EUSTIS ENGINEERING SERVICES, L.L.C.
3011 28th STREET
METAIRIE, LOUISIANA 70002-6019
PN 504-834-0157 / FN 504-834-0354
EMAIL: INFO@EUSTISENG.COM / SITE: WWW.EUSTISENG.COM

1 October 2007

HNTB Corporation
Suite 301
9100 Bluebonnet Center Boulevard
Baton Rouge, Louisiana 70809

Attention Mr. Warren Myers

Gentlemen:

Geotechnical Investigation
State of Louisiana
Lake Hermitage Marsh Creation (BA-42)
Plaquemines Parish, Louisiana
Contract No. 2503-05-46
Eustis Project No. 19666

Transmitted are two copies (one bound and one unbound) of our engineering report covering a geotechnical investigation for the subject project. A copy of this report is also being forwarded to the State of Louisiana, Department of Natural Resources, Baton Rouge, Louisiana, to the attention of Mr. Beau Tate.

Thank you for asking us to perform these services.

Yours very truly,

EUSTIS ENGINEERING SERVICES, L.L.C.

STATE OF LOUISIANA
PAUL REED
License No. 22912
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

PAUL M. REED, P.E.

PMR:jkd/aln

GEOTECHNICAL INVESTIGATION

STATE OF LOUISIANA

LAKE HERMITAGE MARSH CREATION (BA-42)

PLAQUEMINES PARISH, LOUISIANA

CONTRACT NO. 2503-05-46

EUSTIS PROJECT NO. 19666

FOR
HNTB CORPORATION
BATON ROUGE, LOUISIANA

By
Eustis Engineering Services, L.L.C.
Metairie, Louisiana

1 OCTOBER 2007

TABLE OF CONTENTS

GEOTECHNICAL INVESTIGATION
STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA
CONTRACT NO. 2503-05-46
EUSTIS PROJECT NO. 19666

INTRODUCTION

1. This report presents the results of a geotechnical investigation performed for the proposed Lake Hermitage Marsh Creation Project to be located in Plaquemines Parish, Louisiana on the western side of the Mississippi River directly adjacent to Pointe a la Hache and north of Magnolia, Louisiana. Figure 1 shows the vicinity of the project. The investigation was performed in general accordance with Eustis Engineering Services, L.L.C.'s proposal dated 9 January 2007. The project was authorized by HNTB Corporation in their Subcontract Agreement with Eustis dated 29 January 2007.

SCOPE

2. A comprehensive scope of work was provided by the State of Louisiana, Department of Natural Resources entitled *Scope of Services for Lake Hermitage, Geotechnical Investigation and Engineering Services* dated 16 November 2006. In general, the investigation included the drilling of undisturbed sample type soil test borings to determine subsoil stratification and to obtain samples of the subsoils. Soil mechanics laboratory tests, performed on samples obtained from the borings, were used to evaluate the physical properties of the various substrata. From these data, settlement analyses were made to determine the time-settlements of the various features of the project. The analyses were also used to calculate the

stability of the containment levees surrounding the marsh platforms, the stability of a rock breakwater, and shoreline protection.

PROJECT DESCRIPTION

3. The LaDNR intends to dredge sediment from the Mississippi River and create approximately 593 acres of marsh. Ancillary features of the project include 25,000 lineal feet of earthen terraces, 6,000 lineal feet of rock shoreline protection, and an earthen plug. Additional information about the project was provided by the LaDNR and includes the following:

- Marsh Platform

  The marsh platform is the major feature of the project. It will be constructed by transporting sand dredged from the Mississippi River to the site using a slurry mix. To contain the marsh platform, a containment levee will be constructed around the platform area first, then the marsh platform filled with sand.

  Information about the marsh platform was provided by LaDNR and includes the following:

  Mean High Water (MHW) = el 0.87 (NAVD 88 feet)
  Mean Low Water (MLW) = el 0.33 (NAVD 88 feet)
  Mudline Elevation: North = el -0.460
  South = el -2.105
  Elevation at top of platform = el 1.2

- Containment Levees

  The containment levees for the marsh platform will be constructed using soils from a borrow source created near the proposed toe of the levees. The geometry of the containment levees may vary, but, in general they will be designed to meet the following criteria:

Mudline Elevation: North = el -0.460
South = el -2.105
Crest width will range from 4 to 8 feet
Required crest elevation = el 2.2, but a 1 foot freeboard needs to be maintained above the marsh platform.
Design life for this feature is 8 to 12 months.
Factor of safety = 1.3

- The Terraces

  The terraces will be embankments created using in situ materials dredged from an adjacent borrow pit. These embankments will be constructed along the western and southwestern perimeter of the project. Based on information from the LaDNR, the embankments will be 100 to 300 feet wide with a 5 to 30-ft wide crest. The embankment will slope on all four sides from the crest to the mudline. Additional information provided by the LaDNR includes the following:

  Mudline = el -1.444
  Crest elevation = el 2.2, but needs to maintain 1 foot of freeboard above el 1.2

- Rock Breakwater

  Two rock dike positions relative to the lake shoreline have been proposed by the LaDNR. The offshore rock dike will be positioned 100 to 150 feet from the crest of the existing lake shoreline. The onshore rock dike will be located adjacent to the crest of the lake shoreline. The rock dikes are to be designed for a factor of safety equal to 1.3. Based on information provided by the LaDNR, we understand fill will not be placed along the back side of the proposed offshore rock dike, but marsh nourishment fill will be placed to el 1.5 feet behind the onshore rock dike section.

- Sand Shoreline Protection
  The sand fill wedge shoreline protection proposed will consist of a sand berm constructed over the crest of the lake shoreline. The sand wedge will have a 50-ft wide crown with side slopes of 1V:25H (vertical:horizontal) to 1V:50H.

- A pipeline from the Mississippi River to the project.

- The project design life is 20 years.

<u>FIELD INVESTIGATION</u>

4. <u>Soil Borings.</u> The boring locations were determined in the field by a handheld Global Positioning System receiver. Figure 2 shows the approximate boring locations. The latitude and longitude coordinates of the borings are shown on Figure 2 and on the boring logs. Detailed descriptive logs of the borings and laboratory test results are included in Appendix A. Upon completion of drilling, the borings were backfilled with cement-bentonite grout in accordance with current regulatory requirements.

5. The undisturbed soil borings were drilled with a rotary type drill rig. For Borings RB-1 through RB-3, our rig was mounted on a barge and positioned over the borings using anchors and winches. Borings 4 through 12 were drilled using our rotary type drill rig mounted on a marsh buggy. Boring 13 was drilled on land. Undisturbed samples of cohesive or semi-cohesive subsoils were obtained at close intervals or changes in stratum using a 3-in. outside diameter thinwall Shelby tube sampler. The samples were immediately extruded, inspected, and visually classified by Eustis' soil technician. Pocket penetrometer tests were performed on the soil

samples to give a general indication of their shear strength or consistency. The results of these tests are shown on the boring logs in Appendix A under the column heading "PP." Representative samples were then promptly placed in moisture proof containers and sealed for preservation of their natural moisture content.

LABORATORY TESTS

6. Soil mechanics laboratory tests generally consisted of classification tests including natural water content, unit weight, and Atterberg limits. Either unconfined compressive shear (UC) or one-point unconsolidated undrained triaxial compression shear (OB) were performed on undisturbed samples obtained from the borings. Grain size and hydrometer analyses were performed on selected samples taken from the river borings.

7. Oedometer tests were performed on undisturbed samples taken from Lake Hermitage to assess soil compressibility. Tests were generally performed according to ASTM Standards. Specialized testing was also performed on a composite sample created by taking material from Borings RB-1, RB-2, and RB-3. A self-weight consolidation test was attempted, but because of the granular nature of the mixture, the test was terminated and a low pressure consolidation test was performed instead. A composite sample was generated using material from Borings 7, 8, and 11, and a second composite sample using material from Borings 9, 10, and 12. Approximately 600 grams of material were taken from soils in the upper 12 feet of the borings. The material was mixed to form a composite sample. Self-weight consolidation tests were then performed on each of the two composite samples. Testing then followed the procedure recommended in the U.S. Army Corps of Engineers EM1110-2-5027, Appendix D[1]. The results of all of the laboratory tests are tabulated on the boring logs in Appendix A.

---

[1]Confined Disposal of Dredged Material, Department of the Army, U.S. Army Corps of Engineers, Engineering Manual EM1110-2-5027, September 30, 1987

DESCRIPTION OF SUBSOIL CONDITIONS

Stratigraphy

8. Borings completed in the Mississippi River, RB-1 through RB-3, are relatively consistent. The water depth varied from 37 to 55 feet. The boring logs and test results reveal that the subsurface materials to a depth of 40 feet, the terminal depth of the borings, consist of poorly graded sands (SP). These sands vary in density from loose to medium dense near the surface to dense at approximately 30 feet below the mudline.

9. The borings in and around Lake Hermitage (Borings 4 through 12) consist of very soft gray plastic clays to the full depth of the borings. Boring 11, which was drilled to 100 feet below the mudline, shows very soft to soft clays throughout the profile. Boring 13, which is close to the river, shows soft clays to approximately 40 feet underlain by a medium dense sand to 60 feet, the terminal depth of this boring. Figures 3 and 4 provide soil profiles at two selected locations.

ENGINEERING ANALYSES

10. General. Slope stability analyses were performed for the design of the proposed containment levees that will enclose the marsh creation features. It is our understanding the containment levees will be placed at a maximum bottom level (mudline elevation) of el -0.460 and el -2.105, respectively, for the north and south areas. The design requires that the crest of the levee be at el 2.2 after one year. Further, we understand the crest width will be in the range of 4 to 8 feet and the levees will be constructed using in situ material that is dredged from a borrow pit near the levee then mechanically placed. Stability analyses were also conducted for the terraces.

11. Slope stability analyses were conducted by a two-dimensional limit equilibrium stability analysis of selected trial failure surfaces using the computer program PCSTABL[2]. Potential circular arc failure surfaces were evaluated using Spencer's Method. The computer program searched for critical failure surfaces with low computed factors of safety. Moreover, we analyzed the stability of the containment levees assuming crest heights of el 4 to el 5. We included the effects of a borrow area on the stability of the levee, and recommend the borrow area be located no closer than 15 feet from the toe of the levee so that it does not affect stability of the levee.

12. Time-rates of consolidation settlement of the marsh fill material and the underlying subsoils were estimated within the proposed marsh creation and the containment levee areas. Settlement calculations were also performed for the terraces. We acknowledge that there may be differences in the time-settlements of mechanically placed and slurry placed materials. Lee[3] concludes that excavated or hopper placed sand is usually much denser than slurry placed sand. Sladen and Hewitt[4] conclude that relative density within a given fill can vary from approximately 10% to 70%. Further, the factors affecting in situ density are little understood. Therefore, in our settlement calculations, we necessarily made simplifying assumptions that are detailed in this report. The report presents time-rate of settlement curves over the 20-year project life for the north and south marsh platform areas and four marsh fill heights. For both the marsh platforms and the containment levees, we used mudline levels of el -0.45 and el -2.11 for the north and south areas, respectively.

---

[2] R. A. Siegel, *Stabl User Manual, Joint Highway Research Project, Project No. C-36-36K*, Purdue University, West Lafayette, Indiana, 4 June 1975

[3] K. M. Lee, Influence of Placement Method on the Cone Penetration Resistance of Hydraulically Placed Sand Fills, *Canadian Geotechnical Journal*, 2001, Volume 38, pp. 592 - 607

[4] J. A. Sladen and K. J. Hewitt, 1989, Influence of Placement Method on the In Situ Density of Hydraulic Sand Fills, *Canadian Geotechnical Journal*, 1989, Volume 26, pp. 453 - 466

However, for the containment levees, we analyzed time-settlements over a 12-month period using four crest elevations. Settlements were evaluated considering the compressibility characteristics of the marsh and containment levee fills consolidating under their own weight. The settlements were then added to the foundation settlements that we calculated using soil test results from the marsh borings. Recommendations for staged construction of marsh fill creation in conjunction with staged containment levee construction are also provided. Dewatering and decanting requirements for the fill materials are addressed subsequently in this report.

13. The major objective of this restoration project is to use dredged material to create approximately 593 acres of marsh at Lake Hermitage. The project life is established at 20 years. It is our understanding[5] that the level of the marsh platform should be at el 1.2 after 20 years.

14. <u>Construction Materials.</u> We understand the construction materials for the containment levee will be material dredged from a borrow site parallel to the levee toe. For the marsh, the fill material will be hydraulically dredged material from the Mississippi River then transported to the marsh area by slurry. In calculating settlements and stability, we made the following assumptions:

1) The unit weight of the sand fill material is 115 pcf and 100 pcf for the in situ materials. This is the average unit weight at the beginning and the end of the consolidation process.

2) Settlements can be predicted using a finite difference analysis for large strains[6].

---

[5] Personal Communication, Beau Tate, LaDNR

[6] University of Texas, Geotechnical Engineering Center, *Program SD3, Finite Difference Analysis of Consolidation Problems Involving Either One-Dimensional Vertical Flor or Two-Dimensional flow with Drainage Wicks*

3) As the fill settles, the part of the fill that is below water will be considered as buoyant and the buoyant unit weight used in the settlement calculations.

4) The borrow pit for the containment levee is not closer than 15 feet and not closer than 25 feet for the terraces to the toe of any fill slope.

5) The soils to a depth of approximately 10 feet below the mudline are overconsolidated. (Soil parameters used in the analysis are included in Appendix C.)

6) For Southern Louisiana, the c/p ratio is equal to approximately 0.25[7], where c is the undrained cohesion and p is the effective overburden. Soils where c/p>0.25 are considered overconsolidated.

GENERAL RECOMMENDATIONS

Stability Analyses

15. Design Parameters. Based on the soil borings and laboratory tests, the subsoils for the project area were selected from a plot of all of the shear strength data. A summary table of the soil properties we used and plots of the soil properties as a function of depth are shown in Appendix C. Shear strengths among the borings did not vary significantly to substantiate multiple design reaches. For the levee and terrace fill materials, we assumed a wet unit weight of 100 pcf and an undrained cohesion of 150 psf for long term stability. These parameters consider levee and terrace fill to be placed by uncompacted methods as discussed in paragraph 27 of this report. The recommended minimum factor of safety is 1.3.

16. Containment Levees. We analyzed the stability of the containment levee assuming bottom levels of el -0.46 and el -2.105. Figure 5 provides a plot of the crest

[7] Eustis Engineering Company, Inc., "Settlement Calculations," *Manual of Practice*

elevation against an approximate factor of safety for a slope of 1V:3H. Note that geotextile reinforcement of levees has not been considered.

17. Terraces. Figure 6 shows a typical terrace section with a 20-ft wide and 5-ft high crest (el 3.56), and 1V:3H slopes. The analyses show that the factor of safety for this geometry is 1.6. Note that the minimum clearance between the toe of the terrace slope and the top of the borrow pit slope should be maintained at not less than 25 feet.

Settlement Analyses

18. Stress History. Consolidation tests were performed on samples of the subsoils within the marsh borings. These tests indicate the most probable level of preconsolidation is greater than the calculated in situ effective stresses (i.e., the OCR>1). Based on these test results, it appears the clay and silt deposits are precompressed to a depth of approximately 10 feet. Beneath the upper deposits, the underlying clays and clayey silts are slightly overconsolidated to normally consolidated to the terminal analyses depth at 75 feet. For our evaluation of long term settlement of the containment levees and marsh fill areas, we assumed the underlying deposit below approximately 10 feet to be normally consolidated clay with similar compressibility characteristics in the virgin state as the deepest borings sampled. The soil parameters used in our settlement calculations are included in Appendix C.

19. Method of Analyses. Consolidation settlement analyses were performed implementing the Boussinesq stress distribution theory. In addition, magnitude and rate of consolidation settlement were evaluated using finite difference theory.

Settlements were calculated using the Corps of Engineers' Case Program CSETT[8] and the program SD3 developed at the University of Texas[9].

20. Estimated Settlement of Slurried Marsh Fill. The following discussion pertains to the assumption that: (1) marsh filling will take place over one year, (2) levee filling is instantaneous, and (3) terrace filling will take place over 60 days. Secondary consolidation was not included in the settlement calculations as suggested by Cargill[10]. Data from the low pressure consolidation test were used to calculate the time-rate of settlement of slurried marsh fill material while self-weight consolidation tests were used to calculate the time-rate of settlement of dredged material. Figures 7 and 8 show the time settlements of the fill and foundation soils for the north and south marsh platforms.

21. Figure 9 shows the estimated settlements for the terraces for crest heights varying from el 4 to el 6 in 1-ft increments for a bottom level at el -1.44. Note an average unit weight of 100 pcf was used for the dredged marsh platform material[10 11 12 13 14].

---

[8] Alexis E. Templeton, *User's Guide: Computer Program for Determining Induced Stresses and Consolidation Settlements (CSETT)*, U.S. Army Corps of Engineers, Vicksburg, Mississippi, 1984

[9] *University of Texas, Geotechnical Engineering Center, Program SD3, Finite Difference Analysis of Consolidation Problems Involving Either One-Dimensional Vertical Flor or Two-Dimensional flow with Drainage Wicks*

[10] Jeanne-Pierre Bardet, *Experimental Soil Mechanics*, Prentice-Hall, 1997

[11] J. E. Bowles, *Physical and Geotechnical Properties of Soils*, 2nd Edition, 1984

[12] Karl Terzaghi, R. B. Peck, and G. Mesri, *Soil Mechanics in Engineering Practice*, 3rd Edition, 1996

[13] A. R. Jumikis, *Introduction to Soil Mechanics*, D. Van Norstrand Company, 1967

[14] U.S. Army Research and Development Center, *Predicting Geotechnical Parameters of Fine-Grained Dredged Materials Using the Slump Test Method and Index Property Correlations*, Vicksburg, Mississippi, 2004

22. Estimated Settlement of Containment Levee. Figure 10 shows the estimated settlement for the containment levee for crest heights varying from el 5 to el 6.5 in 0.5-ft increments for dredged material. A 1V:3H slope was used in the analyses. However, staged construction may minimize the amount of post construction settlement of the levee section.

23. Shrinkage of Fill. In addition to settlement of the underlying subsoils, settlement or "shrinkage" of the uncompacted fill will occur. Shrinkage is due to desiccation and consolidation of the fill under its own weight and deterioration due to biodegradation of organic fill materials inadvertently placed in the levee section. The desiccation of soft clays proceeds from the exposed surface inward and leads to formation of a crust that becomes thicker with age. Based on similar projects, we estimate volume loss, due to shrinkage of uncompacted fill, will be approximately 15% of the surficial crust formed as the soils lose moisture.

24. Assuming a crust approximately 2.5 feet thick, we estimate an additional 3 to 6 inches of settlement will occur. The amount of time for shrinkage to occur will depend on the amount of organic matter present and variations in the moisture content of the fill. Moisture content is dependent on weather conditions, tidal fluctuations, and ground water levels. We anticipate shrinkage will occur relatively rapidly due to seasonal variations occurring the first year after fill placement. Due to variations in the organic matter present and moisture ranges, shrinkage will generally result in differential settlement along the levee alignment.

Borrow to Fill Ratios

25. Proposed Levee Materials. Estimates of the amount of borrow required to construct the proposed levee section were obtained from the Corps of Engineers based on

data compiled on similar projects[15] [16]. Ratios assume the fill material is placed by an excavator and not by pipeline. Based on the available data, a typical borrow to levee fill ratio is 2:1 for natural moisture contents ranging from approximately 40% to 60%. For higher moisture contents, a borrow to levee fill ratio of 3:1 or more may also occur. The tested water contents may not be indicative of the water contents of the placed material. These borrow to levee fill ratios do not include the volume of fill required due to settlement and shrinkage, which should be added to the theoretical volume prior to estimating the borrow required. In addition, any stripping or removal of organic material, which is considered to be unsuitable for the levee section, is not included in the estimated borrow ratio.

26. Proposed Dredged Sediments. Similar to estimating shrinkage, estimating the borrow to fill ratio for dredged sediments is difficult considering the variability of the potential borrow materials encountered. For sandy sediments, a borrow to fill ratio between approximately 1.25:1 and 1.5:1 may be used where moisture contents are less than 40%. Refer to the previous paragraph for borrow to fill ratios of other soil types.

Construction Recommendations - Levee and Marsh

27. Constructibility. Construction techniques are critical to the constructibility and ultimate stability of the levee section. Our analyses assume the levee fills are placed as recommended and outlined subsequently in this report. We have estimated the amount of displacement which may occur during construction to assist in determining the anticipated fill quantities and cost estimates. The stability

---

[15] Personal Communication, El Pilie, U.S. Army Corps of Engineers, New Orleans District Office

[16] A. D. Parker, D. S. Barrie, and R. M. Snyder, *Planning and Estimating Heavy Construction*

of the levee constructed of in situ materials will be dependent on the borrow materials used and the rate at which the dredged fill is placed.

28. Site Preparation. Uncompacted fill material may be placed directly over any existing vegetation along the proposed levee alignments. Trees and stumps should be cut to existing grade. However, the root mass should remain in place to minimize disturbance of the subgrade and provide additional stability of the levee.

29. Water Levels. Water levels along the project are subject to seasonal and tidal fluctuations. Site conditions should be investigated immediately prior to initiating construction. If possible, placement of the initial fill lifts should not be more than 18 inches of standing water. We understand this is not always possible. However, when there is more than 18 inches of water, it will be difficult to control the fill because of visibility.

30. Containment Levee. The marsh containment levee will be constructed of borrow materials. Large roots and organic matter should not be placed within the levee section. In general, the subsurface soils are not organic. Some organic material was found in the upper 5 feet in Boring 5. This material should not be used for the containment levee construction.

31. Placement of Uncompacted Fill. The borrow material will be placed by uncompacted methods for construction of the levee. Our stability analyses assume these materials will be excavated and placed by mechanical methods using a dragline, clamshell or conventional bucket, or similar mechanical equipment. Uncompacted levee fill should be placed in lifts of no more than 3 feet. Depending on the depth of standing water and moisture content of the borrow materials, consideration should be given to placing an initial fill lift for the entire length of the levee before proceeding to the next lifts. This method will initiate consolidation of foundation soils as well as provide a means for the uncompacted fill to provide a

sufficient wearing surface. This will decrease the potential for slope failure within the fill as the levee is constructed. The borrow material may be shaped with a bulldozer. If alternate excavation and placement methods are considered, Eustis should be contacted to reevaluate stability.

32. Staged Levee Construction. We recommend construction of the levee be performed in stages. Staged construction will allow consolidation of the subsoils to begin and affect a gain in strength in the rapidly consolidating swamp/marsh deposits. This will minimize the potential for lateral plastic deformation of these soils. Staged construction will also minimize localized failures within the uncompacted fill as described above, particularly when these materials remain saturated during initial lift placement. With existing grades generally at el -4, the levee construction to el 5 can be performed in three stages (i.e., Stage 1 constructed to el -1, Stage 2 constructed to el 2, and Stage 3 constructed to el 5).

33. Dredged Marsh Fill. It is our understanding that material for the marsh platform will be dredged then slurried to the location. The placement limits of the hydraulic fill should be based on stability considerations as previously presented as well as construction constraints and environmental factors. For decanting considerations, fill should be placed no higher than 1 foot below the crown of the containment levees.

34. Drainage Controls. During the placement of the hydraulic fill, the contractor should provide drainage control measures to facilitate construction operations. Drainage control measures could include weirs, pipes, and drop inlets. The number, size, and location of these drainage control measures should be considered during the design of the borrow area (for the levee construction) and for the permit application. Some deciding factors will include the position of the dredge and flotation canal, natural slope of the land formations, and type and size of the dredging equipment.

35. Dewatering/Decanting. Self-weight consolidation of the marsh creation fill will create a ponding of water at the surface as the settlement occurs over time. Some of this water may be removed by evaporation, but consideration should be given to decanting free surficial water by weirs.

36. Maintenance. Our stability analyses do not consider an overbuild to maintain the proposed crown elevation for marsh containment. Rather, long term maintenance will be required to accommodate the estimated ongoing settlements. Routine maintenance of the marsh containment levees is essential. This includes adding material to the levee as it settles.

37. Monitoring. Monitoring the performance of the levee and marsh platform are also deemed essential. The fill, the foundations and the fill, and the foundations together should be monitored. We recommend the use of settlement plates or other surveying methods to monitor the actual rates of settlement for the project. Natural variations in the materials placed as well as the desiccation and biodegradation of these deposits may affect our estimates. In addition, construction of the containment area may affect water levels due to tidal fluctuations in areas of the project. If long term performance of the fill placement is to be evaluated, the monitoring should be performed at regular intervals to provide sufficient data.

Shoreline Protection

38. General. As depicted on Figure 12, the shoreline protection will be located along the southeastern lake shoreline. The shoreline protection will consist of either a rock dike or a sand "wedge" berm that will protect the lake shoreline from erosion due to storm surge. Construction of a rock dike erosion control system will include the excavation of a temporary flotation channel that would allow for a barge to draft parallel to the shoreline to place and construct the rock dikes.

39. Furnished Information. A typical cross-section for the shoreline to be protected was provided by the LaDNR and is shown on Figure 13. For this cross-section, the location of the centerline of the sand wedge protection system and two potential locations for the rock dike protection system are also shown on Figure 13. The shoreline protection systems are to be designed and constructed such that the crown elevation will be above el 2.2 feet after 20 years, including settlement. We understand the construction duration will be nine to 12 months. The sand wedge will have a 50-ft wide crown and side slopes of 1V:25H to 1V:50H. The side slope for the lake side of the sand wedge can be no steeper then 1V:25H to deflect energy from the wave action of a storm surge. The design width for the crown of the rock dike protection system is 4 feet. Maximum side slopes of 1V:3H were provided, although actual side slopes are to be determined based on our analyses. The flotation channel will be 80 feet wide and excavated to el -6 feet. The side slopes of the flotation channel and the minimum setback distance from the flotation channel to the toe of the rock dike sections is to be determined by our analyses. Mean high water and mean low water levels are el 0.87 and el 0.33 feet, respectively.

40. Design Parameters. Based on the soil borings and laboratory tests, the subsoils for the shoreline protection area (i.e., Borings 4 through 6) combined into a single soil reach for our analyses. Shear strengths among the borings did not vary significantly to substantiate multiple design reaches. A plot of the soil design parameters is shown in Appendix C. For the sand wedge borrow fill materials, Eustis assumed a wet unit weight of 113 pcf and a friction angle of 30 degrees, based on laboratory test results of samples collected from the Mississippi River borrow borings (Borings RB-1 through RB-3). These parameters consider the borrow fill to be placed by uncompacted methods as discussed in paragraph 27 of this report.

Rock Dikes

41. General. Figure 13 shows the position of the rock breakwater. The purpose of the rock breakwater is to minimize erosion of the marsh platform.

42. Settlement. We estimate settlement of the proposed rock dike sections will be approximately 11 to 12 inches near the center of the crown if constructed to an approximate crown at el 3.5 with side slopes of 1V:3H. Steeper slopes will be difficult to maintain, and flatter slopes will induce more settlement as the rock fill will apply loads over a larger area. These estimates of settlement are due to the placement of rock fill only and do not include the effects of areal subsidence. Based on these estimates, the crown elevation after 20 years will be approximately 2.5 feet.

43. Global Stability. Stability of the proposed rock dikes were evaluated assuming a crown elevation of el 3.5 feet (5-ft height) which includes a sufficient overbuild to account for the estimated settlement while maintaining the minimum crown elevation of el 2.2 feet. A minimum setback of 25 feet was assumed between the flotation channel and the toe of the proposed rock dikes.

44. To evaluate global stability of the rock dike sections, analyses were performed using Slope/W, a computer program developed by Geoslope International, Ltd., and Spencer's Method of Slices. The results of these analyses indicate a factor of safety of less than 1.3 for the rock dike sections constructed to the dimensions described previously.

45. Rock placement for construction of the dikes will result in consolidation of the foundation deposits. The shear strength of the underlying soils will increase as the material consolidates. We have also evaluated a staged construction approach to include gains in strength of the subsoils prior to construction of subsequent lifts.

Utilizing this staged construction approach, with an initial lift constructed to el 2 feet held for six months and subsequent lifts of 1 foot held for three months, we have determined that the gain-in-strength beneath the rock dikes is insufficient to construct the dikes to the minimum crown of el 3.5 feet during a one year construction period. We estimate that with staged construction, the rock dikes may be constructed to a maximum crown of el 3 feet maintaining a minimum factor of safety of 1.3 for global stability. We estimate the rock dikes would have to remain in place for at least two years to induce sufficient strength gains in the subsoils to allow for subsequent lifts to accommodate a final dike crown at el 3.5 feet. Based on these considerations, the rock dike options constructed to the standards required do not appear to be feasible given the project parameters.

46. Eustis has had favorable experience with rock dikes constructed on soft sediments. These designs considered plastic deformation (mud waves) of sediment materials and minimal compacted factors of safety. Preliminary analyses estimated rock dikes with 1V:3H side slopes could be constructed if 5-ft wide stability berms were included in the cross-section. This considers a factor of safety of 1.1. Such dikes may experience continued plastic deformation (and corresponding loss of height) that would require continued maintenance to restore necessary grades. In addition, rock fill necessary for initial construction is estimated to be approximately 50% to 60% of the volume of the net cross-section above the mudline. Therefore, such designs were not persued.

Sand Fill Wedge

47. General. As noted, the proposed sand fill wedge shoreline protection will consist of a sand berm constructed over the crest of the lake shoreline, as shown on Figure 13. Like the rock breakwater, the sand wedge is intended to minimize the erosion of the marsh platforms.

48. Settlement. We estimate settlement near the center of the crown of the proposed sand wedge section will be 18 to 19 inches if constructed to the dimensions described previously to a crown at el 4.2. These estimates of settlement are due to the placement of fill only and do not include the effects of areal subsidence. Based on these estimates, the crown elevation after 20 years will be approximately 2.5 feet.

49. Global Stability. To evaluate global stability of the sand wedge section, analyses were performed using Slope/W and Spencer's Method of Slices. The results of these analyses indicate a factor of safety of approximately 2.7 for global stability of a sand wedge constructed to a crown of el 4.2 with a lake side slope of 1V:50H as shown on Figure 14. A sand wedge with a lake side slope of 1V:25H will have an estimated factor of safety of 2.1 for global stability.

50. Areal Subsidence. Areal subsidence is a result of past filling and lowering of the ground water level over large areas. Areal subsidence is considered a background condition over which man has no control and should be relatively uniform in the project area. Sufficient information is not available in the geotechnical investigation to make accurate estimates of areal subsidence in the project area.

Construction Recommendations - Sand Fill

51. General. We understand the sand fill will be placed hydraulically with very little site preparation. However, we recommend a separator fabric be placed prior to sand fill placement. Also, we recommend containment levees be constructed at the toes of the sand wedge prior to fill placement. These containment levees should extend at least 1 foot above the proposed marsh elevation or high lake water level.

52. Separator Fabric. We recommend a geotextile separator fabric be provided between the lake mudline and the hydraulically placed sand fill. The geotextile

fabric should be a non-woven fabric meeting or exceeding the material requirements for Class C geotextiles as presented in Section 1019 of the Louisiana Standard Specifications for Roads and Bridges, 2006 edition (LSSRB). The fabric should be placed directly on the prepared subgrade in accordance with the manufacturer's construction recommendations and in accordance with Section 203.11 of the LSSRB.

53. Hydraulically Placed Sand Fill. We have assumed the borrow material for the sand fill wedge shoreline protection will be excavated and placed using hydraulic methods. The placement limits of the hydraulic fill should be based on stability considerations as previously presented as well as construction constraints and environmental factors. Fill heights for the proposed sand wedge will vary from 1 to 4 feet. For decanting considerations, fill should be placed no higher than 1 foot below the crown of the sand wedge protection system. After sand fill heights are above the water surface, the sand wedge can be shaped and compacted by rubber-tired compactors or dozers or similar marsh equipment. Actual fill heights may be varied between these limits and based on the environmental goals.

54. Sediment Delivery. A sediment delivery system is proposed to span between the Mississippi River where the source borrow material will be dredged, and the proposed shoreline protection area. The details of this system such as location and alignment are not yet defined. In addition, the proposed pipeline diameter is not known. The proposed sediment delivery route will span across or underneath the Mississippi River levee and LA Highway 23. Operations should be performed in accordance with criteria established by the Corps of Engineers.

Roadway Crossing

55. General. It is our understanding that sand from the Mississippi River will be dredged then delivered through a pipeline to the project site using a slurry mixture.

No other information was provided to us about the construction. Once the design of the pipeline has been established, Eustis should review the plans and adjust our assumptions, and, hence, our recommendations accordingly. Sheeting and bracing should be used to maintain stability of excavations for the proposed jack-and-bore pits. Excavations of 4 feet or less may be stabilized by timber sheeting. Deeper excavations will require the use of steel sheetpiles. The installation of sheeting and sheetpiles may cause vibrations which could affect nearby structures, pavements, and underground utilities. If vibration damage is a concern, vibrations should be monitored during construction.

56. The construction contractor should have the responsibility of adequacy of sheeting and bracing systems. The design of these systems should be made by a registered professional engineer. The construction contractor's engineer should make an independent interpretation of subsoil conditions encountered from the boring logs provided. For preliminary design, an equivalent fluid weighing 100 psf/foot of wall can be used as the active pressure against the wall and 185 psf/foot of wall as the passive pressure in front of the wall.

Excavations

57. General. Excavations necessary for construction of the project features should conform to the requirements of Section 802 of the LSSRB. The construction contractor should have the responsibility for adequacy of sheeting, bracing, and shoring systems, and the design of these systems should be made by a registered professional engineer. The construction contractor's engineer should make an independent interpretation of the subsoil conditions encountered at the borings.

58. OSHA Soil Classification. In accordance with OSHA Standard No. 1926, Subpart P, Appendix A, the subsoils encountered may be classified as Type C soils. This

classification should be used to ensure all excavations and trenching operations comply with OSHA requirements.

59. Dewatering and Pressure Relief. Based on the log of Boring 13, a deep jack-and-bore excavation at this crossing will penetrate soft clays to 40 feet. Therefore, dewatering the excavation may require the use of only sump pumps. Sumps and pumps should provide adequate dewatering to maintain a dry bottom within the excavations near Boring 13.

60. Lateral Movement and Settlement of Adjacent Ground Surface. Settlement of the ground surface in the vicinity of the excavations for the project should be monitored during and after construction as discussed subsequently in this report. The excavation, bracing, and dewatering systems employed by the contractor during construction should be properly designed to maintain a stable excavation in order to prevent lateral movement of the surrounding soils. The subsidence and lateral movement of the soils surrounding the excavations should be controlled and minimized by careful attention to all details of the excavations, bracing, dewatering, backfilling, and installation and removal of the sheetpiles. Lateral movement and settlement of the ground surface can occur due to improper placement and compaction of the bedding and backfill materials. Lowering of the ground water during dewatering may also cause settlement of the ground surrounding the excavation. If settlement due to drawdown of the ground water surface becomes a problem, dewatering should be discontinued and other construction methods considered.

61. Even with careful attention to the above details, available literature indicates settlement adjacent to sheetpile cofferdams can be as much as 2% of the excavation depth. Removal of sheetpiles may result in additional settlement of the surrounding ground surface and adjacent structures. If any structure present within a horizontal distance away from the excavation equal to the overall sheetpile length

is sensitive to lateral movement or additional settlement, consideration should be given to leaving the sheetpiles in place after construction.

62. Base Preparation The jack-and-bore pits should be to sufficient depths to allow for the jack-and-bore features and sufficient cover. Once the excavation bottoms for the jack-and-bore features are cleared of all debris, water, muck, and loose soil, a minimum 12-in. thick working surface should be installed. Additional thickness may be required. We also recommend material separation be provided between the working surface of the jack-and-bore operation and natural subgrade. This may be accomplished with a geotextile stabilization fabric. The geotextile should meet or exceed the material requirements for Class C geotextile presented in Section 1019.01 of the LSSRB. The geotextile should be placed directly on the undisturbed soils in accordance with the manufacturer's construction recommendations. Sufficient geotextile should be placed to line the excavation along its bottom and sides up to a level corresponding to the top of the bedding. The geotextile should extend horizontally between bedding and backfill materials.

63. Working Surface. Crushed stone for the working surface should conform to the requirements of Section 1003.03(d) of the LSSRB. The crushed stone should be placed in lifts of 6 to 8 inches loose measure and compacted to 95% of its maximum dry density determined in accordance with ASTM D 698. If material other than crushed stone is selected for the project, Eustis should be notified to participate in assessing its suitability and developing applicable compaction criteria.

64. Sealant Slab. To provide a stable working platform during construction, a sealant slab may be provided at the base of prepared excavations in lieu of crushed stone. Flowable fill for a sealant slab should meet the material and placement requirements given in Section 710 of the LSSRB.

LIMITATIONS

65. This report has been prepared in accordance with generally accepted geotechnical engineering practice for the exclusive use of HNTB, the LaDNR, and their designated representatives for specific application to the subject site. In the event of any changes in the nature, design, or location of the proposed dredging or marsh creation sites, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report are modified and verified in writing. Should these data be used by anyone other than HNTB, the LaDNR, or their designated representatives, the user should contact Eustis for interpretation of data and to secure any other information which may be pertinent to this project.

66. Our findings and recommendations in this report are based on selected points of field exploration, laboratory testing, and our understanding of the proposed project. Furthermore, our findings and recommendations are based on the assumption that soil conditions do not vary significantly from those found at specific exploratory locations. Variations in soil or ground water conditions could exist between and beyond the exploration points. The nature and extent of these variations may not become evident until construction. Variations in soil or ground water may require additional studies, consultation, and possible revisions to our recommendations.

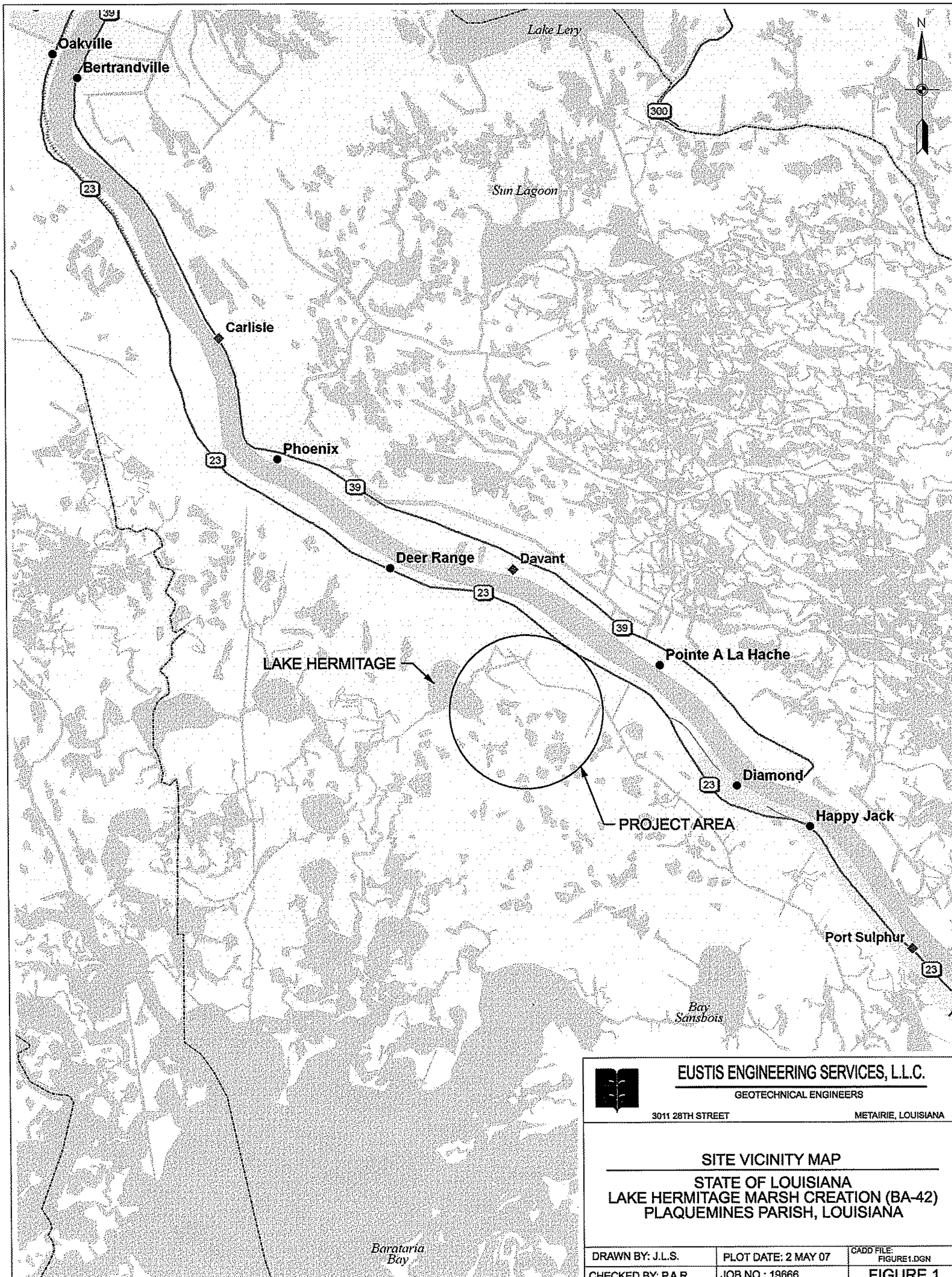
67. Recommendations and conclusions contained in this report are to some degree subjective and should be used only for design purposes. This report should not be included in the contract plans and specifications. However, the results of the soil borings and laboratory tests contained in the Appendices of this report may be included in the plans and specifications.

68. This report is issued with the understanding that the owner or the owner's representative has the responsibility to bring the information and recommendations

contained herein to the attention of the scientists and engineers for the project so they are incorporated into the plans and specifications for the project. The owner or the owner's representative also has the responsibility to take the necessary steps to see that the general contractor and all subcontractors follow such recommendations. It is further understood the owner or the owner's representative is responsible for submittal of this report to the appropriate governing agencies.

69 As the geotechnical engineer of record for this project, Eustis has striven to provide our services in accordance with generally accepted geotechnical engineering practices in this locality at this time. No warranty or guarantee is expressed or implied. This report was prepared for the exclusive use of the client and the client's authorized agents.

70. Eustis should be provided the opportunity for a general review of the final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications. If Eustis is not accorded the privilege of making this recommended review, we can assume no responsibility for misinterpretation of our recommendations.



EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28TH STREET METAIRIE, LOUISIANA

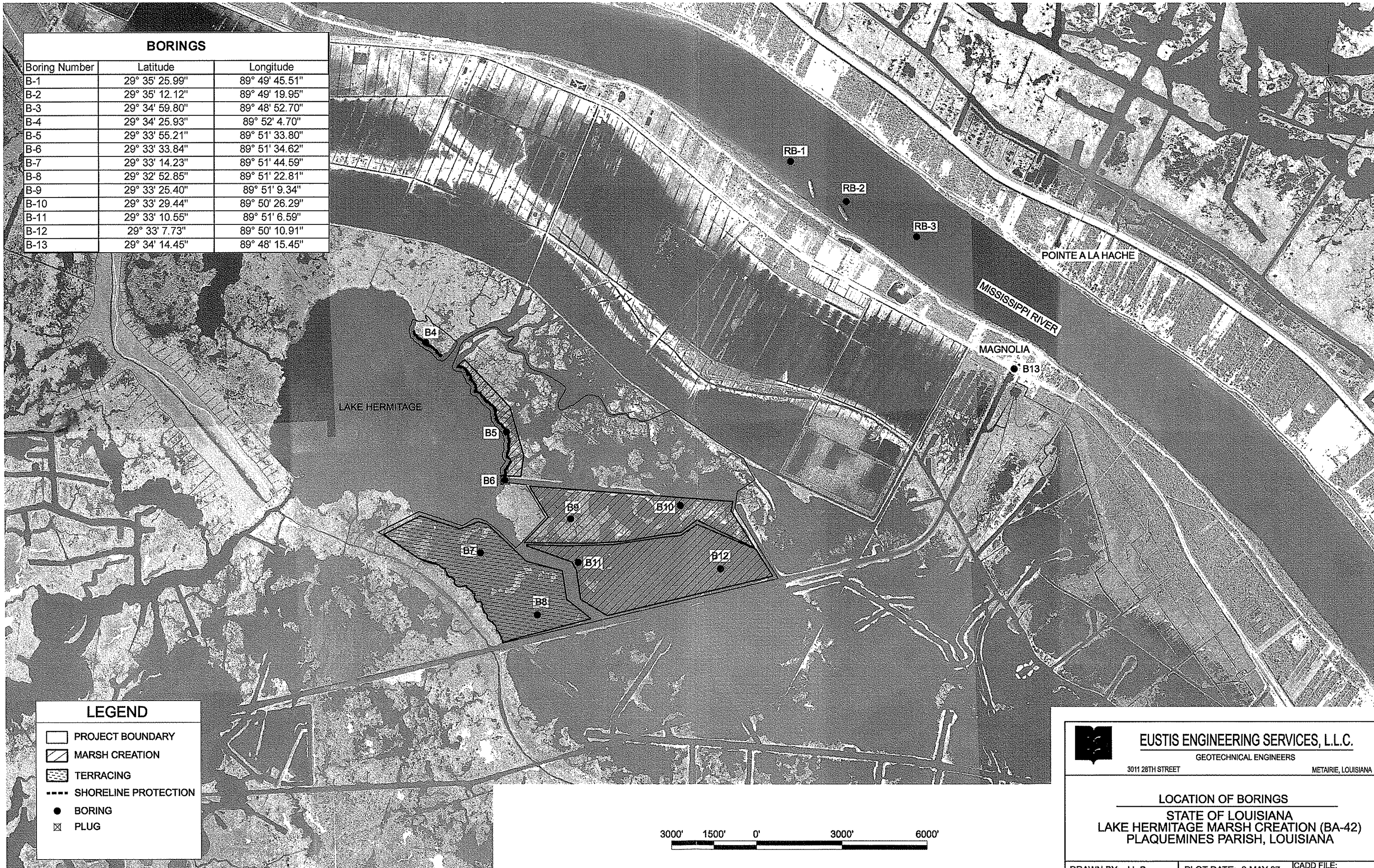
SITE VICINITY MAP

STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 2 MAY 07	CADD FILE: FIGURE1.DGN
CHECKED BY: P.A.R.	JOB NO.: 19666	FIGURE 1

BORINGS

Boring Number	Latitude	Longitude
B-1	29° 35' 25.99"	89° 49' 45.51"
B-2	29° 35' 12.12"	89° 49' 19.95"
B-3	29° 34' 59.80"	89° 48' 52.70"
B-4	29° 34' 25.93"	89° 52' 4.70"
B-5	29° 33' 55.21"	89° 51' 33.80"
B-6	29° 33' 33.84"	89° 51' 34.62"
B-7	29° 33' 14.23"	89° 51' 44.59"
B-8	29° 32' 52.85"	89° 51' 22.81"
B-9	29° 33' 25.40"	89° 51' 9.34"
B-10	29° 33' 29.44"	89° 50' 26.29"
B-11	29° 33' 10.55"	89° 51' 6.59"
B-12	29° 33' 7.73"	89° 50' 10.91"
B-13	29° 34' 14.45"	89° 48' 15.45"



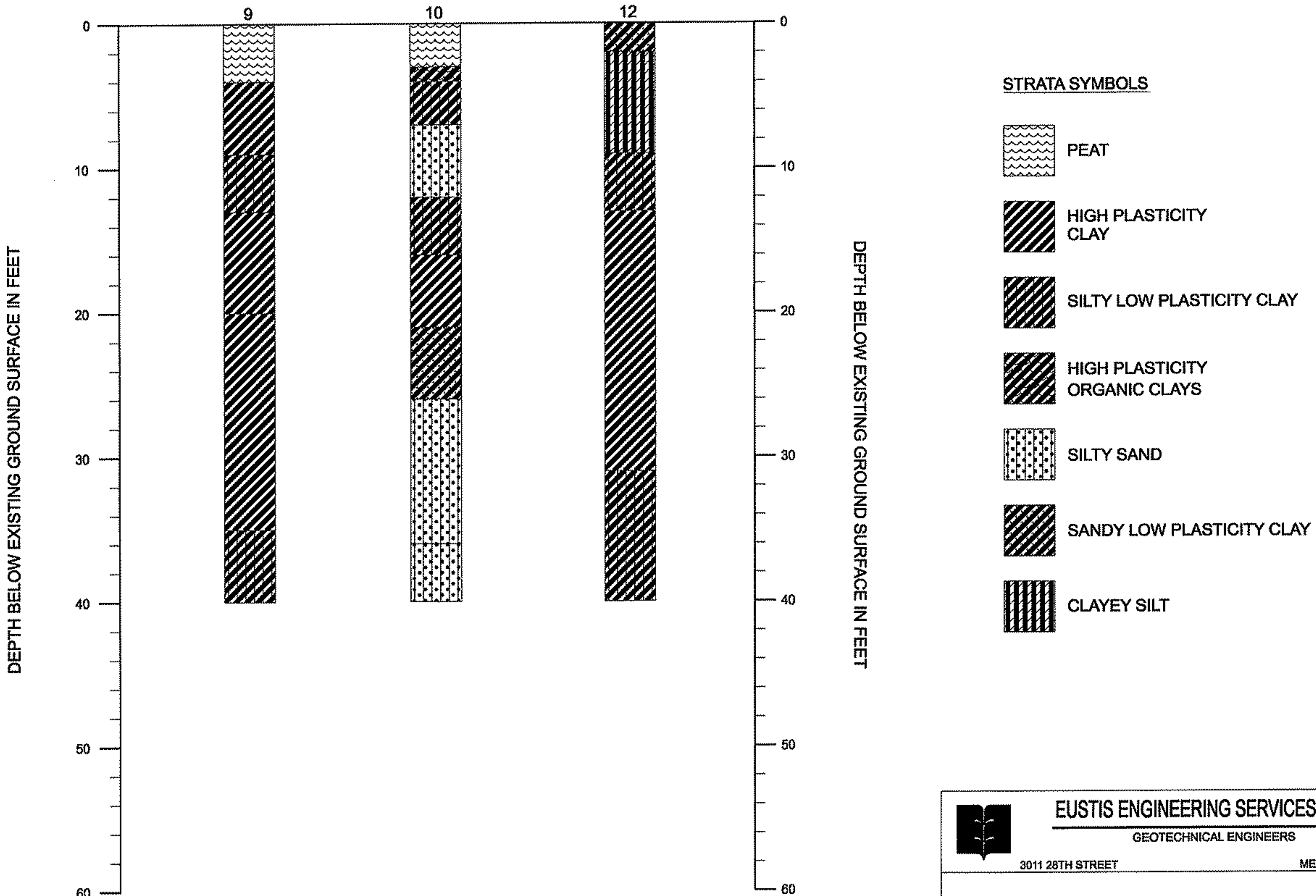
LEGEND

- PROJECT BOUNDARY
- MARSH CREATION
- TERRACING
- SHORELINE PROTECTION
- BORING
- PLUG

EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28TH STREET METAIRIE, LOUISIANA

LOCATION OF BORINGS
STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 3 MAY 07	CADD FILE: FIGURE2.DGN
CHECKED BY: P.A.R.	JOB NO.: 19666	FIGURE 2

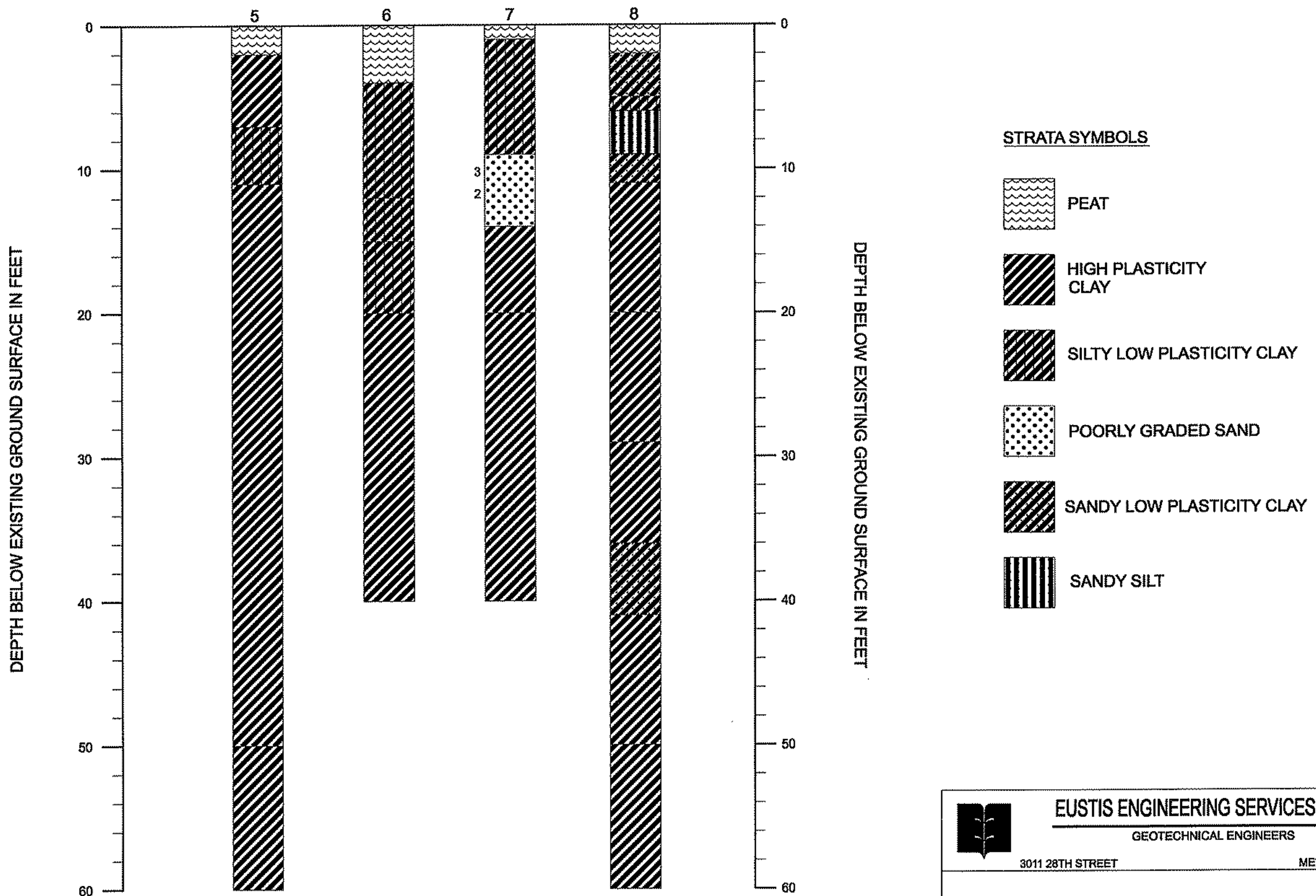


EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28TH STREET METAIRIE, LOUISIANA

SUBSOIL PROFILE

STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA
CONTRACT NO. 2503-05-46

DRAWN BY: J.L.S.	PLOT DATE: 20 SEPT 07	CADD FILE: FIGURE 3.DGN
CHECKED BY: P.A.R.	JOB NO.: 19666	FIGURE 3



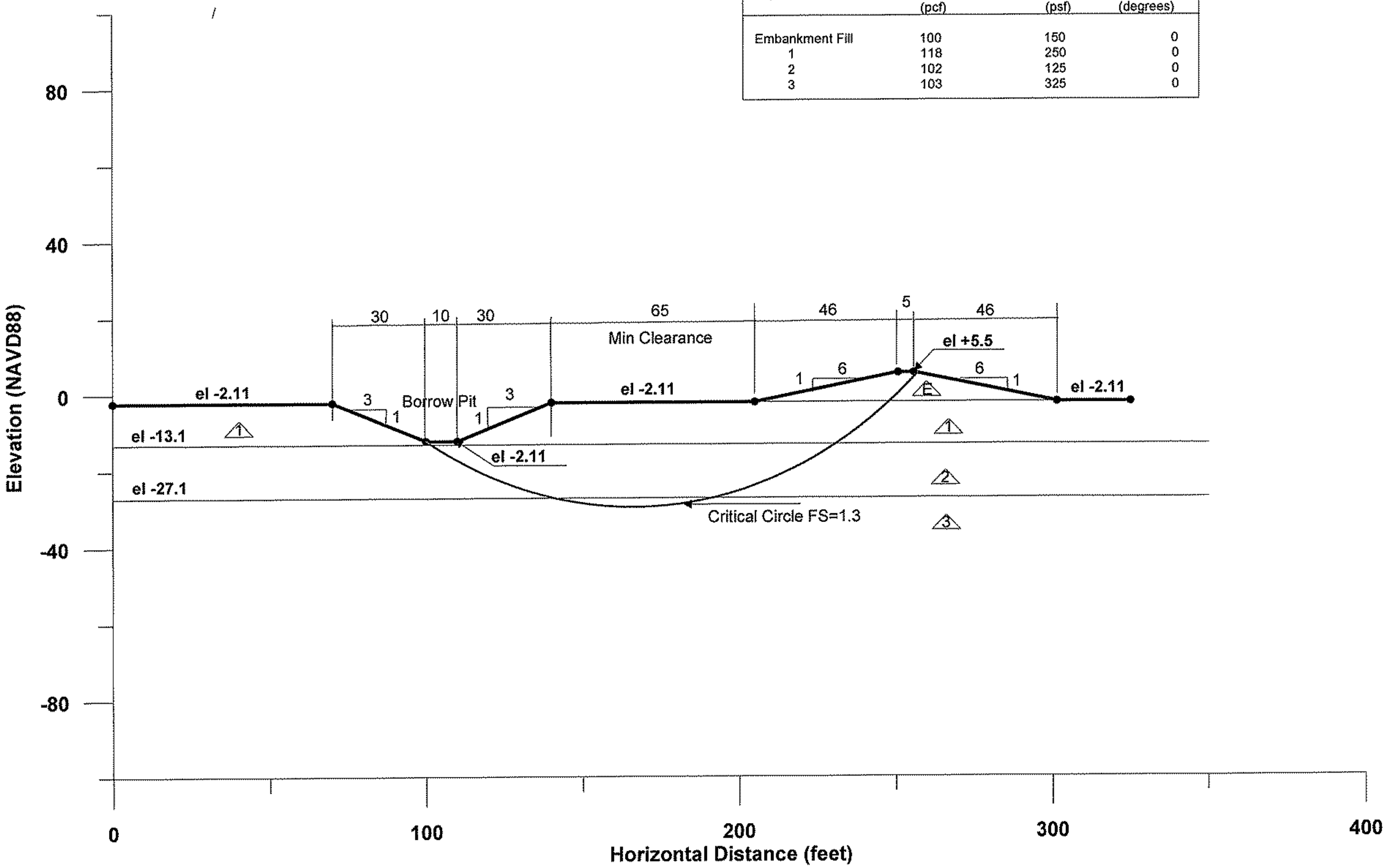
EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28TH STREET METAIRIE, LOUISIANA

SUBSOIL PROFILE

STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA
CONTRACT NO. 2503-05-46

DRAWN BY: J.L.S.	PLOT DATE: 20 SEPT 07	CADD FILE: FIGURE 4.DGN
CHECKED BY: P.A.R.	JOB NO.: 19666	FIGURE 4

Layer	Total Unit Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)
Embankment Fill	100	150	0
1	118	250	0
2	102	125	0
3	103	325	0

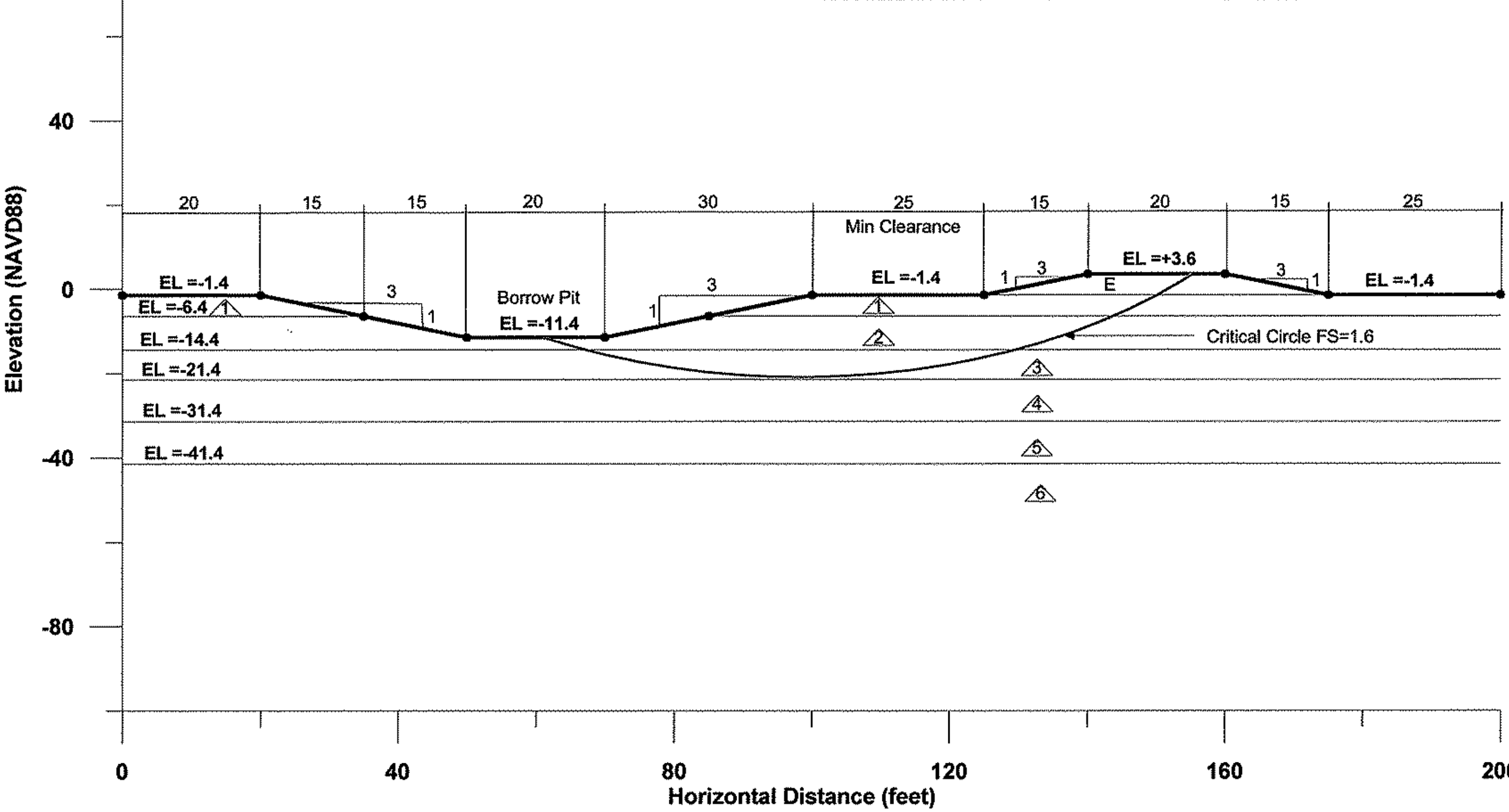


EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28th STREET METAIRIE, LOUISIANA

SLOPE STABILITY ANALYSES FOR THE SOUTH CONTAINMENT LEVEE LAKE HERMITAGE LAFOURCHE PARISH, LOUISIANA

OCTOBER 2007	EE 19666	FIGURE 5

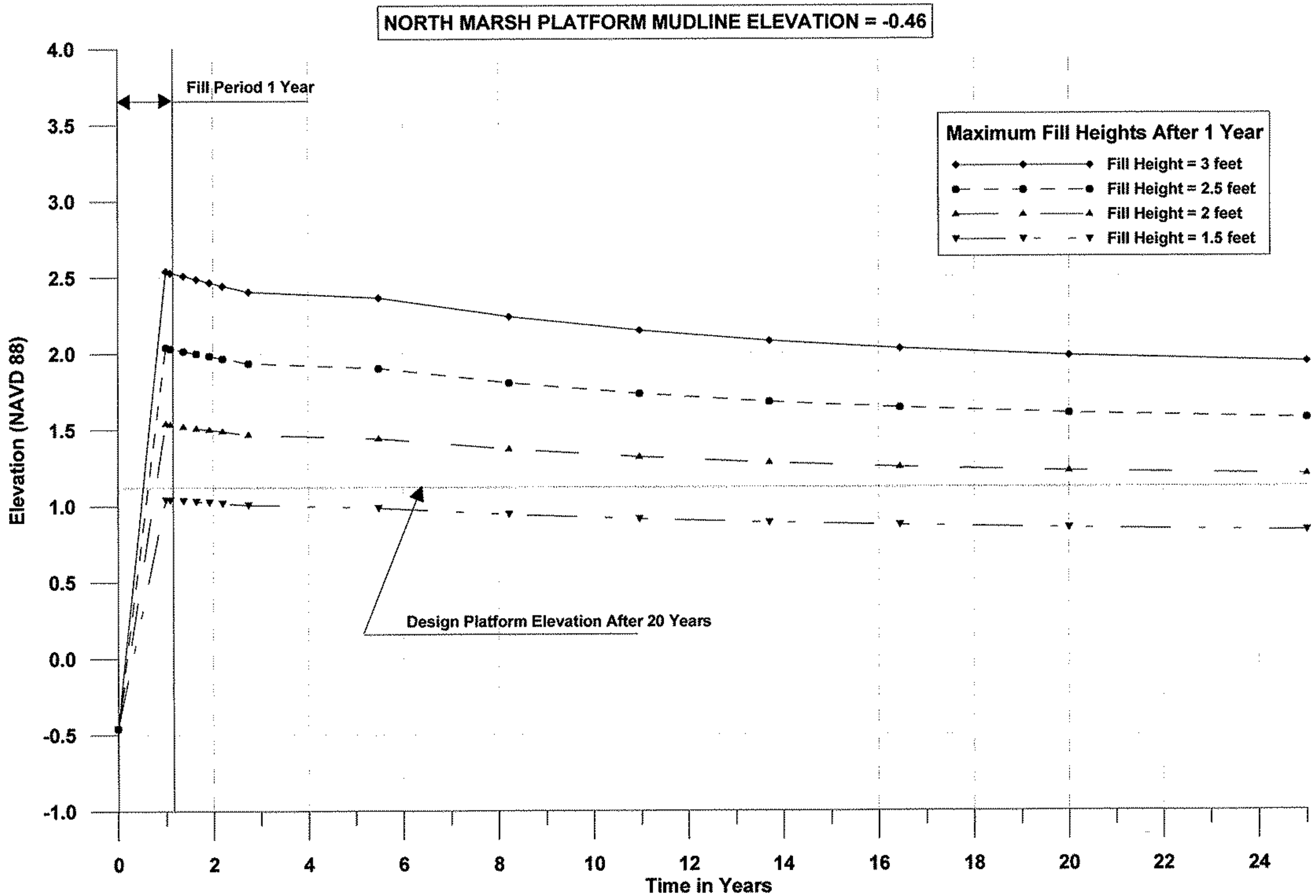
Layer	Total Unit Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)
Embankment Fill	100	150	0
1	118	425	0
2	122	250	0
3	104	100	0
4	102	275	0
5	105	350	0
6	115	550	0



EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28th STREET METAIRIE, LOUISIANA

SLOPE STABILITY ANALYSES FOR THE TERRACES
LAKE HERMITAGE
LAFOURCHE PARISH, LOUISIANA

OCTOBER 2007 EE 19666 FIGURE 6

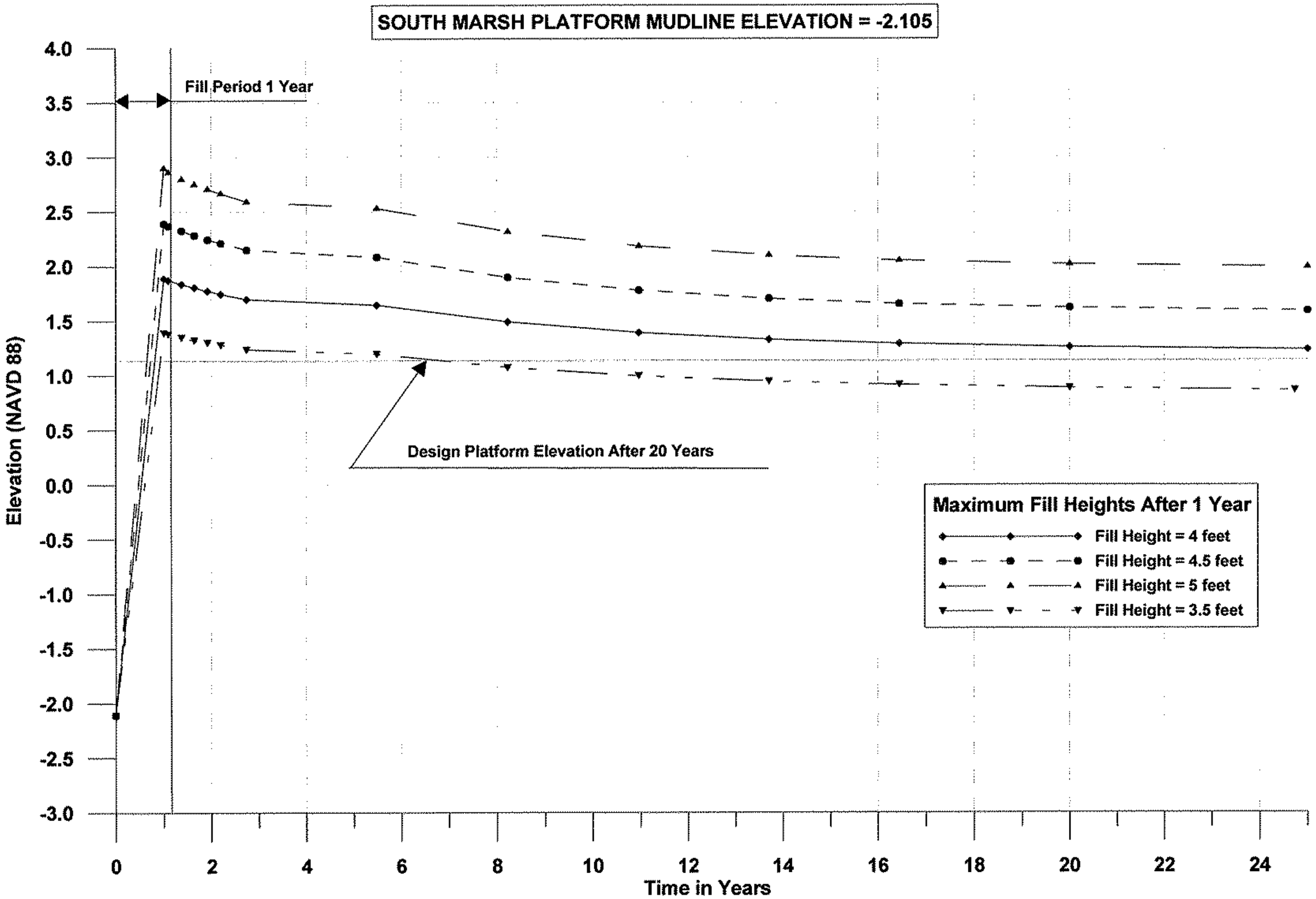


1. Settlements based on sand fill wet density = 115 pcf
2. Large Strain Analyses
3. Coefficient of consolidation constant for each stratum

EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28th STREET METAIRIE, LOUISIANA

TIME SETTLEMENTS OF FOUNDATION + FILL
NORTH MARSH PLATFORM
LAKE HERMITAGE
LAFOURCHE PARISH, LOUISIANA

OCTOBER 2007 | EE 19666 | FIGURE 7

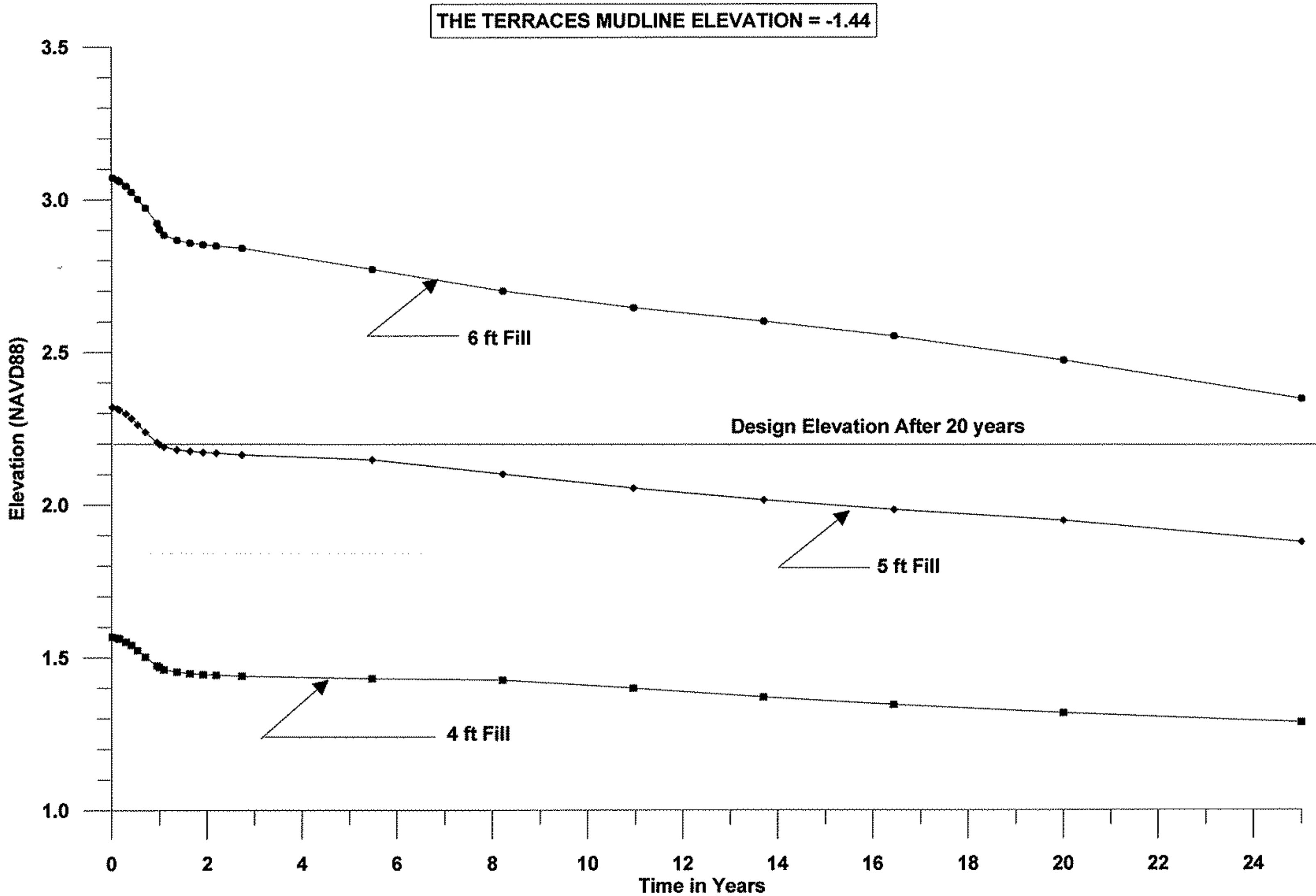


1. Settlements based on sand fill wet density = 115 pcf
2. Large Strain Analyses
3. Coefficient of consolidation constant for each stratum

EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28th STREET METAIRIE, LOUISIANA

TIME SETTLEMENTS OF FOUNDATION + FILL
SOUTH MARSH PLATFORM
LAKE HERMITAGE
LAFOURCHE PARISH, LOUISIANA

OCTOBER 2007 EE 19666 FIGURE 8

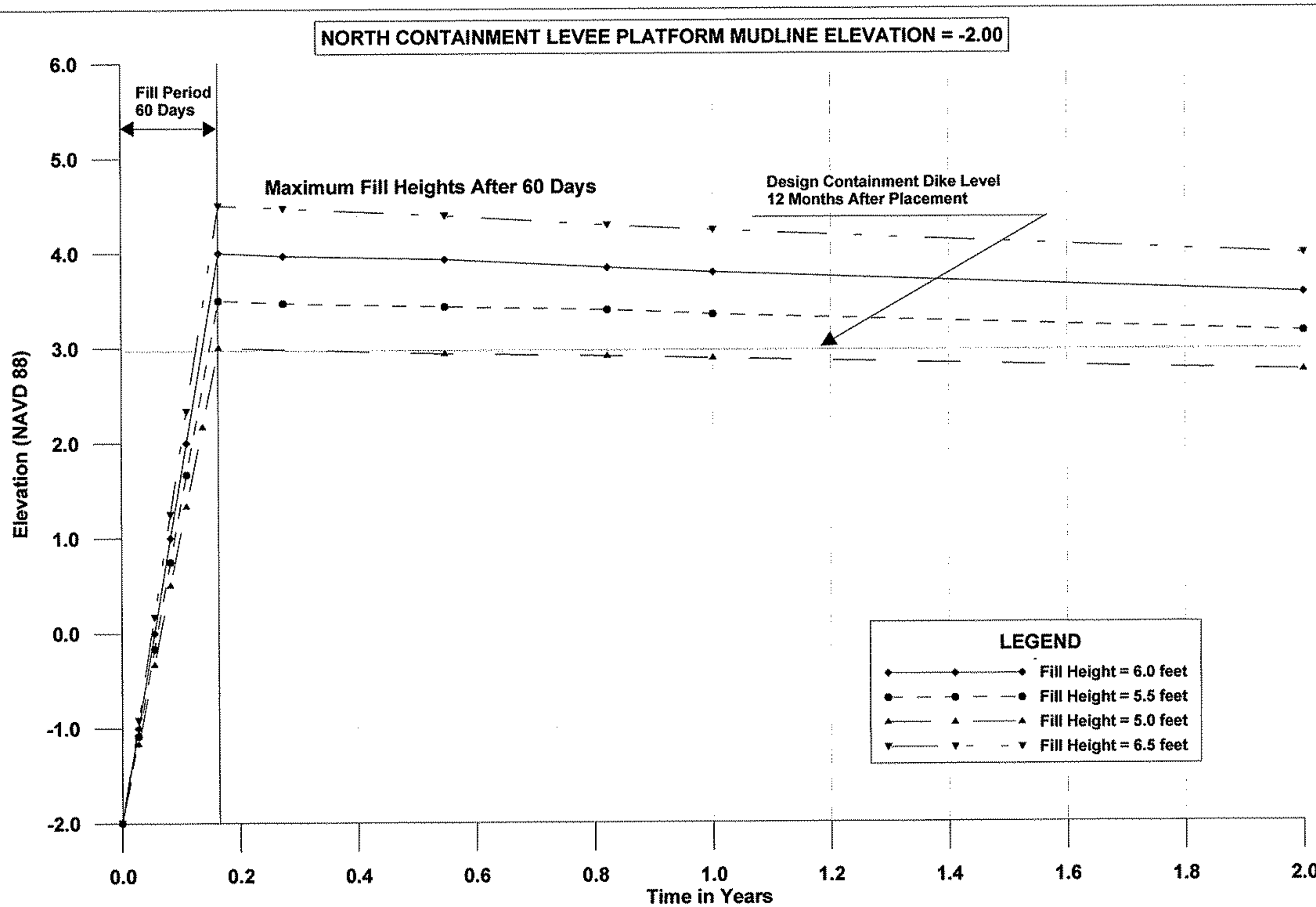


1. Settlements based on dredged fill wet density = 100 pcf
2. Large Strain Analyses
3. Coefficient of consolidation constant for each stratum
4. Settlements include both foundation and fill settlements
5. Fill placed instantaneously

EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28th STREET METAIRIE, LOUISIANA

TIME SETTLEMENTS OF FILL + FOUNDATION
THE TERRACES
LAKE HERMITAGE
LAFOURCHE PARISH, LOUISIANA

OCTOBER 2007 EE 19666 FIGURE 9

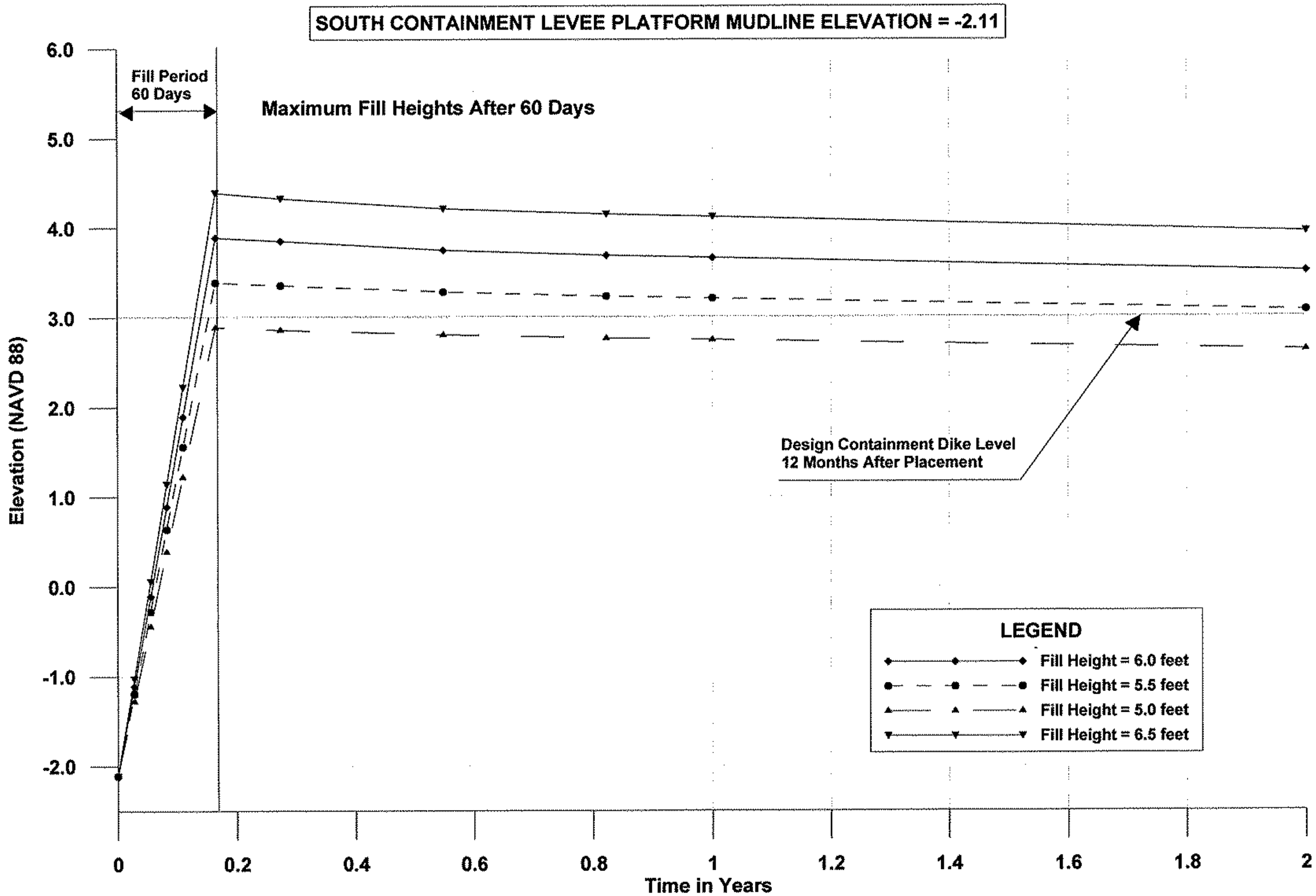


1. Settlements based on dredged clay fill wet density = 100 pcf
2. Large Strain Analyses
3. Coefficient of consolidation constant for each stratum
4. Crest is 10 feet wide with 3H:1V slopes

EUSTIS ENGINEERING AERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28th STREET METAIRIE, LOUISIANA

TIME SETTLEMENTS OF FOUNDATION + FILL
NORTH CONTAINMENT DIKE
LAKE HERMITAGE
LAFOURCHE PARISH, LOUISIANA

OCTOBER 2007 EE 19666 FIGURE 10



1. Settlements based on dredged clay fill wet density = 100 pcf
2. Large Strain Analyses
3. Coefficient of consolidation constant for each stratum
4. Crest is 10 feet wide with 3H:1V slopes

EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28th STREET METAIRIE, LOUISIANA

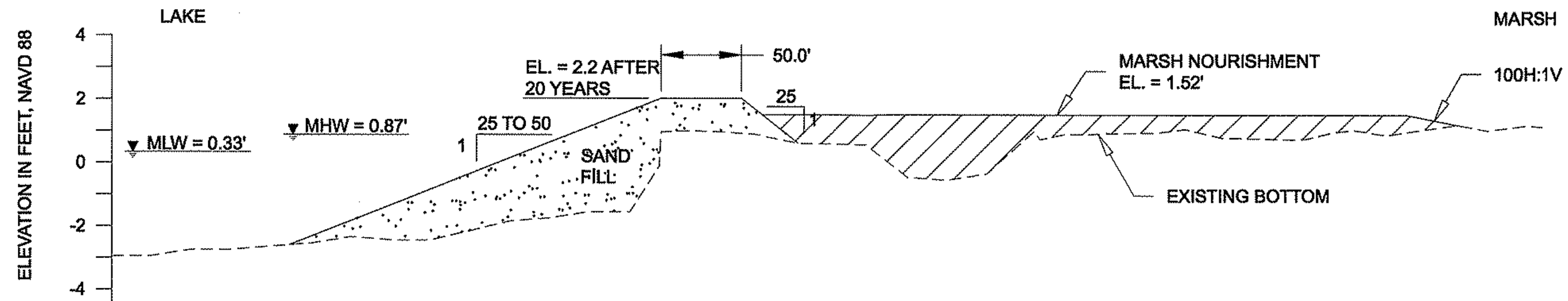
TIME SETTLEMENTS OF FOUNDATION + FILL
SOUTH CONTAINMENT DIKE
LAKE HERMITAGE
LAFOURCHE PARISH, LOUISIANA

OCTOBER 2007 EE 19666 FIGURE 11

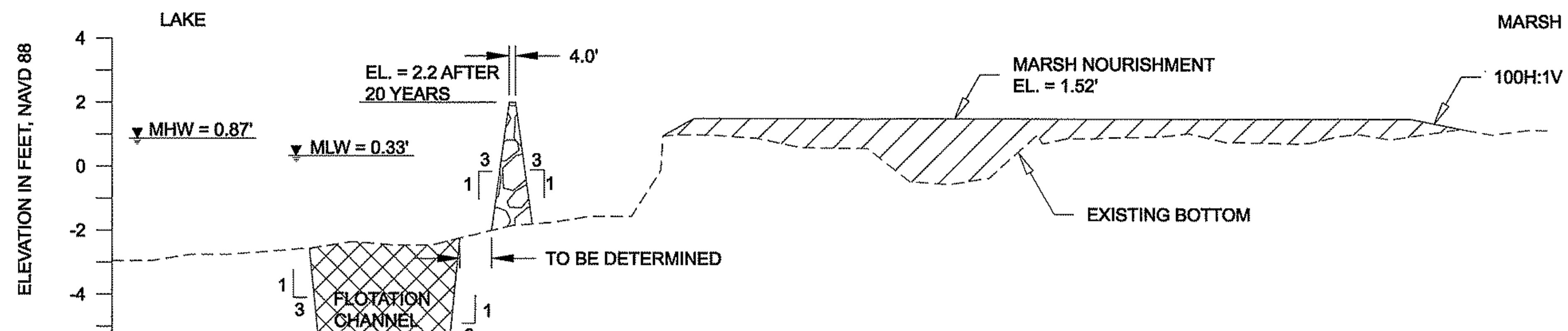
EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28TH STREET METAIRIE, LOUISIANA

SHORELINE PROTECTION LOCATION
STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA

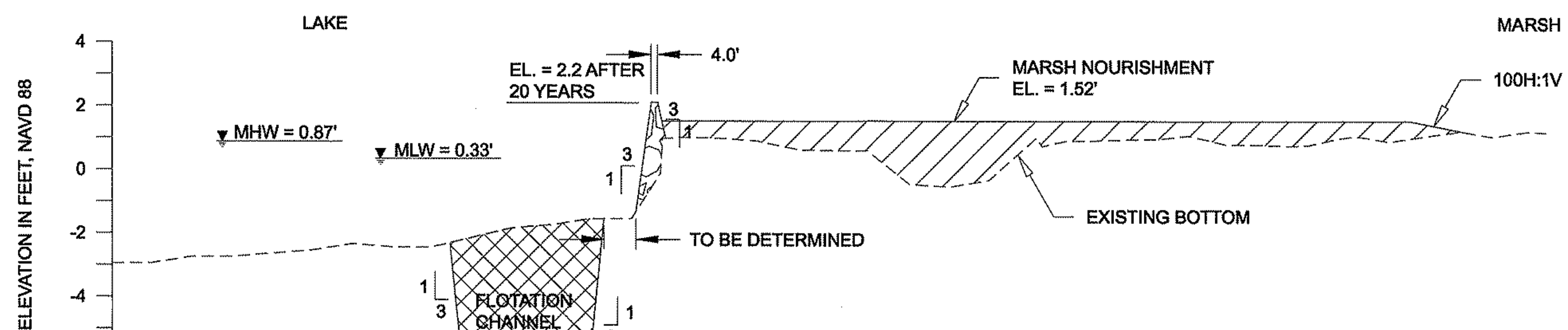
DRAWN BY: J.L.S.	PLOT DATE: 20 SEPT 07	CADD FILE: FIGURE12.DGN
CHECKED BY: P.A.R.	JOB NO.: 19666	FIGURE 12



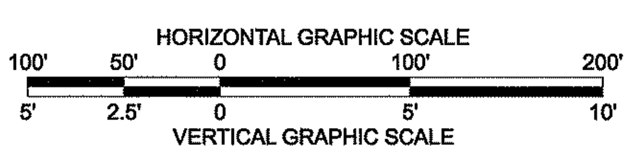
TYPICAL SAND FILL SECTION



TYPICAL OFFSHORE ROCK
DIKE SECTION



TYPICAL ONSHORE ROCK
DIKE SECTION



EUSTIS ENGINEERING SERVICES, L.L.C.

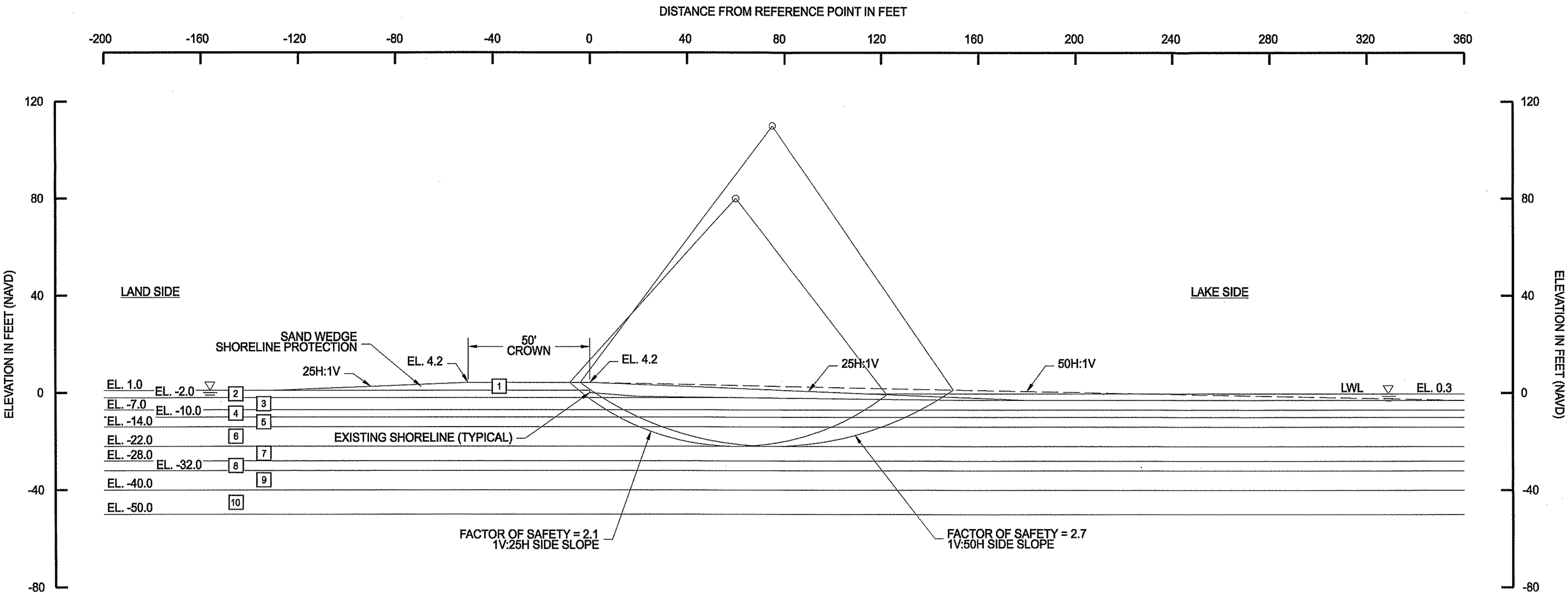
GEOTECHNICAL ENGINEERS

3011 28TH STREET METAIRIE, LOUISIANA

CROSS-SECTION OF SHORELINE PROTECTION

STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA

DRAWN BY: J.L.S.	PLOT DATE: 24 SEPT 07	CADD FILE: FIGURE14.DGN
CHECKED BY: P.A.R.	JOB NO.: 19666	FIGURE 13



SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	UNIT WEIGHT IN PCF	COHESION IN PSF	
				AVG.	BASE
1	HYDRAULICALLY PLACED SAND FILL	30	113	0	0
2	ORGANIC CLAY AND HUMUS	0	100	200	200
3	SILTY CLAY	0	112	90	90
4	SILTY CLAY	0	101	90	90
5	CLAY	0	108	110	110
6	CLAY	0	96	120	120
7	SANDY CLAY	0	97	160	160
8	SILTY CLAY	0	119	200	200
9	SILTY CLAY	0	107	280	280
10	CLAY	0	102	400	400

EUSTIS ENGINEERING SERVICES, L.L.C.
GEOTECHNICAL ENGINEERS
3011 28TH STREET METAIRIE, LOUISIANA

GLOBAL STABILITY
SAND WEDGE SHORELINE PROTECTION

STATE OF LOUISIANA
LAKE HERMITAGE MARSH CREATION (BA-42)
PLAQUEMINES PARISH, LOUISIANA

DRAWN BY: J.L.S.	21 SEPT 2007	FILE: FIGURE14.DGN
CHECKED BY: B.M.C.	JOB NO.: 19666	FIGURE 14