was processed and the color-coded vibracore logs were then plotted directly onto the seismic data using the SonarWiz.MAP +SBP software program. Each color-coded vibracore was plotted on the seismic line that fell closest to its location. All seismic data were then reviewed to determine if any stratigraphy within the vibracores were discernible within the seismic stratigraphy. Most vibracores contained very few stratigraphic layers, consisting mostly of homogenous/semi-homogenous clay material. In the few instances where small, varying stratigraphic layers occurred within the vibracores, the layers were either too small in vertical thickness and/or too similar to the surrounding stratigraphy to elicit a mappable acoustic response within the seismic data.

Furthermore, all of the seismic data exhibited a characteristic gas layer within the record between approximately 5 and 15 feet beneath the seafloor. This gas layer results in full acoustic refusal, not allowing sound penetration, thus preventing the visualization of any seismic stratigraphy beneath this gas layer. This is a common and expected feature in nearshore marine environments offshore Louisiana. Therefore, due to similar stratigraphy within all of the cores (*i.e.* lack of internal reflectors), together with the acoustically resistant gas layer, no seismic stratigraphic reflectors were visible. Consequently, no digitization of subsurface seismic stratigraphic reflectors was able to be conducted.

Upon the completion of processing, all of the seismic data was then exported as a “Web” based project of HTML/JPEG files viewable in any standard web browser software package (Appendix 7).

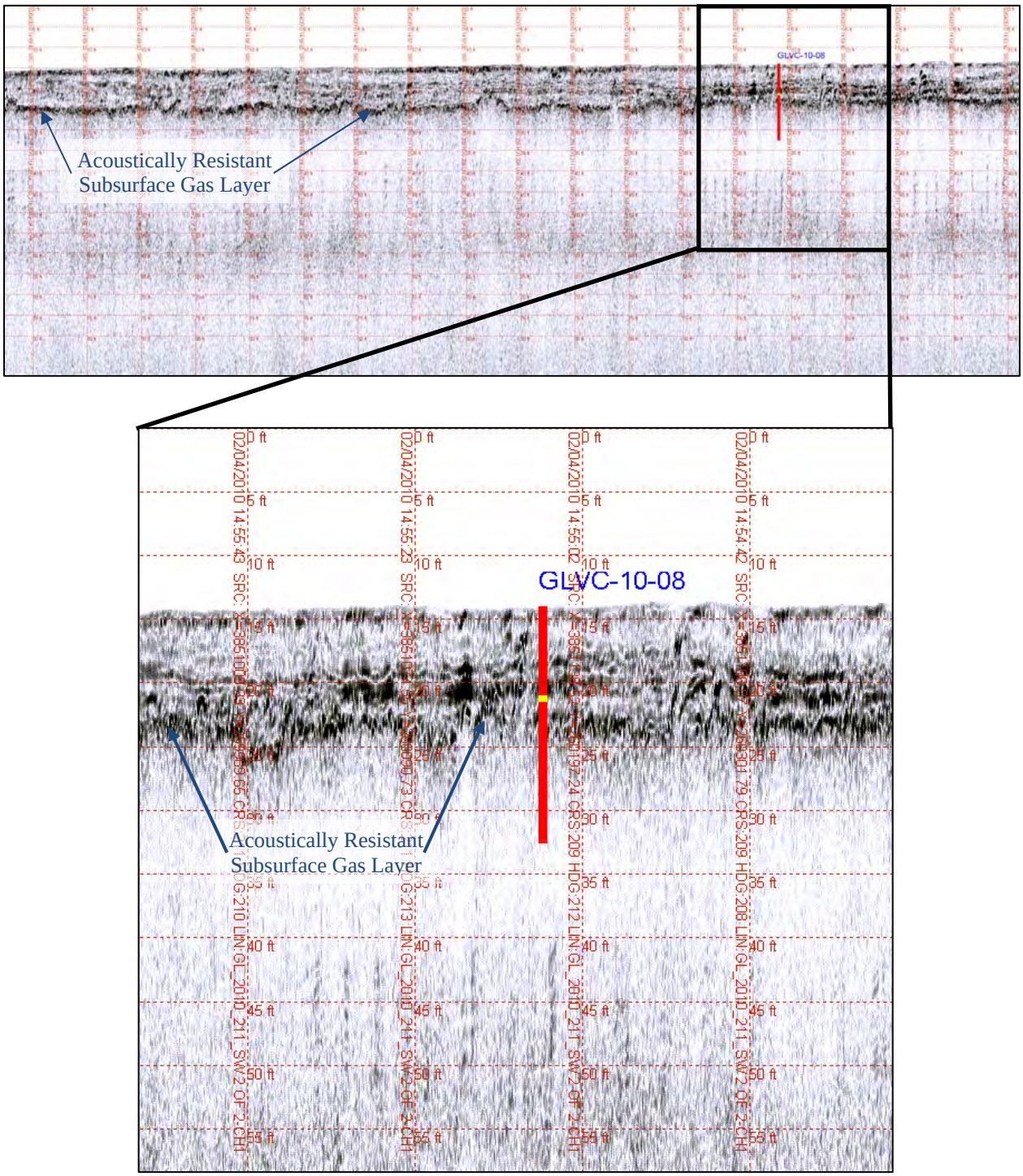
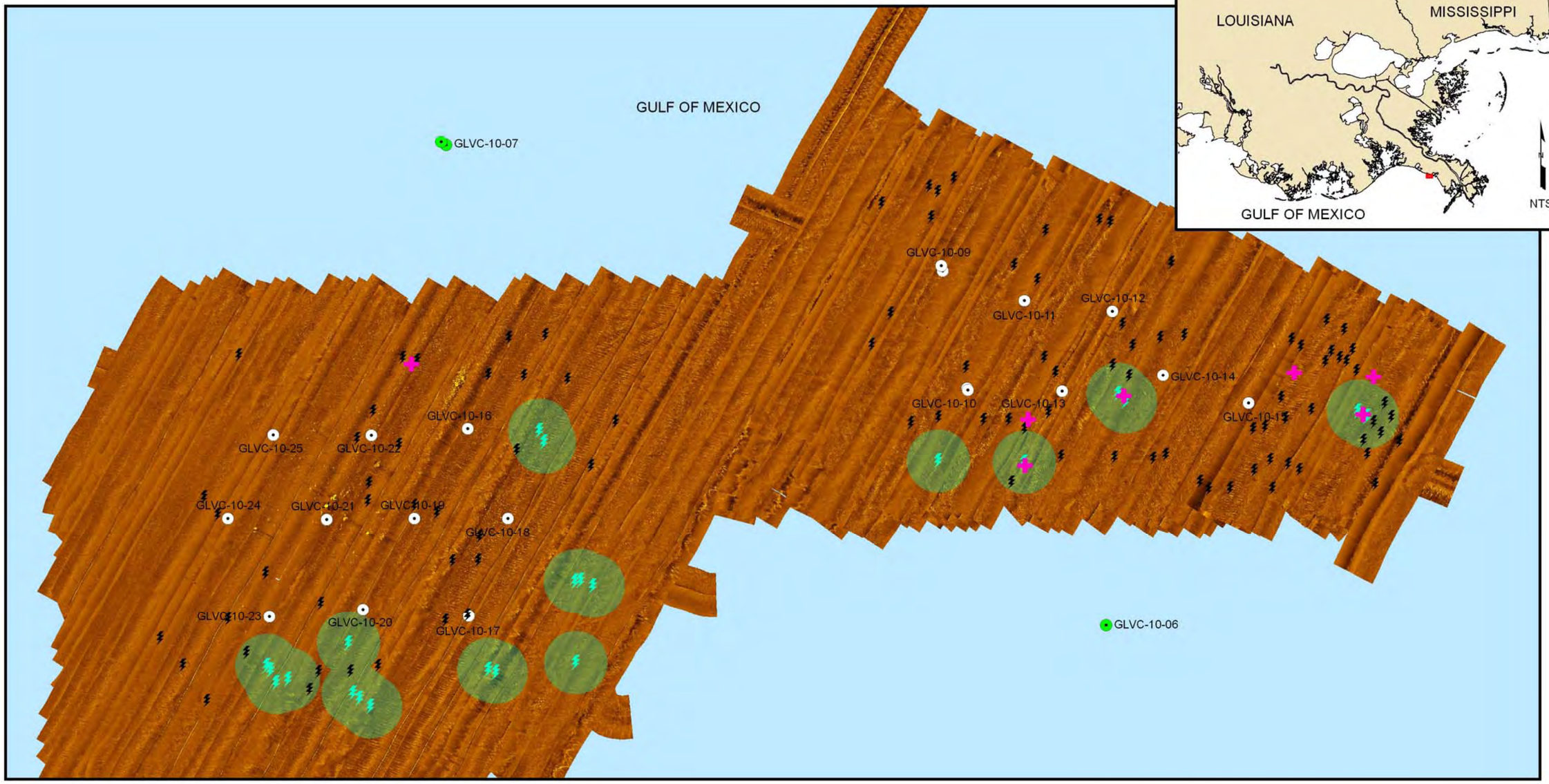


Figure 12. Merged geophysical and vibracore data.

To determine the projects effects on potentially significant submerged cultural resources, Tidewater Atlantic Research, Inc. (TAR) carried out a background literature review and supervised a cultural resource investigation of the proposed borrow area. The cultural resource report compiled by TAR and submitted to SHPO for approval is provided in Appendix 8. TAR's review of background literature indicated that in the vicinity of the proposed borrow area the potential for submerged cultural resources is high due to international, national and regional maritime activities prevalent in the area.

Following the literature review, TAR supervised a magnetometer, sidescan sonar and subbottom profile survey in the vicinity of the two (2) proposed borrow areas. This survey was conducted by CPE in 2010. Analysis of remote sensing data collected during this investigation, identified a total of one hundred and twenty-two (122) magnetic and seven (7) acoustic anomalies with the two (2) borrow areas. The primary area, Grand Liard East, contains seventy (70) individual magnetic anomalies and six (6) acoustic anomalies. Six (6) of the magnetic targets, have signature characteristics suggestive of potentially significant submerged cultural resources. Avoidance of these anomalies by the creation of a 300-ft radius buffer was recommended. The remaining sixty-four (64) magnetic targets have signatures suggestive of modern debris and were not recommended for buffering or further investigation. The secondary borrow area, Grand Liard West, contains fifty-two (52) individual magnetic anomalies and one (1) acoustic anomaly. Sixteen (16) individual magnetic anomalies exhibited signature characteristics suggestive of potentially significant submerged cultural resources. Avoidance or additional investigation of these target areas by a 300 ft radius buffer was recommended. The remaining thirty-six (36) individual anomalies, two (2) of which have an associated sonar target suggestive of dredge pipe, have signature characteristics suggestive of modern debris. No additional investigation of these thirty-six (36) anomalies was recommended. Magnetic anomalies, acoustic anomalies, sidescan mosaics and avoidance buffers are shown in Figure 13.



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).

LEGEND

- ACOUSTIC TARGETS
- MAGNETIC ANOMALIES
- 2010 CPE RECONNAISSANCE VIBRACORES
- 2010 CPE DESIGN LEVEL VIBRACORES
- POTENTIALLY SIGNIFICANT MAGNETIC ANOMALIES
- 300 FT CULTURAL RESOURCE BUFFER

0 500 1,000 Feet

1 inch = 1,000 feet

N

TITLE:

FIGURE 13. SIDESCAN SONAR MOSAIC.

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX.(561) 391-9116

DATE: 05/10/10	BY: BF	COMM NO: 7900.26	FIGURE 13

BORROW AREA DESIGN

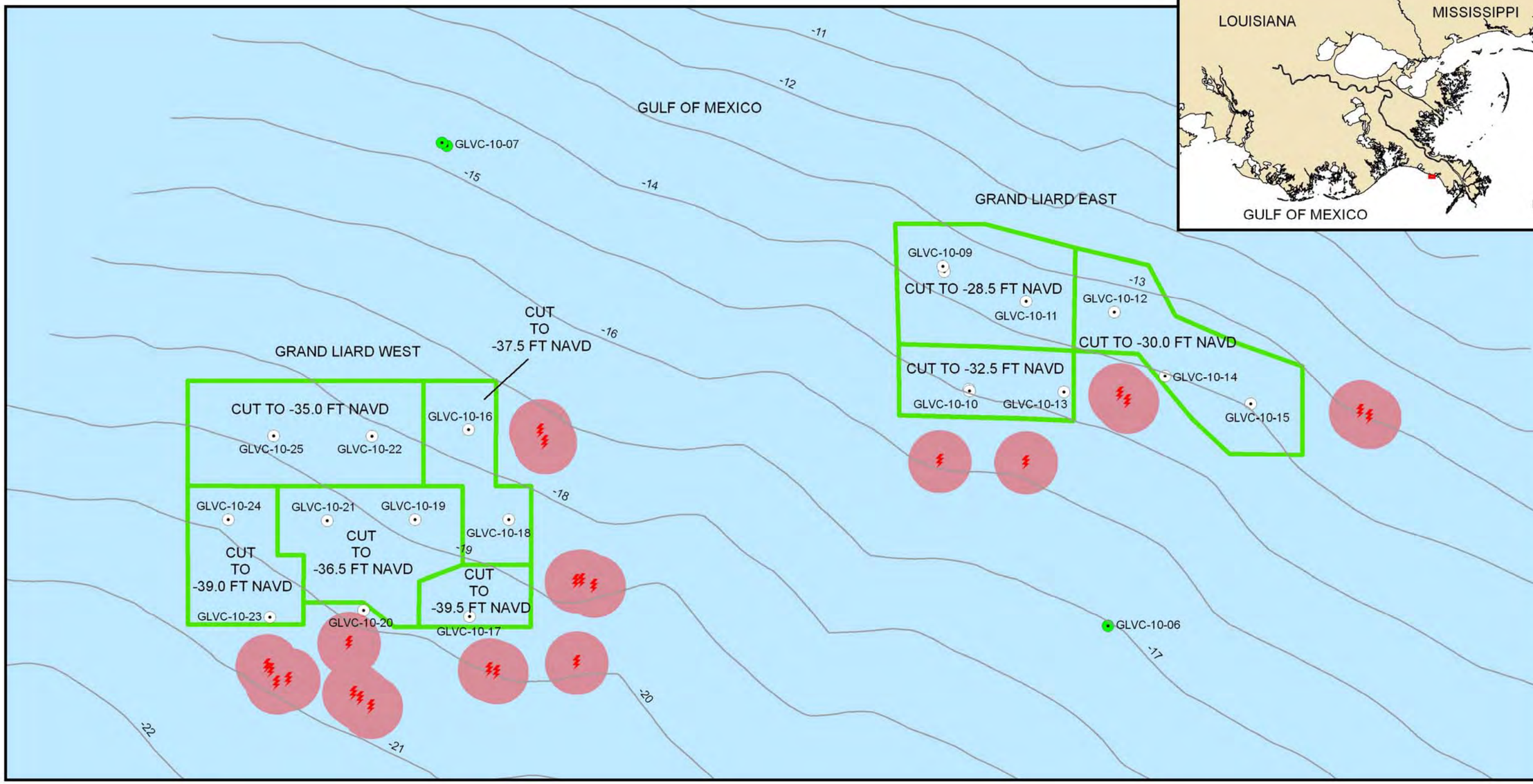
Two (2) final borrow areas, designated Grand Liard East and Grand Liard West were designed. Any identified potential cultural resources were avoided in the borrow area design. These borrow areas contain a total of 7.8 million cy of sediment. The final borrow area design is shown in Figure 14. A borrow area impact analysis was conducted (Appendix 9). No impacts to the shoreline are expected.

Grand Liard East

The final borrow area has three (3) cut elevations that range from -28.5 ft NAVD88 to -32.5 ft NAVD88. The total dredgeable volume in the borrow area was calculated to be approximately 3,015,000 cy. The material in this borrow area is predominantly soft clay with trace shell hash and trace to little sand. The typical Munsell color value is 3.

Grand Liard West

The final borrow area has five (5) cut elevations that range from -35 ft NAVD88 to -39.5 ft NAVD88. The total dredgeable volume in the borrow area was calculated to be approximately 4,765,000 cy. The material in this borrow area is predominantly soft clay with trace sand and trace shell hash. The typical Munsell color value is 3.



NOTES

1. COORDINATES ARE IN FEET BASED ON LOUISIANA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83).

LEGEND

- POTENTIALLY SIGNIFICANT MAGNETIC ANOMALIES
- 2010 CPE BATHYMETRY
- 300 FT CULTURAL RESOURCE BUFFER
- 2010 CPE RECONNAISSANCE VIBRACORES
- 2010 CPE DESIGN LEVEL VIBRACORES

0 500 1,000 Feet

1 inch = 1,000 feet

N

TITLE:

FIGURE 14. BORROW AREA DESIGN.

COASTAL PLANNING & ENGINEERING, INC
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431
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FAX.(561) 391-9116

DATE: 05/10/10	BY: BF	COMM NO: 7900.26	FIGURE 14

CONCLUSIONS

This sediment search investigation followed sequential survey procedures developed by CPE. Phase I, II and III investigations and a cultural resource investigation were conducted.

The data compiled during the Phase I review was evaluated and used to develop a reconnaissance survey plan. The OCPR provided AVS and CPE with a number of proposed borrow areas. Based on the results of the Phase I investigations, CPE recommended six (6) of these areas for further investigation.

During Phase II investigations, CPE conducted reconnaissance level geophysical and vibracore surveys within these six (6) areas. A total of 47 nautical line miles of reconnaissance level geophysical data and eight (8) reconnaissance vibracores were collected. Two (2) sediment resource areas were identified during the Phase II investigations. These two (2) areas were targeted during the Phase III geophysical and cultural resource investigation, which collected approximately 82 nautical miles of geophysical data and sixteen (16) vibracores. Based on the data that was collected up to this point, preliminary borrow area cuts were developed.

In order to satisfy permitting requirements a cultural resource investigation was then conducted. Based on the results of the cultural resource investigation, the marine archaeologist recommended the avoidance of several potentially significant magnetic anomalies by the creation of an avoidance buffer zone around each. Two (2) final borrow areas containing an estimated 7,780,000 cy of sediment were designed which avoided the identified potential cultural resources.

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Appendix L

Wave Model Report

GRAND LIARD MARSH AND RIDGE RESTORATION (BA-68)

APPENDIX 9

BORROW AREA IMPACT ANALYSIS

1.0 SWAN MODEL

The wave transformation analysis for this analysis utilizes the Simulating Waves Nearshore Model (SWAN 40.72AB, Delft Univ. of Technology, 2008), which accounts for refraction, diffraction, wind growth, whitecapping, and bottom damping of spectral waves. SWAN has several advantages over other models. It includes most of the key processes that govern the transformation of nearshore and offshore waves and it can utilize curvilinear grids with non-uniform grid spacing to follow the orientation of the shorelines and offshore contours. Inputs to the SWAN model include bathymetric grids, offshore wave conditions, wind velocities, and water levels. In this model study, steady-state waves were assumed, along with uniform wind velocities and water levels. In addition, the effects of tidal currents were neglected.

2.0 WAVE DATA

Wave cases used in the analysis (Table 1) were based on the 1980-1999 wave hindcast at WIS Station 132 (29°5'N, 89°40'W, -63' NAVD, Figure 1) and extremal wave statistics provided by USACE (2000) (see also CPE, 2003). Water levels and winds were incorporated into the SWAN model along with the incident waves. Water levels were assumed to be equal to the mean tide level at Grand Isle during average conditions and the mean high water elevation at Grand Isle during cold fronts. Winds and water levels during Hurricane Katrina were measured by NOAA (2007) at Grand Isle, LA. For the remaining severe storm cases, water levels were based on the storm stages in CPE (2003) and the wind speeds from USACE (1985). In general, the wave cases were identical to those utilized for the Shell Island borrow area impact analysis by CPE (2009). It should be noted that due to the presence of the Mississippi Delta, the incoming waves from the east-southeast are refracted, resulting in wave directions closer to south-southeast near the borrow areas. More information regarding this effect under Case 3 appears later in this Appendix.

Waves during the average conditions govern long-term erosion and sediment transport. To evaluate the dredging-related impacts on the average wave conditions, 5 cases were considered. These cases include the average wave and the average onshore wave, both of which fall within the two most common direction bands, southeast and south-southeast. Four of the 5 average wave cases examine dredging-related impacts to the prevailing longshore sediment transport from east to west. The 208° wave case examines dredging-related impacts to the wave climate during sediment transport reversals, which often occur during the summer months.

Waves during annual cold fronts govern storm erosion and the associated sediment transport during the winter season, when a majority of the sediment transport occurs. To evaluate dredging-related changes to the wave conditions during cold fronts, two cases were examined:

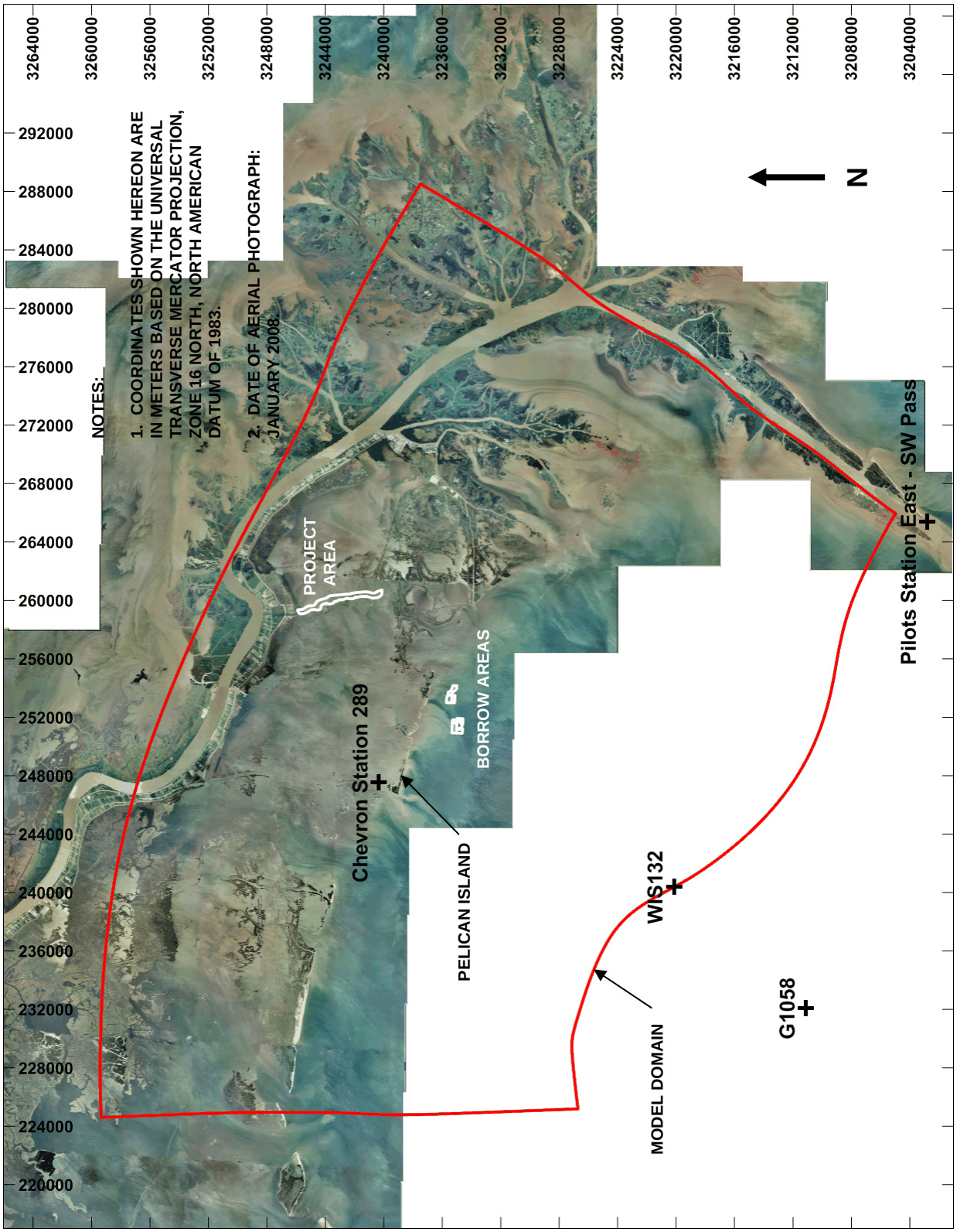

FIGURE 1: Grand Liard SWAN Model Location.

TABLE 1

SWAN WAVE CASES
SHELL ISLAND & GRAND LIARD, LA
(CPE, 2009)

Wave Case	Height (feet)	Period (sec.)	Direction (deg.)	Water Level (feet NAVD)	Wind Velocity (mph)	Wind Velocity (deg.)
ALL WAVES*:						
MEAN (Case 1)	2.7	4.1	144	1.06	14	144
+ 1 σ (Case 2)	2.7	4.1	185	1.06	13	185
ONSHORE WAVES ONLY*:						
- 1 σ (Case 3)	2.8	4.3	126	1.06	14	126
MEAN (Case 4)	2.8	4.3	167	1.06	14	167
+ 1 σ (Case 5)	2.8	4.3	208	1.06	12	208
COLD FRONTS*:						
3/1993 Storm (Case 6)	10.3	9.1	144	1.58	30	125
1/1999 Storm (Case 7)	15.4	11.1	176	1.58	37	170
SEVERE STORM CONDITIONS**						
He, Te (Case 8)	17.4	11.0	177	1.58	47	177
5-YEAR (Case 9)	18.0	11.7	173	4.00	47	173
10-YEAR (Case 10)	20.5	12.4	173	5.90	61	173
20-YEAR (Case 11)	22.9	13.2	173	7.70	75	173
Katrina (2005) (Case 12)	36.9	15.0	147	6.12	65	86

NOTES: * Waves and Winds - WIS Station 132 (29°5' N, 89°40' W, depth 62 feet).
** Waves - CPE (2003), USACE (2000), NOAA (2005b); Winds - USACE (1985), NOAA (2007).

- The March 1993 Storm. This large, extratropical system resulted in high winds and waves from the southern United States to New England. During this storm, the prevailing waves were from the southeast.
- The January 1999 storm. This storm resulted in the highest wave outside hurricane season between 1980 and 1999. During this storm, the prevailing waves from the south-southeast.

During both storms, the longshore sediment transport was generally from east to west near the borrow areas.

Waves during severe storm conditions govern cross-shore sediment transport processes that result in overwash, breaching, and large losses of subaerial land. These cases are based on extremal wave statistics provided by CPE (2003) and USACE (2000) at WIS Station G1058 (29°0' N, 89°45' W, -136' NAVD), located 20 miles south-southwest of Pelican Island. The He, Te case represents the wave height exceeded 12 hours per year. This case governs the depth of

closure, below which sediment motion is negligible (Birkemeier, 1985). The other cases represent the 5, 10, and 20 year storm conditions most commonly experienced during hurricane season, along with Hurricane Katrina (2005), which caused extensive erosion and flooding in the region.

3.0 GRIDS AND BATHYMETRY

3.1 Model Grids

Modeling grids appear in Figure 2. The offshore modeling grid is designed to simulate the propagation of waves from the depth contour at WIS Station 132 (-63' NAVD) to -20' NAVD. The southern grid boundary roughly follows the -63' NAVD depth contour. The nearshore modeling grid is designed to simulate the propagation of waves near the borrow areas and the project area. The northern, southern, and eastern grid limits enclose the back bays areas appearing in Figures 1 and 2. Near the project area, the borrow areas, and the Empire Waterway near the east end of Pelican Island, a tighter grid spacing is used to better resolve wave propagation around these features.

3.2 Bathymetric Data

Bathymetric data for the wave transformation model was compiled from the following sources:

1. Hydrographic surveys of the lower Mississippi River taken by the U.S. Army Corps of Engineers between March and June 2010.

2. Digital elevation models from the U.S. Geological Survey dated 2007.

3. The December 2006 Light Detection and Ranging (LIDAR) survey taken for the Barrier Island Comprehensive Monitoring (BICM) program.

4. The June 2006 hydrographic survey taken for the BICM program.

5. The 2003 LIDAR surveys taken for the Louisiana Statewide GIS program.

6. The February 2000 Shuttle Relief Topography Mission (SRTM).

7. The 1936 hydrographic survey by NOAA.

8. The NOAA "Design-a-Grid".

Within each grid, the newest survey was used first, followed by the older surveys and the NOAA "Design-a-Grid". Within the various bays appearing in Figure 1, little or no data was available. Accordingly, a depth of -2 feet NAVD was assumed within these areas. The resulting bathymetry appears in Figure 3-5.

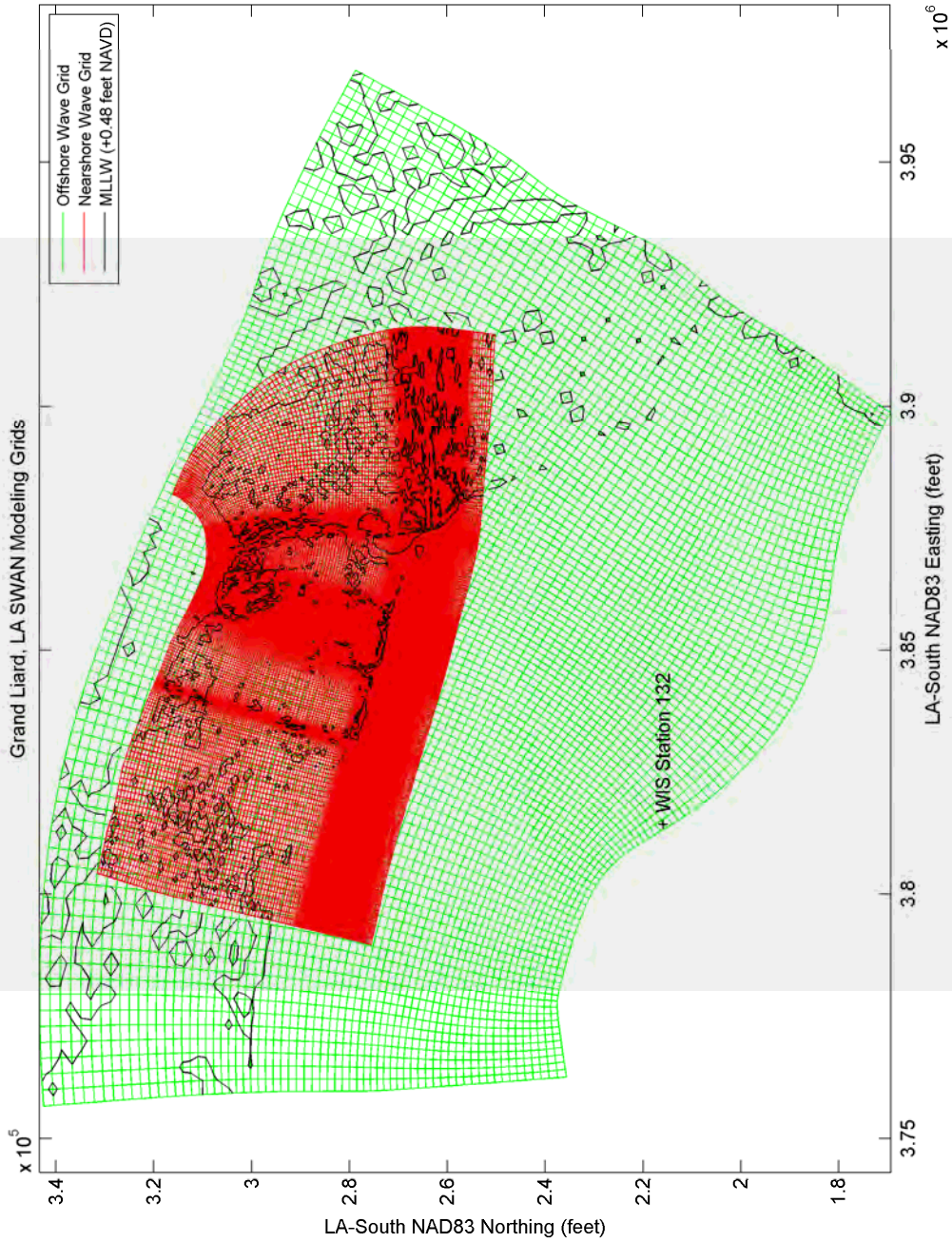

FIGURE 2: Grand Liard, LA SWAN Modeling Grids.

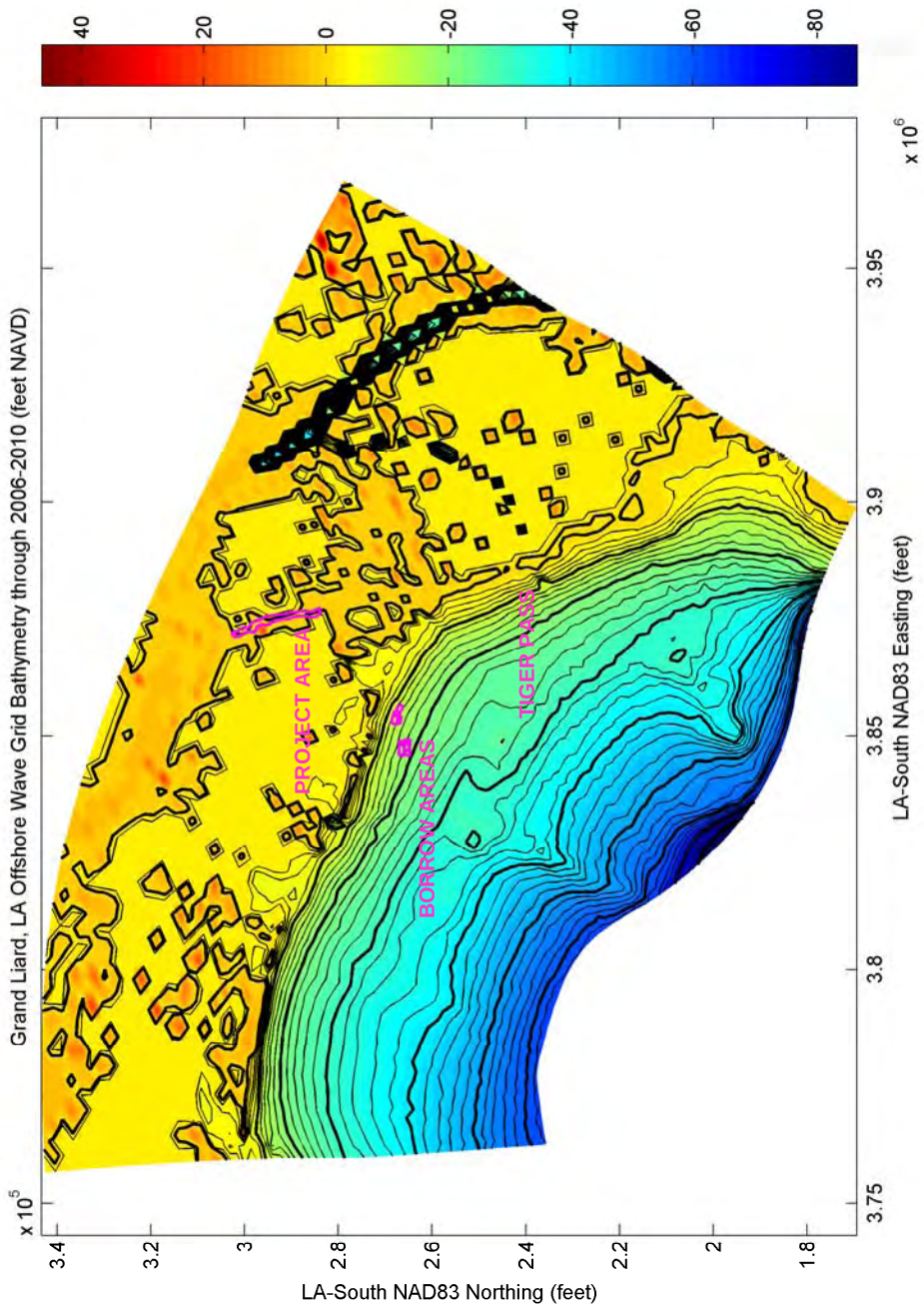

FIGURE 3: Grand Liard, LA Offshore Wave Grid Bathymetry through 2006-2010.

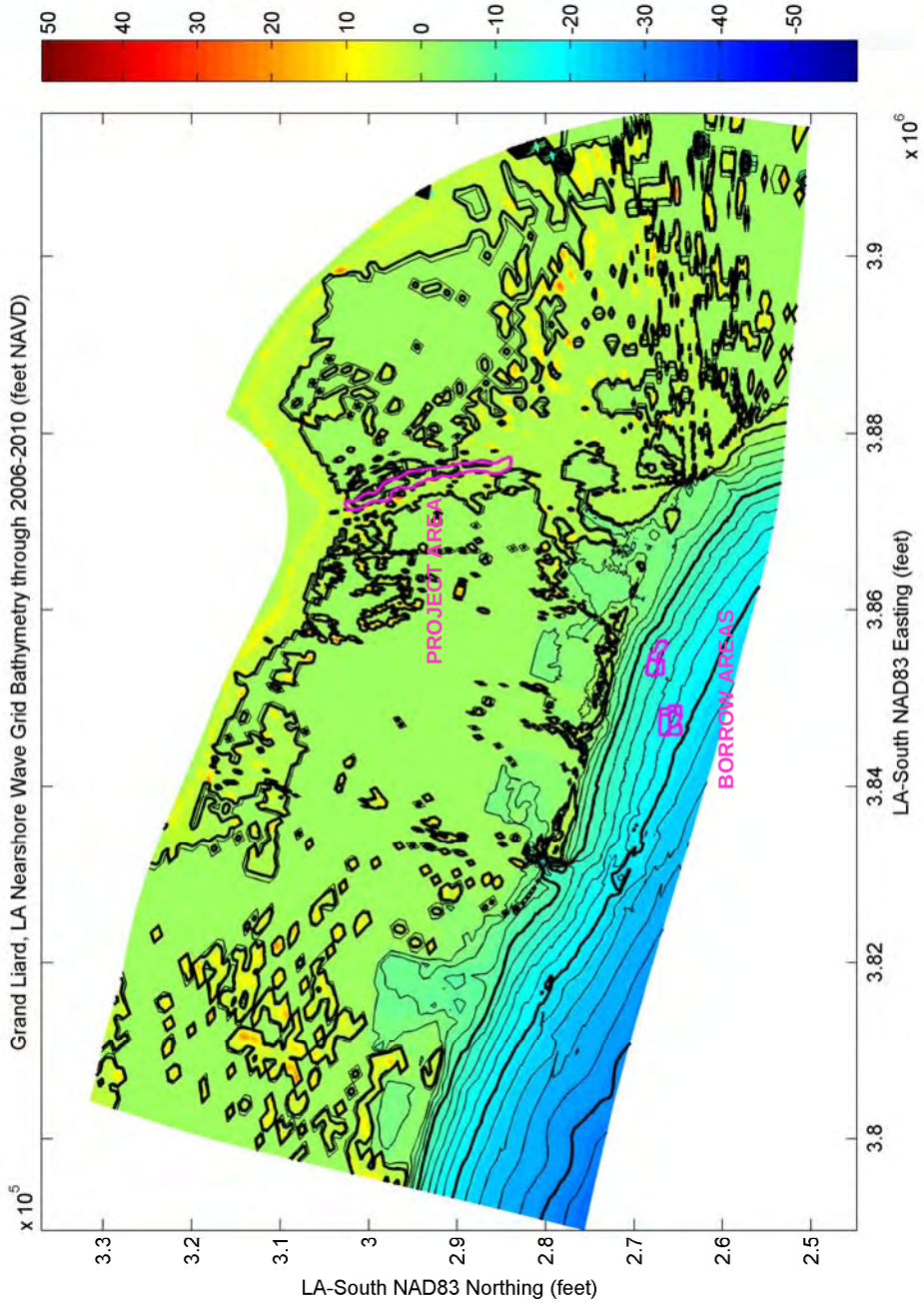

FIGURE 4: Grand Liard, LA Nearshore Wave Grid Bathymetry through 2006-2010.

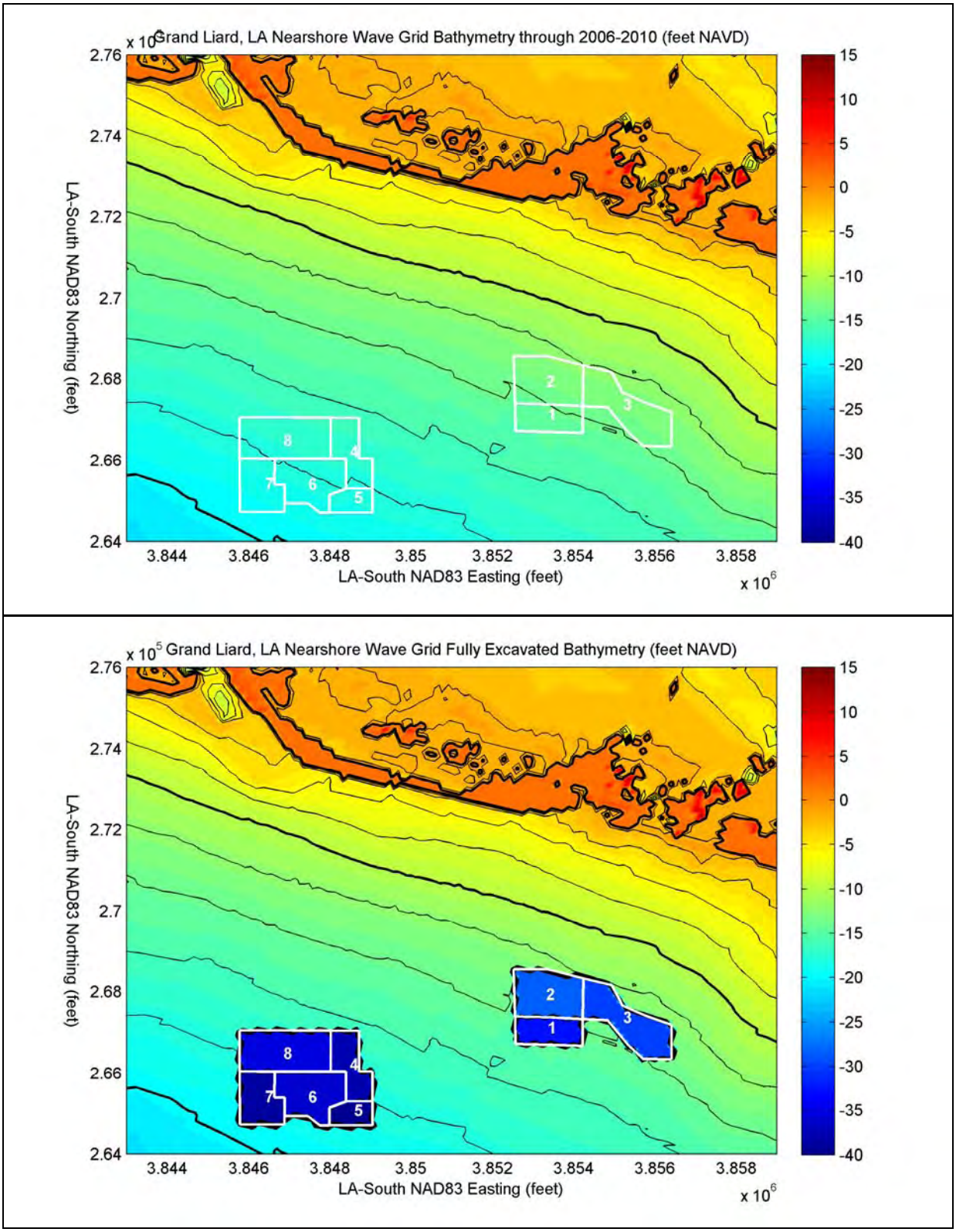

FIGURE 5: Bathymetry near the Borrow Areas.

Offshore contours generally form an elliptical arc, with the major axis running from west-northwest to east-southeast. The average distance between the Gulf shoreline and the -10 foot NAVD contour is about 2 miles. Southwest of the borrow areas and Tiger Pass, the contours protrude about 1-3 miles seaward. West of Pelican Island, subsidence, long-term erosion, and breaching have removed much of the subaerial land. This loss of land has transformed that area into a large, 5 mile wide cove opening directly into the Gulf of Mexico.

The geotechnical investigations for Grand Liard have mapped 2 borrow areas (see Table 2 and Figures 1, 3, 4, and 5). The cut depths of these borrow areas range from -29 to -40 feet NAVD. The excavated conditions appear in Figure 5, and assume that all borrow areas have been completely dredged.

TABLE 2

GRAND LIARD, LA BORROW AREA SUMMARY

Cut Number	Center of Cut LA-South NAD83		Cut Depth (feet NAVD)	Cut Volume (c.y.)	Cut Area (acres)
	E (feet)	N (feet)			
1	3,853,363	267,128	-33	737,000	25.9
2	3,853,320	267,938	-29	1,039,000	43.3
3	3,855,213	267,381	-30	1,239,000	46.9
4	3,848,495	266,217	-38	857,000	27.3
5	3,848,592	265,070	-40	452,000	13.9
6	3,847,471	265,404	-37	1,166,000	41.9
7	3,846,414	265,415	-39	913,000	29.9
8	3,846,860	266,497	-35	1,378,000	51.8
1 to 3			-30	3,015,000	116.1
4 to 8			-37	4,766,000	164.8
ALL			-34	7,781,000	280.9

4.0 MODEL SETTINGS

The SWAN model utilizes a number of settings and calibration parameters, which include the bottom friction coefficients, the breaking coefficients, the whitecapping formulation, and the locally-driven wind growth formulation. For this study, the various model settings were based on the calibration of the model for West Belle Pass, LA (CPE, 2009). Bottom friction was simulated using a JONSWAP bottom friction coefficient of 0.067. Wave breaking was simulated using an α value equal to 1 and a γ value (breaking wave height / breaking depth) equal to 0.73. Whitecapping, locally-driven wind growth, and the default diffraction formulation were also activated.

The only structures included in the model were the Empire Waterway jetties, located near the west end of Pelican Island (see Figure 6). Based on the 2003 LIDAR surveys, the crest elevations of the structures were approximately +4.4' NAVD. The jetties were included in the model as "thin dams", with the default overtopping coefficients for sloped structures. Wave reflection off the structures was assumed to be negligible.

5.0 MODEL RESULTS

SWAN results over the entire grid appear in Sub-Appendix 9-1. Based on those results, wave breaking generally begins at -6 feet NAVD for all 12 cases. Wave heights and directions along the -6 foot NAVD contour appear in Sub-Appendix 9-2.

Changes in the wave height and direction due to borrow area dredging are evaluated in terms of two thresholds:

1. Measureable Changes. In general, significant wave heights can be measured to an accuracy of ±0.2 feet at the most. Wave directions can generally be measured to an accuracy of ±5°.

2. The Bias of the Wave Hindcast. The wave height bias of the 1980-1999 hindcast is +0.66 feet (USACE, 2004). The wave angle bias of the 1980-1999 hindcast offshore of Biloxi, MS, is 8 degrees, based on directional wave measurements from NOAA Buoy 42007 (NOAA, 2005a).

If the changes to the breaking wave height and direction lie within the first threshold, the borrow areas will have negligible impact on the erosion rates of the nearby beaches, since the changes will be undetectable. If the changes to the breaking wave height and direction lie within the second threshold, the borrow areas may have a small impact on the erosion rates. However, the changes will not be large enough to warrant modifications in their design, since the changes will still be within the error margin of the wave hindcast.

5.1 Mean Wave – Case 1

The average wave propagates from the south-southeast (144°), with very gradual changes in height and direction between the offshore boundary and the -6 foot NAVD contour. At the -6 foot NAVD contour, the waves break. The wave direction at this location is on the order of 190°, and the height is on the order of 1.3 to 1.4 feet. Under the average condition, excavation of the borrow areas will not generate any measurable changes in the breaking wave height or direction.

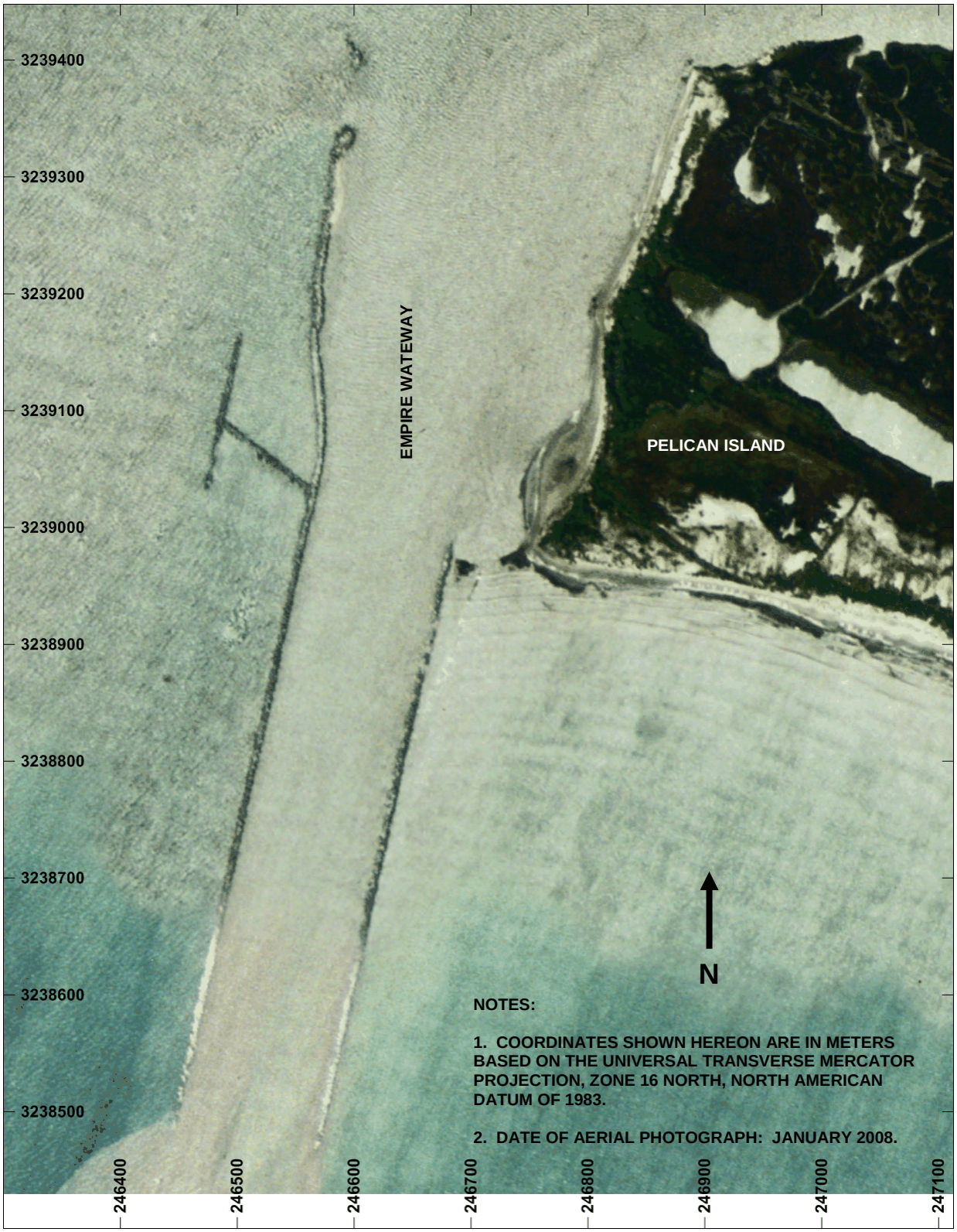

FIGURE 6: Empire Waterway Jetties.

5.2 Mean Wave + 1 Standard Deviation of Wave Direction – Case 2

Average-sized waves from the south (185°) exhibit a very gradual reduction in height between the offshore model boundary and the -4 to -6 foot NAVD contours. Changes in direction over this distance are very small, except near Tiger Pass. Wave heights along the -6 foot NAVD contour are in the 1.5 to 1.7 foot range, with wave directions on the order of 190 to 195°. Excavation of the borrow areas will not generate any measurable changes in the breaking wave height or direction under Case 2 conditions.

5.3 Mean Onshore Wave - 1 Standard Deviation of Wave Direction – Case 3

Average-sized waves from the southeast (128°) are subject to sheltering from the Mississippi Delta, resulting in low nearshore waves. Near the eastern borrow area, small variations in the offshore bathymetry result in a "blip" in the predicted wave height that is on the order of 0.2 feet. These bathymetric variations are most obvious along the -14 to -18 foot NAVD contours. This "blip", which appears to be an overestimate, occurs under the existing conditions only. Excavation of the borrow area eliminates the "blip". Wave heights along the -6 foot NAVD contour are in 1.2 to 1.3 foot range, with wave directions on the order of 160°. Excavation of the borrow areas will not generate any measurable changes in the breaking wave height or direction under Case 3 conditions.

5.4 Mean Onshore Wave – Case 4

The average onshore wave propagates from the south-southeast (167°) and is subject to gradual changes in wave height and direction due to refraction, diffraction, and bottom friction. Near the -6 foot NAVD contour, the wave height ranges from 1.5 to 1.7 feet, with wave directions on the order of 180 to 185°.

Excavation of the borrow areas will not generate any measurable changes in the breaking wave height or direction under Case 4 conditions. Although minor changes in the wave angle occur in the back-bay area, these changes are numerical artifacts of the model, since the corresponding wave heights are very low (0 – 0.3 feet). Given the low wave heights in these areas, the risk of any adverse impact associated with these changes is negligible.

5.5 Mean Onshore Wave + 1 Standard Deviation of Wave Direction – Case 5

Average-sized waves from the south-southwest (208°) exhibit a very gradual reduction in height between the offshore model boundary and the -4 to -6 foot NAVD contours. The wave direction near the -6 foot NAVD contour is similar to the offshore wave direction due to the shoreline orientation. Wave heights near the -6 foot NAVD contour range from 1.5 to 1.7 feet.

Excavation of the borrow areas will not generate any measurable changes in the breaking wave height or direction under Case 5 conditions. Although minor changes in the wave angle occur in the back-bay area, the corresponding wave heights are very low (0 – 0.3 feet). Thus, the risk of any adverse impact associated with these changes is negligible.

5.6 March 1993 Storm – Case 6

Since bathymetry during the March 1993 storm is not available, the results in Sub-Appendices 9-1 and 9-2 show the wave conditions that would occur if a similar storm struck the project area today. Although the offshore wave heights are in the 10 foot range, the south-southeasterly wave direction, bottom friction, and sheltering from the Mississippi Delta result in 4 to 5 foot waves over the borrow areas. Wave heights near the -6 foot NAVD contour range from 3.0 to 3.4 feet, with wave directions in the 180 to 200° range.

Excavation of the borrow areas may result in measurable changes in the wave patterns near the borrow areas. However, it will not generate any measurable changes in the breaking wave height or direction under Case 6 conditions. Although minor changes in the wave angle occur along the back bay areas, the corresponding wave heights are very low (0 – 0.3 feet). Thus, the risk of any adverse impact associated with these changes is negligible.

5.7 January 1999 Storm – Case 7

Since bathymetry during the January 1999 storm is not available, the results in Sub-Appendices 9-1 and 9-2 show the wave conditions that would occur if a similar storm struck the project area today. Between the offshore grid boundary and the western borrow area, the wave height gradually decreases from 15 to 8 feet due to bottom friction. Over the eastern borrow area, wave heights are on the order of 6 feet. Along the -6 foot NAVD, wave heights from 3.0 to 3.6 feet, with wave directions in the 190 to 205° range.

Excavation of the borrow areas may result in measurable changes in the wave patterns near the borrow areas. However, it will not generate any measurable changes in the breaking wave height or direction under Case 7 conditions. Although minor changes in the wave angle occur along the back bay areas, the corresponding wave heights are less than 1 foot. Thus, the risk of any adverse impact associated with these changes is small.

5.8 Wave Exceeded 12 Hours per Year (He, Te) – Case 8

The wave height that governs the depth of closure is approximately 17 feet offshore, and comes from the south. However, given the shoreline orientation and the effect of bottom friction, the corresponding wave heights over the borrow area range from 6 to 8 feet, and come from the south-southwest. Along the -6 foot NAVD contour, the wave direction is on the order of 190 to 200°, with heights ranging from 3.1 to 3.6 feet.

Excavation of the borrow areas may result in measurable changes in the wave patterns near the borrow areas. However, it will not generate any measurable changes in the breaking wave height or direction under Case 7 conditions.

5.9 5, 10, and 20 Year Waves – Cases 9 to 11

Wave patterns during the 5, 10, and 20 year events are similar to Case 8. However, since the offshore waves are larger, the corresponding wave heights over the borrow areas are also larger.

Wave directions near the -6 foot NAVD contour are on the order of 190 to 200°. The corresponding wave heights range from 4.1 to 4.6 feet during the 5 year storm, 4.9 to 5.5 feet during the 10 year storm, and 5.7 to 6.3 feet during the 20 year storm.

Excavation of the borrow areas may result in measurable changes in the wave patterns near the borrow areas during 5, 10, or 20 year events. However, it will not generate any measurable changes in the breaking wave height or direction.

5.10 Hurricane Katrina

Hurricane Katrina (2005) was one of the most catastrophic storms to strike Louisiana. The estimated wave patterns during the peak of Hurricane Katrina appear in Sub-Appendices 9-1 and 9-2. Although the wave heights along the offshore boundary approach 37 feet, the southeasterly wave direction, bottom friction, and sheltering from the Mississippi Delta result in only 7 to 10 foot waves over the borrow areas. Wave heights along the -6 foot NAVD contour are in the 4.8 to 5.5 foot range, making them closer to the 10 year storm rather than the 50 or 100 year storm. The simulated wave patterns during Hurricane Katrina are indicative of the storm's path, which took it west of New Orleans. They also mirror the observed water levels at Grand Isle, which were 1.6 feet lower than the 20 year storm stage (CPE, 2009).

Under conditions similar to Katrina, excavation of the borrow areas may result in measurable changes in the wave patterns near the borrow areas. However, it will not generate any measurable changes in the breaking wave height or direction.

6.0 SEDIMENT TRANSPORT

Potential rates of longshore sediment transport were calculated using the results in Sub-Appendix 9-2. Sediment transport estimates were based on the "CERC Equation" (USACE, 1989):

$$Q = \frac{KH_{sb}^2 C_{gb} \sin(2\theta_b)}{16(G_s - 1)(1 - p)}$$

$$C_g = \frac{1}{2}\frac{L}{T_p}\left[1 + (4\pi d / L) / \sinh(4\pi d / L)\right]$$

$$L = (gT_p^2/\pi) \tanh(2\pi d/L) / 2$$

where

Q = longshore transport rate
K = empirical coefficient (~ 0.01 to 0.39) (Walton & Chiu, 1977; USACE, 1989).
H_{sb} = significant wave height at breaking
C_{gb} = group wave velocity at breaking
L = wavelength

T_p = peak wave period
d = total water depth, including storm stage
θ_b = breaking wave angle relative to the shoreline
G_s = sediment density / water density ~ 2.65
p = sediment porosity ~ 37%

The K was determined by trial and error based on a comparison with the sediment transport values in the *Chaland Headland and Pelican Island Barrier Shoreline Restoration 30% Design Review* (CPE, 2003). Net longshore transport values at the east end of Pelican Island ranged from 10,000 to 45,000 cubic yards per year towards the east. The GENESIS model for this study identified a net value of 21,000 cubic yards per year towards the east. Among the 5 average wave cases (1 to 5), Case 5 generated sediment transport values towards the east. The resulting K value of 0.03 was determine based on a visual fit between the 2003 GENESIS results and the sediment transport rate under Case 5 (Figure 7). Sediment transport rates given all wave cases appear in Sub-Appendix 9-3.

For the 5 average wave cases, potential erosion and accretion rates were calculated based on the following:

$$\frac{\partial V}{\partial t} = -\frac{\partial Q}{\partial s}$$

where

$\frac{\partial V}{\partial t}$ = erosion (-) or accretion (+) rate in c.y./year/foot.
s = distance along the shoreline.

It should be noted that the rates of erosion and accretion rates appearing in Sub-Appendix 9-3 are potential rates based on waves only. They do not include the effects of subsidence, sea level rise, breaching, cross-shore sediment transport, overtopping, overwash, tidal currents, or changes in shoreline orientation. For this reason, the potential erosion and accretion rates do not necessarily match those found in CPE (2003) or other sources. However, the potential erosion and accretion rates show that the borrow areas will have negligible impact on the nearby erosion patterns during average wave conditions.

For the 7 storm cases, longshore sediment transport values are 1 to 2 orders of magnitude higher than corresponding values under the average cases. However, the high wave conditions that are depicted by these cases are only sustained over a few hours to a few days. On time scales such as these, breaching, cross-shore sediment transport, overtopping, and overwash govern volume exert a strong influence on shoreline and volume change. For these reasons, the formula above is not applicable, and erosion and accretion rates are not shown. However, differences in the breaking wave heights and breaking wave angles caused by the excavation of the borrow areas are minor, at worst. Thus, breaching, cross-shore sediment transport, overtopping, and overwash will not change substantially if the borrow areas are completely dredged.

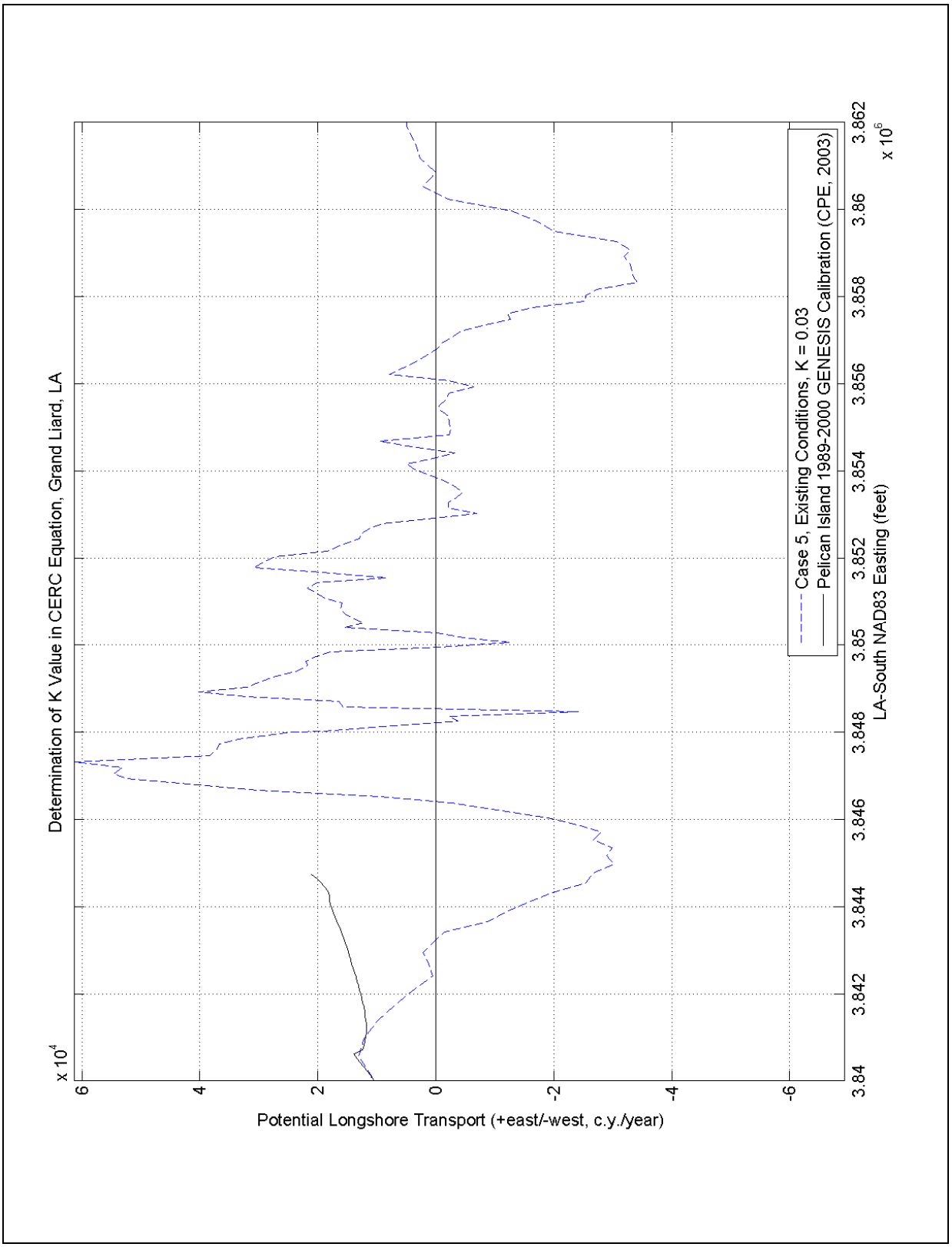

FIGURE 7: Determination of K Value in CERC Equation.

7.0 CONCLUSIONS

A SWAN model has been configured based on the recent and historic surveys, aerial photographs, the USACE (2000, 2004) wave hindcasts, and the model parameters determined during the West Belle Pass model study (CPE, 2009). The model results show that measureable changes to wave patterns could occur near the borrow areas themselves. However, changes to the wave patterns near the shoreline are not large enough to substantially change the erosion rates along adjacent shorelines. Given these findings, modifications to the designs of the borrow areas should not be necessary.

8.0 REFERENCES

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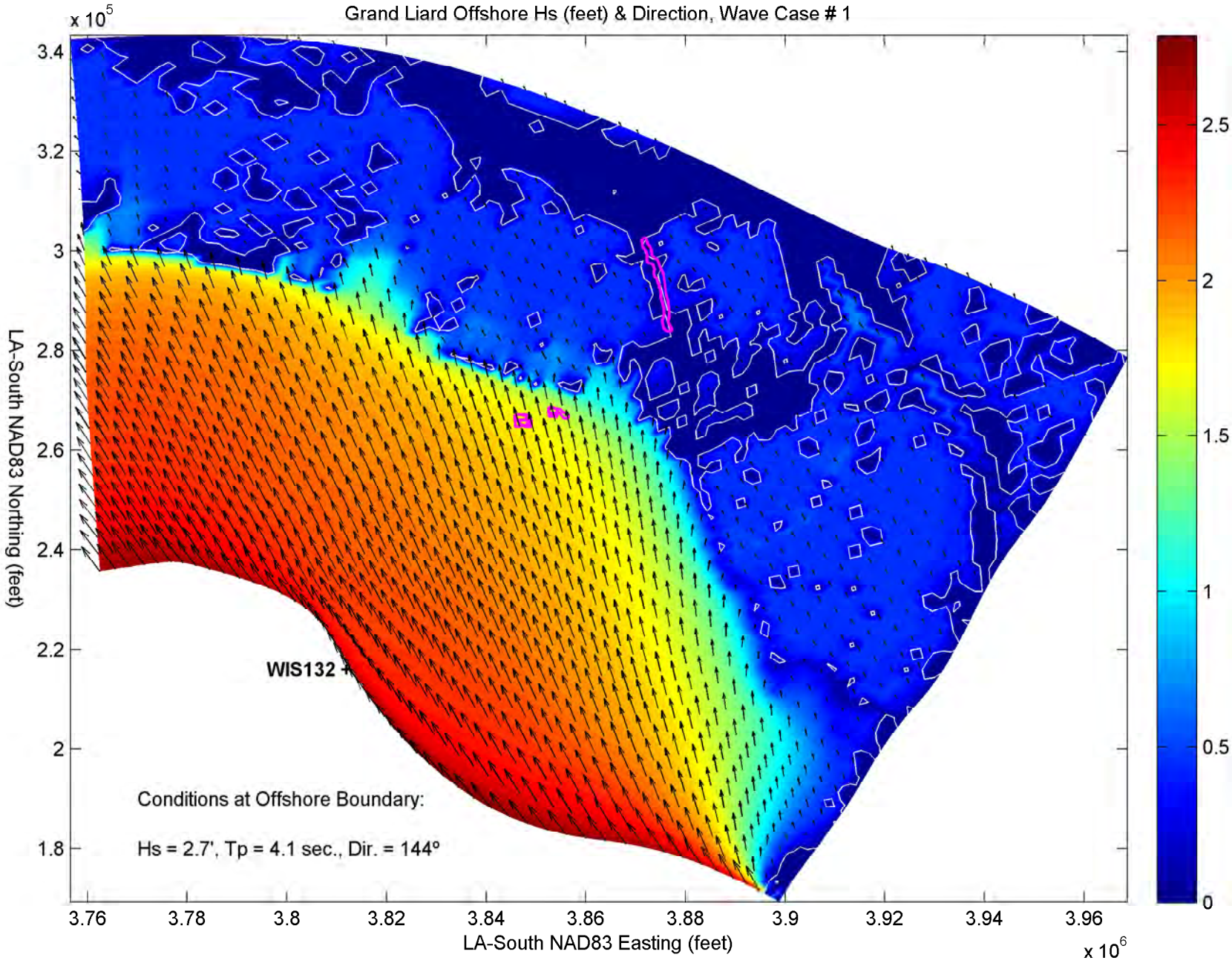
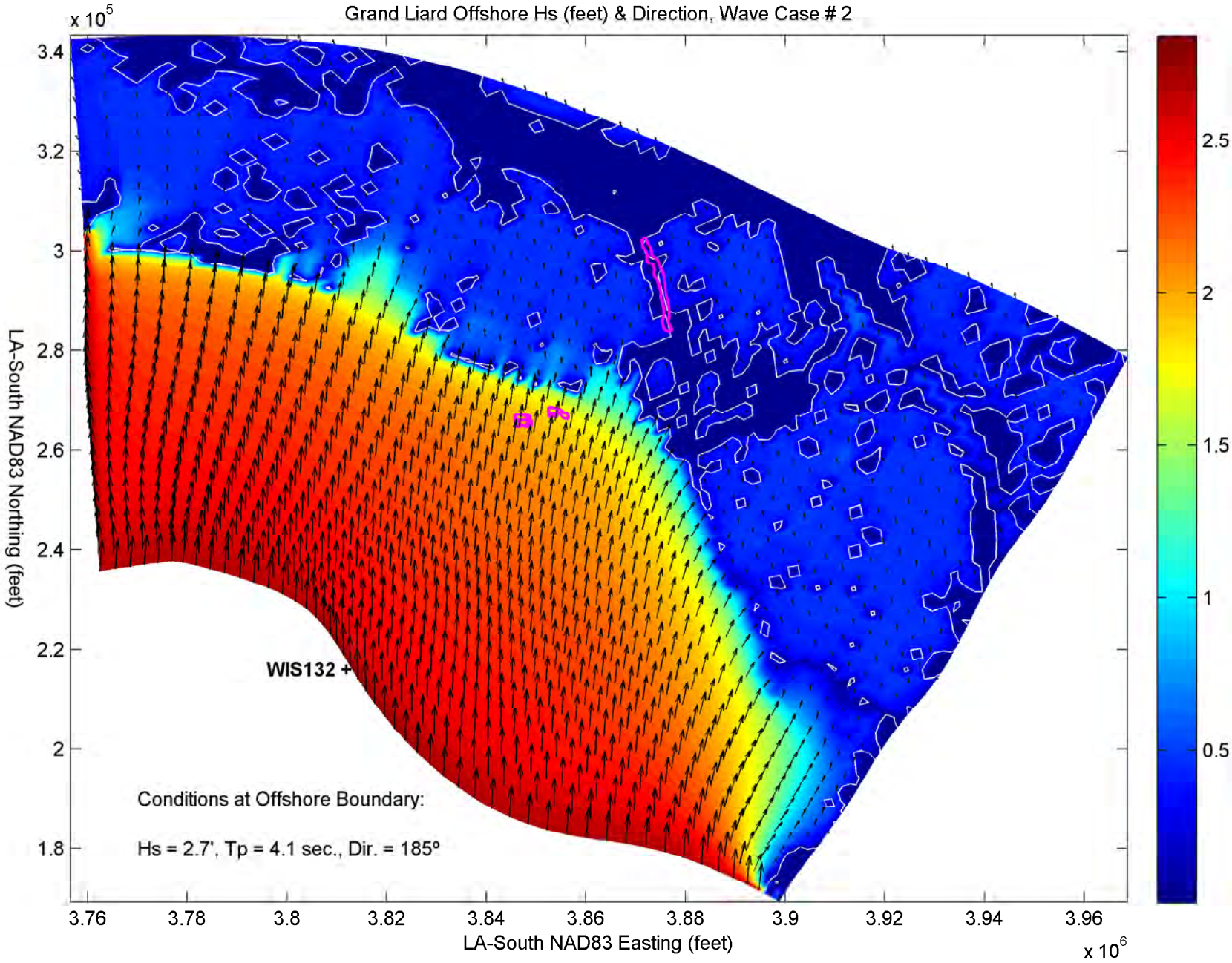
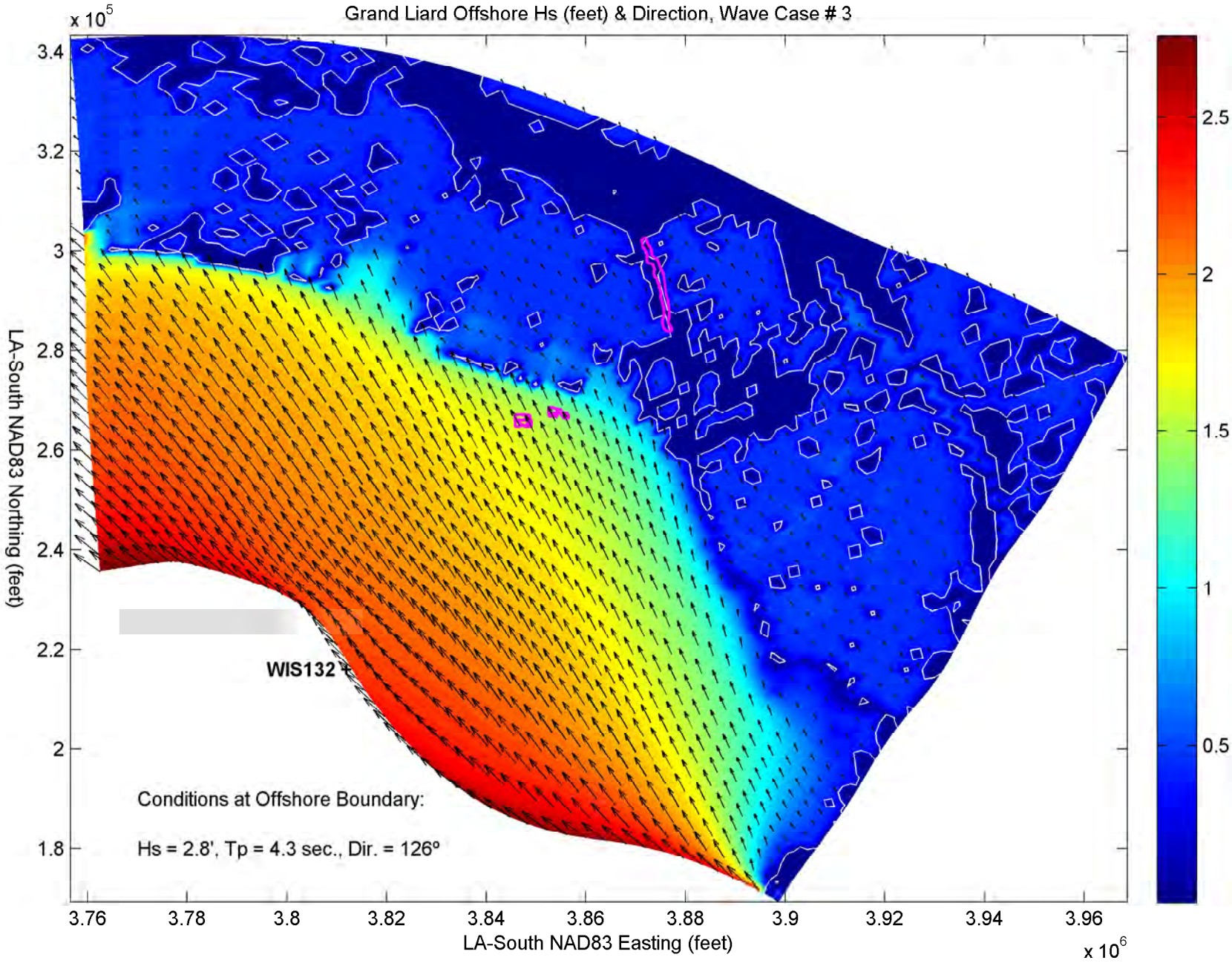
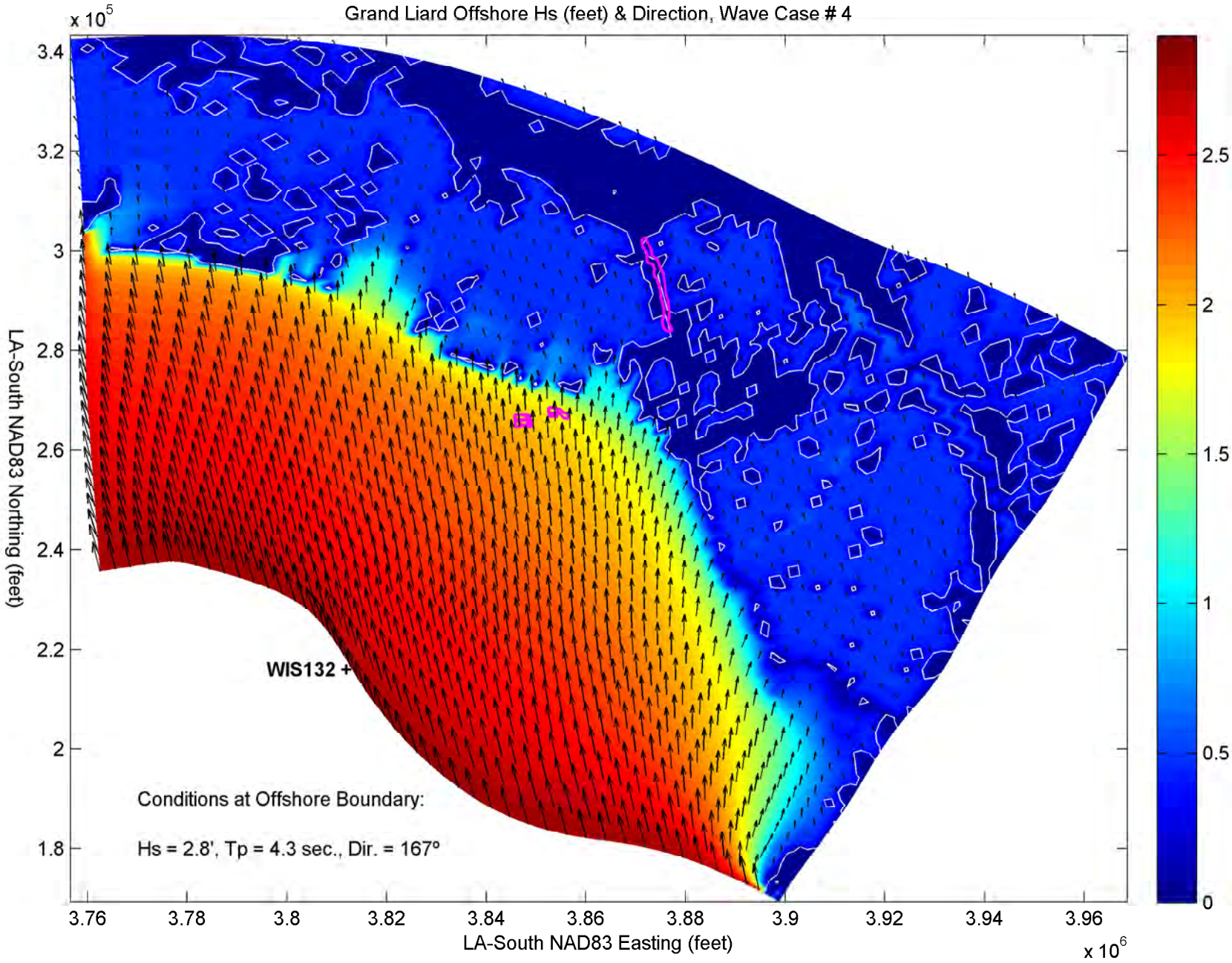
Sub-Appendix 9-1

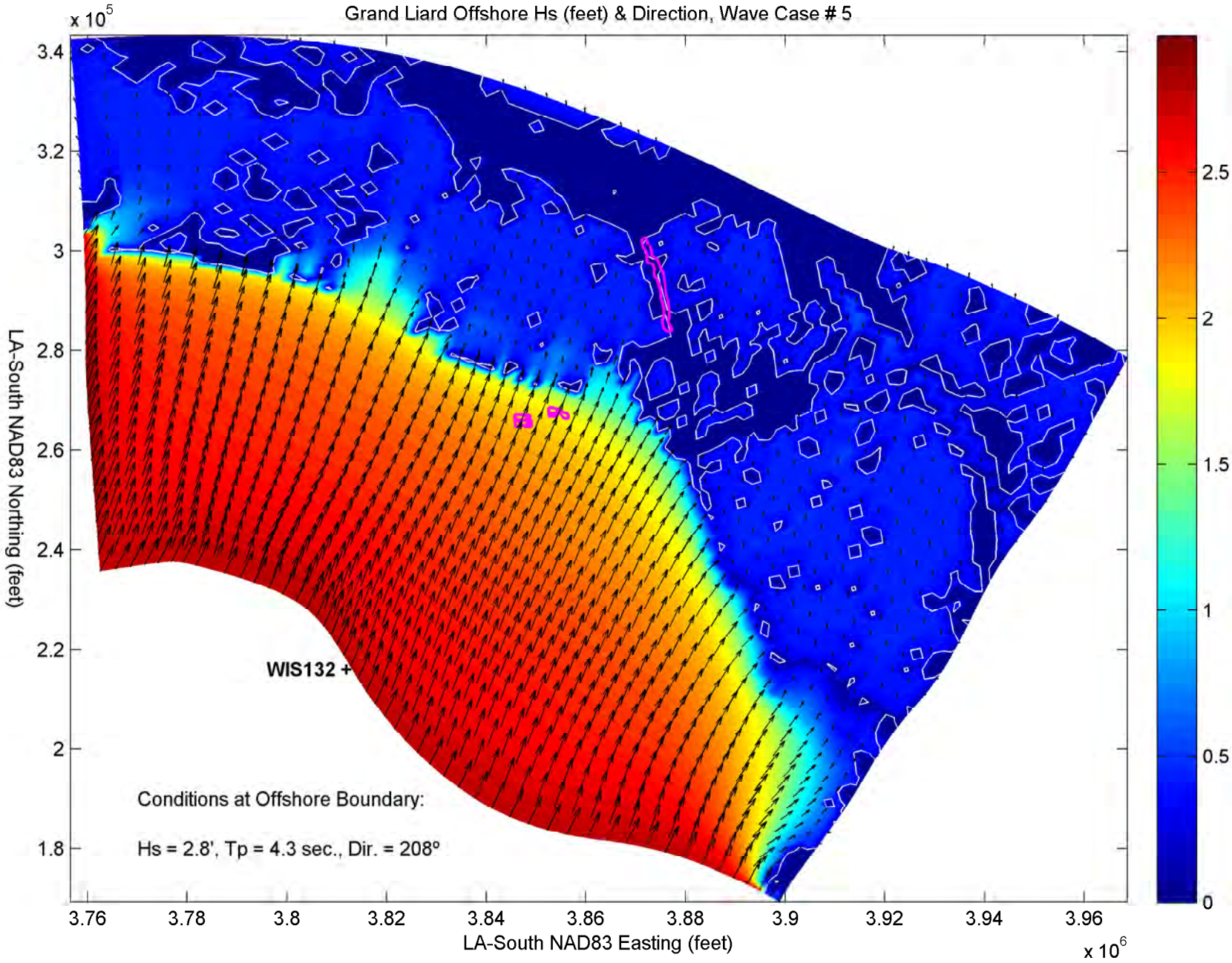
SWAN Model Results over the Entire Model Domain

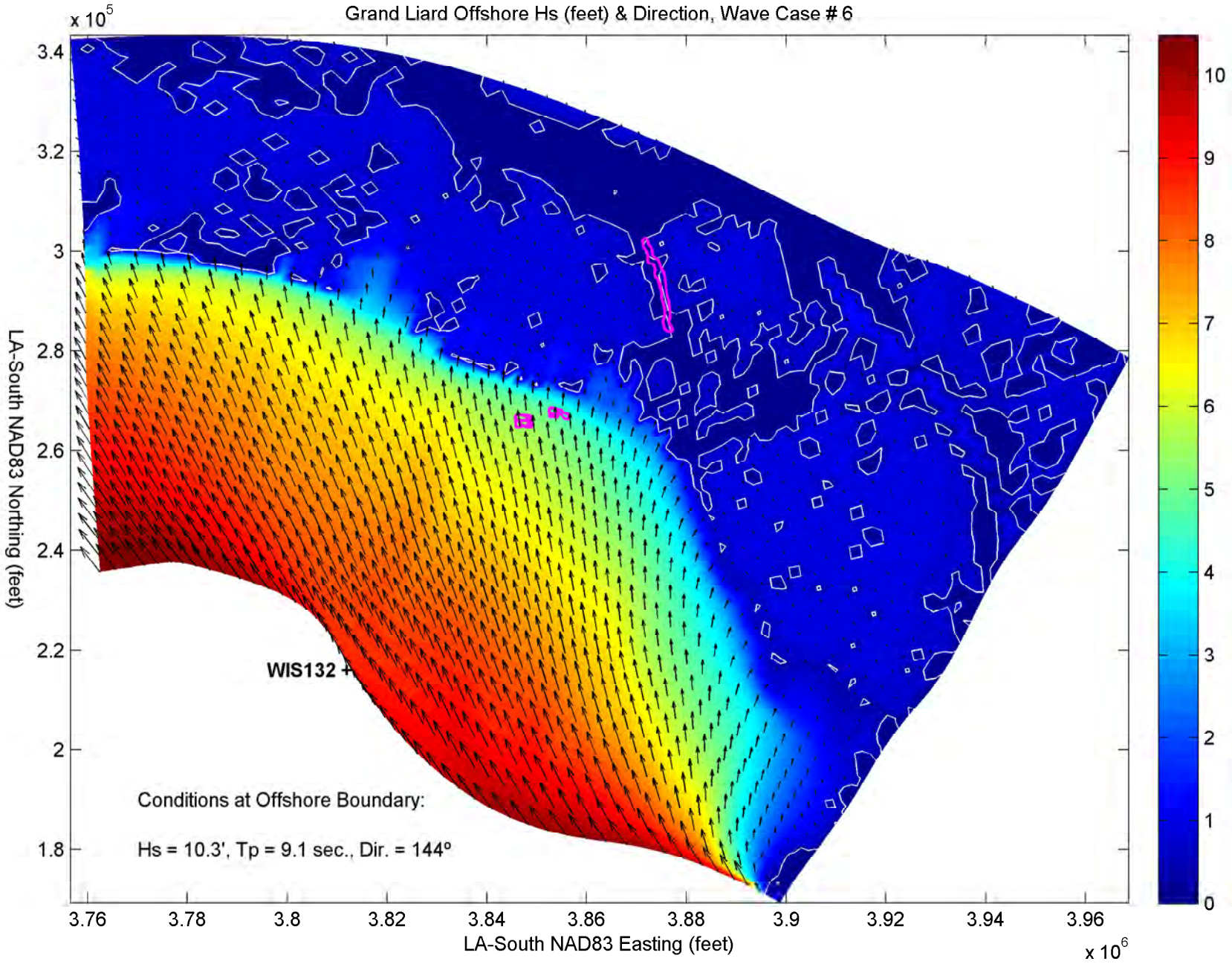

Grand Liard Offshore Hs (feet) & Direction, Wave Case # 1
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 144°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
2.5
2
1.5
1
0.5
0

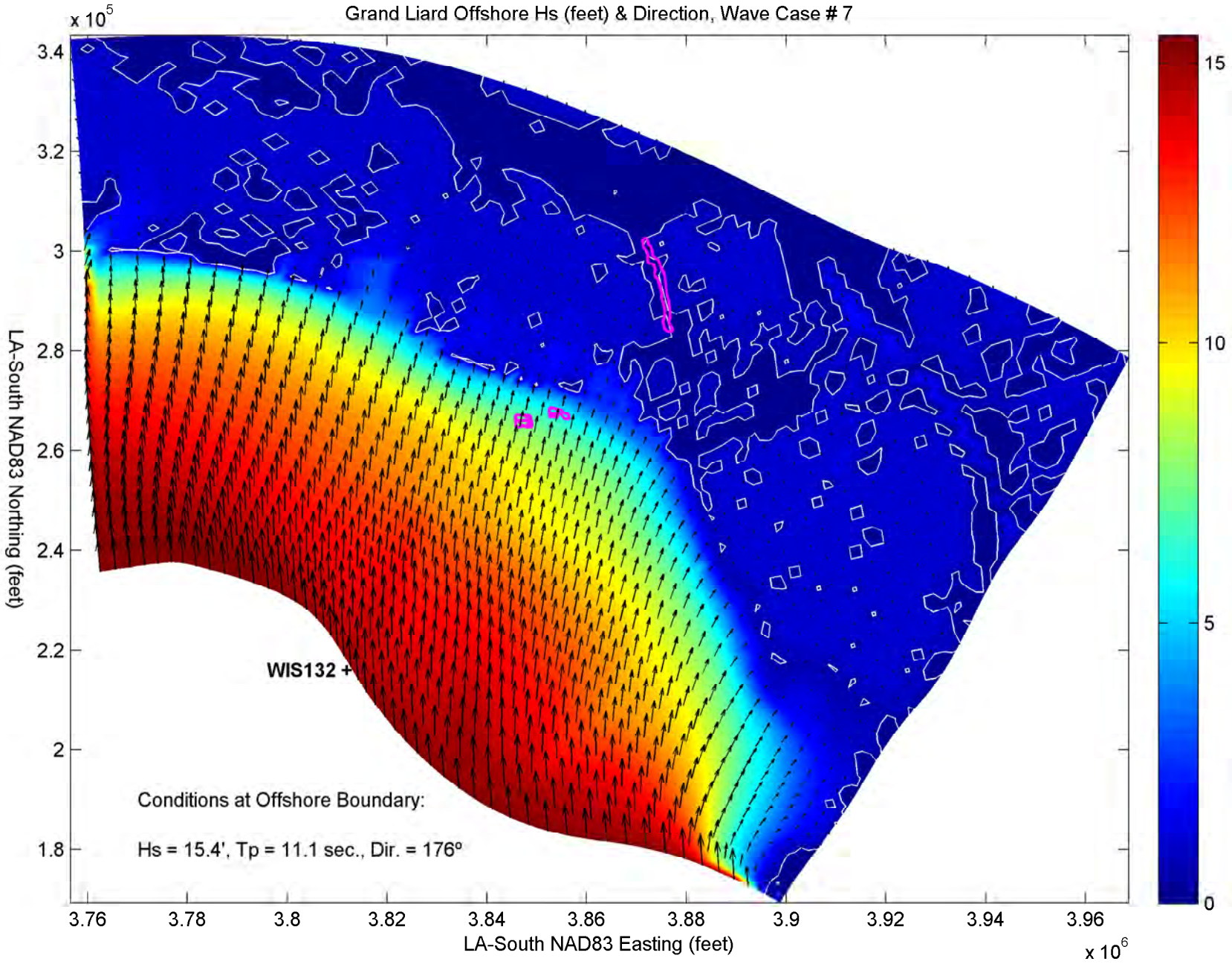

Grand Liard Offshore Hs (feet) & Direction, Wave Case # 2
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 185°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
2.5
2
1.5
1
0.5

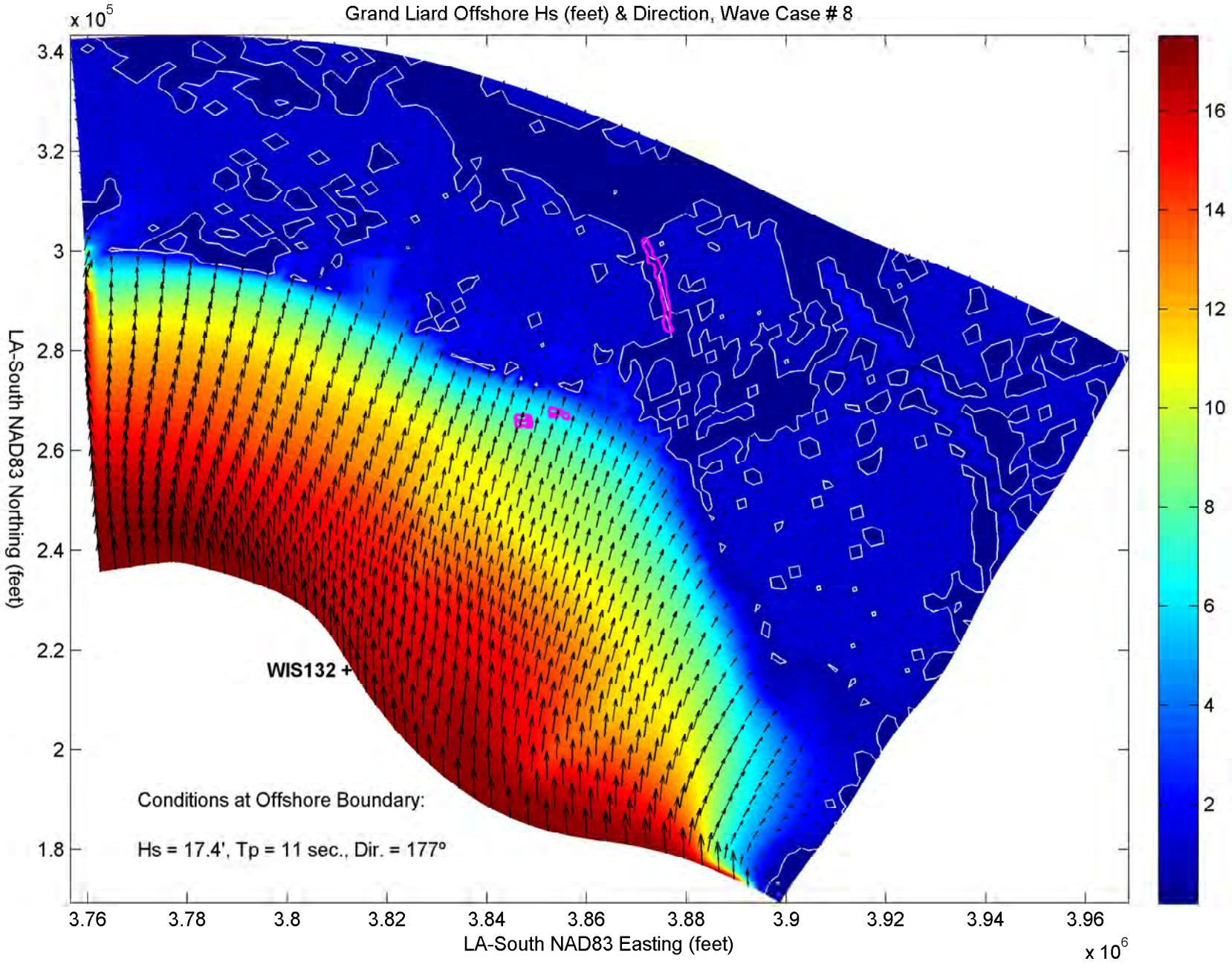

Grand Liard Offshore Hs (feet) & Direction, Wave Case # 3
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 126°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
2.5
2
1.5
1
0.5

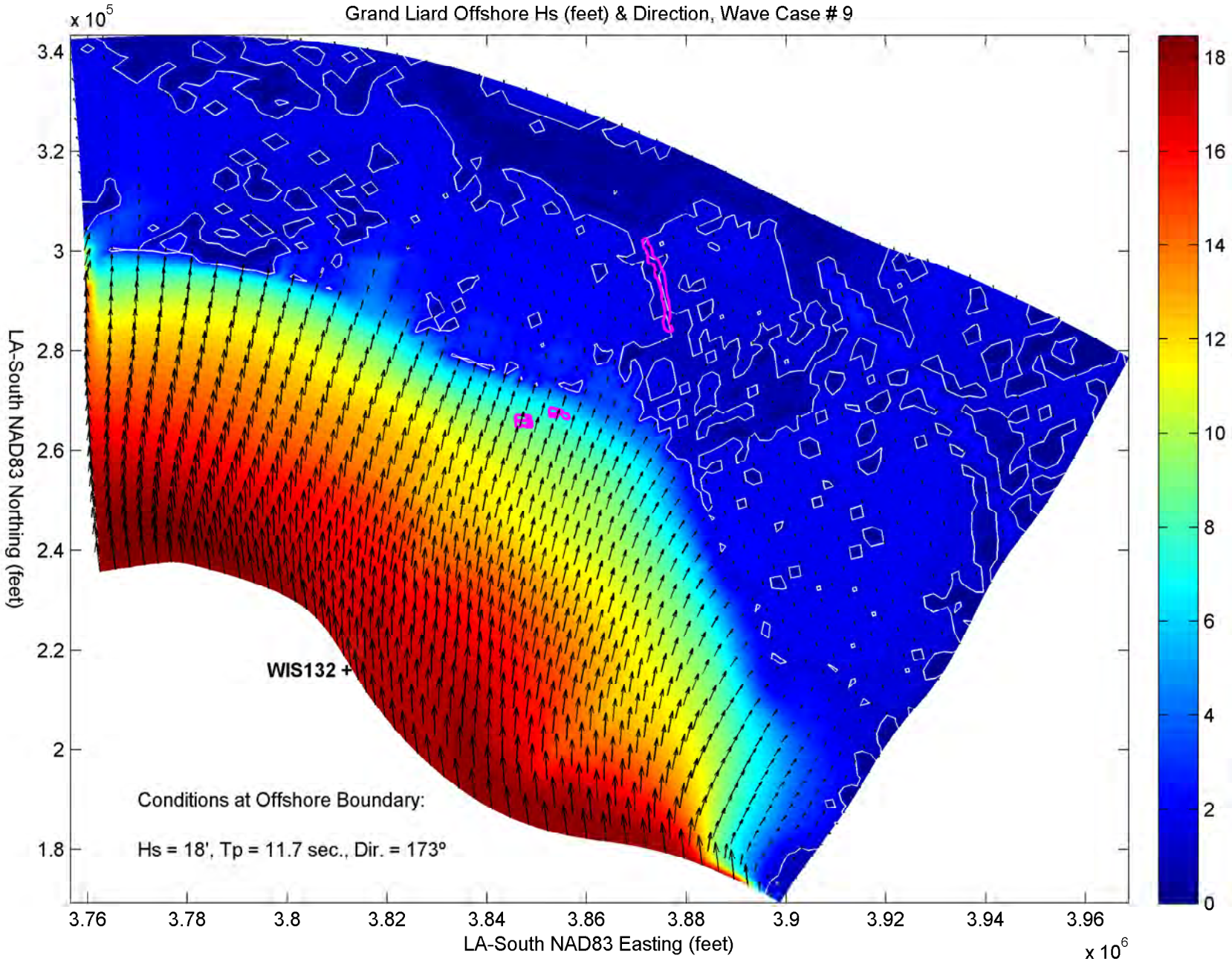

Grand Liard Offshore Hs (feet) & Direction, Wave Case # 4
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 167°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
2.5
2
1.5
1
0.5
0


Grand Liard Offshore Hs (feet) & Direction, Wave Case # 5
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132 +
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 208°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
2.5
2
1.5
1
0.5
0


Grand Liard Offshore Hs (feet) & Direction, Wave Case # 6
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132
Conditions at Offshore Boundary:
Hs = 10.3', Tp = 9.1 sec., Dir. = 144°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
10
9
8
7
6
5
4
3
2
1
0


Grand Liard Offshore Hs (feet) & Direction, Wave Case # 7
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
x 10^6
LA-South NAD83 Easting (feet)
15
10
5
0
WIS132 +
Conditions at Offshore Boundary:
Hs = 15.4', Tp = 11.1 sec., Dir. = 176°


Grand Liard Offshore Hs (feet) & Direction, Wave Case # 8
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132 +
Conditions at Offshore Boundary:
Hs = 17.4', Tp = 11 sec., Dir. = 177°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
16
14
12
10
8
6
4
2


Grand Liard Offshore Hs (feet) & Direction, Wave Case # 9
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132 +
Conditions at Offshore Boundary:
Hs = 18', Tp = 11.7 sec., Dir. = 173°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
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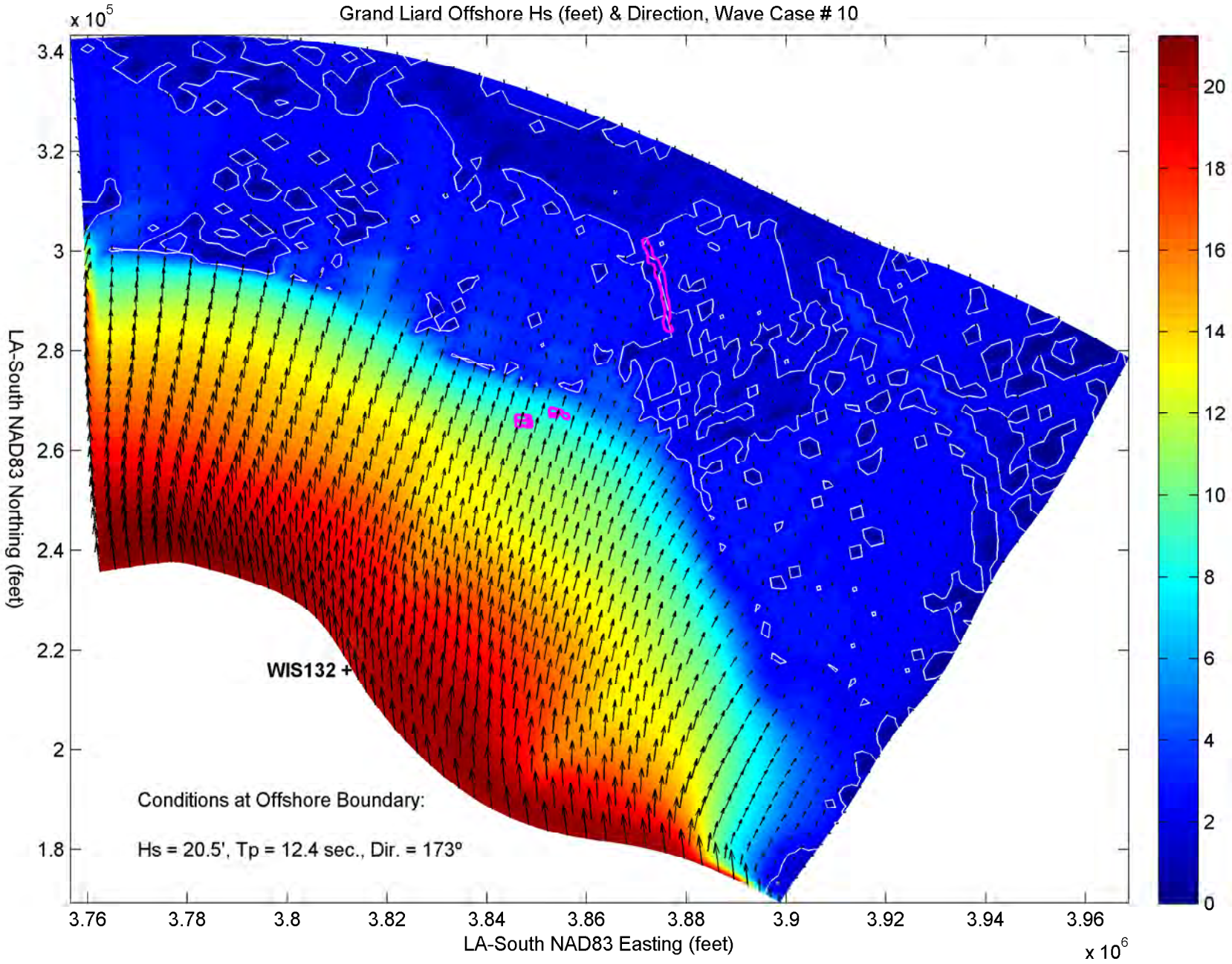
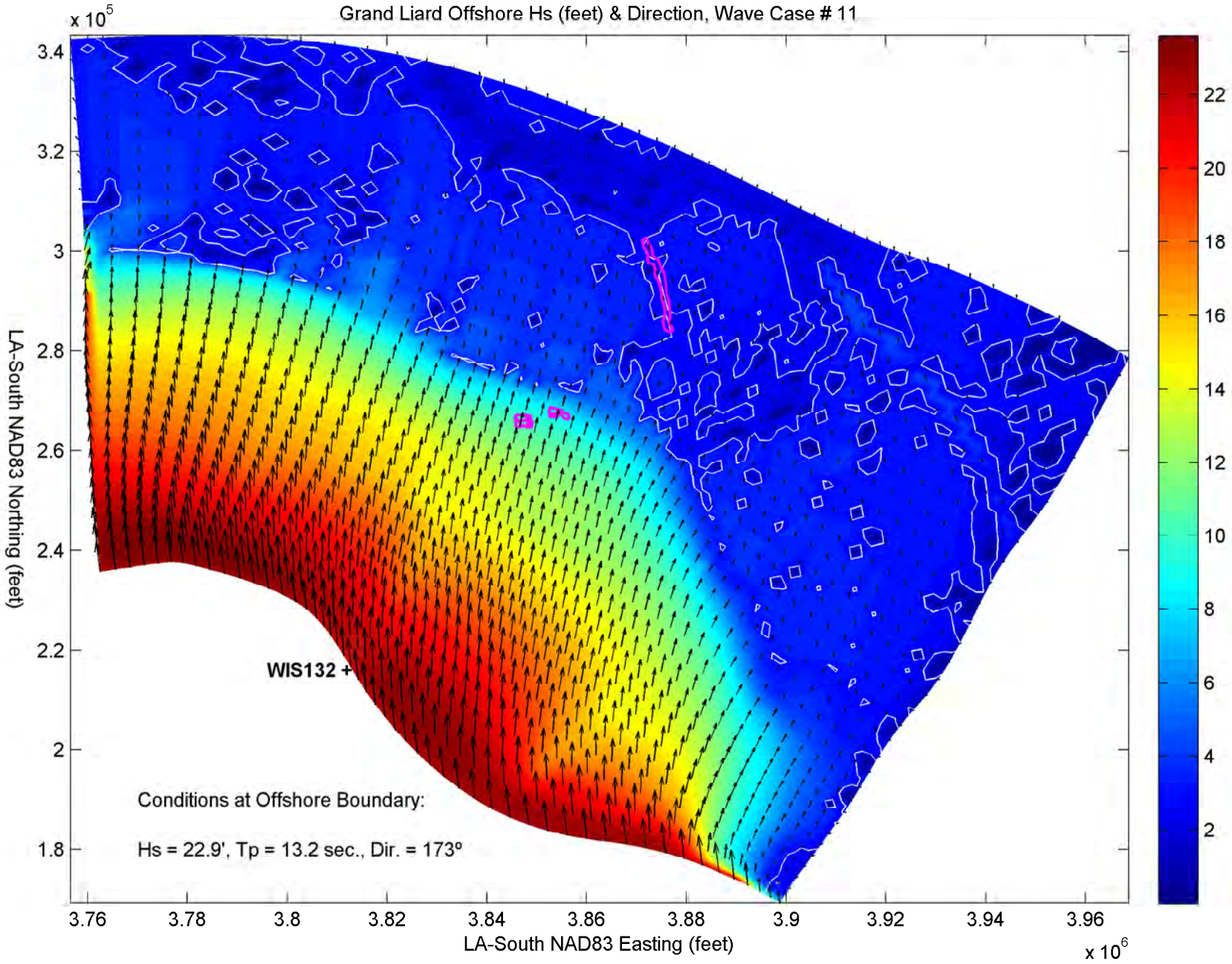
16
14
12
10
8
6
4
2
0


Grand Liard Offshore Hs (feet) & Direction, Wave Case # 10
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132 +
Conditions at Offshore Boundary:
Hs = 20.5', Tp = 12.4 sec., Dir. = 173°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
20
18
16
14
12
10
8
6
4
2
0


Grand Liard Offshore Hs (feet) & Direction, Wave Case # 11
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132 +
Conditions at Offshore Boundary:
Hs = 22.9', Tp = 13.2 sec., Dir. = 173°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
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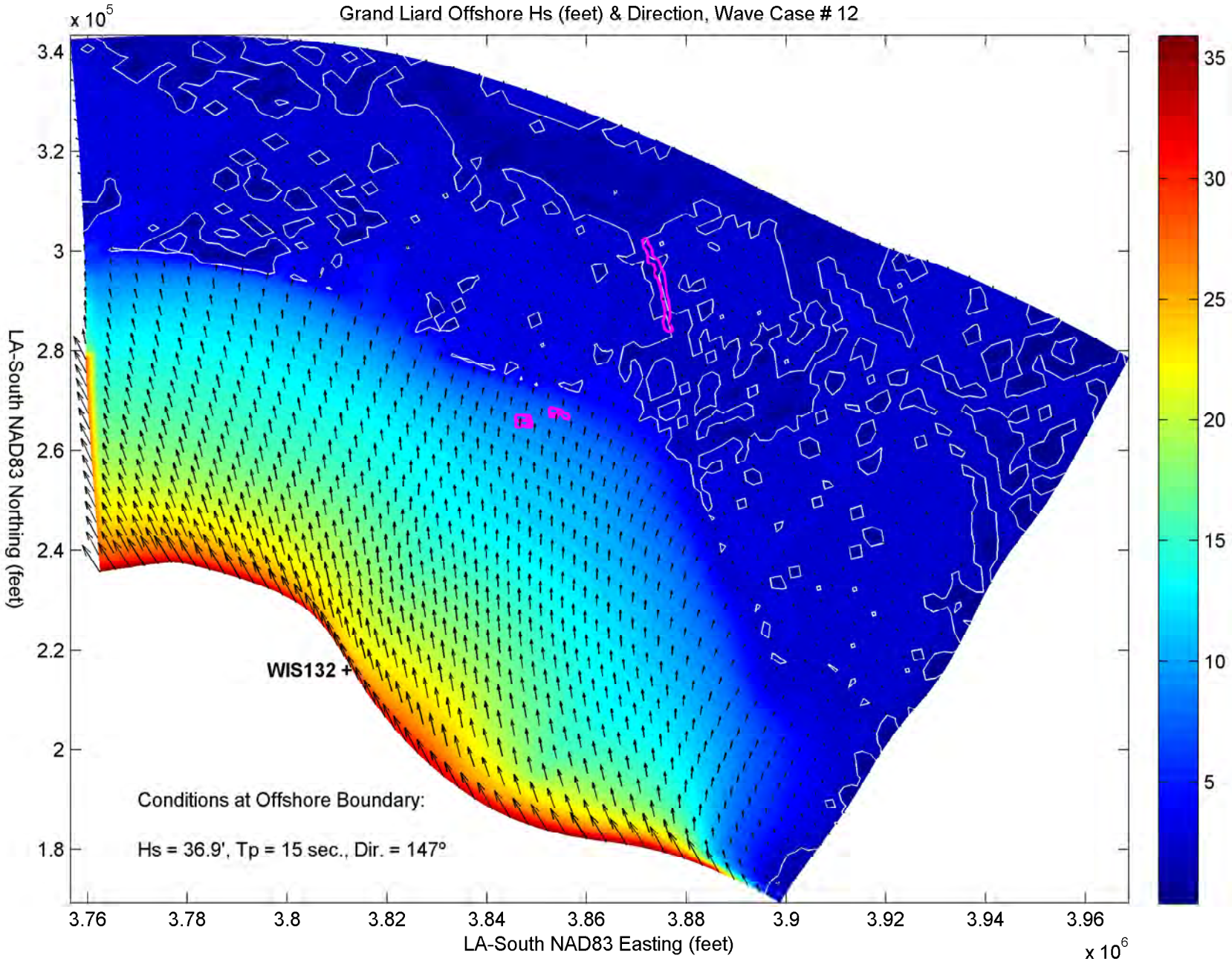
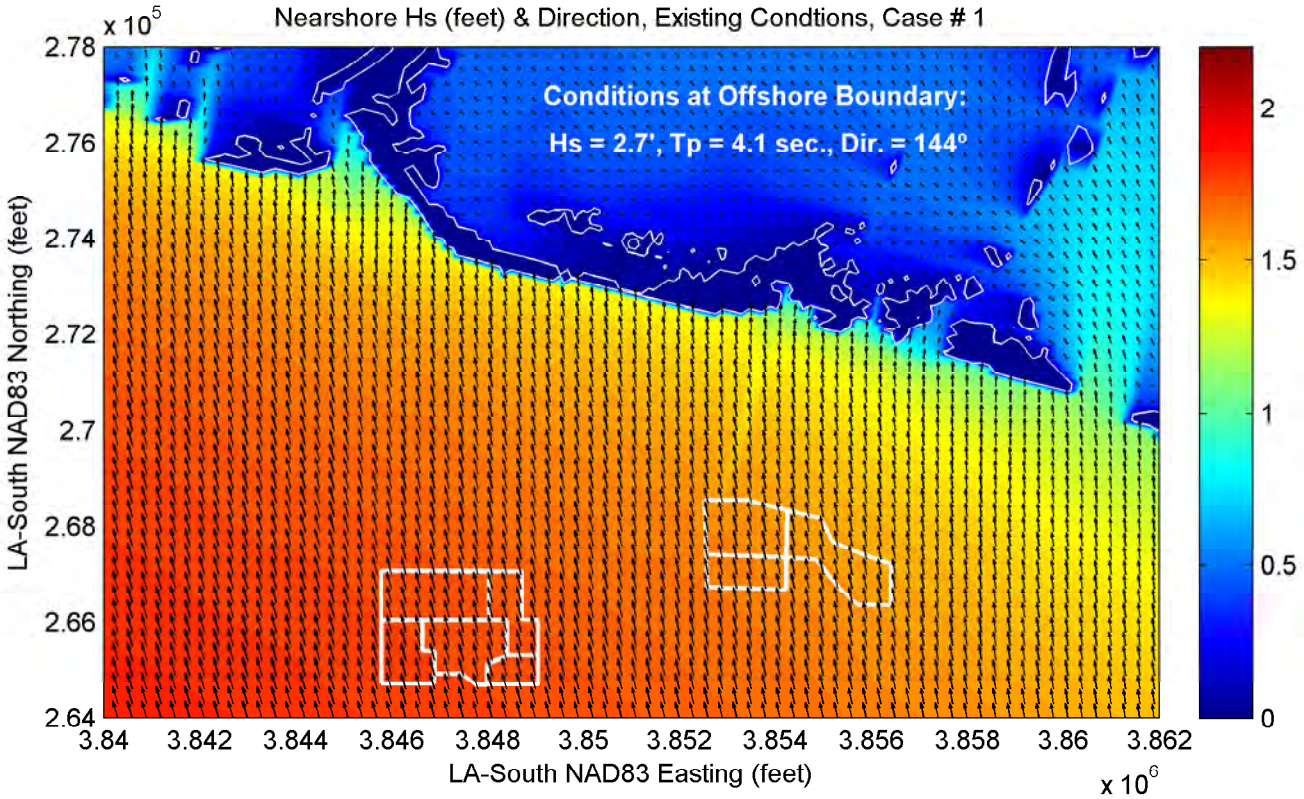
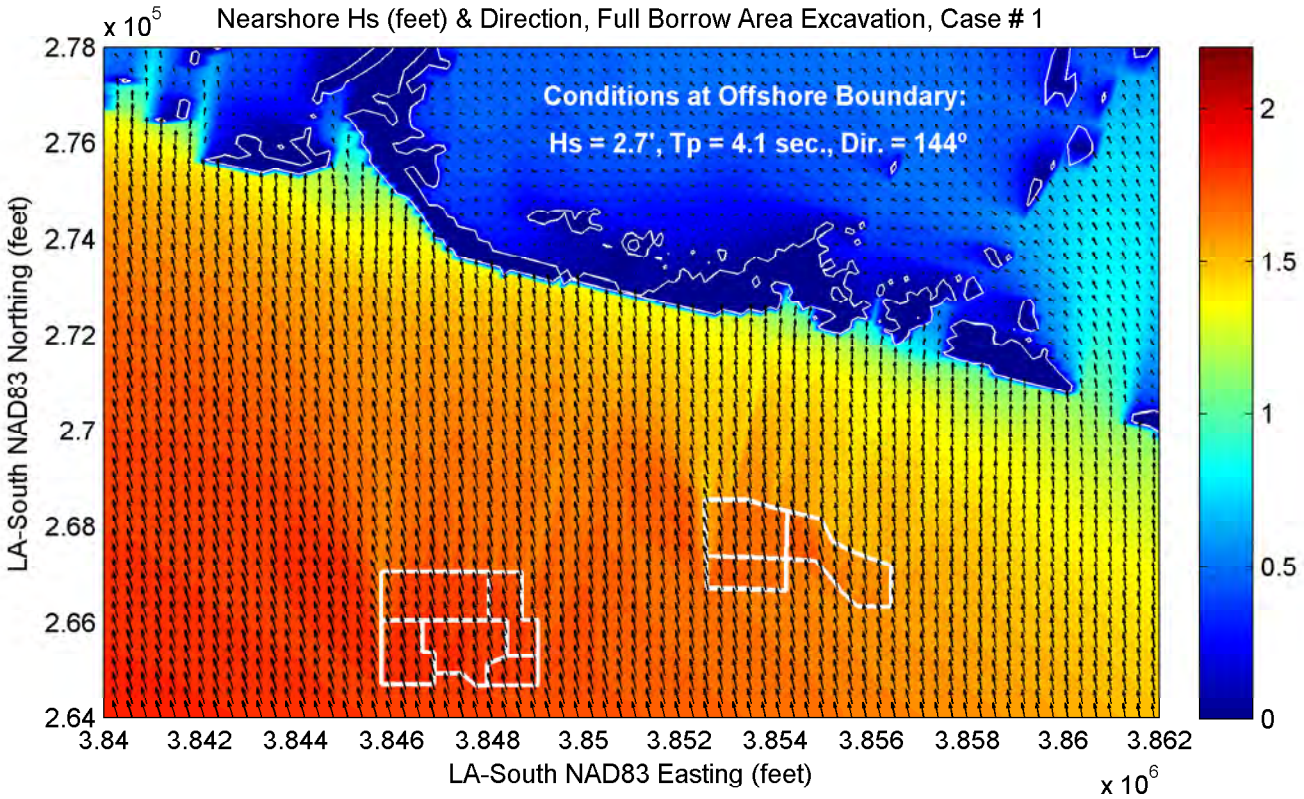
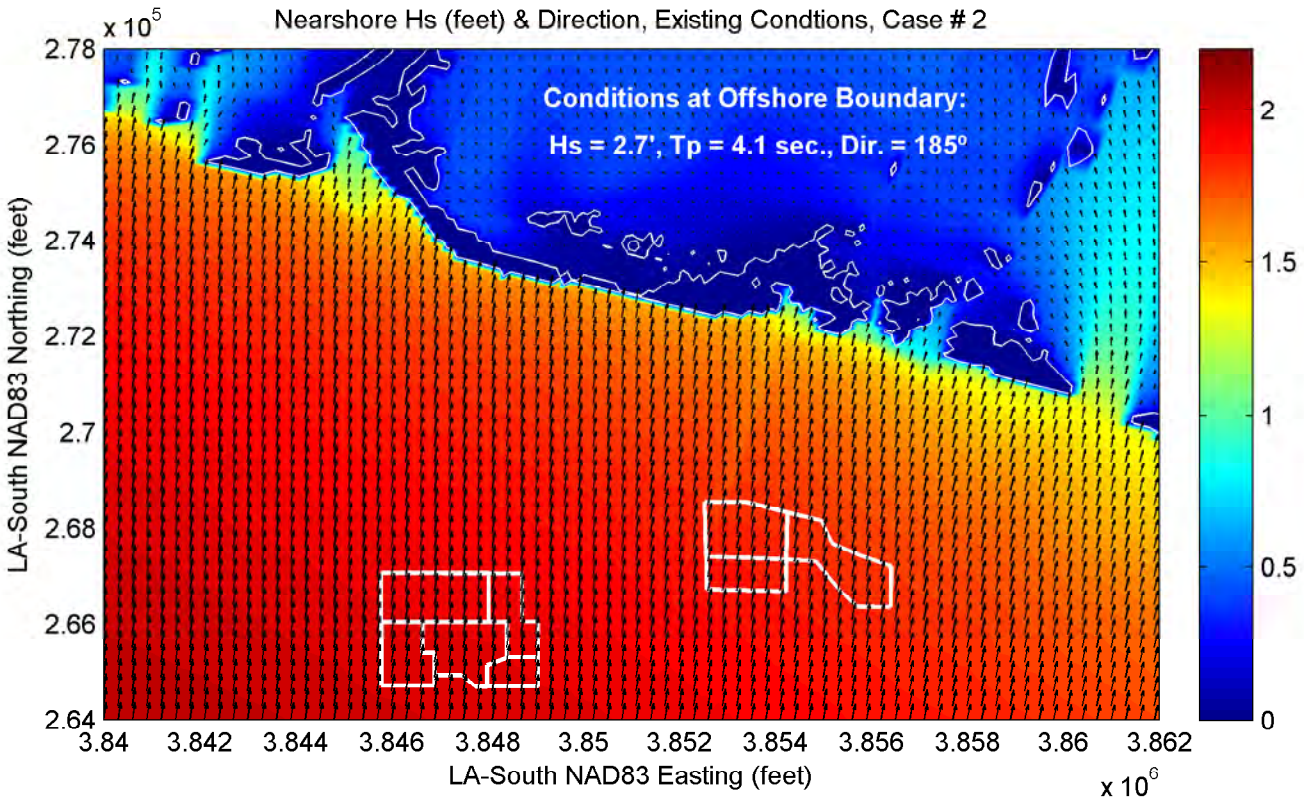
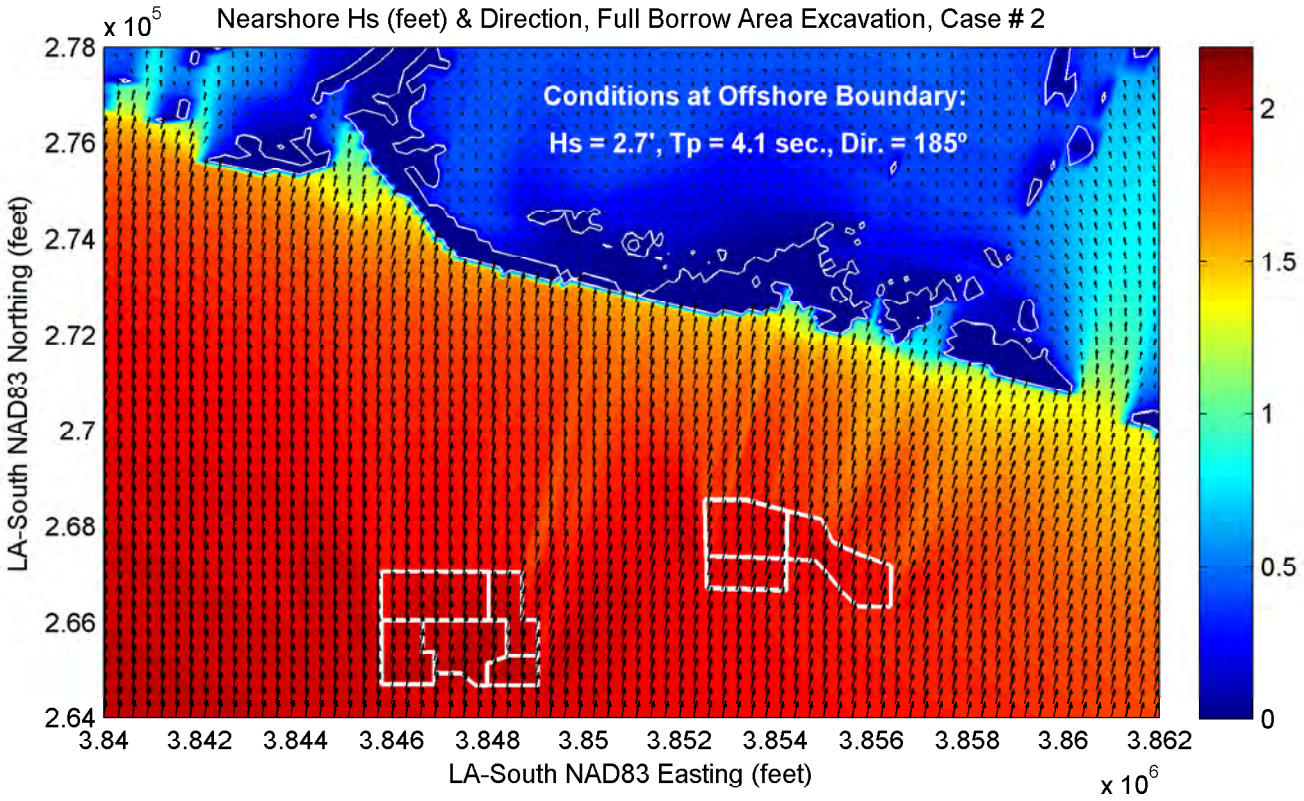
12
10
8
6
4
2

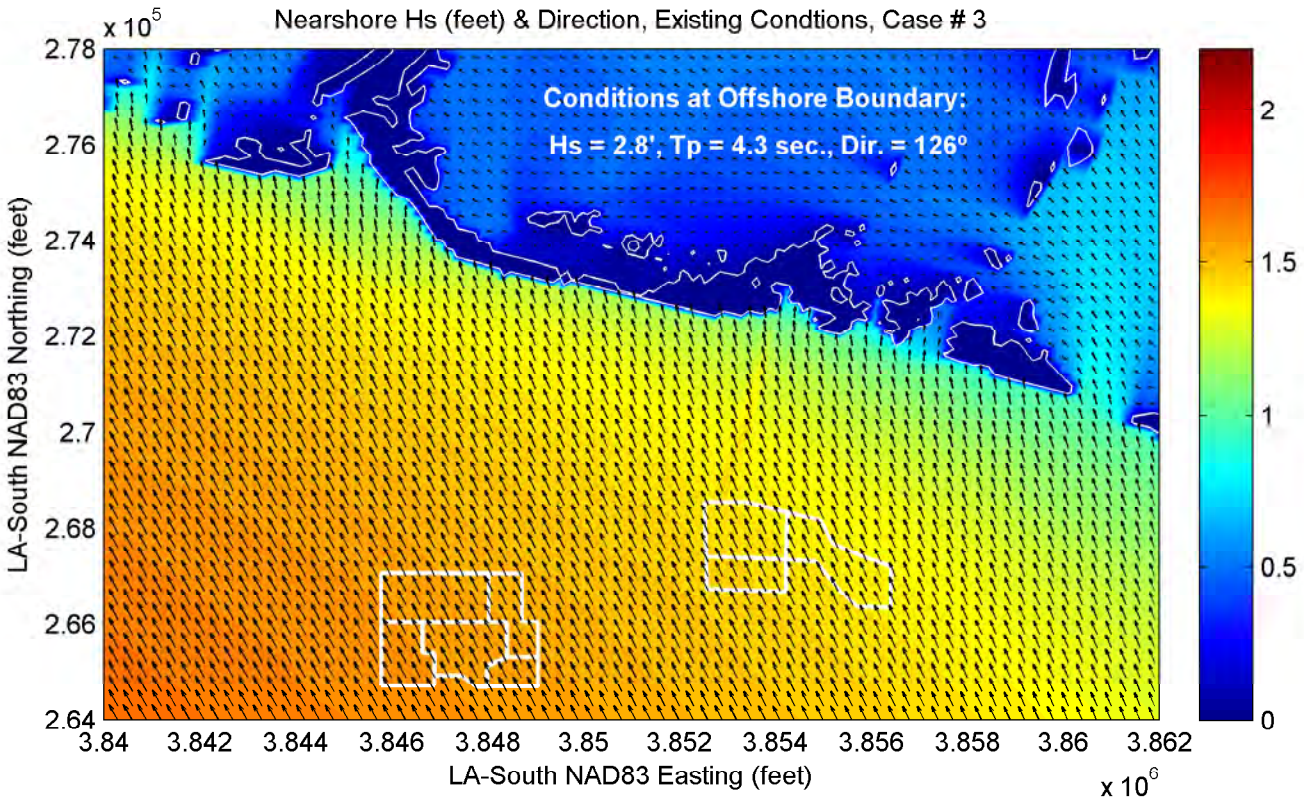

Grand Liard Offshore Hs (feet) & Direction, Wave Case # 12
x 10^5
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
LA-South NAD83 Northing (feet)
WIS132
Conditions at Offshore Boundary:
Hs = 36.9', Tp = 15 sec., Dir. = 147°
3.76
3.78
3.8
3.82
3.84
3.86
3.88
3.9
3.92
3.94
3.96
LA-South NAD83 Easting (feet)
x 10^6
35
30
25
20
15
10
5

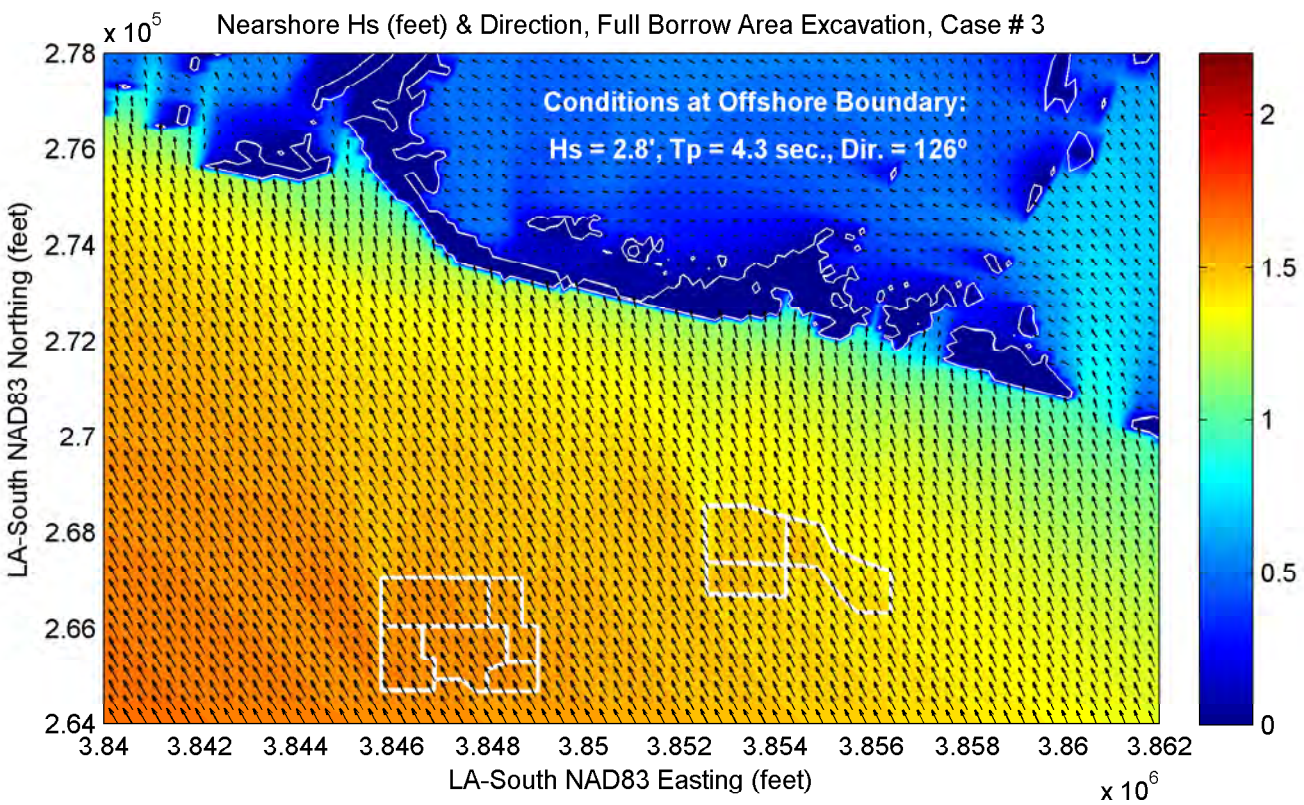

Nearshore Hs (feet) & Direction, Existing Condtions, Case # 1
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 144°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0

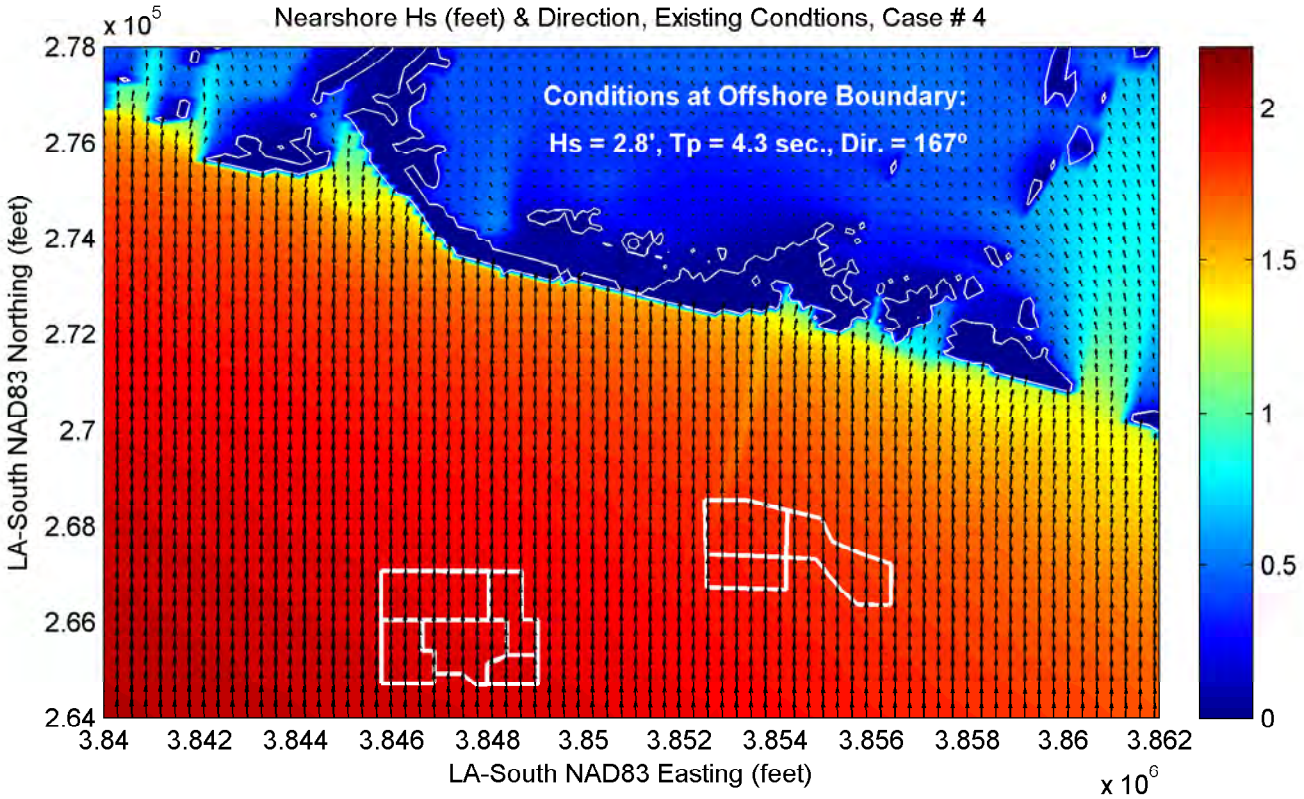

Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 1
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 144°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0

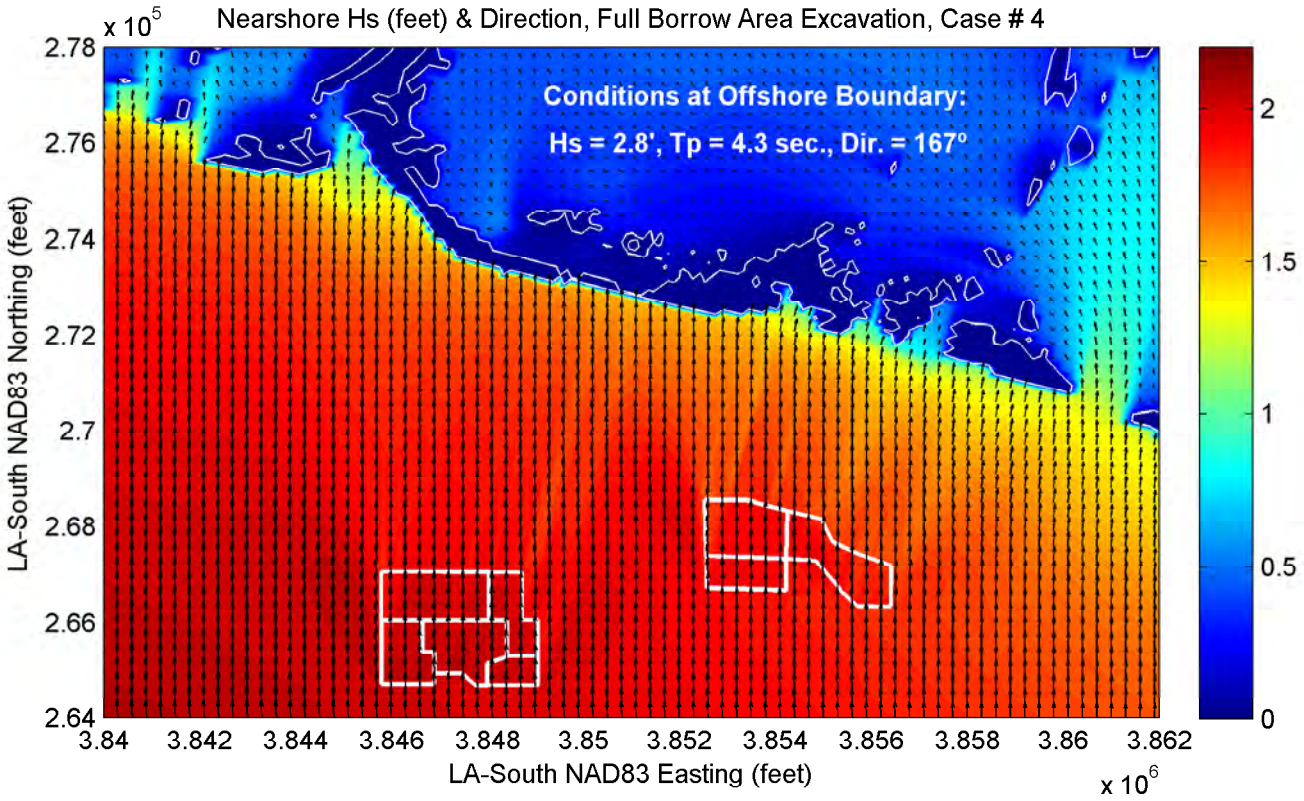

Nearshore Hs (feet) & Direction, Existing Condtions, Case # 2
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 185°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0

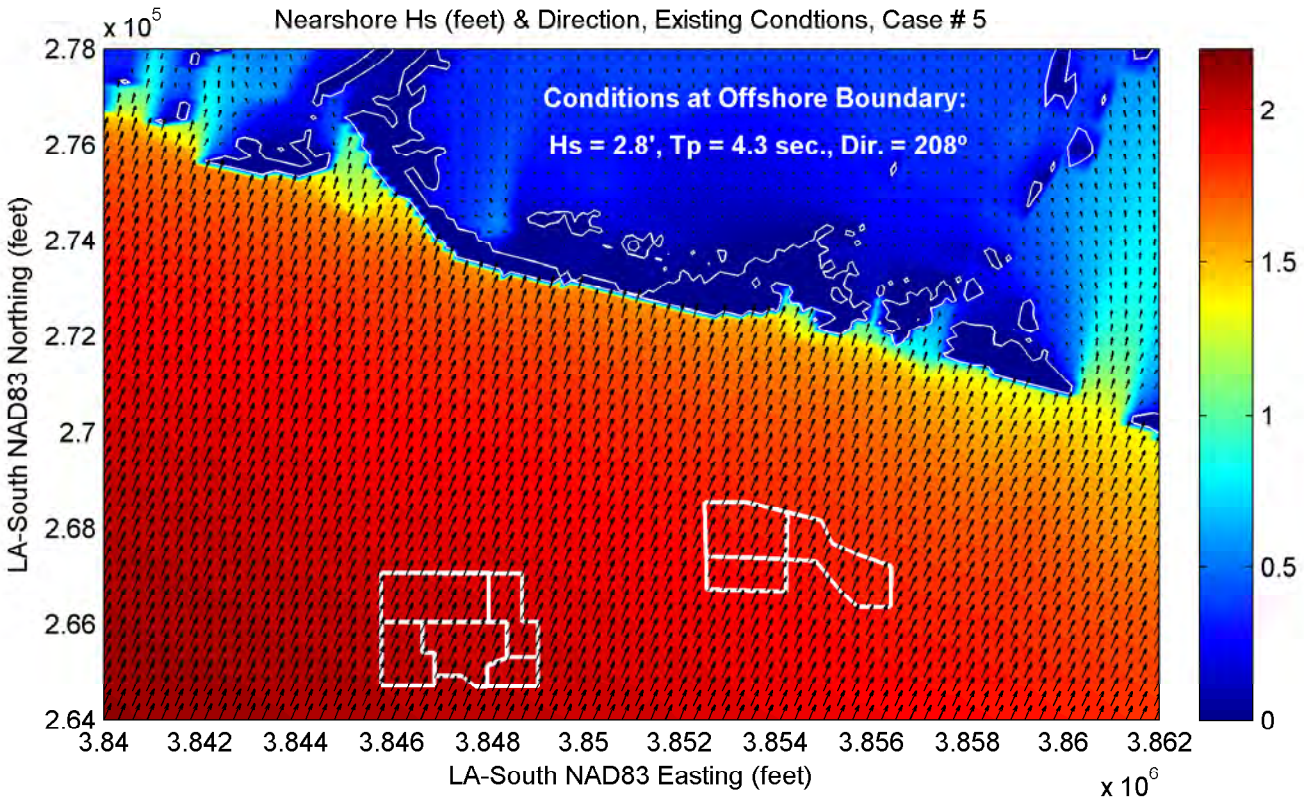

Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 2
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 185°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0

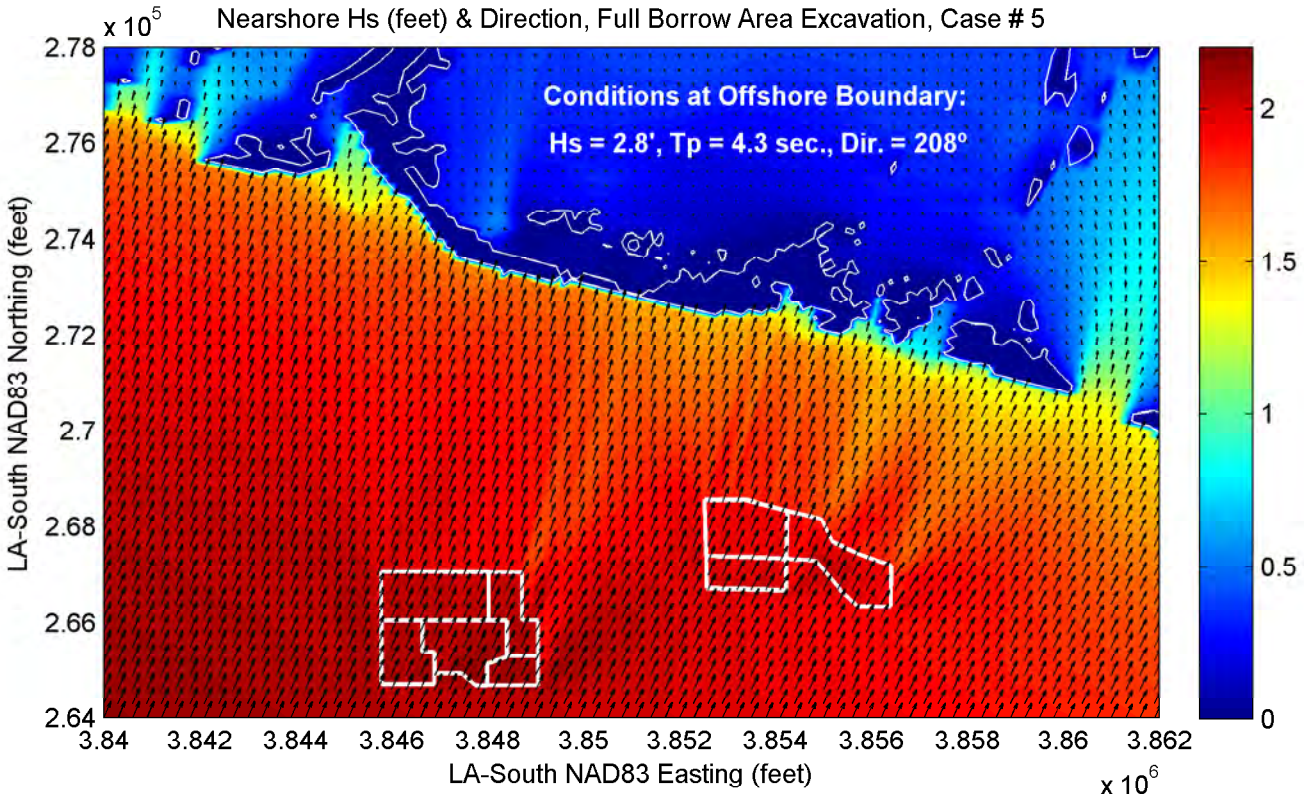

Nearshore Hs (feet) & Direction, Existing Condtions, Case # 3
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 126°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0

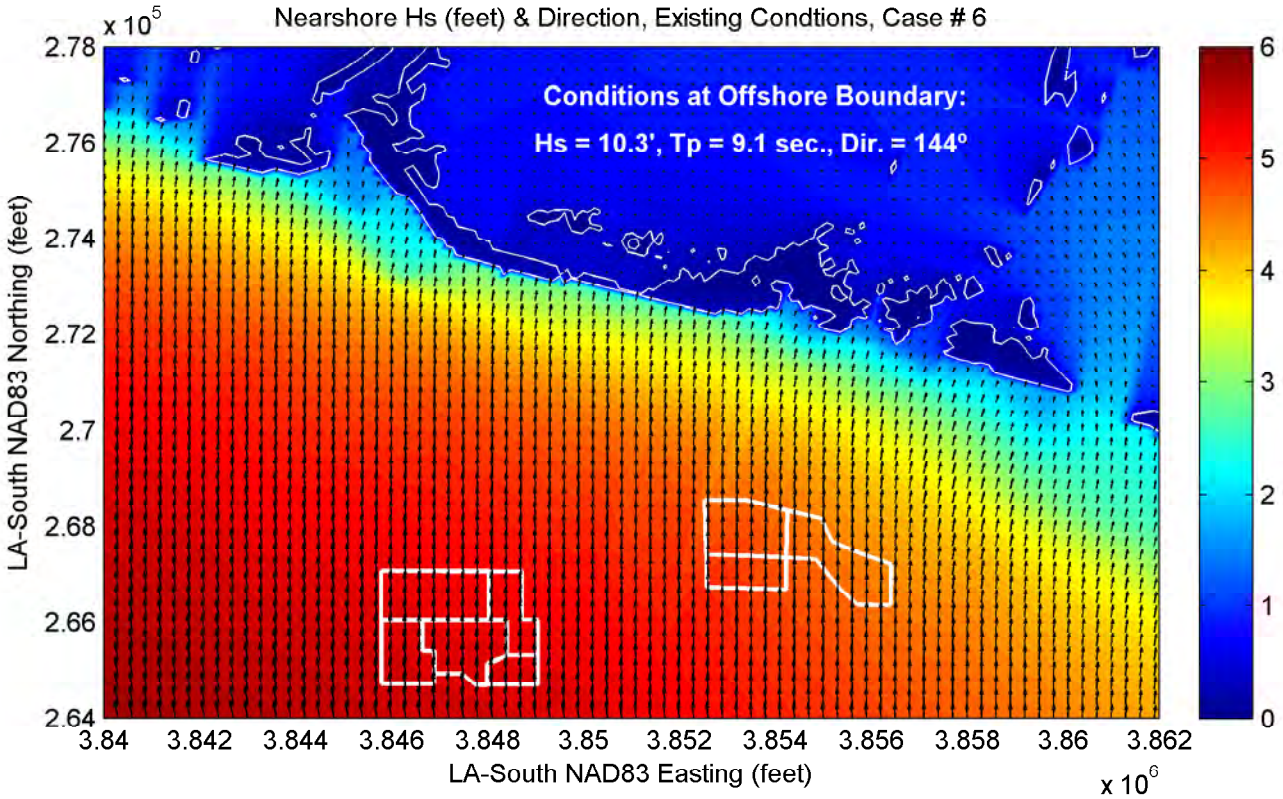

Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 3
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 126°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0

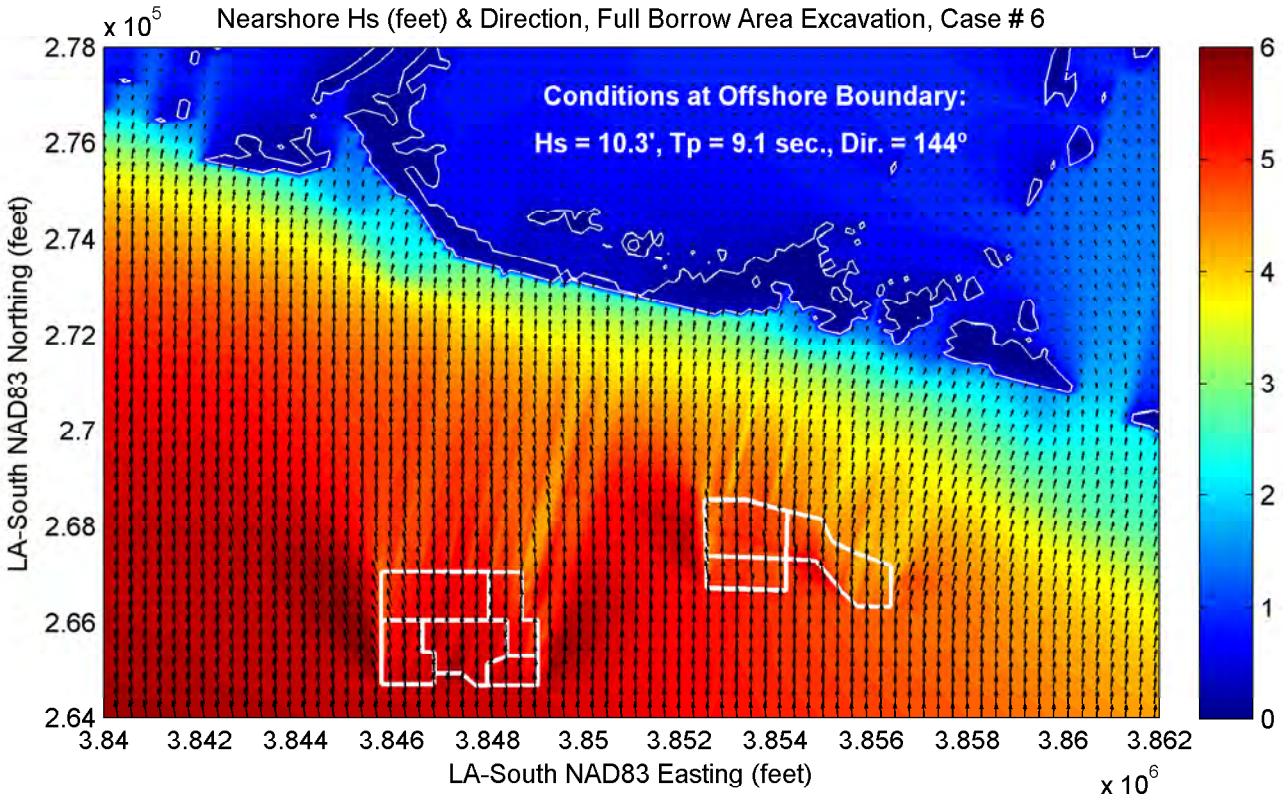

Nearshore Hs (feet) & Direction, Existing Condtions, Case # 4
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 167°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0

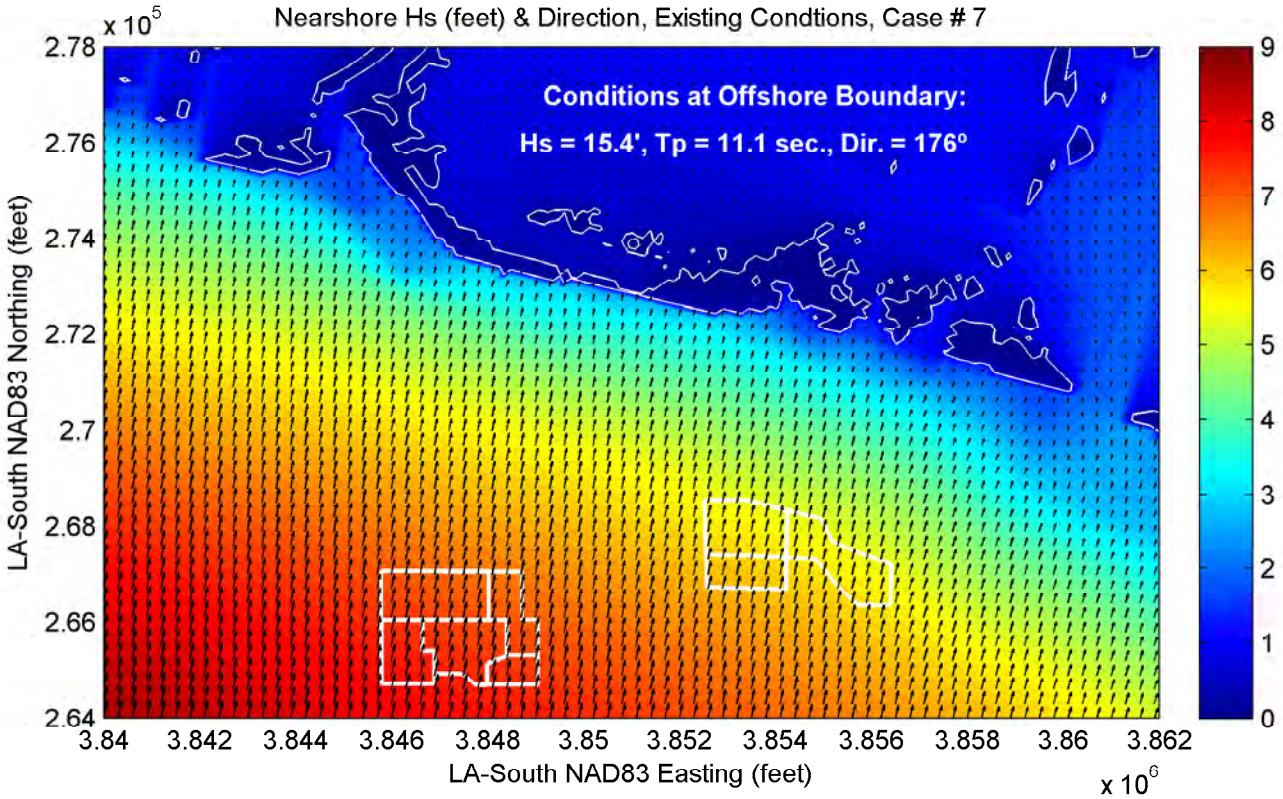

Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 4
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 167°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 5
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 208°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 5
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 208°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
2
1.5
1
0.5
0


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 6
x 10^5
Conditions at Offshore Boundary:
Hs = 10.3', Tp = 9.1 sec., Dir. = 144°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
6
5
4
3
2
1
0


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 6
x 10^5
Conditions at Offshore Boundary:
Hs = 10.3', Tp = 9.1 sec., Dir. = 144°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
6
5
4
3
2
1
0


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 7
Conditions at Offshore Boundary:
Hs = 15.4', Tp = 11.1 sec., Dir. = 176°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
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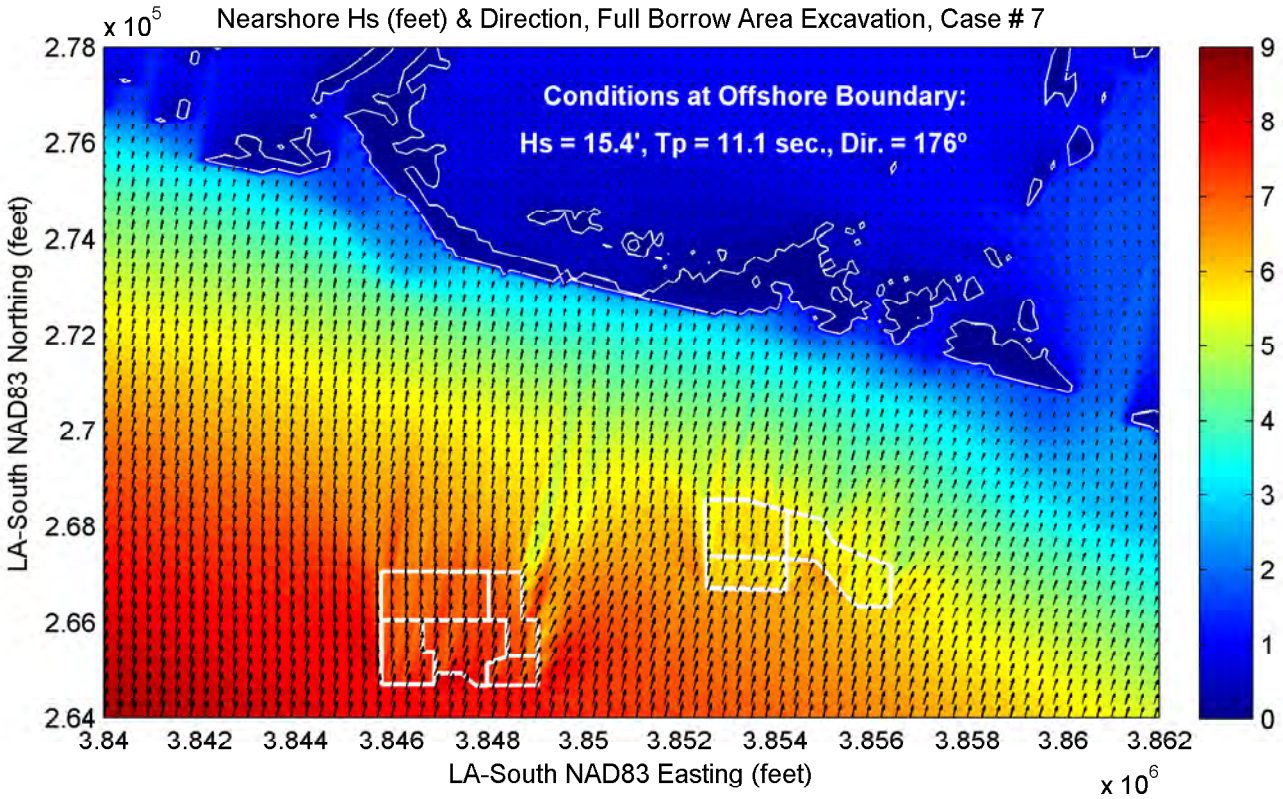
1
2
3
4
5
6
7
8
9


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 7
Conditions at Offshore Boundary:
Hs = 15.4', Tp = 11.1 sec., Dir. = 176°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
0
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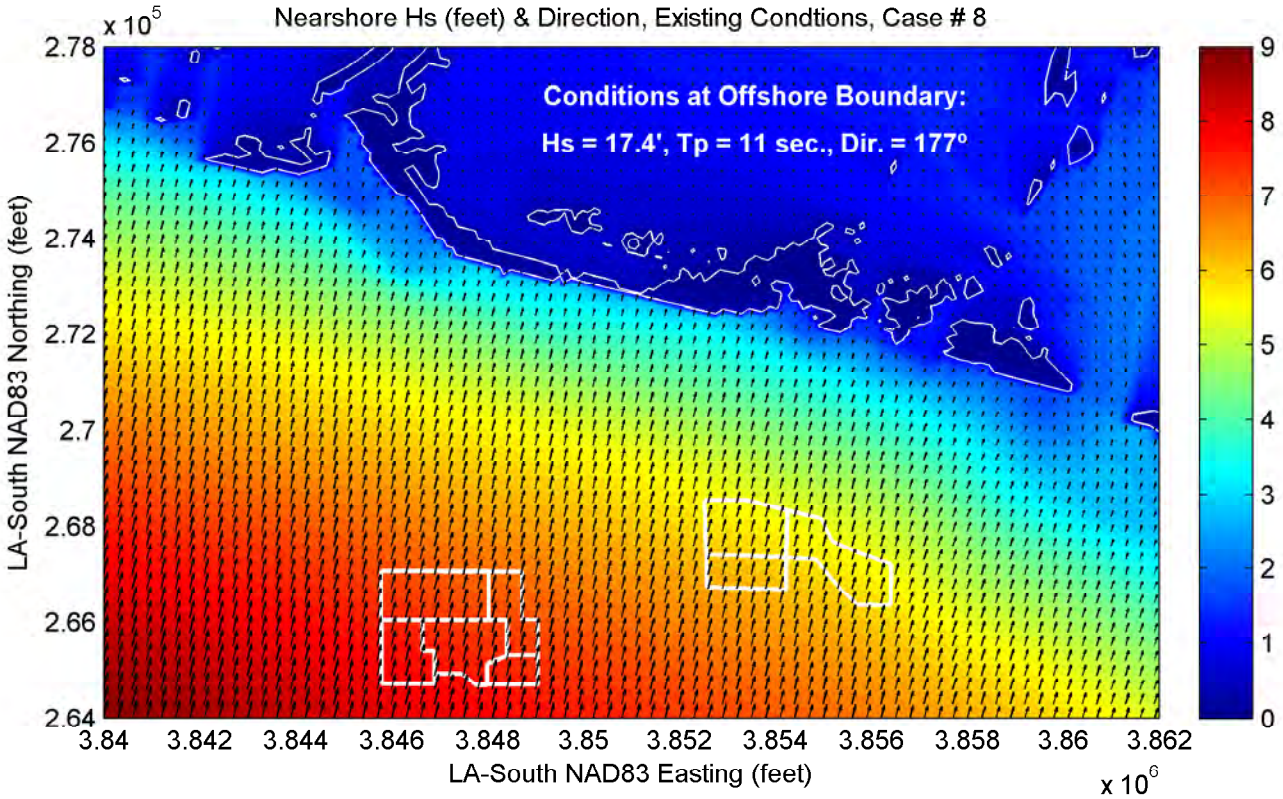
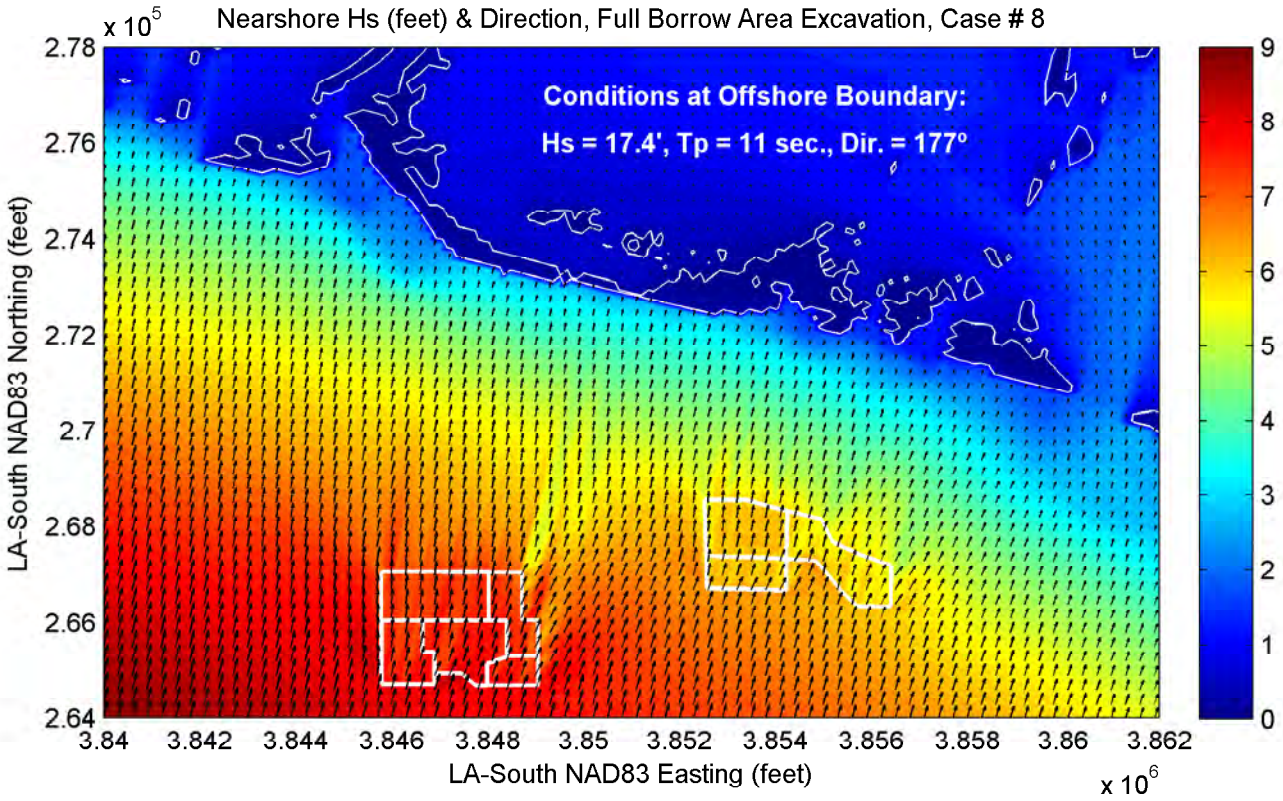
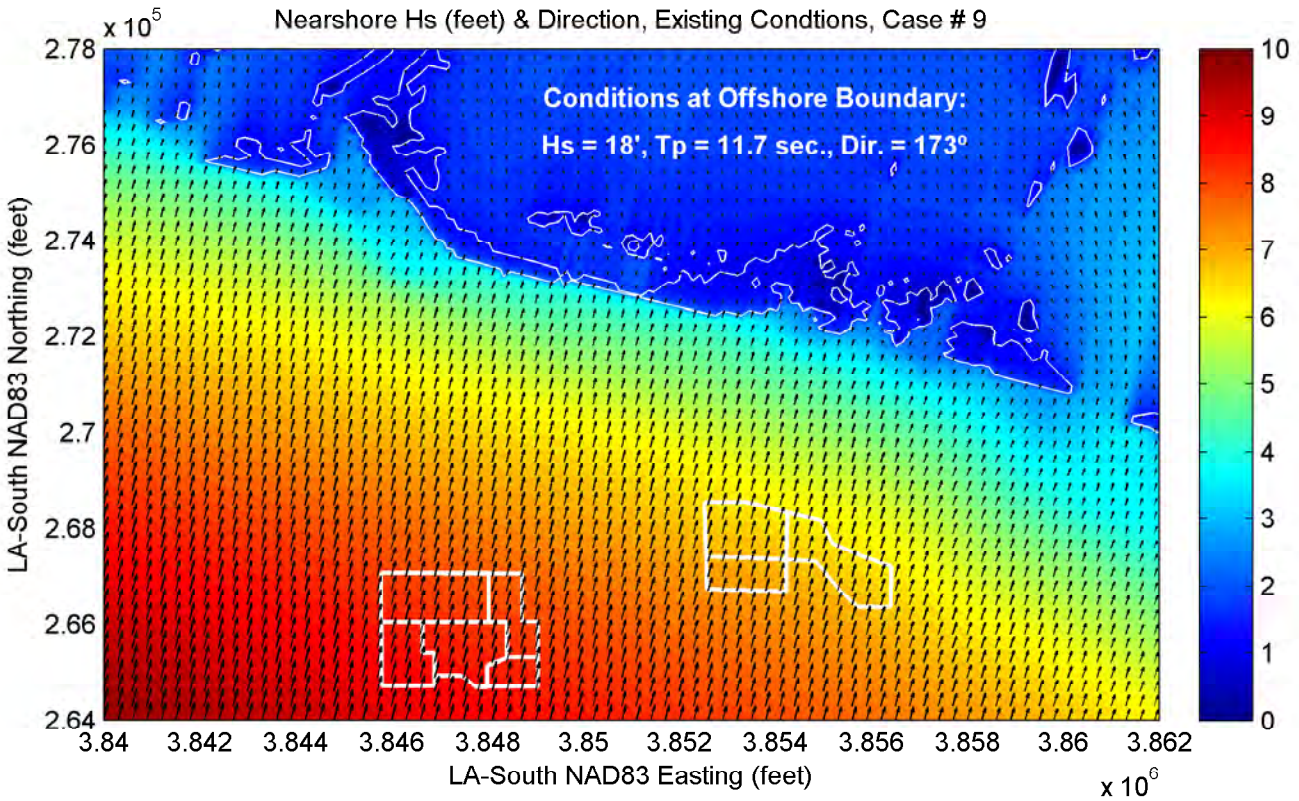
3
4
5
6
7
8
9


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 8
x 10^5
Conditions at Offshore Boundary:
Hs = 17.4', Tp = 11 sec., Dir. = 177°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
9
8
7
6
5
4
3
2
1
0


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 8
x 10^5
Conditions at Offshore Boundary:
Hs = 17.4', Tp = 11 sec., Dir. = 177°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
9
8
7
6
5
4
3
2
1
0


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 9
x 10^5
Conditions at Offshore Boundary:
Hs = 18', Tp = 11.7 sec., Dir. = 173°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
0
1
2
3
4
5
6
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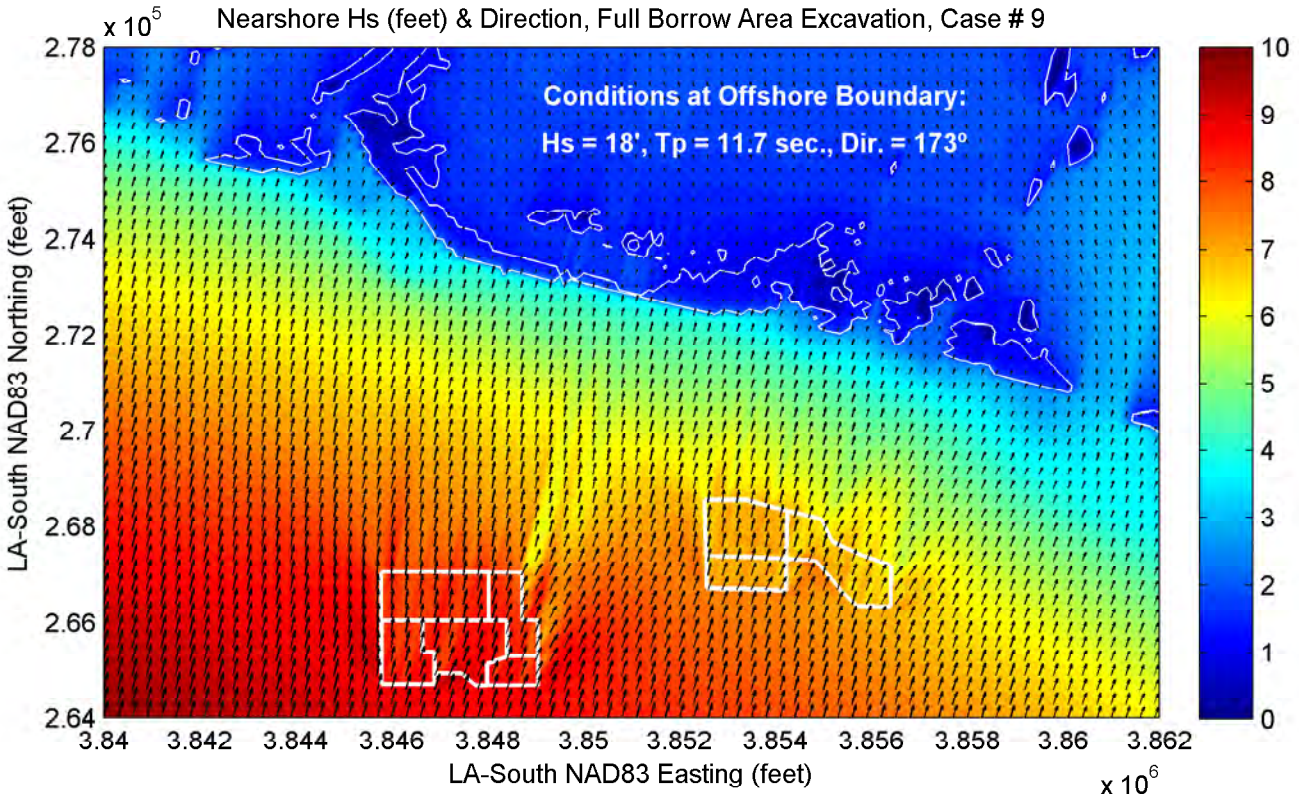
8
9
10


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 9
x 10^5
Conditions at Offshore Boundary:
Hs = 18', Tp = 11.7 sec., Dir. = 173°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
0
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5
6
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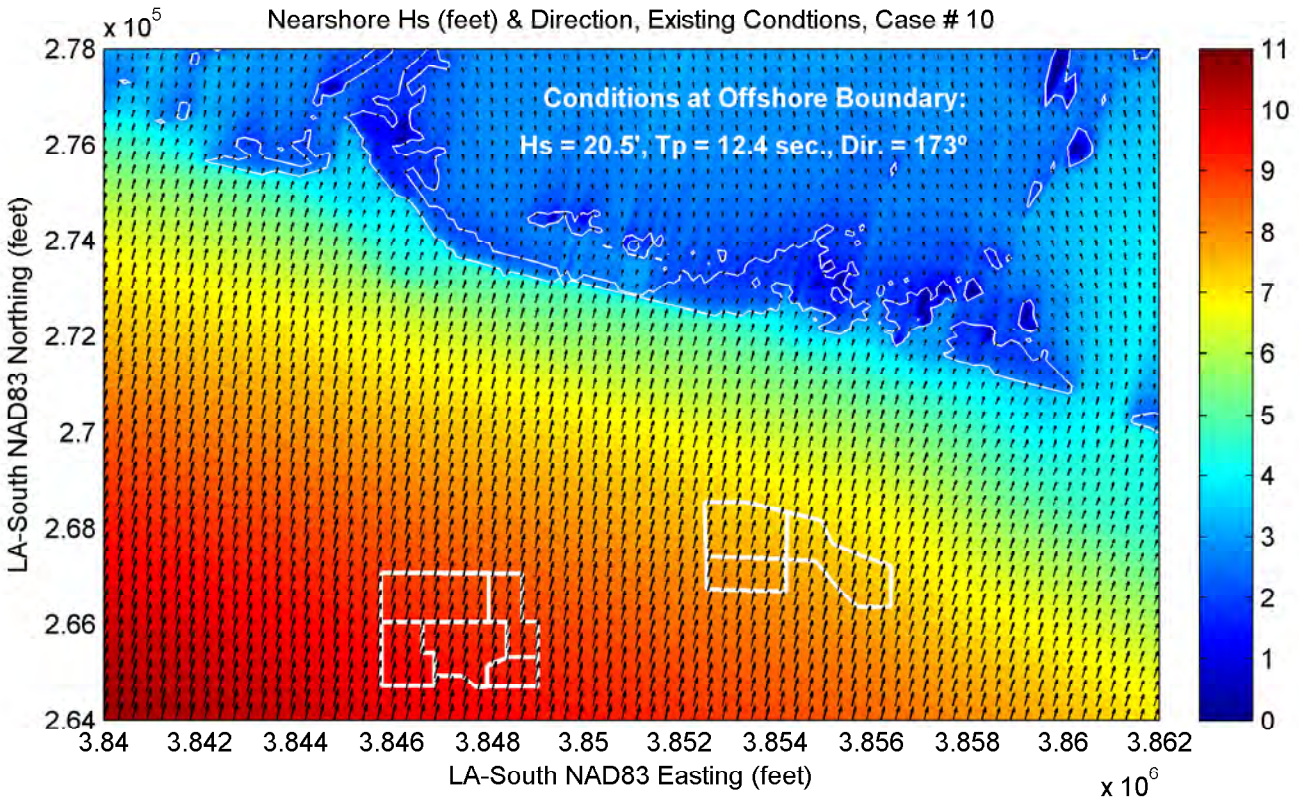
8
9
10


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 10
x 10^5
Conditions at Offshore Boundary:
Hs = 20.5', Tp = 12.4 sec., Dir. = 173°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
0
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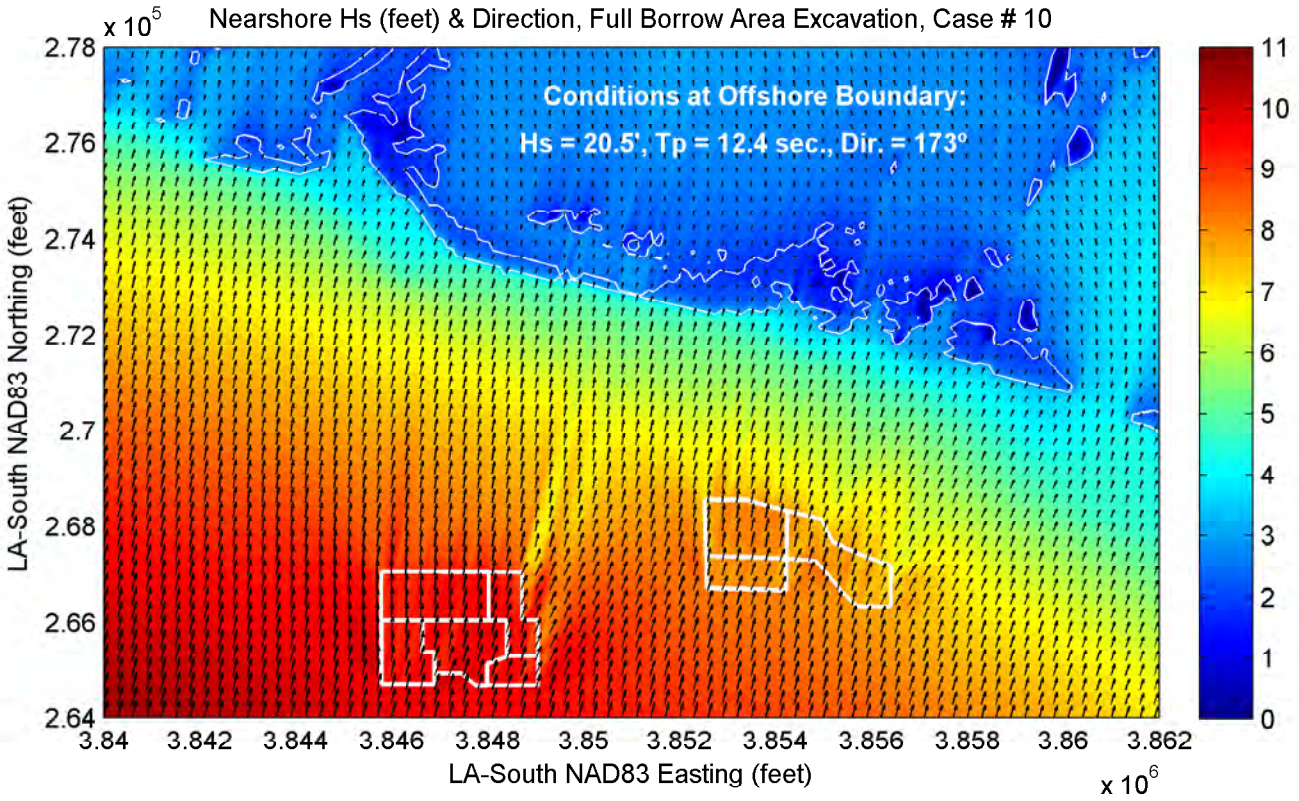
6
7
8
9
10
11


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 10
x 10^5
Conditions at Offshore Boundary:
Hs = 20.5', Tp = 12.4 sec., Dir. = 173°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
0
1
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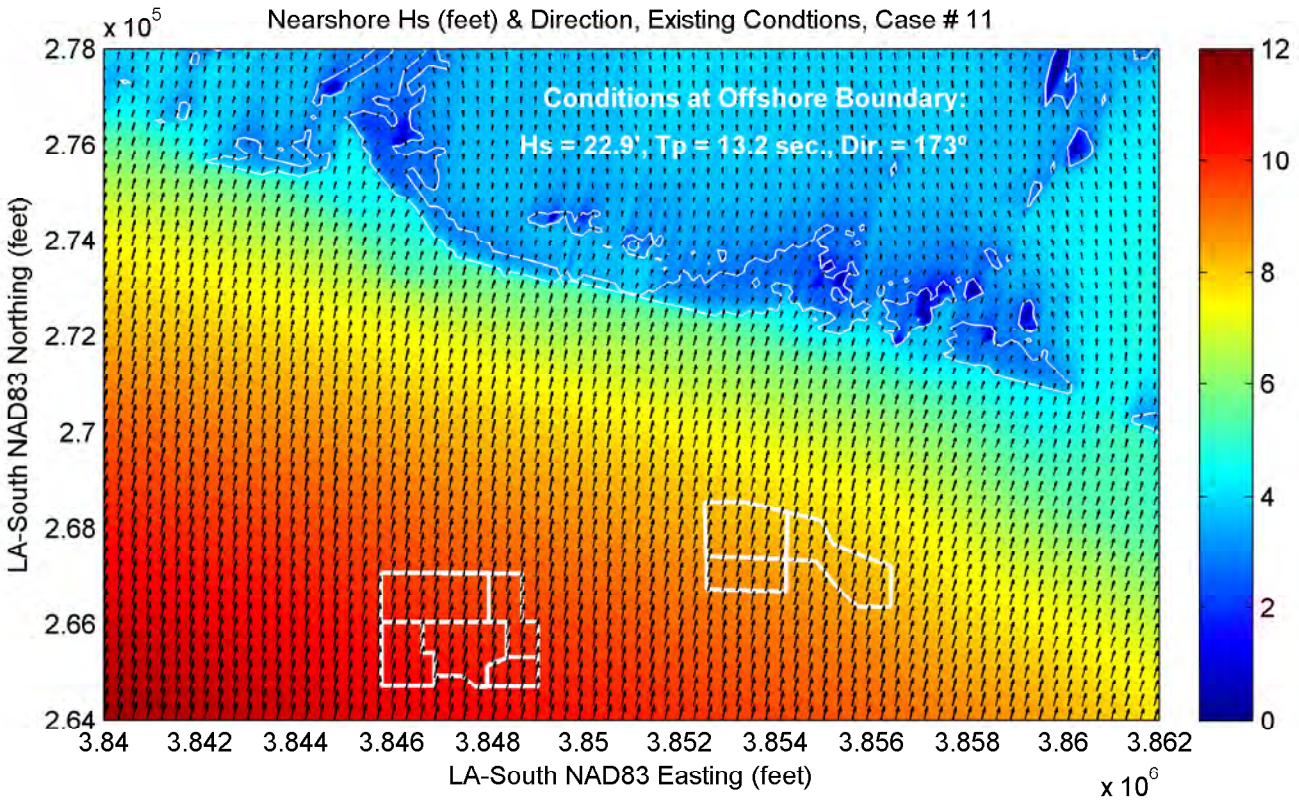
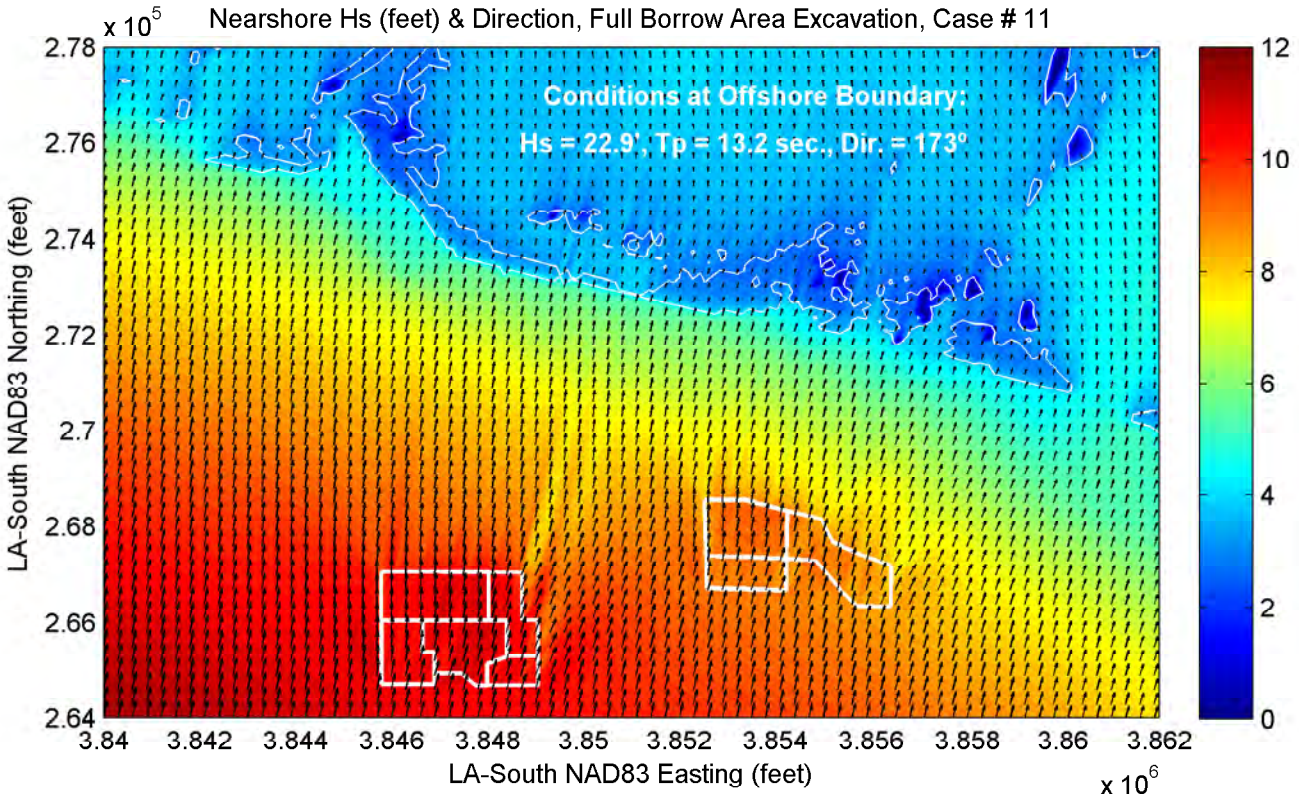
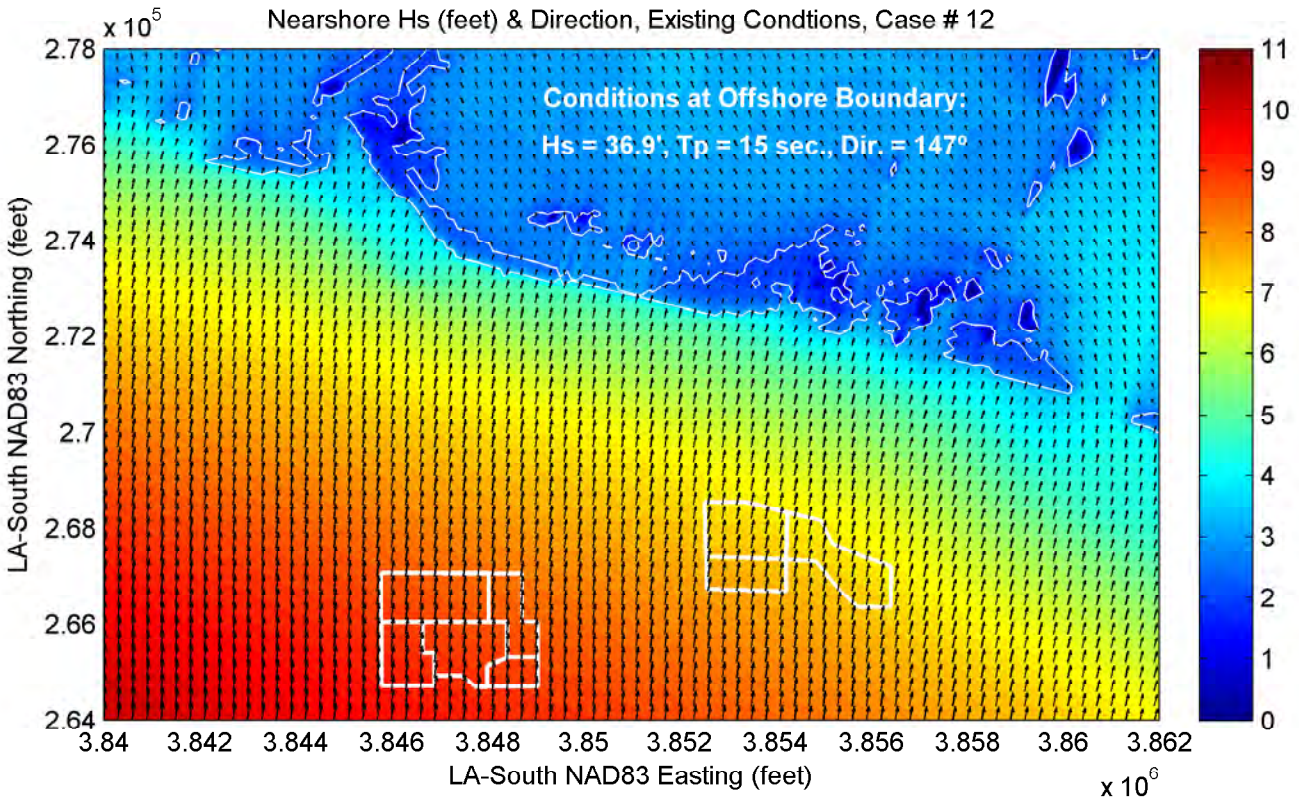
3
4
5
6
7
8
9
10
11


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 11
x 10^5
Conditions at Offshore Boundary:
Hs = 22.9', Tp = 13.2 sec., Dir. = 173°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
12
10
8
6
4
2
0


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 11
x 10^5
Conditions at Offshore Boundary:
Hs = 22.9', Tp = 13.2 sec., Dir. = 173°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
12
10
8
6
4
2
0


Nearshore Hs (feet) & Direction, Existing Condtions, Case # 12
x 10^5
Conditions at Offshore Boundary:
Hs = 36.9', Tp = 15 sec., Dir. = 147°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
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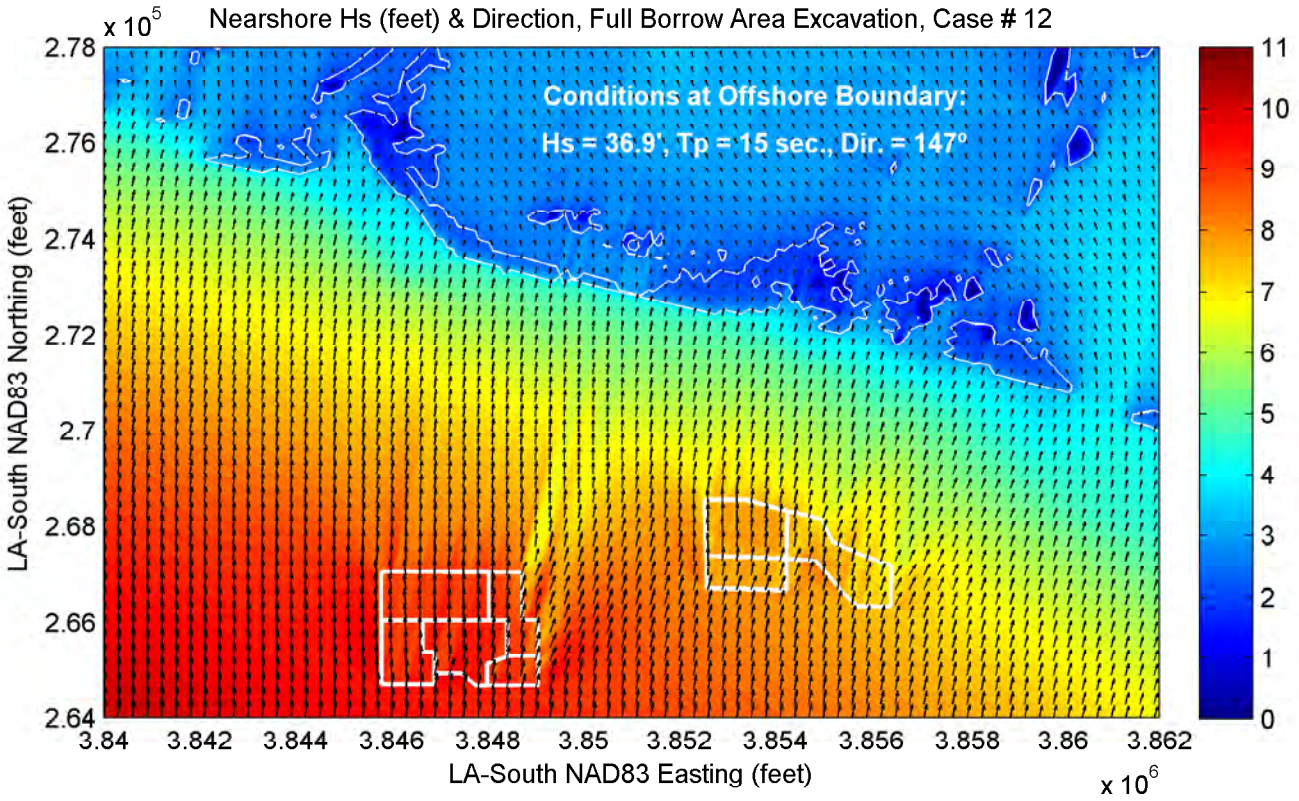
3
4
5
6
7
8
9
10
11


Nearshore Hs (feet) & Direction, Full Borrow Area Excavation, Case # 12
x 10^5
Conditions at Offshore Boundary:
Hs = 36.9', Tp = 15 sec., Dir. = 147°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
0
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2
3
4
5
6
7
8
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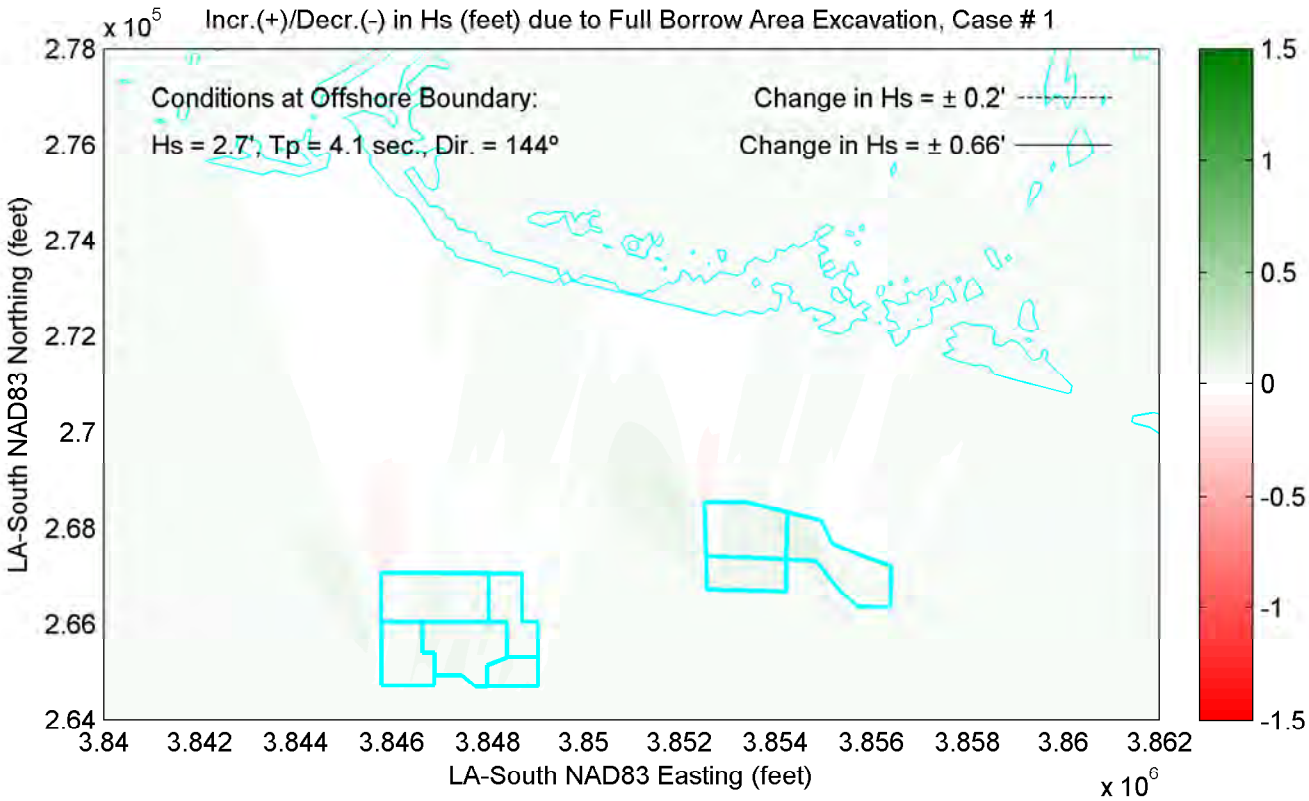
10
11


Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 1
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 144°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
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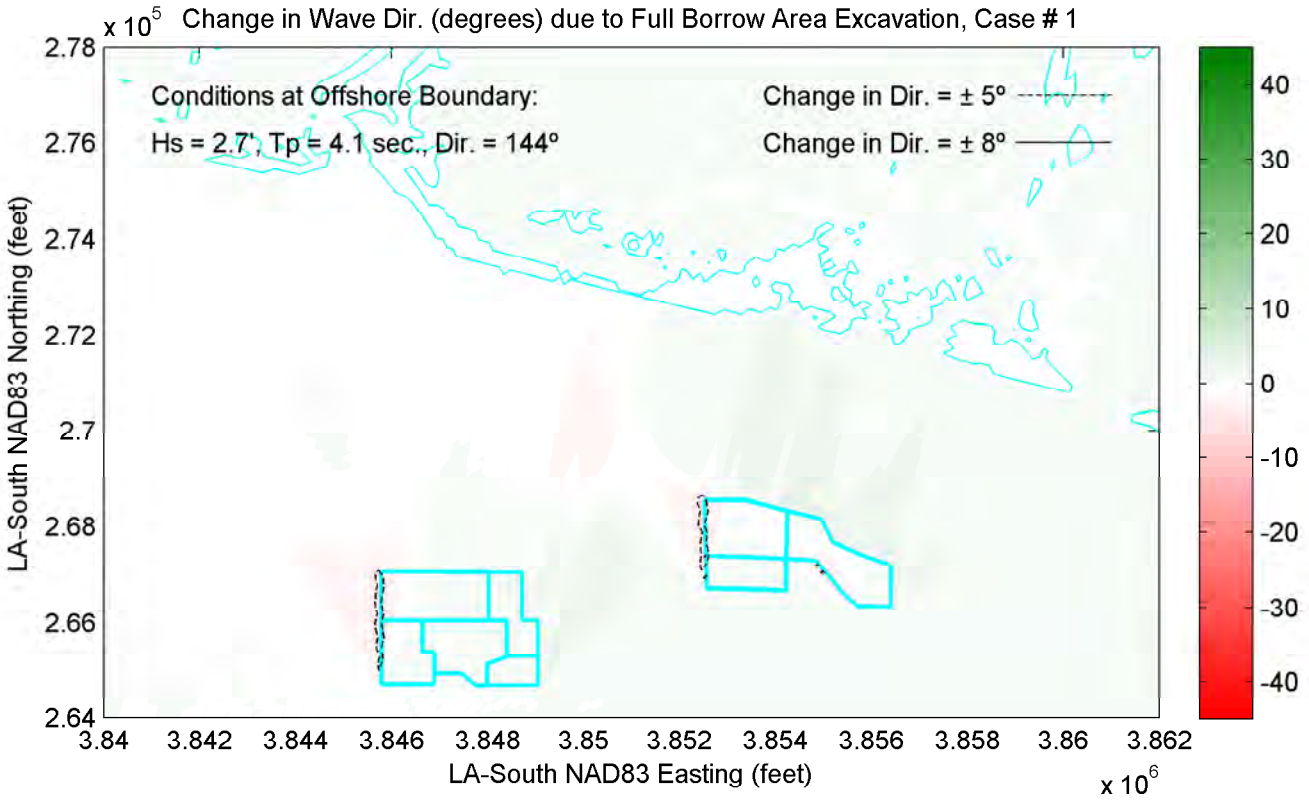
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 1
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 144°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
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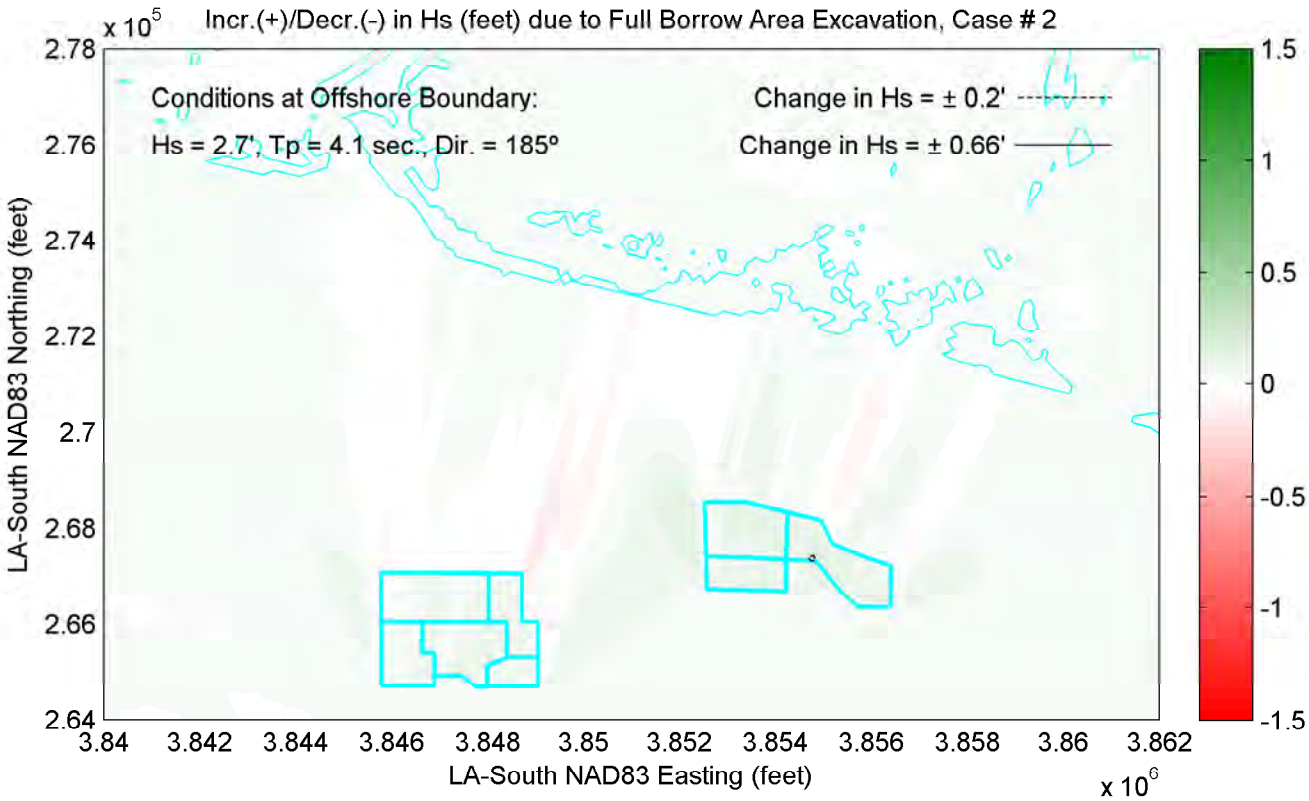
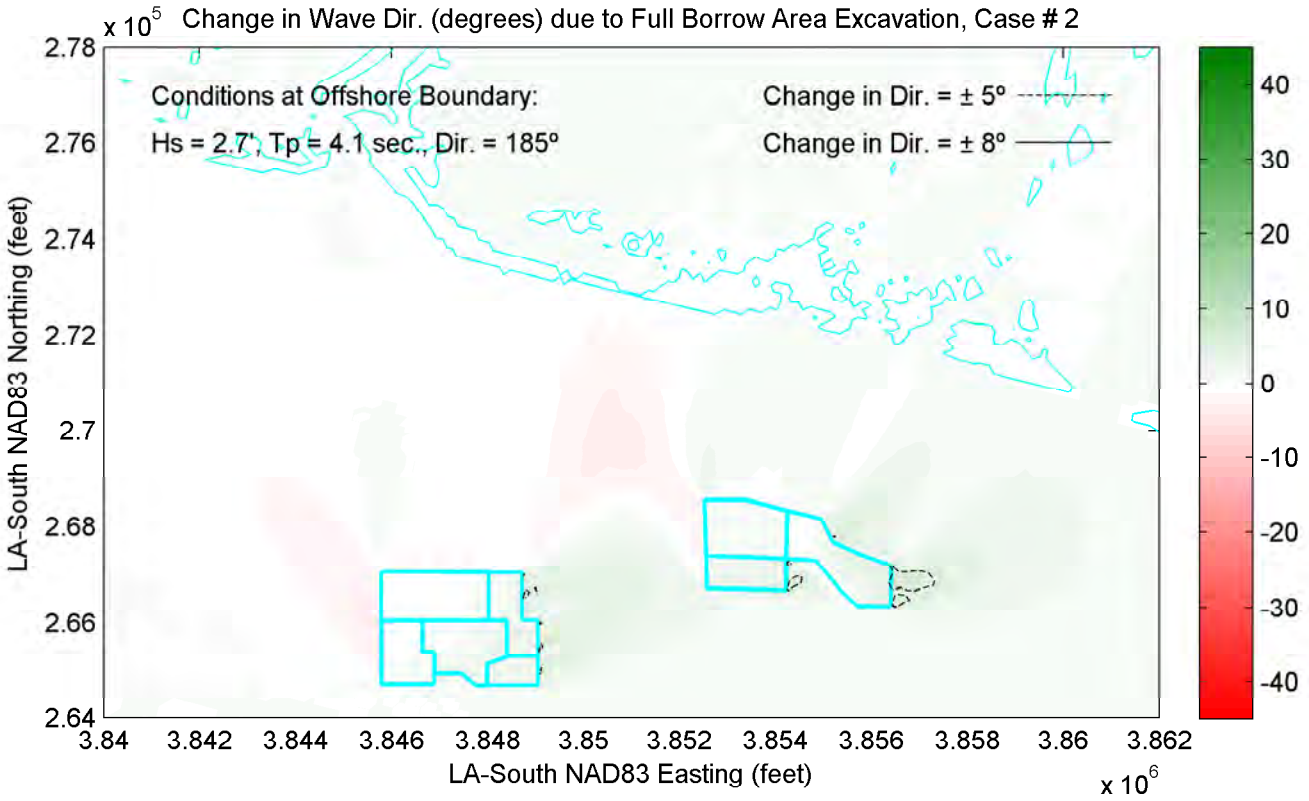
-40


Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 2
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 185°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 2
x 10^5
Conditions at Offshore Boundary:
Hs = 2.7', Tp = 4.1 sec., Dir. = 185°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
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3.862
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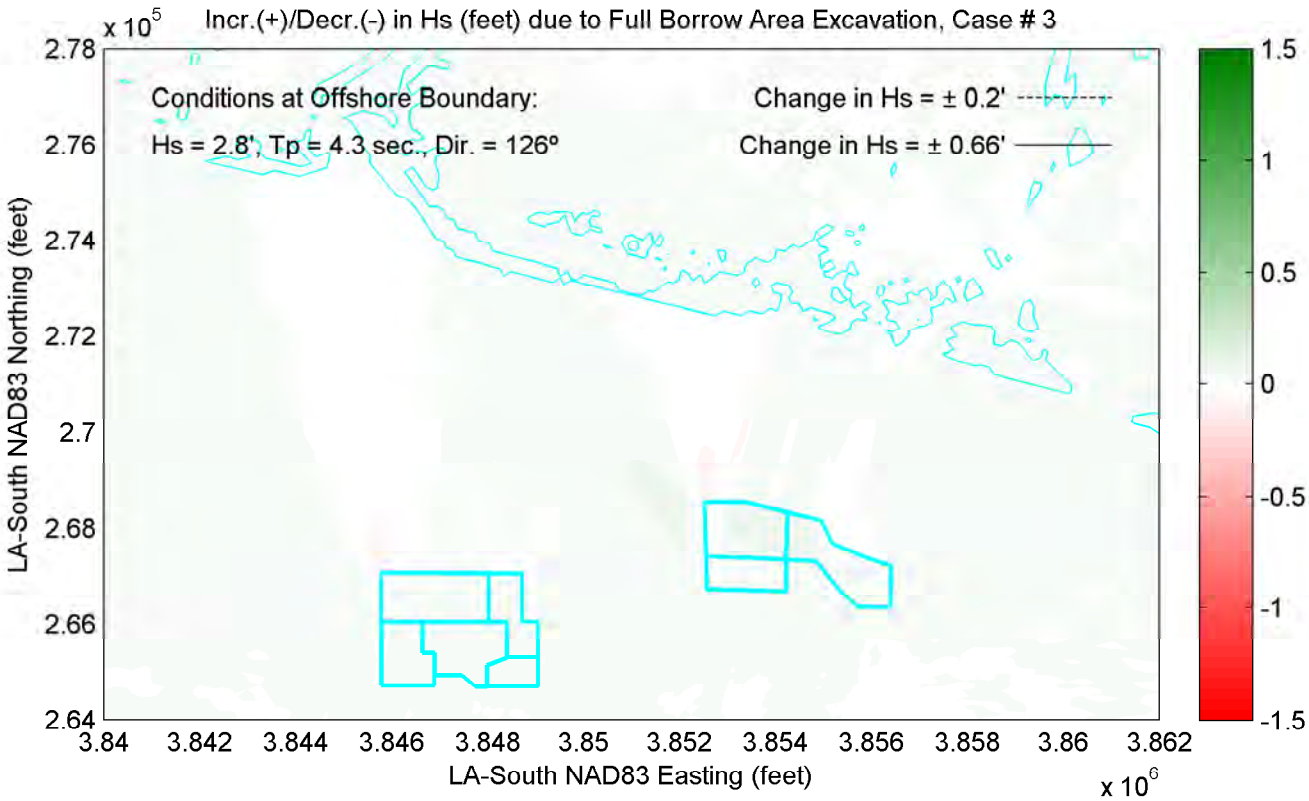
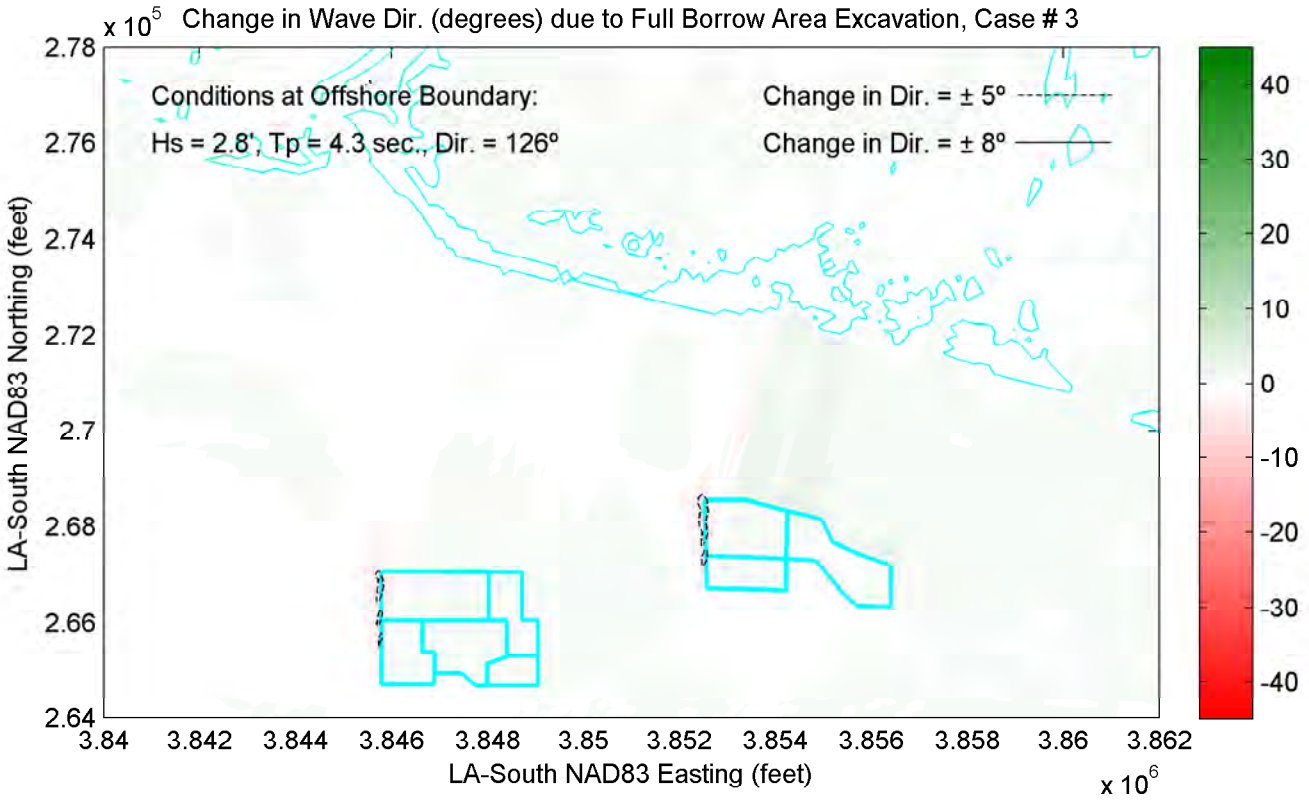

Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 3
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 126°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 3
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 126°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
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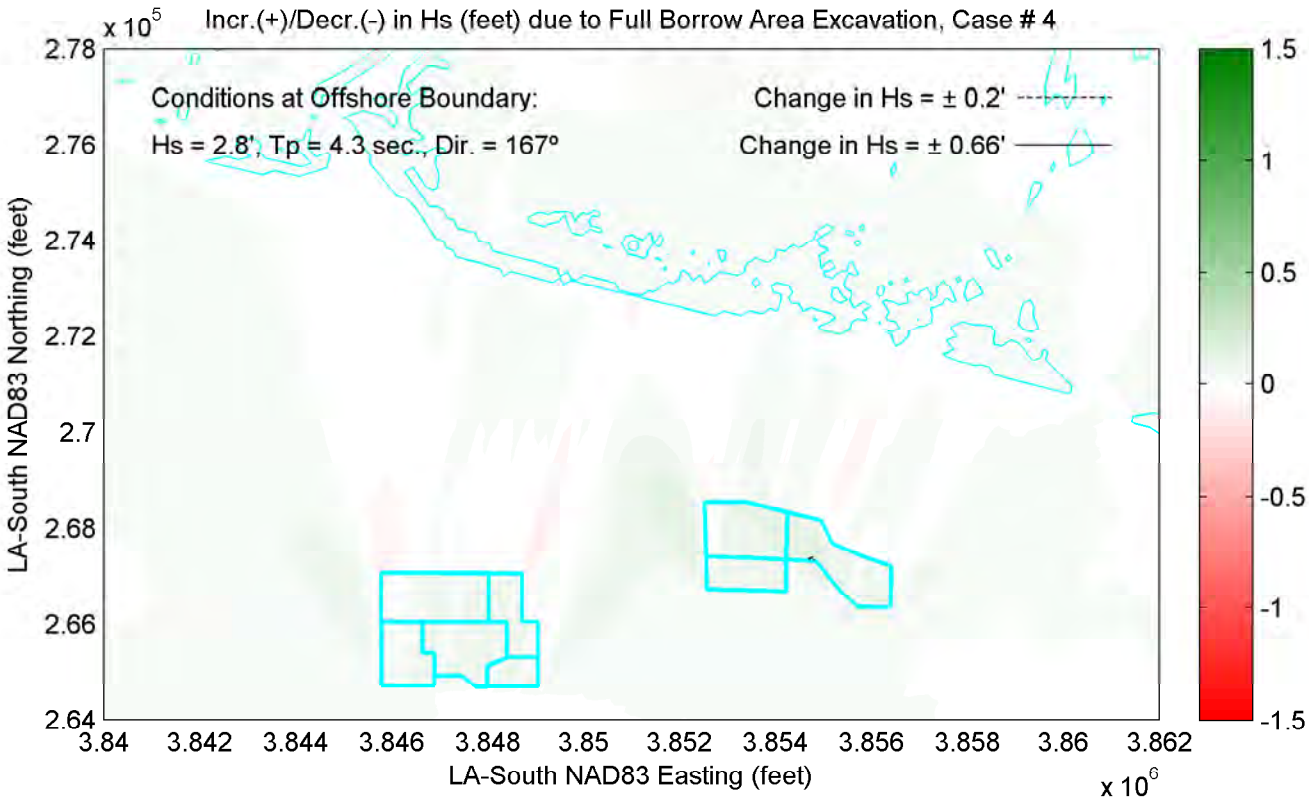
Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 4
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 167°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
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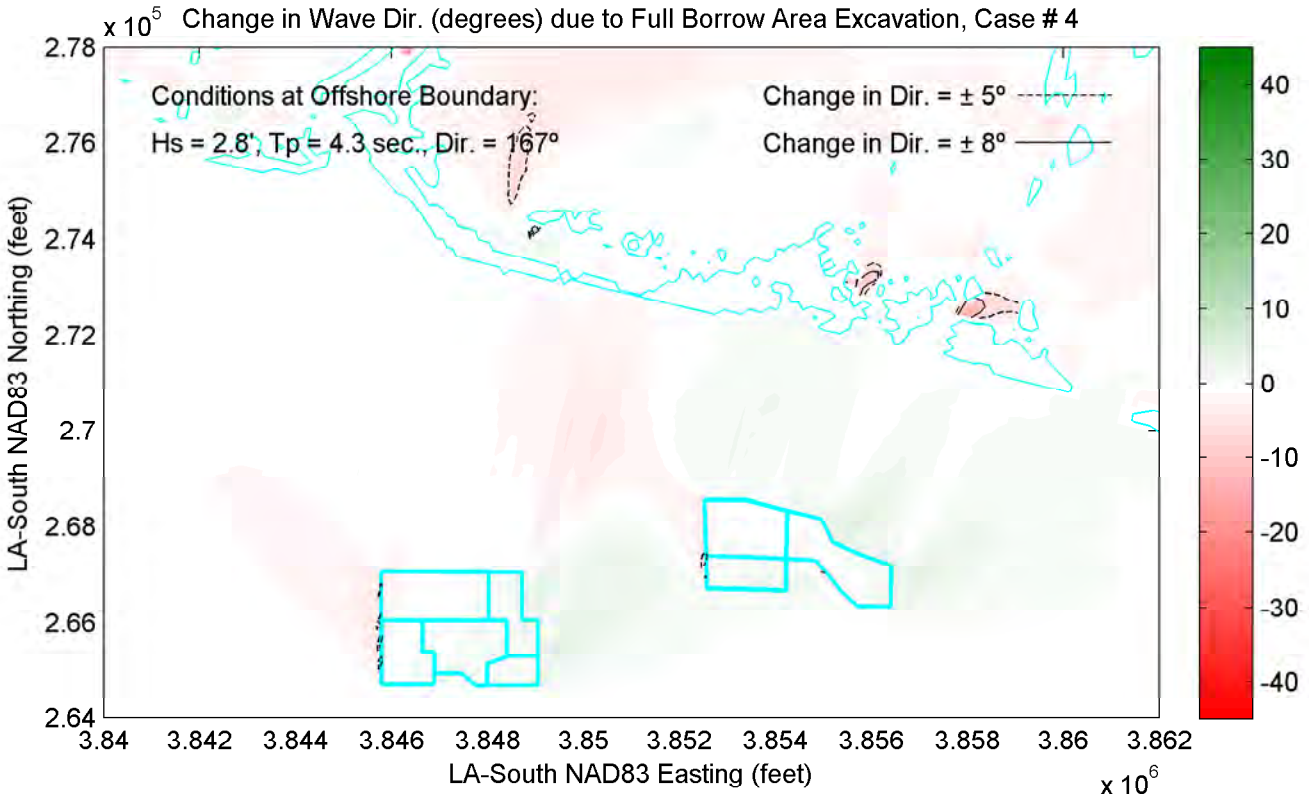
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 4
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 167°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
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3.856
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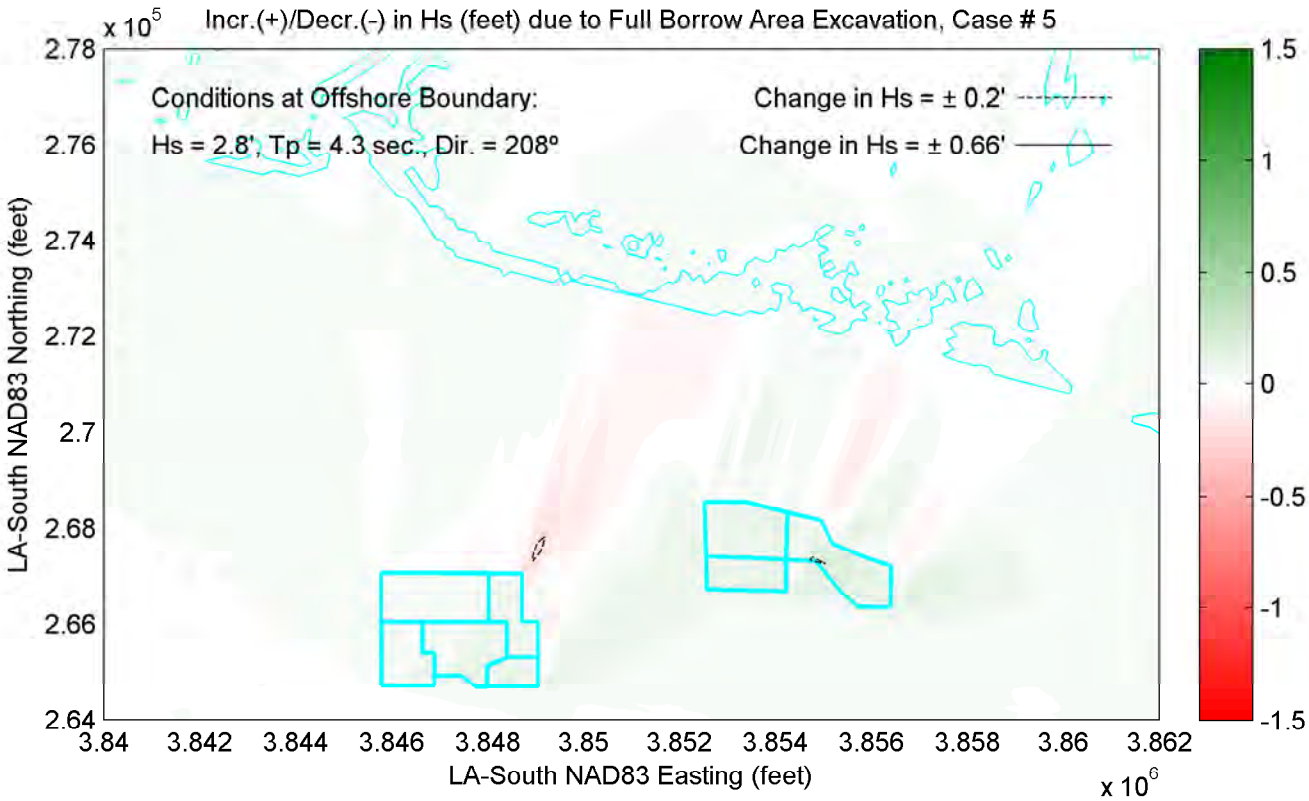
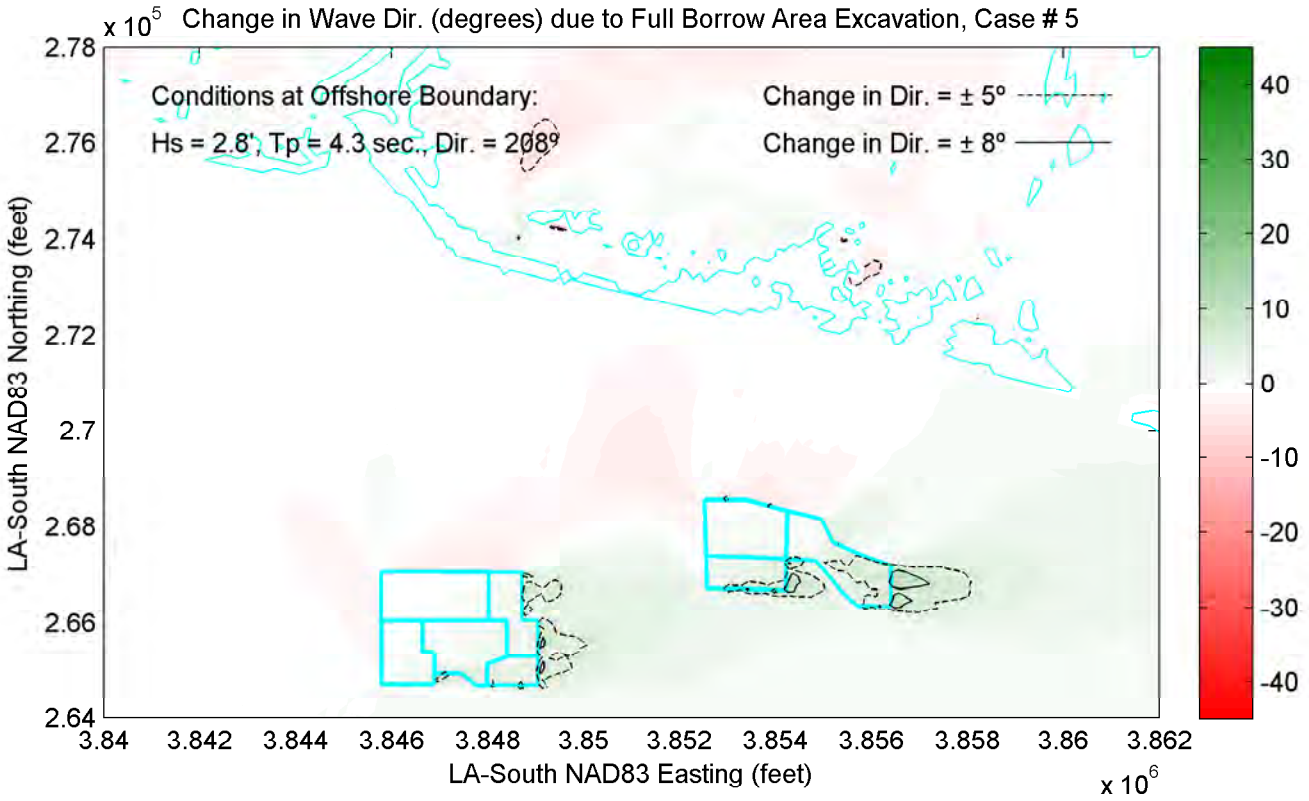

Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 5
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 208°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 5
x 10^5
Conditions at Offshore Boundary:
Hs = 2.8', Tp = 4.3 sec., Dir. = 208°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
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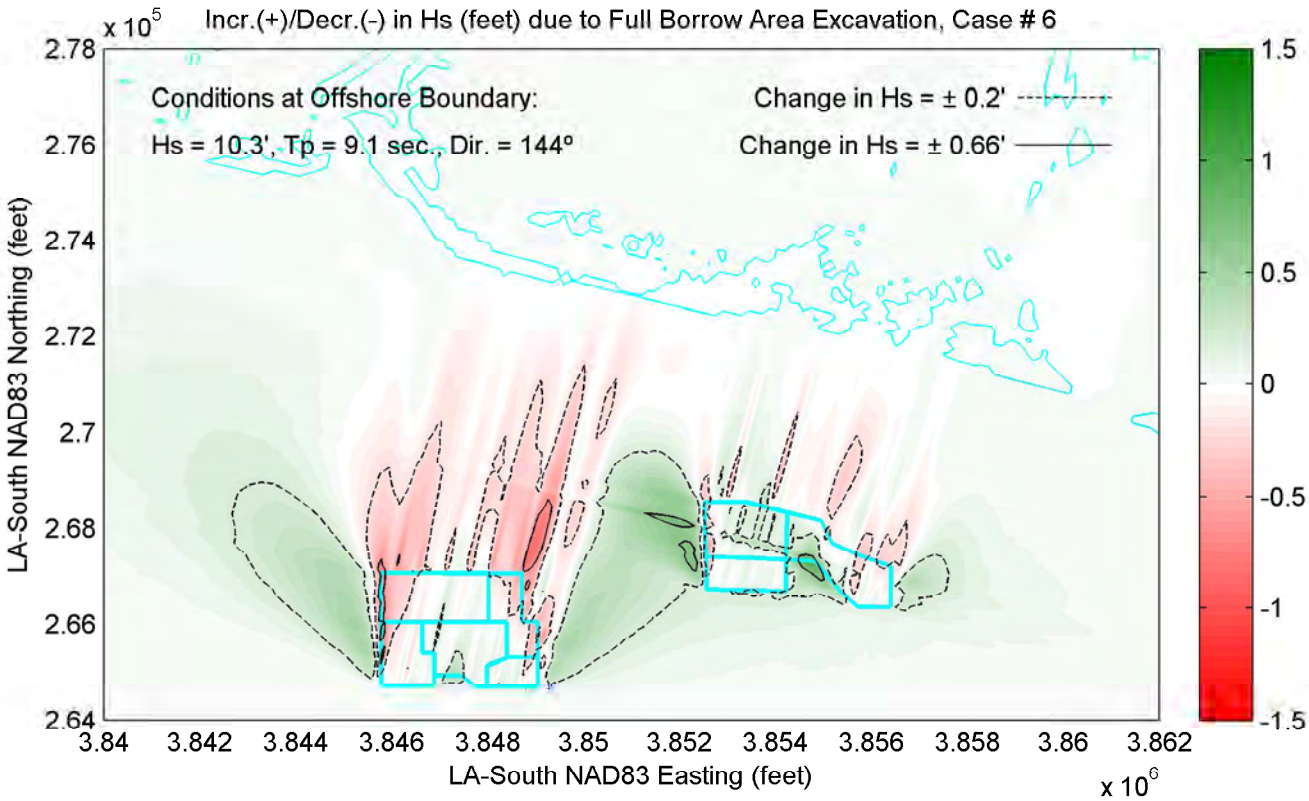
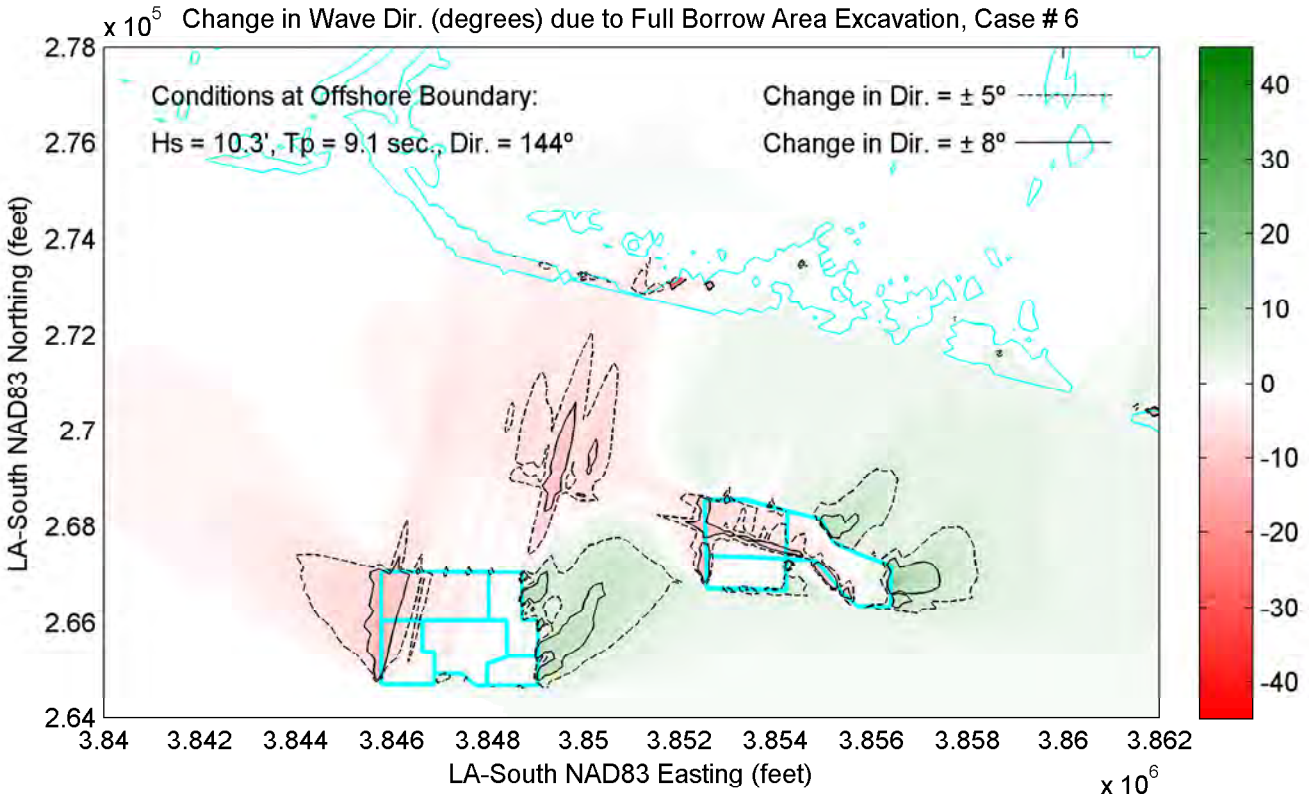
-40


Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 6
Conditions at Offshore Boundary:
Hs = 10.3', Tp = 9.1 sec., Dir. = 144°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 6
Conditions at Offshore Boundary:
Hs = 10.3', Tp = 9.1 sec., Dir. = 144°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
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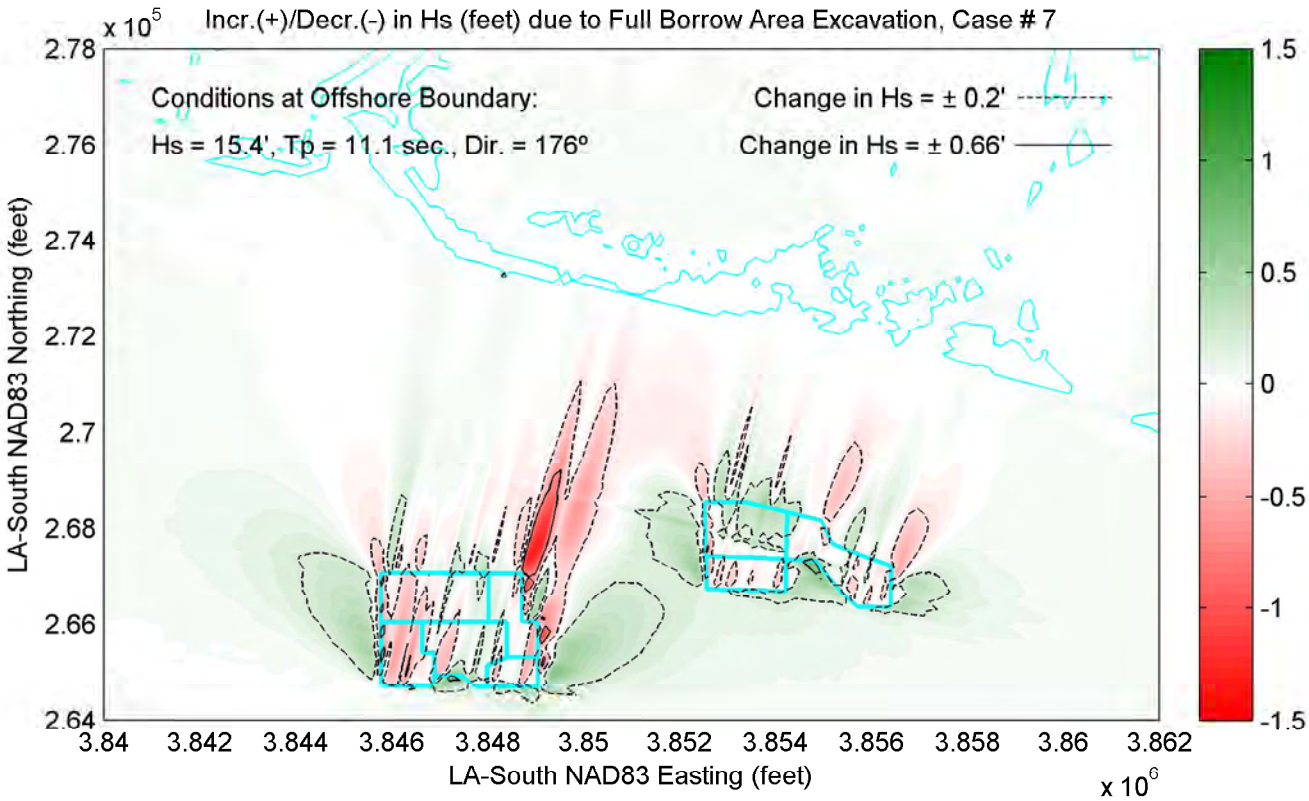
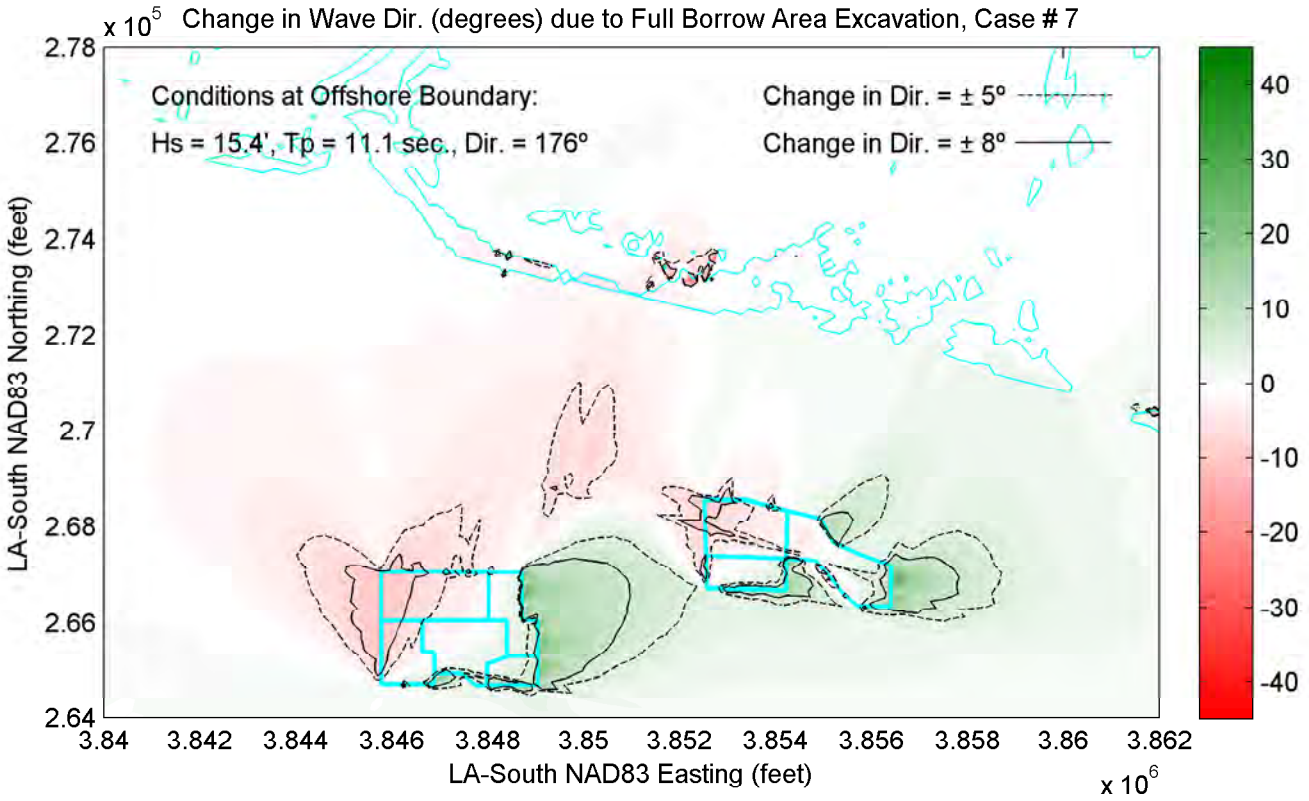
-40


Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 7
x 10^5
Conditions at Offshore Boundary:
Hs = 15.4', Tp = 11.1 sec., Dir. = 176°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 7
x 10^5
Conditions at Offshore Boundary:
Hs = 15.4', Tp = 11.1 sec., Dir. = 176°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
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3.862
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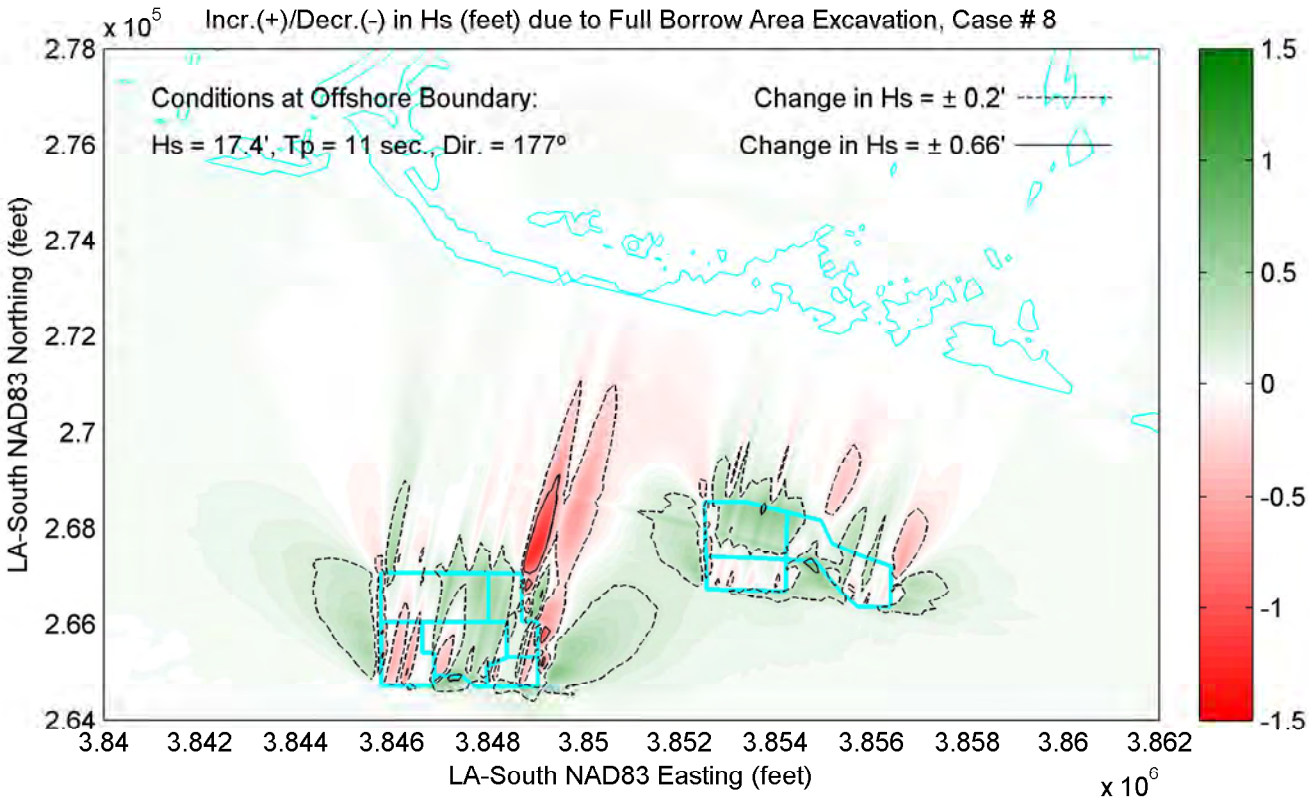
Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 8
x 10^5
Conditions at Offshore Boundary:
Hs = 17.4', Tp = 11 sec., Dir. = 177°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
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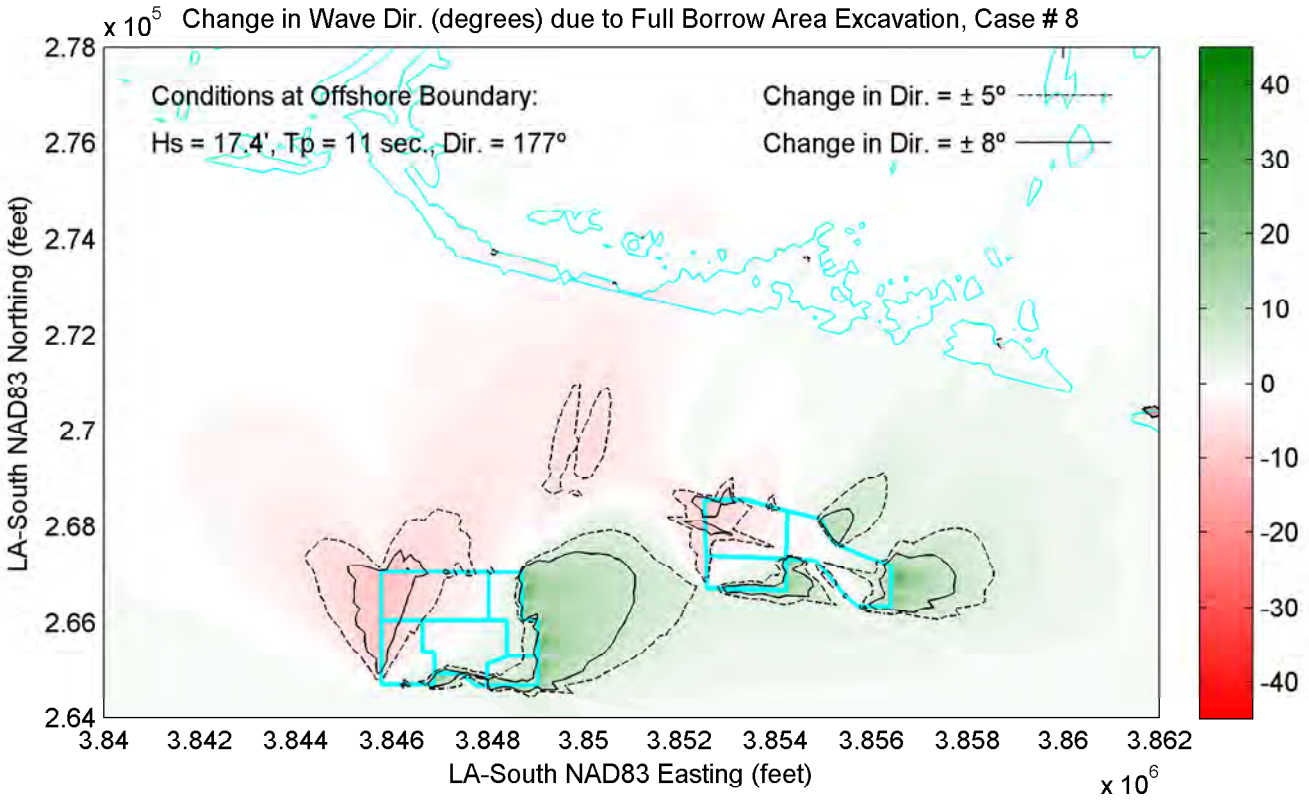
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 8
x 10^5
Conditions at Offshore Boundary:
Hs = 17.4', Tp = 11 sec., Dir. = 177°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
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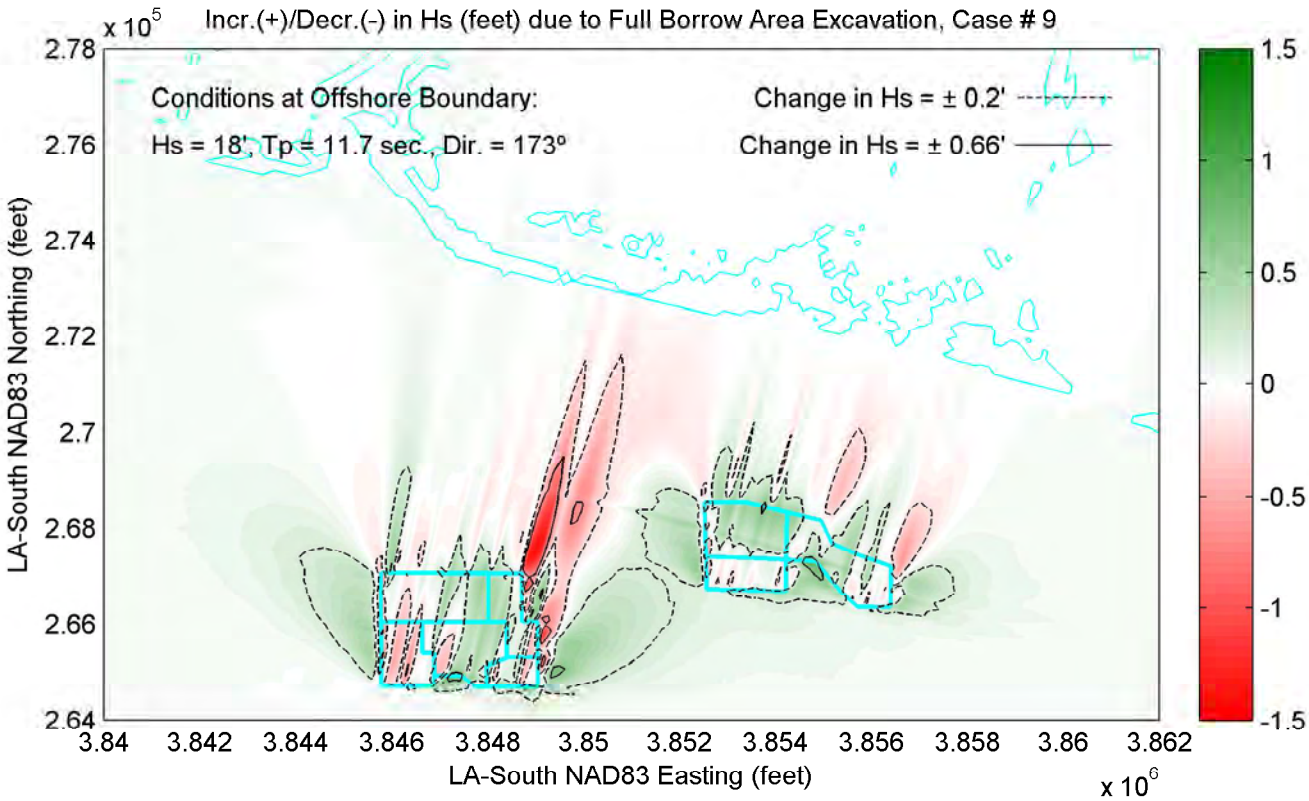
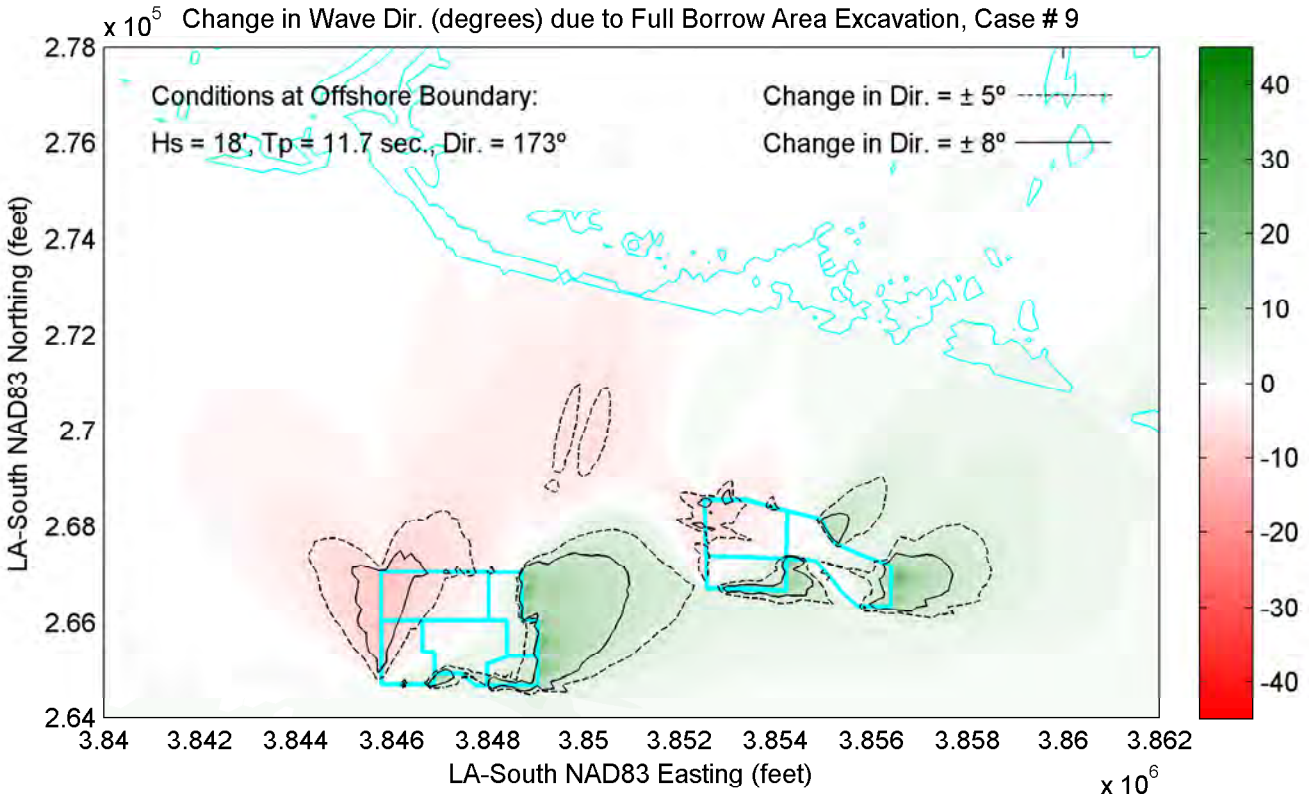
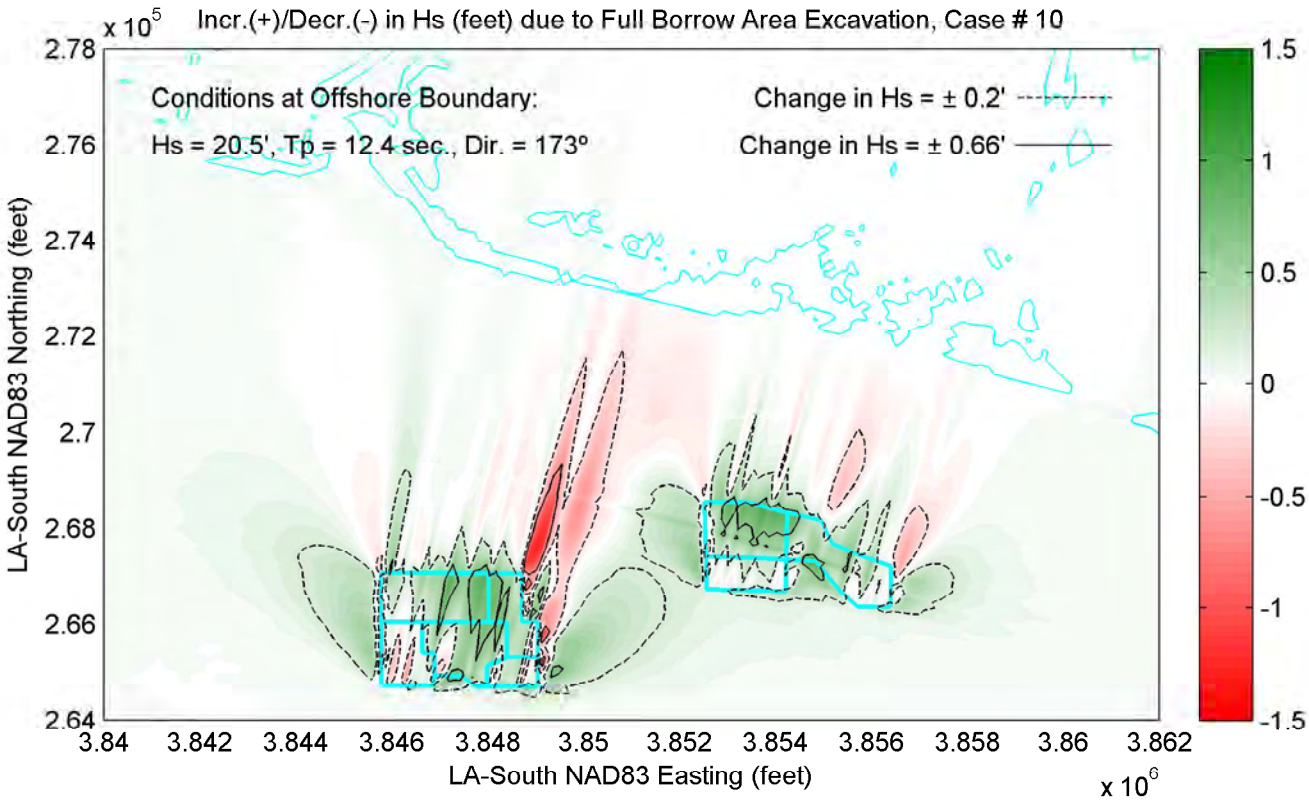

Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 9
x 10^5
Conditions at Offshore Boundary:
Hs = 18', Tp = 11.7 sec., Dir. = 173°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
1.5
1
0.5
0
-0.5
-1
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 9
x 10^5
Conditions at Offshore Boundary:
Hs = 18', Tp = 11.7 sec., Dir. = 173°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6
40
30
20
10
0
-10
-20
-30
-40


Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 10
Conditions at Offshore Boundary:
Hs = 20.5', Tp = 12.4 sec., Dir. = 173°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
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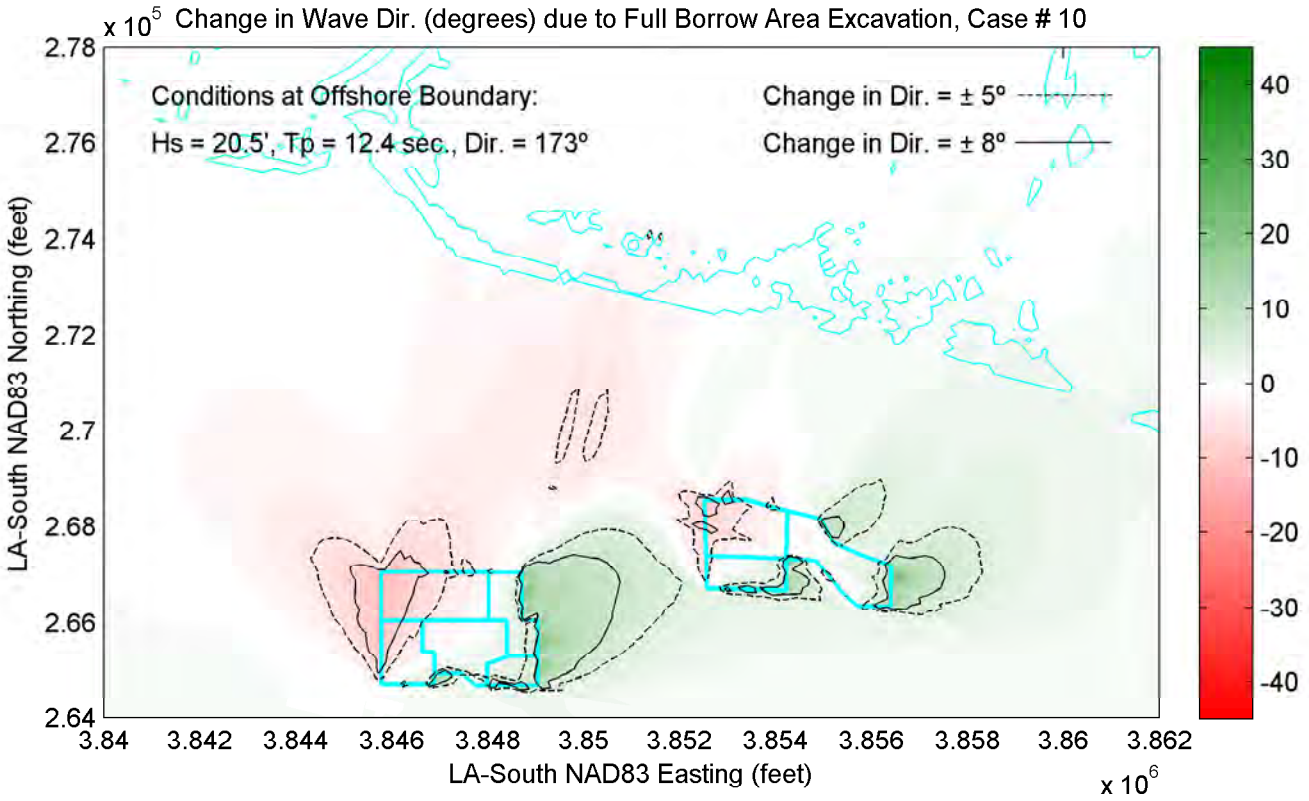
Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 10
Conditions at Offshore Boundary:
Hs = 20.5', Tp = 12.4 sec., Dir. = 173°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
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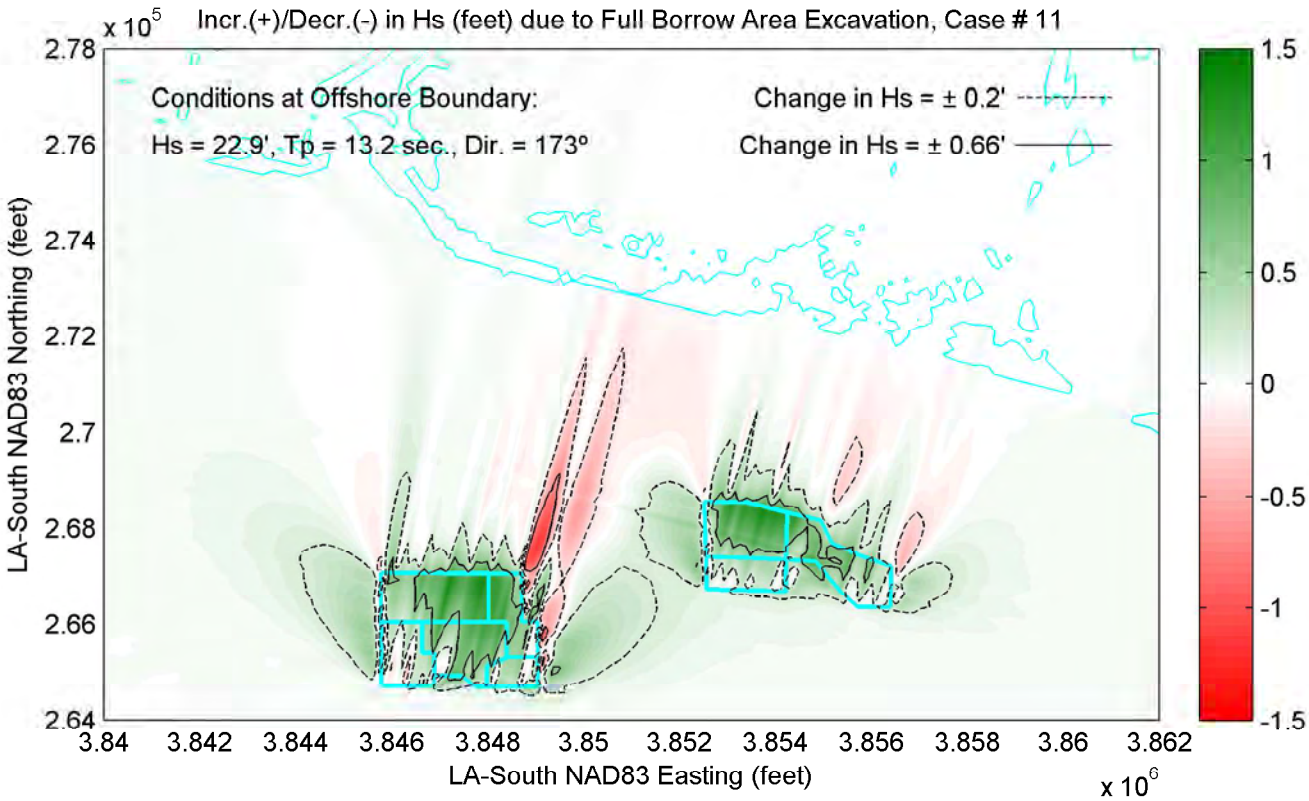
Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 11
Conditions at Offshore Boundary:
Hs = 22.9', Tp = 13.2 sec., Dir. = 173°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
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3.86
3.862
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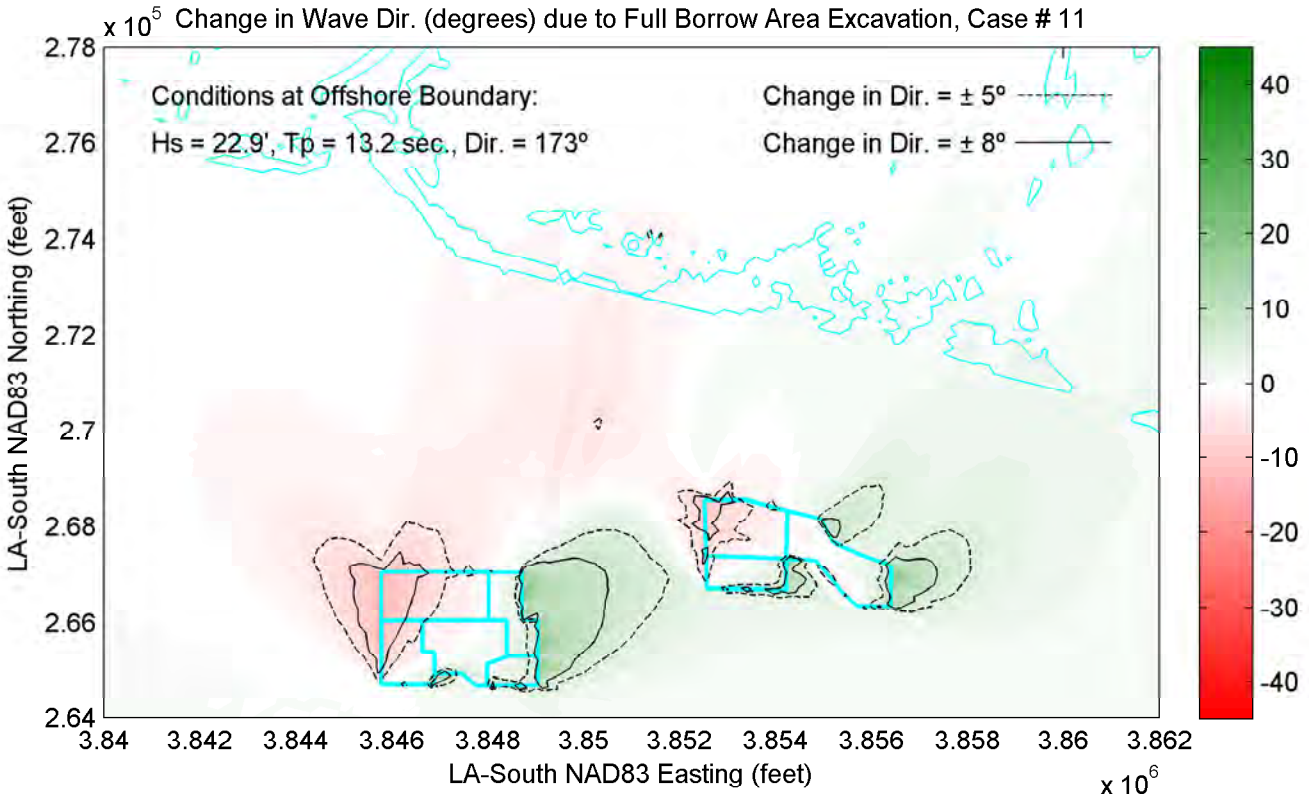
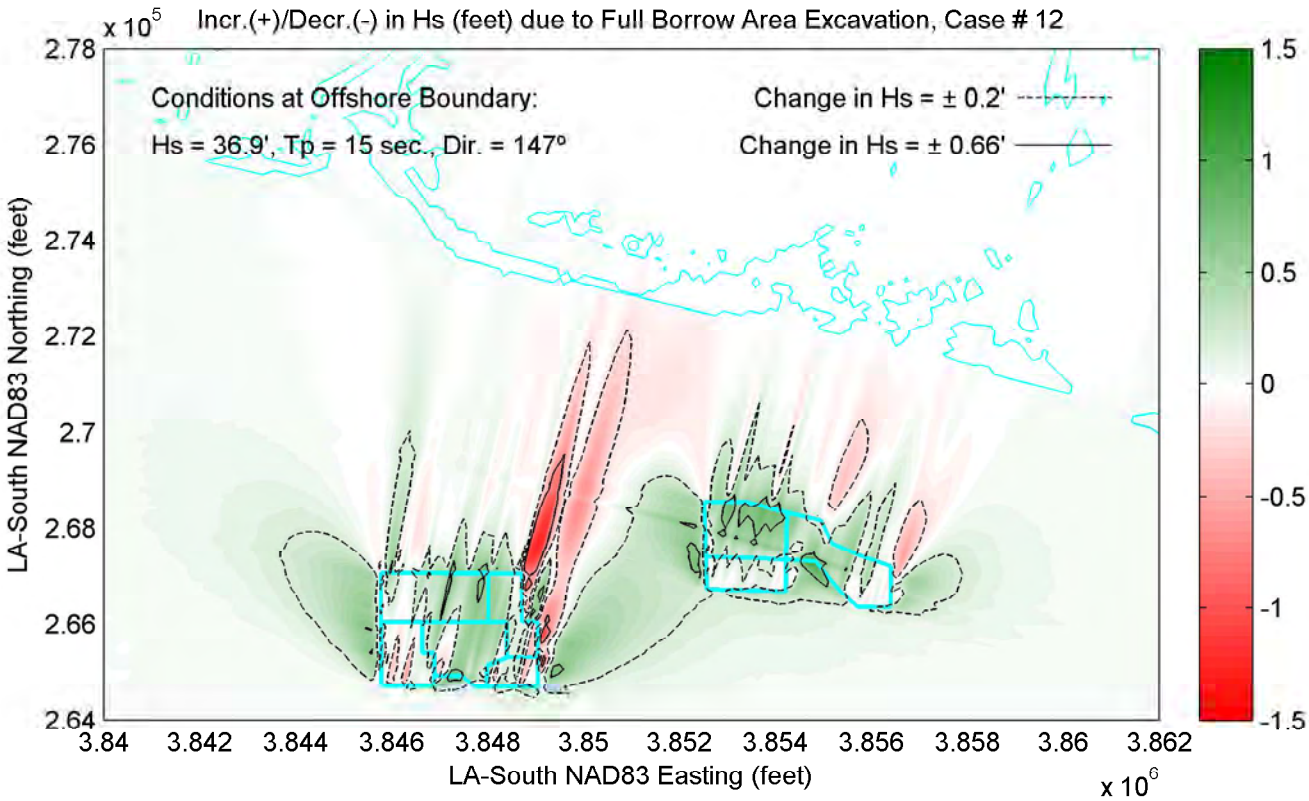
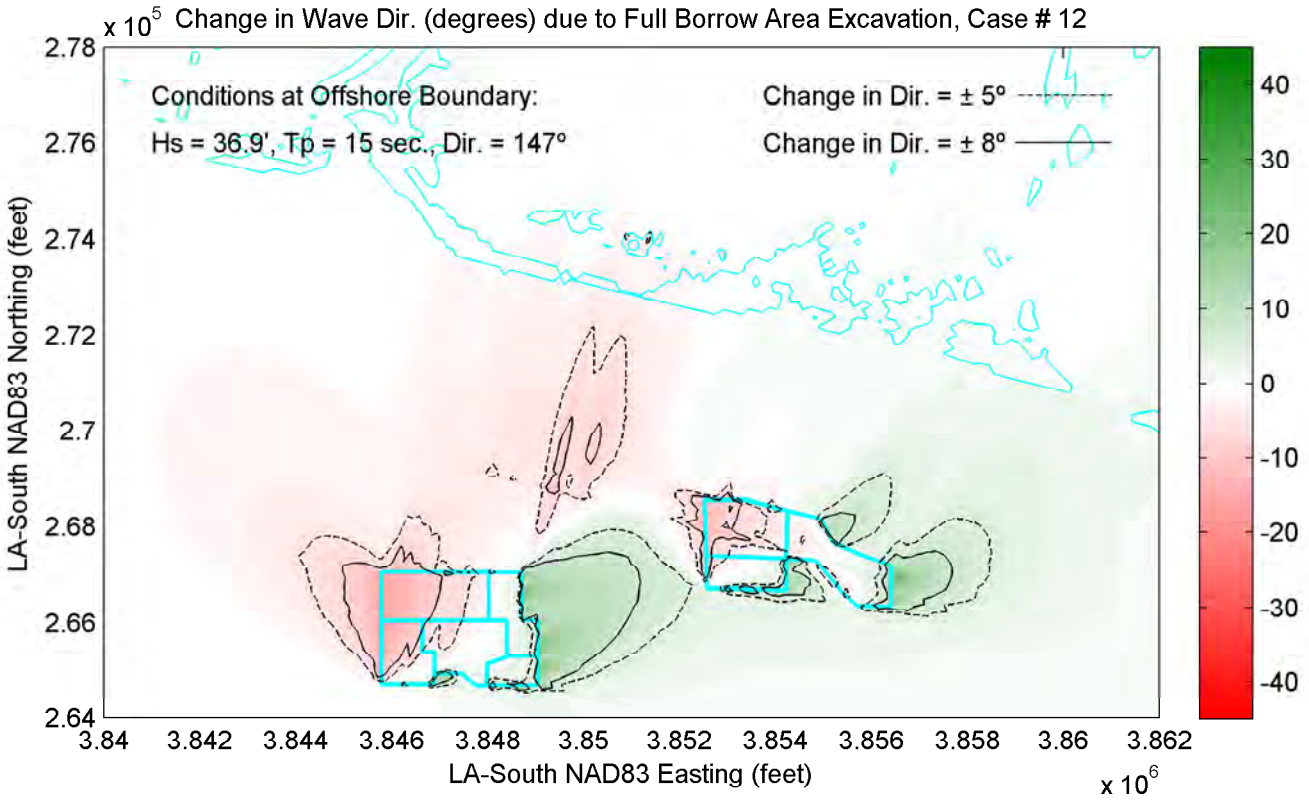
-1.5


Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 11
Conditions at Offshore Boundary:
Hs = 22.9', Tp = 13.2 sec., Dir. = 173°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^5
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
40
30
20
10
0
-10
-20
-30
-40

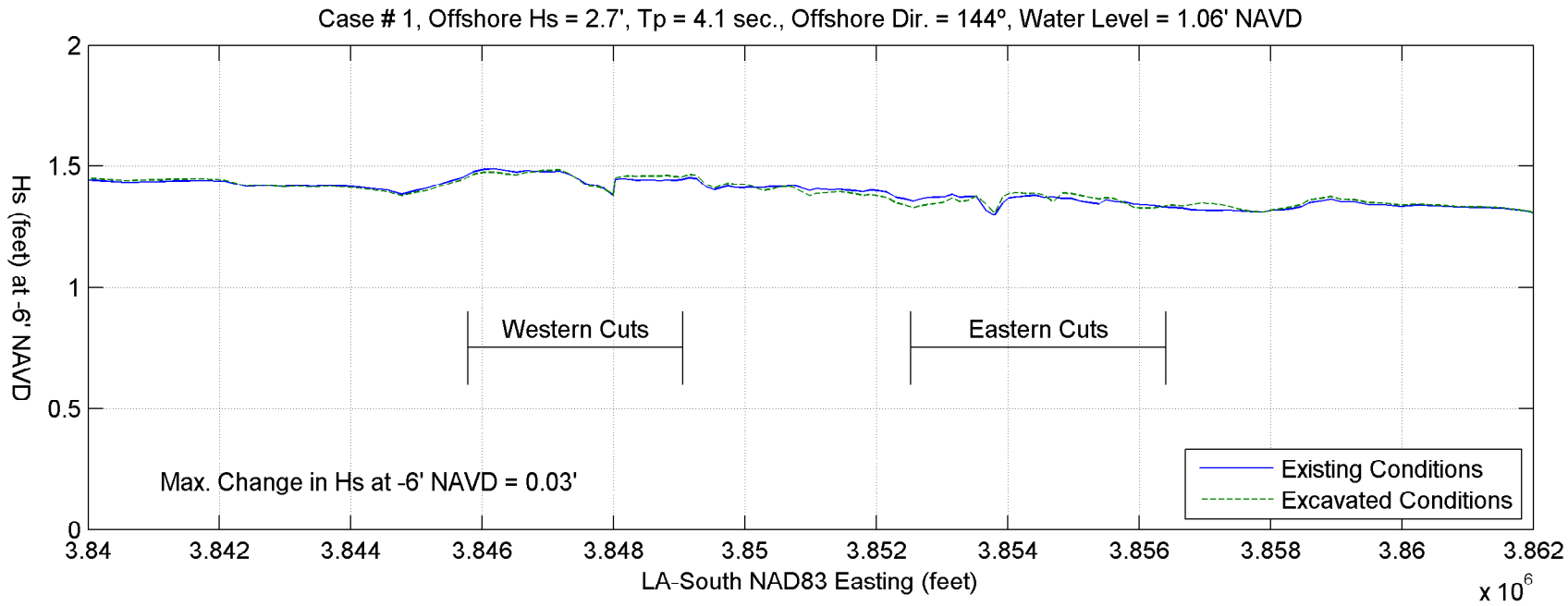

Incr.(+)/Decr.(-) in Hs (feet) due to Full Borrow Area Excavation, Case # 12
x 10^5
Conditions at Offshore Boundary:
Hs = 36.9', Tp = 15 sec., Dir. = 147°
Change in Hs = ± 0.2'
Change in Hs = ± 0.66'
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
1.5
1
0.5
0
-0.5
-1
-1.5

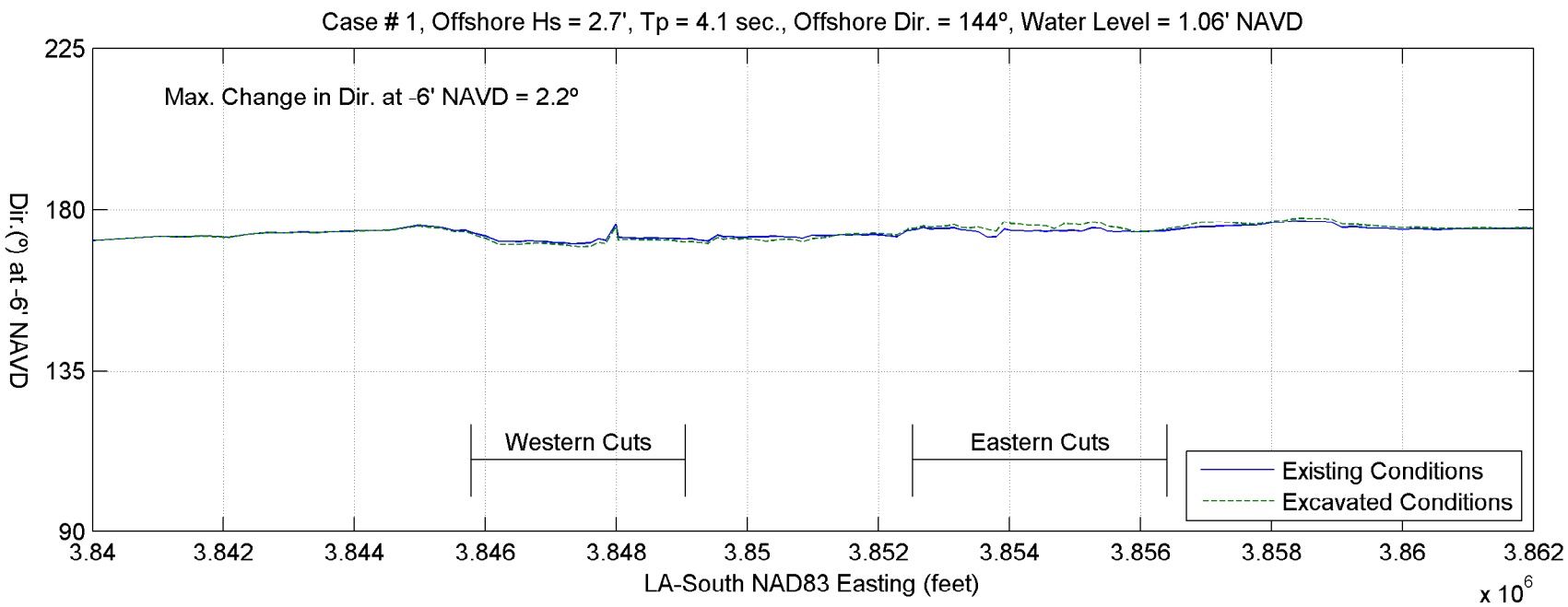

Change in Wave Dir. (degrees) due to Full Borrow Area Excavation, Case # 12
x 10^5
Conditions at Offshore Boundary:
Hs = 36.9', Tp = 15 sec., Dir. = 147°
Change in Dir. = ± 5°
Change in Dir. = ± 8°
LA-South NAD83 Northing (feet)
LA-South NAD83 Easting (feet)
x 10^6
2.78
2.76
2.74
2.72
2.7
2.68
2.66
2.64
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
40
30
20
10
0
-10
-20
-30
-40

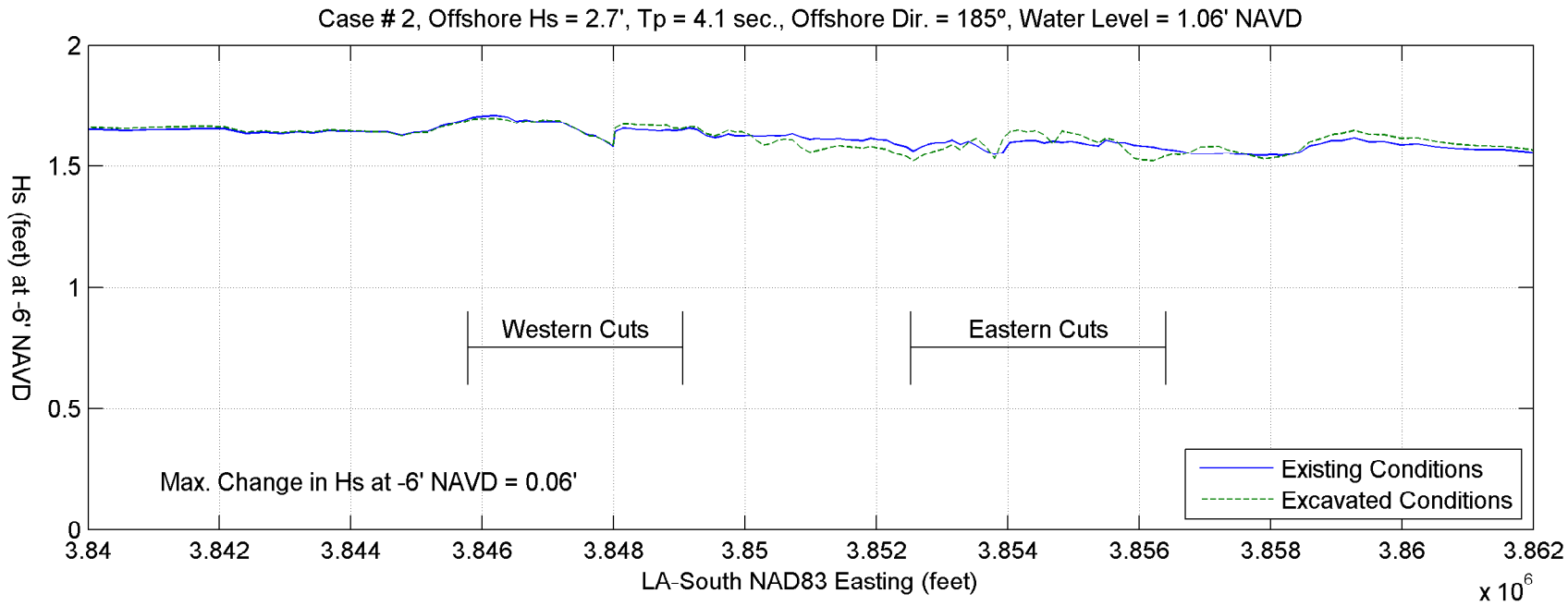
Sub-Appendix 9-2

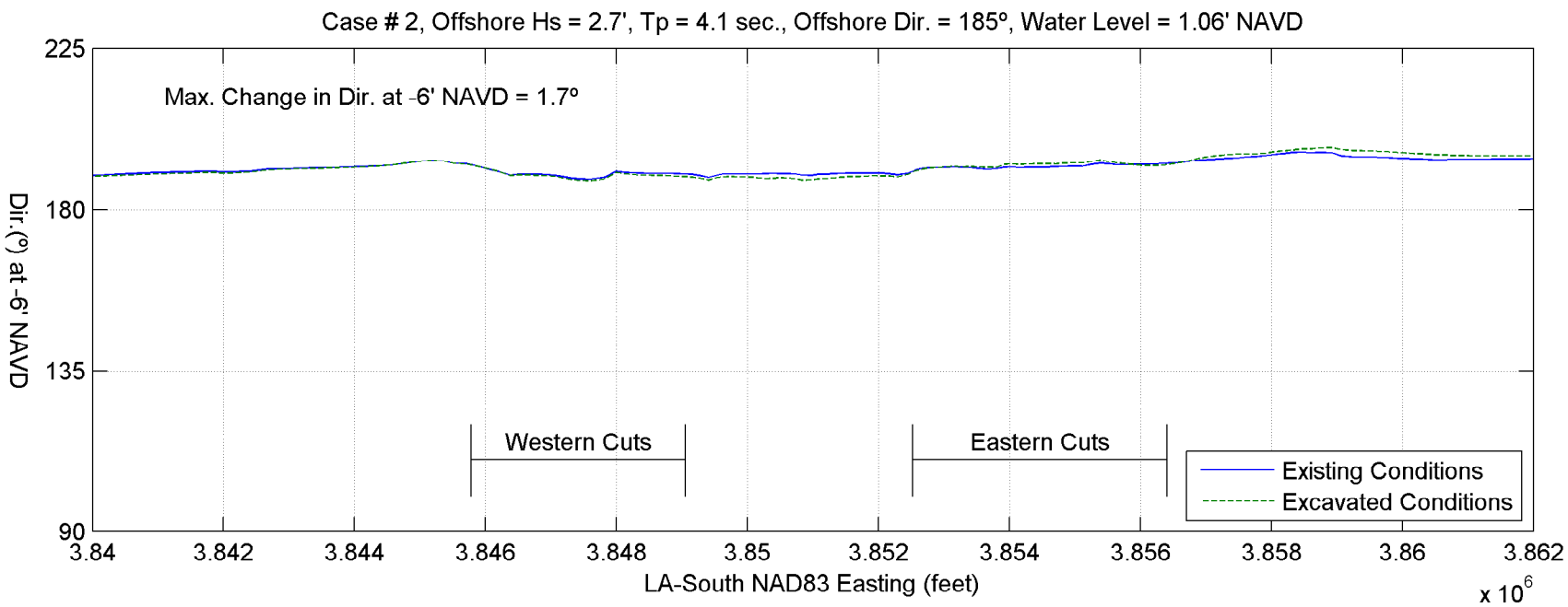
SWAN Model Results at the -6 foot NAVD Contour

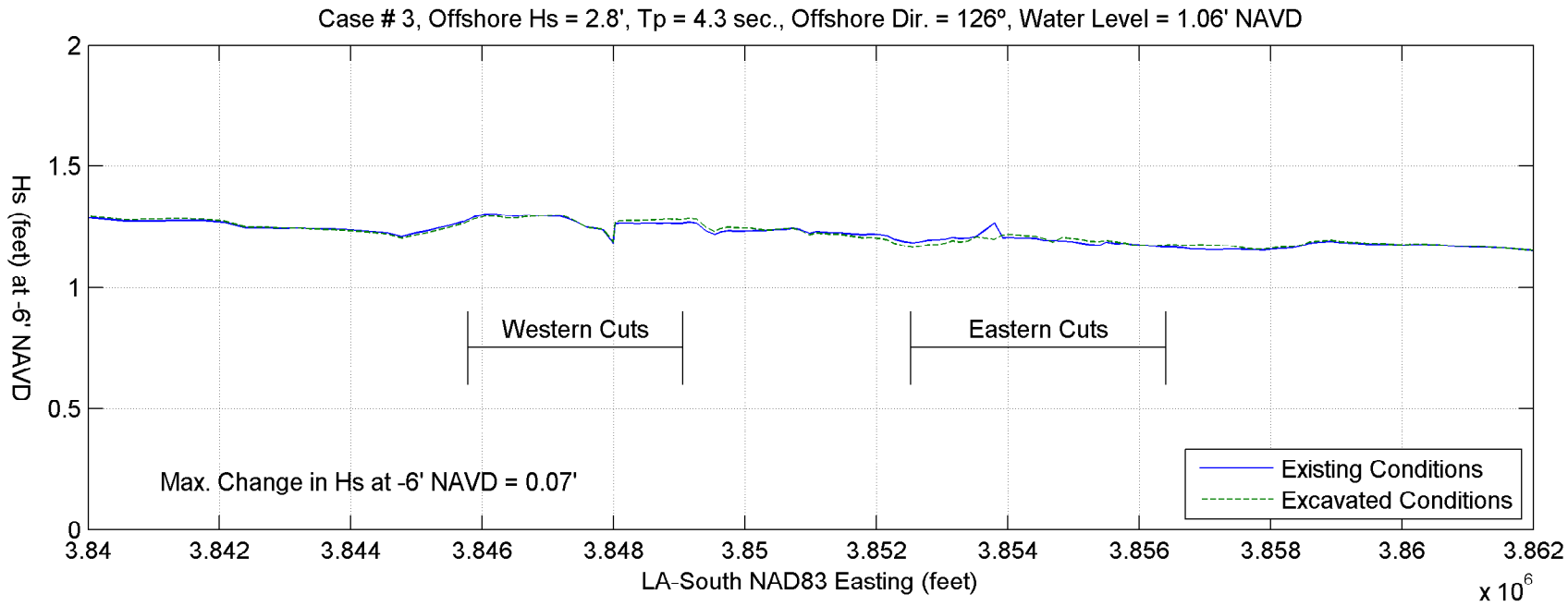
(approximately equal to the breaking depth)

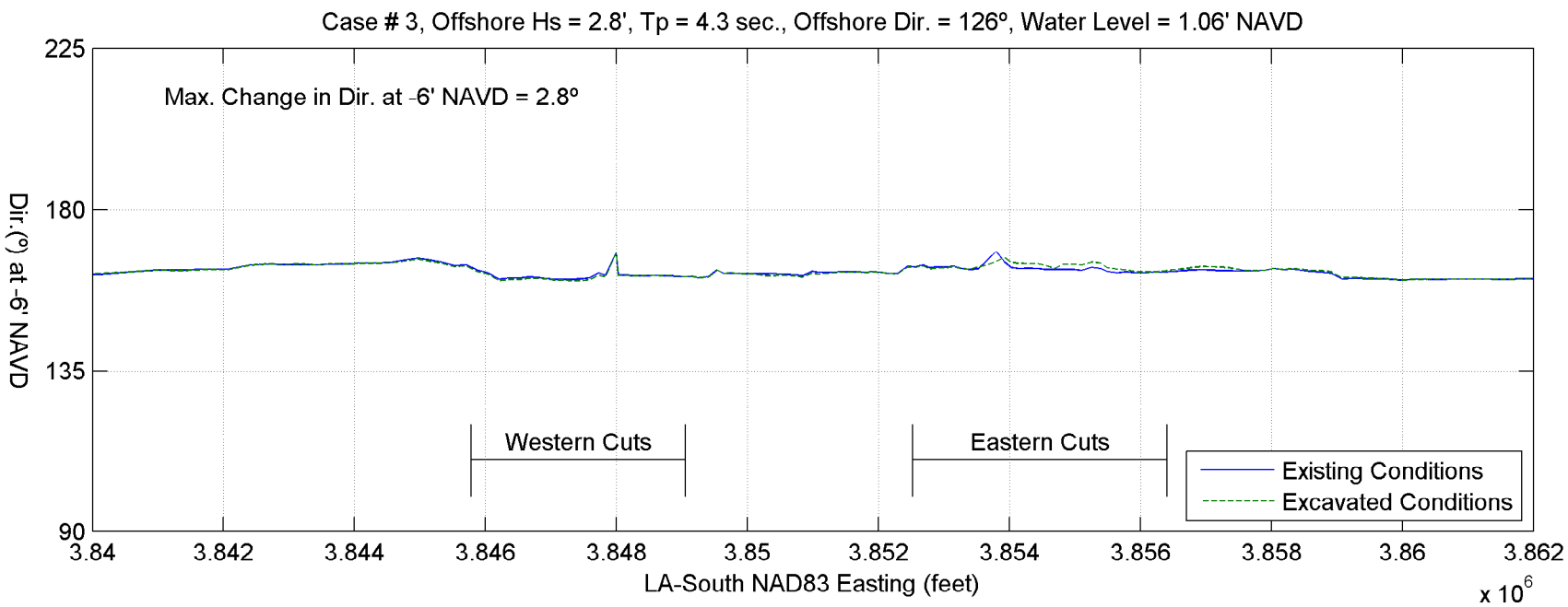

Case # 1, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 144º, Water Level = 1.06' NAVD
Hs (feet) at -6' NAVD
2
1.5
1
0.5
0
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.03'
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

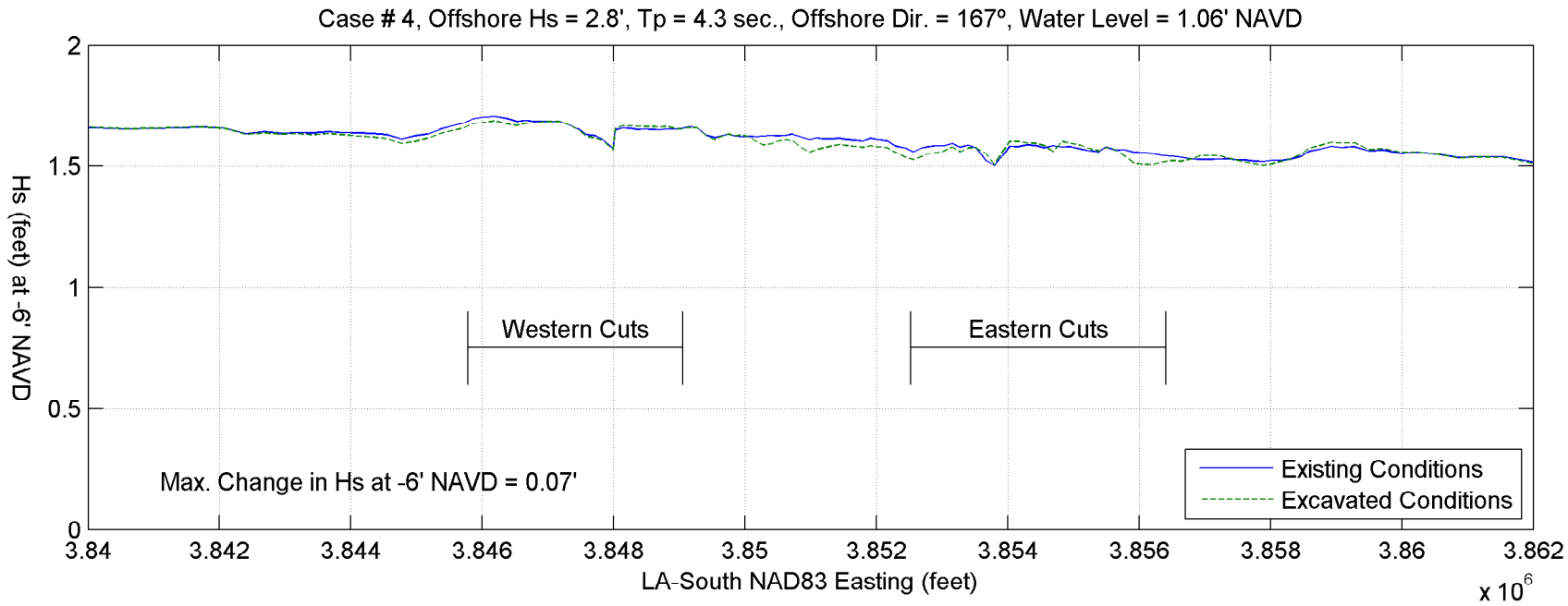

Case # 1, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 144º, Water Level = 1.06' NAVD
Dir.(º) at -6' NAVD
225
180
135
90
Max. Change in Dir. at -6' NAVD = 2.2º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

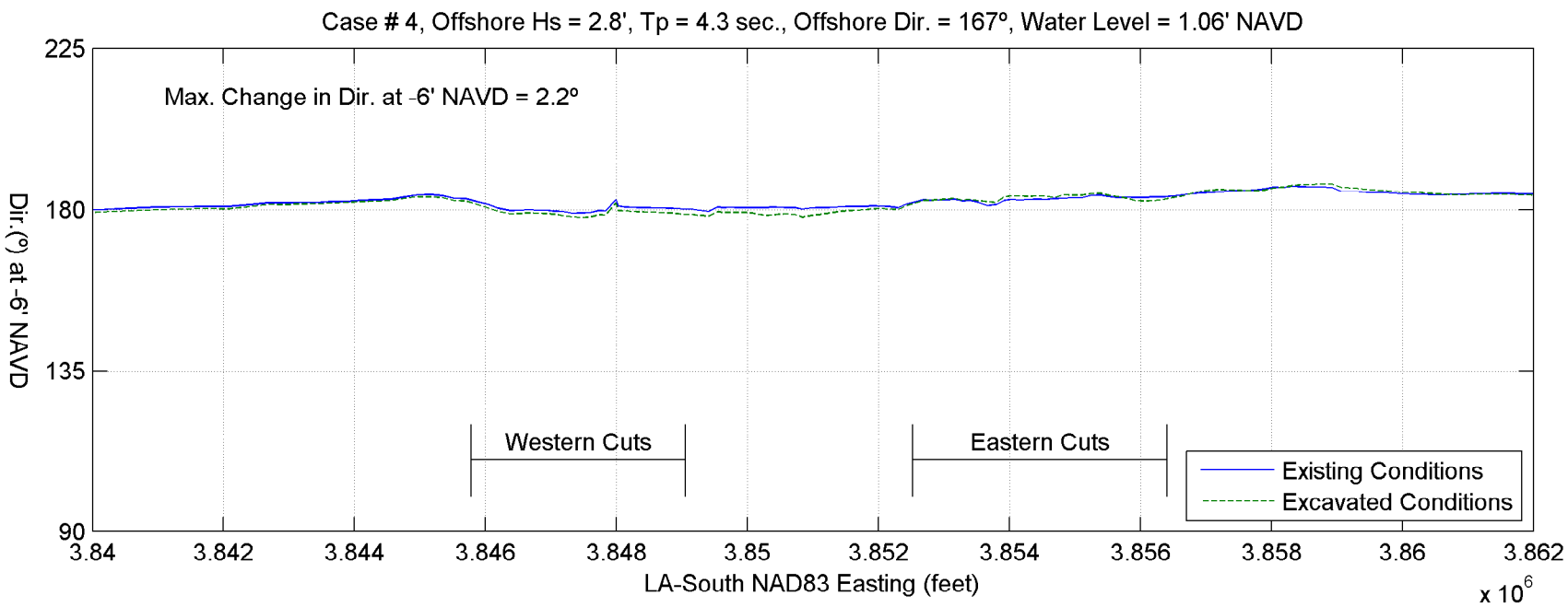

Case # 2, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 185º, Water Level = 1.06' NAVD
Hs (feet) at -6' NAVD
2
1.5
1
0.5
0
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.06'
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

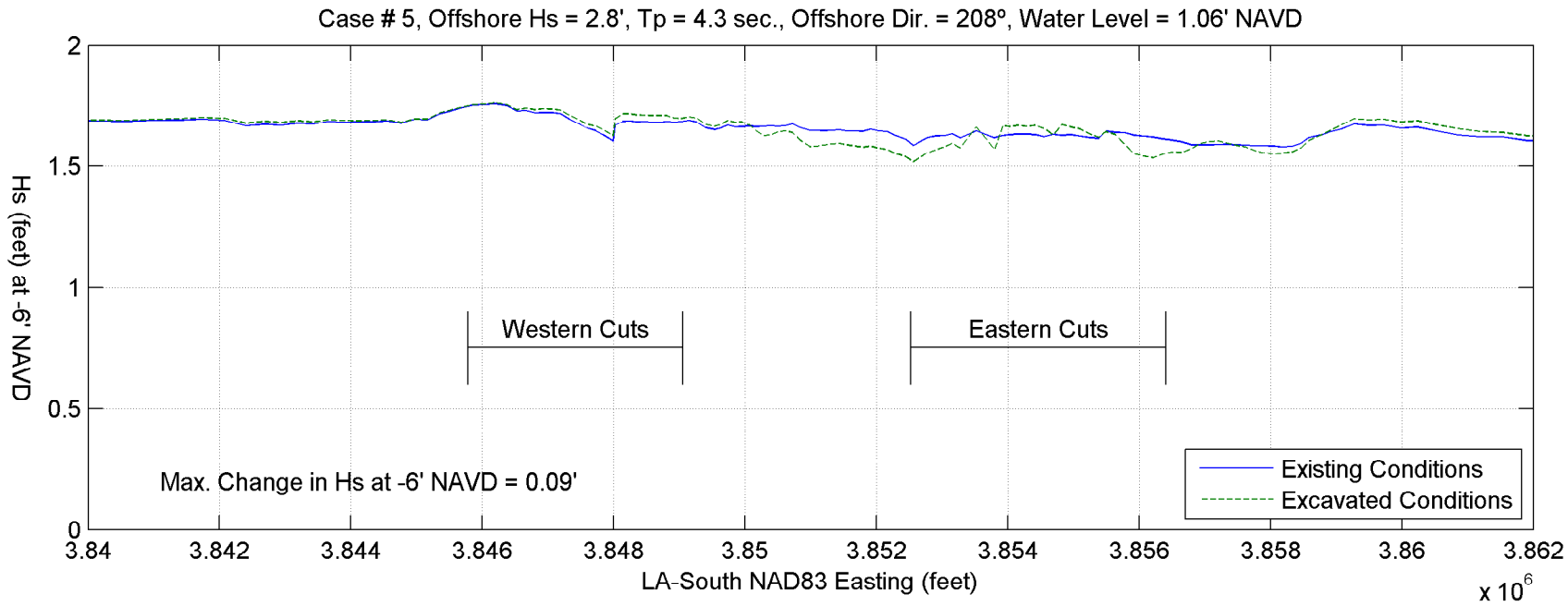

Case # 2, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 185º, Water Level = 1.06' NAVD
Dir.(º) at -6' NAVD
225
180
135
90
Max. Change in Dir. at -6' NAVD = 1.7º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

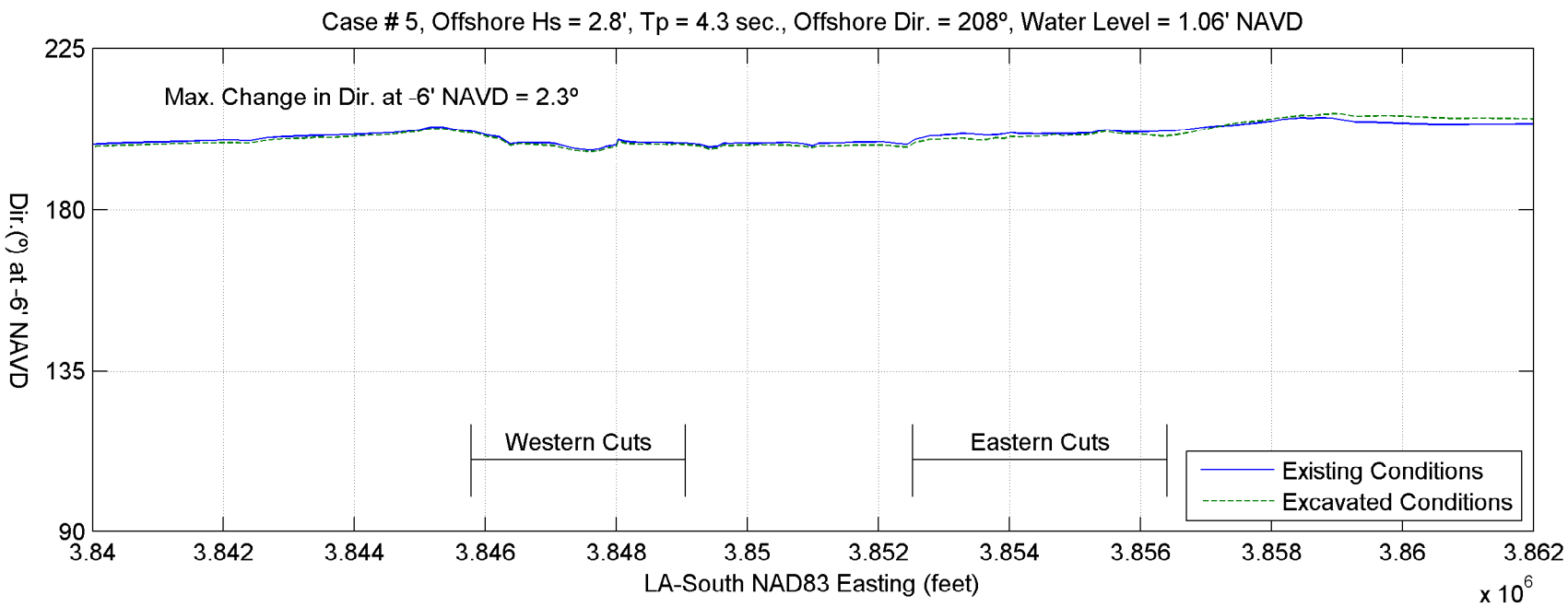

Case # 3, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 126º, Water Level = 1.06' NAVD
Hs (feet) at -6' NAVD
2
1.5
1
0.5
0
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.07'
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

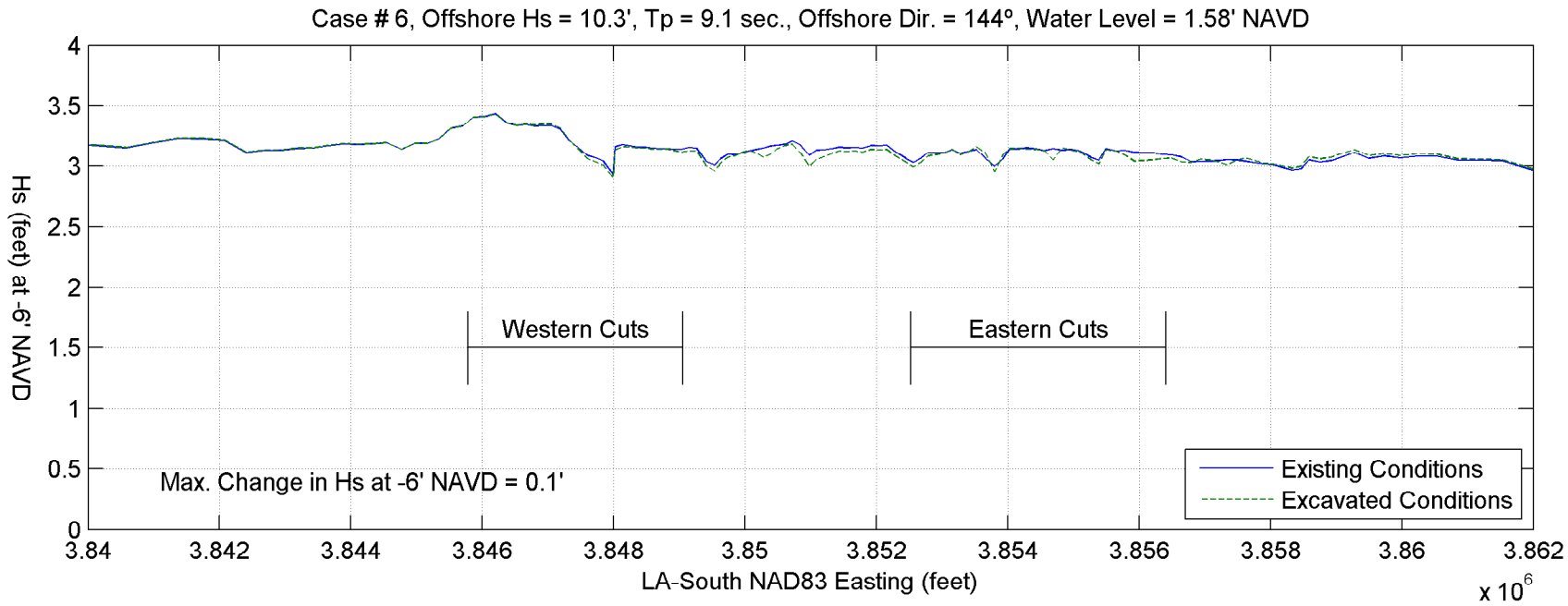

Case # 3, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 126º, Water Level = 1.06' NAVD
Dir.(º) at -6' NAVD
225
180
135
90
Max. Change in Dir. at -6' NAVD = 2.8º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

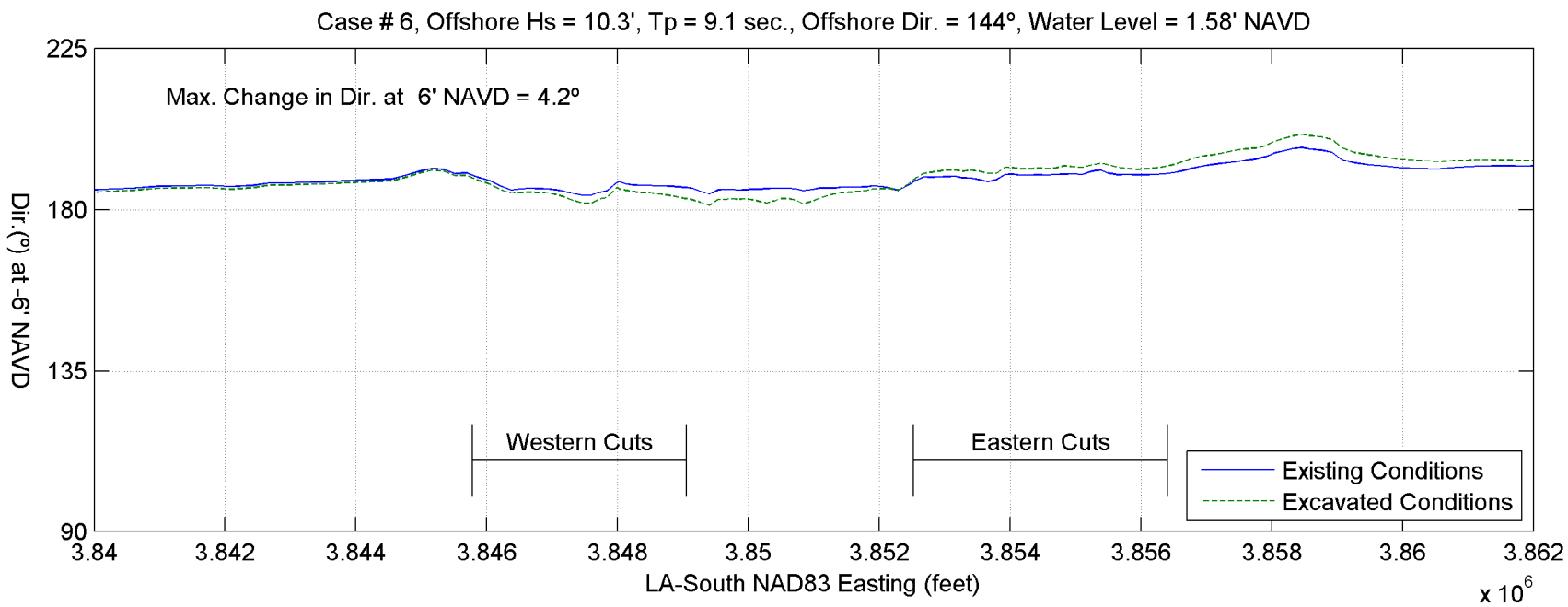

Case # 4, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 167º, Water Level = 1.06' NAVD
Hs (feet) at -6' NAVD
2
1.5
1
0.5
0
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.07'
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

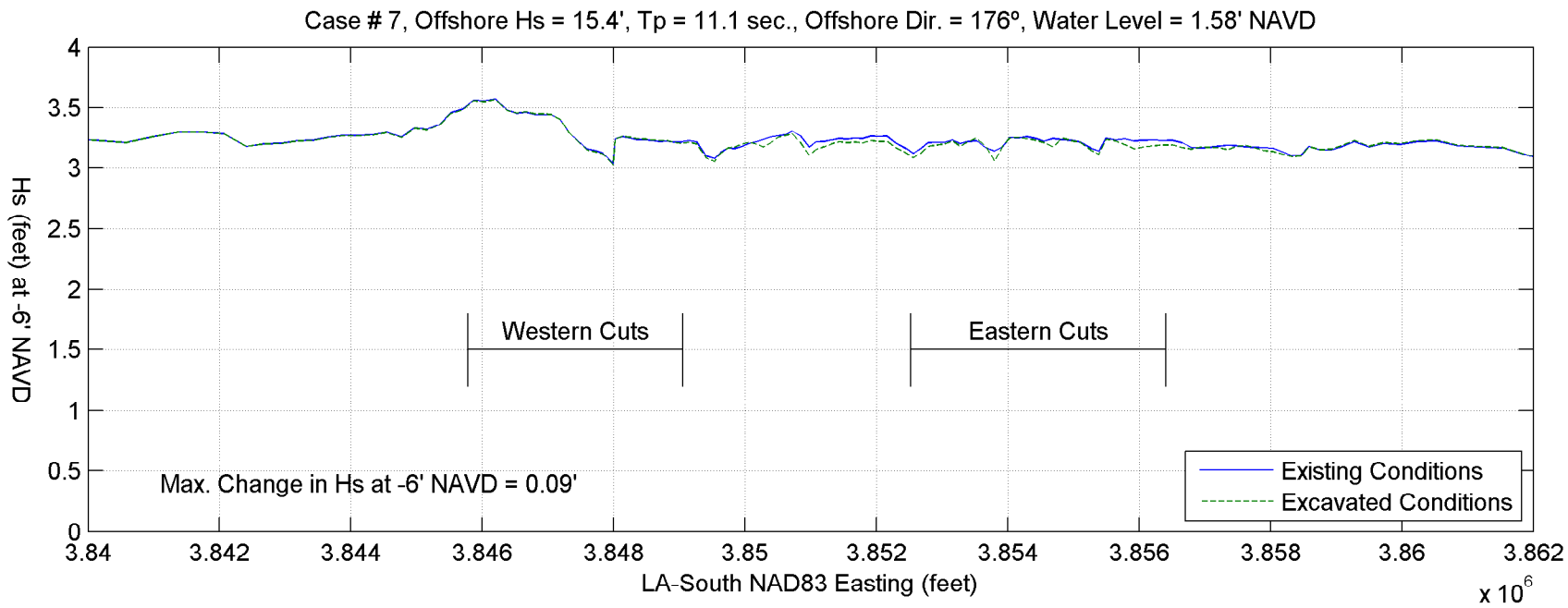

Case # 4, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 167º, Water Level = 1.06' NAVD
Dir.(º) at -6' NAVD
225
180
135
90
Max. Change in Dir. at -6' NAVD = 2.2º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

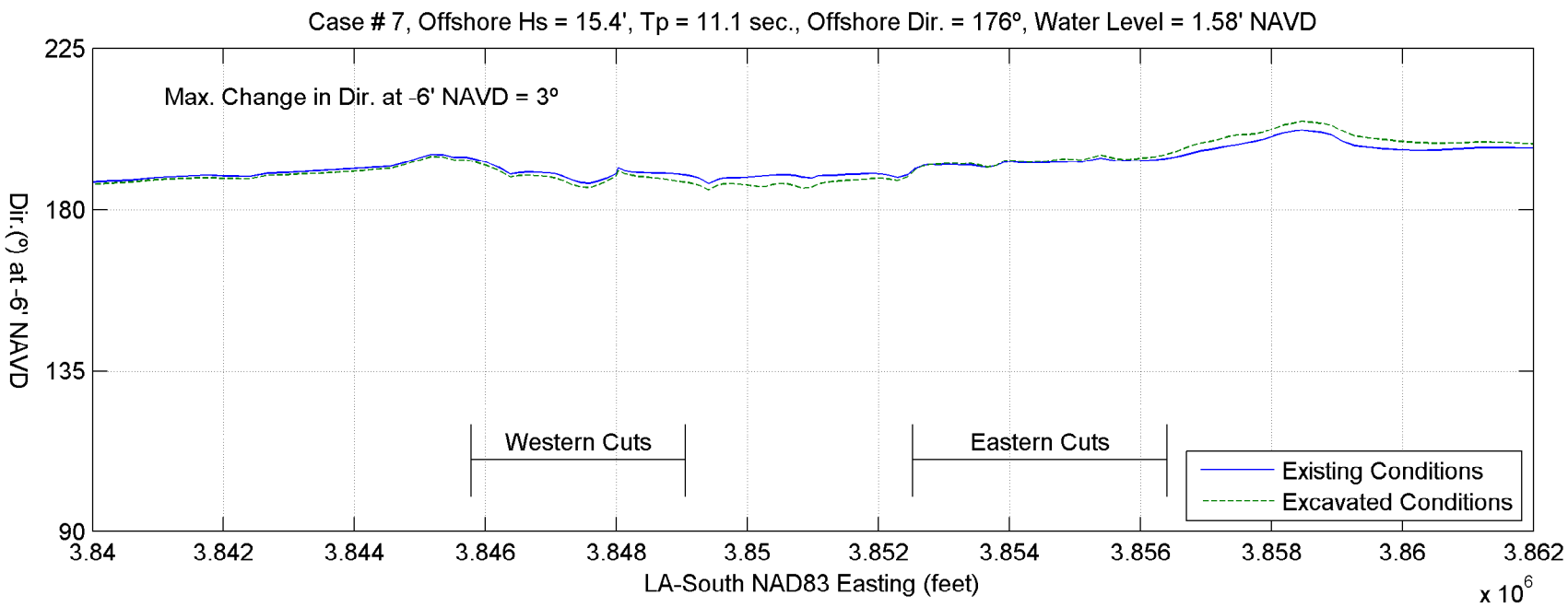

Case # 5, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 208º, Water Level = 1.06' NAVD
Hs (feet) at -6' NAVD
2
1.5
1
0.5
0
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.09'
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

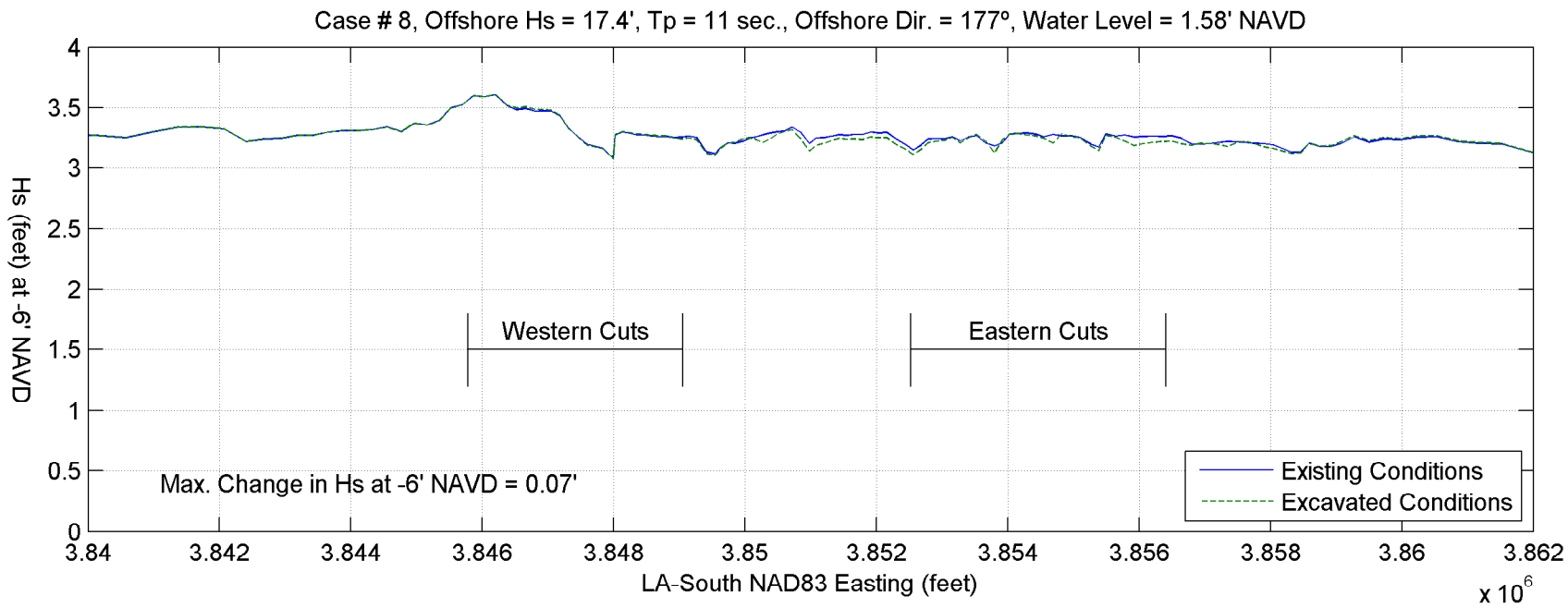

Case # 5, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 208º, Water Level = 1.06' NAVD
Dir.(º) at -6' NAVD
225
180
135
90
Max. Change in Dir. at -6' NAVD = 2.3º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

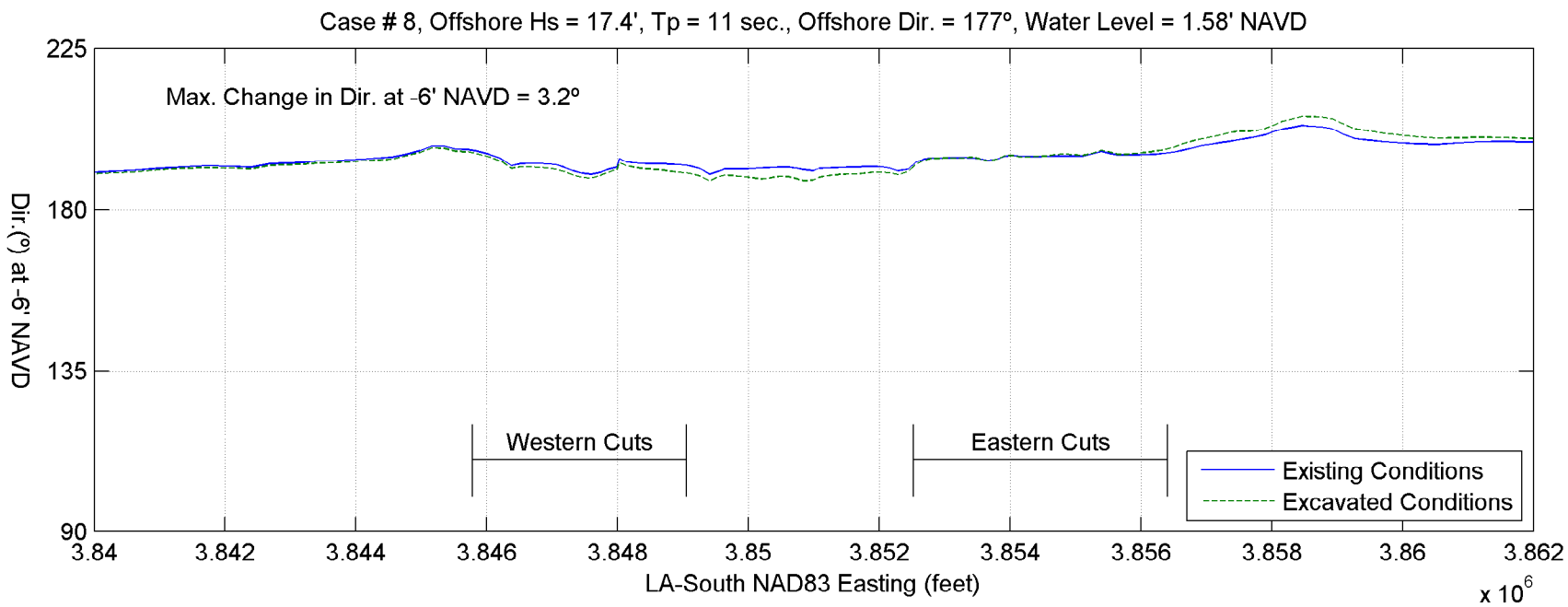

Case # 6, Offshore Hs = 10.3', Tp = 9.1 sec., Offshore Dir. = 144º, Water Level = 1.58' NAVD
Hs (feet) at -6' NAVD
4
3.5
3
2.5
2
1.5
1
0.5
0
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.1'
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

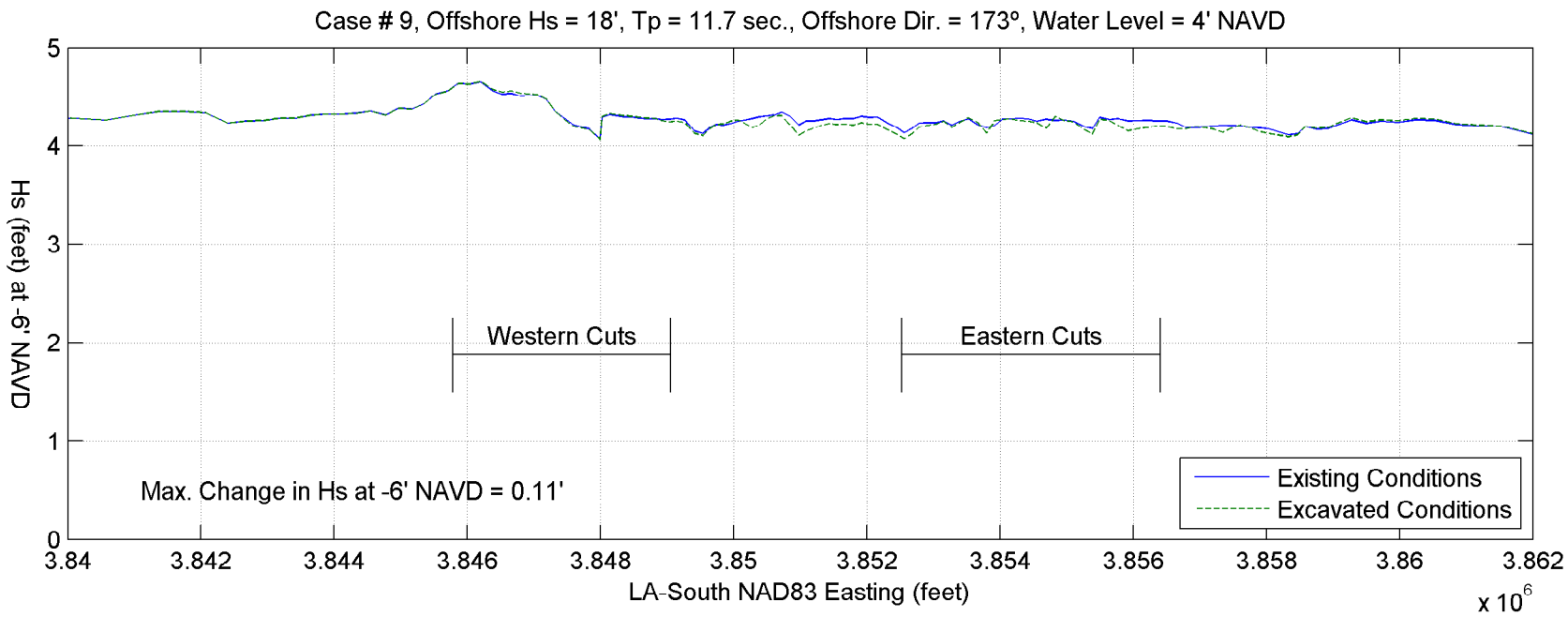

Case # 6, Offshore Hs = 10.3', Tp = 9.1 sec., Offshore Dir. = 144º, Water Level = 1.58' NAVD
Dir.(º) at -6' NAVD
225
180
135
90
Max. Change in Dir. at -6' NAVD = 4.2º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

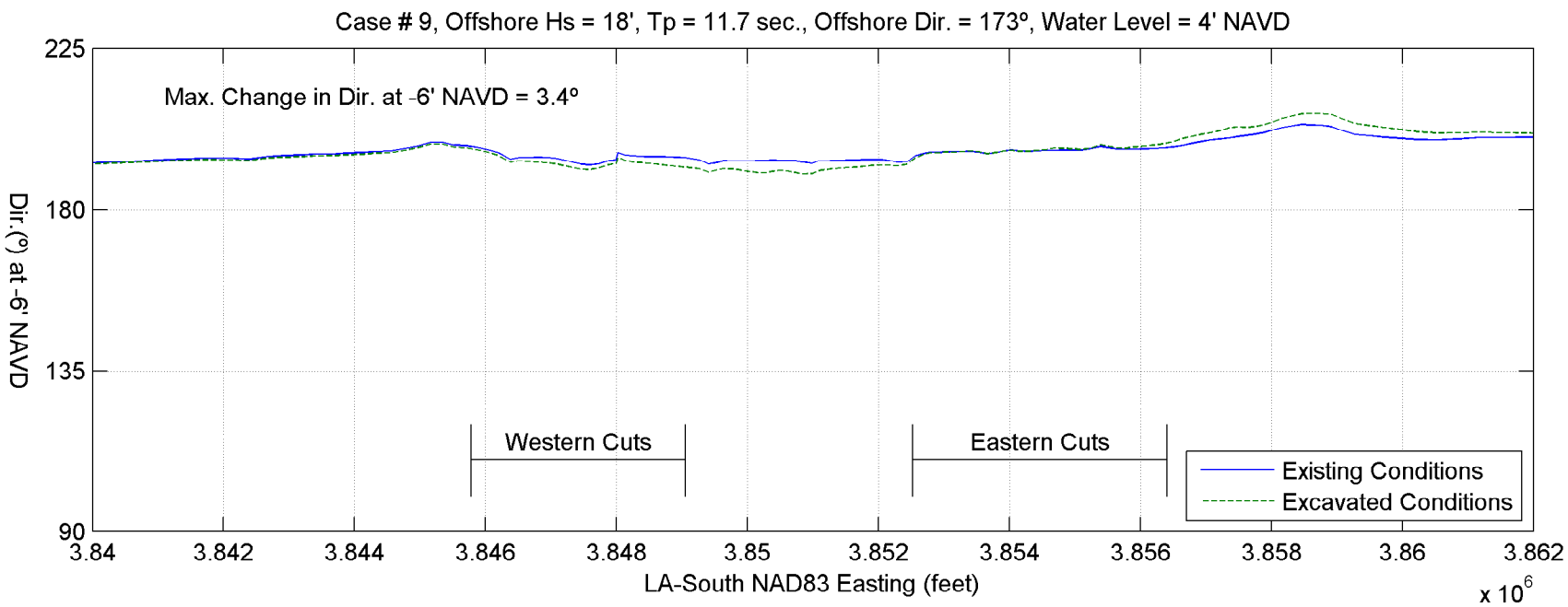

Case # 7, Offshore Hs = 15.4', Tp = 11.1 sec., Offshore Dir. = 176º, Water Level = 1.58' NAVD
Hs (feet) at -6' NAVD
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.09'
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

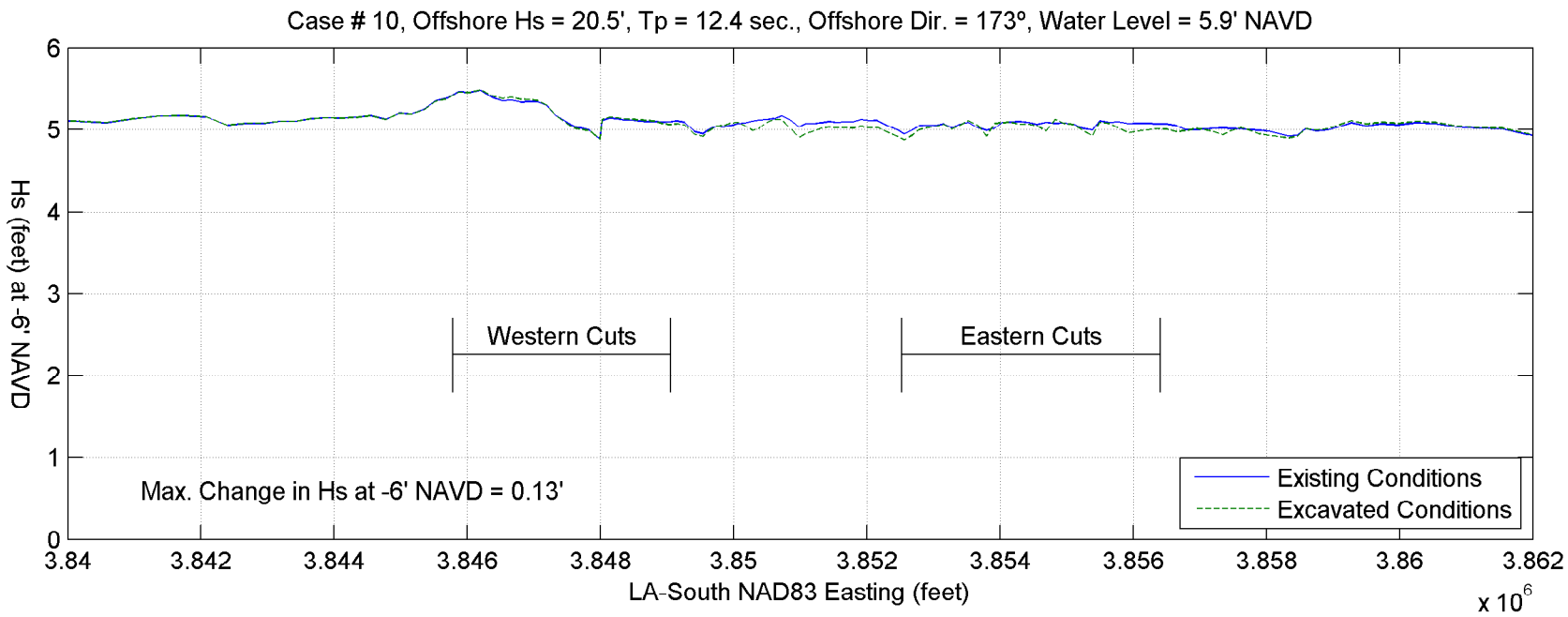

Case # 7, Offshore Hs = 15.4', Tp = 11.1 sec., Offshore Dir. = 176º, Water Level = 1.58' NAVD
Dir.(º) at -6' NAVD
Max. Change in Dir. at -6' NAVD = 3º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

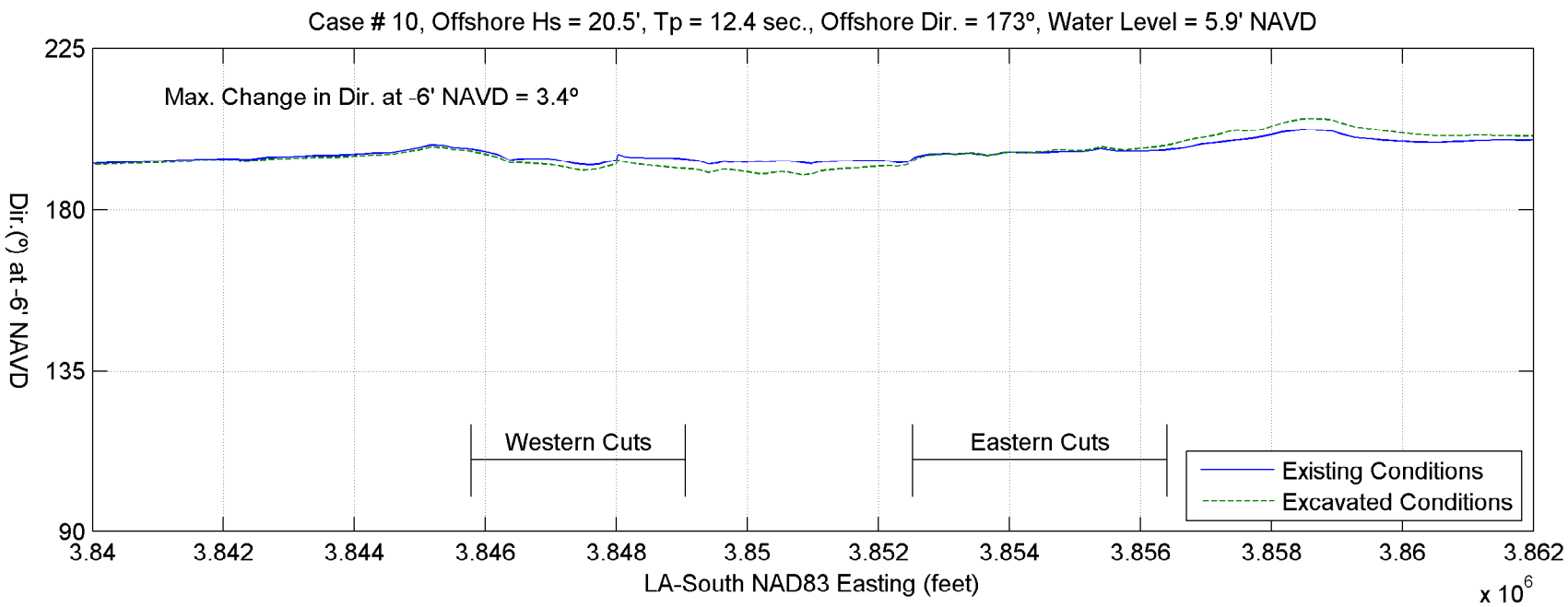

Case # 8, Offshore Hs = 17.4', Tp = 11 sec., Offshore Dir. = 177º, Water Level = 1.58' NAVD
Hs (feet) at -6' NAVD
4
3.5
3
2.5
2
1.5
1
0.5
0
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.07'
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

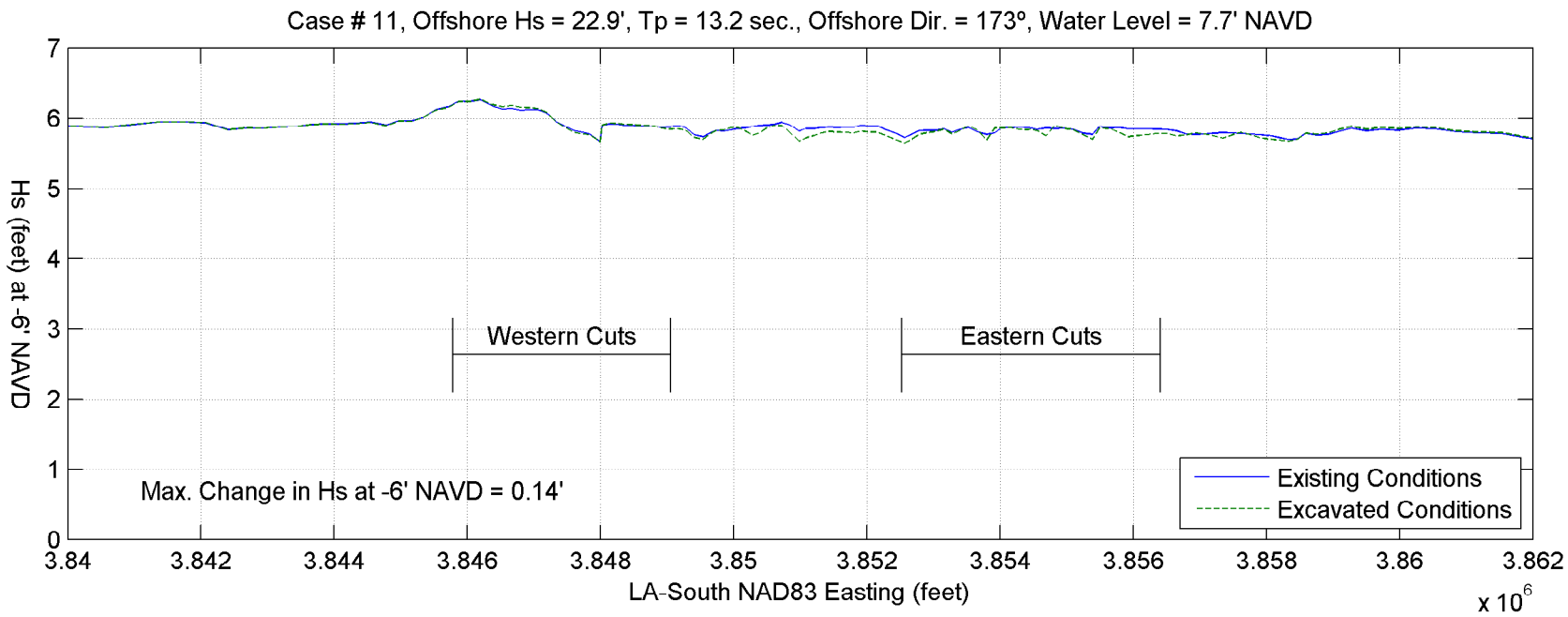

Case # 8, Offshore Hs = 17.4', Tp = 11 sec., Offshore Dir. = 177º, Water Level = 1.58' NAVD
Dir.(º) at -6' NAVD
225
180
135
90
Max. Change in Dir. at -6' NAVD = 3.2º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA-South NAD83 Easting (feet)
x 10^6

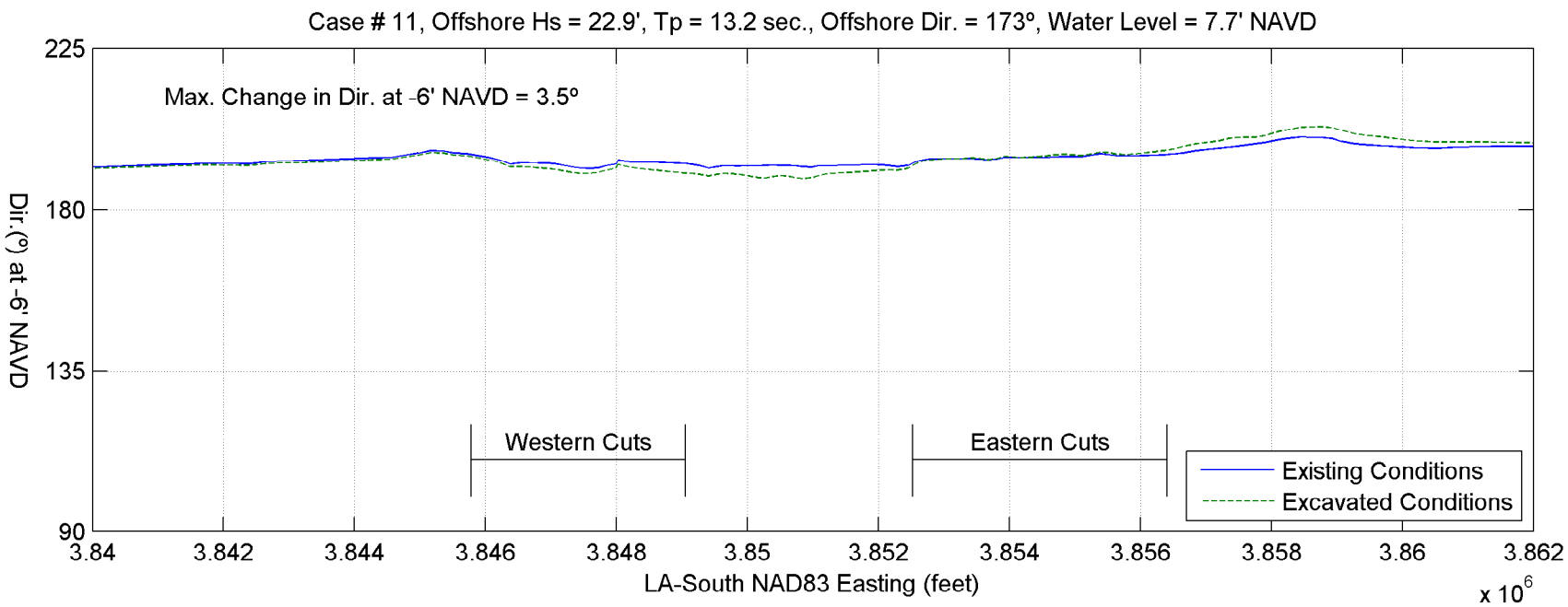

Case # 9, Offshore Hs = 18', Tp = 11.7 sec., Offshore Dir. = 173°, Water Level = 4' NAVD
Hs (feet) at -6' NAVD
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.11'
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

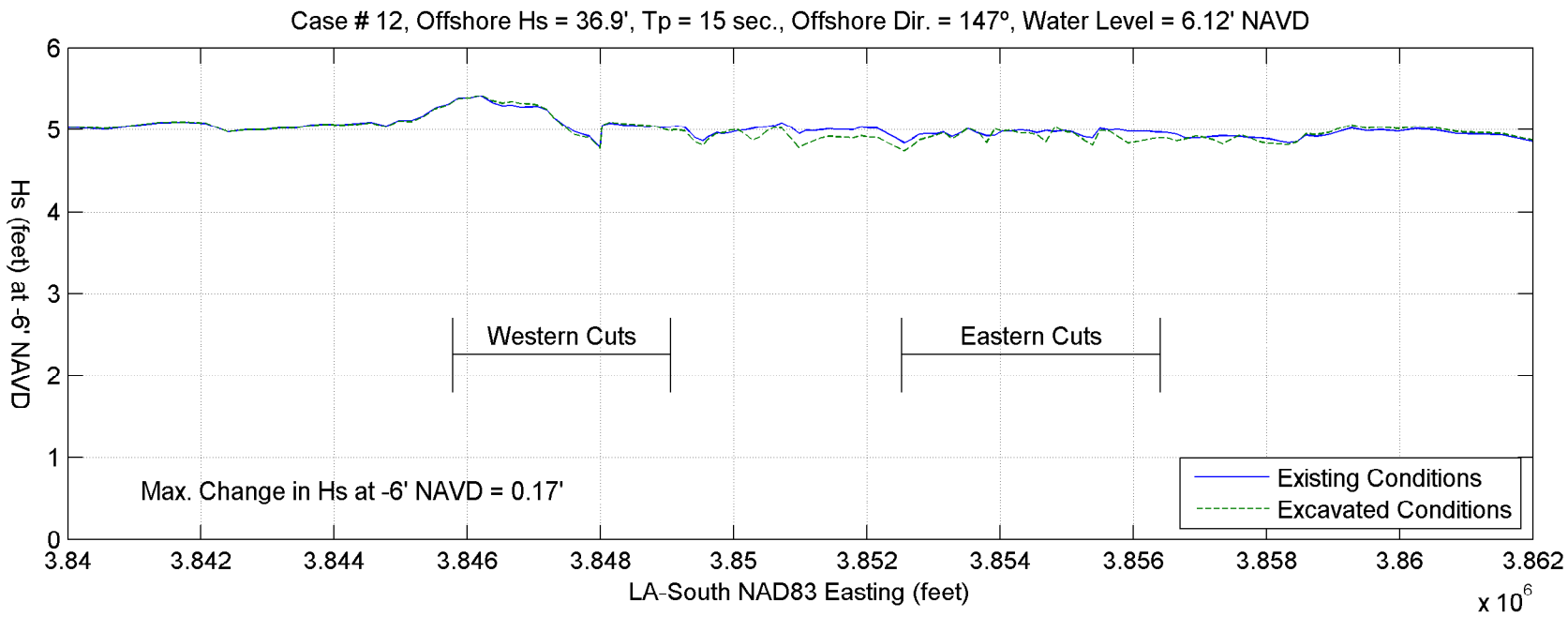

Case # 9, Offshore Hs = 18', Tp = 11.7 sec., Offshore Dir. = 173°, Water Level = 4' NAVD
Dir.(°) at -6' NAVD
Max. Change in Dir. at -6' NAVD = 3.4°
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

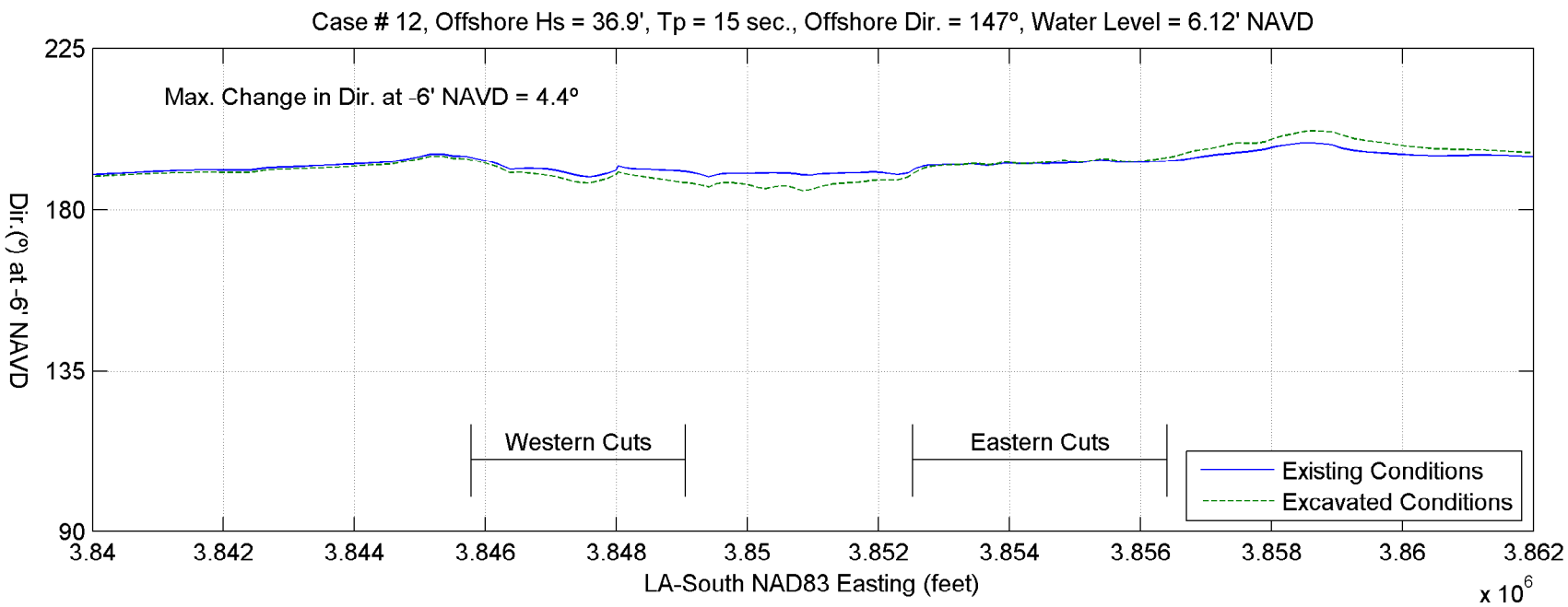

Case # 10, Offshore Hs = 20.5', Tp = 12.4 sec., Offshore Dir. = 173º, Water Level = 5.9' NAVD
Hs (feet) at -6' NAVD
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.13'
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6


Case # 10, Offshore Hs = 20.5', Tp = 12.4 sec., Offshore Dir. = 173º, Water Level = 5.9' NAVD
Dir.(º) at -6' NAVD
Max. Change in Dir. at -6' NAVD = 3.4º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6


Case # 11, Offshore Hs = 22.9', Tp = 13.2 sec., Offshore Dir. = 173º, Water Level = 7.7' NAVD
Hs (feet) at -6' NAVD
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.14'
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

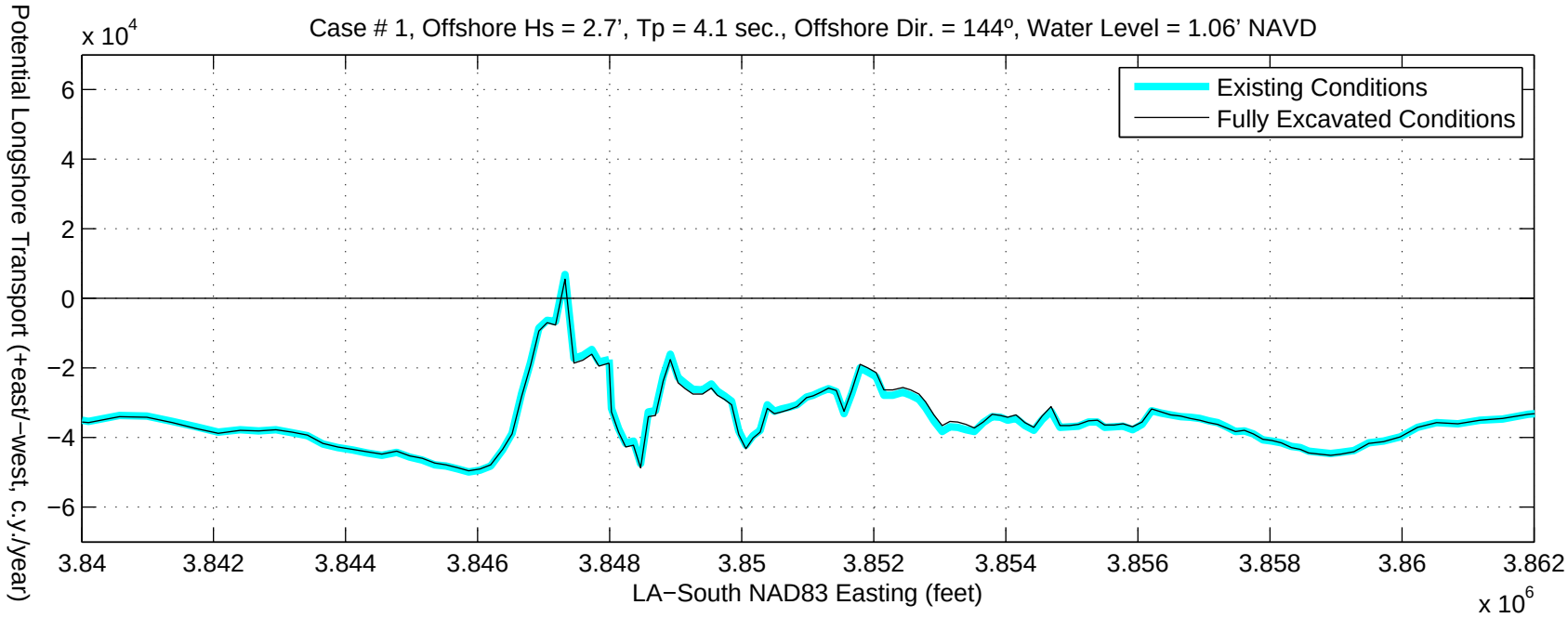

Case # 11, Offshore Hs = 22.9', Tp = 13.2 sec., Offshore Dir. = 173º, Water Level = 7.7' NAVD
Dir.(º) at -6' NAVD
Max. Change in Dir. at -6' NAVD = 3.5º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

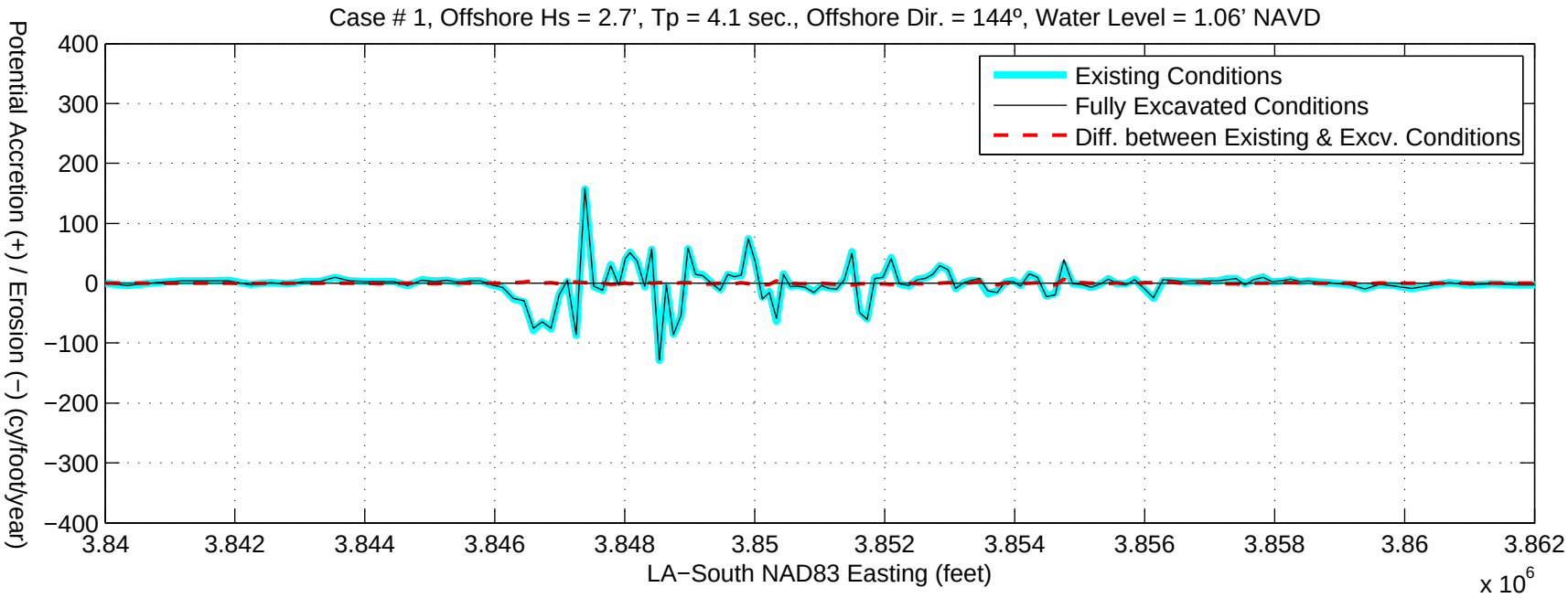

Case # 12, Offshore Hs = 36.9', Tp = 15 sec., Offshore Dir. = 147º, Water Level = 6.12' NAVD
Hs (feet) at -6' NAVD
Western Cuts
Eastern Cuts
Max. Change in Hs at -6' NAVD = 0.17'
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

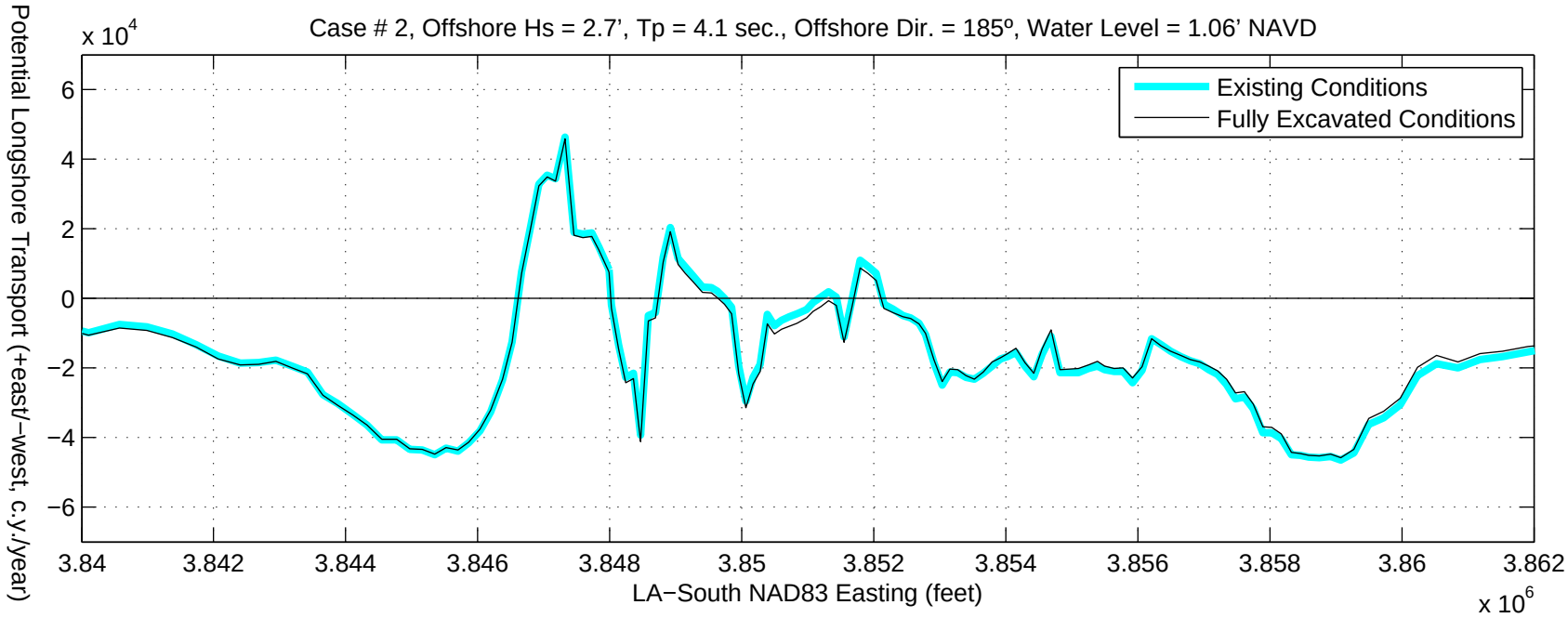

Case # 12, Offshore Hs = 36.9', Tp = 15 sec., Offshore Dir. = 147º, Water Level = 6.12' NAVD
Dir.(º) at -6' NAVD
Max. Change in Dir. at -6' NAVD = 4.4º
Western Cuts
Eastern Cuts
Existing Conditions
Excavated Conditions
LA-South NAD83 Easting (feet)
x 10^6

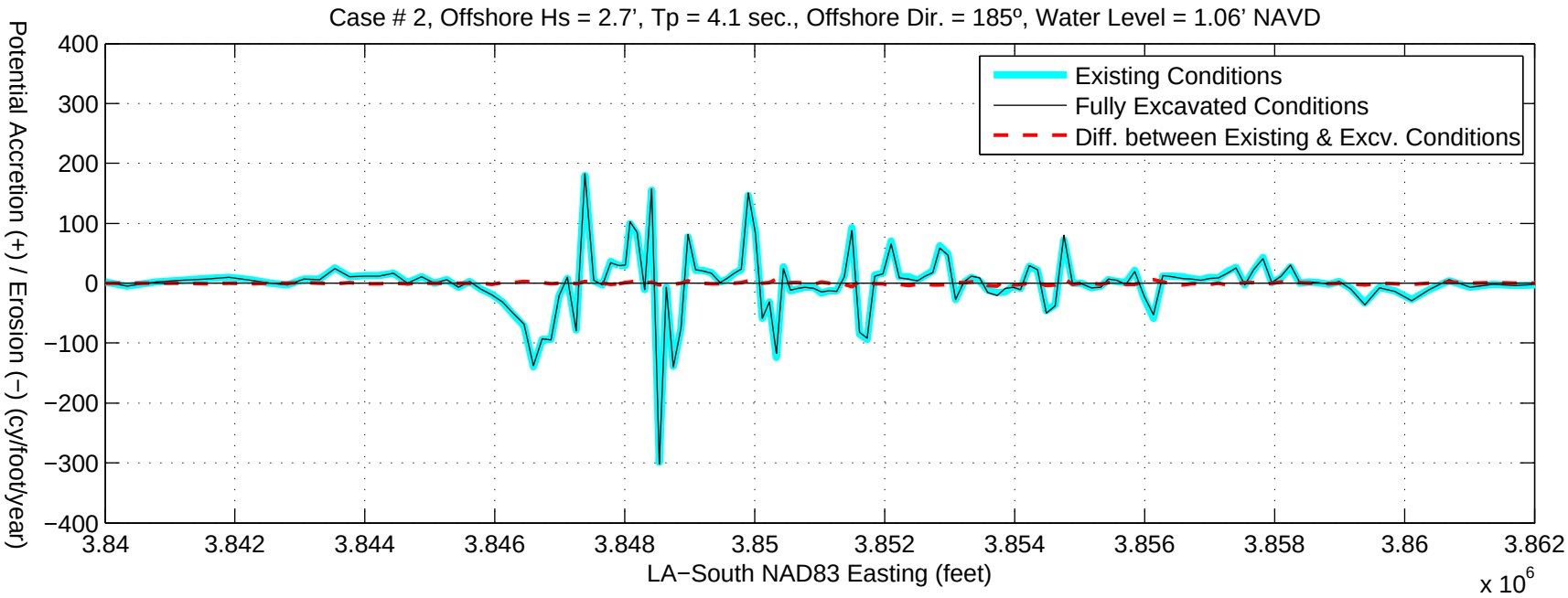
Sub-Appendix 9-3

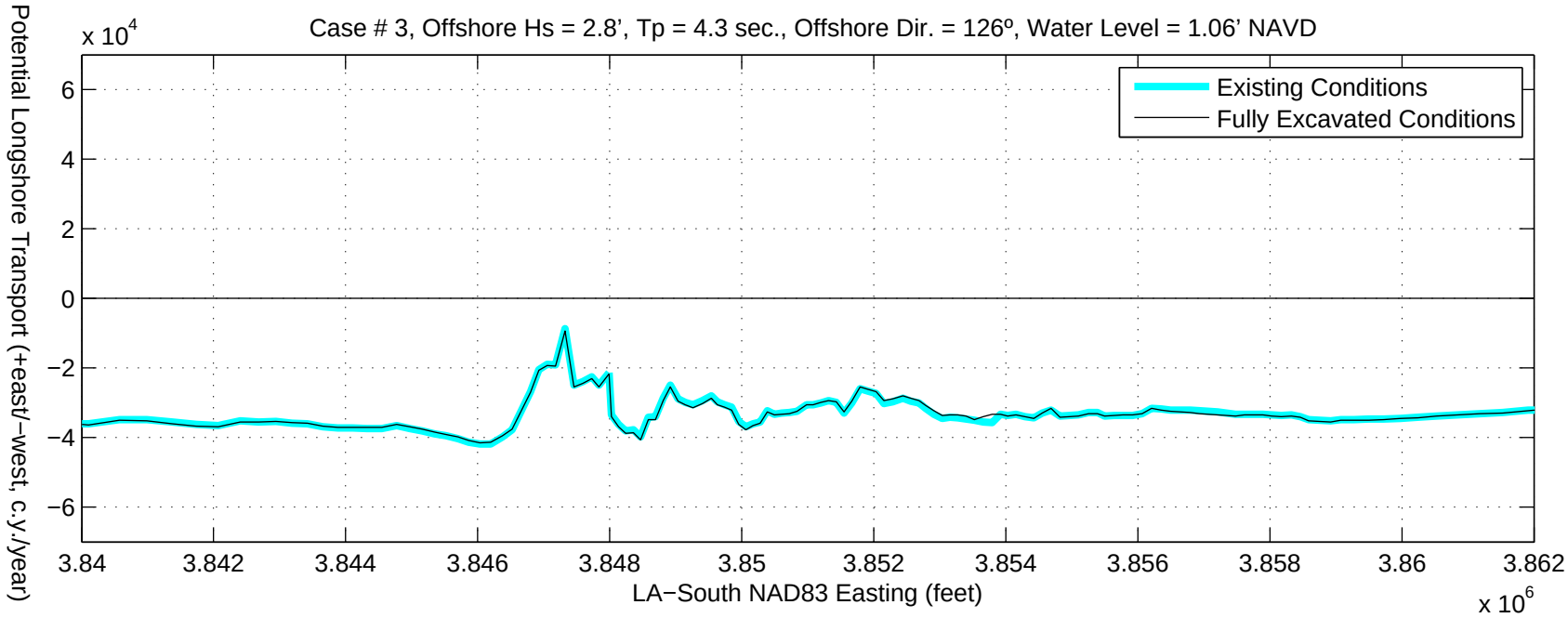
Potential Sediment Transport and Erosion Rates

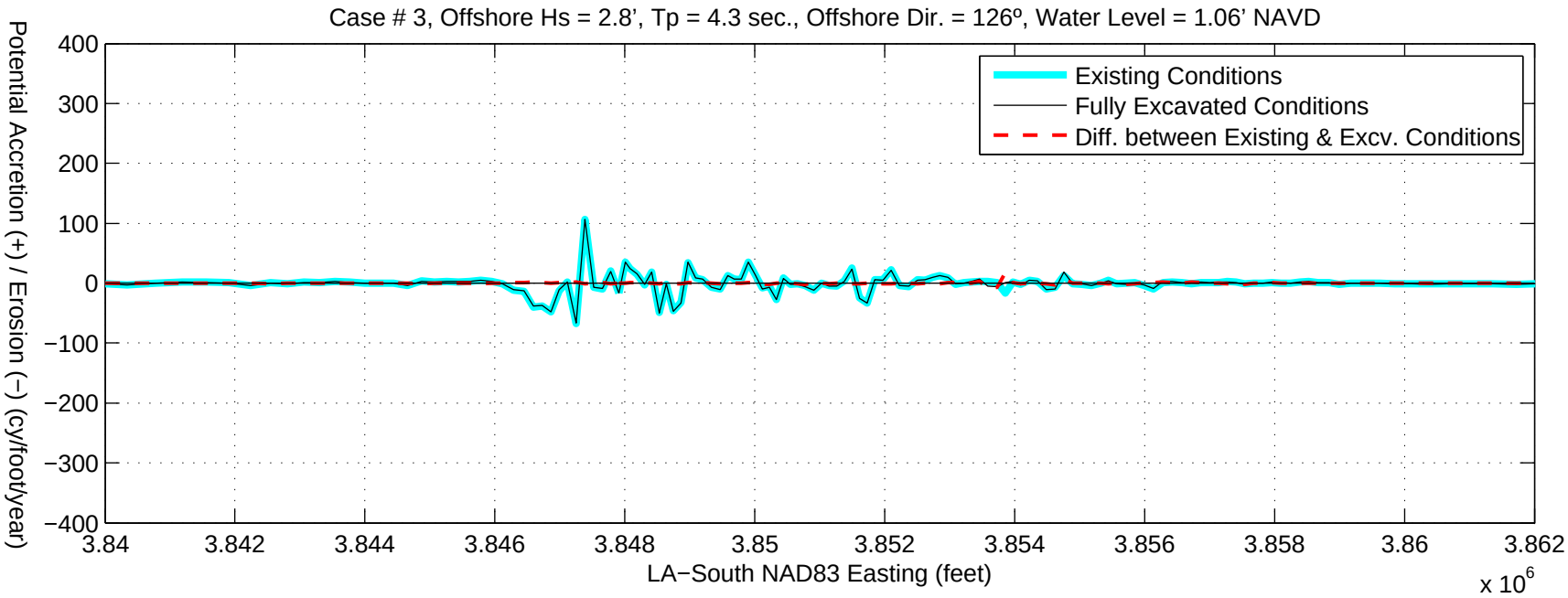

Case # 1, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 144º, Water Level = 1.06' NAVD
x 10^4
Potential Longshore Transport (+east/−west, c.y./year)
6
4
2
0
−2
−4
−6
Existing Conditions
Fully Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6

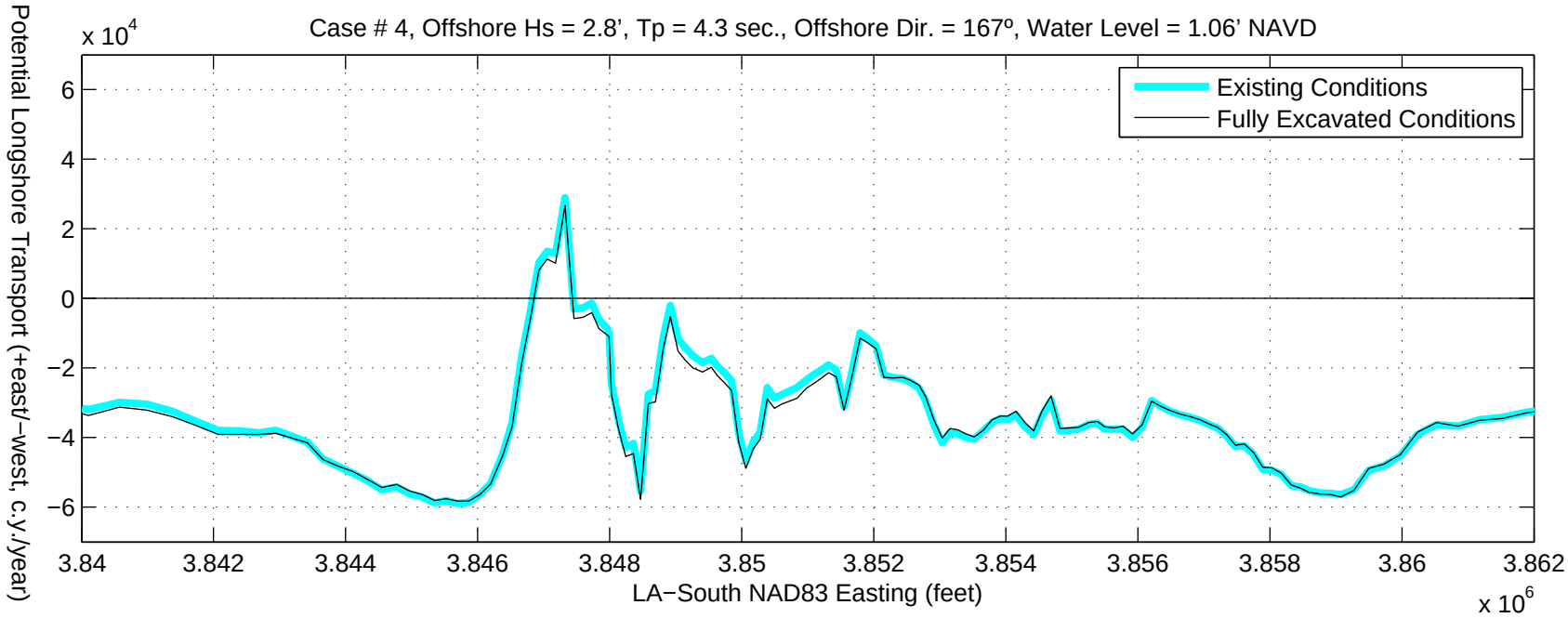

Case # 1, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 144º, Water Level = 1.06' NAVD
Potential Accretion (+) / Erosion (−) (cy/foot/year)
400
300
200
100
0
−100
−200
−300
−400
Existing Conditions
Fully Excavated Conditions
Diff. between Existing & Excv. Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6

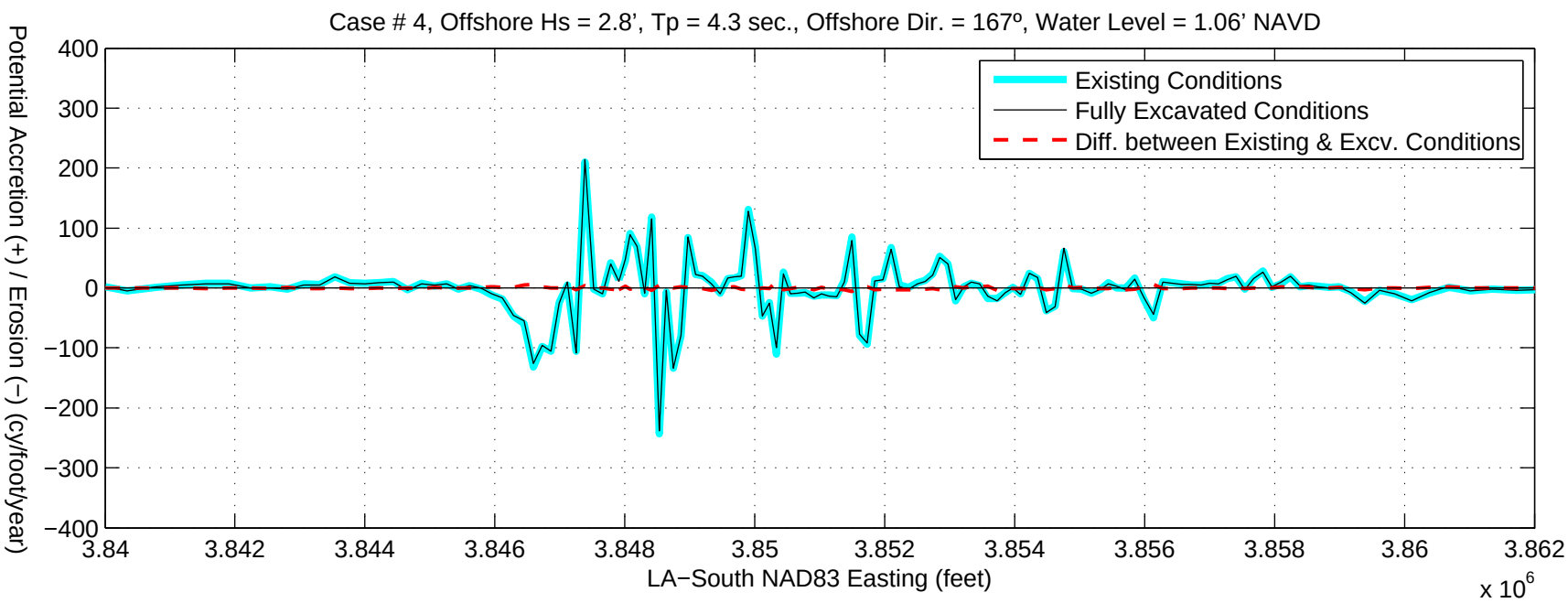

Case # 2, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 185º, Water Level = 1.06' NAVD
x 10^4
Potential Longshore Transport (+east/−west, c.y./year)
6
4
2
0
−2
−4
−6
Existing Conditions
Fully Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6

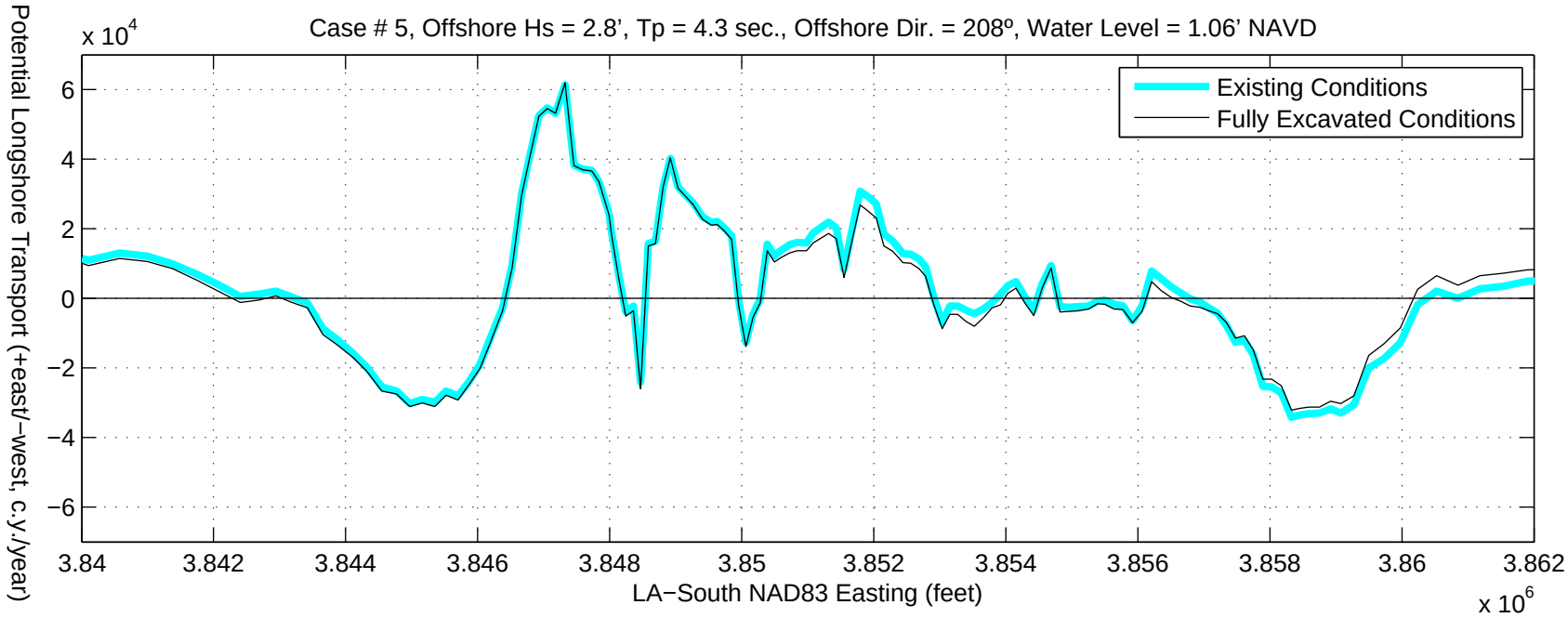

Case # 2, Offshore Hs = 2.7', Tp = 4.1 sec., Offshore Dir. = 185º, Water Level = 1.06' NAVD
Potential Accretion (+) / Erosion (−) (cy/foot/year)
400
300
200
100
0
−100
−200
−300
−400
Existing Conditions
Fully Excavated Conditions
Diff. between Existing & Excv. Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 3, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 126º, Water Level = 1.06' NAVD
x 10^4
Potential Longshore Transport (+east/−west, c.y./year)
6
4
2
0
−2
−4
−6
Existing Conditions
Fully Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 3, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 126º, Water Level = 1.06' NAVD
Potential Accretion (+) / Erosion (−) (cy/foot/year)
400
300
200
100
0
−100
−200
−300
−400
Existing Conditions
Fully Excavated Conditions
Diff. between Existing & Excv. Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 4, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 167º, Water Level = 1.06' NAVD
x 10^4
Potential Longshore Transport (+east/−west, c.y./year)
6
4
2
0
−2
−4
−6
Existing Conditions
Fully Excavated Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 4, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 167º, Water Level = 1.06' NAVD
Potential Accretion (+) / Erosion (−) (cy/foot/year)
400
300
200
100
0
−100
−200
−300
−400
Existing Conditions
Fully Excavated Conditions
Diff. between Existing & Excv. Conditions
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 5, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 208º, Water Level = 1.06' NAVD
x 10^4
Potential Longshore Transport (+east/−west, c.y./year)
6
4
2
0
−2
−4
−6
Existing Conditions
Fully Excavated Conditions
3.84
3.842
3.844
3.846
3.848
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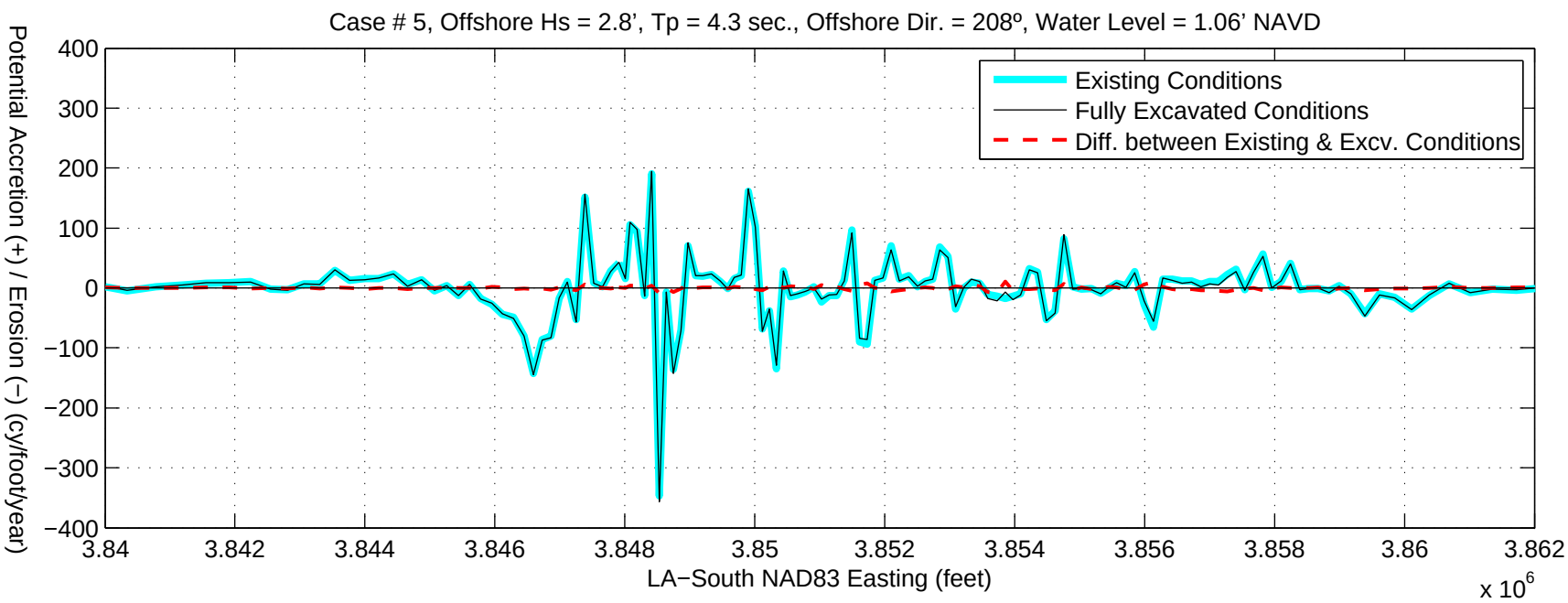
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 5, Offshore Hs = 2.8', Tp = 4.3 sec., Offshore Dir. = 208º, Water Level = 1.06' NAVD
Potential Accretion (+) / Erosion (−) (cy/foot/year)
400
300
200
100
0
−100
−200
−300
−400
Existing Conditions
Fully Excavated Conditions
Diff. between Existing & Excv. Conditions
3.84
3.842
3.844
3.846
3.848
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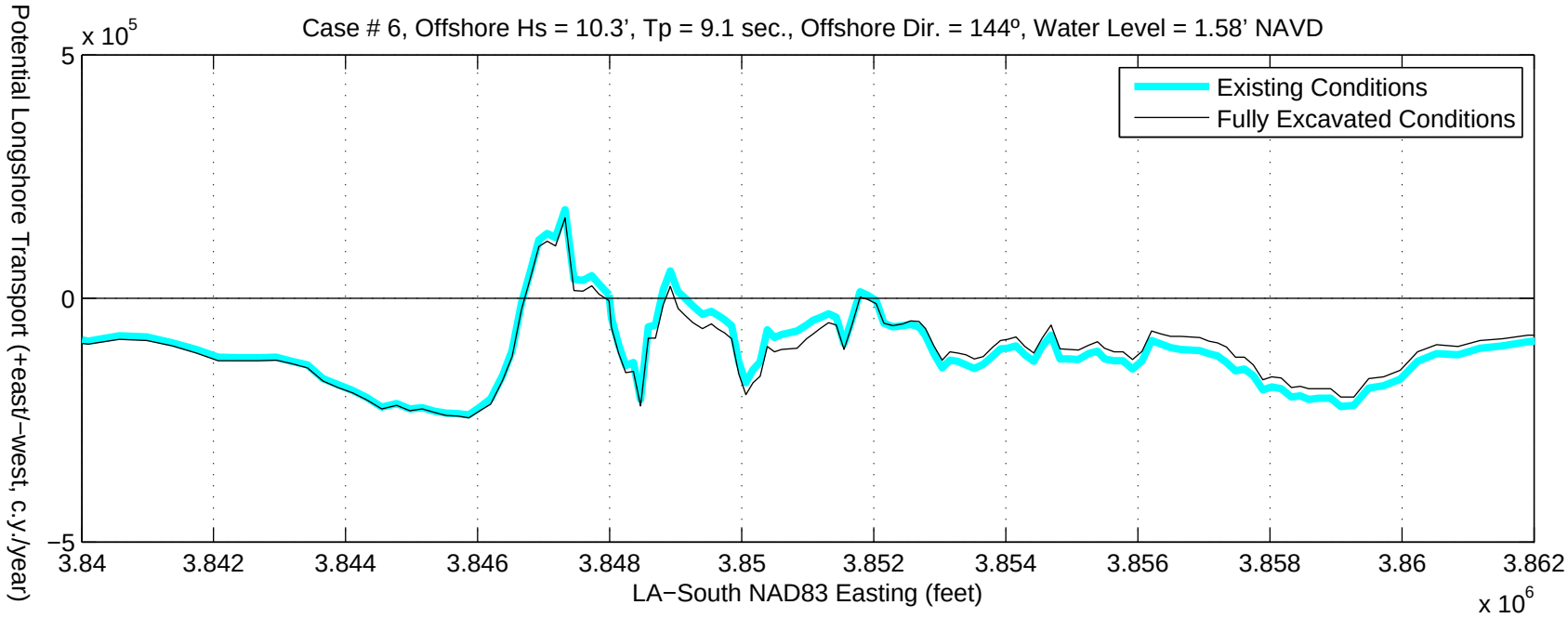
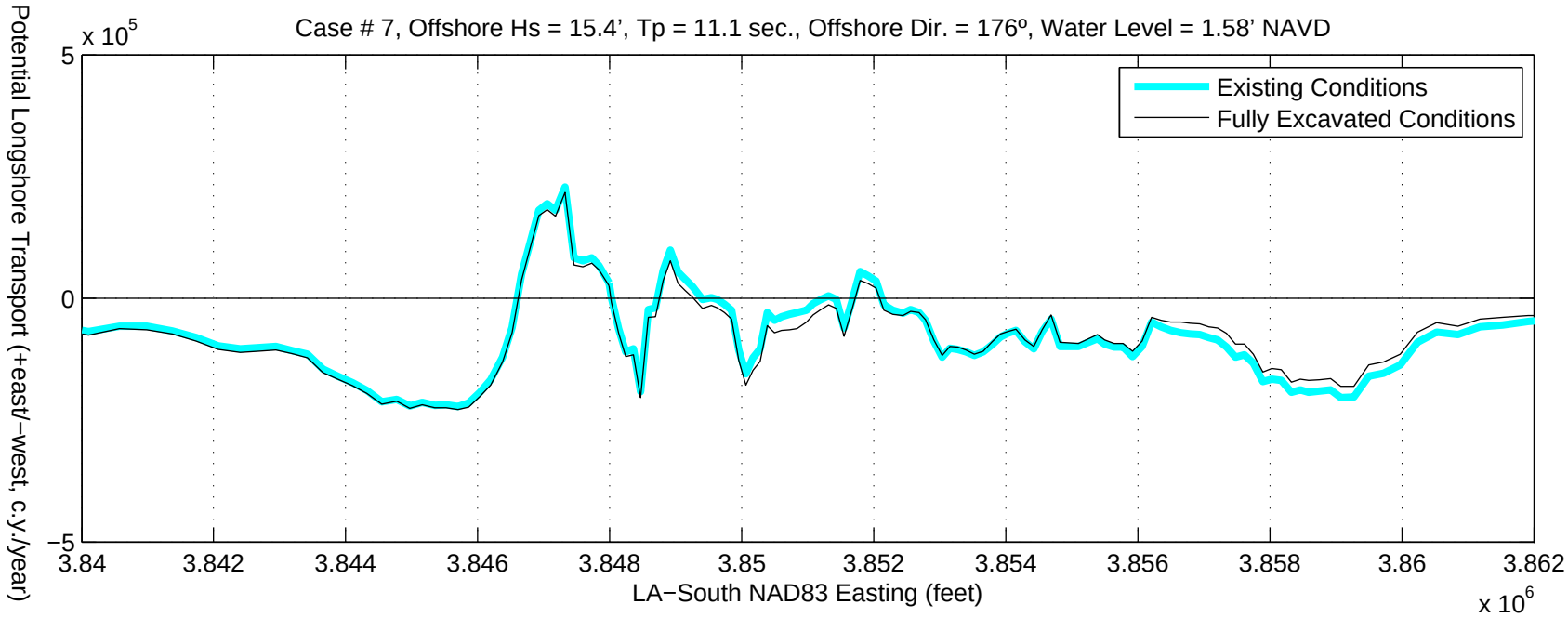
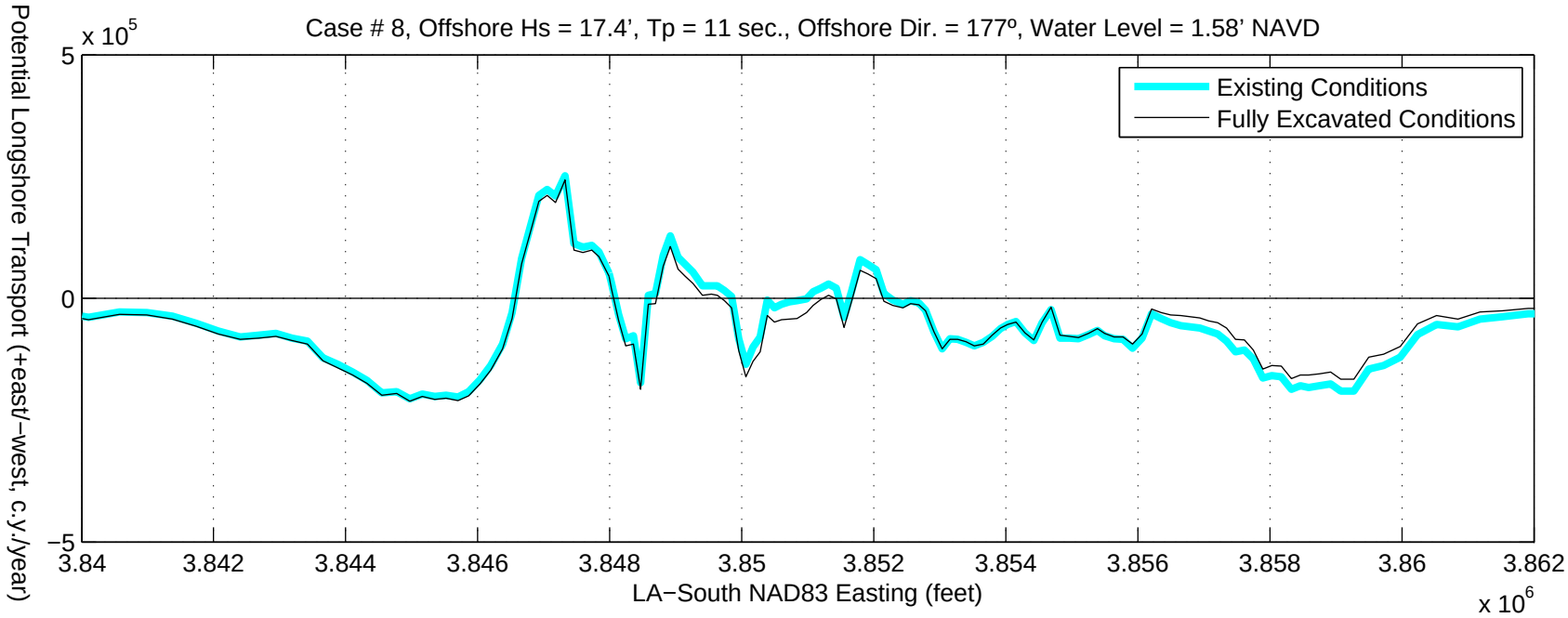
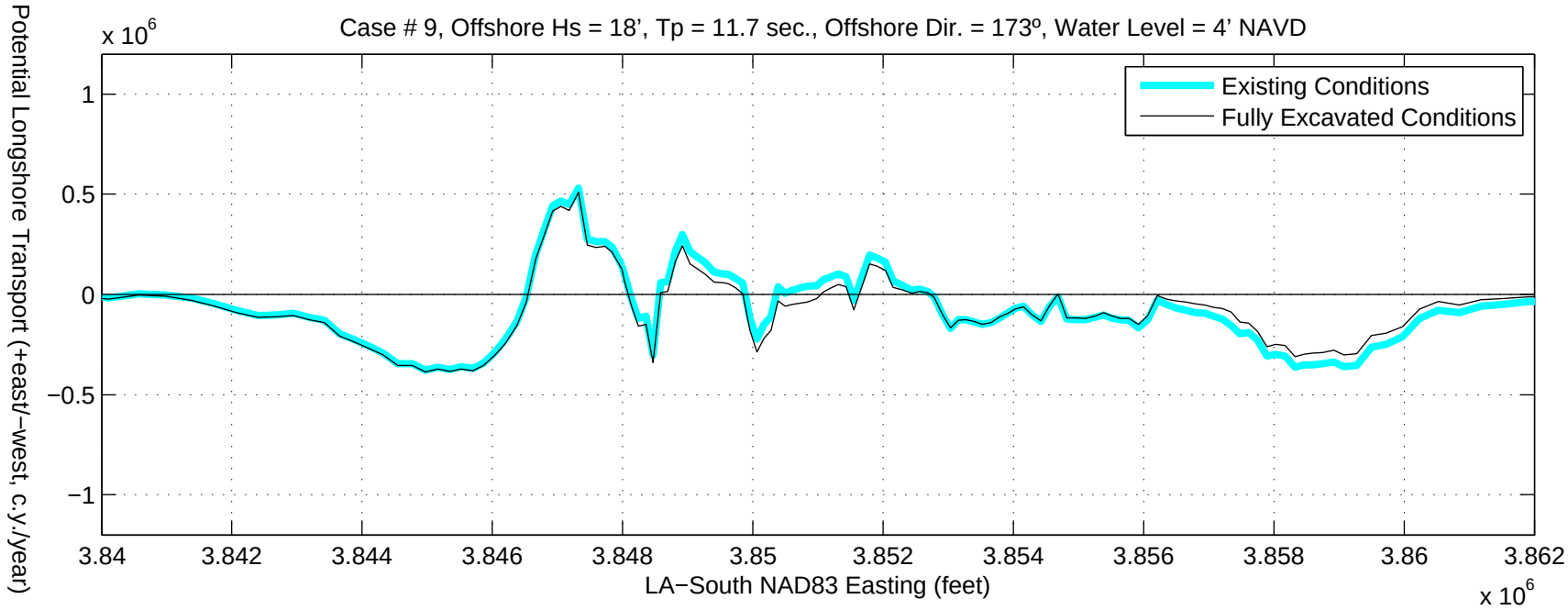
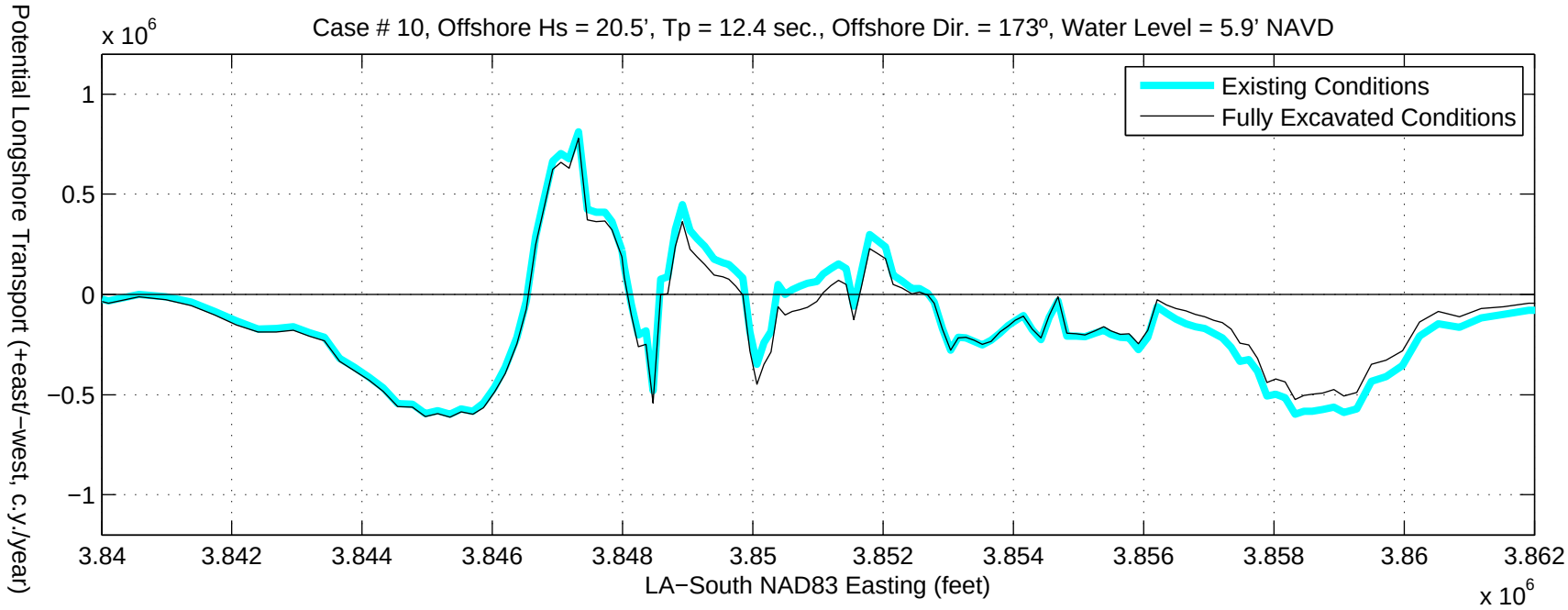
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6

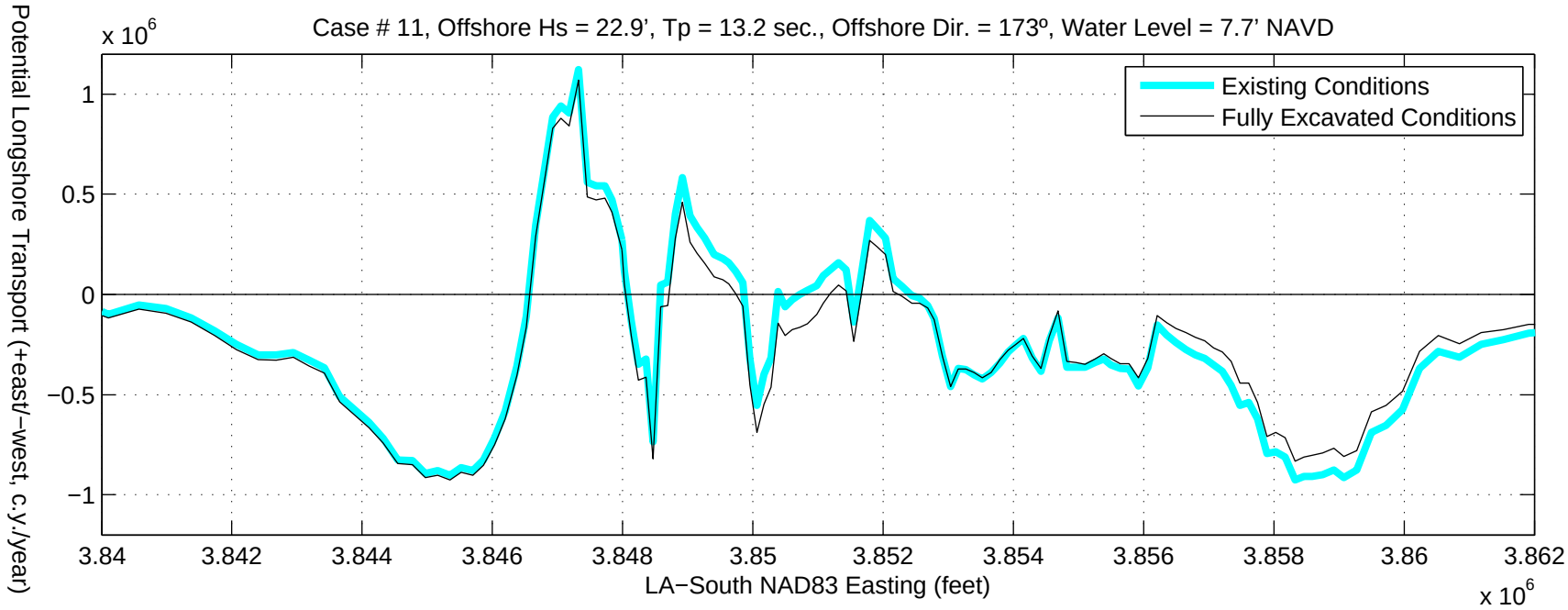

Case # 6, Offshore Hs = 10.3', Tp = 9.1 sec., Offshore Dir. = 144º, Water Level = 1.58' NAVD
Potential Longshore Transport (+east/−west, c.y./year)
x 10^5
5
0
−5
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
x 10^6
LA−South NAD83 Easting (feet)
Existing Conditions
Fully Excavated Conditions

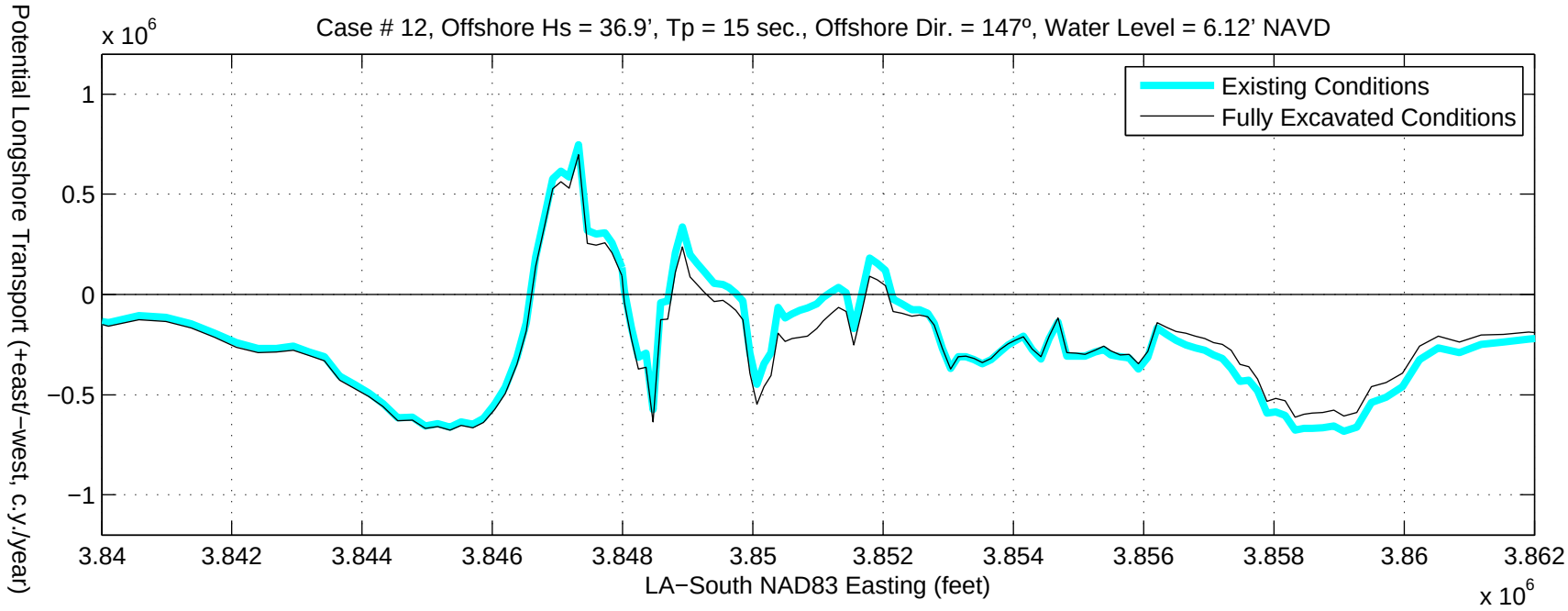

Case # 7, Offshore Hs = 15.4', Tp = 11.1 sec., Offshore Dir. = 176º, Water Level = 1.58' NAVD
Existing Conditions
Fully Excavated Conditions
Potential Longshore Transport (+east/−west, c.y./year)
x 10^5
5
0
−5
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 8, Offshore Hs = 17.4', Tp = 11 sec., Offshore Dir. = 177º, Water Level = 1.58' NAVD
Potential Longshore Transport (+east/−west, c.y./year)
x 10^5
5
0
−5
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
x 10^6
LA−South NAD83 Easting (feet)
Existing Conditions
Fully Excavated Conditions


Case # 9, Offshore Hs = 18', Tp = 11.7 sec., Offshore Dir. = 173º, Water Level = 4' NAVD
x 10^6
Potential Longshore Transport (+east/−west, c.y./year)
1
0.5
0
−0.5
−1
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6
Existing Conditions
Fully Excavated Conditions


Case # 10, Offshore Hs = 20.5', Tp = 12.4 sec., Offshore Dir. = 173º, Water Level = 5.9' NAVD
x 10^6
Existing Conditions
Fully Excavated Conditions
Potential Longshore Transport (+east/−west, c.y./year)
1
0.5
0
−0.5
−1
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6


Case # 11, Offshore Hs = 22.9', Tp = 13.2 sec., Offshore Dir. = 173º, Water Level = 7.7' NAVD
x 10^6
Potential Longshore Transport (+east/−west, c.y./year)
1
0.5
0
−0.5
−1
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6
Existing Conditions
Fully Excavated Conditions


Case # 12, Offshore Hs = 36.9', Tp = 15 sec., Offshore Dir. = 147º, Water Level = 6.12' NAVD
x 10^6
Potential Longshore Transport (+east/−west, c.y./year)
1
0.5
0
−0.5
−1
3.84
3.842
3.844
3.846
3.848
3.85
3.852
3.854
3.856
3.858
3.86
3.862
LA−South NAD83 Easting (feet)
x 10^6
Existing Conditions
Fully Excavated Conditions

Response to Federal Comments: Tye Fitzgerald, E.I.

NRCS (John Jurgenson)

1) The dredging consists of two lifts, and the second lift is equal to or lower than the first lift for all 4 cells. Maybe this is fine; I've just never seen that before.

- Due to significant variations in the subsurface soil, GeoEngineers Inc. was not able to combine fill area borings into one profile. Therefore each fill cell has a different boring which was used to evaluate the settlement and marsh fill height for that fill cell. The higher/heavier first lift will provide greater compaction of the organic sub layer, and squeeze out the subsurface water, providing greater initial compaction of the sub-surface layer. This pre-loading should contribute to enhanced longevity of the created marsh.

2) RSLR is accounted for. I thought CWPPRA had some official stance that they were going to ignore RSLR? (I clarified this with Dain, CWPPRA has no official stance and our agency does not have an official policy either. I have asked that the workgroups discuss for consistency across projects.)

- RSLR has been identified as a major contributor to wetland loss in south Louisiana. Incorporating RSLR into project design and performance projections uses the best science and engineering available.

US Fish (Kevin Roy)

1) <u>Section 5.1 Fill Site Design</u> – On page 25, the final lift elevations are provided for each marsh creation cell. Settlement curves for each of the final lift elevations should be included in the main body of the design report instead of referring the reader to Appendix E.

- This change will be made in the 95% Design submittal.

2) <u>Section 5.1 Fill Site Design</u> – On it is indicated that "Marsh fill volumes were calculated by finding the cross-sectional area of each survey transect, assuming it would be filled to the target 20-year elevation of that cell." This section seems to indicate that information from the settlement curves and construction fill elevations was not used to calculate the marsh fill volumes although section 4.4.1 indicates "The primary purpose of the settlement analysis in marsh creation design is to determine the target construction fill elevation and total volume of material required." This section seems to indicate that the marsh fill volumes could be calculated

based on the target 20-year elevation (i.e., approximately +1.4ft NAVD88) regardless of the construction fill elevation. The calculation methods and relevance of the settlement curves and construction fill elevations should be discussed in greater detail.

- Settlement curves were used to calculate marsh fill volumes. The "target 20-year elevation" used in this analysis was the marsh platform elevation after 20 years of settlement given by the settlement curves. I then calculated the volume of material needed to fill that area assuming little to no voids. Settlement of the sub layer, derived from the geotechnical data, was added to this analysis and will be explained it greater detail in the 95% Design submittal.

3) Section 5.1 Fill Site Design – On page 26, it is indicated that marsh fill acreages were calculated from centerline of the ridge to centerline of the containment dikes for each cell. Instead of using the centerline of the ridge, the marsh fill acreage should be delineated along the +2.5ft NAVD88 contour along the ridge slope. In addition, the Ecological Review indicates that 400 acres of marsh will be created instead of 428 acres as in the design report.

- Marsh and ridge acreages will be updated based on the criteria required for the WVA and submitted in the 95% submittal.

4) Section 5.2 Borrow Site Design – On page 28, it is indicated that a cut to fill ration of 1.3:1 was applied to the marsh fill volumes. What is the basis for that cut to fill ratio? Was that the recommendation of the geotech firm?

- A cut to fill recommendation was not requested from the Geotechnical firm. Instead, the cut to fill ratio was chosen based on the actual cut to fill values of similar constructed projects.

5) Section 6 Ridge Restoration Design – This section should contain settlement curves for the selected construction fill height of +5.0ft NAVD88. This section should also contain fill quantities for the ridge feature for each borrow source (i.e., Bayou Grand Liard and the marsh creation area) and the cut to fill ratio used.

- Settlement curves for the proposed +5.0 feet NAVD 88 design height will be incorporated in the 95% design submittal. Additionally, a half foot construction tolerance will be given to the contractor allowing for a maximum construction elevation of +5.5 feet NAVD 88. Required ridge fill volumes and available borrow volumes from both borrow sources for each construction reach were provided in the Project Plans (Appendix I) posted with the 30% design review information. Additional supporting calculations of required and available fill volumes and estimated cut-to-fill ratio were included in the Design Calculations Package (Appendix H). This information will be presented in summary format in the 95% design submittal.

6) Vegetative plantings proposed for the marsh fill sites and the ridge should be discussed.

- This information will be included in the 95% Design submittal.

7) The report should include a section discussing changes from the Phase 0 approved project.

- This information will be included in the 95% Design submittal.

8) Construction Cost Estimate – The unit cost of $5.19 per cubic yard seems low. During recent PPL21 nominee project evaluations, the CWPPRA Engineering Workgroup settled on $5.50 per cubic yard as the unit cost for marsh creation projects with a Gulf of Mexico borrow site. Many of those projects had much shorter pump distances than the Grand Liard project. Average marsh fill bid prices from many recent projects with Gulf of Mexico borrow sites also range higher (file attached). Justification for $5.19 per cubic yard should be provided.

Also, the standard unit cost for earthen containment dikes used by the Engineering Workgroup has been $3.25 per cubic yard instead of $3.00.

- The project team has reviewed the proposed unit costs for marsh fill and containment dikes. The cost estimate will be revised using $5.55/CY for marsh fill and $3.50/CY for containment dikes.

EPA (Chris Llewellyn)

1.) 'A 17 foot "Gator Tail" vessel' is used to describe the vessel used to perform your inshore magnetometer survey. You may need to add a trademark or copyright logo beside that since it is a trade name. I realize there are other surface drive motor manufacturers that have motors similar to the Gator Tail company (i.e. Proline) but not sure what exactly was used. I am not sure if have to include the trademark or copyright but I just want to give you a heads up.

- This change will be made in the 95% Design submittal.

2.) Did you investigate pre-constructing tidal creeks in this project? They may form via differential settlement but it is somewhat uncertain to what extent. I also realize this is a narrow, linear project seeking to restore a historic ridge and adjacent marsh habitat which means pre-constructed tidal creeks may not be best suited because they may have a negative effect on the overall integrity of the marsh and ridge platform.

- The project team assessed the need to include pre-dredging of tidal creeks and ponds within the fill area. Design surveys suggest that the bathymetry of the marsh fill areas is rather variable with some deeper areas and submerged channels. Due to this variability, combined with site geometry it is expected that differential settlement of the marsh fill will naturally result in formation of open water channels, as has been observed on other

project. The project cost estimate and operations and maintenance plan will include provisions for gapping retention dikes as needed.

3.) I could not locate, in the Containment Dike section of your report, what you intend to do with the containment dike post construction. We prefer to at least gap the dike in several locations to encourage a hydrologic connection but leave this decision up to the project sponsor. A sentence in the report indicating what you intend to do with the containment dikes would be appreciated (i.e. degrade to marsh elevation, gap, leave in place and allowed to erode).

- See previous comment.

4.) During your presentation, you mentioned that you will consider monitoring of the borrow area. As you are aware this is a concern of our Agency and appreciate your inclusion of this in the presentation. With your cooperation, we look forward to discussing this issue with you further in an effort to determine the best way to handle this issue.

- Due to the location of the borrow areas and borrow area geometry, project specific monitoring will include dissolved oxygen monitoring of the borrow area and a reference site. Data collection is proposed for approximately one month during the summer at TYs 1 and 3.

USACE Review (<u>Engineering Division)</u>

1. Ecological Review, page 1, paragraph 1, Introduction; Land loss rates are posted with trend that is increasing. Land loss is currently being measured on land masses in natural state. Report includes settlement curves. Did design include anticipated lateral loss due to higher rates on freshly placed uncompacted fill?

   - Project performance and benefits will be assessed based on the Environmental Workgroup standard methodology for marsh creation projects which includes consideration of project specific and extended area loss rates. Adjustments to future with project loss rates will be in accordance with standard WVA assumptionst.

2. Preliminary Design Report, pg 11, paragraph 3.4, Marsh Elevation Survey; Disagree with Project Team assertion that Marsh Site 3 is not a good representation of healthy marsh. Area was likely selected because it included desired vegetation. Site 3 is important because it opens range of elevation for healthy marsh.

   - Area 3 was initially selected for marsh elevation surveys based on cursory review of aerial photography. However, assessment of the specific location the survey team used for Area 3 suggests that the area has had large pockets of broken marsh since at least 1998.and the specific location of the detailed survey does not appear to represent robust and densely vegetated marsh.

3. Preliminary Design Report, pg 19, paragraph 4.3.2, Stability Analysis – Earthen Ridge; Report mentions a stability berm of 20, 15, and 40 feet. Are these constructed features or simply offset distances for borrow excavation.

   - Those are offset distances for the borrow excavation.

4. Preliminary Design Report, pg 20, paragraph 4.3.2, Stability Analysis – Earthen Ridge; All evaluations were done with a target elevation of (+)5.5 ft. FOS was met. Perhaps an analysis should be done to see how high the ridge can be constructed while maintaining minimum FOS. Ridge cannot be too high.

   - We have a limited amount of borrow material to construct the ridge. We are already exhausting most of our available bayou borrow material to construct the ridge and will need to borrow from the marsh fill area for the remainder. A higher ridge would also entail a wider ridge and with more material from the fill area. Borrowing that amount of material from the interior will leave permanent low elevation areas in the fill area.

5. Preliminary Design Report, pg 21, paragraph 4.4.2, Settlement Analysis – Earthen Containment Dikes; What is the 6 inches of consolidation assumed attributed to? Please add explanation.

   - The six inches of consolidation assumed is the immediate consolidation that would occur during construction.

6. Preliminary Design Report, pg 21, Table 3; Lift elevations are given with only a 60 day period of dewatering between lifts. Fill material is pumped in suspension to open water areas. Be sure to allow adequate dewatering of cell for such a short period of time, i.e. muddy water over the spill box.

   - The lift scenario requiring 60 day dewatering periods were not chosen for this design.

7. Preliminary Design Report, pg 26, paragraph 5.2, Borrow Site Design; Change “you” to “to” on sentence about dropping sites due to cultural resource issues.

   - Corrected

8. Preliminary Design Report, pg 28, Opening sentence; Change “lose” to “loss”.

   - Corrected

9. Preliminary Design Report, pg 31, Figure 11; Add stability berm if they are a constructed feature.

   - This change will be made in the 95% Design submittal.

10. The soil test results should be presented.

- A copy of the Geotechnical report and borings were posted on the ftp site. Additional volumes are available upon request.

11. Appendix F, Figures II-B1 to II-B4. The derivation of the soil stratification should be shown.

    - A copy of the Geotechnical report and borings were posted on the ftp site. Additional volumes are available upon request.