TERREBONE BASIN BARRIER ISLAND AND BEACH NOURISHMENT / WEST BELLE HEADLAND RESTORATION (TE-143 / TE-118)

APPENDIX H

WEST BELLE HEADLAND GEOTECHNICAL ENGINEERING ANALYSIS REPORT

TERREBONNE AND LAFOURCHE PARISHES, LOUISIANA

STATE OF LOUISIANA
COASTAL PROTECTION AND RESTORATION AUTHORITY

JUNE 2019

Geotechnical Engineering Report—Revision 1

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

for

Stantec, Inc.

September 8, 2017

GeoEngineers
Earth Science + Technology

Geotechnical Engineering Report – Revision 1

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East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

File No. 16715-036-00

September 8, 2017

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INTRODUCTION

GeoEngineers, Inc. (GeoEngineers) is pleased to present this Back-Barrier Geotechnical Engineering Report in support of the East Timbalier Island Restoration (TE-118) Project located in Lafourche Parish, Louisiana. Our services have been completed for Stantec, Inc. (Stantec – formerly MWH) under Subcontract No. S10505929- 102014-OM, MWH Job No. 10505929. The project location is shown in Figure 1, and relevant site and project features are shown in Figures 2a and 2b and in Figures 3a and 3b.

Our understanding of the project is based on the information provided by Stantec, Coastal Engineering Consultants, Inc. (CEC) and our August 25, 2015 proposal. We understand the project consists of building beach, dune, and marsh at East Timbalier Island and at the West Belle Pass Barrier Headland. The Coastal Protection and Restoration Authority (CPRA) requested a geotechnical investigation, laboratory testing, and geotechnical engineering recommendations for the construction of these project features. Discussions of our geotechnical engineering recommendations are included in this report. A discussion of our geotechnical field investigation and laboratory testing results were presented in our Geotechnical Data Report submitted on October 14, 2016.

All elevations described in this report, including figures and appendices, are referenced to the North American Vertical Datum of 1988 (NAVD 88), Geoid 12A.

This revision incorporates the results of our September 1, 2017 addendum letter, as requested by CPRA. This request was communicated to us by Stantec on September 6, 2017.

SITE CONDITIONS

Site Geology

The processes that created and re-shaped land in the project area provide an explanation for the variability in subsurface conditions encountered by GeoEngineers during our field exploration. Figure 4 shows the TE- 118 site is located within the Bayou Lafourche delta, which included Bayou Lafourche, Bayou Moreau, and numerous distributaries of these bayous. Bayou Lafourche was a major distributary channel of the Mississippi River, carrying an estimated 12 percent of the river flow until it was isolated from the river in 1904 by the construction of a dam in Donaldsonville, Louisiana (The Holocene Geology of the Central Louisiana Coastal Zone, van Heerden, Kemp and Roberts, Louisiana Geological Society, March 1996). The Bayou Lafourche delta created the Caminada-Moreau coastline, which began eroding following the abandonment of the Bayou Lafourche delta (Environmental Data and Conceptual Design for the Protection of Oil Production Facilities at East Timbalier Island, Suhayda, Paragon Engineering Services, October 1991). Sand deposited by the delta was transported westward, creating the barrier islands to the west of Bayou Lafourche, including East Timbalier Island and the West Belle Pass Barrier Headland. When the delta was abandoned and the sand source cut off, natural sediment transport processes continued, contributing to erosion of the deltaic headlands and barrier islands.

East Timbalier Island and the West Belle Pass Barrier Headland have some of the highest recorded rates of Gulf and bayside shore movements (Louisiana Barrier Island Erosion Study, Atlas of Shoreline Changes in Louisiana from 1853 to 1989, Williams, Penland, and Sallenger, U.S. Department of the Interior and

Louisiana Geological Survey, 1992). East Timbalier Island was created as a result of lateral spit accretion and breaching. However, its migration landward is due to washover processes caused by wave and tidal actions carrying sand across the island where it is deposited. The landward migration has appeared to occur at a rate consistent with shoreline retreat on the gulfside of the island until the 1950s when the seawalls were constructed. The seawall construction inhibited washover processes from occurring, resulting in bay shoreline recession. The morphological changes in the shorelines of East Timbalier and the West Belle Pass Barrier Headland have most likely been affected by a lack of replenishment of sediments caused by the abandonment of Bayou Lafourche, the construction and later modification of the Belle Pass jetties in 1940 and 1956, respectively, the change in tidal influence at Raccoon Pass, and large storm events that occurred in the Gulf of Mexico (Barrier Spit Evolution and Primary Consolidation of Backbarrier Facies: West Belle Pass Barrier, LA, Kramer III, University of New Orleans, 2016). The changes in the footprint of East Timbalier Island and the West Belle Pass Barrier Headland between 1887 and 2015 are evident as presented in Figure 5.

Surface Conditions

East Timbalier Island

East Timbalier Island is bordered to the south by the Gulf of Mexico and to the north by Timbalier Bay. The north side of the island is protected from wind and wave action in the Gulf, which results in generally calmer water north of the island. Beaches and dunes are planned along the entire length of East Timbalier Island. The mudline/ground surface elevation is variable across the project footprint with elevations varying from +6 feet to -18 feet at the extreme limits. Lower mudline elevations are more prevalent in the west beach and dune creation areas of the project footprint, southwest of the existing East Timbalier Island footprint in open water. Two marsh creation areas are also planned on East Timbalier Island: one on the east side of the island and one on the west side of the island. The mudline within the east marsh creation area is relatively flat with elevations ranging between 0 feet and -2 feet while the mudline within the west marsh creation area varies between elevations -1 foot to -8 feet, sloping downward to the south.

The project area also has extensive oil and gas infrastructure, which will require considerable coordination with various companies, an important consideration when planning fill placement for beach, dune, containment dike, and marsh construction. Placement of fill on top of utilities will impose additional stresses, potentially exceeding the allowable stresses of the pipe materials. In addition, careful maneuvering of fill placement equipment will be required to avoid contact with infrastructure at the site.

East Timbalier Island is also home to several bird species, including skimmers and terns, which nest on the island. Two of our boring locations (ET-8 and ET-9) had to be relocated to maintain a sufficient distance from nesting birds at the time of our field exploration.

West Belle Pass Barrier Headland

The West Belle Pass Barrier Headland is located west of Belle Pass on the Caminada-Moreau Headlands. The West Belle Pass Barrier Headland is bordered to the south by the Gulf of Mexico and to the north by Timbalier Bay. An earlier phase of the West Belle Pass Barrier Headland restoration was completed in 2012, which included construction of 9,800 feet of beach and dune and 150 acres of back-barrier marsh (CPRA Project TE-52). Since construction, scarping along the southern beach face has occurred due to erosion and the spit on the western end has expanded. Our soil borings were performed in and around the area where the spit has developed, as shown in Figure 3b.

Subsurface Conditions

The subsurface conditions discussed below are based on the soil borings completed for this project, our field observations, and our experience in the project area. Subsurface profiles based on our field explorations are presented in Figures 6a, 6b, and 6c. Appendix A contains the design soil profiles associated with our explorations. Although conditions may vary between and beyond our field explorations, we have generalized subsurface conditions, as described in the following sections.

East Timbalier Island

The project footprint for restoration of East Timbalier Island encompasses the existing island and areas to the north and south of the island. Some of our soil borings were completed on the island itself, and others were performed in open water. Based on our field exploration and laboratory test results, the stratigraphy at East Timbalier Island was divided into two zones: the west zone, included borings ET-1, ET- 2, ET-4, ET-4b, and ET-10 and the east zone, included borings ET-5 through ET-9 and ET-4 and ET-4b. Borings ET-4 and ET-4b were completed between the two zones on East Timbalier Island and the data appeared to have similarities to both sets of data. The East and West Zones were both subdivided to better account for pre-consolidation effects in areas previously loaded by the migrating island. East Timbalier Island design profile zones are depicted in Figure 3a.

Within the west zone, soil borings ET-4, ET-4b, and ET-10 were performed closer to the existing island footprint than ET-1 and ET-2, which were performed farther away in open water. Sand and silty sand were encountered at the surface of both ET-4 and ET-10 to an elevation of about -17 feet to -21 feet, while sand was not encountered at the surface of ET-1 and ET-2, except about 1.5 feet of sand with silt in boring ET-1. Below the sand in our west zone soil borings, we encountered very soft to medium clay and silty clay soils to the completion depth of our borings. Silt lenses and layers were observed at frequent intervals in the clay and silty clay soils down to about elevation -40 feet. A cross-section of the west zone soil borings is presented in Figure 6a. Considering the difference in the near-surface soil conditions encountered in the west zone borings, two separate design profiles were developed to evaluate slope stability and bearing capacity, as presented in Appendix A designated profiles West-A (borings ET-1 and ET-2) and West-B (borings ET-4, ET-4b, and ET-10).

Beach and dune settlement calculations on the west side of East Timbalier Island were based on two separate design profile zones, as presented in Appendix A. Zone 1 (ET-2 and ET-4) is closer to the current island footprint and represents areas that have previously experienced load from the island. Zone 2 (ET-1 and ET-10) is farther north and west from the existing Island and has not previously experienced substantial loading from the island.

Within the east zone, sand and silty sand were encountered at the surface of our soil borings to about elevation -13 feet to -18 feet. This upper sand stratum extended to about elevation -26 feet in boring ET-5; however, more clay soils were encountered in this stratum of boring ET-5. Below the sands, very soft to medium clay and silty clay soils were encountered to the completion depths of our borings. Silt lenses and layers were observed at frequent intervals in the clay and silty clay soils down to about elevation -40 feet. Two design profiles were used to complete beach and dune settlement calculations on the east side of East Timbalier Island: the Central Zone, consisting of soil borings ET-4 and ET-5, and the general East Zone, comprising all soil borings on the eastern half of the island. The Central Zone represents an area of the island that is eroded from its historic shape, and has been previously loaded by island sands. A cross-section of the east zone soil borings is presented in Figure 6b.

West Belle Pass Barrier Headland

We encountered very loose to firm clayey and silty sand soils and silt in our West Belle Pass soil borings from the mudline/ground surface to about elevations -20 feet to -22 feet. This was followed by very soft to medium silty clay, sandy clay, and clay generally interbedded with silt and sand layers, lenses, and streaks to the soil boring completion depths. Clayey sand and silty sand were encountered in boring WBP-1 below about elevation -87.5 feet. Sandy clay was encountered in boring WBP-4 below about elevation -89 feet to the completion depth of our boring. A cross-section of the West Belle Pass Barrier Headland soil borings is presented in Figure 6c.

CONCLUSIONS AND RECOMMENDATIONS

Slope Stability and Bearing Capacity

The project calls for construction of beaches, dunes, and marsh fill area containment dikes on both East Timbalier Island and the West Belle Pass Barrier Headland.

GeoEngineers evaluated slope stability of the proposed containment dike, beach, and dune alignments using Spencer's Method in GeoStudio's Slope/W computer program. Cross-sections were selected for the stability analyses based on the geometry of the containment dikes, beach, and dunes in conjunction with the variation of the existing mudline elevation and the various existing design soil profiles. The selected cross-sections represent conservative geometry for evaluation of each case. Multiple cross-sections were selected for some of the cases described below to evaluate the range in existing mudline conditions present within the project limits. The following cases were evaluated for slope stability:

- Stability of the containment dike into the marsh area (pre-construction of the marsh).
- Stability of the containment dike into the bay (post-construction of the marsh).
- Stability of the containment dike into the borrow channel (West Belle Pass Barrier Headland only), both before marsh fill (stability into the interior borrow channel) and after marsh fill has been placed (stability into the exterior borrow channel).
- Stability of the beach and dune into the marsh area (pre-construction of the marsh).
- Stability of the beach and dune into Timbalier bay (sections of the dune without marsh behind them).
- Stability of the beach and dune into the Gulf of Mexico.

The stationing presented in Figures 2a and 2b, existing mudline and proposed fill elevations, and geometry were provided by CEC. The stability analyses were evaluated for the provided geometries and a one-foot construction overbuild tolerance. Details of the assumed geometries are included in figures presented in Appendix B. The water level was assumed to be at elevation -0.37 feet, which is the mean low water level provided in the Typical Section sheets of the TE-118 Draft Permit Drawings document, dated 09-13-2016.

East Timbalier Island

GeoEngineers evaluated slope stability and bearing capacity for containment dikes with a crown elevation of +5.3 feet with a 1-foot construction overbuild for East Timbalier Island. We assumed the beach, dune, and containment dikes would be constructed of sand fill material from the TE-118 SP1 and SP2 and TE- 118 SS1 borrow sites. Slope stability was evaluated for the stability of the containment dike into the marsh creation area before marsh fill placement (Stations 50+00 and 130+00) and stability of the containment dike into Timbalier Bay after marsh fill placement (Stations 50+00 and 130+00). The factors of safety for the slope stability cases evaluated were greater than the required minimum factor of safety of 1.2. The bearing capacity calculations completed for the containment dikes were found to be stable with factors of safety greater than 2.0.

Slope stability was also evaluated for the beach and dune alignment, with crown elevations of +5.0 feet and +7.5 feet, respectively, with a 1-foot construction overbuild. Slope stability was evaluated for the stability of the beach and dune into the marsh creation area before placement of the marsh fill (Stations 40+00, 50+00, and 130+00), stability of the beach and dune into Timbalier Bay (Station 70+00), and stability of the beach and dune into the Gulf (Stations 70+00, 102+50, and 130+00). The factors of safety for the slope stability cases evaluated were greater than the required minimum factor of safety of 1.2.

The results of the slope stability analyses for East Timbalier Island are presented in Figures B-1 through B- 6 of Appendix B. The figures are arranged by order of increasing station number.

West Belle Pass Barrier Headland

GeoEngineers evaluated slope stability and bearing capacity for containment dikes with a crown elevation of +5.5 feet with a 1-foot construction overbuild for the West Belle Pass Barrier Headland. It was assumed the beach and dune would be constructed of sand fill material from the TE-118 SP1 and SP2 and TE-118 SS1 borrow sites. It was assumed in situ material would be used to construct the containment dike. The in-situ material encountered in our soil borings was composed mostly of sand and silt to the proposed depth of the borrow channel. The borrow channel excavation, which is within the marsh creation area, was modeled to be a minimum of 30 feet away from the toe of the containment dike slope with a side slope of 3H:1V or flatter and a maximum bottom elevation of -8.0 feet. A surcharge load of 260 pounds per square foot (psf) was also placed on the 30-foot wide bench to represent a marsh buggy excavator for our analyses. Slope stability was evaluated for the stability of the containment dike into the borrow channel excavation before placement of the marsh fill (Stations 140+00 and 155+00) and stability of the containment dike into the bay after placement of the marsh fill (Station 155+00). The factors of safety for the slope stability cases evaluated were greater than the required minimum factor of safety of 1.2. The bearing capacity calculation completed for the containment dike was found to be stable with a factor of safety greater than 2.0.

Slope stability was also evaluated for the beach and dune alignment with crown elevations of +5.0 feet and +7.5 feet, respectively, plus a 1-foot construction overbuild. Slope stability was evaluated for the stability of the beach and dune into the marsh creation area before placement of the marsh fill (Station 140+00) and stability of the beach and dune into the Gulf (Station 170+00). The factors of safety for the slope stability cases evaluated were greater than the required minimum factor of safety of 1.2.

The results of the slope stability analyses for West Belle Pass are presented in Figures B-7 through B-9 of Appendix B. The figures are arranged by order of increasing station number.

Settlement

One-dimensional consolidation tests were performed on select samples from our soil borings. The results of these tests were included in our Geotechnical Data Report for the East Timbalier Island Restoration

(TE- 118) Project dated October 14, 2016. We have included the reconstructed consolidation curves in our calculations package. Using our consolidation test results, along with correlations of compressibility parameters with soil index properties, settlement parameter profiles were created for East Timbalier Island and the West Belle Pass Barrier Headland. Four settlement parameter profiles were created for East Timbalier Island: two for the west zone (Zone 1 and 2) and two for the east zone (Central Zone and East Zone). These settlement parameter profiles each correspond to a design cross-section station, as shown in the elastic settlement summary table on page 7. In addition, drainage distances were defined for our soil profiles based on review of our soil borings and observations of drainage layers and interfaces. Our settlement parameters and drainage distances are also included in our calculations package.

We understand the marsh fill material for East Timbalier Island may be obtained from the TE-118 MB1 borrow site. A low-stress consolidation test was performed on vibracore samples obtained from TE- 118 MB1 provided by Ocean Surveys, Inc. (OSI). The results of this low-stress consolidation test (Composite Sample 1, CS-1) were presented to MWH in our Sediment Properties Geotechnical Report dated March 10, 2016. Alternatively, sand fill material from the TE-118 SP1 and SP2 and TE-118 SS1 borrow sites may be used to create the marsh fill areas on East Timbalier.

We understand the marsh fill material on the West Belle Pass Barrier Headland may be obtained from the TE-52 MB borrow site. CEC provided low-stress consolidation test results from Fugro Consultants, Inc. Report No. 5507-4055 dated March 6, 2009. Two of the low-stress consolidation tests were performed on samples obtained from the TE-52 MB borrow site, WBVC-08-44 and WBVC-08-46.

The low-stress consolidation data from the TE-118 MB1 borrow site and the TE-52 MB borrow site were used to develop the parameters needed to evaluate marsh fill material settlement.

Discussions of the beach and dune settlement, containment dike settlement, and marsh fill settlement are presented in the following sections.

Beach and Dune Settlement

GeoEngineers evaluated settlement of the beach and dune alignments using traditional one-dimensional consolidation theory and Boussinesq stress distribution. Total settlement will include both consolidation settlement and elastic settlement. Elastic settlement is the result of immediate compression of the underlying soils during placement of fill (i.e. during construction). Based on our professional judgment and experience, we estimate the elastic settlement to be 20 percent of the long-term consolidation settlement. It is difficult, however, to distinguish elastic settlement from consolidation settlement during construction. Elastic settlement will be offset by fill placement during construction and is not likely to be directly observed. It is important to note, however, that elastic settlement and consolidation settlement during construction will increase the fill quantity required to reach the design elevation and should be considered for fill quantity estimates.

GeoEngineers considered beach and dune fill material settlement negligible because the fill material will be generally composed of sand. Settlement within the sand fill material will likely occur during the construction process.

We selected cross-sections for settlement analysis based on the design fill profile geometry in conjunction with existing mudline elevation variation and the various existing design soil profiles. The selected cross-sections represent conservative fill thicknesses for each alignment. Beach and dune fill was assumed to have been placed instantaneously as a single lift at time of construction. Water was assumed to be at the mean water elevation of +0.26-foot. The mean water level was taken as the average of the mean high water (MWH) elevation (+0.88-foot) and the mean low water (MLW) elevation (-0.37-foot). MHW and MLW values were taken from the Typical Section drawings in the TE-118 Draft Permit Drawings document dated September 13, 2016.

East Timbalier Island

GeoEngineers evaluated settlement for the beach and dune alignment at East Timbalier Island with crown elevations of +5.0 feet and +7.5 feet, respectively. Four settlement property profiles were developed to evaluate settlement for East Timbalier Island: two for the west zone and two for the east zone, each corresponding to a design cross-section at which beach and dune settlement was evaluated (shown in the table below). East Timbalier Island beach and dune fill elevation change due to foundation soil consolidation settlement is presented in Appendix C, Figures C-1 through C-8. Elastic settlement estimates are not included in the Appendix C data, but are presented in the following table for the beach and dune centerline settlement points. Settlement points identified in the table below are defined in the Appendix C figures.

EAST TIMBALIER ISLAND – BEACH AND DUNE ELASTIC SETTLEMENT

Station (Settlement Zone)	Case	Settlement Point	Estimated Elastic Settlement (in)
47+50 (East Zone)	Beach	S3	6
		S5	6
	Dune	S4	8
102+50 (Central Zone)	Beach	S3	12
		S5	4
	Dune	S4	11
130+00 (West Zone 1)	Beach	S3	10
		S5	10
	Dune	S4	12
West of 130+00 (West Zone 2)	Beach	S3	10

West Belle Pass Barrier Headland

GeoEngineers evaluated settlement for the West Belle Pass Barrier Headland beach and dune alignment with crown elevations of +5.0 feet and +7.5 feet, respectively. The change in fill elevation of the beach and dune at the West Belle Pass Barrier Headland due to consolidation settlement of the foundation soils at the West Belle Pass Barrier Headland is presented in Appendix C, Figure C-9. Elastic settlement for the West Bell Pass Barrier Headland beach and dune is not included in the Appendix C data, but is presented in the following table.

WEST BELLE PASS BARRIER HEADLAND – BEACH AND DUNE ELASTIC SETTLEMENT

Station	Case	Settlement Point	Estimated Elastic Settlement (in)
170+00	Beach	S3	6
		S5	6
	Dune	S4	8

Other Beach and Dune Settlement Considerations

GeoEngineers evaluated the design section at East Timbalier Station 130+00 to see the effect of settlement and sea-level rise on overall settlement with time, assuming the fill template remains intact, as placed, over the 20-year project life. Figure C-10 shows the effect of increased fill submergence with time on overall settlement. We expect fill submergence effects will generally reduce settlement across the project footprint, whether caused by mudline settlement under the fill load, sea-level rise, or some combination of the two. These effects will vary based on the amount of fill placed.

Station 130+00 was also used to illustrate settlement-induced deflections for buried pipeline at various embedment depths, as shown in Figure C-11. Based on our analysis, burying pipelines deeper will not significantly mitigate settlement effects. Some other ways to prepare pipelines to accommodate settlement include installing the pipelines in a vault designed to settle without placing excessive stress on the pipe and using flexible connections with enough give to allow the pipe to move without straining or damaging pipe connections.

Containment Dike Settlement

As with the settlement analyses for the beach and dune alignments, the containment dike was evaluated for consolidation settlement using traditional one-dimensional consolidation theory and Boussinesq stress distribution. As with our beach and dune settlement analyses, we estimate the elastic settlement of the foundation soils to be about 20 percent of the long-term consolidation settlement. We considered containment dike fill material settlement negligible because the fill material will be composed mostly of sand. Sand fill material settlement will likely occur during the construction process.

Cross-sections were selected to represent conservative fill thicknesses for each alignment. Containment dike fill was assumed to have been placed instantaneously is a single lift at time of construction, and water was assumed to be at elevation +0.26 foot, based on the Typical Section sheets in the TE-118 Draft Permit Drawings document dated September 13, 2016.

East Timbalier Island

GeoEngineers evaluated settlement for East Timbalier Island back barrier marsh containment dikes constructed to a crown elevation of +5.3 feet. As previously mentioned, two profiles were developed to evaluate settlement for East Timbalier Island. Within the west zone, a mudline elevation of -4.0 feet was used to compute settlement of the foundation soils due to construction of the containment dike based on the cross-section at Station 130+00. Within the east zone, a mudline elevation of -1.5 feet was used to compute settlement of the foundation soils due to construction of the containment dike based on the cross-section at Station 50+00. The change in containment dike crown elevation with time due to the consolidation settlement of the foundation soils at East Timbalier is presented in Figure D-1 of Appendix D. Elastic settlement estimates are not included in the data presented in Appendix D, but are presented in the following table for the containment dikes at East Timbalier Island.

EAST TIMBALIER ISLAND – CONTAINMENT DIKE ELASTIC SETTLEMENT

Station	Initial Mudline Elevation (ft)	Estimated Elastic Settlement (in)
50+00	-1.5	6
130+00	-4.0	7

West Belle Pass Barrier Headland

GeoEngineers evaluated settlement of the proposed West Belle Pass Barrier Headland containment dike with a crown elevation of +5.5 feet. A mudline elevation of -0.5 foot was assumed based on the cross-section at Station 155+00. The change in the containment dike's crown elevation with time due to the consolidation settlement of the foundation soils at the West Belle Pass Barrier Headland is presented in Figure D-2 of Appendix D. The elastic settlement is not included in the data presented in Appendix D. However, the estimated elastic settlement is presented in the following table for the containment dike at the West Belle Pass Barrier Headland.

WEST BELLE PASS BARRIER HEADLAND – CONTAINMENT DIKE ELASTIC SETTLEMENT

Station	Initial Mudline Elevation (ft)	Estimated Elastic Settlement (in)
155+00	-0.5	4

Marsh Fill Settlement

Consolidation settlement and time rate of settlement analyses for the marsh creation areas were performed using the United States Army Corps of Engineers (USACE) computer program Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill (PSDDF). Low-stress consolidation test results were used to determine the dredged fill material properties. For both East Timbalier Island and the West Belle Pass Barrier Headland, fill placement was assumed to occur in a single 75-day construction period based on information provided by CEC. The end-of-construction target fill elevation was taken to be between elevation +3 feet and +4 feet, and the water level was modeled at the mean water elevation of +0.26 foot, based on the previously referenced Draft Permit Drawings document.

Marsh fill settlement and foundation soil settlement were combined to estimate total post-construction marsh fill surface settlement. Initial mudline settlement due to marsh construction was computed for a construction period of 75 days. Marsh fill surface elevation change due to marsh fill and foundation soil consolidation settlement and marsh fill desiccation is presented in Appendix E, Figures E-1 through E- 7.

Marsh fill settlement was computed for both East Timbalier Island zones using material properties from the TE-118 MB1 borrow site and from the alternative TE-118 SP1 and SP2 and TE-118 SS1 borrow sites (Ship Shoal). A mudline elevation of -1.0 foot was assumed to evaluate the marsh fill settlement within the east zone. Due to mudline variation within the west marsh creation area footprint, marsh fill settlement was evaluated for two initial mudline elevations, shown in the table below. West Belle Pass Barrier Headland marsh fill settlement was computed assuming an initial mudline elevation of 0 feet. Initial mudline elevation, mudline elevation at end of construction (EOC), and total end-of-construction marsh fill thickness are summarized in the following table.

ESTIMATED MARSH FILL THICKNESSES

Location	Target Fill Elevation (feet)	Initial Mudline Elevation (feet)	EOC Mudline Elevation (feet)	Total Marsh Fill Thickness at EOC (feet)
East Timbalier Island – East Zone	+3.0	-1.0	-1.4	4.4
	+4.0	-1.0	-1.5	5.5
East Timbalier Island – East Zone (Ship Shoal Alt.)	+3.0	-1.0	-1.5	4.5
	+4.0	-1.0	-1.6	5.6
East Timbalier Island – West Zone	+3.0	-2.0	-2.3	5.3
	+4.0	-2.0	-2.5	6.5
	+3.0	-6.5	-7.1	10.1
	+4.0	-6.5	-7.2	11.2
East Timbalier Island – West Zone (Ship Shoal Alt.)	+3.0	-2.0	-2.5	5.5
	+4.0	-2.0	-2.6	6.6
	+3.0	-6.5	-7.3	10.3
	+4.0	-6.5	-7.4	11.4
West Belle Pass Barrier Headland	+3.0	0.0	-0.3	3.3
	+4.0	0.0	-0.4	4.4

Compressible Foundation Depth

Restoration area footprints on East Timbalier Island and the West Belle Pass Barrier Headland approach widths of 1,000 to 3,000 feet in areas along the project alignment. Our deepest soil borings extended to a depth of 100 feet beneath the existing mudline within the project limits. At a depth of 100 feet, the change in stress applied by the proposed fill to the foundation soils will still be felt. Based on geologic maps in the project area, we expect sand or hard over-consolidated clay to be present at depth. We believe our deeper soil borings on the West Belle Pass Barrier Headland may have been encroaching on this sand at the termination depth. We do not expect significant consolidation in soil deeper than 100 feet below grade.

Construction Considerations

Based on the site work and evaluations completed for this project, the following are offered with respect to construction.

- Our evaluations are based on a limited number of investigations over a wide area. Our evaluations indicate variability throughout the site. As such, CPRA should expect localized areas during construction that may require location-specific remedies. GeoEngineers offers our services during construction to address issues that may arise.

- Areas of the project footprint on East Timbalier Island will have substantial thicknesses of fill placed, especially in the southwest corner of the project. Total settlement on the order of 6 to 7 feet may be observed in areas of beach and dune creation over the life of the project. However, foundation soils are such that bearing capacity and slope stability do not appear to be a concern. Therefore, construction of the beach and dune and containment dikes does not require placement of fill in lifts.
- For containment dike construction, a bench at least 30 feet wide must be maintained between the toe of the dike and the excavation cut slope. We recommend marsh buggies remain close to the dike toe without treading on the toe itself.
- Water levels can significantly affect construction and dike stability. High water levels may increase erosion, while low water levels reduce fill buoyancy and can cause failures. Sandy fill material can be particularly difficult when exposed to tidal variations, as it will wash to a flatter slope more readily than clay. As previously discussed, sand borrow material is planned to construct the containment dikes, dunes, and beaches. The design slopes of these features are generally flat; however, erosion is a significant short-term concern for sand embankments. There are methods of mitigating erosion of sand such as clay capping, use of a filter fabric, or armoring the slopes, if deemed necessary. Evaluation of these options was outside our current scope; however, we are willing to discuss alternatives.
- As previously expressed, careful thought and attention should be exercised while planning and executing the placement of fill material at the site due to the significant amount of oil and gas infrastructure present at the site. A thorough magnetometer/gradiometer survey should be undertaken to identify as many subsurface obstructions as practical, and measures must be taken to prevent pipeline damage during construction and as a result of settlement.

LIMITATIONS

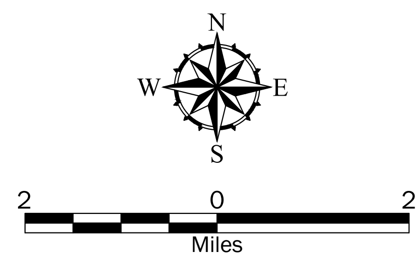
The information presented in this report is based on field explorations and evaluations completed for this study and judgments made by GeoEngineers, Inc. This report is specific to this site and should not be used other than for the design of the East Timbalier Island Restoration (TE-118) Project located in Lafourche Parish, Louisiana. We have provided the requested information for the geotechnical engineering report in this document. Soil borings, laboratory test results, and other data are contained the in the geotechnical investigation data report companion to this document. A calculation package detailing analysis specifics is also presented under separate cover.

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 expressed or implied should be understood.

Please refer to Appendix F titled “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

FIGURES

P:\16\16715036\00\CAD\1671503600_F1_VicinityMap.dwg TAB:Vicinity Map Date Exported: 09/15/16 - 9:56 by kcook



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. cannot 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.

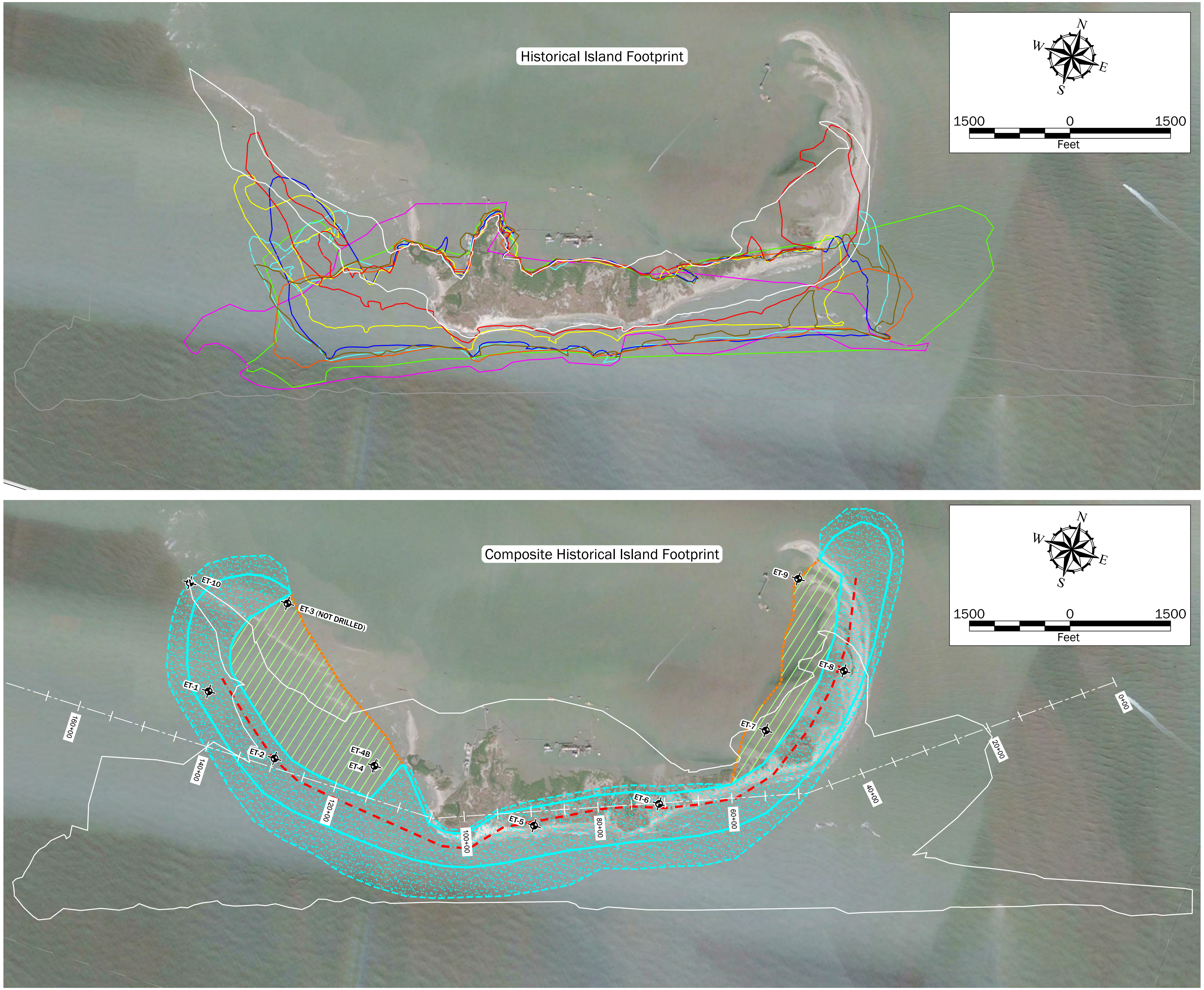
Data Source:
Aerial image was taken from Google Earth, Imagery Dated: 1/25/2015

Vicinity Map

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure 1



Historical Island Footprint Legend

- 11/1989
- 02/03/1998
- 01/26/2004
- 09/08/2005
- 09/29/2005
- 06/18/2006
- 08/22/2008
- 08/27/2009
- 09/12/2011
- 11/14/2012

Composite Historical Island Footprint Legend

- ET-1 Boring Location
- Beach Crest
- Beach & Dune Fill
- Marsh Fill
- Beach Fill Extents
- Dune Crest Alignment
- Marsh Dike Alignment
- Historical Island Outline
- 100+00 Alignment and Stationing

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. cannot 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

Data Source:

1. Soil boring Locations were provided by John Chance Land Surveys, Inc.
2. Aerial was taken from Google Earth Pro., Imagery Dated: 1/25/2015.
3. Alignment and stationing information provided by Coastal Engineering Consultants, Inc., Dated: 1/2017.
4. Historical island outlines were taken from Google Earth Pro., dates vary.

Historical Island Footprints
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure 2a

P:\16\1671503600\CAD\Geotech\1671503600_F2a_Historical Island Footprint.dwg TAB:Project Outline - ET Date Exported: 06/21/17 - 14:23 by kcook

Legend

WBP-1 Boring Location
Beach Crest
Beach & Dune Fill
Marsh Fill
Beach Fill Extents
Dune Crest Alignment
Marsh Dike Alignment
120+00 Alignment and Stationing

N W E S

600 0 600
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. cannot 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

Data Source: Soil boring locations were provided by John Chance Land Surveys, Inc.
Aerial was taken from Google Earth Pro., Imagery Dated: 1/25/2015.
Alignment and stationing information provided by Coastal Engineering Cosultants, Inc., drawings: 15225 WBP LS Plan View & XS.dwg, project number: 15.077, sheet 3 of 7, dated: August 2016.

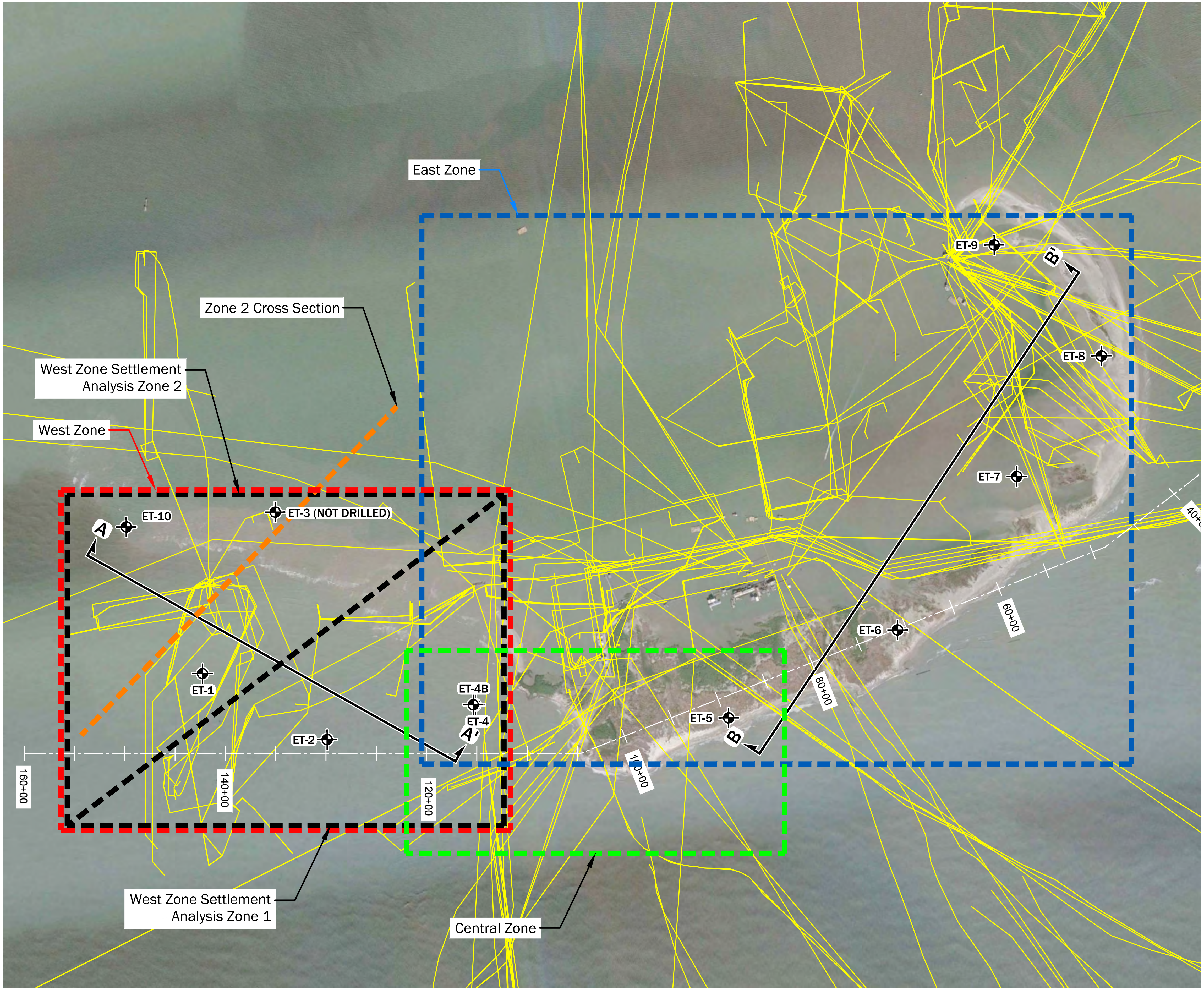
Project Outline
West Belle Pass - Barrier Headland

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure 2b

P:\16\1671503600\CAD\Geotech\1671503600_F2b_Project Outline.dwg TAB:Project Outline - WBP Date Exported: 06/23/17 - 7:21 by kcook



Boring Details			
Boring #	Latitude	Longitude	Depth (ft)
ET-1	N29°04'02.6"	W90°20'27.2"	50'
ET-2	N29°03'56.0"	W90°20'13.3"	50'
ET-3	NOT DRILLED		
ET-4	N29°03'59.3"	W90°19'56.7"	50'
ET-4B	N29°03'59.3"	W90°19'56.9"	50'-100'
ET-5	N29°03'57.8"	W90°19'28.3"	80'
ET-6	N29°04'06.3"	W90°19'09.3"	50'
ET-7	N29°04'21.3"	W90°18'55.8"	50'
ET-8	N29°04'33.1"	W90°18'46.2"	50'
ET-9	N29°04'44.1"	W90°18'58.1"	100'
ET-10	N29°04'17.1"	W90°20'35.6"	50'

Legend

ET-1 Boring Location

Existing Pipelines

A A' Cross Section Location

200+00 Alignment and Stationing

N W E S

1000 0 1000
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. cannot 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

Data Source: Soil boring coordinates and existing pipeline information provided by John Chance Land Surveys, Inc.
Aerial was taken from Google Earth Pro., Imagery Dated: 1/25/2015.
Alignment and stationing information provided by Coastal Engineering Cosultants, Inc., drawings: West Belle Pass Plan View and Preliminary Design Plan View, project number: 15.077, sheets 3&4 of 7, dated: August 2016.

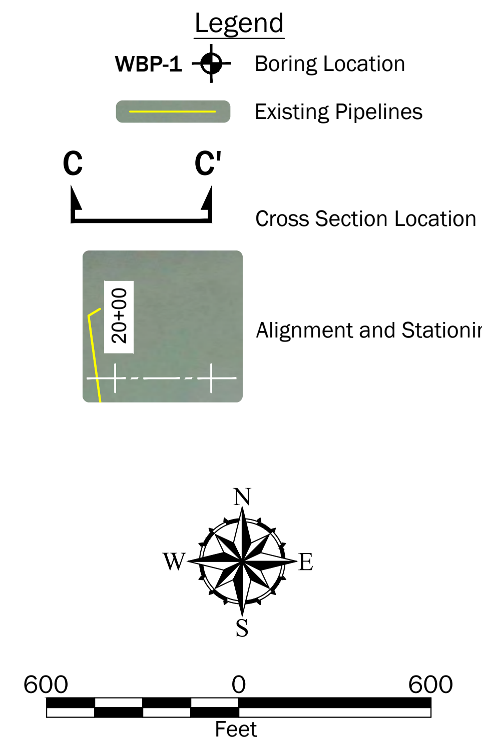
Soil Boring Location Plan
East Timbalier (ET) Borings

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure 3a

Boring Details			
Boring #	Latitude	Longitude	Depth (ft)
WBP-1	N29°06'05.2"	W90°16'19.2"	100'
WBP-2	N29°05'50.4"	W90°16'14.8"	50'
WBP-3	N29°05'59.0"	W90°15'58.0"	50'
WBP-4	N29°05'45.0"	W90°15'52.9"	100'
WBP-5	N29°06'03.9"	W90°16'32.3"	50'



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. cannot 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

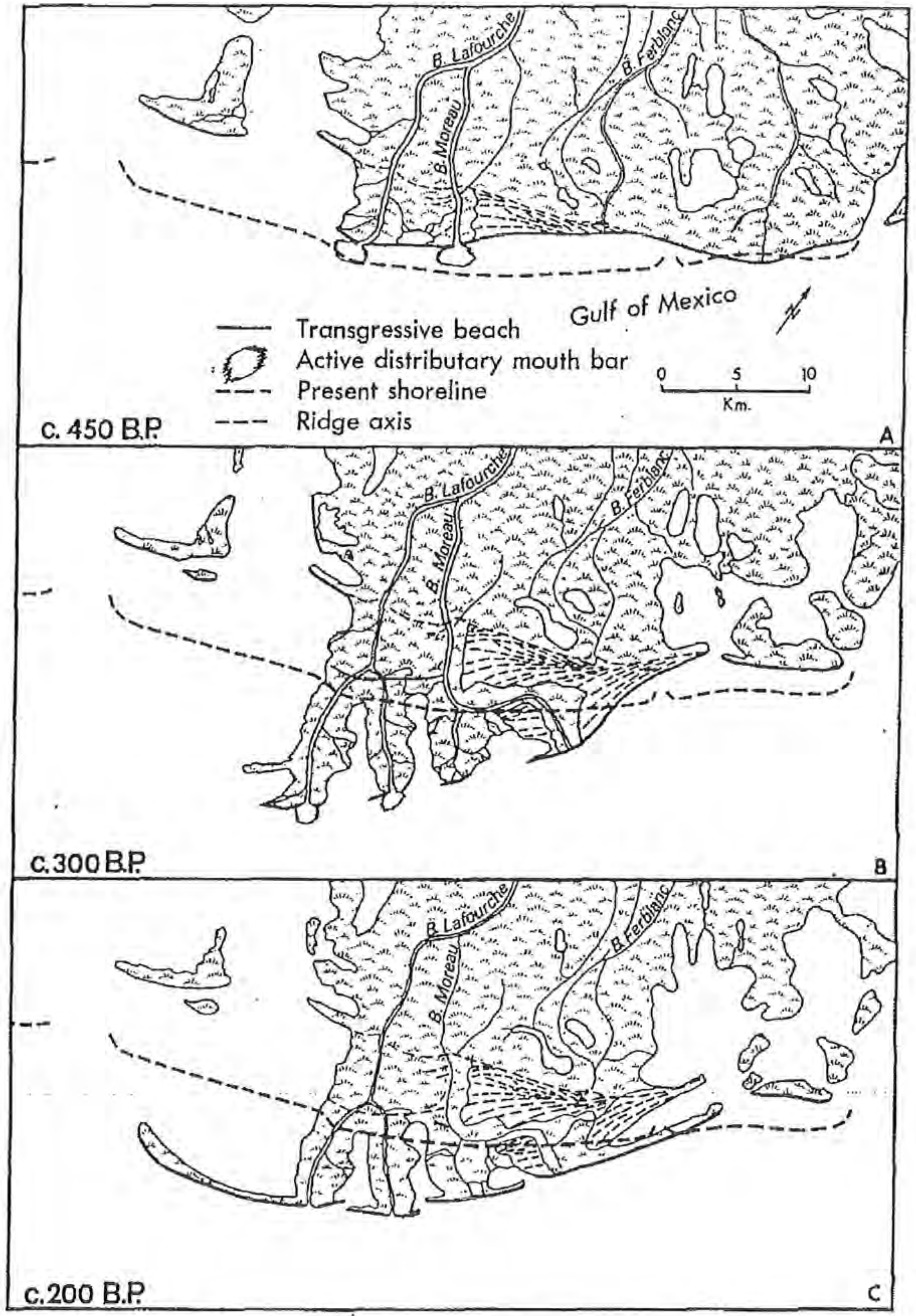
Data Source: Soil boring coordinates and existing pipeline information provided by John Chance Land Surveys, Inc.
Aerial was taken from Google Earth Pro., Imagery Dated: 1/25/2015.
Alignment and stationing information provided by Coastal Engineering Cosultants, Inc., drawings: West Belle Pass Plan View and Preliminary Design Plan View, project number: 15.077, sheets 3&4 of 7, dated: August 2016.

Soil Boring Location Plan
West Belle Pass (WBP) Borings

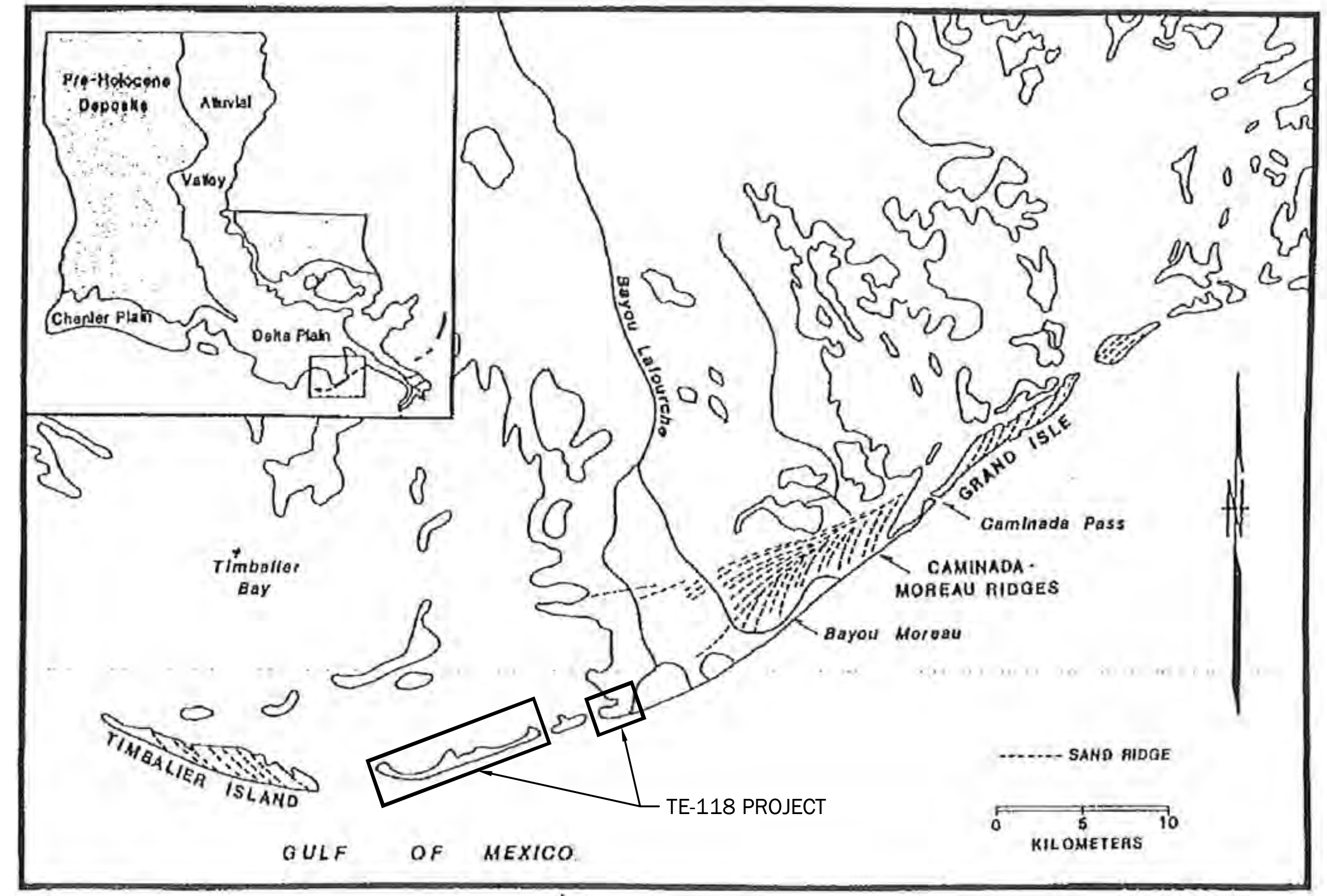
East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure 3b



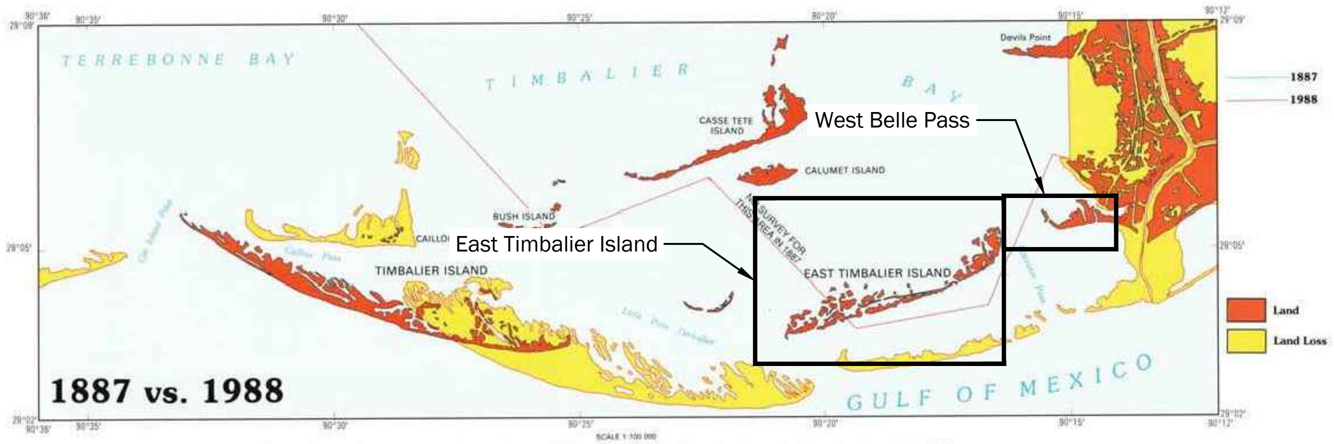
B.P. = BEFORE PRESENT

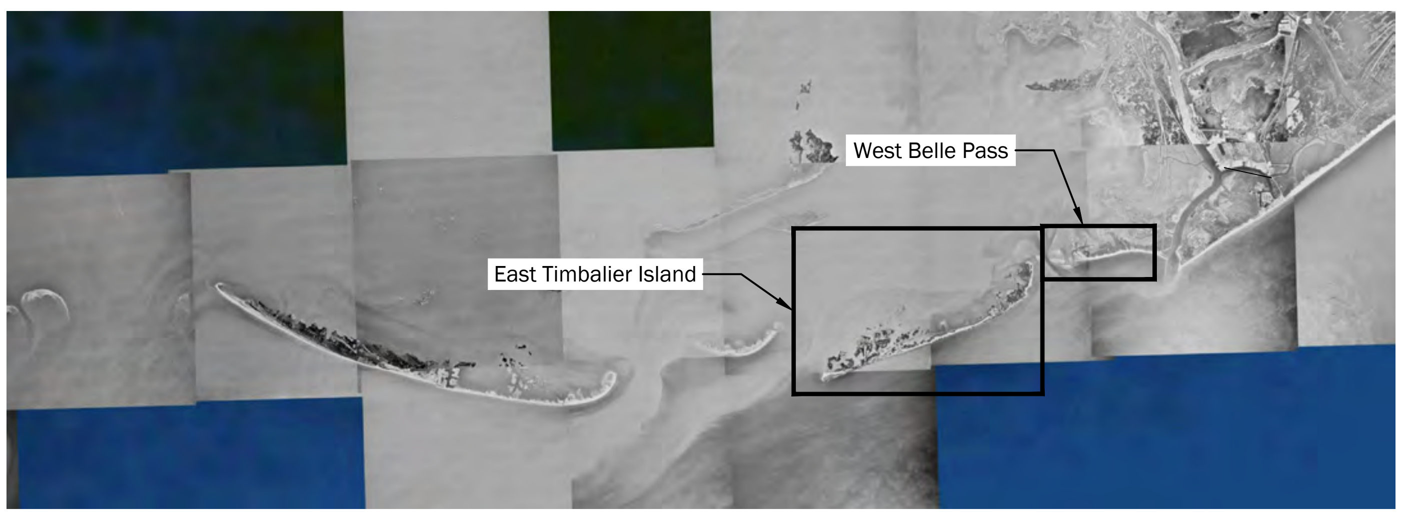


Reference: Images were taken from Figures 20 and 20c of The Holocene Geology of the Central South Louisiana Coastal Zone, Louisiana Geological Survey, Pages 52 and 55, Dated March 1996

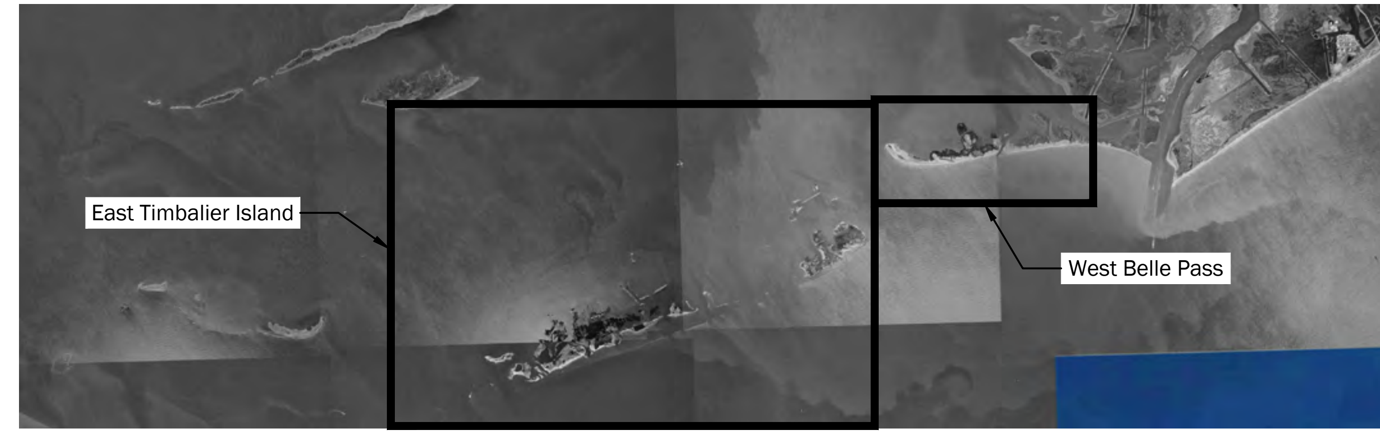
Notes:
1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record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

Caminada-Moreau Ridge Plain	
East Timbalier Island Restoration (TE-118) Project Lafourche Parish, Louisiana	
GEOENGINEERS	Figure 4

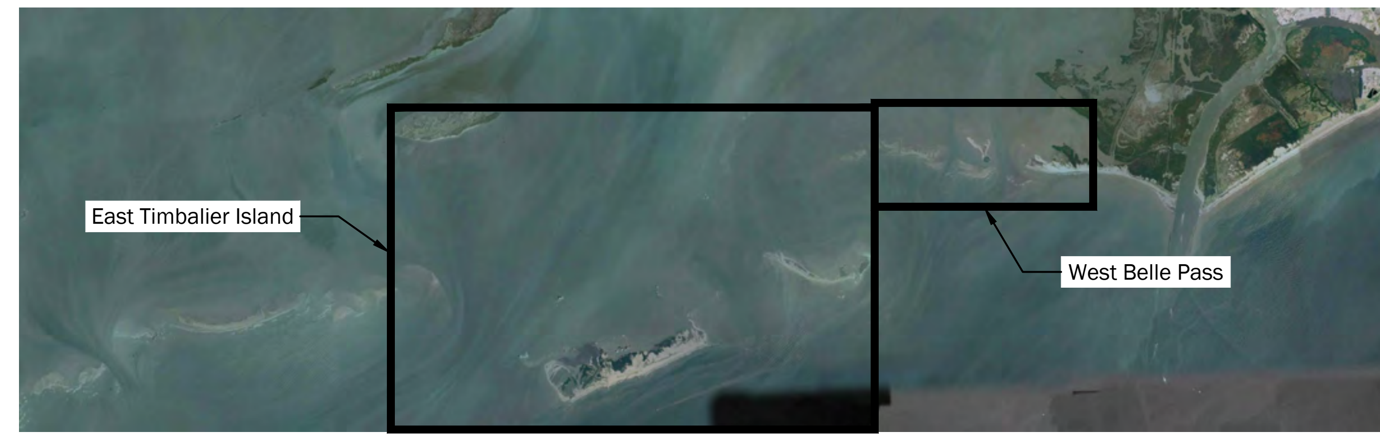




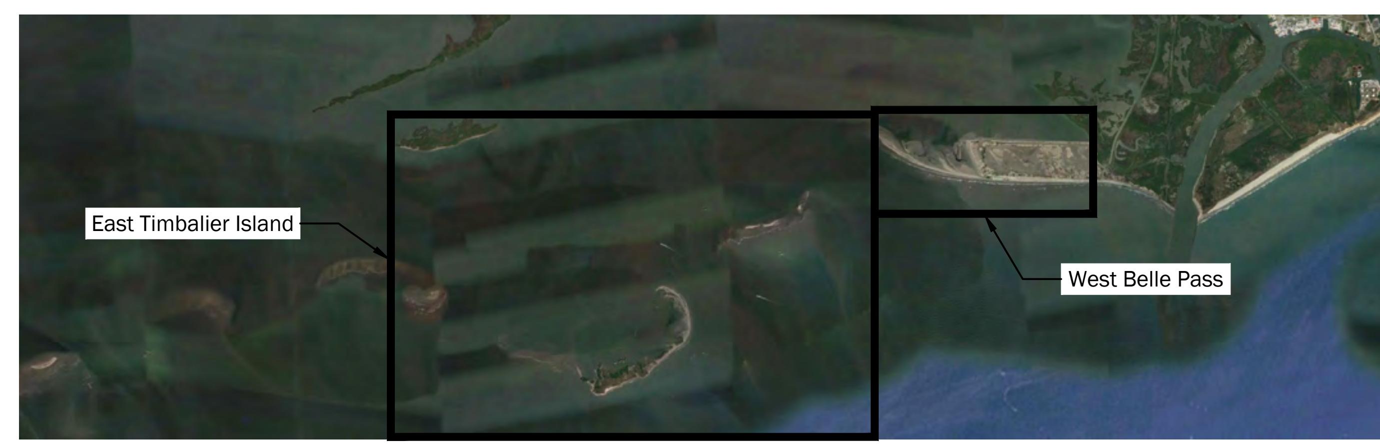
Aerial Dated: 11/8/1989
Scale: NTS



Aerial Dated: 2/3/1998
Scale: NTS



Aerial Dated: 7/22/2007
Scale: NTS



Aerial Dated: 1/25/2015
Scale: NTS

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. cannot 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.

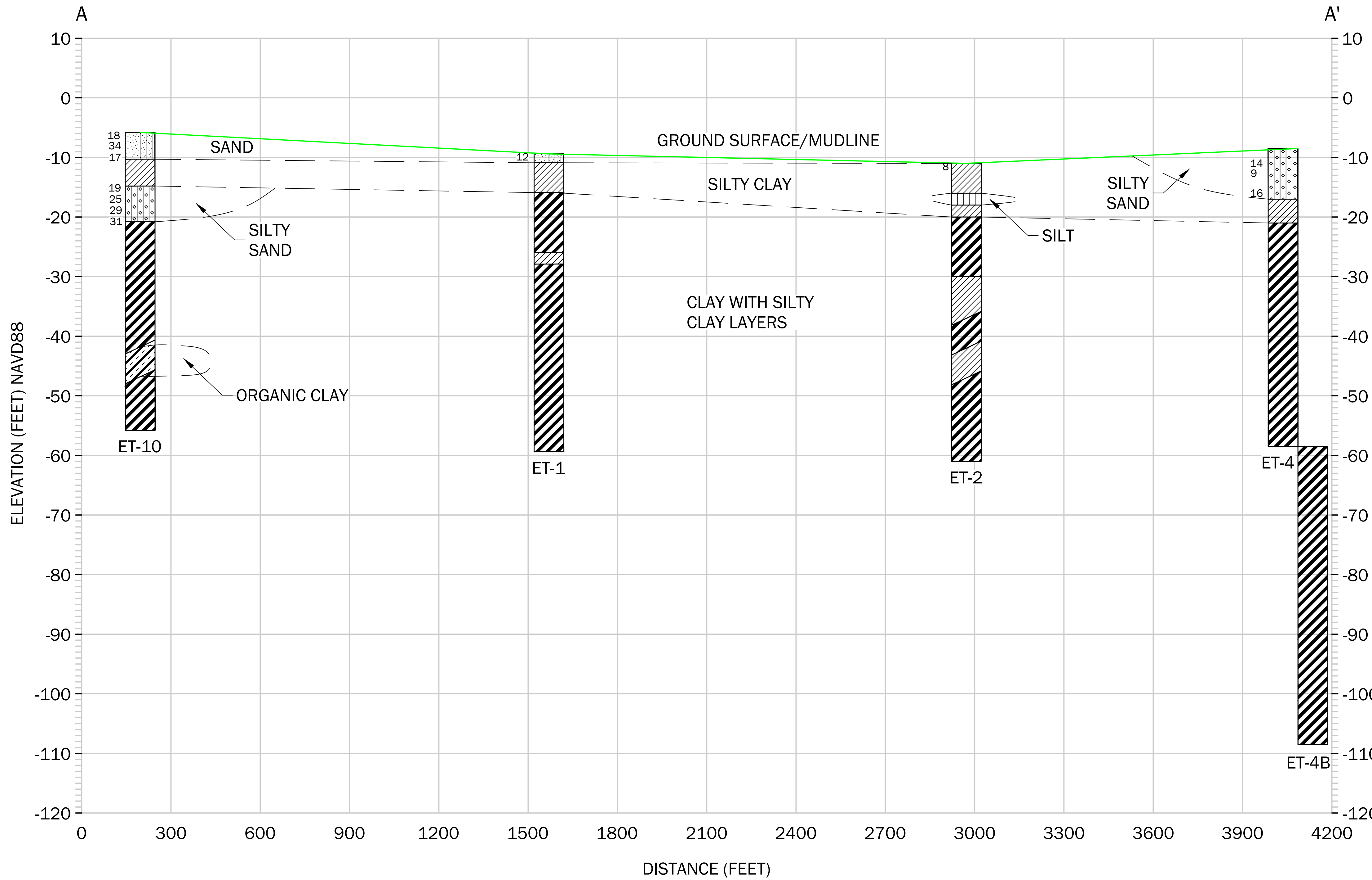
Data Source:
1. 1887 vs 1998 land comparison image was taken from US Geological Survey, Atlas of Shoreline Changes from 1853 to 1989, Page 54, Dated 1992
2. Aerial images were taken from Google Earth Pro, Imagery Dated: 11/8/1989, 2/3/1998, 7/22/2007, 1/25/2015

Land Loss Comparison
1887 to 2015

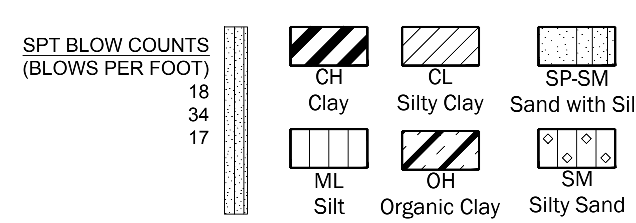
East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure 5



Boring Legend



Notes:

1. The locations of all features shown are approximate.
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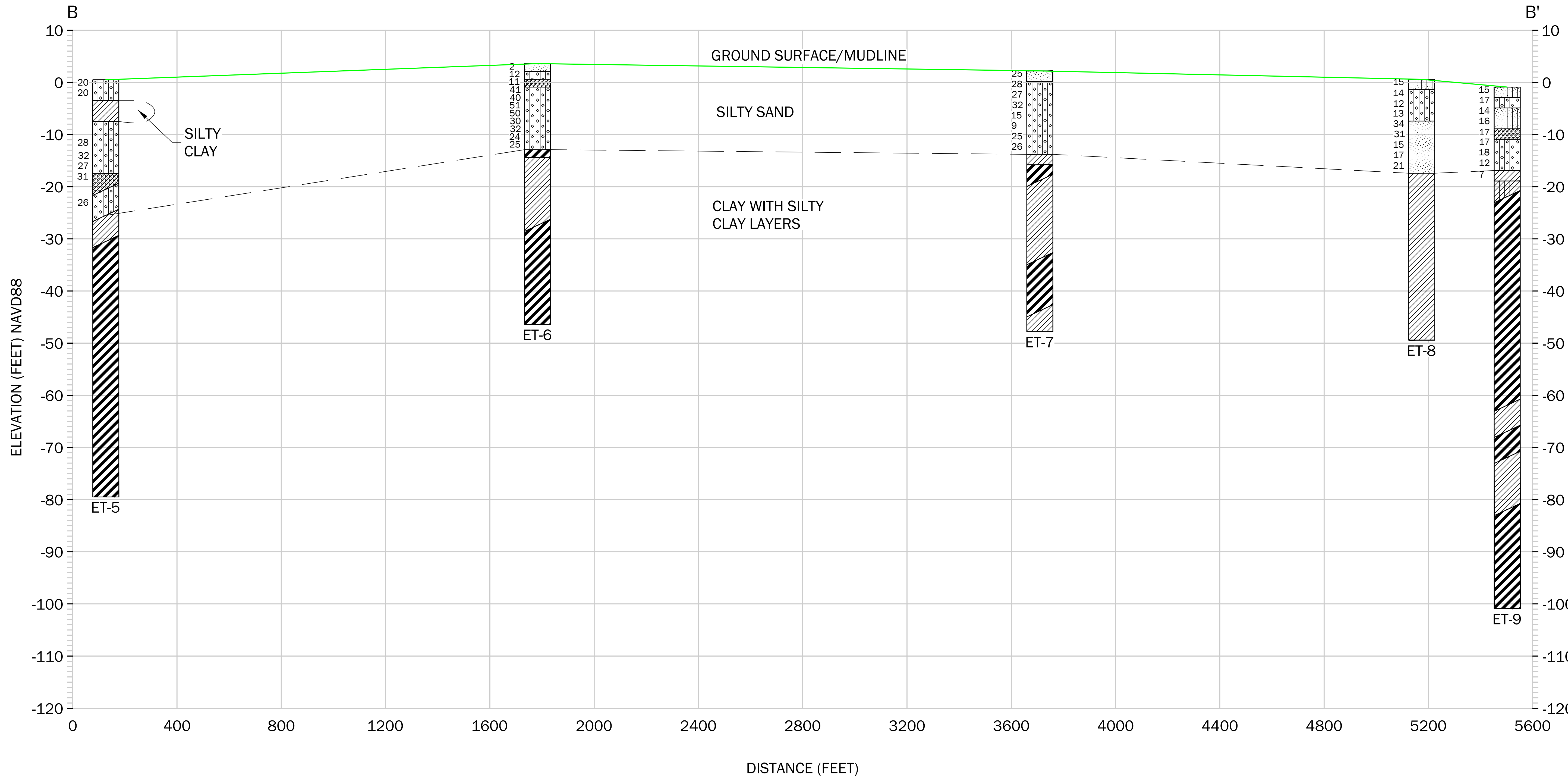
P:\16\1671503600\CAD\Geotech\1671503600_F6a-6c_Subsurface Profiles.dwg TAB:Profile A-A' Date Exported: 06/23/17 - 7:24 by kcook

Subsurface Profile - East Timbalier A - A'

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure 6a



Boring Legend

SPT BLOW COUNTS (BLOWS PER FOOT)
18
34
17

CH Clay	CL Silty Clay	SP-SM Sand With Silt	CL-ML Clayey Silt
SP Sand	SC Clayey Sand	SM Silty Sand	

Notes:
1. Boring ET-5 was terminated at a depth of 80 feet because a gas pocket was encountered. Refer to text for additional details.
2. The locations of all features shown are approximate.
3. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot 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.

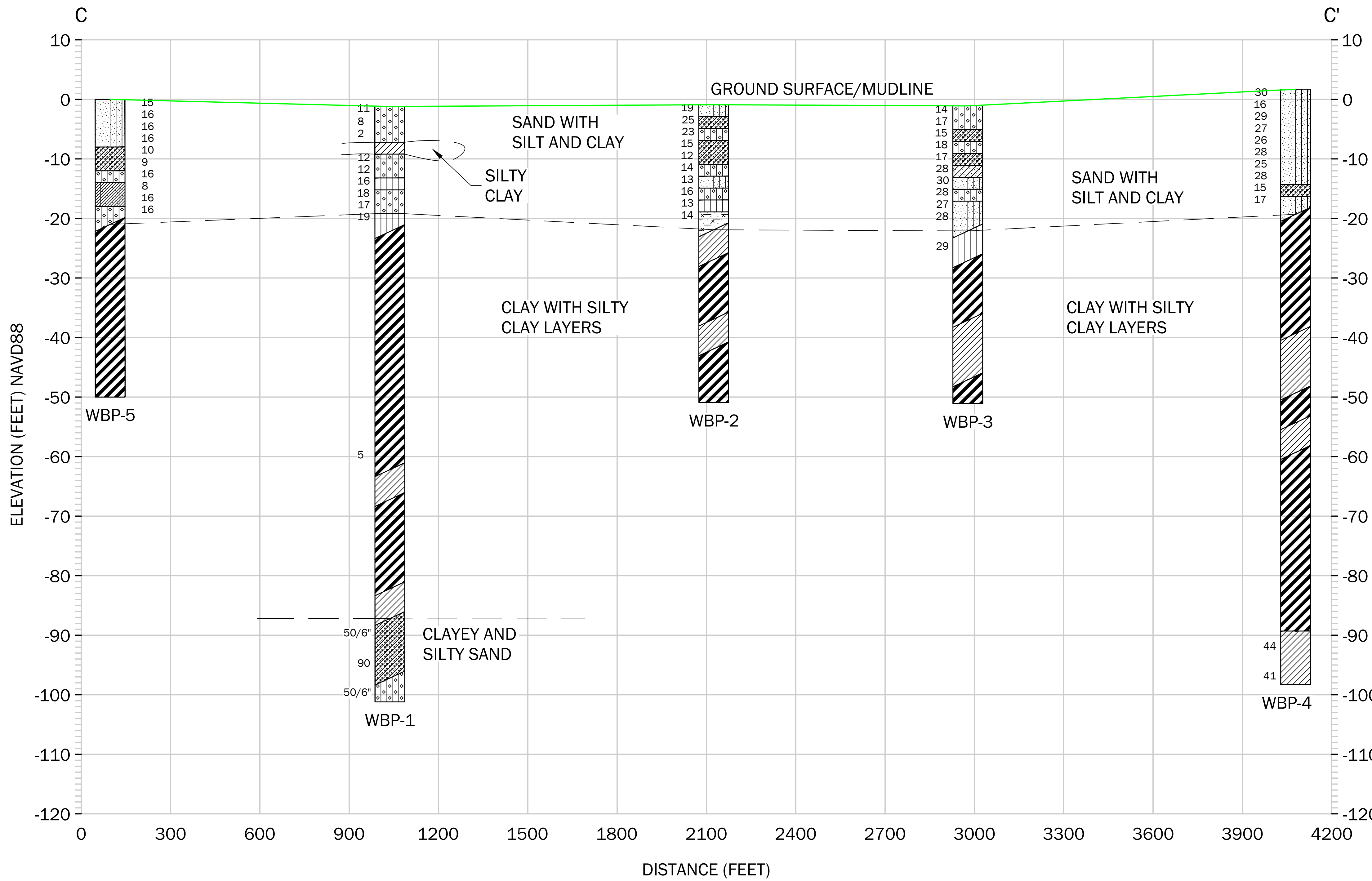
Subsurface Profile - East Timbalier B - B'

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure 6b

P:\16\1671503600\CAD\Geotech\1671503600_F6a-6c_Subsurface Profiles.dwg TAB:Profile B-B' Date Exported: 06/23/17 - 7:25 by kcook



Boring Legend

SPT BLOW COUNTS (BLOWS PER FOOT)

CH	Clay
CL	Silty Clay
SC-SM	Silty Clayey Sand
ML	Silt
SP-SM	Sand with Silt
SM-SC	Silty Sand with Clay
SC	Clayey Sand
SM	Silty Sand
SP-SC	Sand with Clay

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. cannot 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 Profile - West Belle Pass C - C'

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

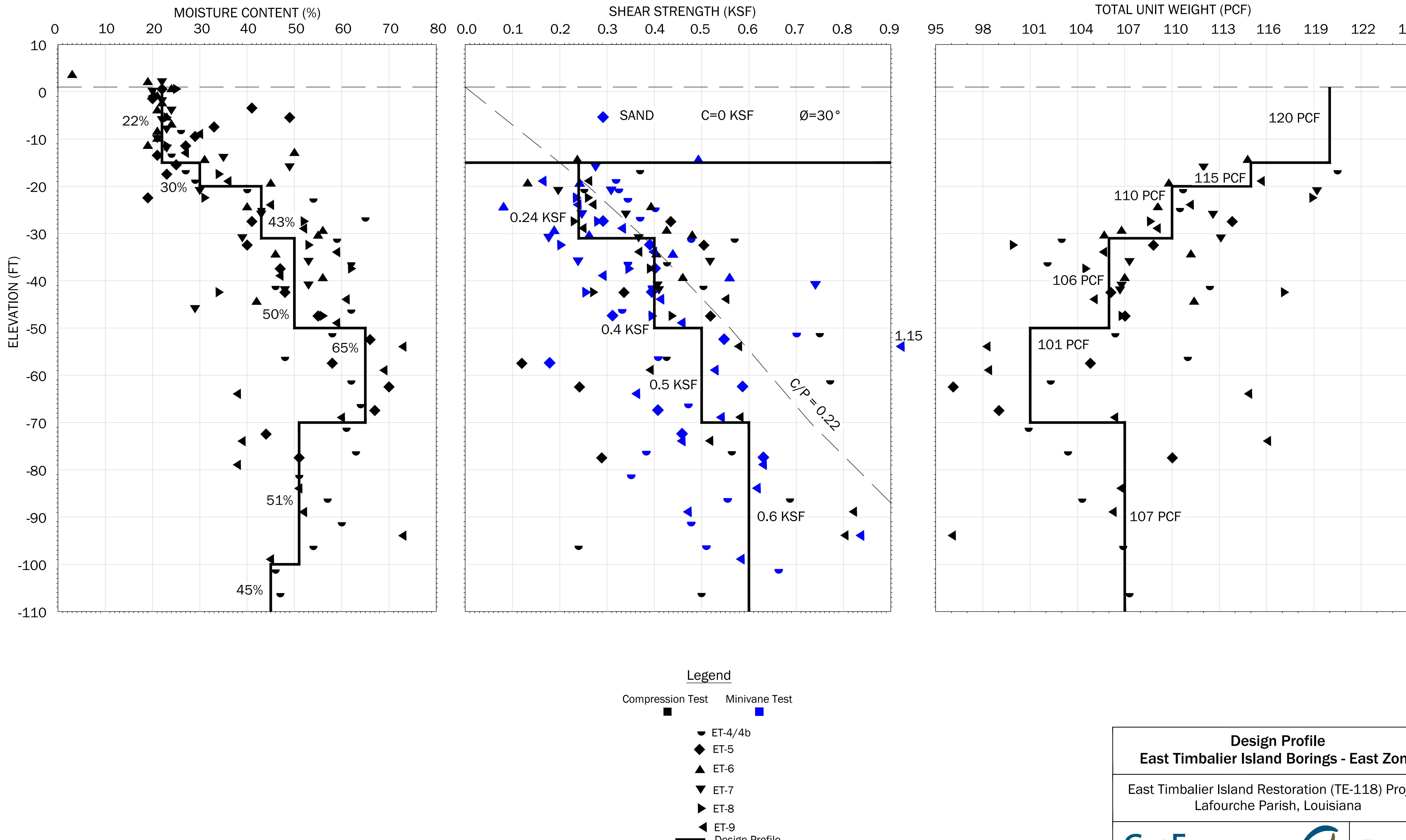
GEOENGINEERS

Figure 6c

P:\16\1671503600\CAD\Geotech\1671503600_F6a-6c_Subsurface Profiles.dwg TAB:Profile C-C' Date Exported: 06/23/17 - 7:26 by kcook

APPENDICES

APPENDIX A
Soil Design Profiles



Design Profile
East Timbalier Island Borings - East Zone

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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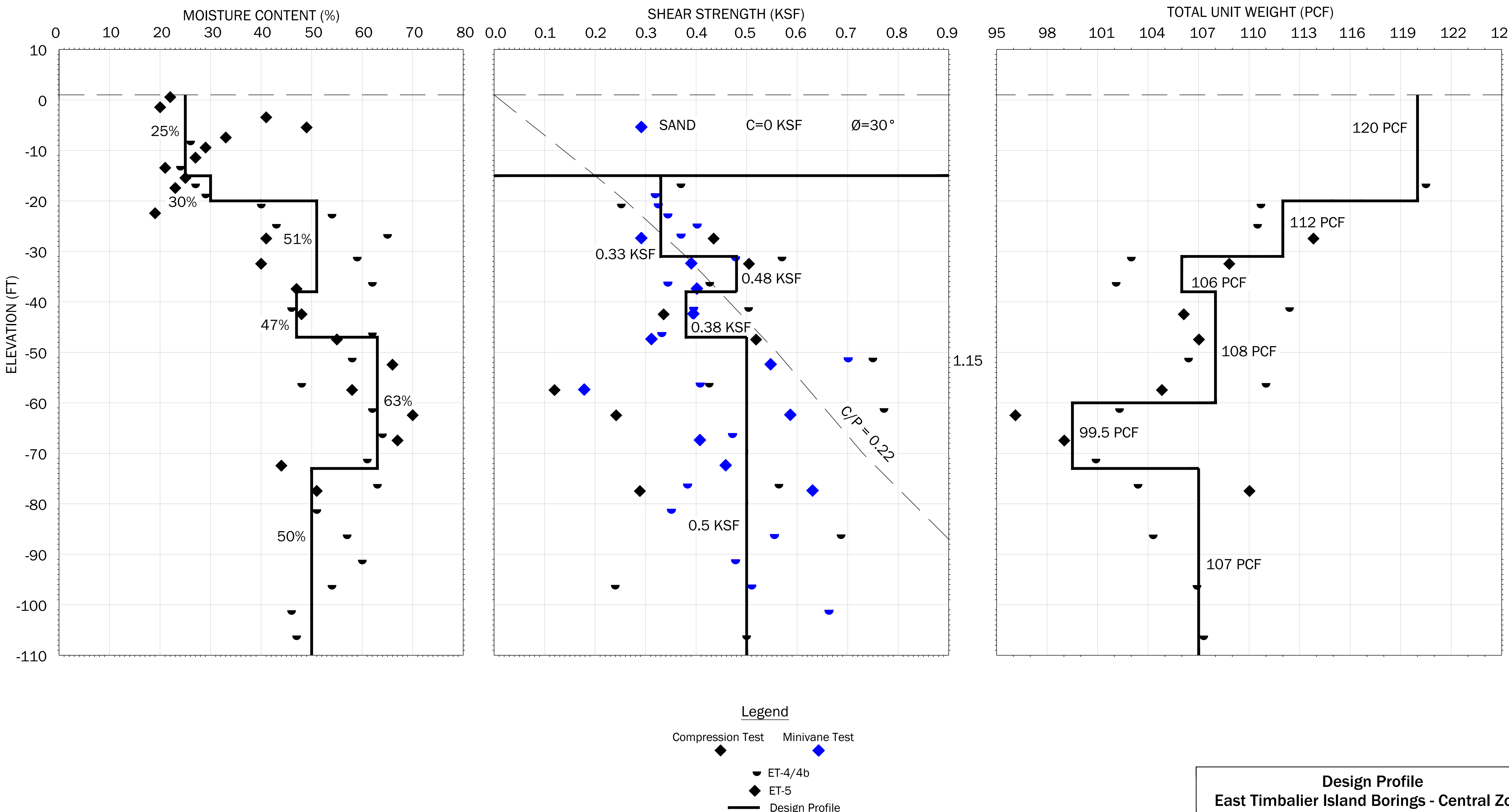
Figure A-1

\\geoengineers.com\wan\Projects\16\16715036\00\CAD\Lab Graphs.dwg TAB:ET Set 2 Date Exported: 11/22/16 - 9:48 by ncomeaux



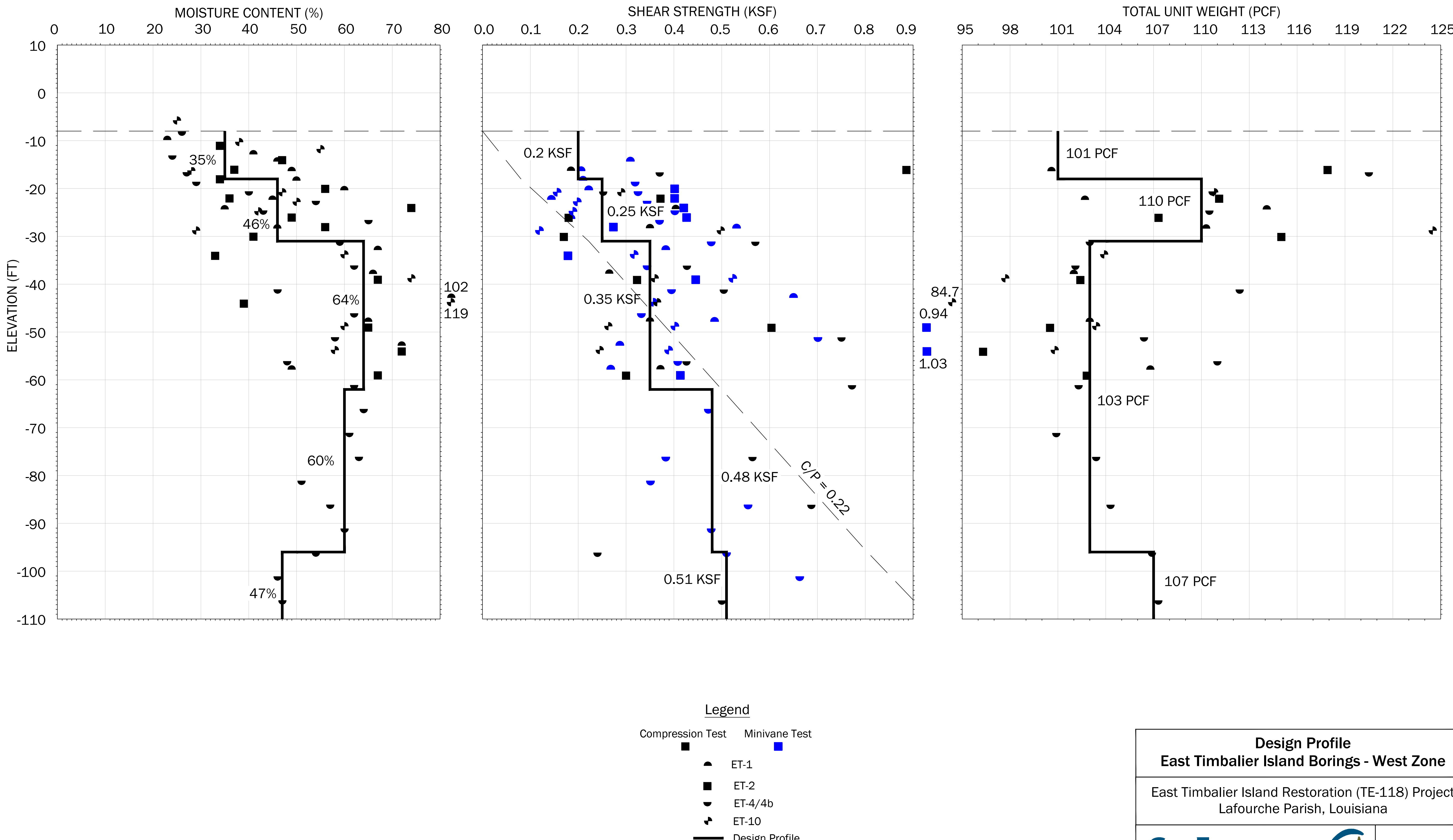
P:\16\16715036\00\CAD\Geotech\1671503600_Appendix A_Design Profile_1_20942_5619.sv$.dwg TAB:ET Set 3 Date Exported: 08/30/17 - 15:01 by kcook

Design Profile
East Timbalier Island Borings - Central Zone

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure A-1a

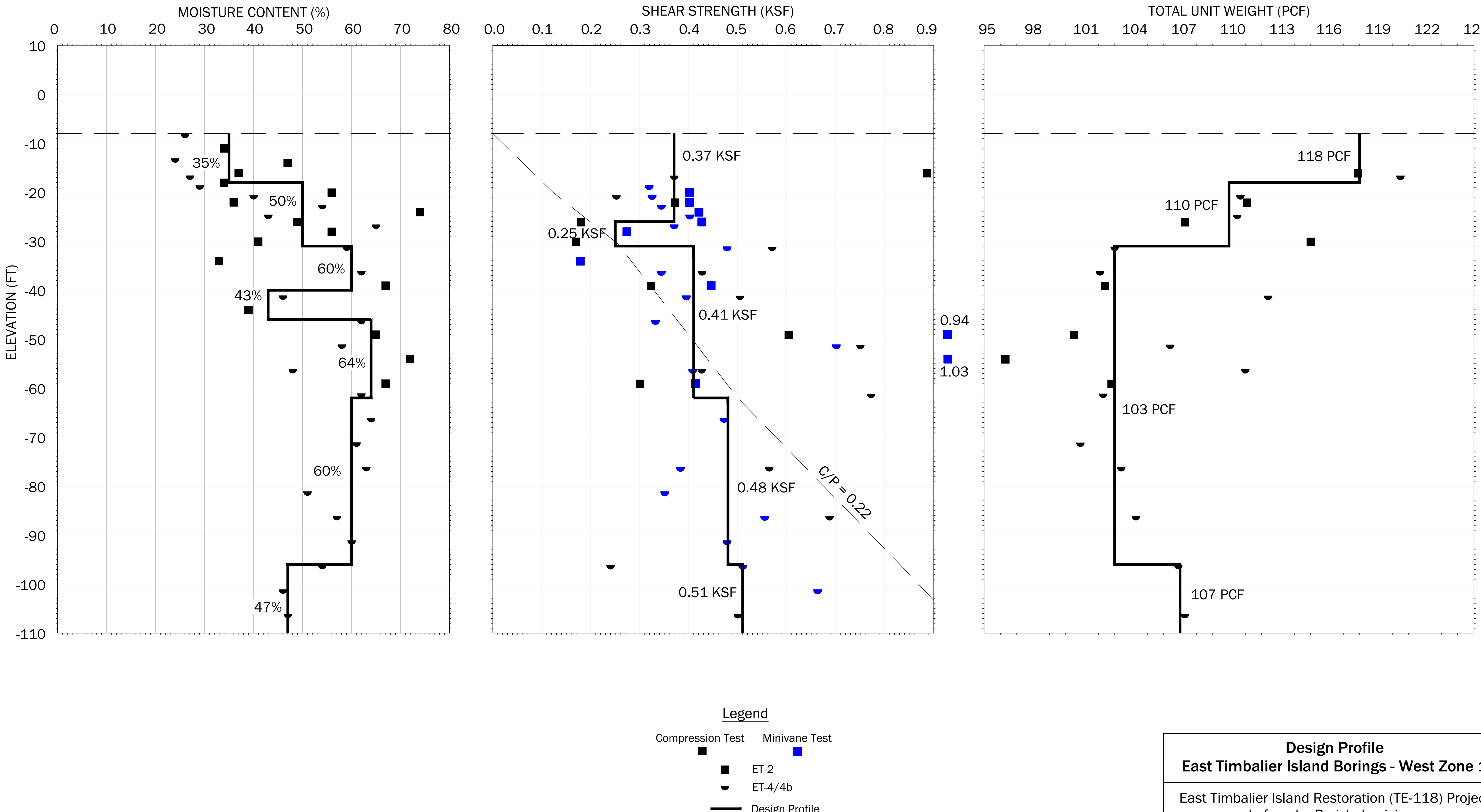


Design Profile
East Timbalier Island Borings - West Zone

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure A-2



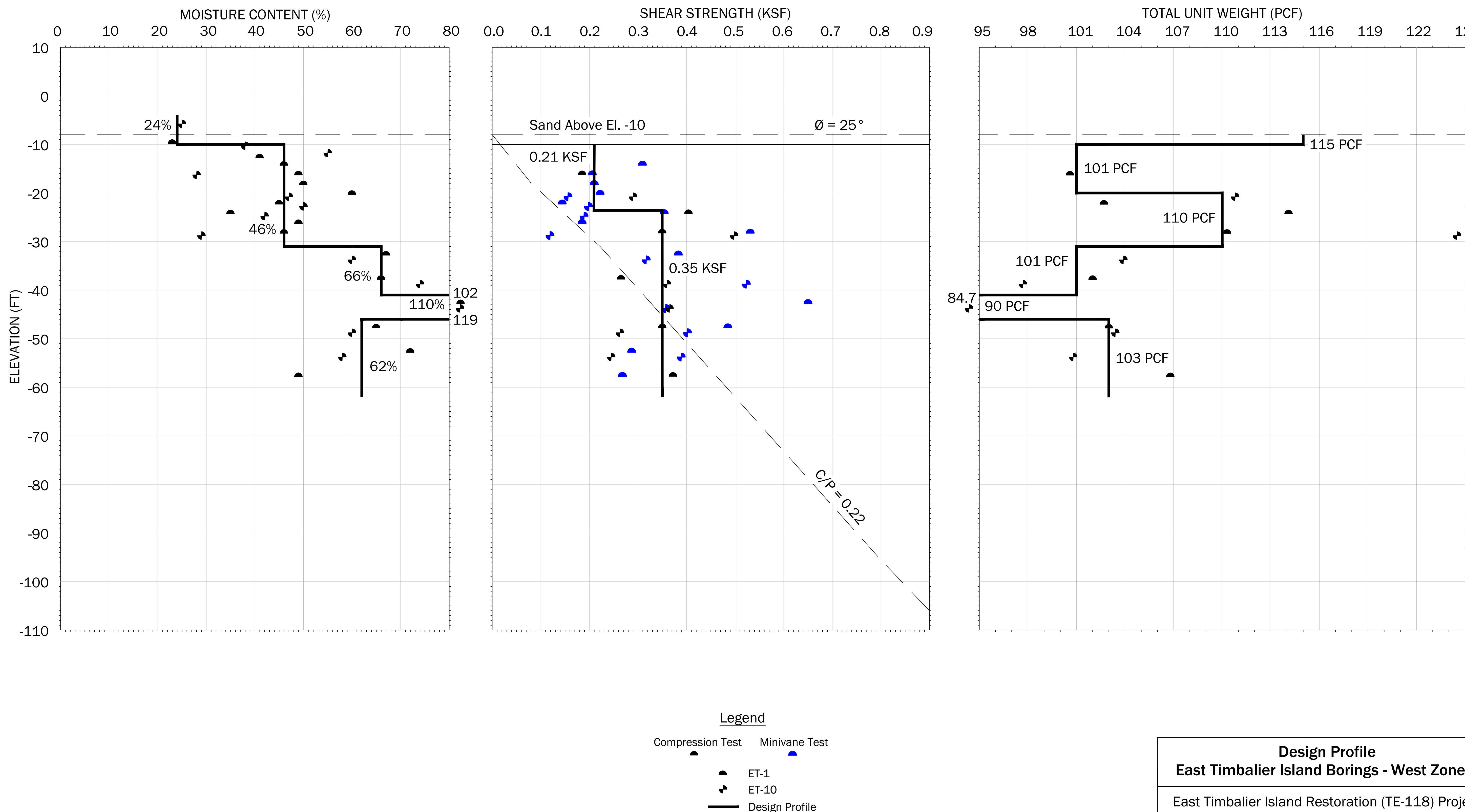
Design Profile
East Timbalier Island Borings - West Zone 1

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure A-2a

P:\16\1671503600\CAD\Geotech\1671503600_Appendix A_Design Profile.dwg TAB:ET Set 1 (3) Date Exported: 06/06/17 - 13:47 by kcook

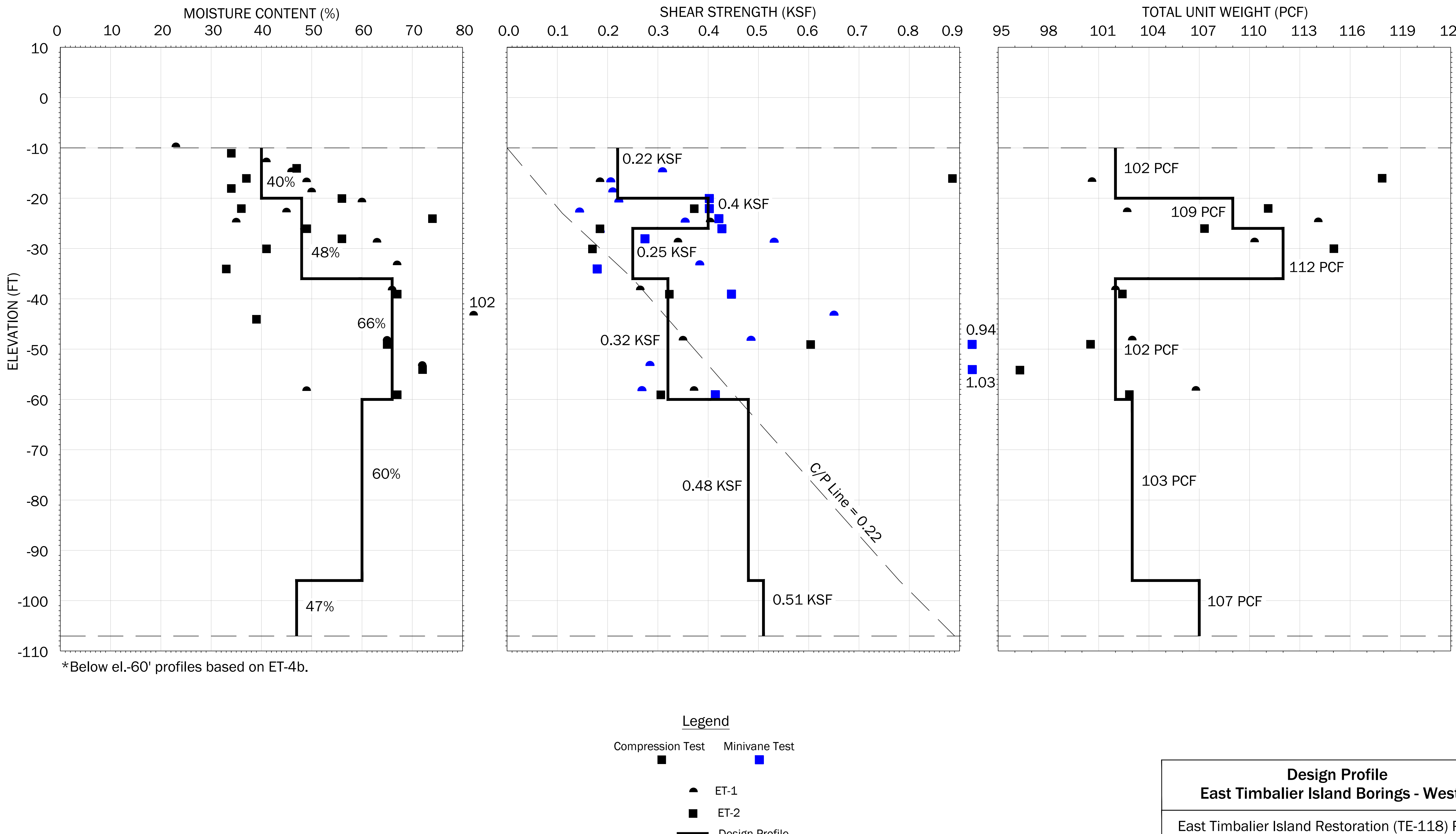


Design Profile
East Timbalier Island Borings - West Zone 2

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure A-2b

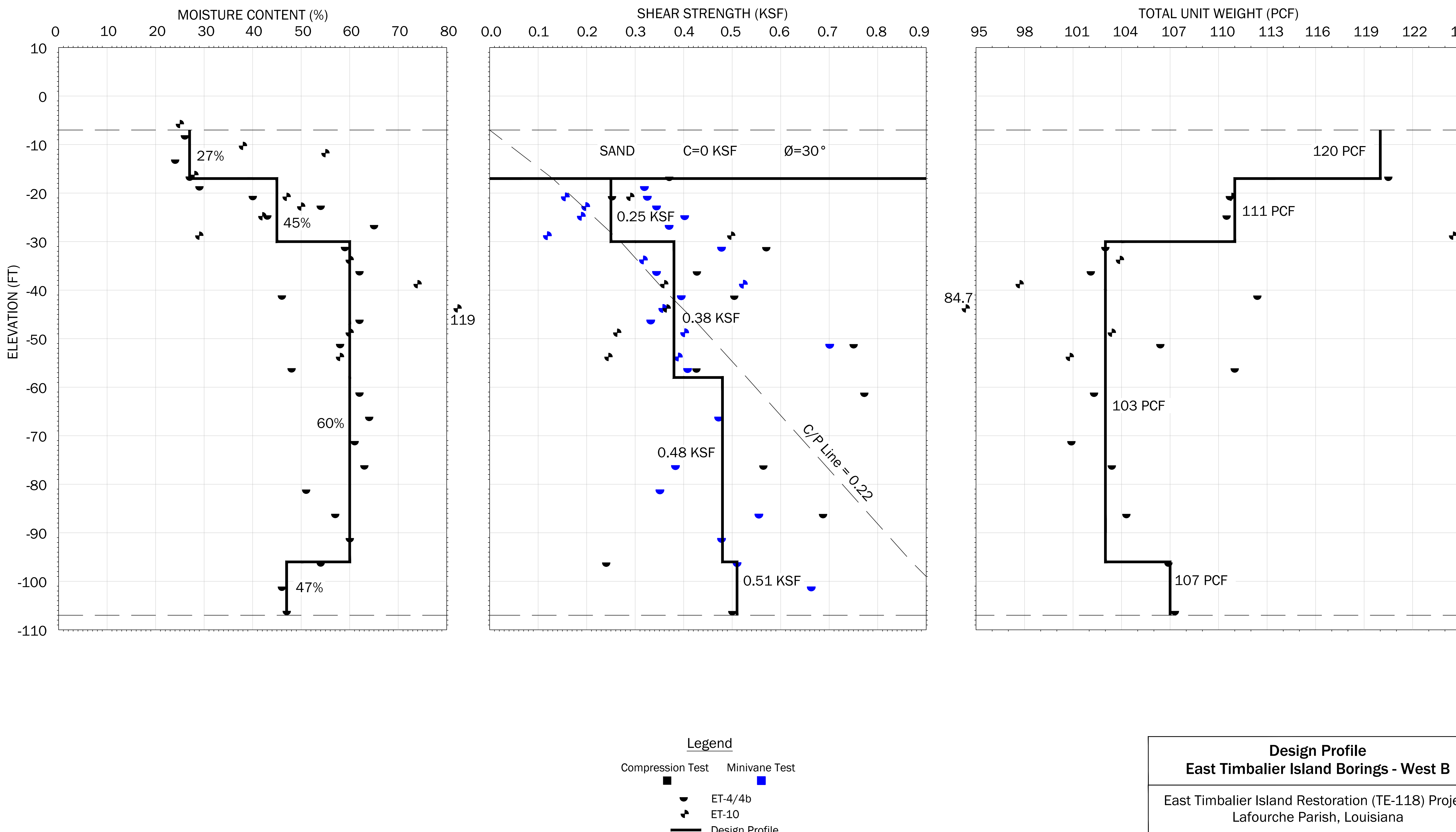


Design Profile
East Timbalier Island Borings - West A

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure A-3



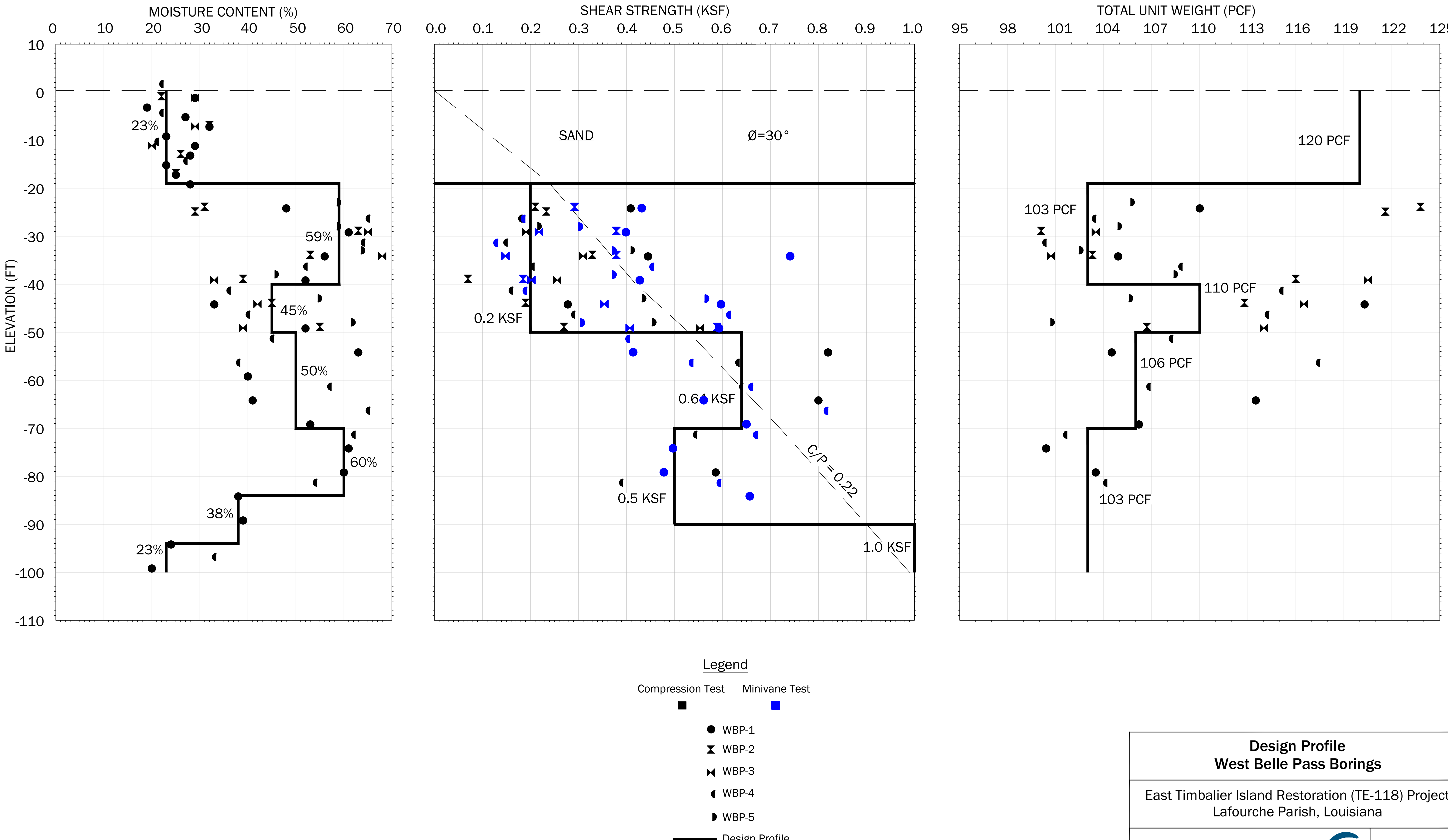
Design Profile
East Timbalier Island Borings - West B

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure A-4

\\geoengineers.com\wan\Projects\16\16715036\00\CAD\Lab Graphs.dwg TAB:ET Combined (5) Date Exported: 11/22/16 - 10:05 by nconeaux



Design Profile
West Belle Pass Borings

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure A-5

APPENDIX B
Slope Stability Analysis

APPENDIX B
CALCULATION APPROACH FOR SLOPE STABILITY AND BEARING CAPACITY OF CONTAINMENT DIKES, DUNES, AND BEACHES

Containment dike, beach, and dune slope stability was evaluated for the East Timbalier Island Restoration (TE-118) project using optimized circular search parameters with Spencer's method in the GEO-SLOPE International Limited computer program SLOPE/W (GeoStudio 2012). Bearing capacity of the containment dikes was also evaluated. Design considerations for the evaluations are described below.

1. Selected conservatively representative design profiles. For East Timbalier Island, the design profiles developed for the eastern zone along with the West-A profile and West-B profile were used in our stability analyses.
2. Used mean low water elevation of -0.37 feet NAVD 88, as provided in the TE-118 Draft Permit Drawings, Typical Section sheets, dated September 13, 2016.
3. Used surveyed mudline elevation at each exploration for bottom elevation of the fill.
4. Acceptable factor of safety for slope stability = 1.2.
5. Acceptable factor of safety for bearing capacity = 1.5.
6. Included a 1-foot construction overbuild tolerance in the stability analyses and bearing capacity analyses.
7. The slope stability was evaluated for the following conditions:
    a. Stability of the containment dike into the marsh area (pre-construction of the marsh).
    b. Stability of the containment dike into the bay (post-construction of the marsh).
    c. Stability of the containment dike into the borrow channel with a marsh buggy excavator load on the bench between the dike and borrow excavation (West Belle Pass Barrier Headland only).
    d. Stability of the beach and dune into the marsh area (pre-construction of the marsh).
    e. Stability of the beach and dune into Timbalier Bay (sections of the dune without marsh behind them).
    f. Stability of the beach and dune into the Gulf of Mexico.
8. The bearing capacity of the containment dikes was evaluated using the method for bearing on sand over soft clay as outlined in Chapter 4 of *Principles of Foundation Engineering*, 6th Edition by Das (2007). Stratum thicknesses, weighted average shear strengths of the clay below the sand, and the equivalent loaded width were used to estimate the ultimate bearing capacity.

The values for unit weight and angle of internal friction for the containment dikes and beach and dune alignments are dependent on the installation methods and can vary significantly depending on fill disturbance, voids in the constructed cross section, and dewatering of fill above the water table. Based on the design profiles developed for the project, 20° and 120 pcf were assigned as the fill friction angle and total unit weight, respectively, for the containment dikes at East Timbalier Island and the dune and beach alignments of both East Timbalier Island and the West Belle Pass Barrier Headland. A friction angle of 20° and total unit weight of 115 pcf were assigned as the fill friction angle and unit weight, respectively, for the containment dikes at West Belle Pass Headland.

For competent foundation soils, the following geometry generally produces adequate stability:

East Timbalier Island Containment Dike:

1. 25H:1V side slopes
2. Crown elevation of +6.3 feet
3. Crown width of 30 feet

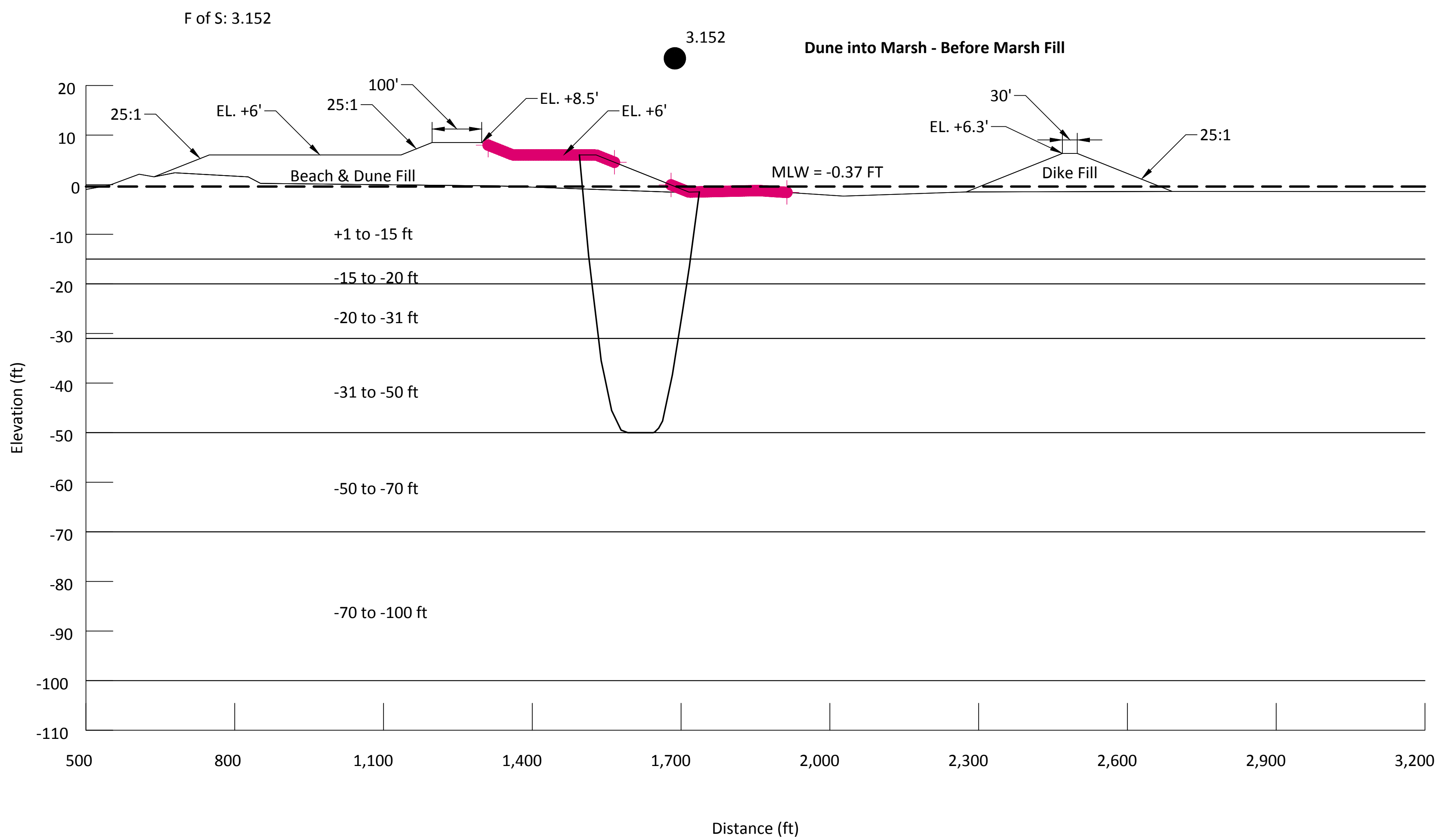
West Belle Pass Barrier Headland Containment Dike:

1. 10H:1V side slopes
2. Crown elevation of +6.5 feet
3. Crown width of 10 feet
4. Construction bench width of 30 feet

East Timbalier Island and West Belle Pass Barrier Headland Beach and Dune:

1. 25H:1V beach and dune side slopes
2. Dune crown elevation of +8.5 feet
3. Dune crown width of 100 feet
4. Beach elevation of +6.0 feet

This appendix contains the stability analysis results and bearing capacity analysis spreadsheets.



Soil Profile: East Timbalier - East
Name: +1 to -15 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -15 to -20 ft Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 240 psf Phi': 0 °
Name: -20 to -31 ft Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion': 240 psf Phi': 0 °
Name: -31 to -50 ft Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion': 400 psf Phi': 0 °
Name: -50 to -70 ft Model: Mohr-Coulomb Unit Weight: 101 pcf Cohesion': 500 psf Phi': 0 °
Name: -70 to -100 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 600 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

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Slope Stability
East Timbalier - Sta 40+00

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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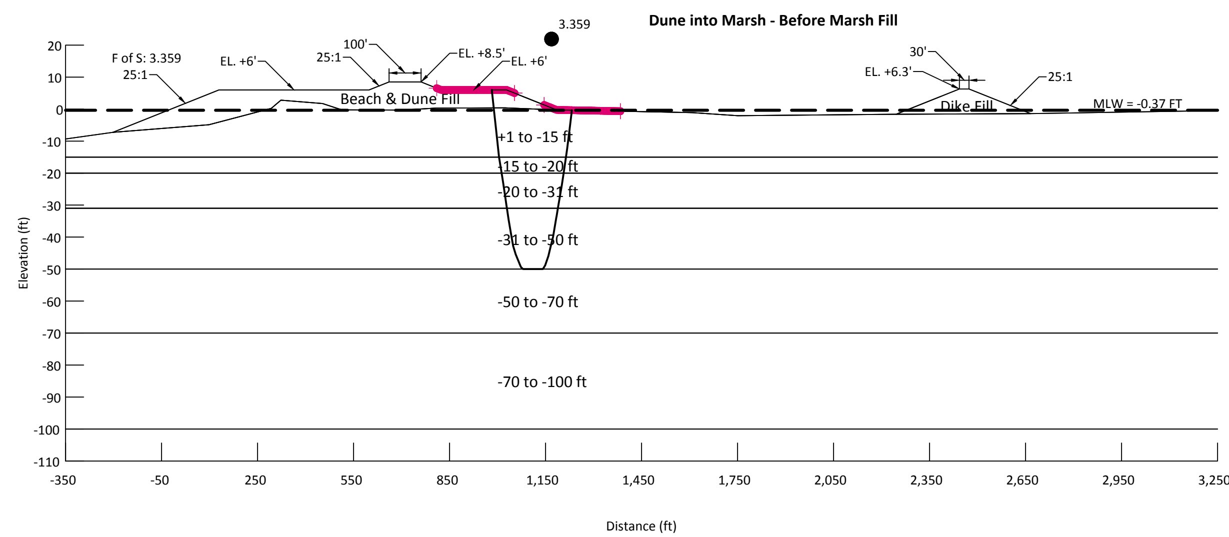
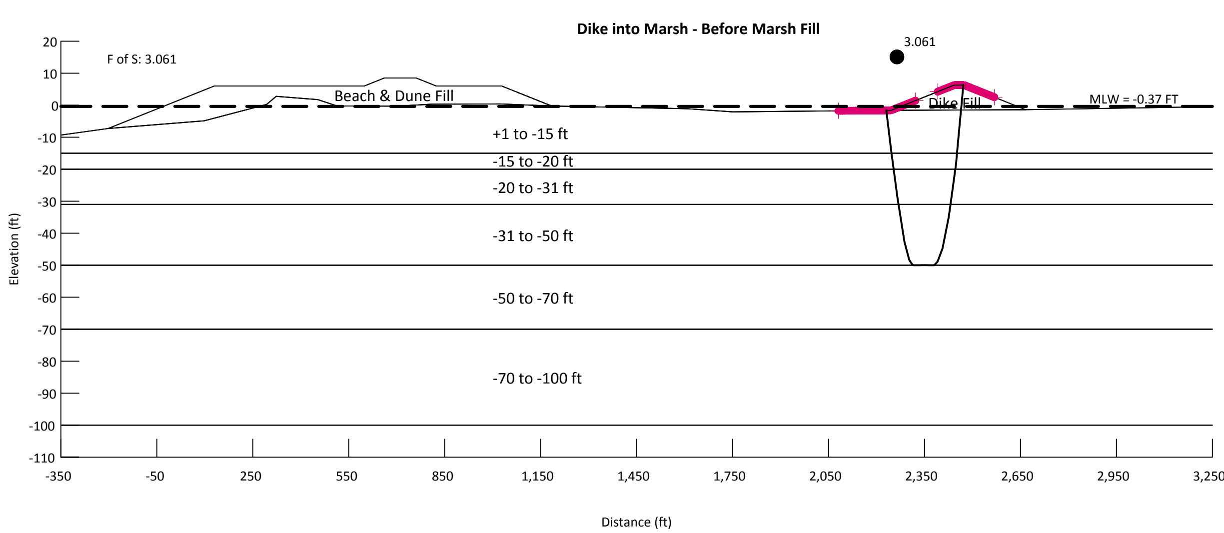
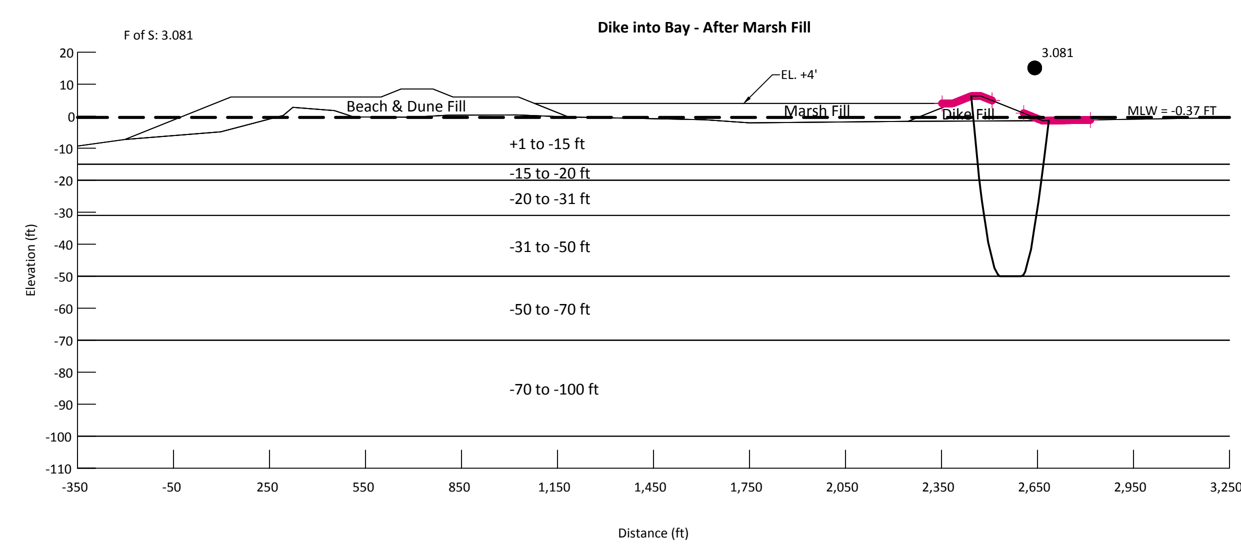
Figure B-1







Soil Profile: East Timbalier - East
Name: +1 to -15 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -15 to -20 ft Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 240 psf Phi': 0 °
Name: -20 to -31 ft Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion': 240 psf Phi': 0 °
Name: -31 to -50 ft Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion': 400 psf Phi': 0 °
Name: -50 to -70 ft Model: Mohr-Coulomb Unit Weight: 101 pcf Cohesion': 500 psf Phi': 0 °
Name: -70 to -100 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 600 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °

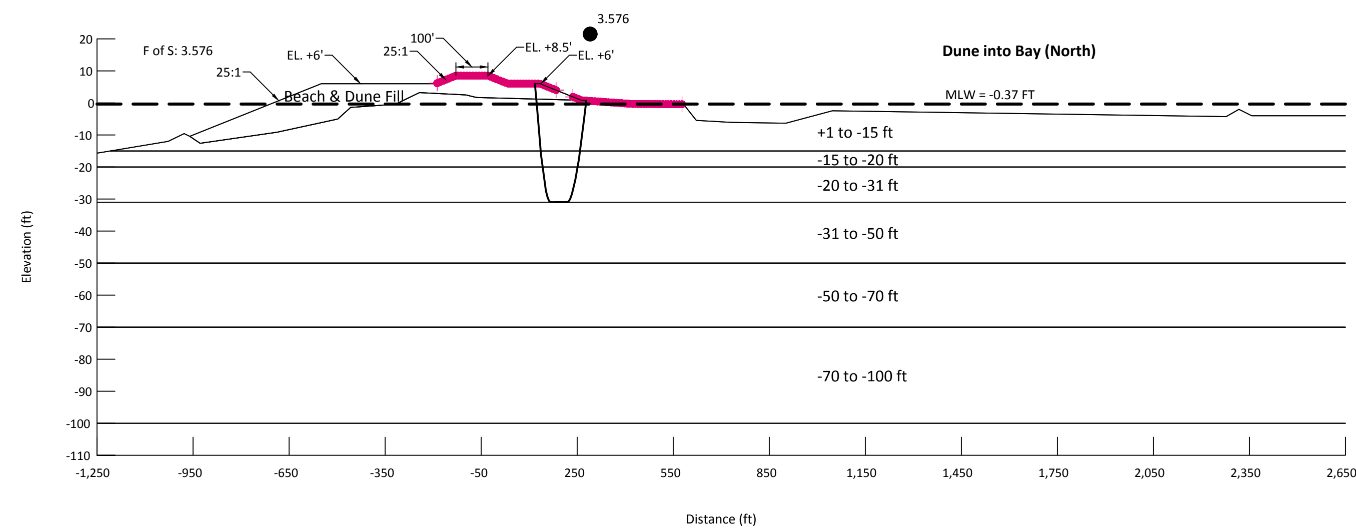
Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

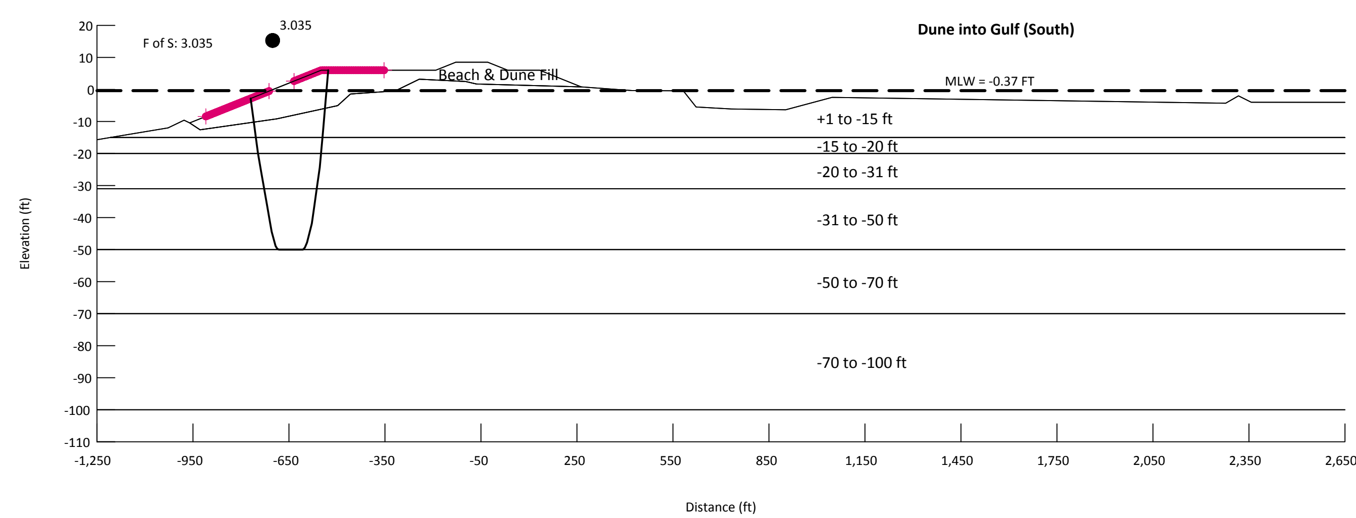
Slope Stability
East Timbalier - Sta 50+00

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure B-2





Soil Profile: East Timbalier - East

Name: +1 to -15 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -15 to -20 ft Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 240 psf Phi': 0 °
Name: -20 to -31 ft Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion': 240 psf Phi': 0 °
Name: -31 to -50 ft Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion': 400 psf Phi': 0 °
Name: -50 to -70 ft Model: Mohr-Coulomb Unit Weight: 101 pcf Cohesion': 500 psf Phi': 0 °
Name: -70 to -100 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 600 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

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Slope Stability
East Timbalier - Sta 70+00

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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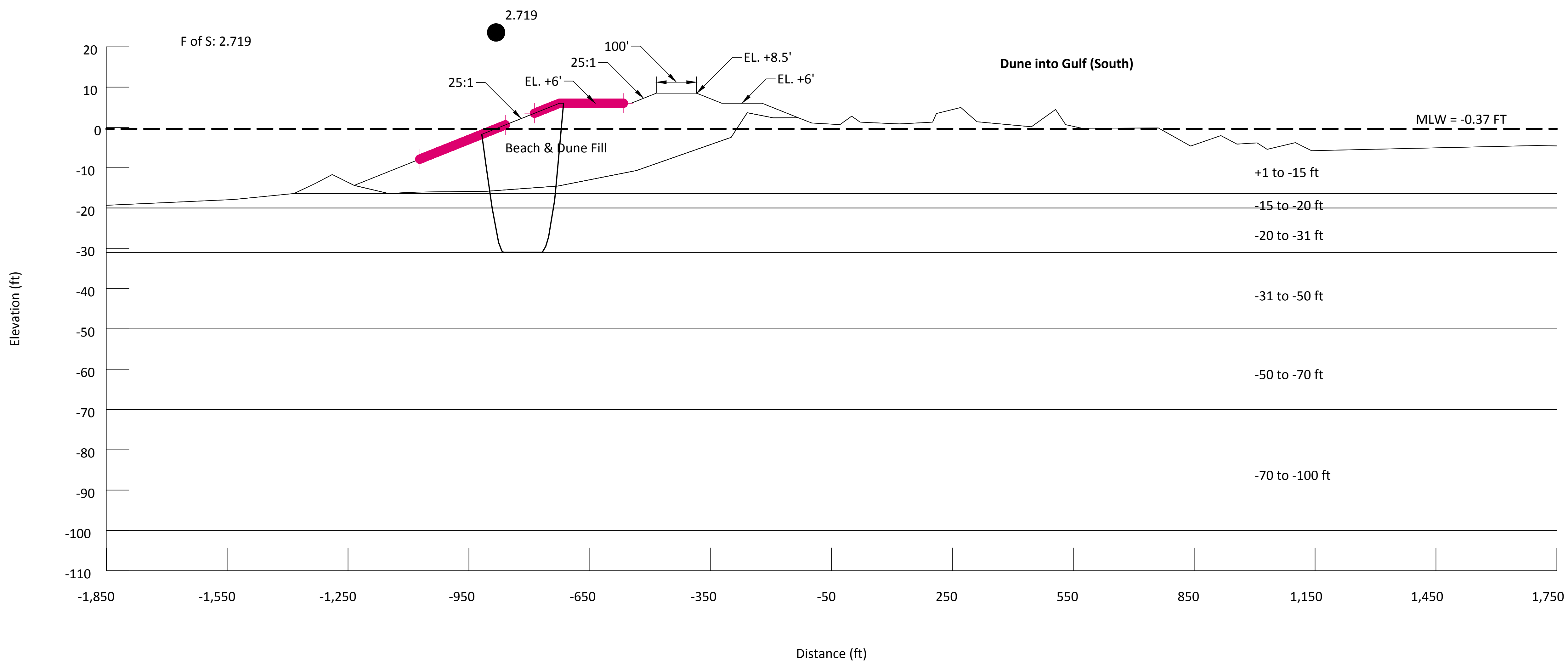
Figure B-3



Soil Profile: East Timbalier - East
Name: +1 to -15 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -15 to -20 ft Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 240 psf Phi': 0 °
Name: -20 to -31 ft Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion': 240 psf Phi': 0 °
Name: -31 to -50 ft Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion': 400 psf Phi': 0 °
Name: -50 to -70 ft Model: Mohr-Coulomb Unit Weight: 101 pcf Cohesion': 500 psf Phi': 0 °
Name: -70 to -100 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 600 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

Slope Stability
East Timbalier - Sta 102+50

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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Figure B-4

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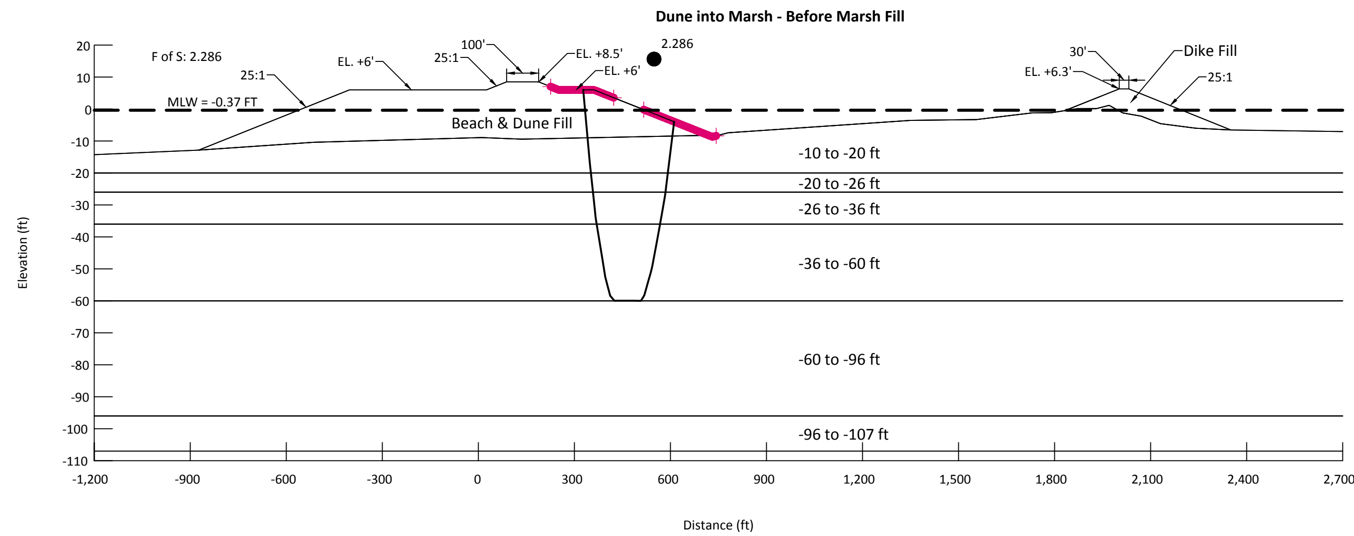

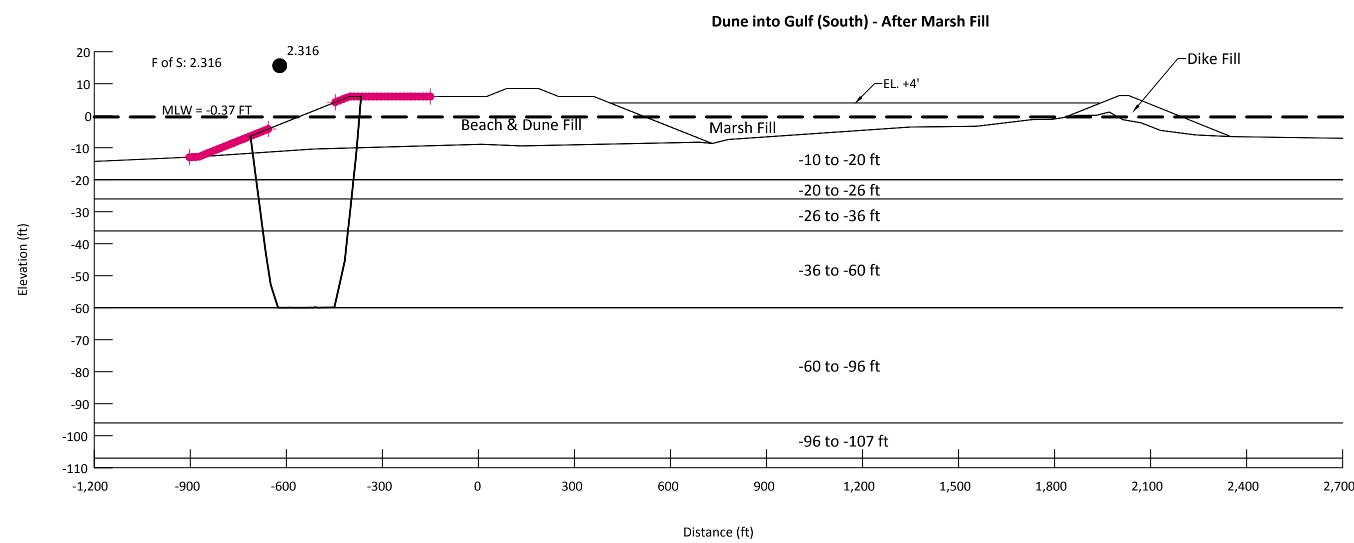

Soil Profile: East Timbalier - West A
Name: -10 to -20 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 220 psf Phi': 0 °
Name: -20 to -26 ft Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 400 psf Phi': 0 °
Name: -26 to -36 ft Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 250 psf Phi': 0 °
Name: -36 to -60 ft Model: Mohr-Coulomb Unit Weight: 102 pcf Cohesion': 320 psf Phi': 0 °
Name: -60 to -96 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 480 psf Phi': 0 °
Name: -96 to -107 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 510 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

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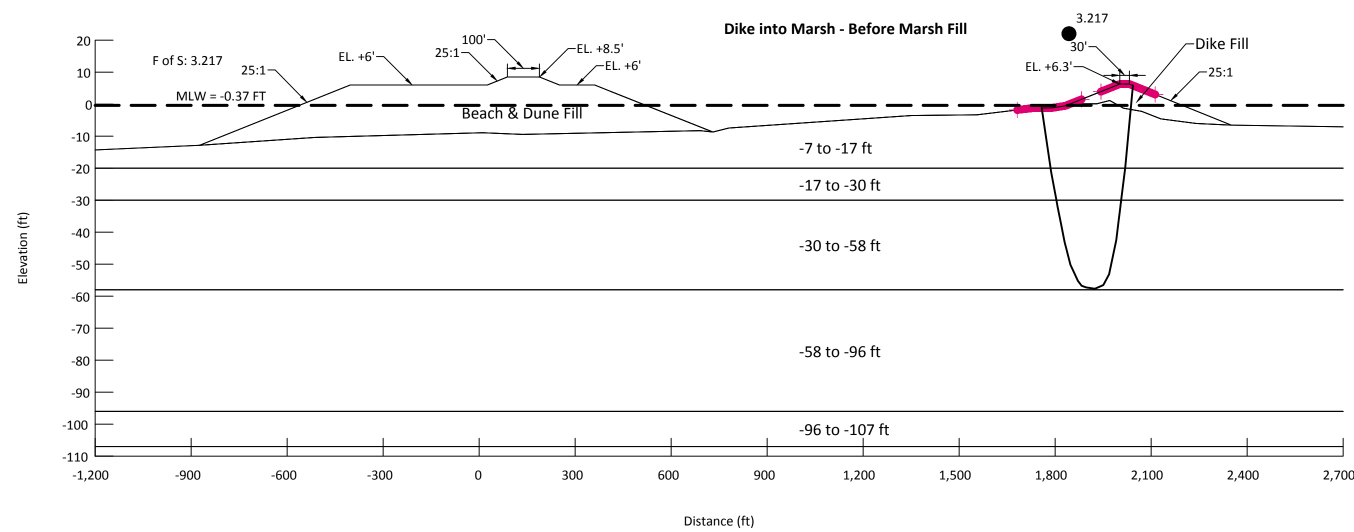
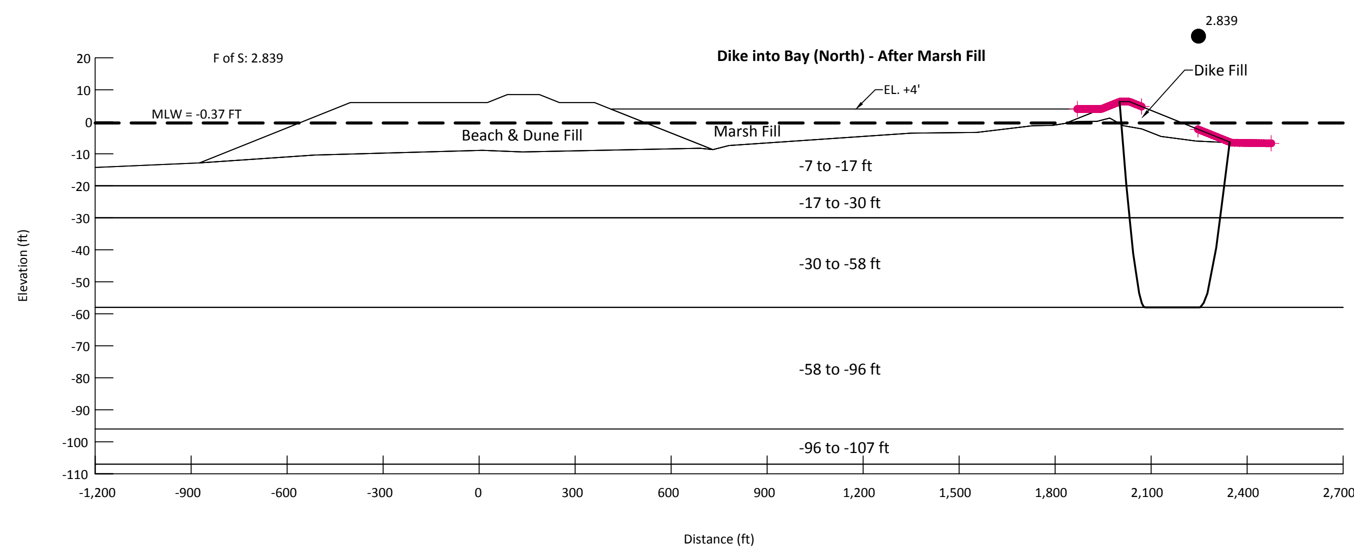
Slope Stability
East Timbalier - Sta 130+00

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure B-5





Soil Profile - East Timbalier - West B
Name: -7 to -17 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -17 to -30 ft Model: Mohr-Coulomb Unit Weight: 111 pcf Cohesion': 250 psf Phi': 0 °
Name: -30 to -58 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 380 psf Phi': 0 °
Name: -58 to -96 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 480 psf Phi': 0 °
Name: -96 to -107 ft Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion': 510 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °
Name: Marsh Fill Model: Mohr-Coulomb Unit Weight: 109 pcf Cohesion': 100 psf Phi': 0 °
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

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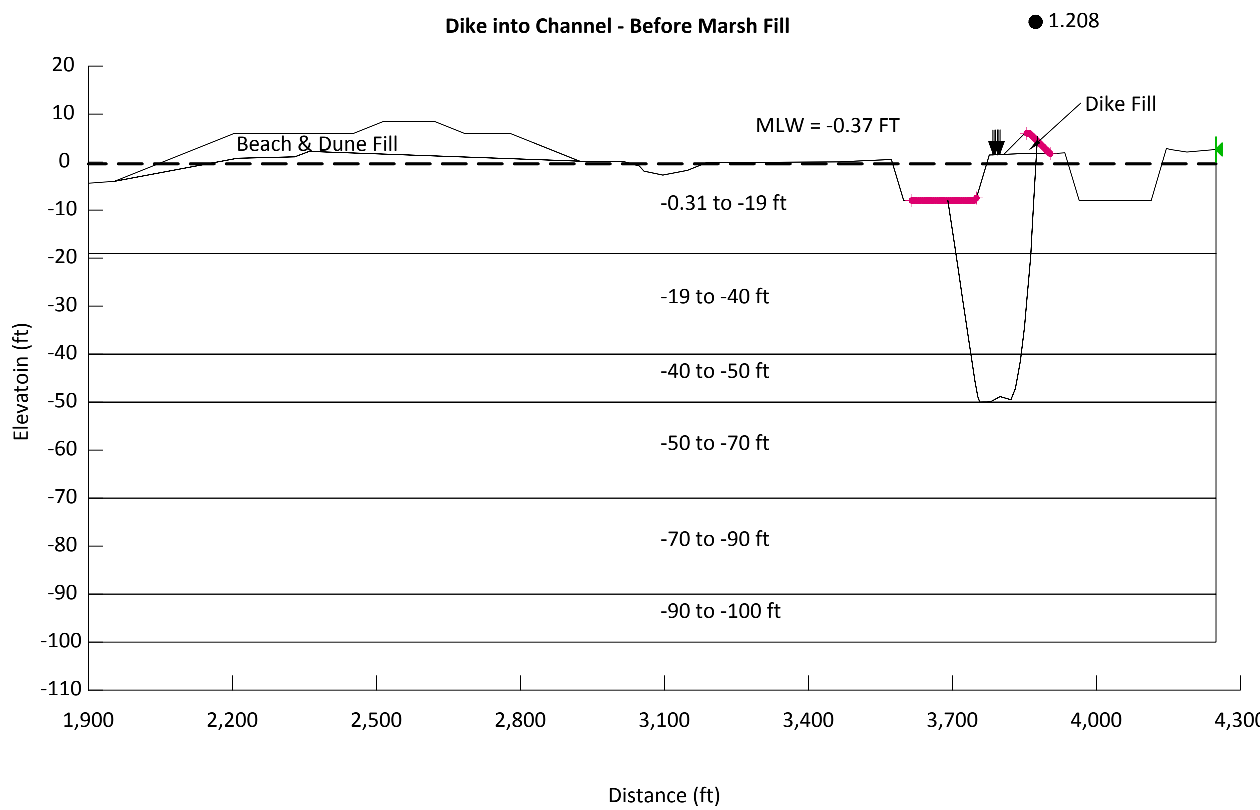
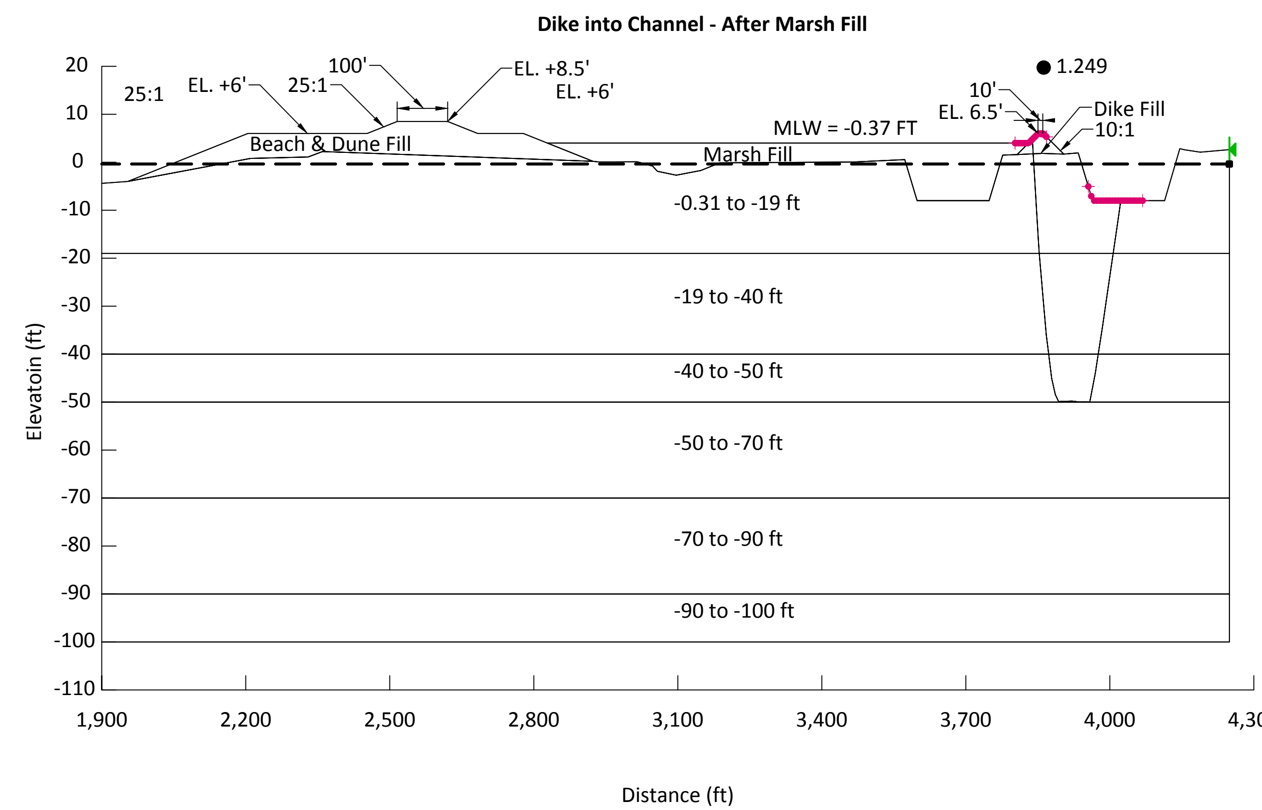
Slope Stability
East Timbalier - Sta 130+00

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure B-6





Soil Profile: West Belle Pass
Name: -0.31 to -19 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -19 to -40 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 200 psf Phi': 0 °
Name: -40 to -50 ft Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion': 200 psf Phi': 0 °
Name: -50 to -70 ft Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion': 640 psf Phi': 0 °
Name: -70 to -90 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 500 psf Phi': 0 °
Name: -90 to -100 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 1,000 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 20 °
Name: Marsh Fill Model: Mohr-Coulomb Unit Weight: 80 pcf Cohesion': 100 psf Phi': 0 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

Slope Stability
West Belle Pass - Sta 140+00

West Belle Pass Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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Figure B-7

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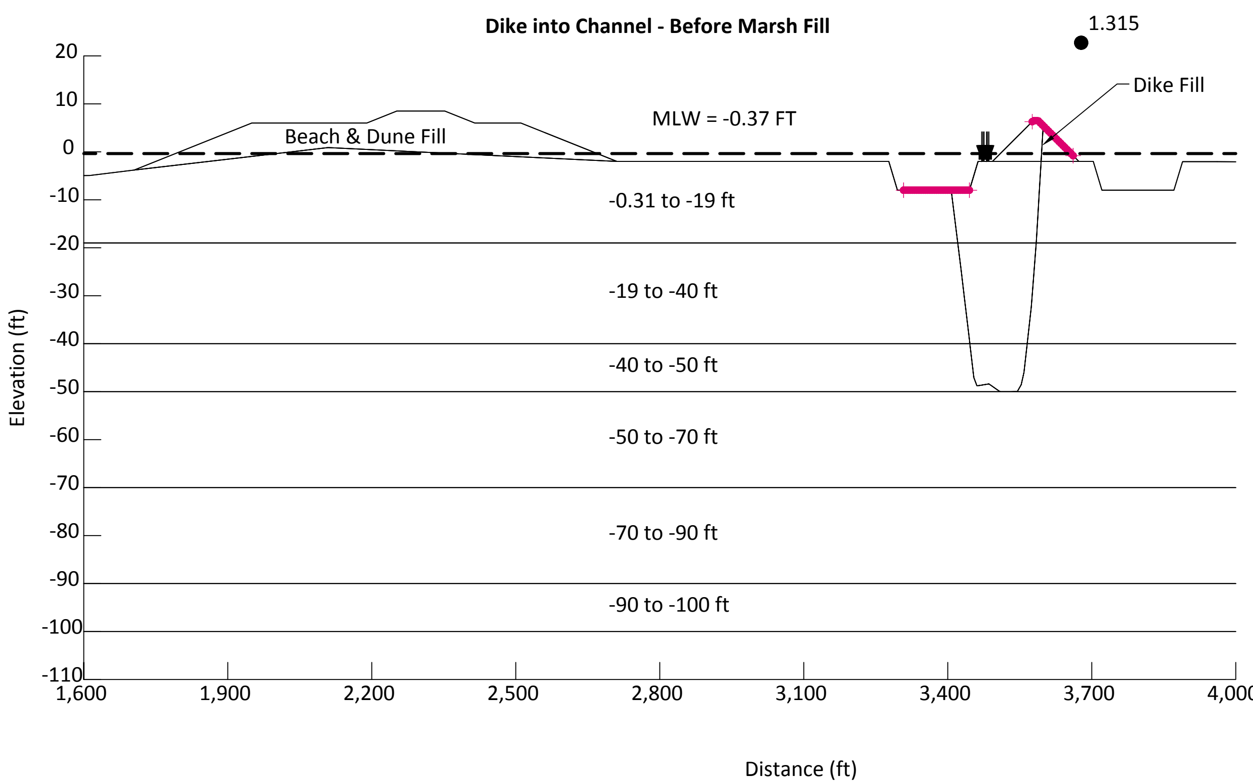

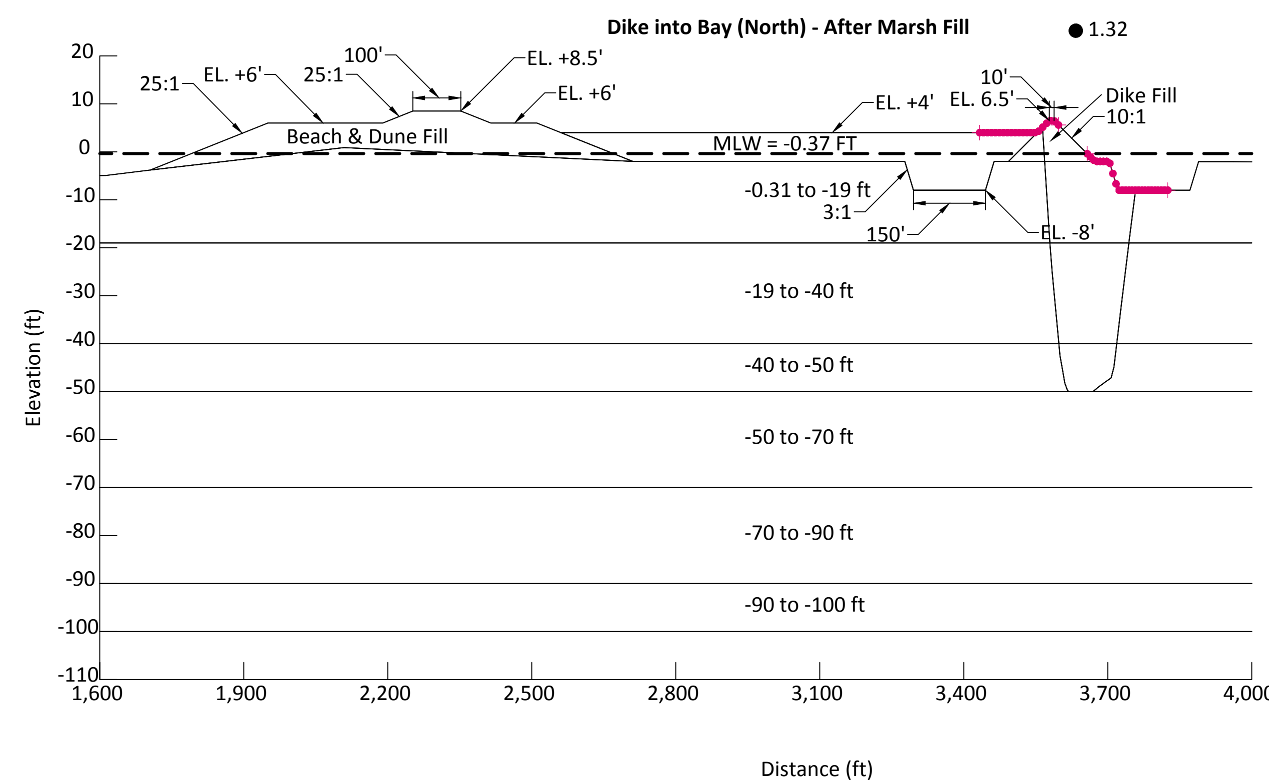

Soil Profile: West Belle Pass
Name: -0.31 to -19 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -19 to -40 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 200 psf Phi': 0 °
Name: -40 to -50 ft Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion': 200 psf Phi': 0 °
Name: -50 to -70 ft Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion': 640 psf Phi': 0 °
Name: -70 to -90 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 500 psf Phi': 0 °
Name: -90 to -100 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 1,000 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °
Name: Marsh Fill Model: Mohr-Coulomb Unit Weight: 89 pcf Cohesion': 100 psf Phi': 0 °
Name: Dike Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 20 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

Slope Stability
West Belle Pass - Sta 155+00

West Belle Pass Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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Figure B-8

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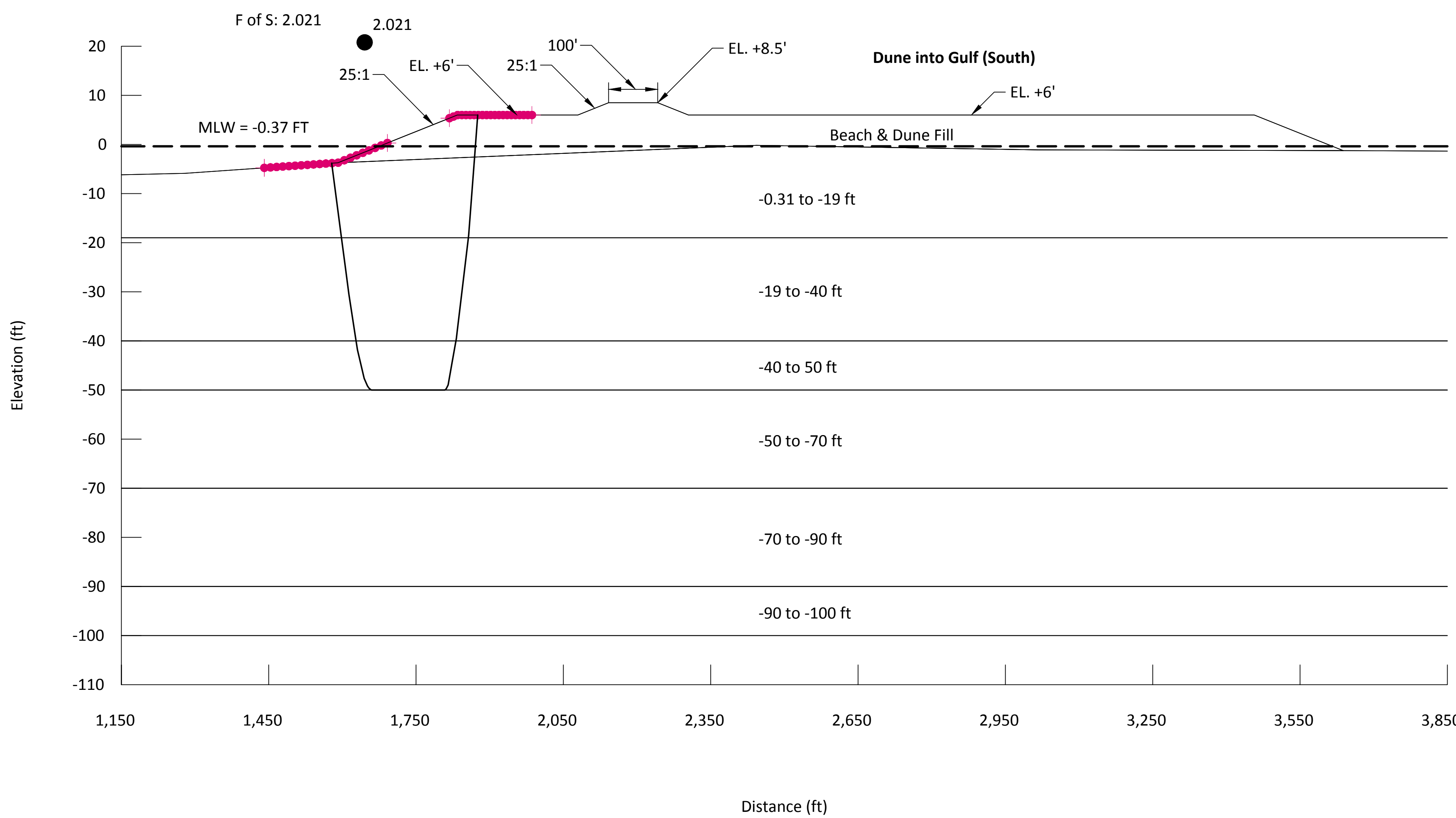

Soil Profile: West Belle Pass
Name: -0.31 to -19 ft Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: -19 to -40 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 200 psf Phi': 0 °
Name: -40 to 50 ft Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion': 200 psf Phi': 0 °
Name: -50 to -70 ft Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion': 640 psf Phi': 0 °
Name: -70 to -90 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 500 psf Phi': 0 °
Name: -90 to -100 ft Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion': 1,000 psf Phi': 0 °
Name: Beach & Dune Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 20 °

Notes:
1. Failure surfaces and factors of safety have been optimized.
2. Slope stability analysis included a 1-foot construction overbuild tolerance.
3. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.

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Slope Stability
West Belle Pass - Sta 50+00

West Belle Pass Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure B-9

Project: East Timbalier Island Restoration (TE-118)

direct input

Project Id: 16715-036-00

Deliverable Title: Bearing Capacity for In-Situ Fill

Containment Dike Foundation Bearing Capacity on Sand over Soft Clay

Identifier	Crown Elevation (ft, NAVD 88)	Crown Width (ft)	Assumed Average Mudline Elevation	Water Elevation (ft, NAVD 88)	Assumed Fill Unit Weight (pcf)	Side Slopes (#H:1V)	Depth of First Layer, T (ft)	Equivalent Width of Dike, B (ft)	T/B	First Layer Cohesion, C1 (psf)	Second Layer Cohesion, C2 (psf)[10]	C2/C1	φ'	Dike Section Length, L (ft)	Bearing Capacity Factor, $N_{c(2)}$[3]	Bearing Capacity Factor, $N_{\gamma(1)}$[7]	Bearing Capacity Factor, $N_{q(1)}$[7]	q_2/q_1	K_s (See figure below)	Bearing Capacity of the Bottom Soil Layer, q_b (psf)	Bearing Capacity of the Top Soil Layer, q_t (psf)	Simplified Dike Pressure, psf	Weighted Average Dike Pressure, psf	Simplified Factor of Safety[11]	Weighted Dike pressure Factor of Safety[11]
ET 210+00	6.3	30	-4	-0.37	120	25	13	287.5	0.05	Sand	420	#N/A	30	3050	5.14	22.4	18.4	0.012	1.00	2178	180320	1003.7	868.9	2.15	2.48
ET 130+00	6.3	30	-1.5	-0.37	120	25	13.5	225	0.06	Sand	475	#N/A	30	3600	5.14	22.4	18.4	0.017	1.00	2468	141120	863.7	810.1	2.83	3.01

Bearing Capacity in Layered Soils with Sand above Soft Clay from Das (2007)[4]

$$q_{ult}^{8} = (1+0.2*B/L)*5.14*C_2 + \gamma'_1*H^2*(1+B/L)*(1+2D_f/H)*(K_s*\tan\phi'_1/B) + \gamma'_1*D_f \le \gamma'_1*D_f*N_{q(1)}*F_{qs(1)} + 0.5*\gamma'_1*B*N_{\gamma(1)}*F_{\gamma s(1)}$$

Where,

$$K_s = fn(q2/q1) = [(c_2*N_{c(2)})/(0.5*\gamma'_1*B*N_{\gamma(1)}), \phi'_1]$$

$$F_{qs} = 1 + (B/L)*\tan\phi' = 1 \text{ for cts load, and}$$

$$F_{\gamma s} = 1 - 0.4*(B/L) = 1 \text{ for cts load}$$

Bearing Capacity Factors (Vesic)

φ'	N_c	N_γ	N_q
0	5.14	0.0	1.0
10	8.3	1.2	2.5
15	11.0	2.6	3.9
20	14.8	5.4	6.4
25	20.7	10.9	10.7
30	30.1	22.4	18.4
35	46.1	48.0	33.3
40	75.3	109.4	64.2

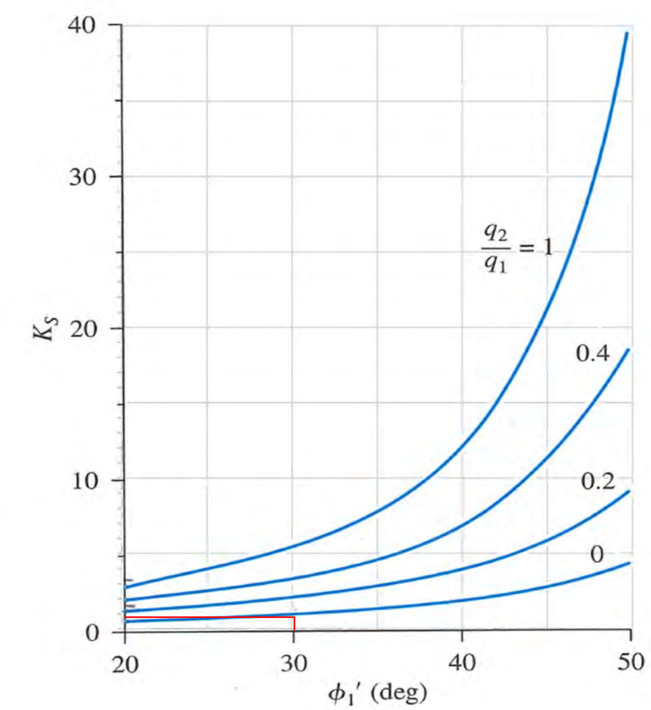


Figure 4.9 Meyerhof and Hanna's punching shear coefficient K_s

Notes:

1 Embankment geometries based on slope stability with dredged fill material
2 Bearing calculation based on NAVFAC DM-7 Figure 11-5
3 For profiles with surface sand layers, Nc of soft clay layer under sand per Vesic (1973). Otherwise, NAVFAC DM-7 Figure 11-5 (i.e., Group 2 - tangent circle curve used for T/B = 0.05).
4 *Principles of Foundation Engineering, 6th Ed.,* Section 4.3. Df is depth of foundation below soil surface = 0 ft. H = height of top soil layer
5 Water unit weight assumed to be ~64 pcf (salt water)
6 Effective unit weight of sand assumed as 56 pcf for bearing calculation
7 Bearing capacity factors based on Terzaghi's bearing capacity equations, as reported in the tables in Das, for Clay (φ = 0) and loose sand
8 B/L goes to 0 as L increases in length. Treat embankment as truly continuous, no shape factors included in analysis.
9 Punching shear calculation uses the method proposed by Meyerhof and Hanna (1978) and Meyerhoff (1974)
10 Second layer cohesion is weighted average below the top layer
11 Factor of safety for soft clay over stronger clay limited to Nc*c'2 = 5.14*C2/applied pressure
12 Mean Low Water taken from Typical Section Sheets in Draft Permit Drawings, dated 9/13/16

Project: East Timbalier Island Restoration (TE-118)

Project Id: 16715-036-00

Deliverable Title: Bearing Capacity for In-Situ Fill

direct input

Containment Dike Foundation Bearing Capacity on Sand over Soft Clay																									
Identifier	Crown Elevation (ft, NAVD 88)	Crown Width (ft)	Assumed Average Mudline Elevation	Water Elevation (ft, NAVD 88)	Assumed Fill Unit Weight (pcf)	Side Slopes (#H:1V)	Depth of First Layer, T (ft)	Equivalent Width of Dike, B (ft)	T/B	First Layer Cohesion, C1 (psf)	Second Layer Cohesion, C2 (psf)[10]	C2/C1	ϕ'	Dike Section Length, L (ft)	Bearing Capacity Factor, $N_{c(2)}$[3]	Bearing Capacity Factor, $N_{\gamma(1)}$[7]	Bearing Capacity Factor, $N_{q(1)}$[7]	q_2/q_1	K_s (See figure below)	Bearing Capacity of the Bottom Soil Layer, q_b (psf)	Bearing Capacity of the Top Soil Layer, q_t (psf)	Simplified Dike Pressure, psf	Weighted Average Dike Pressure, psf	Simplified Factor of Safety[11]	Weighted Dike pressure Factor of Safety[11]
WBP 35+00	6.5	10	-2	-0.37	115	10	17	95	0.18	Sand	481	#N/A	30	3450	5.14	22.4	18.4	0.046	1.00	2562	54264	873.2	797.7	2.83	3.10

Bearing Capacity in Layered Soils with Sand above Soft Clay from Das (2007)[4]
q_{ult}[8] $= (1+0.2*B/L)*5.14*C_2 + \gamma'_1*H^2*(1+B/L)*(1+2D_f/H)*(K_s*\tan\phi'_1/B) + \gamma'_1*D_f \leq \gamma'_1*D_f*N_{q(1)}*F_{qs(1)} + 0.5*\gamma'_1*B*N_{\gamma'(1)}*F_{\gamma s(1)}$
Where,
$Ks = fn(q2/q1) = [(c_2*N_{c(2)})/(0.5*\gamma'_1*B*N_{\gamma(1)}), \phi'_1]$
$F_{qs} = 1 + (B/L)*\tan\phi' = 1$ for cts load, and
$F_{\gamma s} = 1 - 0.4*(B/L) = 1$ for cts load

Bearing Capacity Factors (Vesic)

ϕ'	N_c	N_γ	N_q
0	5.14	0.0	1.0
10	8.3	1.2	2.5
15	11.0	2.6	3.9
20	14.8	5.4	6.4
25	20.7	10.9	10.7
30	30.1	22.4	18.4
35	46.1	48.0	33.3
40	75.3	109.4	64.2

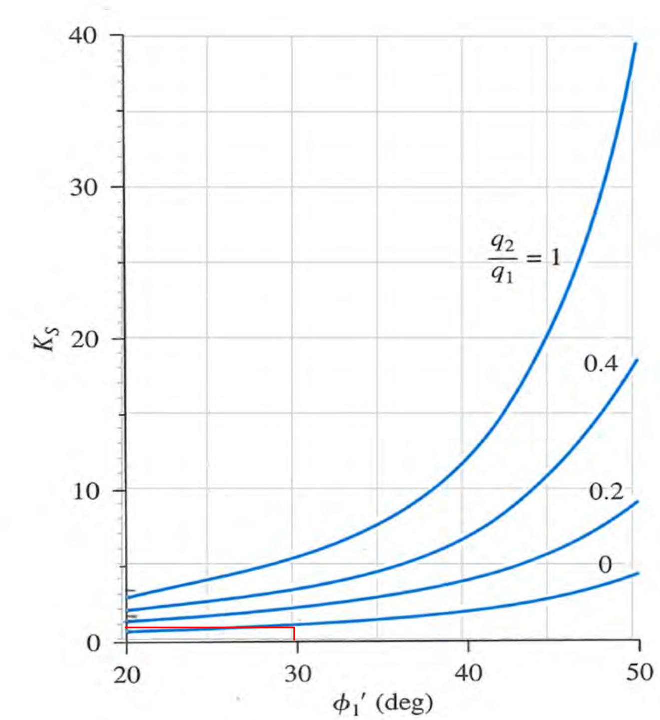


Figure 4.9 Meyerhof and Hanna's punching shear coefficient K_s

Notes:

1. Embankment geometries based on slope stability with dredged fill material
2. Bearing calculation based on NAVFAC DM-7 Figure 11-5
3. For profiles with surface sand layers, Nc of soft clay layer under sand per Vesic (1973). Otherwise, NAVFAC DM-7 Figure 11-5 (i.e., Group 2 - tangent circle curve used for T/B = 0.05).
4. *Principles of Foundation Engineering, 6th Ed.,* Section 4.3. Df is depth of foundation below soil surface = 0 ft. H = height of top soil layer
5. Water unit weight assumed to be ~64 pcf (salt water)
6. Effective unit weight of sand assumed as 56 pcf for bearing calculation
7. Bearing capacity factors based on Terzaghi's bearing capacity equations, as reported in the tables in Das, for Clay (ϕ = 0) and loose sand
8. B/L goes to 0 as L increases in length. Treat embankment as truly continuous, no shape factors included in analysis.
9. Punching shear calculation uses the method proposed by Meyerhof and Hanna (1978) and Meyerhoff (1974)
10. Second layer cohesion is weighted average below the top layer
11. Factor of safety for soft clay over stronger clay limited to Nc*c'2 = 5.14*C2/applied pressure
12. Mean Low Water taken from Typical Section Sheets in Draft Permit Drawings, dated 9/13/16

APPENDIX C
Beach and Dune Settlement Analysis

APPENDIX C
CALCULATION APPROACH FOR BEACH AND DUNE SETTLEMENT

1. Settlement parameters were developed for the eastern and western zones of East Timbalier Island and for the West Belle Pass Headland. For the western zone of East Timbalier Island, the combined design profile was used to develop the settlement parameters. The following description explains how the parameters were developed.

    a. A total of fifteen consolidation tests were completed at various soil borings to represent various soil layers across the site.

    b. Graphs for each consolidation test were reconstructed to determine compression (Cc), recompression (Cr), and vertical consolidation (Cv) coefficients, initial void ratios (e0), and maximum past pressures (Pc).

    c. Correlations presented in equations 1 through 4 (shown in the attached spreadsheets) were used to calculate specific gravity, e0, Cc, and Cr for all soil layers.

    d. GeoEngineers developed correlations based on the analyses of the consolidation test results as follows:

        - Cv values were determined based on moisture content using a graphical correlation developed by GeoEngineers based on this and other coastal projects.
        - w vs. Cc: Cc=0.0186*w-0.2698 was found to provide sufficient accuracy based on the test data for this project for all compressible soil types. Cc for each of the soil layers was determined based on the moisture contents estimated during soil profile development.
        - Cr was assumed to be 10% of the Cc value.

    e. For soil layers without a representative consolidation test, the above-mentioned correlations/calculation methods were used to estimate Cc, Cr, and Cv.

    f. Maximum past pressure (Pc) was obtained from the consolidation test curves for the soil layers with a representative consolidation test. Only a few of the consolidation tests indicated overconsolidated soils, so GeoEngineers assumed the soils in the project area are predominantly normally consolidated. Recompression was considered only in select profiles.

2. In this area, clay shear strength for a normally consolidated soil profile is approximately 22 percent of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles.

3. Due to the broad fill area, the drainage is considered vertical for all soil layers. The presence of small sand and silt layers and lenses within the clay has been considered in the drainage path evaluation.

4. CEC provided design fill cross-section and current ground surface elevation profiles across the entire project area. The following design considerations were used in the analysis for both East Timbalier Island and the West Belle Pass Barrier Headland:

    a. Dune fill elevation to +7.5 feet

b. Beach fill elevation to +5 feet

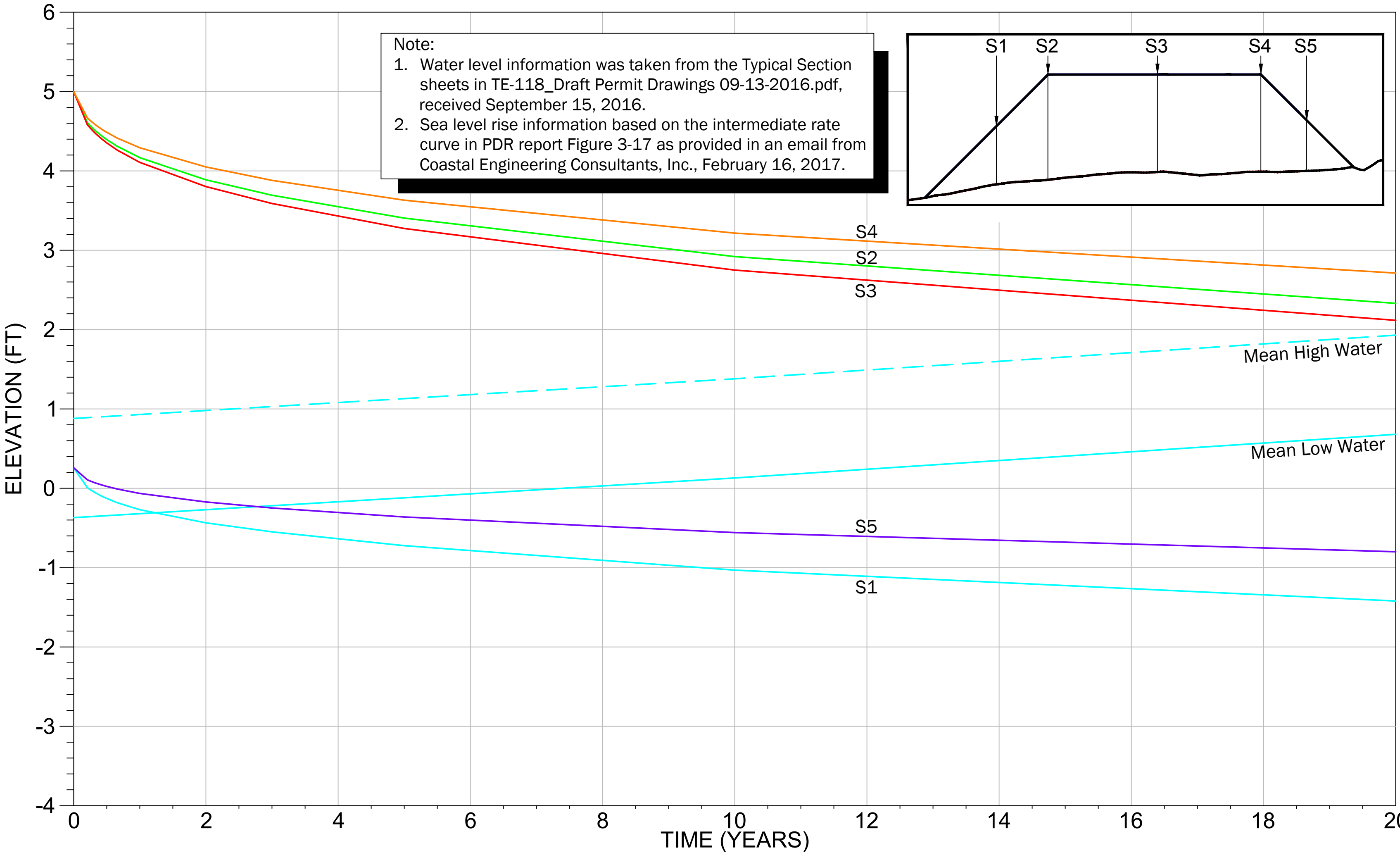
c. Dune and beach side slopes of 25H:1V

d. Unit weight of 120 pcf

e. Water was assumed to be at the mean water level of +0.26 feet based on the values provided in the TE-118 Draft Permit Drawings, Typical Section sheets, dated September 13, 2016.

5. The primary consolidation settlement of the beach and dune alignments were calculated using one-dimensional consolidation theory and Boussinesq stress distribution in the SETANL computer program. Beach and dune fill was assumed to have been placed instantaneously as a single lift at time of construction.

This appendix contains results of beach and dune settlement calculations.



Fill Elevation (ft)								
Settlement Point	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
S1	0.3	-0.1	-0.1	-0.3	-0.6	-0.7	-1.0	-1.4
S2	5.0	4.5	4.4	4.2	3.7	3.4	2.9	2.3
S3	5.0	4.5	4.4	4.1	3.6	3.3	2.8	2.1
S4	5.0	4.6	4.5	4.3	3.9	3.6	3.2	2.7
S5	0.3	0.1	0.0	-0.1	-0.3	-0.4	-0.6	-0.8

West of Sta. 130+00 Settlement vs Time
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure C-1

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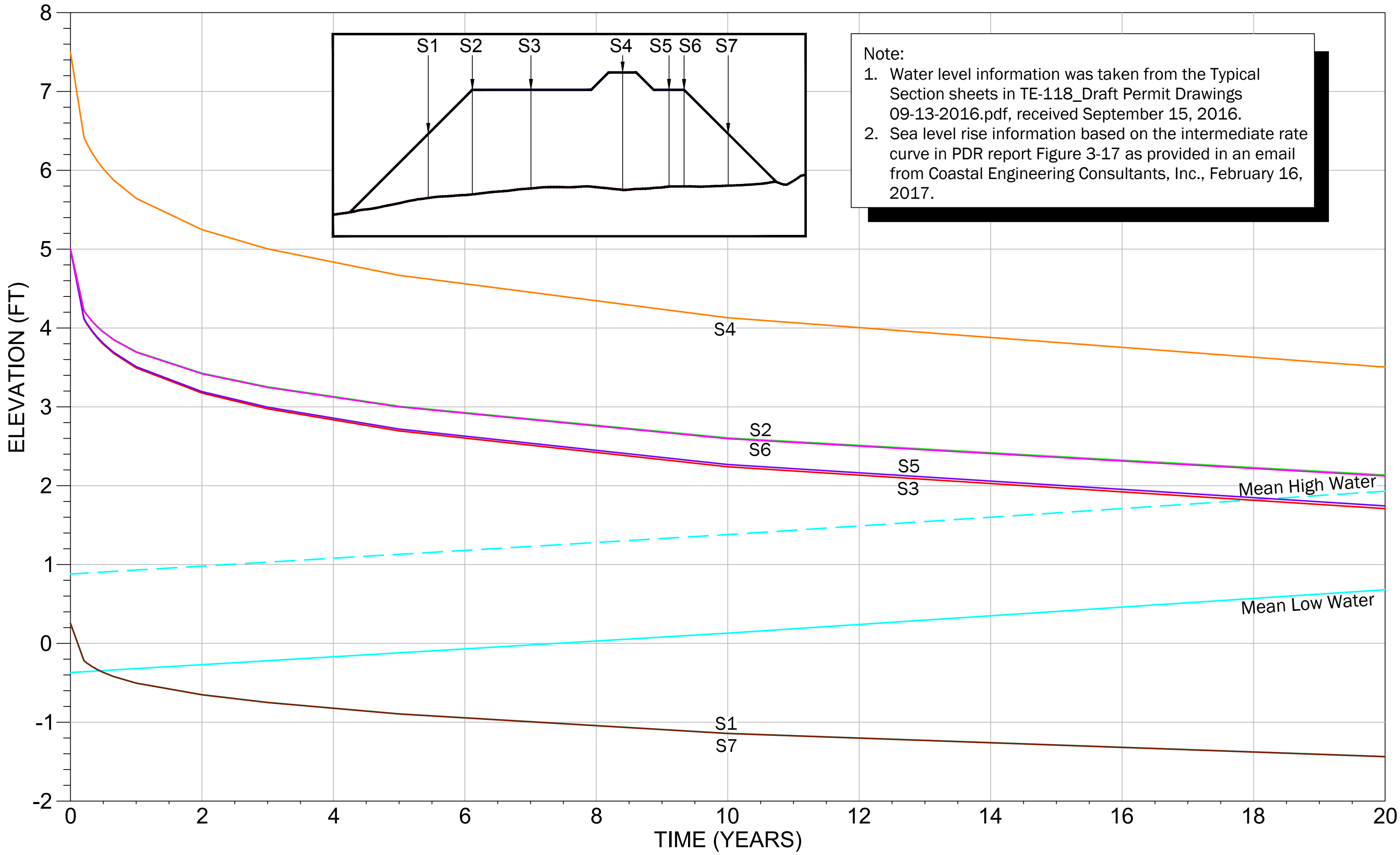

Fill Elevation (ft)								
Settlement Point	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
S1	0.3	-0.2	-0.3	-0.5	-0.7	-0.8	-1.1	-1.4
S2	5.0	4.1	4.0	3.7	3.3	3.0	2.6	2.1
S3	5.0	4.0	3.8	3.5	3.0	2.7	2.2	1.7
S4	7.5	6.2	6.0	5.6	5.0	4.7	4.1	3.5
S5	5.0	4.0	3.8	3.5	3.0	2.7	2.3	1.7
S6	5.0	4.1	4.0	3.7	3.2	3.0	2.6	2.1
S7	0.3	-0.2	-0.3	-0.5	-0.7	-0.8	-1.1	-1.4

Sta. 130+00 Settlement vs Time
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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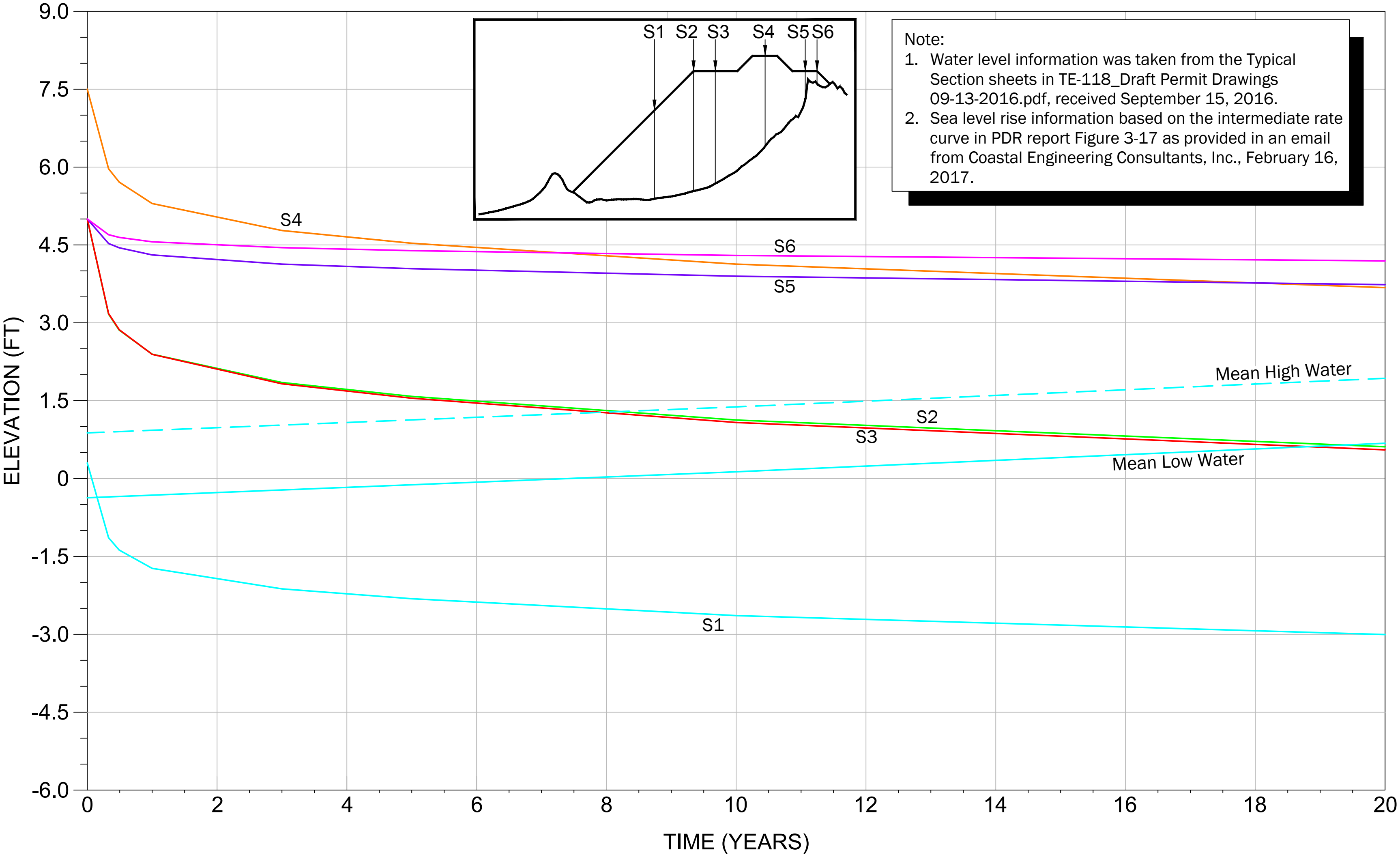
Figure C-2

P:\16\16715036\00\CAD\Geotech\1671503600_Appendix C D E_Settlement.dwg TAB:ET STA 102+50 Date Exported: 08/29/17 - 16:05 by kcook



Note:

1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

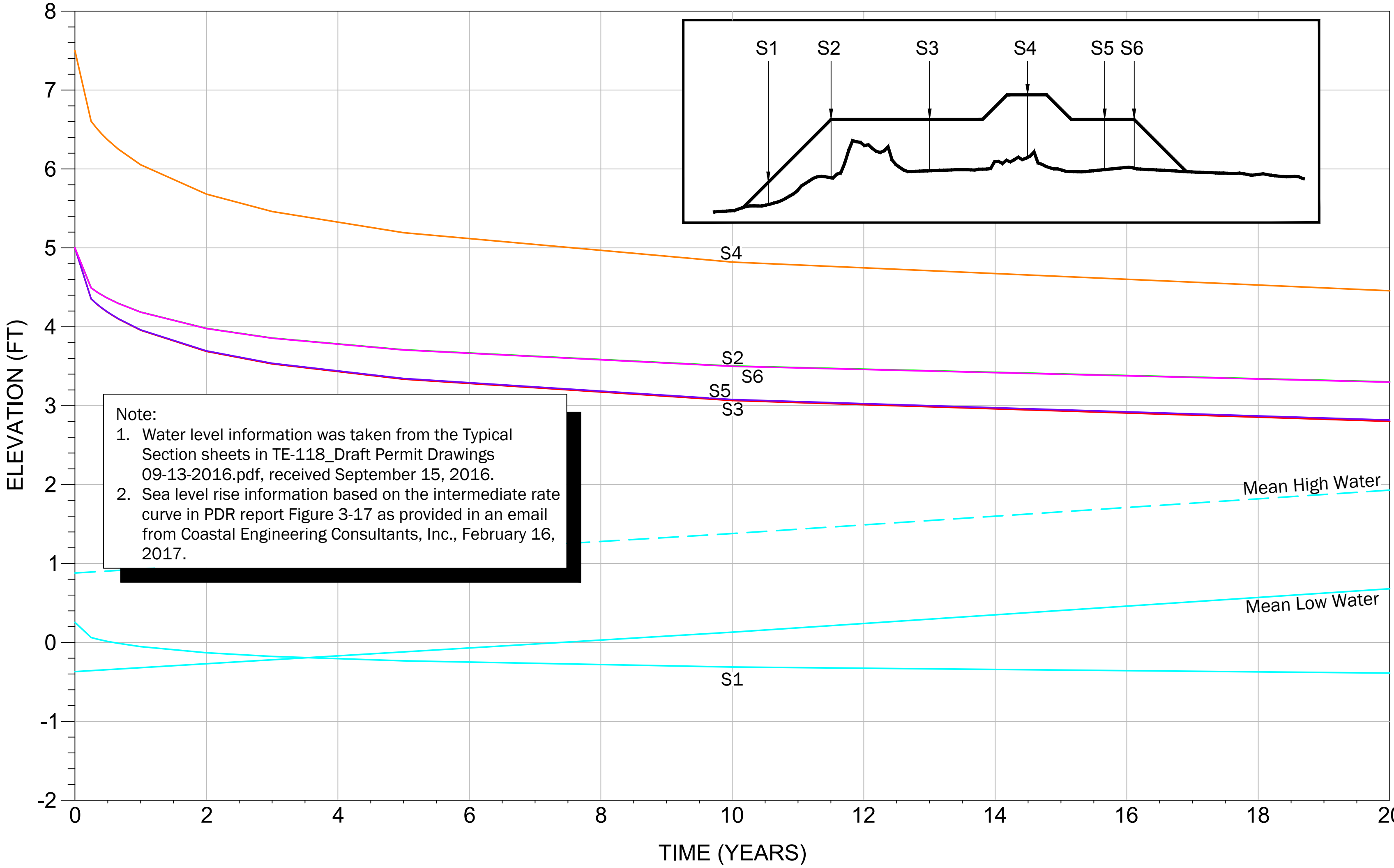
	Fill Elevation (ft)							
Settlement Point	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
S1	0.3	-1.1	-1.4	-1.7	-2.1	-2.3	-2.6	-3.0
S2	5.0	3.2	2.9	2.4	1.9	1.6	1.1	0.6
S3	5.0	3.2	2.9	2.4	1.8	1.5	1.1	0.6
S4	7.5	6.0	5.7	5.3	4.8	4.5	4.1	3.7
S5	5.0	4.5	4.4	4.3	4.1	4.0	3.9	3.7
S6	5.0	4.7	4.6	4.6	4.4	4.4	4.3	4.2

Sta. 102+50 Settlement vs Time
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure C-3



Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

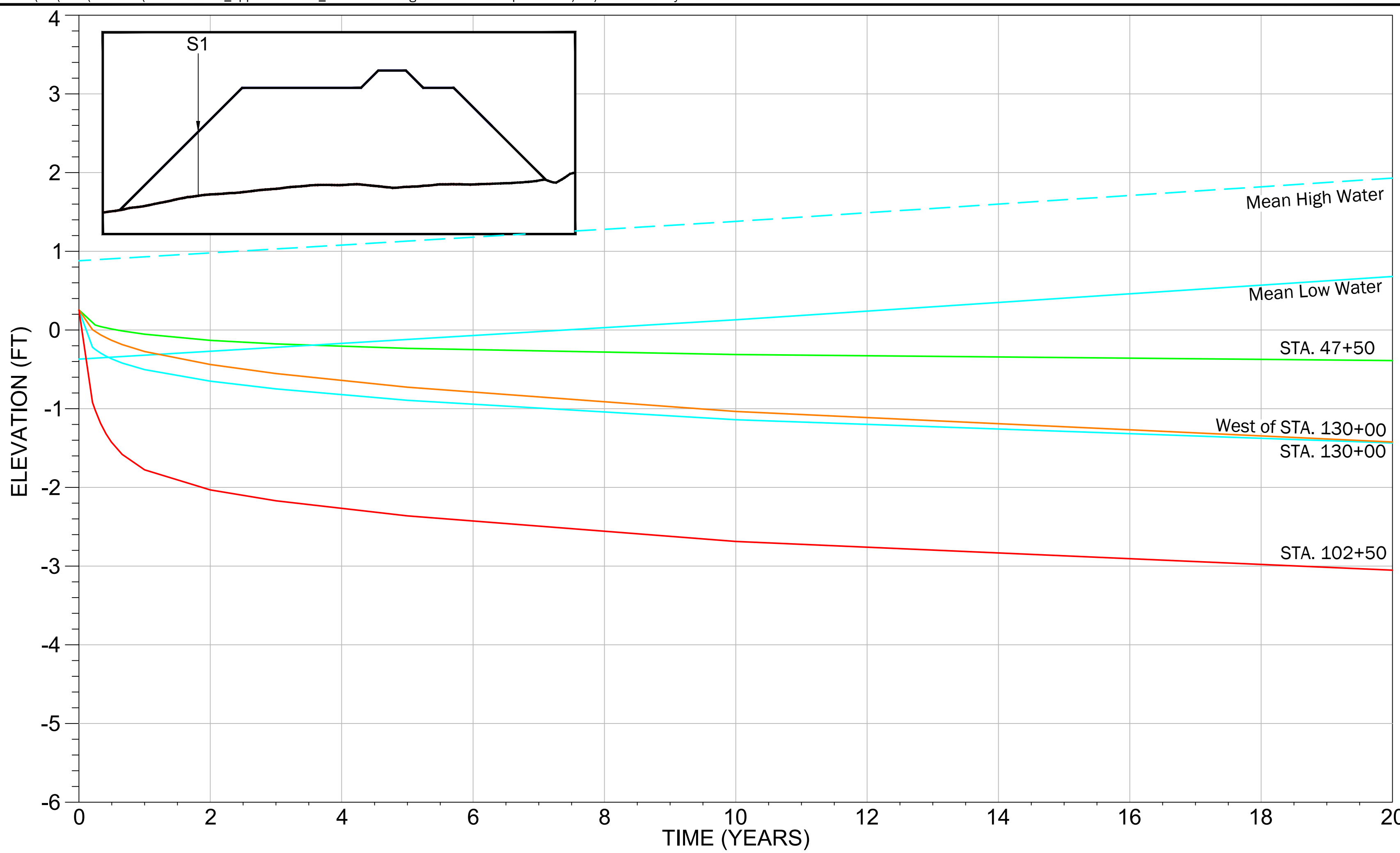
Fill Elevation (ft)								
Settlement Point	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
S1	0.3	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4
S2	5.0	4.4	4.4	4.2	3.9	3.7	3.5	3.3
S3	5.0	4.3	4.2	4.0	3.5	3.3	3.1	2.8
S4	7.5	6.5	6.4	6.1	5.5	5.2	4.8	4.5
S5	5.0	4.3	4.2	4.0	3.5	3.3	3.1	2.8
S6	5.0	4.4	4.4	4.2	3.9	3.7	3.5	3.3

Sta. 47+50 Settlement vs Time
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure C-4



Fill Elevation (ft)								
Station	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
47+50	0.3	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4
102+50	0.3	-1.1	-1.4	-1.7	-2.1	-2.3	-2.6	-3.0
130+00	0.3	-0.2	-0.3	-0.5	-0.7	-0.8	-1.1	-1.4
West of 130+00	0.3	-0.1	-0.1	-0.3	-0.6	-0.7	-1.0	-1.4

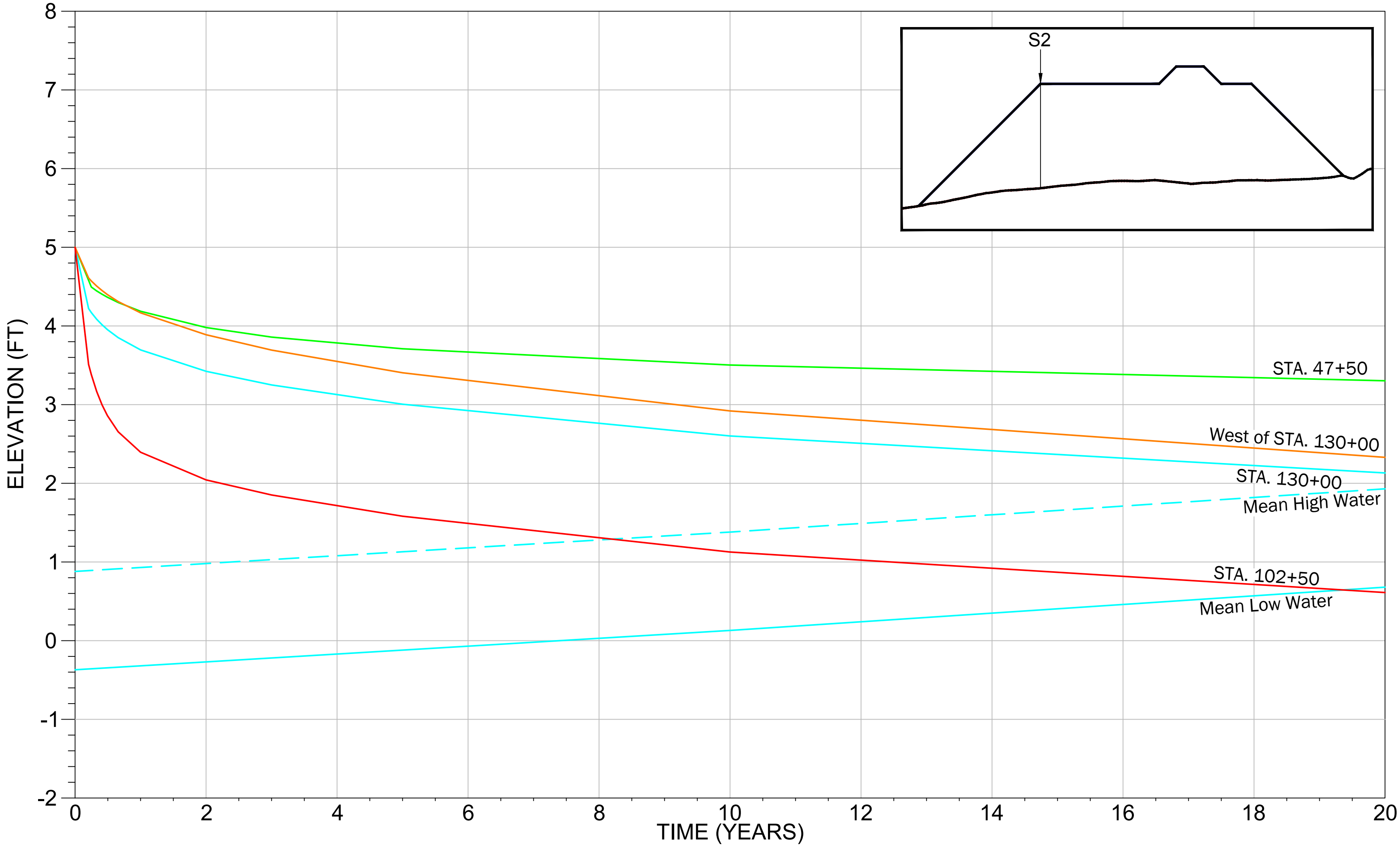
Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Beach Slope at Waterline Settlement vs Time (S1)
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure C-5



Fill Elevation (ft)								
Station	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
Sta. 47+50	5.0	4.4	4.4	4.2	3.9	3.7	3.5	3.3
Sta. 102+50	5.0	3.2	2.9	2.4	1.9	1.6	1.1	0.6
Sta. 130+00	5.0	4.1	4.0	3.7	3.3	3.0	2.6	2.1
West of 130+00	5.0	4.5	4.4	4.2	3.7	3.4	2.9	2.3

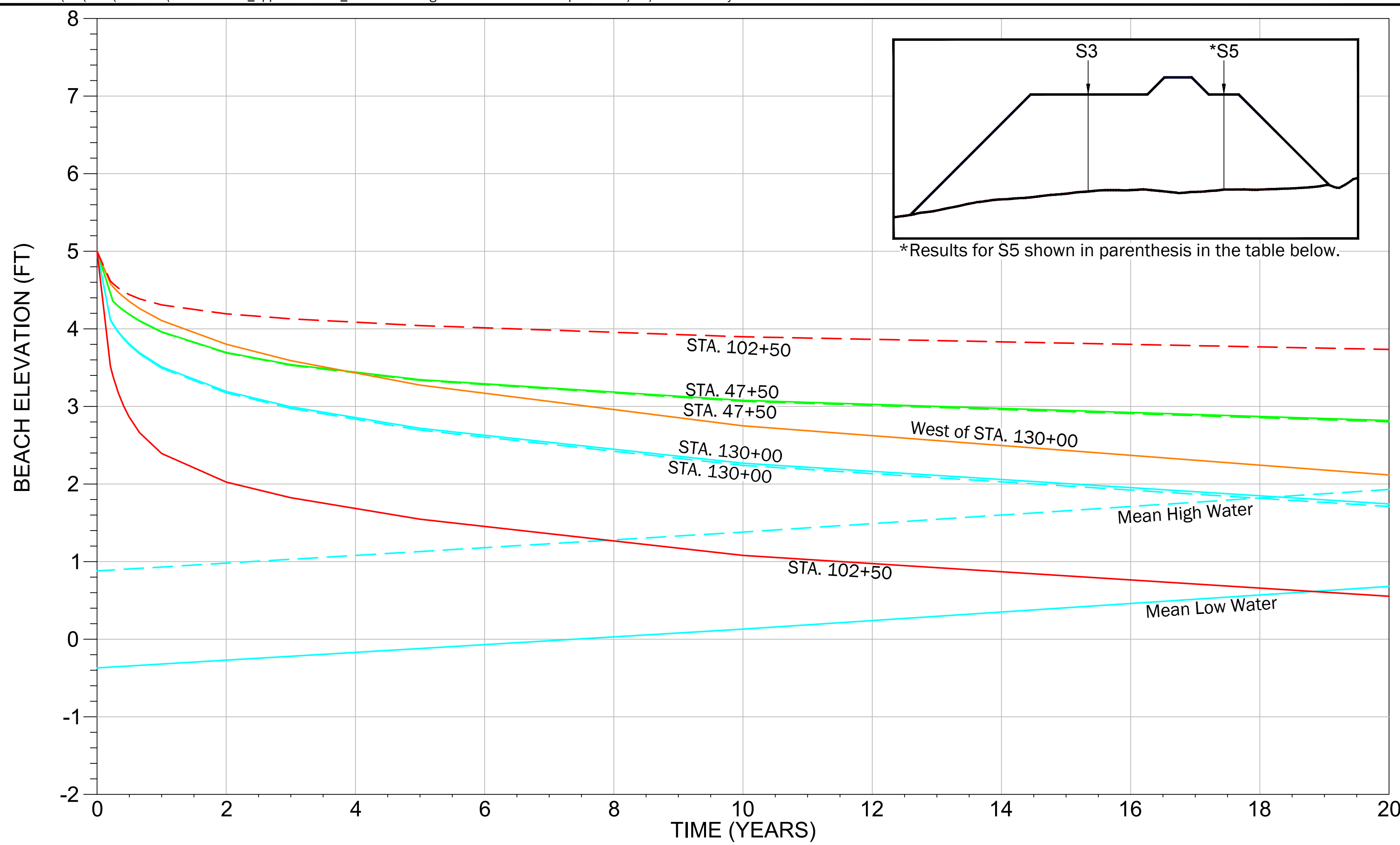
Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Edge of Beach Settlement vs Time (S2)
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure C-6



Beach Elevation (ft)								
Station	End of Construction	120 Days	180 Days	1 Years	3 Years	5 Years	10 Years	20 Years
47+50	5.0	4.3 (4.3)	4.2 (4.2)	4.1 (4.1)	3.5 (3.5)	3.3 (3.3)	3.1 (3.1)	2.8 (2.8)
102+50	5.0	3.2 (4.5)	2.9 (4.4)	2.4 (4.3)	1.8 (4.1)	1.5 (4.0)	1.1 (3.9)	0.6 (3.7)
130+00	5.0	4.0 (4.0)	3.8 (3.8)	3.5 (3.5)	3.0 (3.0)	2.7 (2.7)	2.2 (2.2)	1.7 (1.7)
West of 130+00	5.0	4.5	4.4	4.1	3.6	3.3	2.8	2.1

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Beach Settlement vs Time
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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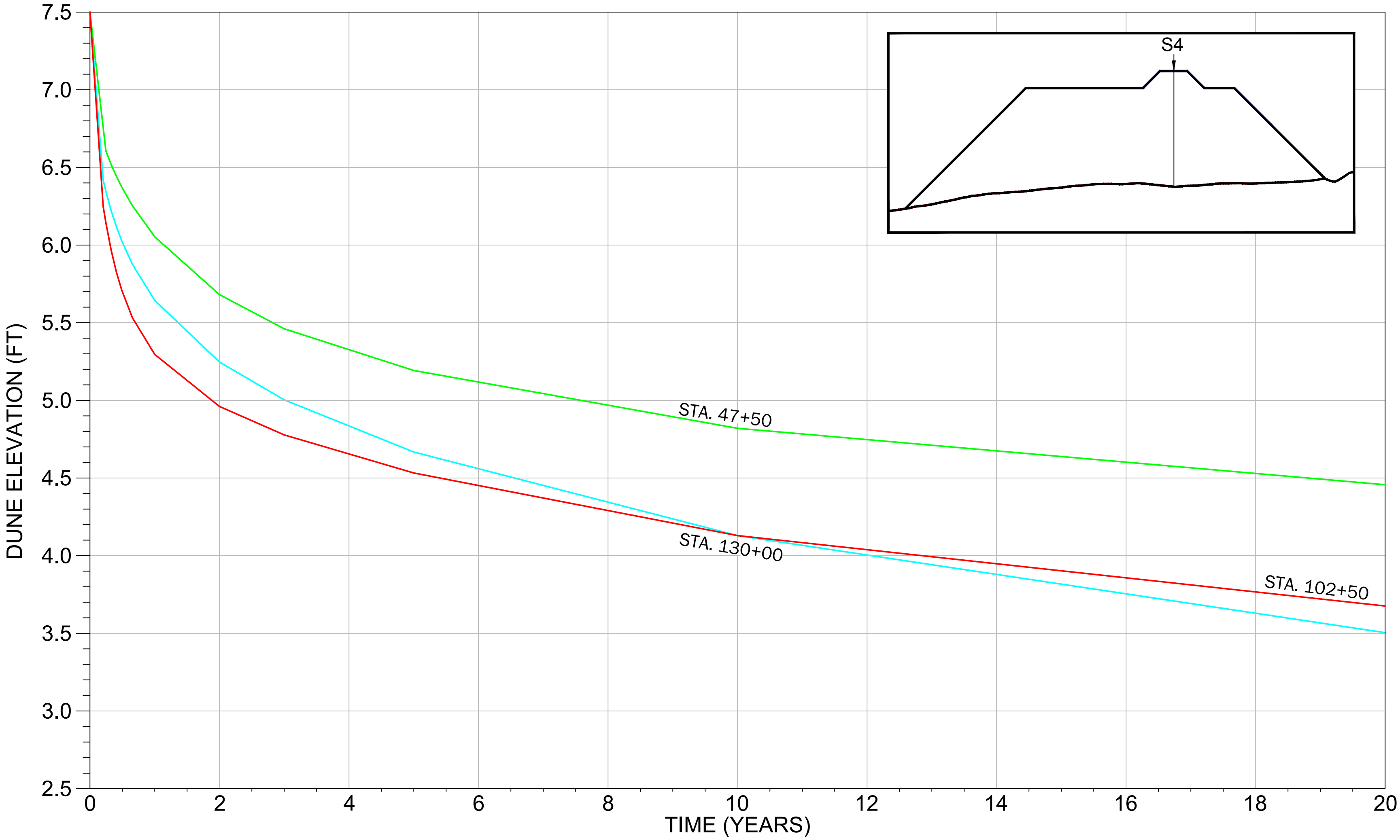
Figure C-7



Dune Elevation (ft)								
Station	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
130+00	7.5	6.2	6.0	5.6	5.0	4.7	4.1	3.5
102+50	7.5	6.0	5.7	5.3	4.8	4.5	4.1	3.7
47+50	7.5	6.5	6.4	6.1	5.5	5.2	4.8	4.5

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Dune Settlement vs Time
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure C-8

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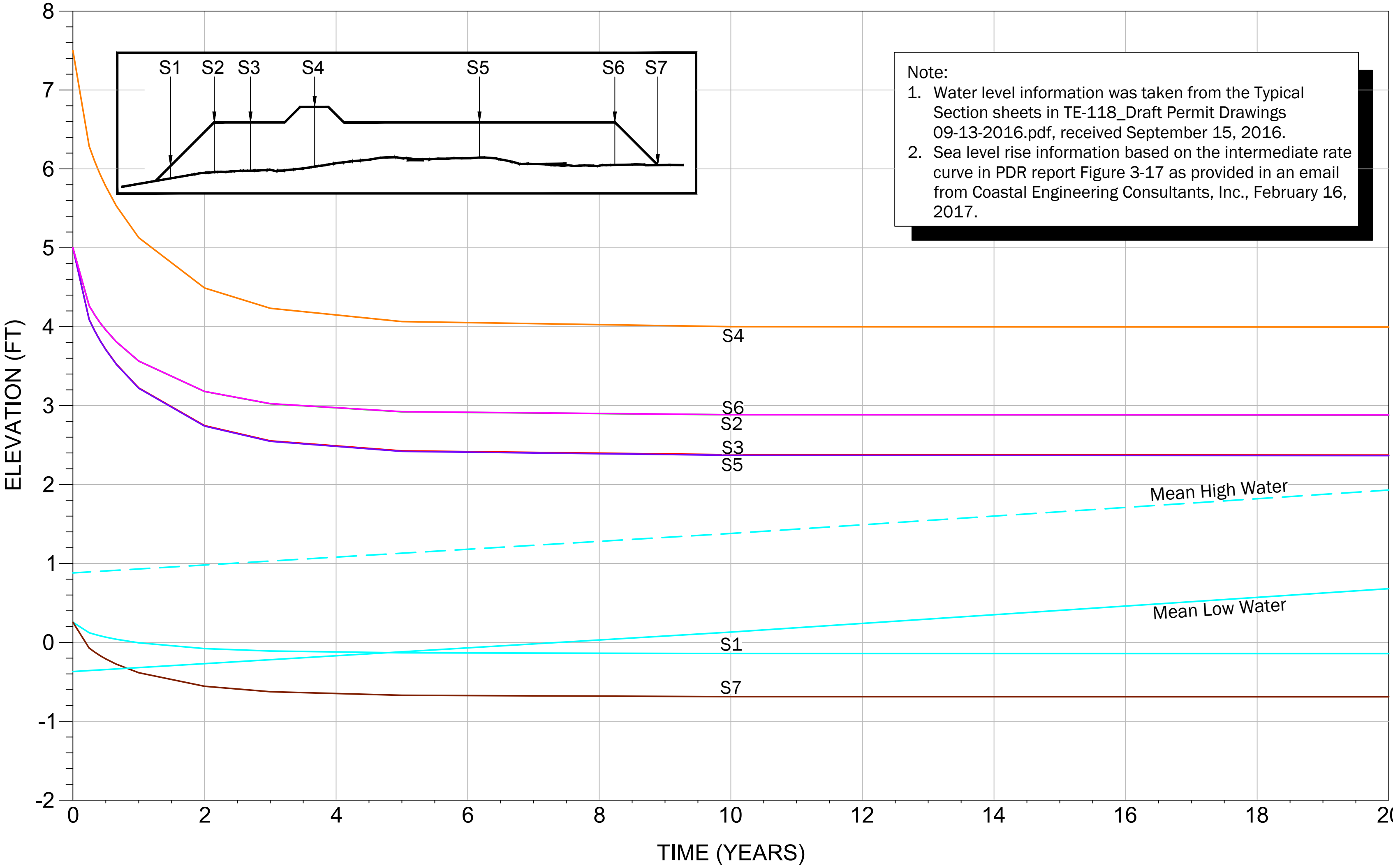


Settlement Point	Fill Elevation (ft) End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
S1	0.3	0.1	0.1	0.0	-0.1	-0.1	-0.1	-0.1
S2	5.0	4.2	4.0	3.6	3.0	2.9	2.9	2.9
S3	5.0	4.0	3.7	3.2	2.6	2.4	2.4	2.4
S4	7.5	6.1	5.8	5.1	4.2	4.1	4.0	4.0
S5	5.0	4.0	3.7	3.2	2.6	2.4	2.4	2.4
S6	5.0	4.2	4.0	3.6	3.0	2.9	2.9	2.9
S7	0.3	-0.1	-0.2	-0.4	-0.6	-0.7	-0.7	-0.7

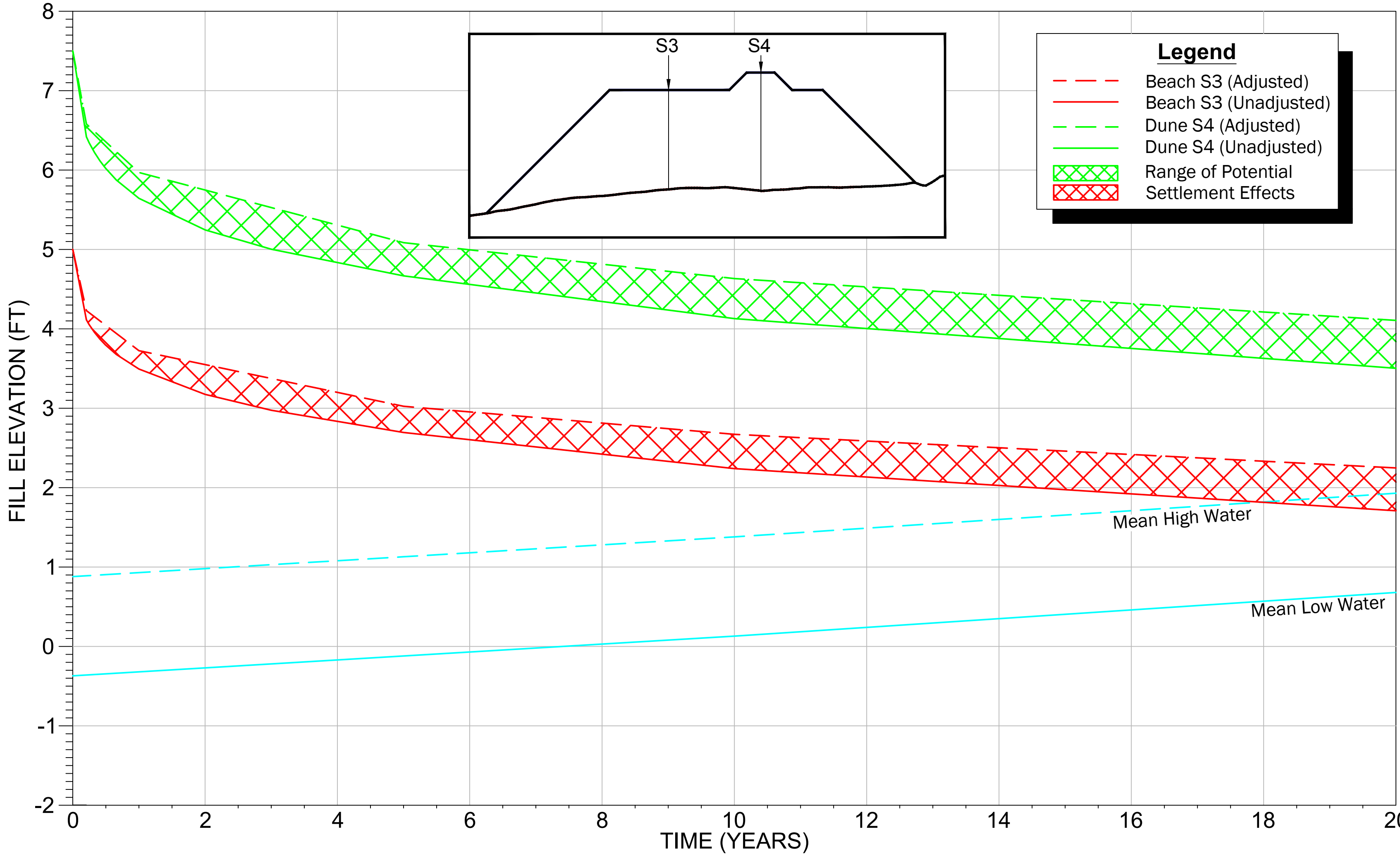
Station 170+00 Settlement vs Time
West Belle Pass

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure C-9

P:\16\16715036\00\CAD\Geotech\1671503600_Appendix C D E_Settlement.dwg TAB:Effect of Incremental Settlement Date Exported: 06/22/17 - 15:22 by kcook



Time	Fill Surface Elevation (ft)			
	Beach		Dune	
	Adjusted	Unadjusted	Adjusted	Unadjusted
0 Days	5.0	5.0	7.5	7.5
75 Days	4.2	4.1	6.6	6.2
1 Year	3.7	3.5	6.0	5.6
5 Years	3.0	2.7	5.1	4.7
10 Years	2.7	2.2	4.6	4.1
20 Years	2.2	1.7	4.1	3.5

Note:
1. Adjusted refers to pressure adjustments due to incremental settlement over time and sea-level rise. Unadjusted values assume as-built section constant pressure is for the project life.
2. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
3. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Effect of Incremental Settlement and Sea Level Rise on Fill Elevation vs Time (Sta. 130+00)

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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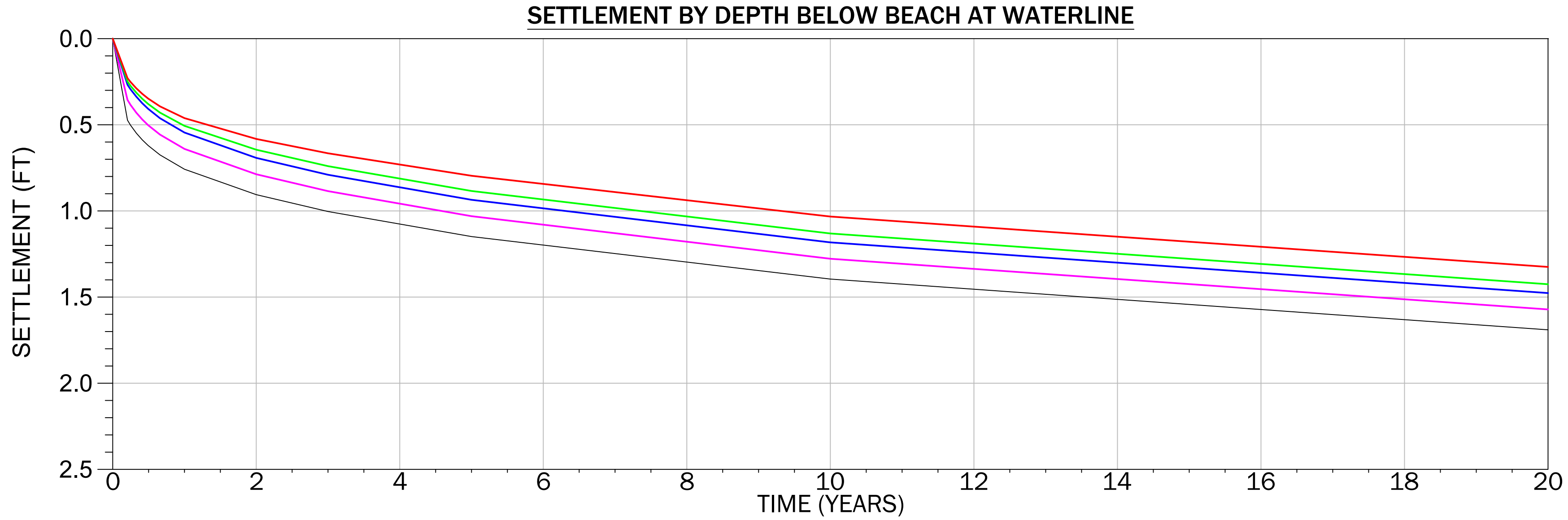
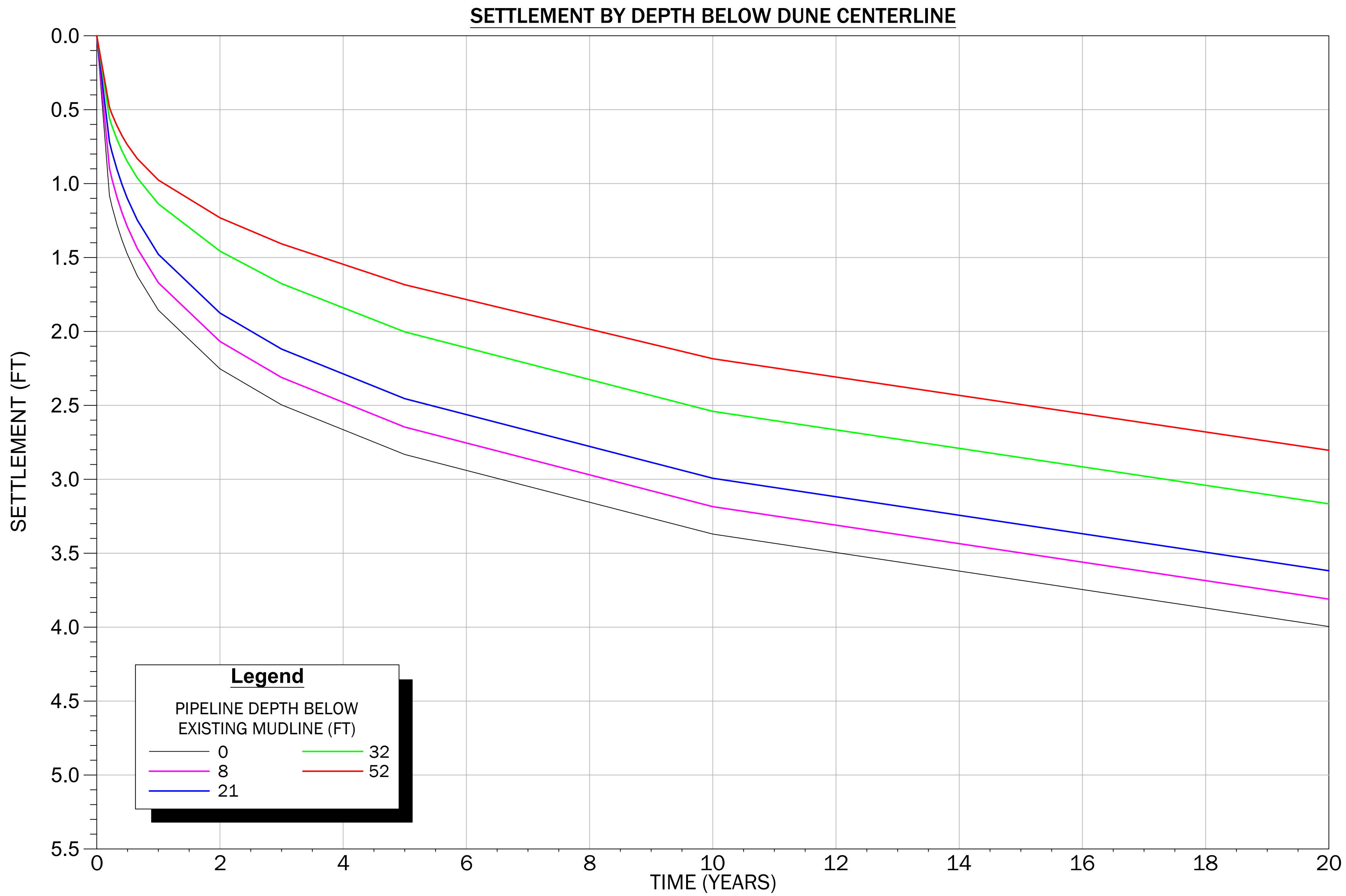
Figure C-10

SETTLEMENT BY DEPTH BELOW BEACH AT WATERLINE



SETTLEMENT BY DEPTH BELOW DUNE CENTERLINE

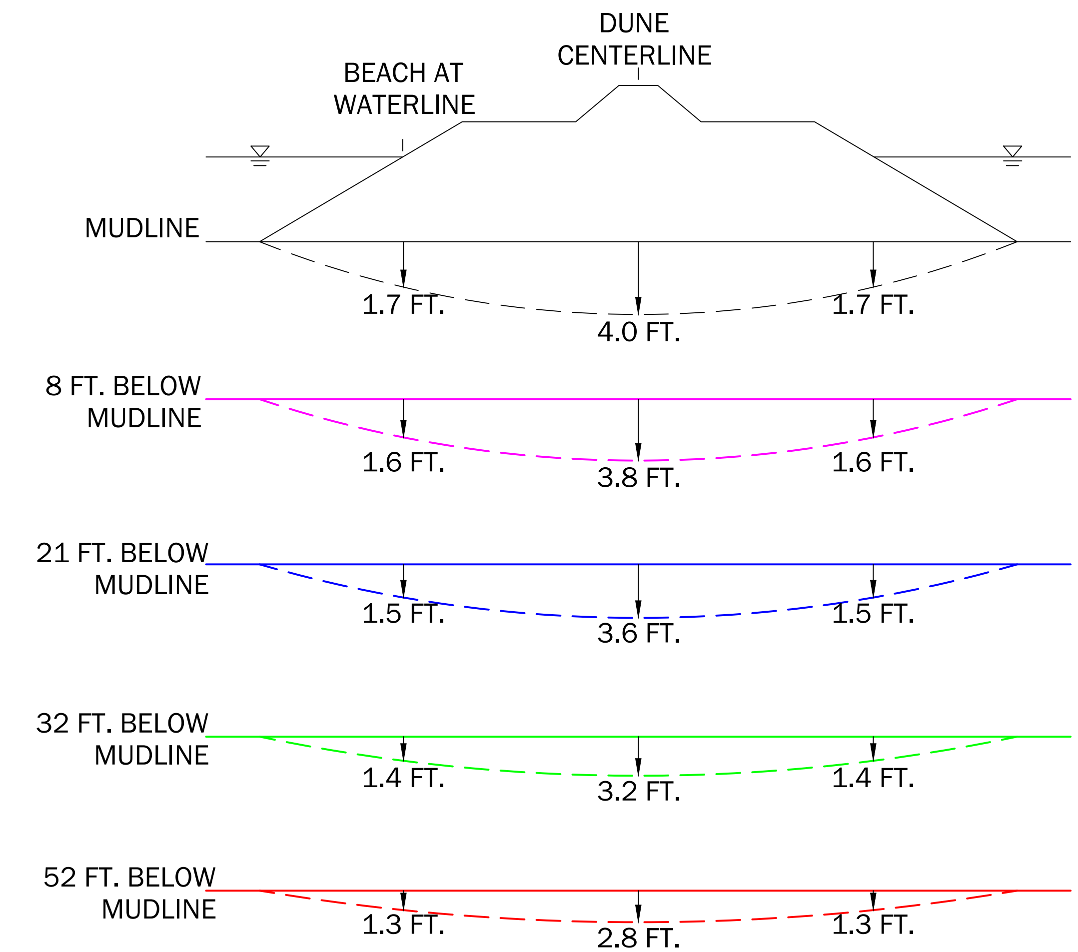


SETTLEMENT BY DEPTH BELOW BEACH AT WATERLINE (FT)					
PIPELINE DEPTH BELOW EXISTING MUDLINE (FT)	180 DAYS	1 YEAR	5 YEARS	10 YEARS	20 YEARS
0	0.6	0.8	1.1	1.4	1.7
8	0.5	0.6	1.0	1.3	1.6
21	0.4	0.5	0.9	1.2	1.5
32	0.4	0.5	0.9	1.1	1.4
52	0.3	0.5	0.8	1.0	0.3

*SETTLEMENT CALCULATIONS BASED ON STATION 130+00 SETTLEMENT

SETTLEMENT BY DEPTH BELOW DUNE CENTERLINE (FT)					
PIPELINE DEPTH BELOW EXISTING MUDLINE (FT)	180 DAYS	1 YEAR	5 YEARS	10 YEARS	20 YEARS
0	1.5	1.9	2.8	3.4	4.0
8	1.3	1.7	2.6	3.2	3.8
21	1.1	1.5	2.5	3.0	3.6
32	0.8	1.1	2.0	2.5	3.2
52	0.7	1.0	1.7	2.2	2.8

*SETTLEMENT CALCULATIONS BASED ON STATION 130+00 SETTLEMENT



NOT TO SCALE

Legend

Prior to Island Construction
20 Years Post-Construction

Effect of Embankment on Pipeline Settlement

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure C-11

APPENDIX D
Containment Dike Settlement Analysis

APPENDIX D
CALCULATION APPROACH FOR CONTAINMENT DIKE SETTLEMENT

1. Settlement parameters and drainage considerations were developed as described in the calculation approach description for beach and dune settlement in Appendix C.
2. CEC provided design fill cross-section and current ground surface elevation profiles across the entire project area. The following design considerations were used in the analysis:

   East Timbalier Island:

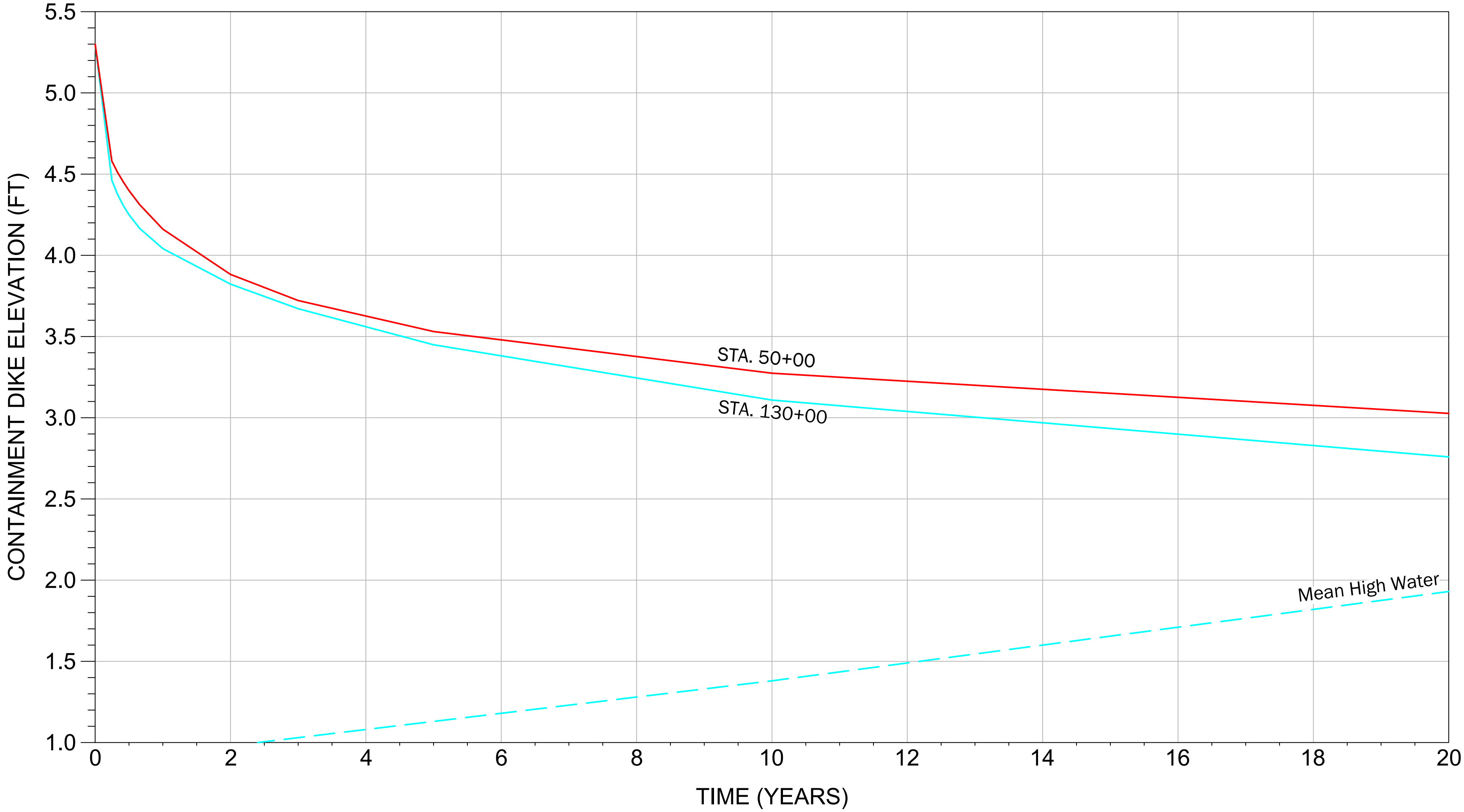
   a. 25H:1V side slopes
   b. Crown elevation of +5.3 feet
   c. Crown width of 30 feet
   d. Fill unit weight of 120 pcf

   West Belle Pass Barrier Headland:

   a. 10H:1V side slopes
   b. Crown elevation of +5.5 feet
   c. Crown width of 10 feet
   d. Fill unit weight of 115 pcf
3. The primary consolidation settlement of the beach and dune alignments were calculated using one-dimensional consolidation theory and Boussinesq stress distribution in the SETANL computer program. Containment dike fill was assumed to have been placed instantaneously as a single lift at time of construction.

This appendix contains results of containment dike settlement calculations.

P:\16\16715036\00\CAD\Geotech\1671503600_Appendix C D E_Settlement.dwg TAB:ET Containment Dike Date Exported: 03/06/17 - 17:05 by kcook



Containment Dike Elevation (ft)									
Station	Initial Mudline	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
130+00	El. -4.0 ft.	5.3	4.4	4.3	4.0	3.7	3.4	3.1	2.8
50+00	El. -1.5 ft.	5.3	4.5	4.4	4.2	3.7	3.5	3.3	3.0

Note:

1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Containment Dike Settlement vs Time
East Timbalier Island

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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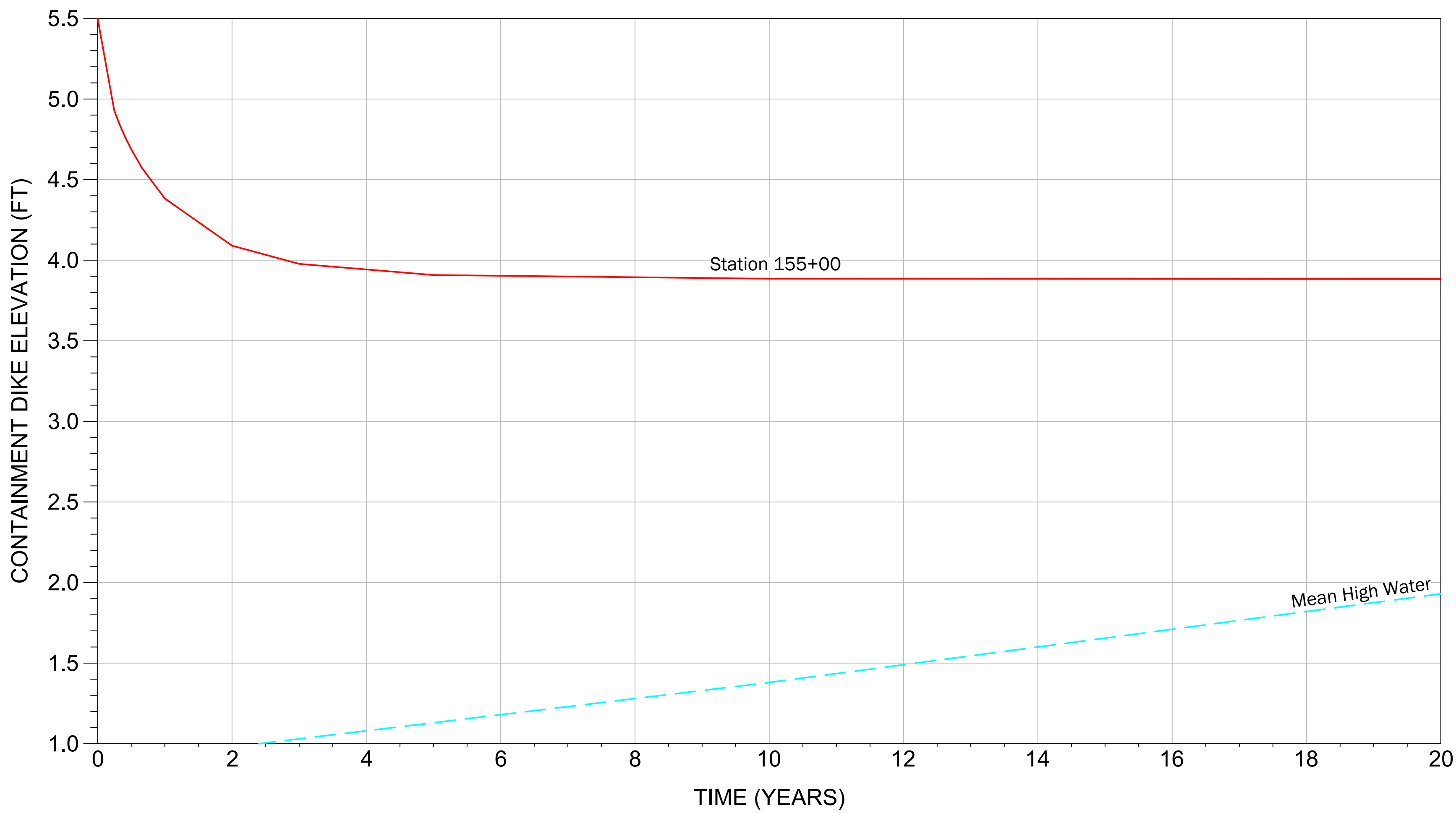
Figure D-1



Containment Dike Elevation (ft)									
Station	Initial Mudline	End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
155+00	El. -0.5 ft.	5.5	4.8	4.7	4.4	4.0	3.9	3.9	3.9

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Containment Dike Settlement vs Time
West Belle Pass

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GeoEngineers

Figure D-2

APPENDIX E
Marsh Settlement Analysis

APPENDIX E
CALCULATION APPROACH FOR MARSH FILL AND FOUNDATION SETTLEMENT

1. Settlement parameters and drainage considerations were developed as described in the calculation approach description for beach and dune settlement in Appendix C.
2. For the marsh fill material, consolidation parameters were obtained from low-stress consolidation test results. For East Timbalier Island, we had information from one composite sample within the proposed borrow area (Composite Sample 1, CS-1). For the West Belle Pass Barrier Headland, we were provided test results for two samples from the proposed borrow area (WBVC-08-44 and WBVC-08-46).
3. Based on the information provided by CEC, the target marsh elevation is +3.0 feet NAVD88 at the end of construction with a 1-foot overbuild tolerance.

Settlement of the marsh creation area consists primarily of two separate processes: consolidation of 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 foundation 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 the effective vertical stress and corresponding settlement at various time intervals after fill placement. The typical steps at each time interval included the following:

1. Calculated settlement for the foundation soil beneath the fill based on the elapsed time and the effective stress calculated for the application of a single lift of fill, and determined the new mudline elevation.
2. From PSDDF, determined the change in thickness of the dredged fill to calculate the fill density and the new fill surface elevation. The new fill surface elevation is influenced by both the foundation settlement and the change in fill thickness computed by PSDDF.
3. Re-computed the effective vertical stress based on the new fill surface and mudline elevations and a constant water elevation of +0.26 feet.
4. Used the new, lower effective stress to re-compute settlement.

This was repeated at days 90, 120, 150, 180, 240, 365 (1 year), 730 (2 years), 1095 (3 years), 1825 (5 years), 3650 (10 years), and 7300 (20 years). To model the settlement occurring within the hydraulic fill during the construction period (75 days), we applied multiple 15-day lifts to the dredged fill during the construction period. We assumed that the dredged fill placed between 0 to 15 days is more consolidated than that placed in the later stage of construction. A unit weight was calculated using a specific gravity of 2.65 for East Timbalier and 2.70 for West Belle Pass and using an average void ratio from the combination of each fill lift at the end of construction. This unit weight was used to compute the load from the marsh fill at the end of construction and estimate the time-rate settlement.

The sum of the dredged fill settlement and the underlying soil settlement was used to determine the total settlement at the surface of the dredged fill area after completion of fill placement. Settlement of dredged fill evaluations were performed for a scenario with fill placed to a surface elevation of +3.0 feet and +4.0 feet at the end of construction.

This appendix contains results of marsh fill and foundation settlement analysis.

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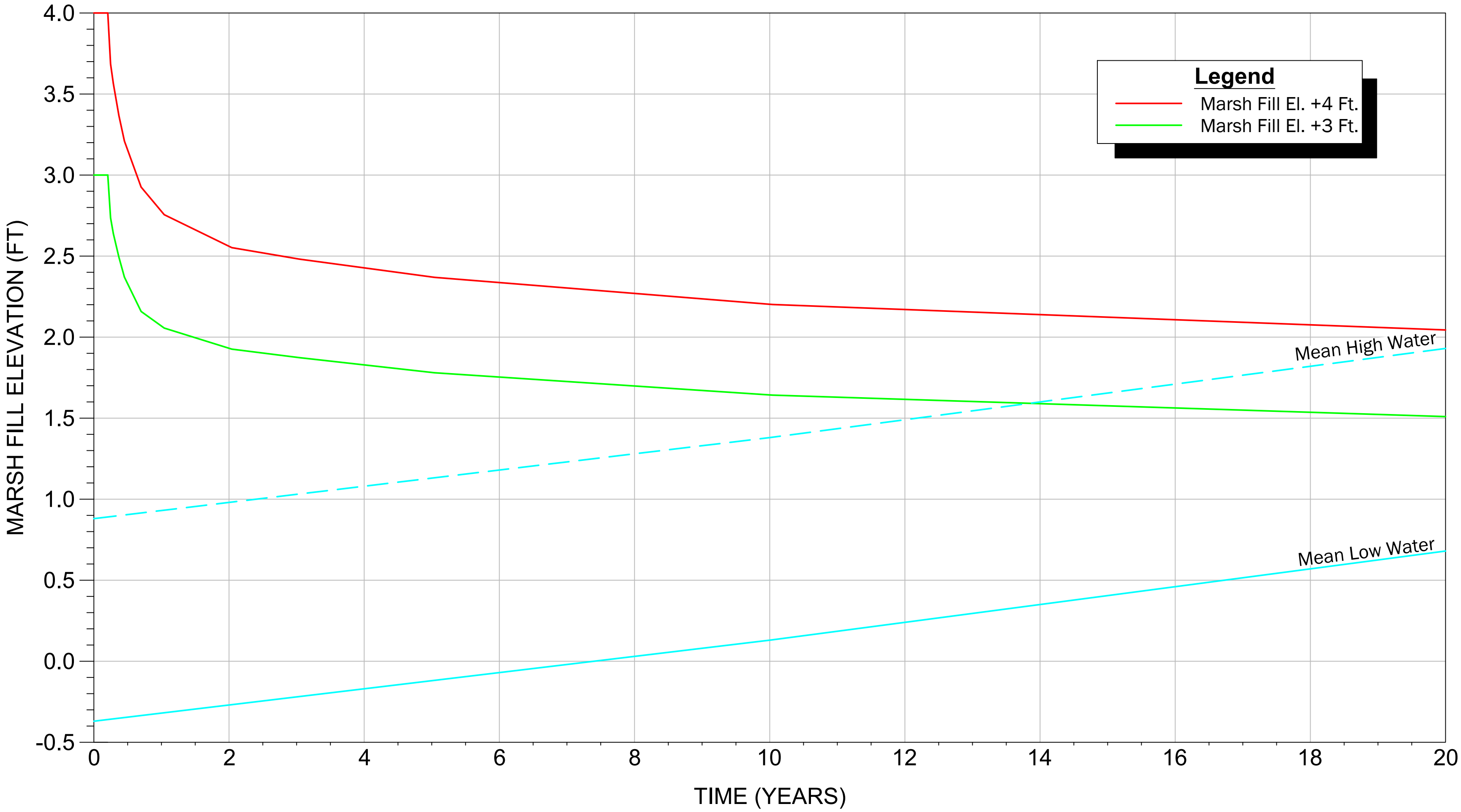

Marsh Fill Elevation (ft)							
75 Days End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
3.0	2.6	2.3	2.1	1.9	1.8	1.6	1.5
4.0	3.5	3.2	2.8	2.5	2.4	2.2	2.0

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Marsh Fill Settlement vs Time
East Timbalier West Zone - Mudline El. -2.0 ft.

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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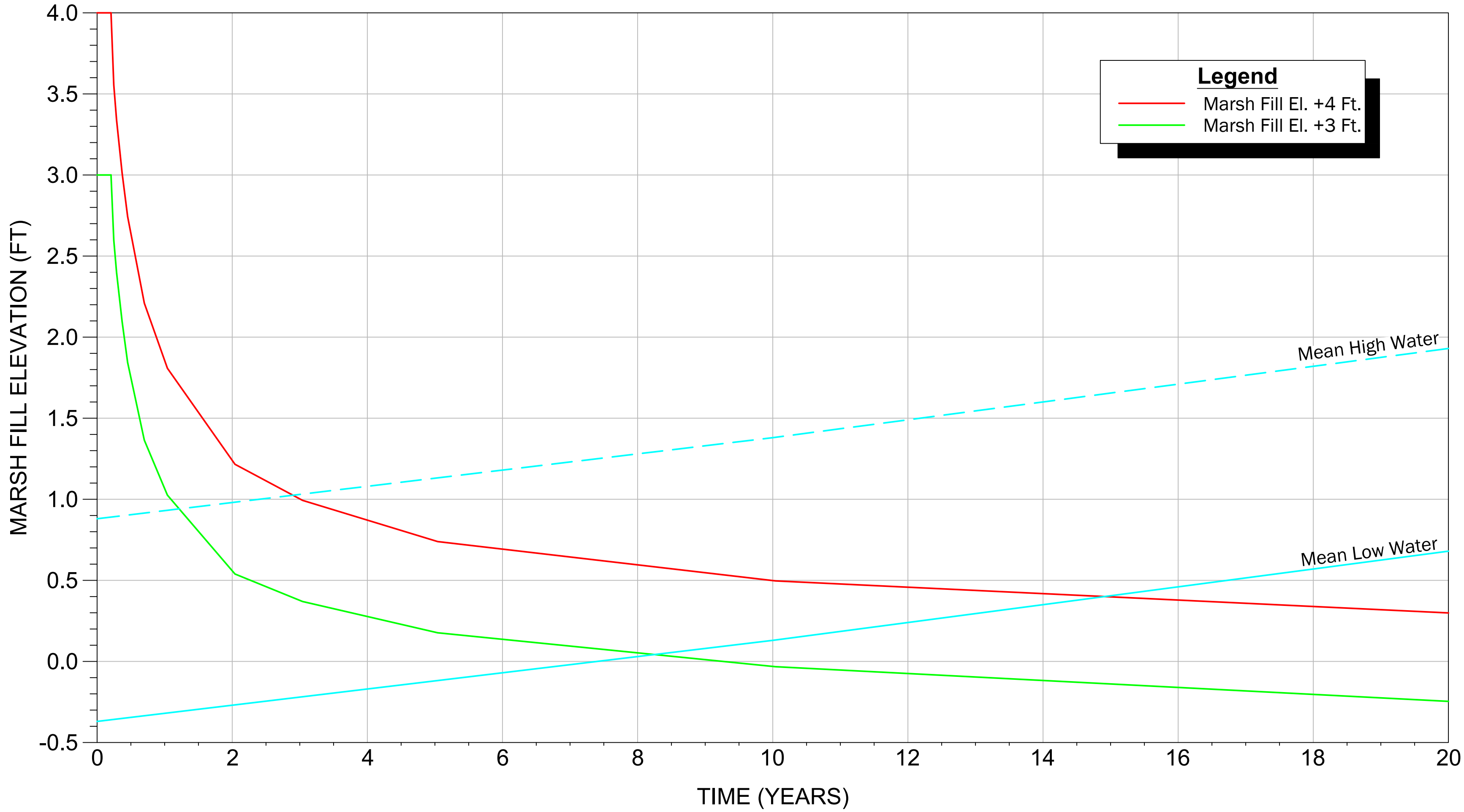
Figure E-1

P:\16\16715036\00\CAD\Geotech\1671503600_Appendix C D E_Settlement.dwg TAB:ET Marsh Fill -6.5 Date Exported: 03/06/17 - 11:39 by kcook



Marsh Fill Elevation (ft)							
75 Days End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
3.0	2.2	1.8	1.0	0.4	0.2	0.0	-0.2
4.0	3.2	2.7	1.8	1.0	0.7	0.5	0.3

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Marsh Fill Settlement vs Time
East Timbalier West Zone - Mudline El. -6.5 ft.

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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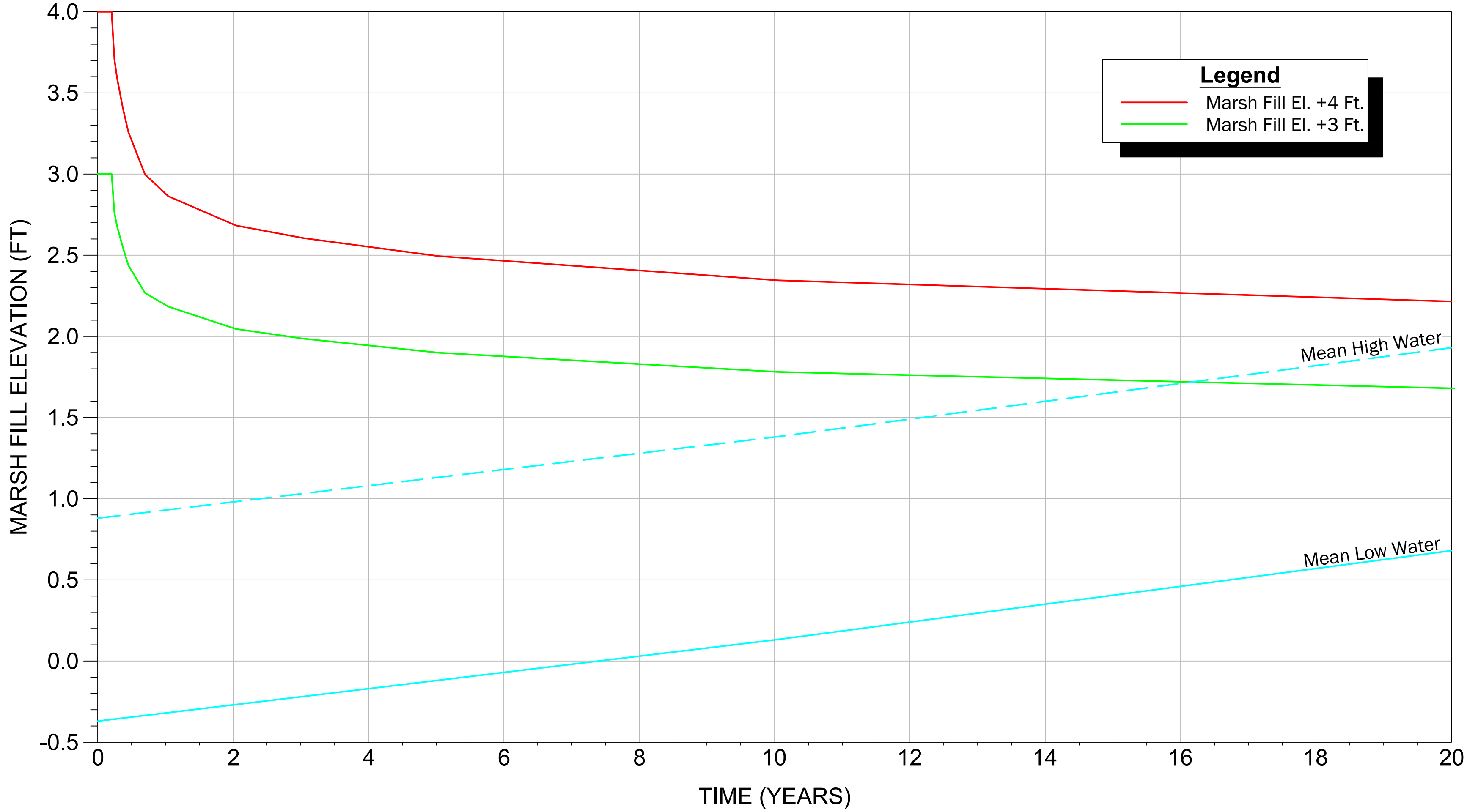
Figure E-2

P:\16\16715036\00\CAD\Geotech\1671503600_Appendix C D E_Settlement.dwg TAB:ET Marsh Fill -1.0 Date Exported: 03/06/17 - 11:39 by kcook



Marsh Fill Elevation (ft)							
75 Days End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
3.0	2.6	2.4	2.2	2.0	1.9	1.8	1.7
4.0	3.5	3.2	2.9	2.6	2.5	2.3	2.2

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Marsh Fill Settlement vs Time
East Timbalier East Zone - Mudline El. -1.0 ft.

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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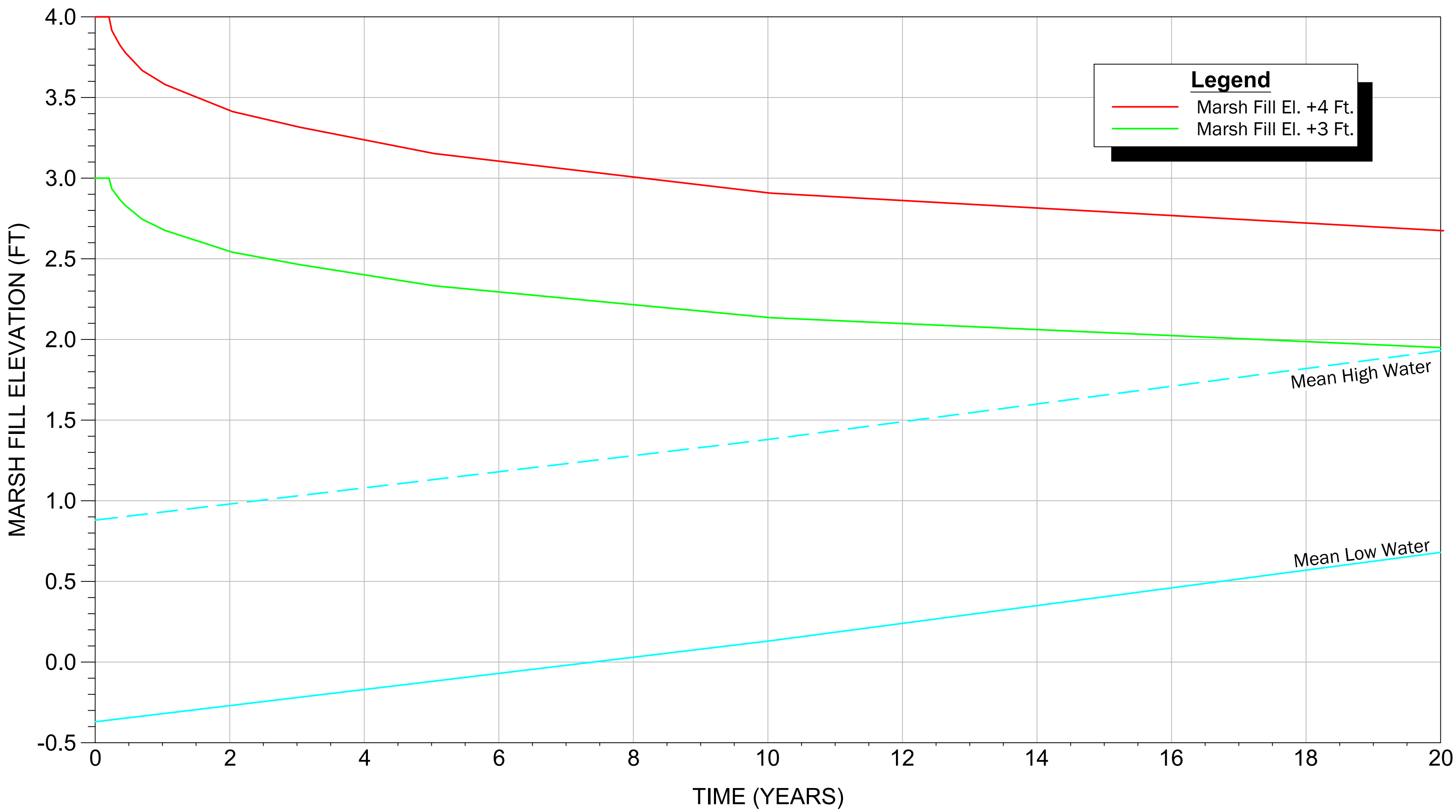
Figure E-3



Marsh Fill Elevation (ft)							
75 Days End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
3.0	2.9	2.8	2.7	2.5	2.3	2.1	1.9
4.0	3.9	3.7	3.6	3.3	3.2	2.9	2.7

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Marsh Fill Settlement vs Time
Ship Shoal Fill Alternative
East Timbalier West Zone - Mudline El. -2.0 ft.

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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Figure E-4

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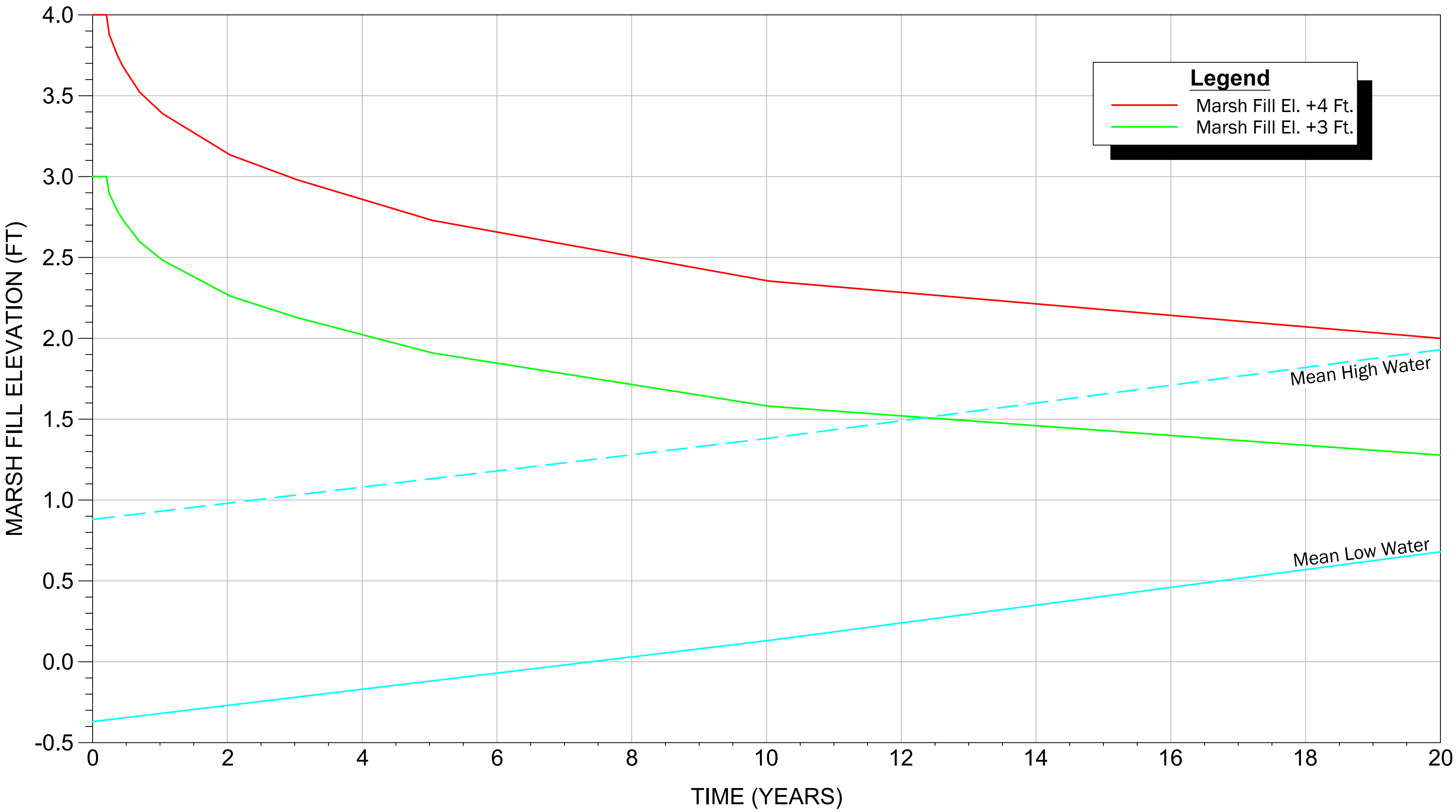

Marsh Fill Elevation (ft)							
75 Days End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
3.0	2.8	2.7	2.5	2.1	1.9	1.6	1.3
4.0	3.8	3.6	3.4	3.0	2.7	2.4	2.0

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Marsh Fill Settlement vs Time
Ship Shoal Fill Alternative
East Timbalier West Zone - Mudline El. -6.5 ft.

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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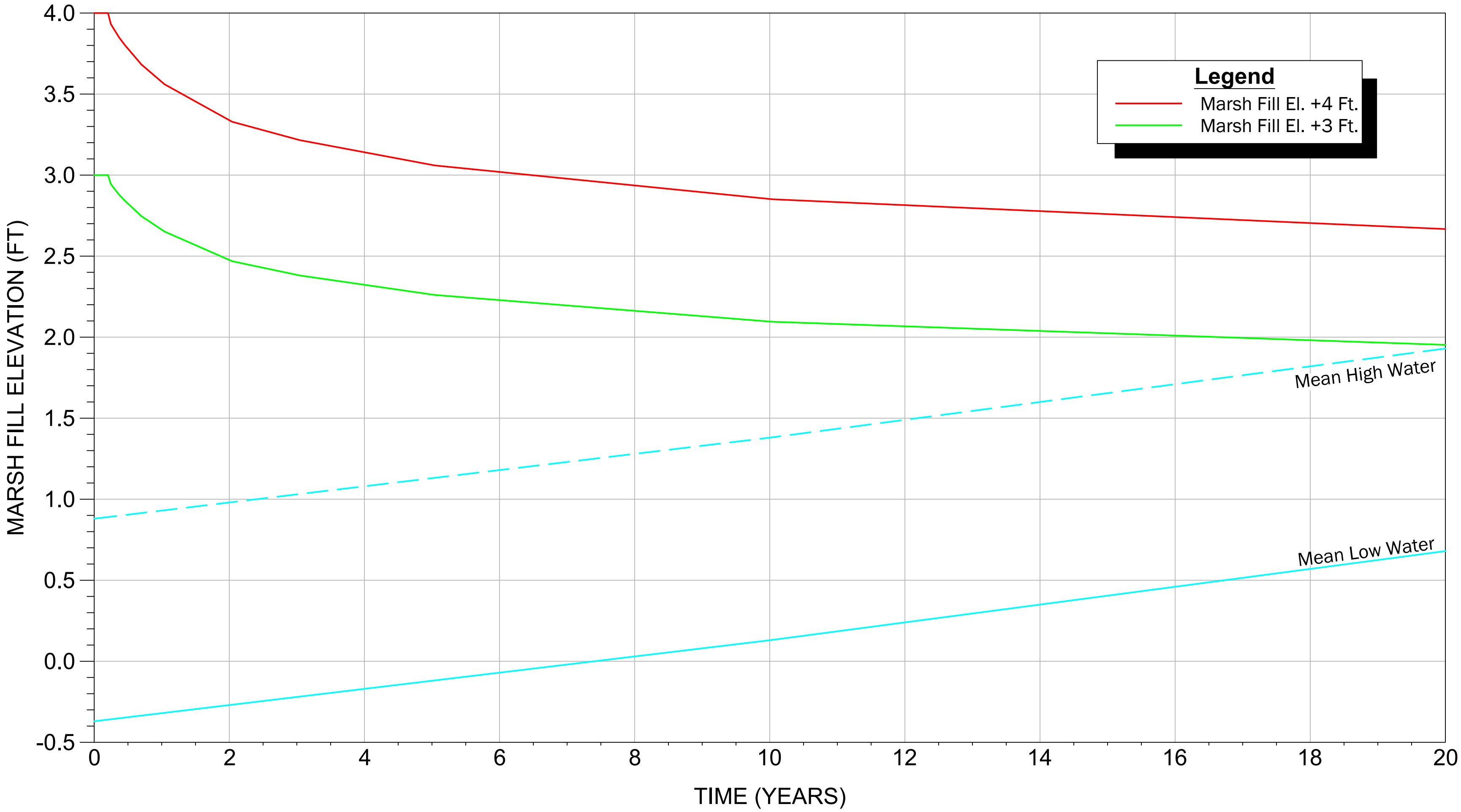
Figure E-5

P:\16\16715036\00\CAD\Geotech\1671503600_Appendix C D E_Settlement.dwg TAB:ET Fill -1 Ship Date Exported: 03/06/17 - 13:22 by kcook



Marsh Fill Elevation (ft)							
75 Days End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
3.0	2.9	2.8	2.7	2.4	2.3	2.1	2.0
4.0	3.9	3.8	3.6	3.2	3.1	2.9	2.7

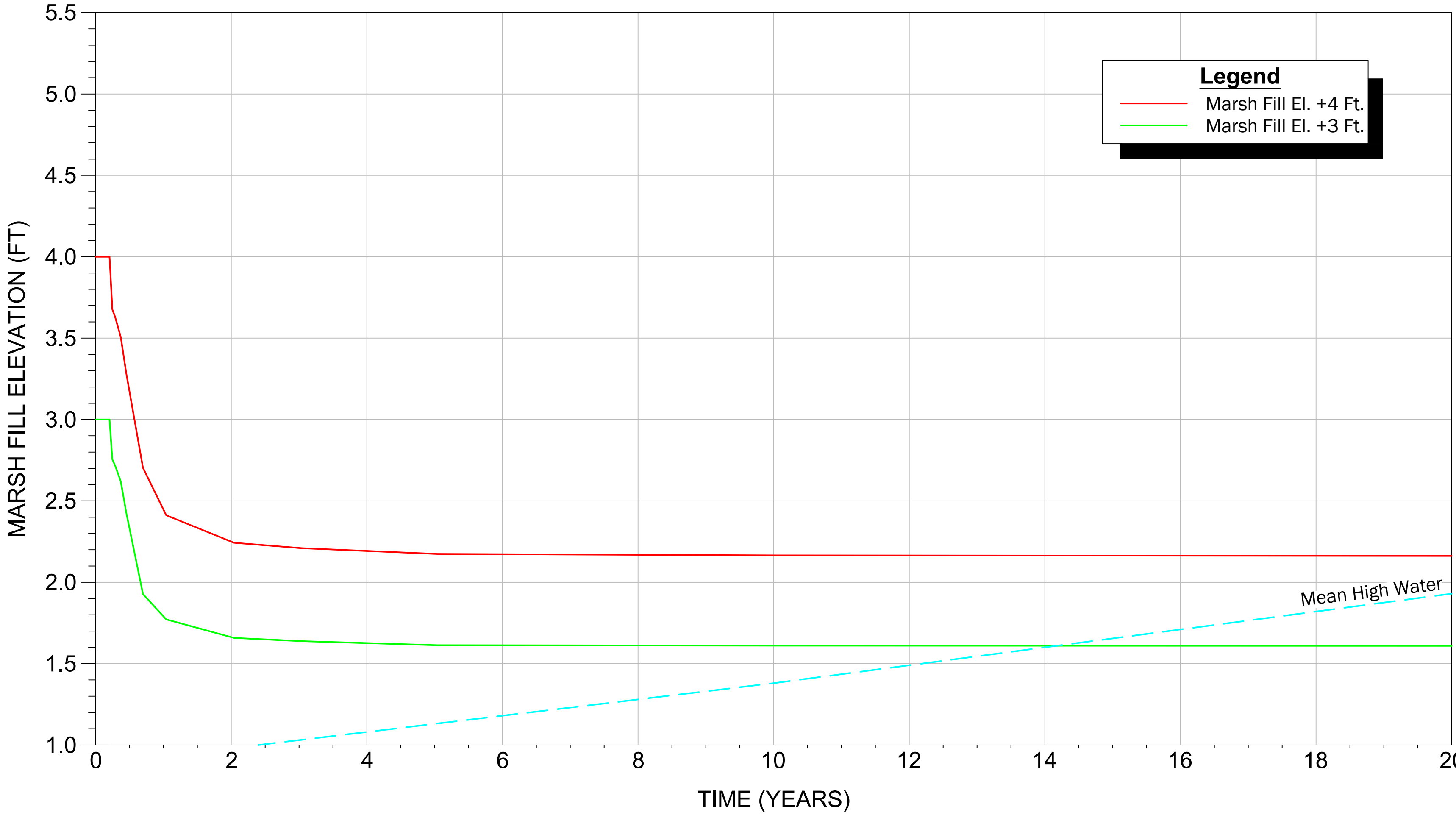
Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Marsh Fill Settlement vs Time
Ship Shoal Fill Alternative
East Timbalier West Zone - Mudline El. -1.0 ft.

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

GEOENGINEERS

Figure E-6



Marsh Fill Elevation (ft)							
75 Days End of Construction	120 Days	180 Days	1 Year	3 Years	5 Years	10 Years	20 Years
3.0	2.7	2.3	1.8	1.6	1.6	1.6	1.6
4.0	3.6	3.2	2.4	2.2	2.2	2.2	2.2

Note:
1. Water level information was taken from the Typical Section sheets in TE-118_Draft Permit Drawings 09-13-2016.pdf, received September 15, 2016.
2. Sea level rise information based on the intermediate rate curve in PDR report Figure 3-17 as provided in an email from Coastal Engineering Consultants, Inc., February 16, 2017.

Marsh Fill Settlement vs Time
West Belle Pass - Mudline El. 0.0 ft.

East Timbalier Island Restoration (TE-118) Project
Lafourche Parish, Louisiana

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Figure E-7

APPENDIX F
Report Limitations and Guidelines for Use

APPENDIX F
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

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 Stantec, Inc. (Stantec) and the Louisiana Coastal Protection and Restoration Authority (CPRA) 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 STANTEC and CPRA, 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 East Timbalier Island Restoration (TE-118) Project. 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.

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1 Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

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, hurricanes, 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.

Have we delivered World Class Client Service?

Please let us know by visiting **www.geoengineers.com/feedback**.

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