Volume II: Preliminary Geotechnical Engineering Report

Lost Lake Marsh Creation and Hydrologic Restoration Project
Terrebonne Parish, Louisiana

for

Louisiana Office of Coastal Protection and Restoration (OCPR)

August 8, 2011

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Volume II: Preliminary Geotechnical Engineering Report

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

for
Office of Coastal Protection and Restoration

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GeoEngineers

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PRELIMINARY

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Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72) Terrebonne Parish, Louisiana

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Table of Contents

INTRODUCTION **1**

PROJECT UNDERSTANDING **1**

SCOPE OF SERVICES **1**

SUBSURFACE CONDITIONS **4**

Borrow Area Stratigraphy 4

CONCLUSIONS AND RECOMMENDATIONS **4**

General 4
Marsh Creation 5
Settlement (Soil Borings B-7, 11, through 18) 5
Hydraulic Dredging Fill to Cut Ratio 7
Containment Dike 8
Slope Stability (Soil Borings B-7, 11, through 18) 8
Settlement (Soil Borings B-7, 11, through 18) 8
Bearing Capacity (Soil Borings B-7, 11 through 18) 9
Earthen Terrace 10
Slope Stability (Soil Borings B-16, 17 and 18) 10
Settlement (Soil Borings B-16, 17 and 18) 10
Bearing Capacity (Soil Borings B-16, 17 and 18) 11

CONSTRUCTION CONSIDERATIONS **11**

LIMITATIONS **12**

FIGURES

Figure II-1. Vicinity Map
Figure II-2. Site Plan with Soil Boring Locations
Figure II-3. Site Plan with Transect Layout Map
Figure II-4. Recommended Containment Dike
Figure II-5. Recommended Earthen Terrace

PRELIMINARY

APPENDICES

Appendix II-A. Settlement Analyses for Marsh Fill and Foundation Soils
Summary of Settlement Calculations
Figures II-A1 through II-A9 - Marsh Fill and Foundation Soils Time-Rate Settlement
Appendix II-B. Slope Stability and Settlement Analyses for Containment Dike
Summary of Slope Stability and Settlement Calculations
Figures II-B1 through II-B8 - Containment Dike Slope Stability Evaluations
Figures II-B9 through II-B16 - Containment Dike Time-Rate Settlement
Appendix II-C. Slope Stability and Settlement Analyses for Earthen Terrace
Summary of Slope Stability and Settlement Calculations
Figures II-C1 through II-C3 - Earthen Terrace Slope Stability Evaluations
Figures II-C4 through II-C6 - Earthen Terrace Time-Rate Settlement
Appendix II-D. Report Limitations and Guidelines for Use

INTRODUCTION

This report provides geotechnical engineering recommendations for the Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72) and in accordance with the scope of services presented in the Office of Coastal Protection and Restoration (OCPR) request dated March 22, 2011, and our proposal dated March 29, 2011. The site location and a site map are shown in Figures II-1 and II-2, respectively. The main body of the engineering report contains our interpreted geotechnical subsurface conditions and engineering recommendations. A summary of our slope stability and settlement calculations for marsh, containment dike and earthen terrace are provided in Appendix II-A, Appendix II-B and Appendix II-C, respectively. All elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88).

PROJECT UNDERSTANDING

Our understanding of the project is based on the information provided in our proposal dated March 29, 2011, and subsequent communications with OCPR.

The proposed project is estimated to create approximately 465 acres of marsh between Lake Pagie and Bayou Decade, north of Bayou Decade, and along the northwestern Lost Lake Shoreline. In addition, 30,000 linear feet (26 acres) of terraces will be constructed to reduce fetch in an area of deteriorated marsh. Eight (8) water control structures have been proposed to be replaced with variable-crest structures to increase freshwater flow into surrounding marshes. As shown on Figure I-2, the project features include:

- Earthen Containment Dikes: Construction of earthen dikes to contain approximately 465 acres of newly created marsh.
- Marsh: Creation of approximately 465 acres of marsh habitat by using a hydraulic dredge to pump dredged material from the Lost Lake borrow site (Borings B-6, and B-8 through B-10) into the marsh fill area.
- Earthen Terraces: Construction of approximately 30,000 linear feet (26 acres) of terraces to reduce fetch in an area of deteriorated marsh.
- Variable Crest Weirs: Construction of variable crest weirs to replace eight (8) water control structures to increase freshwater flow into surrounding marshes.

SCOPE OF SERVICES

The purpose of our services was to collect geotechnical data and perform geotechnical analyses to develop recommendations for marsh creation and hydrologic restoration. Our specific scope of services included the following:

1. Contacted Louisiana "One-Call" to clear the boring locations of potential underground utilities, and notified the local property owners and OCPR prior to performing soil borings at this site.

2. Contacted landowners to get access permission at the project area prior to our performing the geotechnical exploration program.

3. Obtained the Coastal Use Permit from the Department of Natural Resources, Office of Coastal Management, written documentation from USACE. Provided this documentation to OCPR.

4. Drilled a total of 20 soil borings to depths selected by the OCPR, and at the locations shown on Figure 1 and described below. These explorations were completed with a pontoon rig and a marsh buggy mounted drill rig. Global Positioning System (GPS) data was collected at all sampling locations using a handheld GPS (Latitude, Longitude). Samples were collected continuously in the top 20 feet and then 5 feet center to center to boring completion depths as requested in Section 4.4 of "Scope TE-72" and agreed to on February 22, 2011. An experienced field representative of GeoEngineers logged the borings and obtained soil samples from the following:

   a. Four soil borings (B-6, B-8, B-9, and B-10), each 20 feet in depth below mudline in the borrow area;

   b. Eight soil borings (B-7, B-11 through B-15, B-17 and B-18), each 40 feet in depth below the mudline;

   c. Seven soil borings (B-1 through B-5, B-19 and B-20), each 50 feet in depth below the mudline; and

   d. One soil boring (B-16) 60 feet in depth below mudline.

5. A survey of the exploration locations was done prior to the investigation to check for existing pipelines, provide NAVD 88 Latitude, Longitude, and the elevations of mudline and water level at the boring locations. This was completed by our subcontractor, T. Baker Smith (TBS). TBS also performed a gradiometer survey at each boring location to clear the area of any pipelines.

6. Performed laboratory testing on select undisturbed-type specimens plus Standard Penetration Test (SPT) plugs. Samples will be lab classified and subjected to strength with stress-strain plots, unit weight, moisture content, Atterberg limit, sieve, hydrometer, specific gravity and consolidation testing as requested in the Section 4.5 of "Scope TE-72". Mini-vane shear tests will be performed on the recovered undisturbed-type samples.

7. Evaluated subsurface data and identified appropriate design profiles representing different sections of the proposed containment dikes, earthen terraces and variable crest weirs. Tasks included:

   a. Preparing boring logs;

   b. Reconstructing consolidation curves to develop design parameters and stress history profile;

   c. Develop representative shear strength profiles; and

PRELIMINARY

   d. Develop soil compressibility profiles.

8. For each design profile:

   a. Earthen Containment Dikes and Terraces:

      i. Performed a stability analysis to evaluate what geometry is required for the dike and terrace configurations (construction elevation, side slopes and crown width);

      ii. Provided settlement curves, including immediate and consolidation settlement due to self weight compaction and subsurface soils; and

      iii. Provided recommendations related to setup time required for the newly placed material before dredged fill slurry is placed in containment area

   b. Marsh Creation Area:

      i. Performed settlement evaluations using PSDDF and settlement programs starting with initial placement, then on intervals of 1, 5, 10 and 20 years after placement, followed by ultimate settlement (50 years);

      ii. Completed three self weight consolidation tests and one settling column test with a water salinity test based on the borrow area borings (B-6, B-8, B-9 and B-10);

      iii. Estimated the initial marsh fill elevation required to meet the target marsh elevation that was provided by OCPR. The marsh fill heights to be evaluated were also provided by OCPR (El. +3 feet and +2.5 feet);

      iv. Provided cut to fill ratio for construction; and

   c. Variable Crest Weirs:

      i. Working on providing hydraulic and foundation designs for the weir structures;

      ii. Working on providing design for foundation and cut-off wall; and

9. Provided the deliverables as requested in Section 5 of “Scope TE-72”.

10. Prepared a final data report, engineering report and calculation package for all the elements of services performed.

The options for structures are being evaluated by GeoEngineers in discussion with OCPR and will be provided as an addendum to this report at a later date.

PRELIMINARY

SUBSURFACE CONDITIONS

Based on the field exploration data and subsequent laboratory testing, sixteen (16) design soil profiles were developed. Due to significant variation in soil borings, grouping of soil borings could not be performed. In general, soil borings encountered very soft cohesive soil with varying amounts of organic matter. Layers of peat were encountered at few of the borings at various depths. Semi-cohesive and non-cohesive soils were encountered at soil borings B-2, B-11, B-16 and B-18 at intermittent depths. The thickness of the semi-cohesive and non-cohesive soil were less than 5 feet and consisted of one or more of silt, clayey silt, and clayey sand layers.

For additional information, please refer to the detailed soil boring logs provided in the geotechnical data report for this project.

Borrow Area Stratigraphy

Based on the four soil borings (B-6, B-8, 9 and 10) performed in the borrow area, predominantly cohesive soil were encountered for the entire depth of exploration. The cohesive soil consisted of very soft clay with varying amounts of organic matter and shell fragments.

For additional information, please refer to the detailed soil boring logs provided in the geotechnical data report for this project.

CONCLUSIONS AND RECOMMENDATIONS

General

Based on the investigation results, the proposed improvement area is generally suitable for the proposed containment dike and earthen terrace construction, and marsh creation. The summary results of the slope stability and settlement analyses are presented in Tables below. Details of the analysis methods are presented in Appendices II-A through II-C for slope stability and settlement.

The overall bearing capacity of the containment dike and earthen terrace must be satisfactory, with or without geotextile reinforcement. If an embankment is determined to be unsafe based on overall bearing capacity, stability can be improved by adding berms or by extending the base of the embankment to provide a mat and thus spread the load to a greater area. If the overall stability of the embankment is not satisfied, there is no point in trying to reinforce the embankment. The overall bearing capacity for the containment dike and earthen terrace have been analyzed and are presented in respective sections below.

GeoEngineers performed stability analyses using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory to evaluate the stability of earth slopes. Subsurface soil properties were estimated using the results of subsurface explorations and associated laboratory testing. The soil units and soil properties used in the stability model are included in the geotechnical data report.

Identifying the critical slip surface with the lowest factor of safety was accomplished by an iterative process by which the program calculated the factor of safety for a large number of potential slip surfaces. A minimum required factor of safety of 1.2 against failure was used for this project.

GeoEngineers performed settlement analyses for the containment dike, earthen terrace and marsh fill sections based on Terzaghi's one-dimensional linear consolidation theory. Settlement parameters were developed using consolidation test results. Correlations based on consolidation test data from this project and similar projects, and published correlations were used to develop settlement parameters.

In addition to consolidation settlement, there will be elastic settlement. Estimates of elastic settlement, which occurs during earth fill placement, are about 20 percent of the long-term consolidation settlement. The total settlement will be the consolidation settlement plus the construction (immediate elastic) settlement. However, the construction settlement will not be recognized because more earthen fill will be placed to achieve the required end-of-construction elevation during construction.

Another component of settlement for this project is settlement within fill placed at the site. For dredged fill, a computer program model was used to estimate the primary consolidation, secondary compression and desiccation. For material installed for the containment dike and earthen terrace, a shrinkage value equal to 10% of the dike/terrace soil above water was considered. Settlement figures presented in this report show the estimated MHW and MLW levels provided by OCPR.

Marsh Creation

Settlement (Soil Borings B-7, 11, through 18)

The average existing marsh mudline surface was determined based on the survey information provided by OCPR (presented in the geotechnical data report). The water level was assumed to be at elevation +1.0 feet, NAVD 88 based on the mean water level provided by OCPR. Our estimates indicate that the marsh settlement results in marsh surface elevations are between the projected MHW and MLW for the design period.

The height of dredged material in a contained area is reduced by primary consolidation, secondary compression, and desiccation within the dredged fill, as well as settlement of soil beneath the fill. The consolidation settlement and time rate of settlement analyses within the dredged fill for the marsh creation area were performed using the Primary consolidation, Secondary compression, and Desiccation of Dredged Fill (PSDDF) program. Laboratory tests performed on composite samples prepared from the proposed borrow area soils were used to establish the input parameters for the dredged fill materials. The composite soil samples test results are in Volume I, Geotechnical Investigation Data Report, Appendix I-C, Sediment Geotechnical Properties.

In addition to the dredged material settlement, the existing soil beneath the dredge fill areas will experience consolidation settlement from the additional fill overburden placed during dredging. This settlement was determined using load area dimensions and pressure consistent with the dredged fill.

The sum of the dredged fill settlement and the underlying soil settlement was used to determine the total settlement that will be realized at the surface of the dredged fill area after filling is complete. Dredged fill settlement evaluations are performed for single lift scenario with projected fill placed to an elevation of +2.0, +2.5 and +3.0 feet, NAVD 88. In these cases, the final elevation of dredged fill over a 20-year design life was estimated to be between the provided MHW and MLW for the design life.

Figures II-A1 through II-A9 in Appendix II-A provide both graphical and tabular summaries of marsh elevation versus time for a 20-year period for single lift scenario.

Based on the combined settlement of the dredged fill and underlying soil, the estimated elastic settlement for each marsh fill scenario is provided in Table 1 below. The elastic construction settlement should be added to the total dredged fill height for purposes of quantity estimates.

TABLE 1. ELASTIC CONSTRUCTION SETTLEMENT OF FOUNDATION SOILS IN MARSH FILL AREA

Design Profile	Initial Marsh Fill Elevation (Feet NAVD 88)	Estimated Elastic Construction Settlement (inches)
7	+3	5
	+2.5	4
	+2	3
11	+3	5
	+2.5	4
	+2	3
12	+3	5
	+2.5	4
	+2	3
13	+3	6
	+2.5	5
	+2	4
14	+3	5
	+2.5	4
	+2	3
15	+3	6
	+2.5	5
	+2	4
16	+3	6
	+2.5	5
	+2	4
17	+3	5

PRELIMINARY

Design Profile	Initial Marsh Fill Elevation (Feet NAVD 88)	Estimated Elastic Construction Settlement (inches)
	+2.5	4
	+2	3
18	+3	5
	+2.5	4
	+2	3

Hydraulic Dredging Fill to Cut Ratio

The fill to cut ratio evaluation was based on settling column and self-weight consolidation tests results, which are included in Appendix I-C, and design guidance in the United States Army Corps of Engineers (USACE) publication EM-1110-2-5027.

TABLE 2. FILL TO CUT RATIO FOR DREDGED FILL

Time Period for Initial Hydraulic Dredge Material Consolidation (days)	Fill to Cut Ratio
2	2.9
30	2.3
60	2.2
125	2.0
Bulking Factor – Approx. 2 days	3

The "bulking factor," which gives a similar ratio as the USACE method for the short duration of two days, is based on guidance from the "Handbook of Dredging Engineering" by John B. Herbich (2nd Edition, pages 6.25-27). Based on these values, and an assumed construction period longer than 60 days, we suggest the use of a fill to cut ratio equal to 2 for estimating purposes. In other words, for every 2 cubic yards (CY) placed in the marsh site, 1 CY will be cut from the dredging areas. These estimates are applicable only to hydraulically filled marsh creation areas; mechanically dredged areas will be different.

It must be understood that these fill to cut ratios are not the same as the ratio of as-constructed in-place cut volume to in-place fill volume ratio that have been observed for completed coastal restoration projects in South Louisiana. Typically, it takes approximately 1.3 to 1.5 CY of in-place hydraulically removed borrow material to fill 1.0 CY in the placement area. This number can vary significantly depending upon the material being dredged, placement area size, containment, and other factors. Typically coarser fill materials (sands) placed in larger fill areas with good containment require less cut to fill the desired area. The current project has predominantly cohesive soils in the borrow areas.

Containment Dike

Slope Stability (Soil Borings B-7, 11, through 18)

Slope stability analyses were performed for a typical containment dike section with an adjacent borrow channel to determine the minimum required horizontal distance from the borrow channel to the containment dike, and determine side slopes, as shown in Figure II-4.

The analysis results indicate that side slopes of 3H:1V for the containment dike will provide a 1.2 factor of safety or greater on the borrow channel side of the embankment for all sections. The containment dike sections were analyzed with a 15-foot berm from the dike toe to the borrow channel bank. The borrow channel was assumed to be excavated to a maximum elevation of -10 feet, NAVD 88 and with a 3H:1V bank slope. Geotextile was not required to achieve a factor of safety greater than 1.2. Results are summarized in Table 3 below.

The OCPR requires at least one foot of freeboard on the marsh crown during placement of dredged fill. Based on this, marsh fill containment requirements, an initial completed containment dike elevation of +4.0 feet, NAVD 88 is recommended.

Figures II-B1 through II-B9 in Appendix II-B show the critical failure surface in the containment dike section for soil borings B-7, 11 through 18.

TABLE 3. CONTAINMENT DIKE SLOPE STABILITY ANALYSIS RESULTS

Design Profile	Location	Side slopes (H:V)	Factor of Safety
7	Marsh Side	3H:1V	1.61
11	Marsh Side	3H:1V	1.55
12	Marsh Side	3H:1V	1.27
13	Marsh Side	3H:1V	1.73
14	Marsh Side	3H:1V	1.42
15	Marsh Side	3H:1V	1.48
16	Marsh Side	3H:1V	1.56
17	Marsh Side	3H:1V	2.09
18	Marsh Side	3H:1V	1.78

Settlement (Soil Borings B-7, 11, through 18)

All settlements were based on side slopes of 3H:1V with a 5-foot crown width and earthen fill to elevation +4.0 feet, NAVD 88. Table 4 provides a summary of settlement estimates for both construction activities and consolidation settlement for the containment dike. Time rate of settlement versus elevation over a 20-year period is shown for each of the design profiles in

PRELIMINARY

Figures II-B9 through II-B17 in Appendix II-B. The containment dikes will settle along with the marsh area settlement.

TABLE 4. CONTAINMENT DIKE SETTLEMENT ESTIMATES

Design Profile	Initial Fill Elevation (feet)	Estimated Settlement* (inches)					
		Construction Settlement	Consolidation Settlement(1)				
		Elastic	6 months	1 Year	5 Years	10 Years	Long-term (20 Years)
7	+4.0	2	6	7	11	12	14
11	+4.0	1	8	8	9	9	9
12	+4.0	2	6	7	10	12	14
13	+4.0	1	5	5	7	7	8
14	+4.0	1	5	5	7	8	9
15	+4.0	1	5	6	8	9	10
16	+4.0	1	6	7	9	9	11
17	+4.0	1	5	5	7	7	8
18	+4.0	1	5	6	8	9	11

*Estimated construction settlement is not included in the estimated consolidation settlement.

Bearing Capacity (Soil Borings B-7, 11 through 18)

The containment dikes were checked for overall bearing capacity and were determined to be satisfactory as shown in the Table 5 below.

TABLE 5. OVERALL BEARING CAPACITY RESULTS

Design Profile	Side slopes (H:V)	Factor of Safety
7	3H:1V	4.5
11	3H:1V	5.2
12	3H:1V	4.2
13	3H:1V	6.6
14	3H:1V	6.2
15	3H:1V	6.5
16	3H:1V	5.9
17	3H:1V	6.1
18	3H:1V	5.2

Earthen Terrace

Slope Stability (Soil Borings B-16, 17 and 18)

Slope stability analyses were performed for a typical earthen terrace section and an adjacent borrow channel to determine the minimum required horizontal distance from the borrow channel to the terrace embankment, and determine side slope, as shown in Figure II-5.

A terrace section with a crown width of 10 feet with side slopes of 3H:1V provide a factor of safety greater than 1.2 for the earthen terrace. The terrace sections were analyzed with a 15-foot berm between the embankment toe and the borrow channel bank. The borrow channel was assumed to be excavated to a maximum elevation of -10 feet, NAVD 88 and with a 3H:1V bank slope. Geotextile was not required to achieve a factor of safety greater than 1.2. Results are summarized in Table 6 below.

Figures II-C1 through II-C3 in Appendix II-C show the critical failure surface in the earthen terrace section for soil borings B-16, 17, and 18.

TABLE 6. EARTHEN TERRACE SLOPE STABILITY ANALYSIS RESULTS

Design Profile	Side slopes (H:V)	Factor of Safety
16	3H:1V	1.51
17	3H:1V	1.87
18	3H:1V	1.82

Settlement (Soil Borings B-16, 17 and 18)

All settlements were based on side slopes of 3H:1V with a 10-foot crown width and earthen fill to elevation +4.0 feet, NAVD 88. Table 7 provides a summary of settlement estimates for both construction activities and consolidation settlement for the containment dike. Time rate of settlement versus elevation over a 20-year period is shown for each of the design profiles in Figures II-C4 through II-C6 in Appendix II-C.

TABLE 7. EARTHEN TERRACE SETTLEMENT ESTIMATES

Design Profile	Initial Fill Elevation (feet)	Estimated Settlement (inches)					
		Construction Settlement	Consolidation Settlement(1)				
		Elastic	6 months	1 Year	5 Years	10 Years	Long-term (20 Years)
16	+4.0	2	6	7	10	10	12
17	+4.0	1	5	5	7	8	8

PRELIMINARY

Design Profile	Initial Fill Elevation (feet)	Estimated Settlement (inches)					
		Construction Settlement	Consolidation Settlement(1)				
		Elastic	6 months	1 Year	5 Years	10 Years	Long-term (20 Years)
18	+4.0	2	6	6	8	10	12

Estimated construction settlement is not included in the estimated consolidation settlement.

Bearing Capacity (Soil Borings B-16, 17 and 18)

The earthen terrace sections were checked for overall bearing capacity and were determined to be satisfactory as shown in the Table 8 below.

TABLE 8. OVERALL BEARING CAPACITY RESULTS

Design Profile	Side slopes (H:V)	Factor of Safety
16	3H:1V	4.9
17	3H:1V	5.4
18	3H:1V	5.2

CONSTRUCTION CONSIDERATIONS

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

- The borrow area material predominantly consists of cohesive soils. Based on our experience on previous projects, there is a possibility of soil balling to occur during dredging process. If there is a source for granular material in the vicinity of the project, it is recommended to consider that site to get borrow material for the marsh creation.
- For the earthen terraces and containment dikes, a cut to fill ratio of approximately 1.1 to 1 is recommended (i.e. 10% loss) for mechanical dredging.
- In addition to settlement, organic materials excavated from a submerged condition and placed as fill above the water level, are likely to experience significant shrinkage as they dry. Based on our experience with similar coastal soil, we have considered a value of 10% of the fill height above water for shrinkage while estimating the settlement for containment dike and earthen terrace.
- Slope stability evaluations only considered static conditions. Equipment working from a berm between adjacent borrow trench and embankment fill areas, may create stability issues from repeated motions such as fill excavation and placement.

- In places where the earthen terrace and containment dikes are placed over pipelines, there is the potential for the pipeline to be damaged not only from impact loading associated with construction, but also from deflection associated with settlement.
- Calculations indicate that a geotextile is not necessary to construct a stable terrace or containment dike. If OCPR elects to place a geotextile beneath the terrace, debris including branches and wood debris may interfere. Removal of this debris should be accomplished in a manner that minimizes disturbance of underlying soil, otherwise the benefits of the geotextile may be lost by the reduction in strength of the underlying soil.

LIMITATIONS

The information presented in this report is based on the soil borings and soil testing completed for this study, and judgments made by the certifying engineers. This report is specific to this site and should not be used other than for the design of the Lost Lake Marsh Creation and Hydrologic Restoration (TE-72) project located in Terrebonne Parish, Louisiana. We have provided the requested information for the geotechnical investigation report. Additional geotechnical data and calculations are in Volumes I and III.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions express or implied should be understood.

Any electronic form or hard copy of this document (email, text, table, and/or figure), if provided, and any attachments are only a copy of a master document. The master hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to Appendix II-D titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

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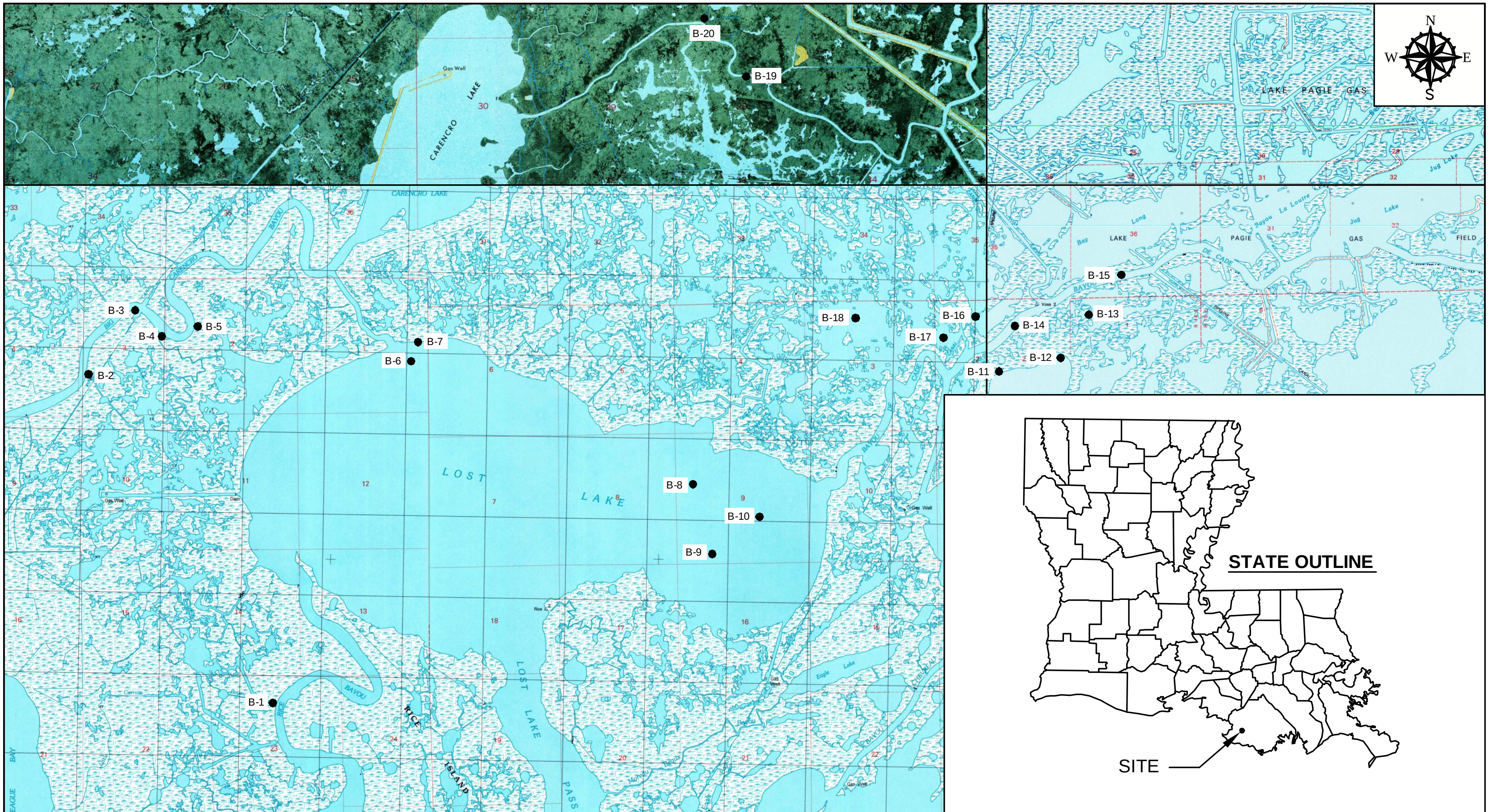

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FEET

Note:
The locations of all features shown are approximate.

Reference: Topographic map taken from USGS, Quad 24K, LA_Carencro_Bayou, Dated 1980
Topographic map taken from USGS, Quad 24K, LA_Lost_Lake, Dated 1998
Topographic map taken from USGS, Quad 24K, LA_Lake_Penchant, Dated 1994
Topographic map taken from USGS, Quad 24K, LA_Lake_Merchant, Dated 1994

LEGEND

● B-1 Borehole Location

VICINITY MAP

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-1

BOREHOLE DETAILS			
BOREHOLE #	LATITUDE	LONGITUDE	TOTAL DEPTH (FT)
B-1	N29° 19' 02.0"	W91° 05' 27.0"	50
B-2	N29° 21' 13.5"	W91° 06' 50.4"	50
B-3	N29° 21' 39.4"	W91° 06' 33.3"	50
B-4	N29° 21' 27.5"	W91° 06' 18.4"	50
B-5	N29° 21' 32.7"	W91° 06' 00.8"	50
B-6	N29° 21' 19.6"	W91° 04' 27.2"	20
B-7	N29° 21' 27.5"	W91° 04' 20.7"	40
B-8	N29° 20' 25.7"	W91° 02' 14.6"	20
B-9	N29° 19' 57.4"	W91° 02' 05.6"	20
B-10	N29° 20' 16.2"	W91° 01' 42.7"	20
B-11	N29° 21' 16.1"	W90° 59' 54.3"	40
B-12	N29° 21' 21.9"	W90° 59' 25.9"	40
B-13	N29° 21' 49.5"	W90° 59' 14.1"	40
B-14	N29° 21' 32.8"	W90° 59' 47.4"	40
B-15	N29° 21' 54.7"	W90° 58' 58.0"	40
B-16	N29° 21' 37.0"	W91° 00' 05.0"	60
B-17	N29° 21' 29.0"	W91° 00' 20.0"	40
B-18	N29° 21' 37.0"	W91° 01' 00.0"	40
B-19	N29° 21' 14.1"	W91° 01' 49.5"	50
B-20	N29° 21' 37.2"	W91° 02' 09.4"	50

*Due to access issues and existing pipelines, borings were drilled as close to the surveyed locations as practical with the equipment available

LEGEND

B-1 Borehole Location

N W E S

4000 0 4000

Feet

Notes:

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

Reference: Aerial Image provided by OCPR, 20-503_lost lake orthos2.jpg, Dated 3/10/2011

SITE PLAN WITH SOIL BORING LOCATIONS

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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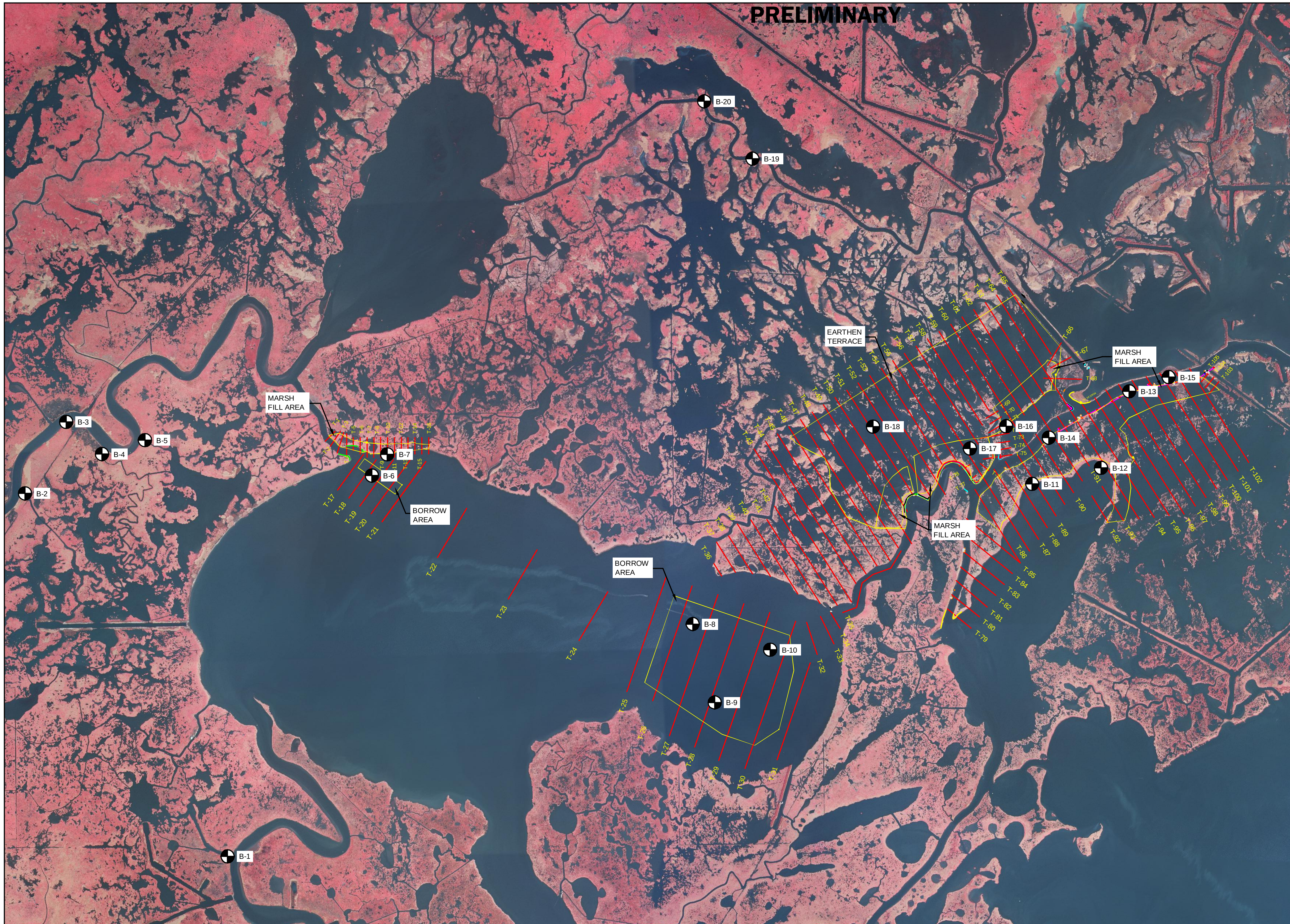
Figure II-2

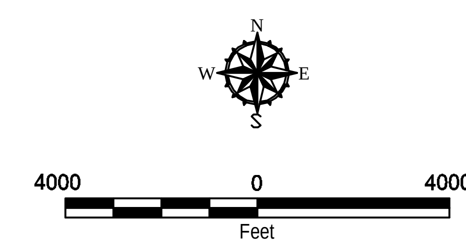
VT : KMC

P:\16\1671502\00\CAD\Volume I\SITE PLAN.dwg\TAB:Layout1 modified on Aug 08, 2011 - 12:06pm



LEGEND

B-1 Borehole Location



VT : KMC

P:\16\1671502\00\CAD\Volume I\SITE PLAN with Transect.dwg\TAB:Layout1 modified on Aug 05, 2011 - 2:14pm

Notes:
1. The locations of all features shown are approximate.
Reference: Aerial Image provided by OCPR, 20-503_lost lake orthos2.jpg, Dated 3/10/2011

SITE PLAN WITH TRANSECT LAYOUT MAP

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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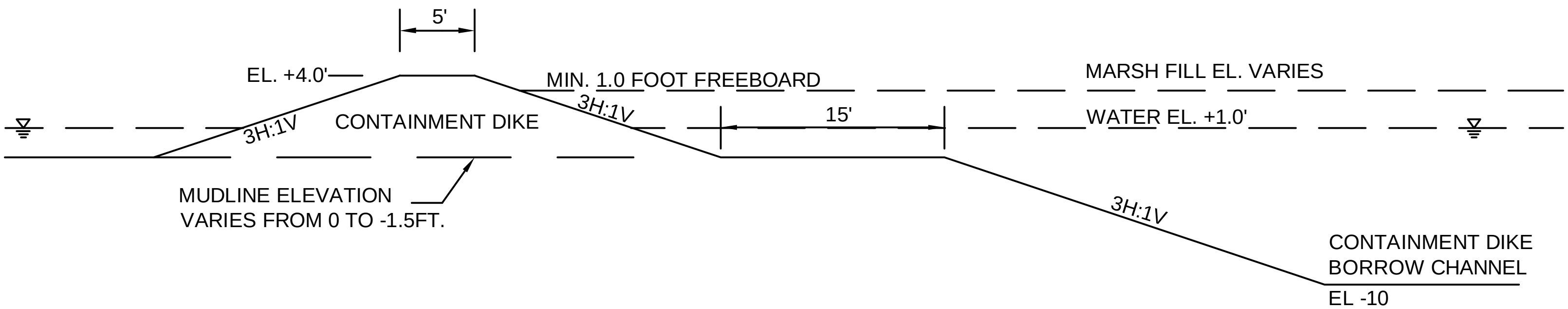
Figure II-3

PRELIMINARY

P:\16\16715020\00\CAD\Volume II\Recommended sections.dwg\TAB:Layout1 modified on Aug 08, 2011 - 8:06am VT : KMC



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

RECOMMENDED CONTAINMENT DIKE

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-4

PRELIMINARY

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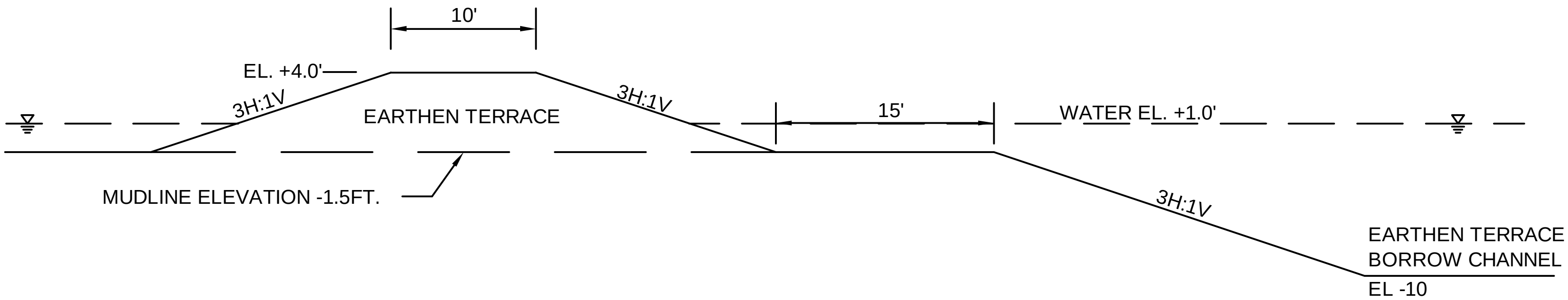

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers,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

RECOMMENDED EARTHEN TERRACE

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-5

PRELIMINARY

APPENDICES

Appendix II-A
Settlement Analyses for Marsh Fill and Foundation Soils

PRELIMINARY

Calculation Checksheet

Project No. 16715-020-00 Project Title: Lost Lake Marsh Creation

Deliverable Title: Geotechnical Engineering Report

Calculations Description: Settlement and Time Rate of Settlement Calculations for Marsh Fill.

Originator: V. Tammineni Checked by: J. Pruett Date: August 5, 2011

Checking method (describe): Verified parameters and checked computations

Comments: Settlement calculations were performed using a settlement analysis program based on one-dimensional consolidation theory. Soil settlement characteristics were determined based on soil properties, published correlations, and correlations developed based on this and other coastal projects. Time rate of settlement was estimated using spreadsheet calculations based on published equations.

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PRELIMINARY

Settlement Calculation Approach for the Dredged Fill Marsh Creation Area
Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)

1. Settlement parameters were developed for each soil layer for all borings as shown in the spreadsheets provided in Appendix I-E. Settlement parameters for Borings B-7, B-11 through B-18 were used for settlement estimates for the marsh creation area. The following description explains how the parameters were developed.
    - (a) One consolidation test was done for each soil boring and the samples for the consolidation test were selected from varying depths and materials.
    - (b) Consolidation test results were analyzed and graphs were reconstructed to determine compression (C_c), recompression (C_r), and vertical consolidation (C_v) coefficients, initial void ratios (e_0) and maximum past pressures (P_c).
    - (c) Correlations presented in equations 1 through 4 (shown in the attached spreadsheets) were used to calculate e_0 and C_c for all the soil layers.
    - (d) GeoEngineers developed different correlations based on the analyses of the consolidation test results as follows:
        - (i) Void Ratio (e_o) was estimated based on water content test results for various samples and the best fit curve drawn through plotted points from consolidation test results.
        - (ii) Moisture Content (w) Vs. C_v: A best fit curve was drawn through the plotted points from this and other coastal projects and C_v for the soil layers were obtained depending upon the moisture content.
        - (iii) w Vs. C_c: C_c=0.0054*((w*S.G.)-35) was found to provide sufficient accuracy based on the test data for this and other projects for all compressible soil types; C_c was obtained for the soil layers based on the moisture content.
        - (iv) C_r was taken to be 10% of C_c for all cohesive and semi-cohesive soils.
    - (e) For the soil layers without a representative consolidation test, the above mentioned correlations were used to estimate C_c, C_r, C_v, and e_0.
    - (f) Past previous pressure (P_c) were obtained from the consolidation test curves for the soil layers with a representative consolidation test. For other soil layers, the overconsolidation ratio (OCR) was estimated from the equation OCR = (c/(P_0' * 0.22))^(1/0.8). This equation was taken from Figure 7.1 of "Recommended practice for soft ground site characterization," by Charles Ladd and Don DeGroot. P_c was estimated by multiplying the overburden pressure (P_0) by OCR.
    - (g) In some cases where P_0 was greater than P_c, P_0 was used as the maximum past pressure instead of P_c for the settlement analysis assuming the layers to be normally consolidated.
2. In this area, clay shear strength for a normally consolidated soil profile will be approximately 22% of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles. Based on this relationship, it appears that the top 13-40 feet of the soil profile is slightly over-consolidated in all the design groups. This affects the settlement parameters selected for design within this zone.
3. Due to the broad fill area, the drainage is vertical for all the soil layers. Drainage to the phreatic surface or to the nearest granular soil layer has been considered for these soil layers. The presence of small sand and silt layers within clay was considered in the drainage path evaluation.

Settlement of the marsh creation area consists primarily of two separate processes: consolidation of the dredged fill and consolidation of the foundation soils. Consolidation of the dredged fill was modeled using PSDDF (Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill), a program created for the United States Army Corps of Engineers to simulate finite strain consolidation in dredged fill materials. Consolidation of the foundations soils was modeled iteratively using a one-dimensional consolidation program.

To account for the effects of progressive dredged fill densification and submergence below the waterline caused by foundation soil settlement, we re-computed effective vertical stress and corresponding settlement at various time intervals after fill placement. The typical steps at some time = t were as follows:

1. Calculate settlement for soil beneath the fill based on the elapsed time and the effective stress calculated for the previous time t and determine the new mudline elevation.
2. From PSDDF determine the change in the thickness of the fill computed by PSDDF to determine the fill material density, and the new fill surface elevation. The new fill surface elevation will be reduced by both the foundation settlement and the change in fill thickness from PSDDF.
3. Re-compute the effective vertical stress based on the new elevations of the fill surface and mudline, and a constant water elevation of 0.0 feet NAVD 88.
4. Use the new lower effective stress to re-compute settlement

This was repeated for 45, 60, 90, 180, 365, 1095 (3 years), 1460 (4 years), 1825 (5 years), 3650 (10 years), 7300 days (20 years) and 18,250 (50 years). Day 1 of the PSDDF calculation was taken as 30 days after the start of filling, allowing 30 days to complete placing hydraulic fill. Therefore day 30 for foundation soil settlement calculations equals day 1 for PSDDF calculations.

The sum of the dredge fill settlement and the underlying soil settlement was used to determine the total settlement that will be realized at the surface of the dredge fill area after filling is complete. Settlement of dredged fill evaluations were performed for single lift scenario with fill placed to an elevation of +2.0, +2.5 and +3.0 feet. In all the cases, the final elevation of dredged fill remained between the mean high water and mean low water levels provided by OCPR.

PRELIMINARY

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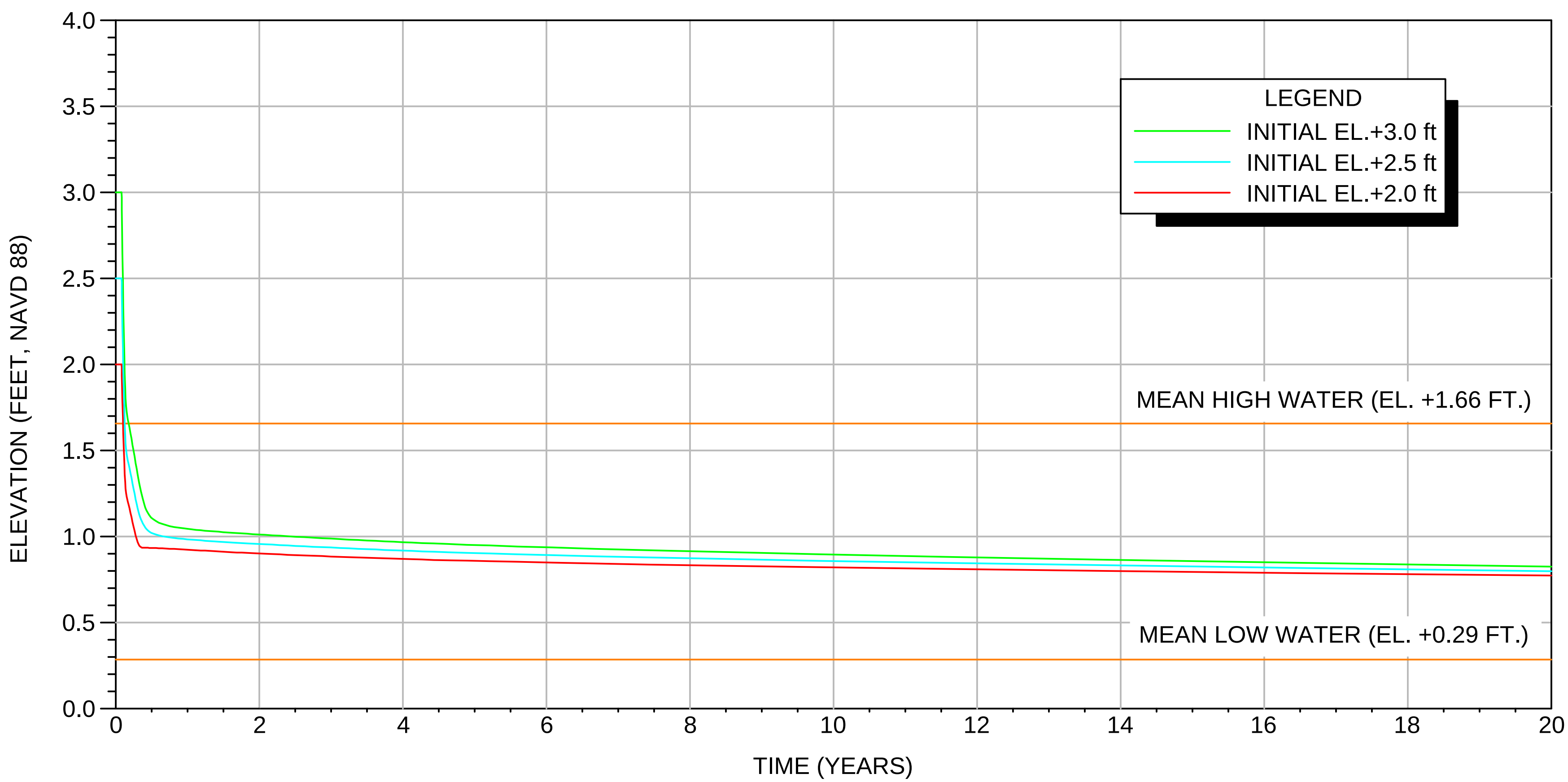

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	1.08	1.04	1.01	0.95	0.89	0.83	0.74
2.5	1.01	0.98	0.96	0.90	0.85	0.80	0.73
2.0	0.94	0.92	0.90	0.86	0.82	0.77	0.72

MARSH SETTLEMENT
ELEVATION VS. TIME (B-7)

Lost Lake Marsh Creation and Hydrologic
Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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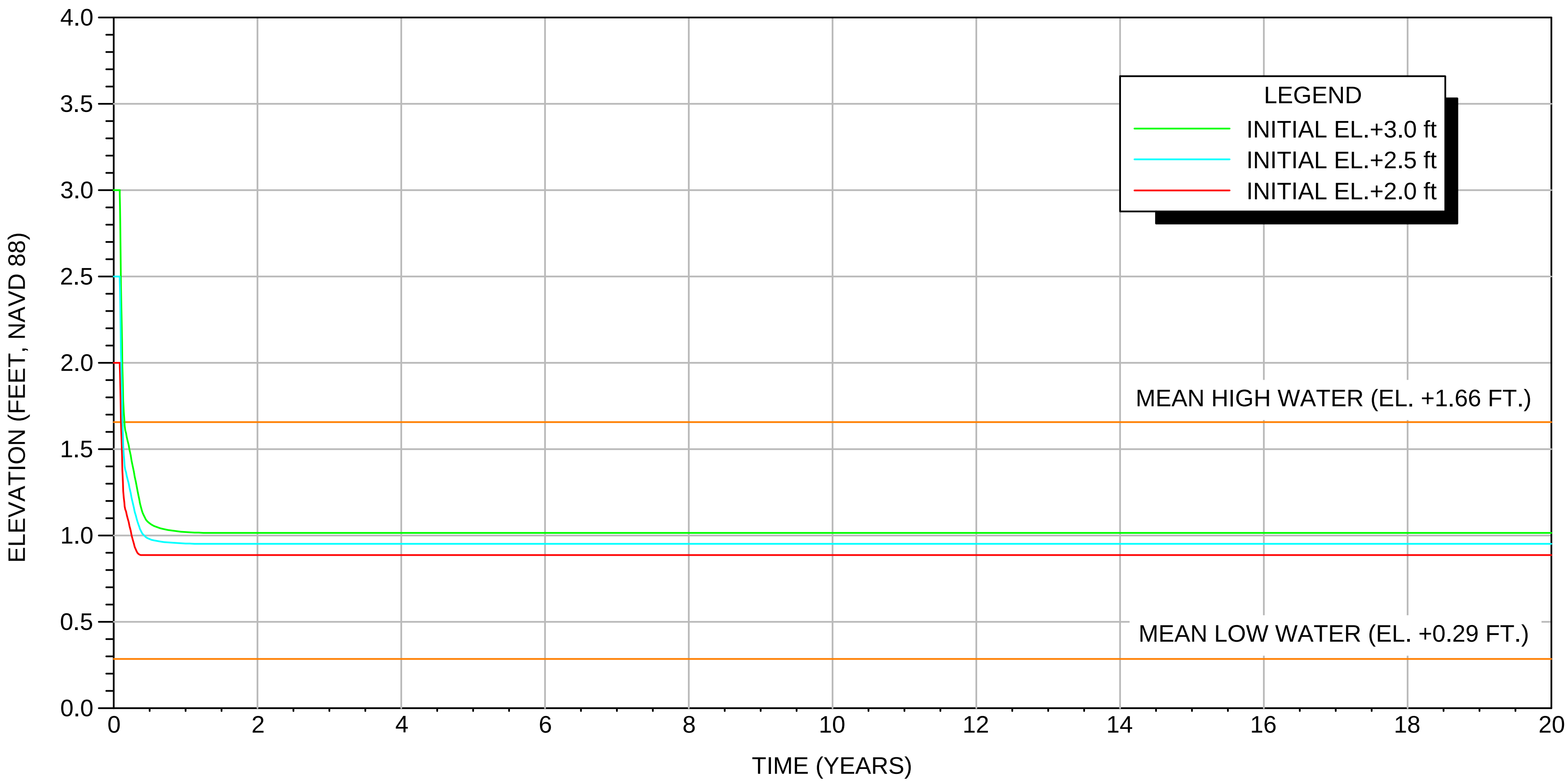
Figure II-A1

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-11 modified on Aug 08, 2011 - 1:09pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	1.04	1.01	1.01	1.01	1.01	1.01	1.01
2.5	0.97	0.95	0.95	0.95	0.95	0.95	0.95
2.0	0.89	0.89	0.89	0.89	0.89	0.89	0.89

MARSH SETTLEMENT
ELEVATION VS. TIME (B-11)

Lost Lake Marsh Creation and Hydrologic
Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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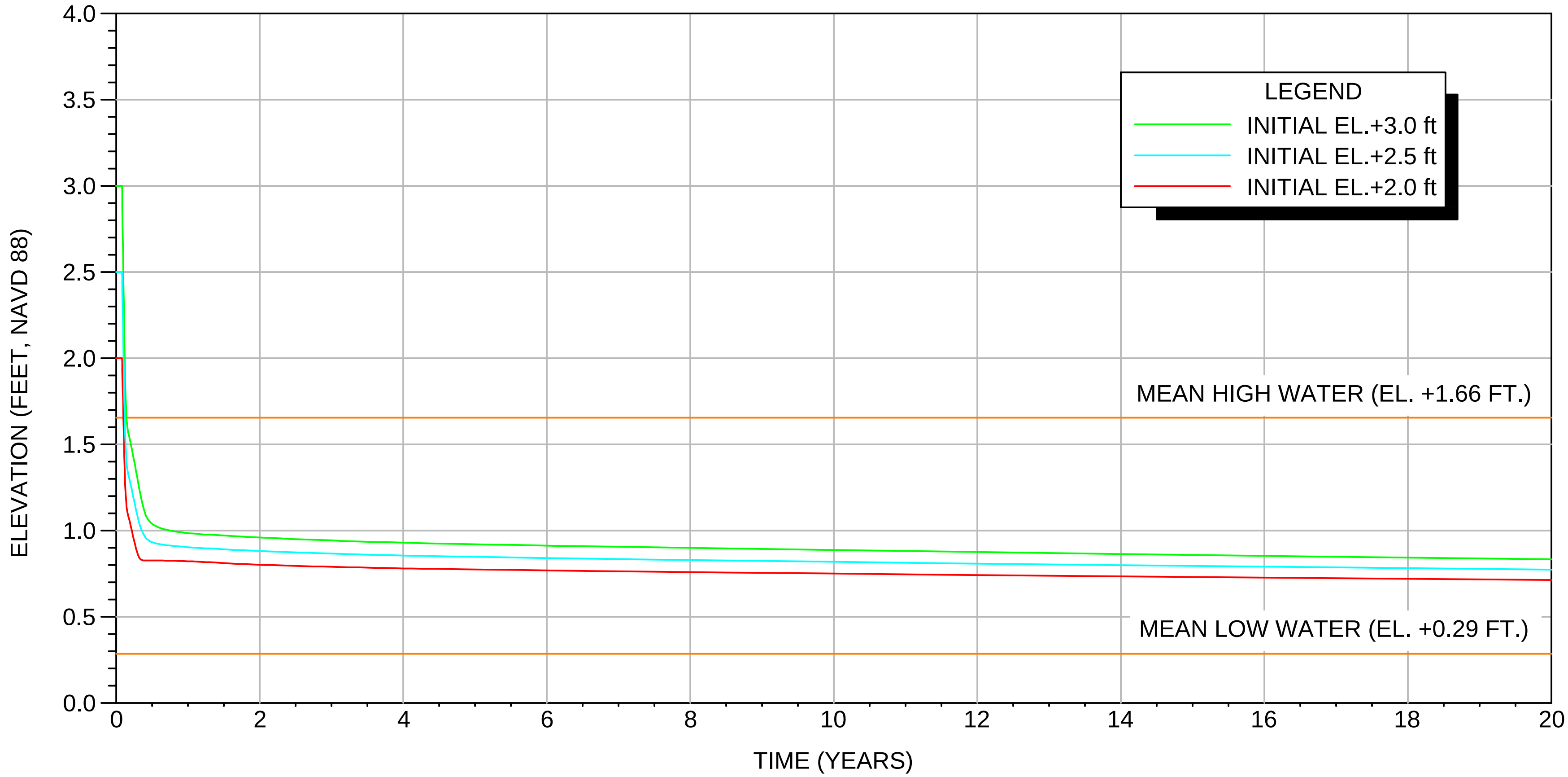
Figure II-A2

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-12 modified on Aug 08, 2011 - 1:09pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	1.02	0.98	0.96	0.92	0.88	0.83	0.74
2.5	0.92	0.90	0.88	0.85	0.82	0.77	0.70
2.0	0.83	0.82	0.80	0.77	0.75	0.71	0.65

MARSH SETTLEMENT ELEVATION VS. TIME (B-12)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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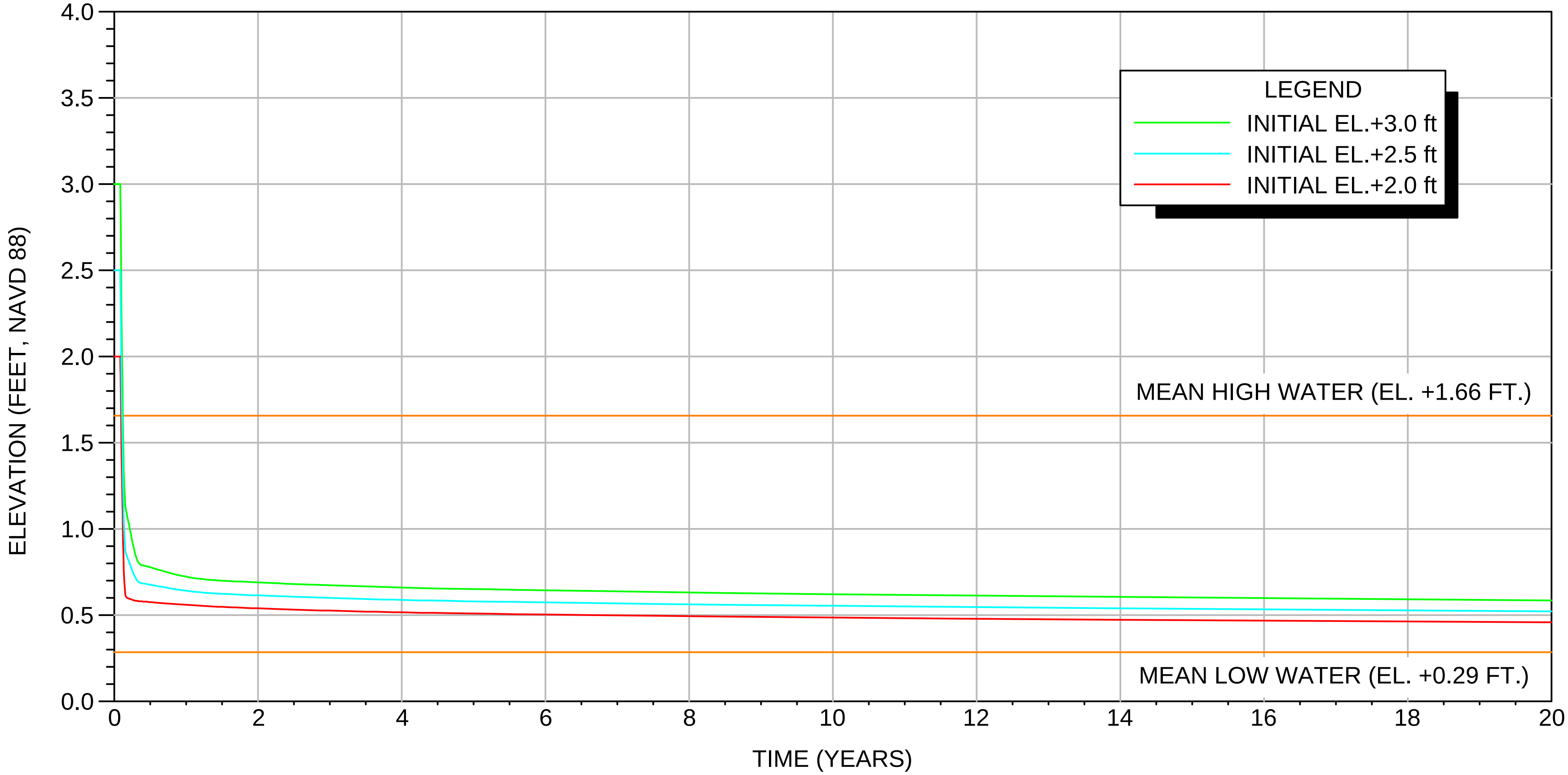
Figure II-A3

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-13 modified on Aug 08, 2011 - 1:09pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	0.78	0.71	0.69	0.65	0.62	0.59	0.55
2.5	0.68	0.64	0.61	0.58	0.55	0.52	0.49
2.0	0.58	0.56	0.54	0.51	0.48	0.46	0.43

MARSH SETTLEMENT
ELEVATION VS. TIME (B-13)

Lost Lake Marsh Creation and Hydrologic
Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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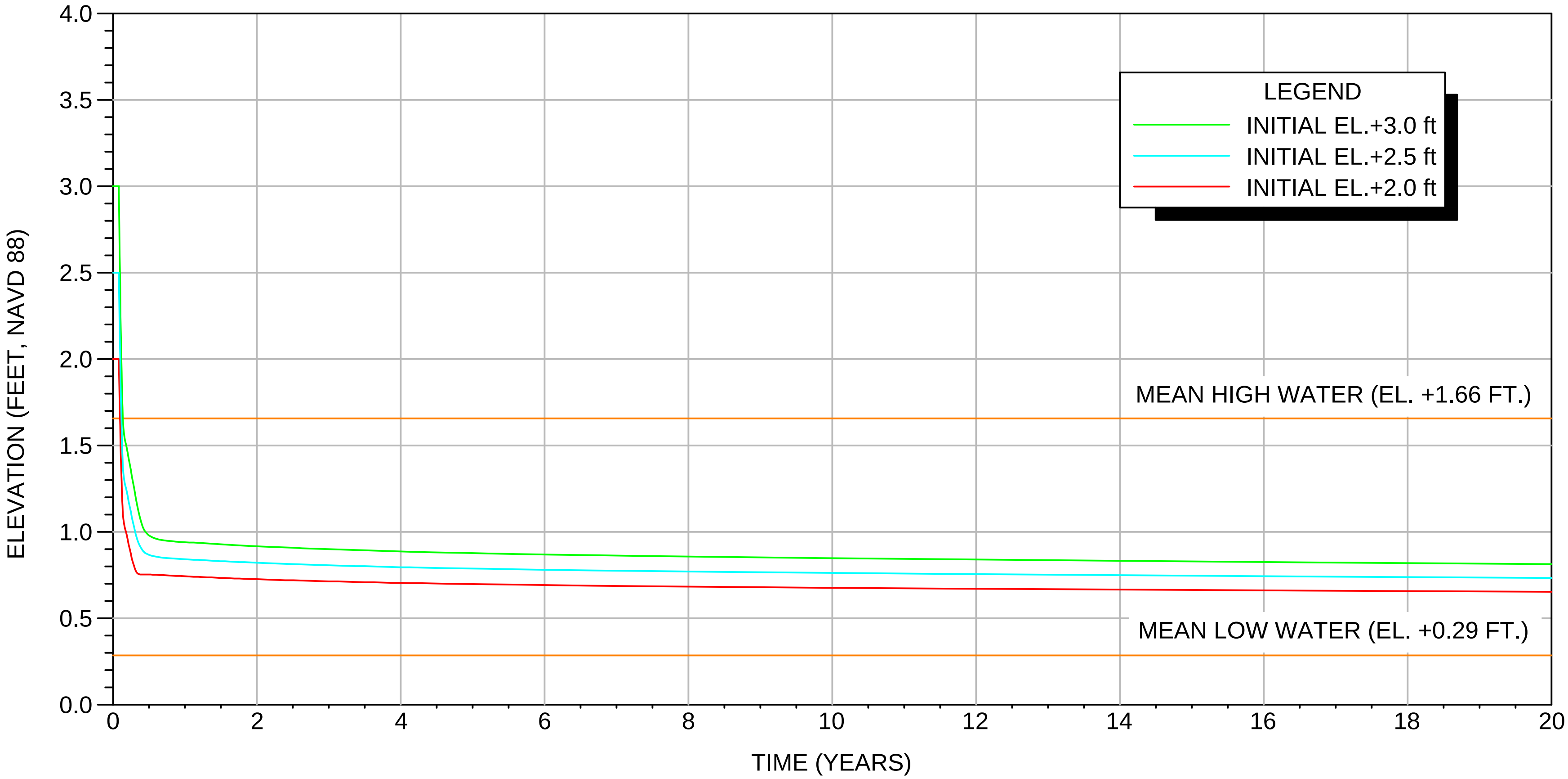
Figure II-A4

PRELIMINARY



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	0.95	0.94	0.92	0.88	0.84	0.81	0.78
2.5	0.85	0.84	0.82	0.79	0.76	0.73	0.71
2.0	0.75	0.74	0.73	0.70	0.67	0.65	0.63

MARSH SETTLEMENT
ELEVATION VS. TIME (B-14)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-A5

PRELIMINARY

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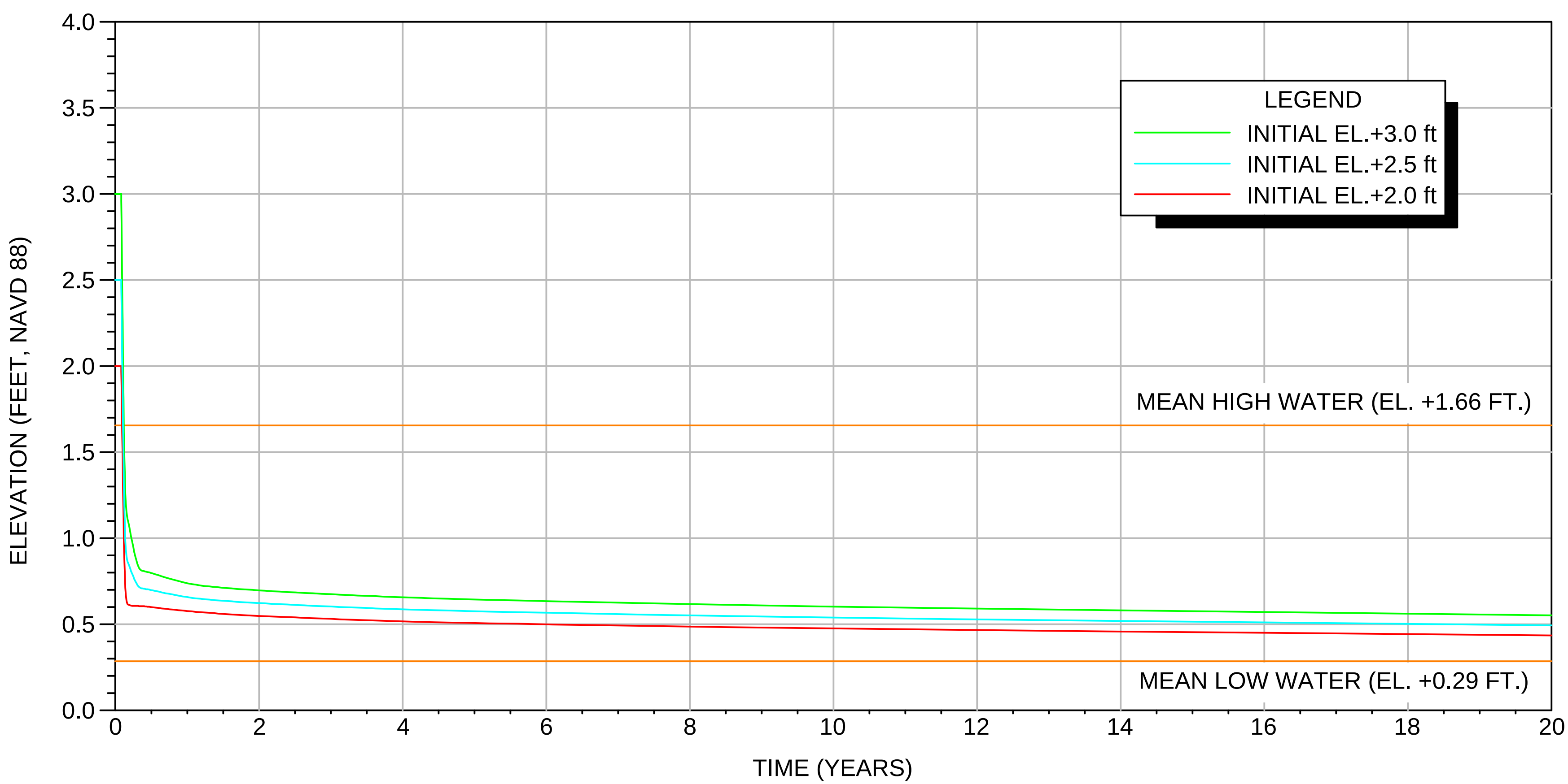

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	0.80	0.72	0.69	0.63	0.58	0.54	0.50
2.5	0.70	0.65	0.62	0.57	0.53	0.49	0.45
2.0	0.60	0.58	0.55	0.51	0.47	0.44	0.40

MARSH SETTLEMENT
ELEVATION VS. TIME (B-15)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-A6

PRELIMINARY

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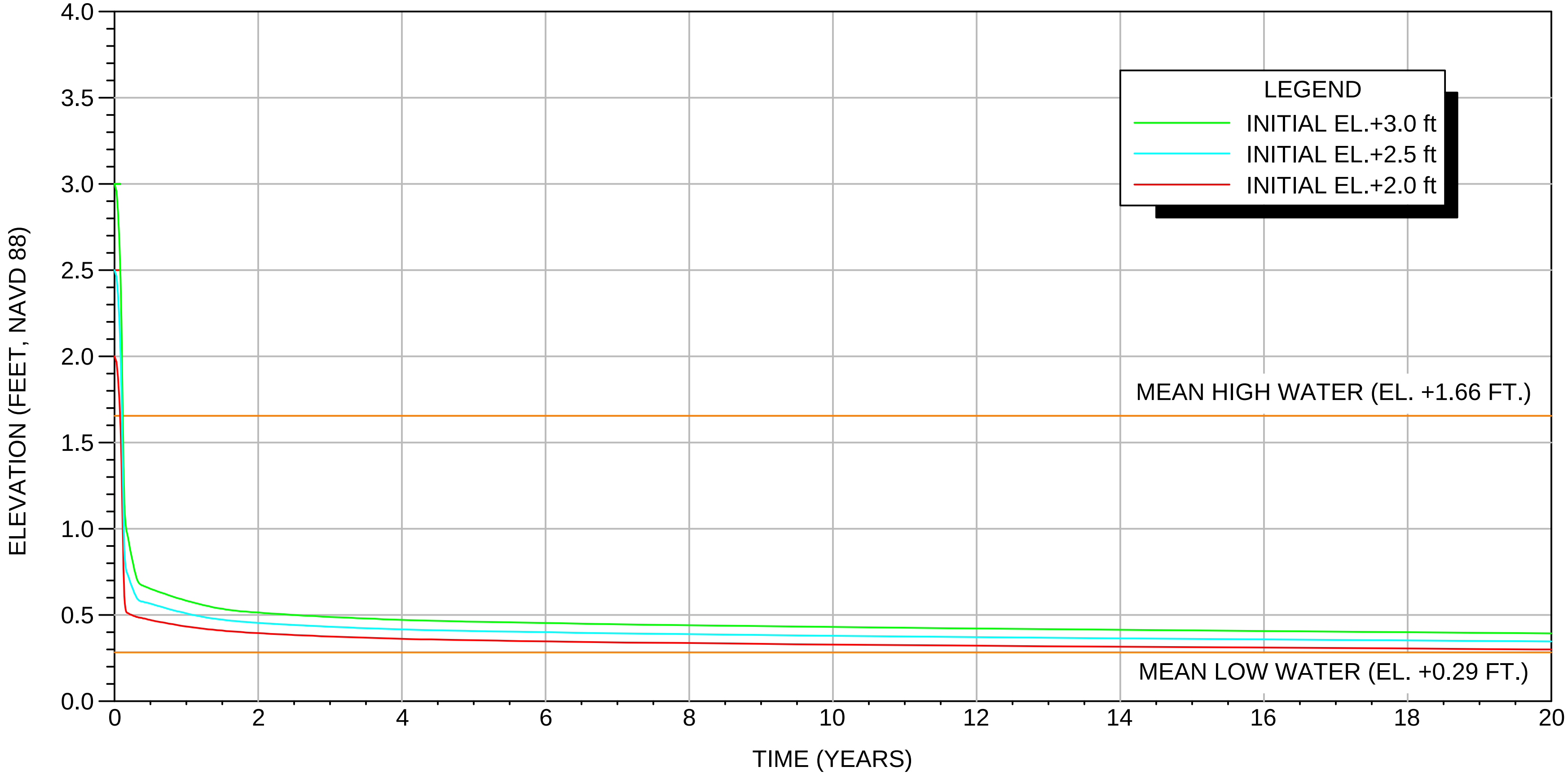

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	0.66	0.58	0.51	0.46	0.43	0.40	0.35
2.5	0.57	0.51	0.45	0.41	0.38	0.35	0.30
2.0	0.47	0.43	0.39	0.35	0.33	0.30	0.26

MARSH SETTLEMENT
ELEVATION VS. TIME (B-16)

Lost Lake Marsh Creation and Hydrologic
Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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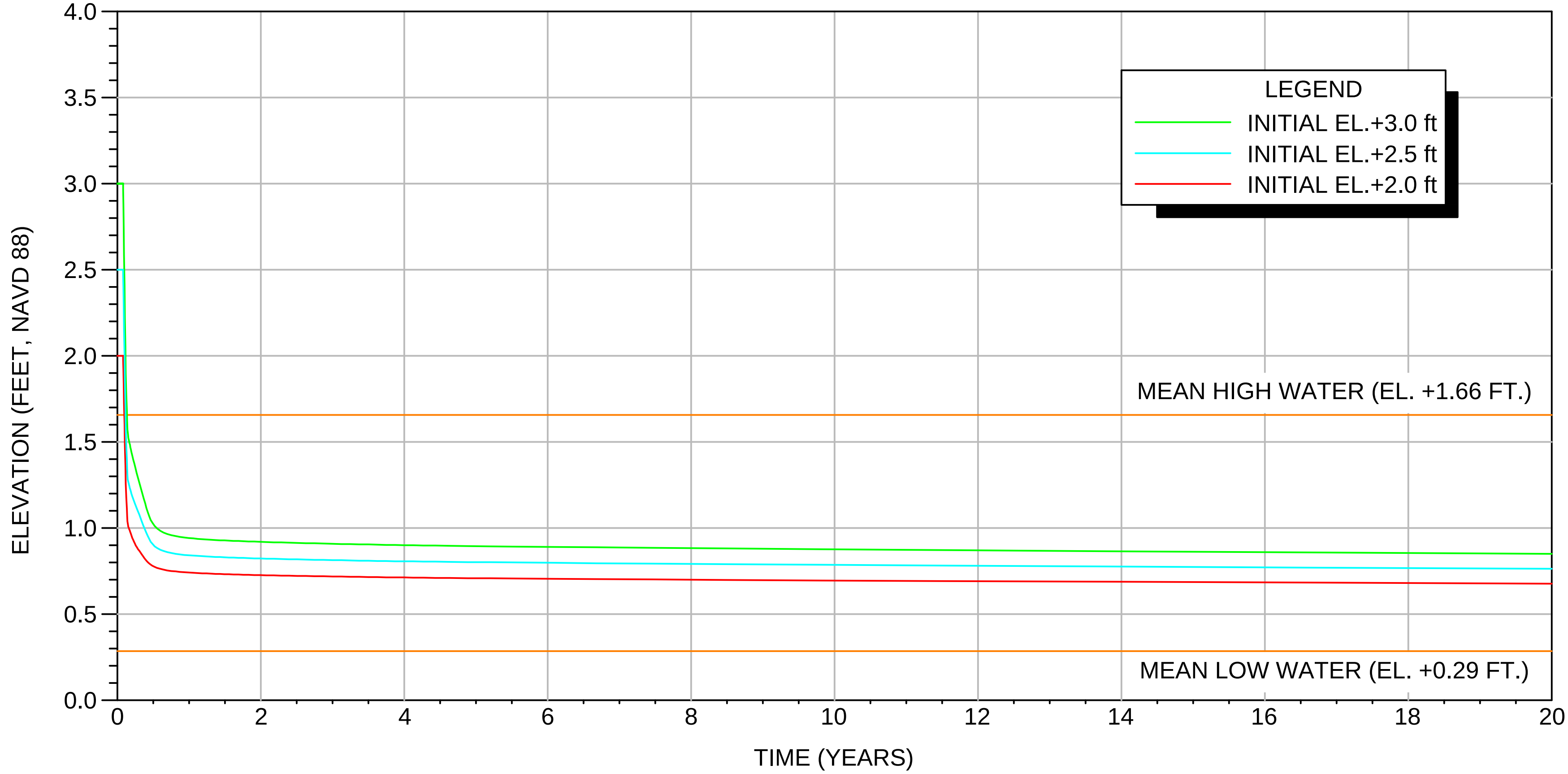
Figure II-A7

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-17 modified on Aug 08, 2011 - 1:09pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	0.97	0.94	0.92	0.89	0.87	0.85	0.83
2.5	0.86	0.84	0.82	0.80	0.78	0.76	0.74
2.0	0.76	0.74	0.73	0.71	0.69	0.68	0.66

MARSH SETTLEMENT
ELEVATION VS. TIME (B-17)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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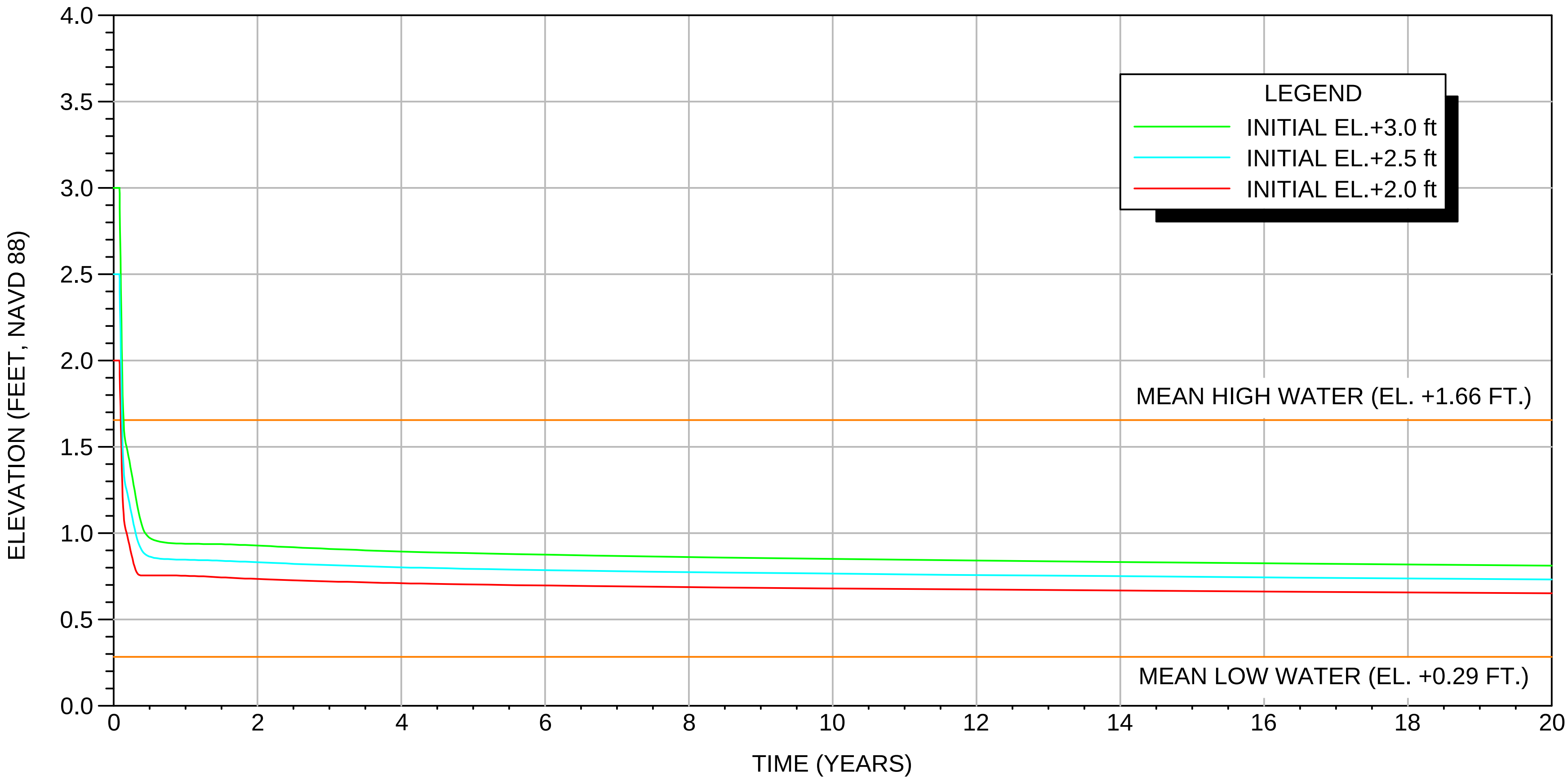
Figure II-A8

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-18 modified on Aug 08, 2011 - 1:09pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
3.0	0.95	0.94	0.93	0.88	0.85	0.81	0.77
2.5	0.85	0.85	0.83	0.79	0.76	0.73	0.70
2.0	0.76	0.76	0.73	0.70	0.68	0.65	0.62

MARSH SETTLEMENT ELEVATION VS. TIME (B-18)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-A9

PRELIMINARY

Calculation Checksheet

Project No. 16715-020-00 Project Title: Lost Lake Marsh Creation

Deliverable Title: Geotechnical Engineering Report

Calculations Description: Fill to cut ratio for dredge fill from borrow area

Originator: C. Eustis/V. Tammineni Checked by: VT / [signature] Date: August 5, 2011

Checking method (describe): Verified parameters and checked analyses

Comments: The fill to cut ratio evaluation was based on settling column and self-weight consolidation tests results, which are included in Appendix I-C, and design guidance in the United States Army Corps of Engineers (USACE) publication EM-1110-2-5027.

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project Lost Lk. - Fill to Cut Ratio project no. 16715-020-00

by [signature] date 5 JUL **PRELIMINARY** sheet 1 of 6 checked by VT

465 acres of marsh creation for this project

$A = 465 \text{ acres} \times 43{,}560 \text{ ft}^2/\text{acre} = 20255400 \text{ ft}^2$

Say el 2 Fill surface + 1' water (est.) = 3' = H   OK

$A \times H = \frac{20255{,}400 \text{ ft}^2 (3')}{27 \text{ ft}^3/\text{yd}^3} = 2{,}250{,}600 \text{ yd}^3$

Say cut to Fill = 1.2 from experience

Vol to be dredged $= 1.2(2{,}250{,}600 \text{ yd}^3) = 2{,}700{,}720 \text{ yd}^3$

Say 24" size dredge cuts 900 yd^3/hr.* for dredge operating 12 hrs/day *

Estimate time for dredging: $\frac{2{,}700{,}720 \text{ yd}^3}{900 \text{ yd}^3/\text{hr}} = 3001 \text{ hrs}$

$= 3001 \text{ hrs} \div 24 \text{ hrs/day}$

$= 125 \text{ days}$

Design solids concentration = Cd

$Cd = 229.17 X^{0.0915}$ From Dr. Moe's report p. 3, Figure 3 where x = days

Use Average of duration of dredging $= \frac{125 \text{ days}}{2} = 62.5 \text{ days}$

$Cd = 229.17(62.5)^{0.0915}$

$Cd = 334.57 \text{ g/L}$

$G_{s\,AVG} = 2.71$ ** from (2.70, 2.71, 2.72) 2.71 = Weavg

$e_0 = \frac{G_s \gamma_w}{Cd} - 1 = \frac{2.71(1000 \text{ g/L})}{334.57 \text{ g/L}} - 1 = 7.10$ OK

* EM 1110-2-5027 30 Sept 87 p. C-15

** From Dr. Zhang's report p 4. Table 2

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project Lost Lk - Fill to Cut Ratio project no. 16715-020-00

by [signature] date 5 JUL PRELIMINARY sheet 2 of 6 checked by VT

B-6, 8, & 9 are Composite Sample CS1, CS2, CS3, respectively

Boring No.	Composite No.	Wc AVG From Boring
B-6	C-1	102.7%
B-8	C-2	99.6%
B-9	C-3	116.4%

} 106.2% = Wc avg

$e_i = \frac{W_c\ avg\ (G_s\ avg)}{S_d}$ Sd = 1.0

$e_i = \frac{1.062\ (2.71)}{1.0} = 2.878$ ✓

predominantly cohesive soils 95%

Vol. Fines = 95% ⇒ .95 (2,700,720 yd³)

Vol. Fines = 2,565,684 yd³

Vol. Sand = 135,036 yd³

$V_{Fill} = V_{Fines} \left[\frac{e_o - e_i}{1 + e_i} + 1 \right]$

$V_{Fill\ Fines} = 2{,}565{,}684\ yd^3 \left[\frac{7.10 - 2.878}{3.878} + 1 \right]$ 2.0887 OK

V Fill Fines = 5,358,945 yd³

V Sand Fill = 135,036 yd³

V Fill TOTAL = 5,493,981 yd³ OK

$\frac{V\ Fill\ TOTAL}{V\ cut} = \frac{5{,}493{,}981\ yd^3}{2{,}700{,}720\ yd^3} = 2.03$ OK project Lost Lk. Bulking Factor (BF) project no. 16715-020-00

by [illegible] date 5 JUL PRELIMINARY sheet ____ of 6 checked by VT

Reference: Handbook of Dredging Engineering
by John B. Herbich
McGraw-Hill, 2nd Edition

p. 1.27 ① Bulking Factor = .005(LL) + 2.66
② " " = .0043(PI) + 2.80
③ " " = .31(LI) + 2.87, $LI = \frac{W_c - PL}{PI}$

From Dr. Zhang's report: 3 tests CS1, CS2, & CS3

B-6 = CS1
① LL = 92.0%, BF = .005(92.0) + 2.66 = 3.12
② PL = 28.7%, BF = .0043(28.7) + 2.80 = 2.92
③ compute LI, BF = .31(1.17) + 2.87 = 3.23
BF_{AVG} = 3.09

W_c = 102.7 from sh.2, $LI = \frac{102.7 - 28.7}{63.3} = 1.17$

B-8 = CS2
① LL = 74%, BF = .005(74.0) + 2.66 = 3.03
② PL = 27.8%, BF = .0043(27.8) + 2.80 = 2.92
③ $LI = \frac{99.6 - 27.8}{46.2} = 1.554$, BF = .31(1.554) + 2.87 = 3.35
BF_{AVG} = 3.10

B-9 = CS3
① LL = 114%, BF = .005(114.0) + 2.66 = 3.23
② PL = 34%, BF = .0043(34.0) + 2.80 = 2.95
③ $LI = \frac{116.4 - 34.0}{80.0} = 1.03$ BF = .31(1.03) + 2.87 = 3.19
BF_{AVG} = 3.12

AVERAGE BF_{AVG} of the 3 borings/Tests

BF = Bulking Factor = $\frac{3.09 + 3.10 + 3.12}{3} = 3.10$

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$C_d = y = 229.17x^{0.0915}$ x = 2 days

$C_d = 229.17(1)^{.0915} = 229.2$ g/L

$e_o = \frac{G_s \gamma_w}{C_d} - 1 = \frac{2.71(1000 \text{ g/L})}{229.2 \text{ g/L}} - 1 = 10.82$

$e_i = \frac{1.062(2.71)}{1.0} = 2.878$ (as before)

$V_{Fill} = V_{Fines}\left[\frac{e_o - e_i}{1 + e_i} + 1\right]$

$V_{Fill} = 2{,}565{,}684 \text{ yd}^3 \left[\frac{10.82 - 2.878}{3.878} + 1\right]$ 3.048

$V_{Fill_{Fines}} = 7{,}820{,}110 \text{ yd}^3$

V_{sand} 135,036 yd³

$V_{fill_{TOTAL}}$ = 7,955,146 yds

$\frac{V_{Fill\ TOTAL}}{V_{cut}} = \frac{7{,}955{,}146 \text{ yd}^3}{2{,}700{,}720 \text{ yds}} = 2.94$

<u>Note</u> Bulking Factor = 3.10 (p. 3) compares to fill to cut ratio of 2.94 @ 2 days time

For $x = \frac{30}{2}$ days. = 15 days. (avg.)

$C_d = 229.17x^{0.0915}$

$= 229.17(15)^{0.0915} = 293.61 \text{ g/L}$

$e_0 = \frac{G_s \gamma_w}{C_d} - 1 = \frac{2.71\ (1000\ \text{g/L})}{293.61} - 1 = 8.23$

$e_i = \frac{1.062 \times 2.71}{1.0} = 2.878$ (as before)

$V_{Fill} = V_{fines}\left[\frac{e_0 - e_i}{1+e_i} + 1\right] = 2{,}565{,}684\ \text{yd}^3 \left[\frac{8.23 - 2.878}{3.878} + 1\right]$

$= 2.38 \times 2565684 = 6{,}106{,}566\ \text{yd}^3$

$V_{sand} = 135{,}036\ \text{yd}^3$

$V_{Fill\ Total} = 6{,}106{,}566 + 135{,}036 = 6{,}241{,}602\ \text{yd}^3$

$\frac{V_{Fill\ Total}}{V_{cut}} = \frac{6{,}241{,}602\ \text{yd}^3}{2{,}700{,}720\ \text{yd}^3} = 2.31$

60 days

$x = \frac{60}{2} = 30$ days.

$C_d = 229.17\, x^{0.0915} = 312.83\ \text{g/L}$

$e_i = 2.878$ (as before)

$e_0 = \frac{G_s \gamma_w}{C_d} - 1 = \frac{2.7 \times 1000}{312.83} - 1 = 7.6$

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$$V_{\text{Fill fines}} = V_{\text{fines}} \left[\frac{e_o - e_i}{1+e_i} + 1 \right] = 2,565,684 \text{ yd}^3 \left[\frac{7.6 - 2.878}{3.878} + 1 \right]$$

$$= 5,689,758 \text{ yd}^3$$

$$V_{\text{sand}} = 135,036 \text{ yd}^3$$

$$V_{\text{Fill Total}} = 5,824,794 \text{ yd}^3$$

$$\frac{V_{\text{Fill}}}{V_{\text{cut}}} = \frac{5824794}{2700720} = 2.16$$

PRELIMINARY

Appendix II-B
Slope Stability and Settlement Analyses for Containment Dike

PRELIMINARY

Calculation Checksheet

Project No. 16715-020-00 Project Title: Lost Lake Marsh Creation

Deliverable Title: Geotechnical Engineering Report

Calculations Description: Settlement, Time Rate Settlement and Slope Stability Analyses for Dike Fill.

Originator: S. Malla Checked by: V. Tammineni Date: August 4, 2011

Checking method (describe): Verified parameters and checked computations

Comments: Settlement calculations were performed using a settlement analysis program based on one-dimensional consolidation theory. Soil settlement characteristics were determined based on soil properties, published correlations, and correlations developed based on this and other coastal projects. Time rate of settlement was estimated using spreadsheet calculations based on published equations. Spencer's method of slope stability analyses were done by using the SLOPE/W program.

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PRELIMINARY

Slope Stability Calculation Approach for the Containment Dike
Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)

1. A total of 9 borings (Boring 7, 11 through 18) were considered for checking the slope stability of the containment dikes.

2. Subsurface profiles for each boring were developed based on shear strength, unit weight, and moisture content.

3. The following dimensions, slopes and elevations were used to start the slope stability analyses of the dikes:
    i. Dike slopes of 3H:1V
    ii. Crown width of 5 feet
    iii. Bench width (distance between toe of the dike and excavation access channel) of 15 feet.
    iv. Excavation slope of 3H:1V from the mudline to excavation bottom
    v. Elevations of dike crown, phreatic surface, and excavation bottom are +4.0 feet, +1 foot and -10 feet, NAVD 88, respectively.
    vi. For borings 7, 11 and 12, a mudline elevation of El 0 feet, NAVD88 was assumed and for borings 13 thru 18, El -1.5 feet, NAVD 88 was assumed.

4. The results of our analyses indicate that the dimensions, slopes and elevation mentioned above will provide a factor of safety greater than 1.2 for the dikes in all profiles.

GeoEngineers performed stability analyses for the dikes using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory to evaluate the stability of earth slopes. Subsurface soil properties were estimated using the results of subsurface explorations and associated laboratory testing. The factor of safety for the earthen embankment for various slopes was analyzed using the Spencer method. The Spencer method considers both shear and normal interslice forces. The method involves a circular search and takes into account both moment and force equilibrium.

PRELIMINARY

Settlement Calculation Approach for the Dike
Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)

1. Based on the transects provided by OCPR, mudline elevation for borings 7, 11 and 12 was assumed to be at El 0.0 feet, NAVD 88 and that for borings 13 thru 18 at El -1.5 feet, NAVD 88. The dike crown and the phreatic surface were assumed to be at El +4 feet, NAVD 88 and El +1 feet, NAVD 88, respectively.

2. Settlement parameters were developed for each soil layer for borings 7 and 11 thru 18. The following description explains how the parameters were developed.
   (a) One consolidation test was done for each soil boring and the samples for the consolidation test were selected from varying depths and materials.
   (b) A total of 9 consolidation test results were analyzed and graphs were reconstructed to determine compression (C_c), recompression (C_r) and vertical consolidation (C_v) coefficients, initial void ratios (e_0) and maximum past pressures (P_c).
   (c) Correlations presented in equations 1 through 4 (shown in the attached spreadsheets) were used to calculate e_0, C_c and C_r for the soil layers without a representative consolidation test.
   (d) C_v for all the soil layers were obtained depending upon the moisture content from a best fit curve shown herewith this calculation package. The best fit curve was drawn through the plotted C_v points obtained from the consolidation tests of this and previous coastal projects done by GeoEngineers.
   (e) Past previous pressures (P_c) for the soil layers were estimated from the equation $P_c = [[C_u/ (P'_0 *0.22)]^{(10/8)}]* P'_0$, where P'_0 is the effective overburden pressure. For the soil layers with a representative consolidation test, P_c was selected by analyzing the values obtained from the equation and the test.

3. It was assumed that the clay shear strength for a normally consolidated soil profile for this project to be approximately 22% of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles. Based on this relationship, it appears that approximately top 15 feet of the soil profile is slightly over-consolidated in all borings used for settlement analyses. This affected P_c selected for design within this zone.

4. For calculation of pressures at borings 7, 11 and 12, an effective dike unit weight was calculated based on 3 feet at 85 pounds per cubic foot (pcf) and 1 foot at 22.6 pcf (the buoyant unit weight of the dike). For borings 13 thru 18 pressures, an effective dike unit weight was calculated based on 3 feet at 85 pounds per cubic foot (pcf) and 2.5 feet at 22.6 pcf.

5. Effective load distribution was considered for the terrace and dikes. The stressed zone was assumed to extend below the loaded area at 1H: 2V to El -60 feet, NAVD 88, approximately.

6. Drainage path to the phreatic surface or to the nearest granular soil layer or out of the 1H: 2V stress-zone was analyzed for all the soil layers. The presence of small sand and silt layers within clay was also considered in the drainage path evaluation. Drainage distance of a soil layer was selected such that the time it would take for the pore water to drain out following that drainage path was the least one.

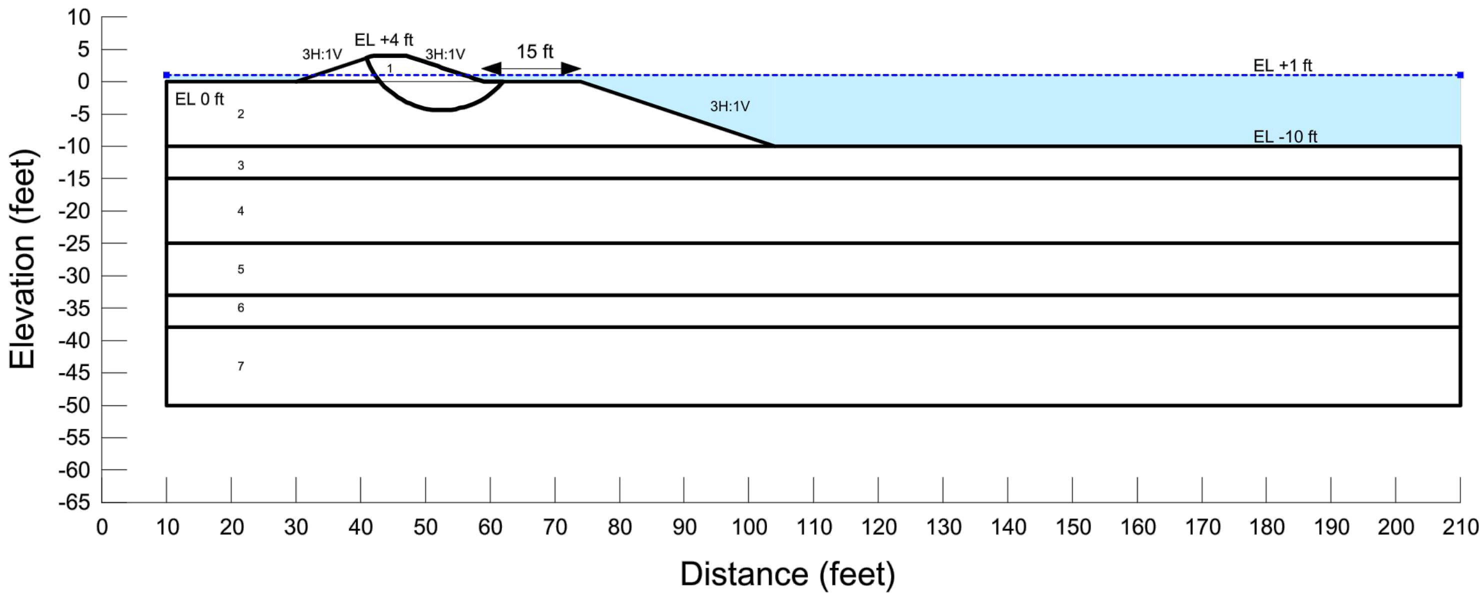
7. The SETANL program was used for the calculation of settlement of dikes based on settlement parameters mentioned above. The program calculates settlement based on Terzaghi's one dimensional linear consolidation theory and the program outputs are included with the settlement calculation package. The time rate settlements for all dikes were calculated using a spreadsheet as shown in the calculation package.

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SLOPE STABILITY.dwg\TAB:B1 modified on Aug 08, 2011 - 1:02pm VT : KMC

Name: 1. Containment Dike Fill Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Organic Clay - 1 Unit Weight: 86 pcf Cohesion: 80 psf Phi: 0 °
Name: 3. Organic Clay - 2 Unit Weight: 86 pcf Cohesion: 120 psf Phi: 0 °
Name: 4. Clay - 1 Unit Weight: 100 pcf Cohesion: 120 psf Phi: 0 °
Name: 5. Clay - 2 Unit Weight: 100 pcf Cohesion: 180 psf Phi: 0 °
Name: 6. Organic Clay - 3 Unit Weight: 100 pcf Cohesion: 150 psf Phi: 0 °
Name: 7. Clay - 3 Unit Weight: 100 pcf Cohesion: 150 psf Phi: 0 °

FOS: 1.61



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-7

Lost Lake Marsh Creation and Hydrologic
Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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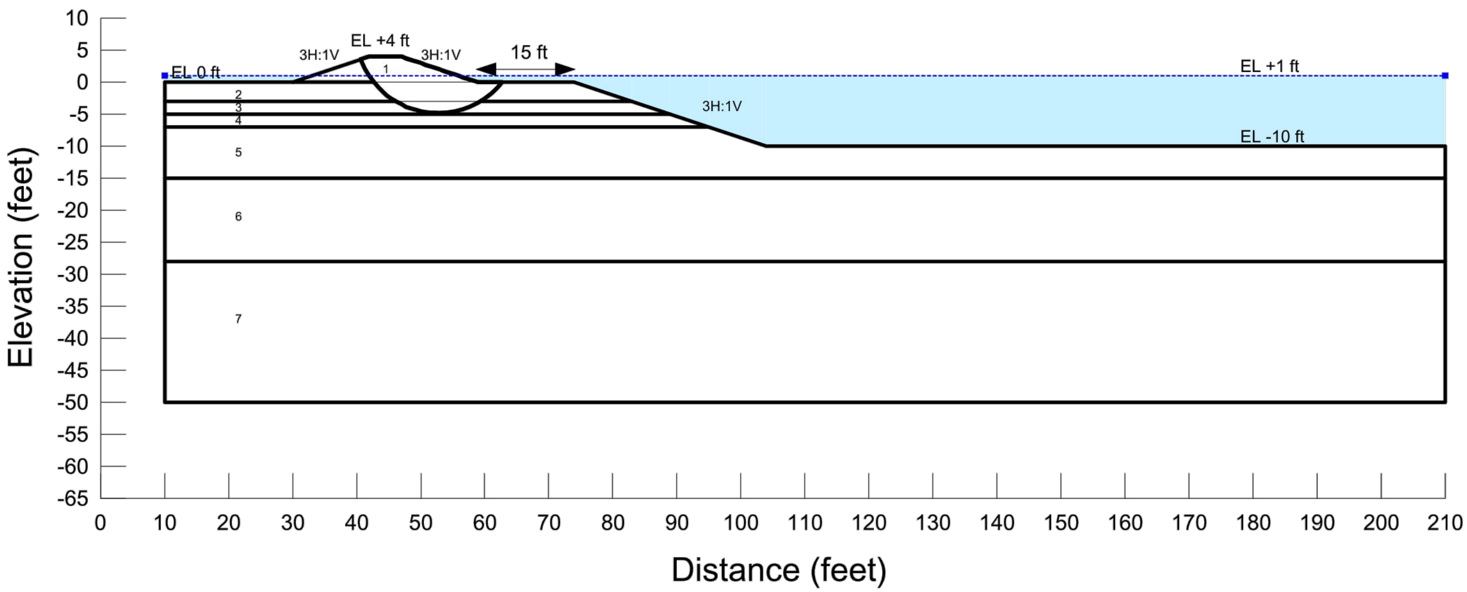
Figure II-B1

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SLOPE STABILITY.dwg\TAB:B2 modified on Aug 08, 2011 - 1:02pm VT : KMC

Name: 1. Containment Dike Fill Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Peat-1 Unit Weight: 69 pcf Cohesion: 100 psf Phi: 0 °
Name: 3. Organic Clay - 1 Unit Weight: 84 pcf Cohesion: 60 psf Phi: 0 °
Name: 4. Clay - 1 Unit Weight: 100 pcf Cohesion: 180 psf Phi: 0 °
Name: 5. Clay - 2 Unit Weight: 115 pcf Cohesion: 180 psf Phi: 0 °
Name: 6. Clay - 3 Unit Weight: 115 pcf Cohesion: 140 psf Phi: 0 °
Name: 7. Clay - 4 Unit Weight: 105 pcf Cohesion: 350 psf Phi: 0 °

FOS: 1.55



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-11

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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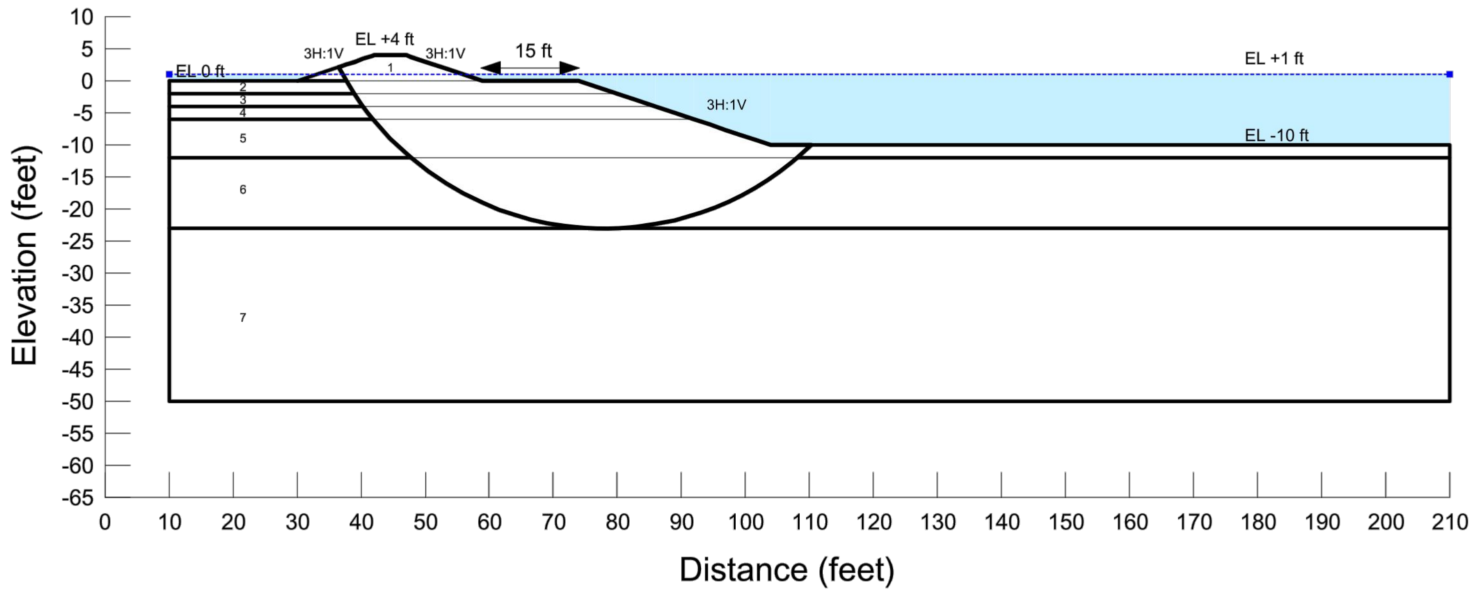
Figure II-B2

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SLOPE STABILITY.dwg\TAB:B3 modified on Aug 08, 2011 - 1:02pm VT : KMC

Name: 1. Containment Dike Fill Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Clay-1 Unit Weight: 105 pcf Cohesion: 370 psf Phi: 0 °
Name: 3. OL-1 Unit Weight: 80 pcf Cohesion: 110 psf Phi: 0 °
Name: 4. Peat Unit Weight: 80 pcf Cohesion: 110 psf Phi: 0 °
Name: 5. Clay - 2 Unit Weight: 92 pcf Cohesion: 80 psf Phi: 0 °
Name: 6. Clay -3 Unit Weight: 92 pcf Cohesion: 80 psf Phi: 0 °
Name: 7. Clay - 4 Unit Weight: 92 pcf Cohesion: 170 psf Phi: 0 °

FOS: 1.27



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-12

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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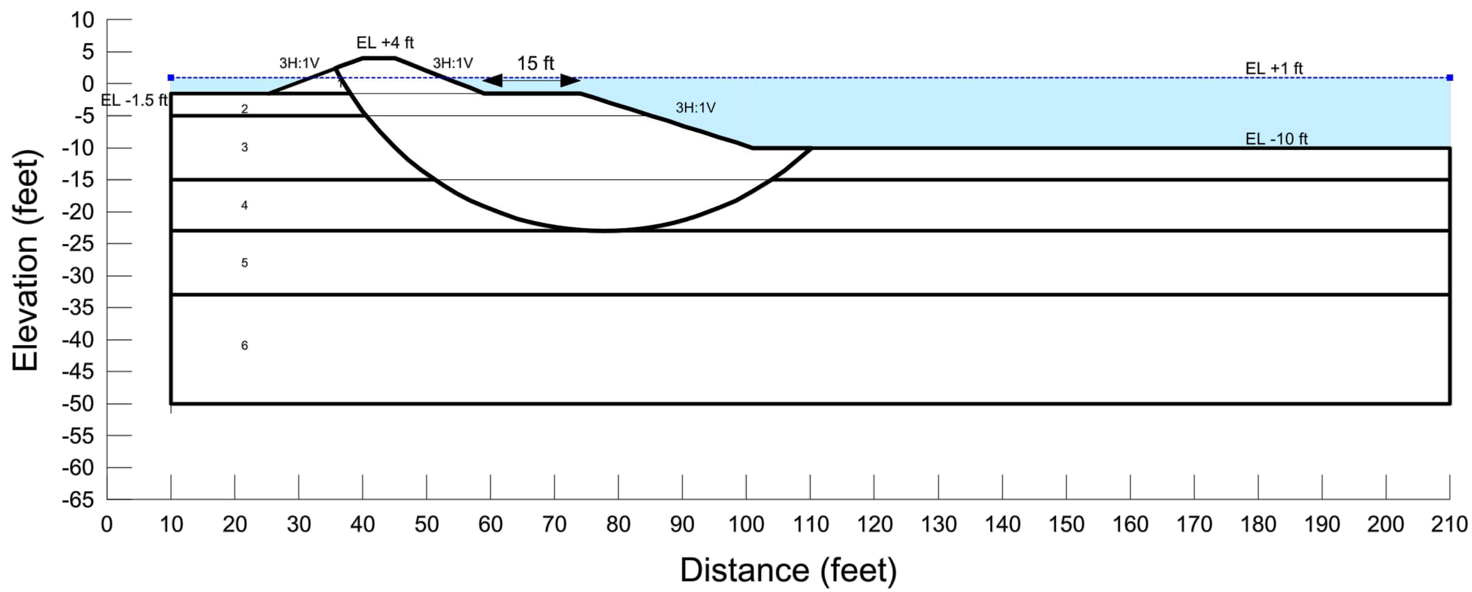
Figure II-B3

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SLOPE STABILITY.dwg\TAB:B4 modified on Aug 08, 2011 - 1:02pm VT : KMC

Name: 1. Containment Dike Fill Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Clay-1 Unit Weight: 105 pcf Cohesion: 190 psf Phi: 0 °
Name: 3. Clay - 2 Unit Weight: 117 pcf Cohesion: 190 psf Phi: 0 °
Name: 4. Clay - 3 Unit Weight: 117 pcf Cohesion: 150 psf Phi: 0 °
Name: 5. Clay - 4 Unit Weight: 108 pcf Cohesion: 450 psf Phi: 0 °
Name: 6. Clay - 5 Unit Weight: 108 pcf Cohesion: 300 psf Phi: 0 °

FOS: 1.73



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-13

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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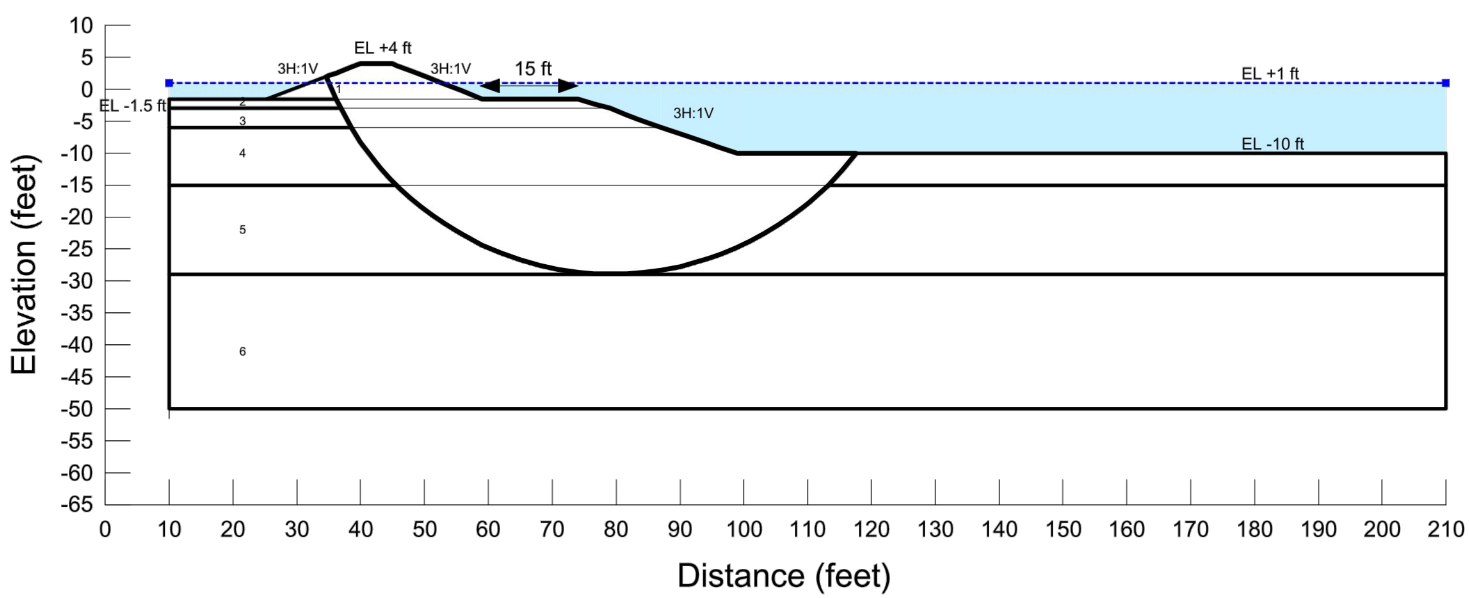
Figure II-B4

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SLOPE STABILITY.dwg\TAB:B5 modified on Aug 08, 2011 - 1:02pm VT : KMC

Name: 1. Containment Dike Fill Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Clay-1 Unit Weight: 105 pcf Cohesion: 150 psf Phi: 0 °
Name: 3. Clay - 2 Unit Weight: 105 pcf Cohesion: 150 psf Phi: 0 °
Name: 4. Clay - 3 Unit Weight: 105 pcf Cohesion: 210 psf Phi: 0 °
Name: 5. Clay - 4 Unit Weight: 105 pcf Cohesion: 110 psf Phi: 0 °
Name: 6. Clay - 5 Unit Weight: 105 pcf Cohesion: 330 psf Phi: 0 °

FOS: 1.42



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-14	
Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72) Terrebonne Parish, Louisiana	
GEOENGINEERS	Figure II-B5

PRELIMINARY

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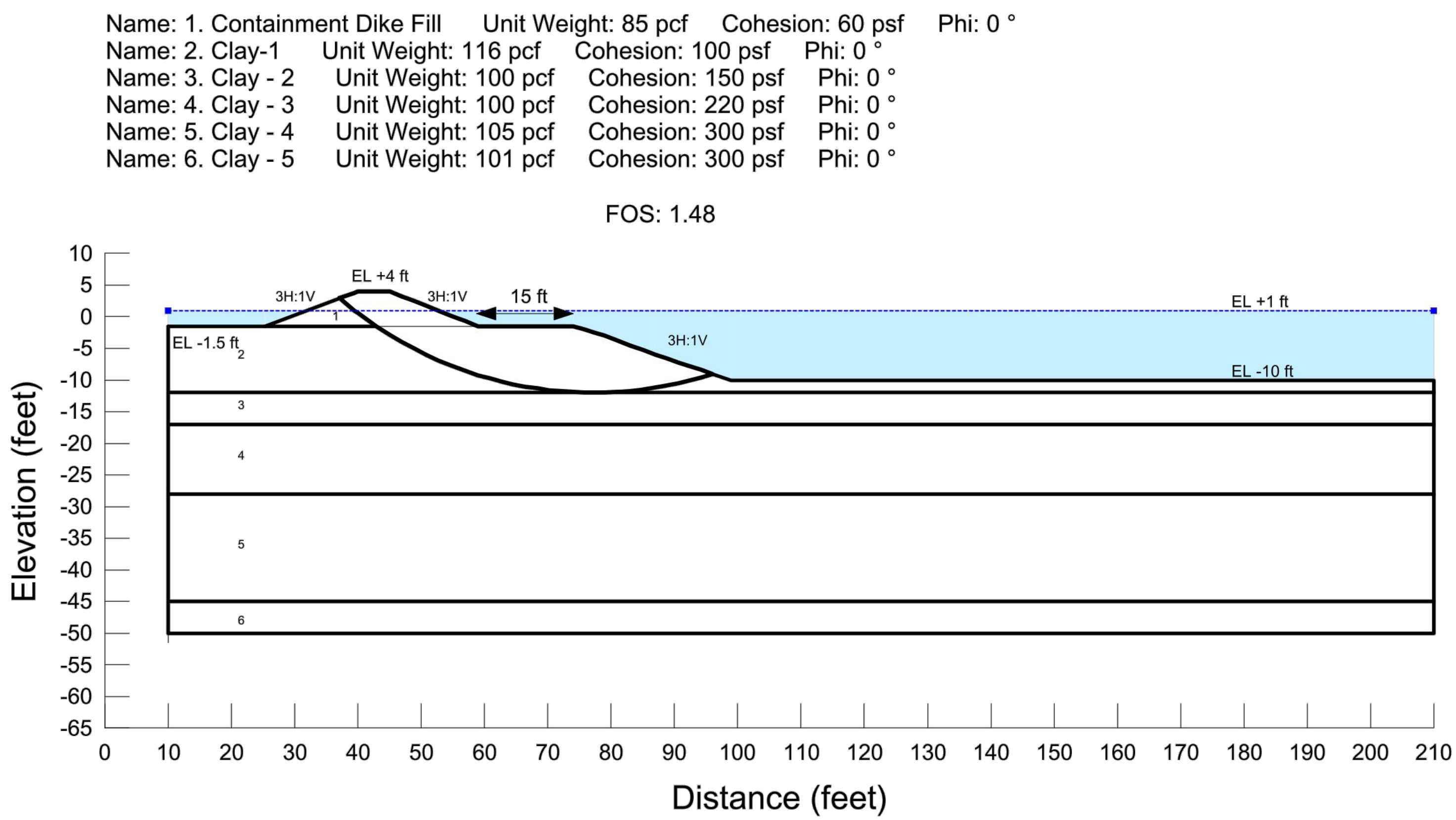

CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-15

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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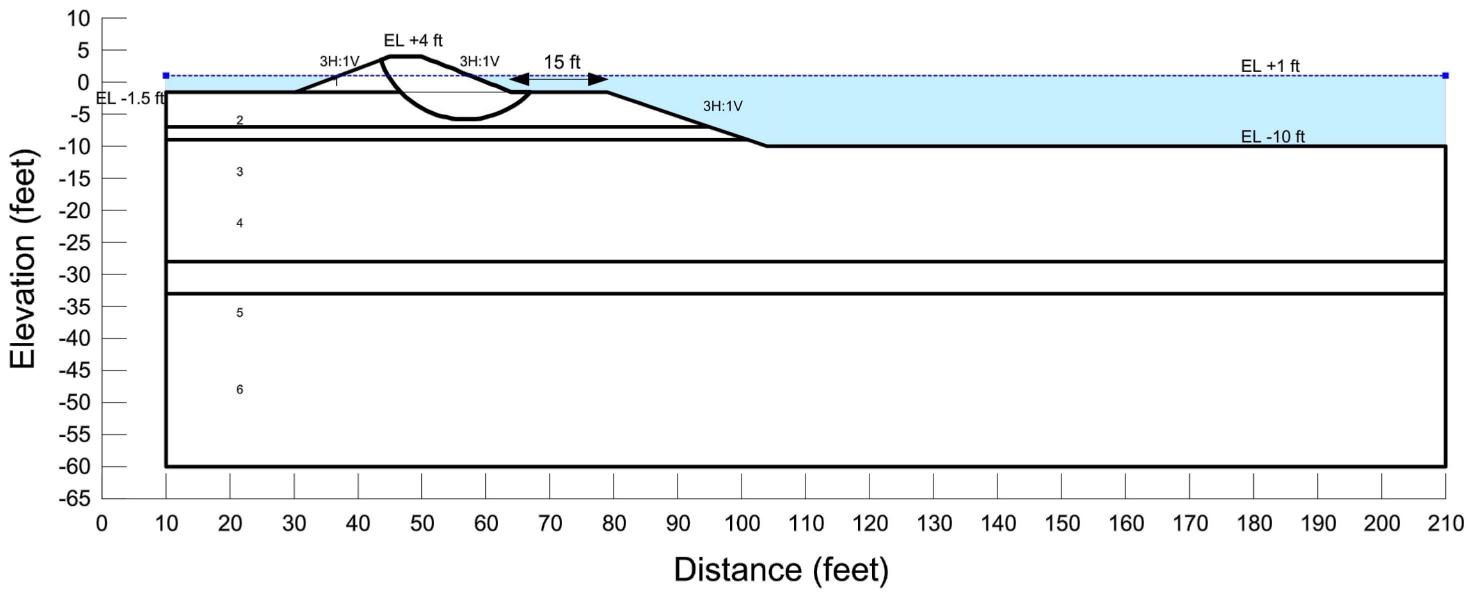
Figure II-B6

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SLOPE STABILITY.dwg\TAB:B7 modified on Aug 08, 2011 - 1:02pm VT : KMC

Name: 1. Earthen Terrace Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Peat - 1 Unit Weight: 85 pcf Cohesion: 90 psf Phi: 0 °
Name: 3. Organic Clay - 1 Unit Weight: 92 pcf Cohesion: 190 psf Phi: 0 °
Name: 4. Clay - 1 Unit Weight: 102 pcf Cohesion: 190 psf Phi: 0 °
Name: 5. Peat - 2 Unit Weight: 72 pcf Cohesion: 150 psf Phi: 0 °
Name: 6. Clay -2 Unit Weight: 85 pcf Cohesion: 150 psf Phi: 0 °

FOS: 1.56



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-16

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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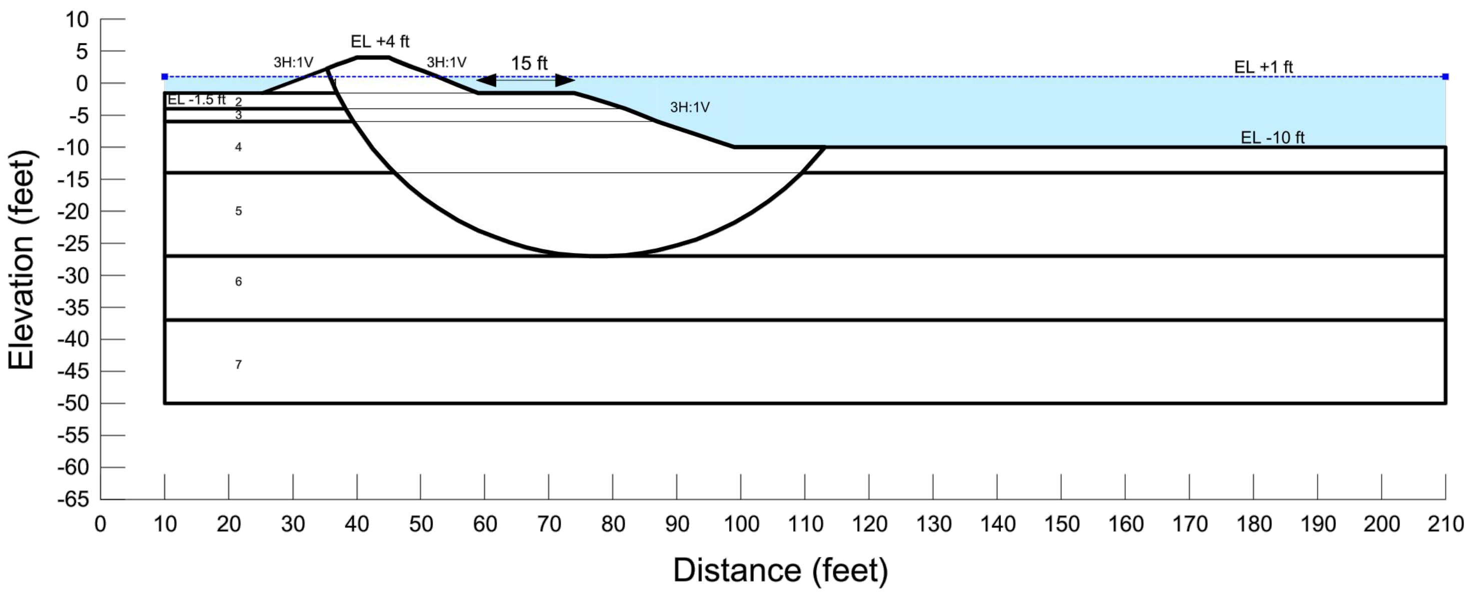
Figure II-B7

PRELIMINARY

Name: 1. Containment Dike Fill Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Organic Clay - 1 Unit Weight: 95 pcf Cohesion: 100 psf Phi: 0 °
Name: 3. Organic Clay - 2 Unit Weight: 101 pcf Cohesion: 160 psf Phi: 0 °
Name: 4. Clay - 1 Unit Weight: 115 pcf Cohesion: 160 psf Phi: 0 °
Name: 5. Clay - 2 Unit Weight: 110 pcf Cohesion: 200 psf Phi: 0 °
Name: 6. Organic Clay -3 Unit Weight: 97 pcf Cohesion: 250 psf Phi: 0 °
Name: 7. Peat - 1 Unit Weight: 79 pcf Cohesion: 250 psf Phi: 0 °

FOS: 2.09



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-17

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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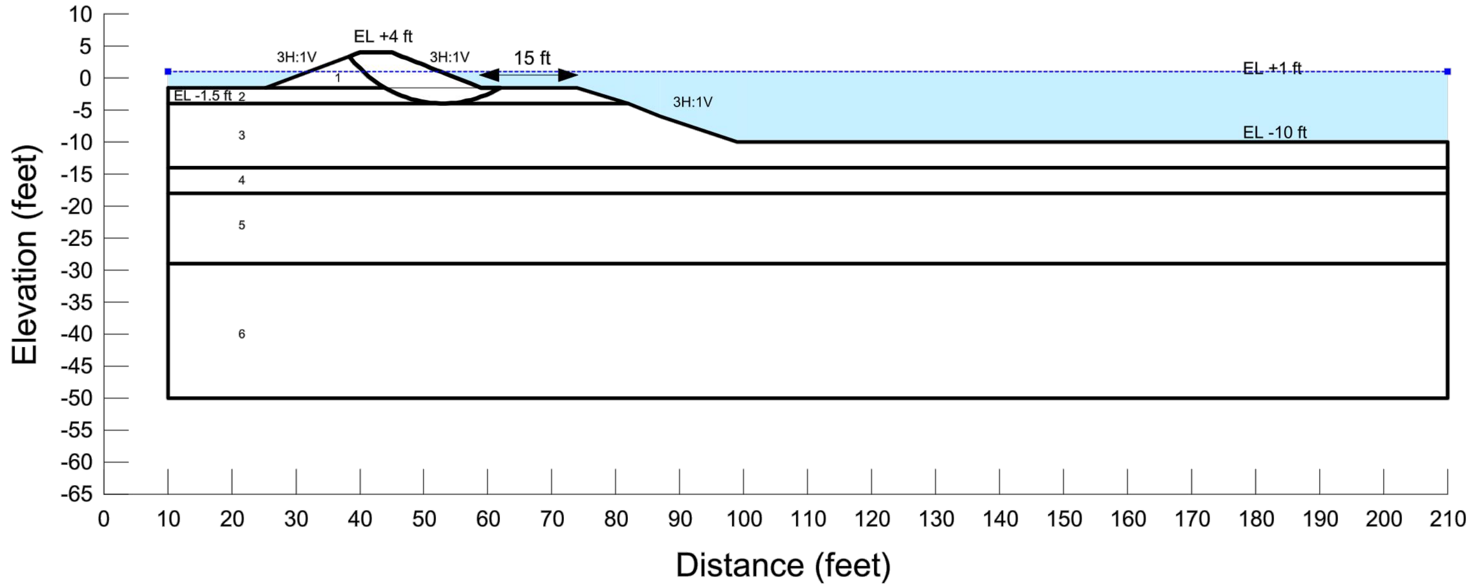
Figure II-B8

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SLOPE STABILITY.dwg\TAB:B9 modified on Aug 08, 2011 - 1:02pm VT : KMC

Name: 1. Containment Dike Fill Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Organic Clay - 1 Unit Weight: 85 pcf Cohesion: 100 psf Phi: 0 °
Name: 3. Clay - 1 Unit Weight: 105 pcf Cohesion: 150 psf Phi: 0 °
Name: 4. Sand Unit Weight: 120 pcf Cohesion: 0 psf Phi: 20 °
Name: 5. Clay - 2 Unit Weight: 100 pcf Cohesion: 180 psf Phi: 0 °
Name: 6. Organic Clay -2 Unit Weight: 80 pcf Cohesion: 150 psf Phi: 0 °

FOS: 1.78



CONTAINMENT DIKE SLOPE STABILITY EVALUATION - B-18

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-B9

PRELIMINARY

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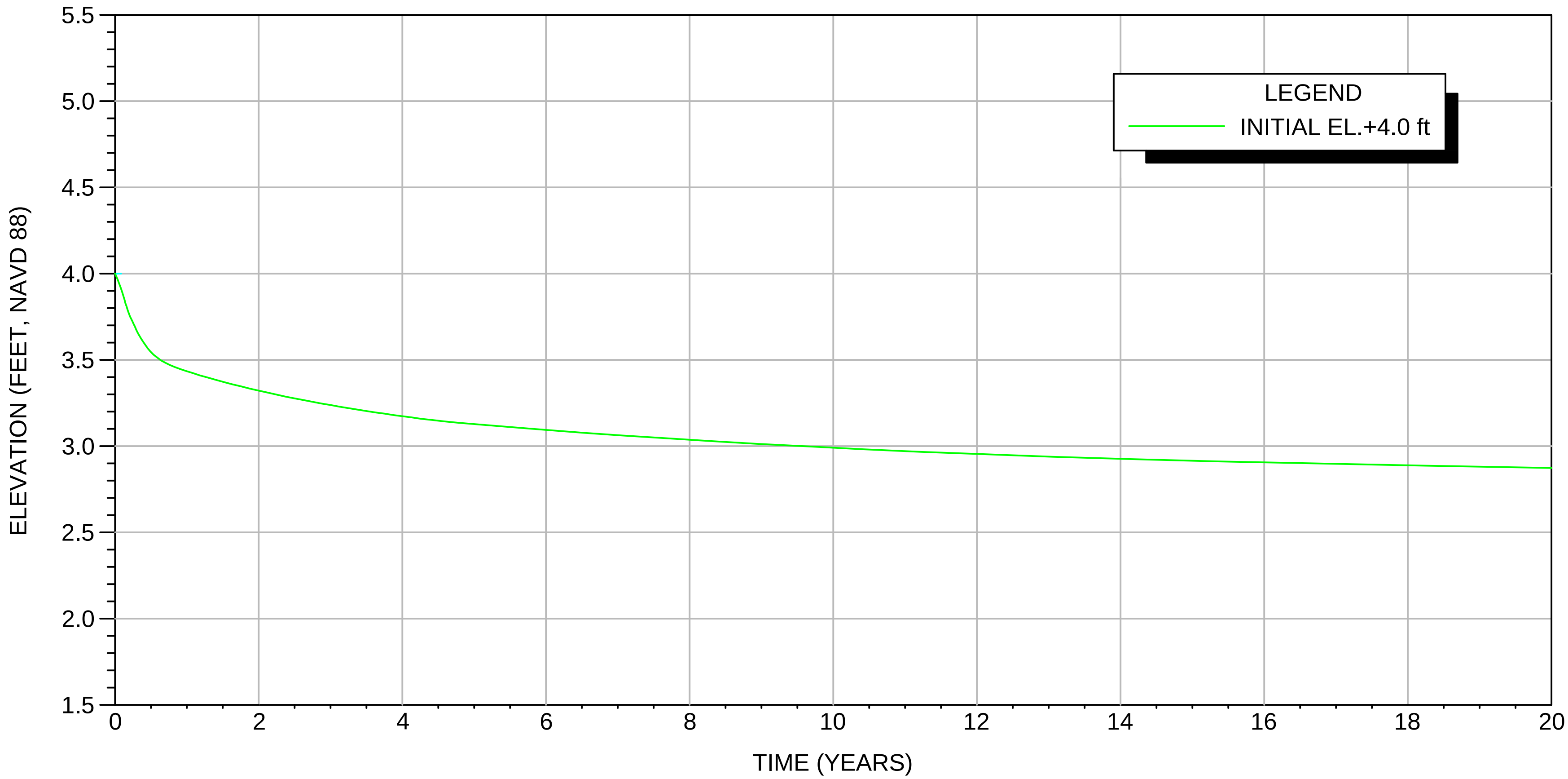

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.51	3.42	3.31	3.12	2.96	2.87	2.82

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-7)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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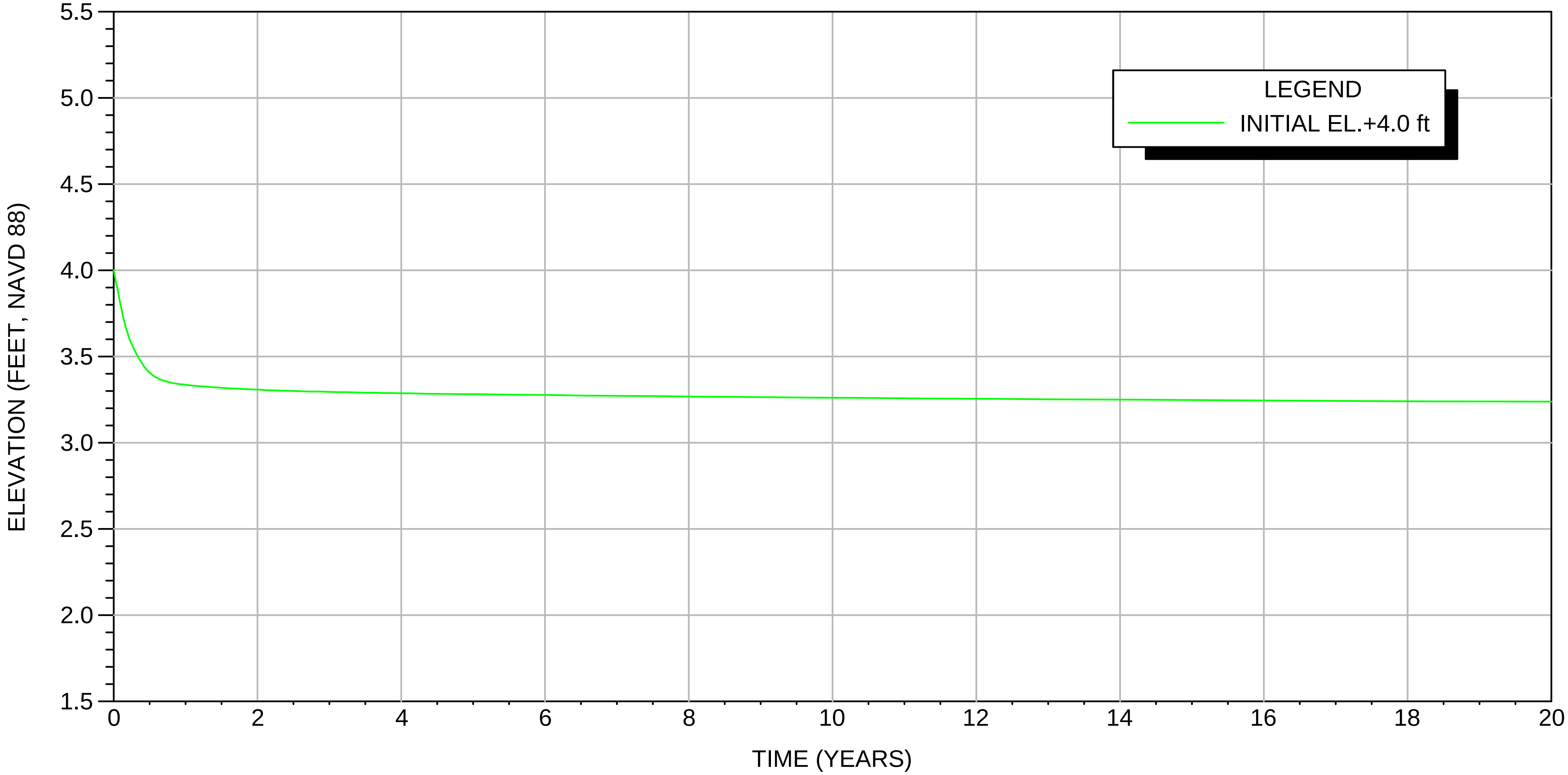
Figure II-B10

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-11 CD modified on Aug 08, 2011 - 1:10pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.37	3.33	3.31	3.28	3.26	3.24	3.22

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-11)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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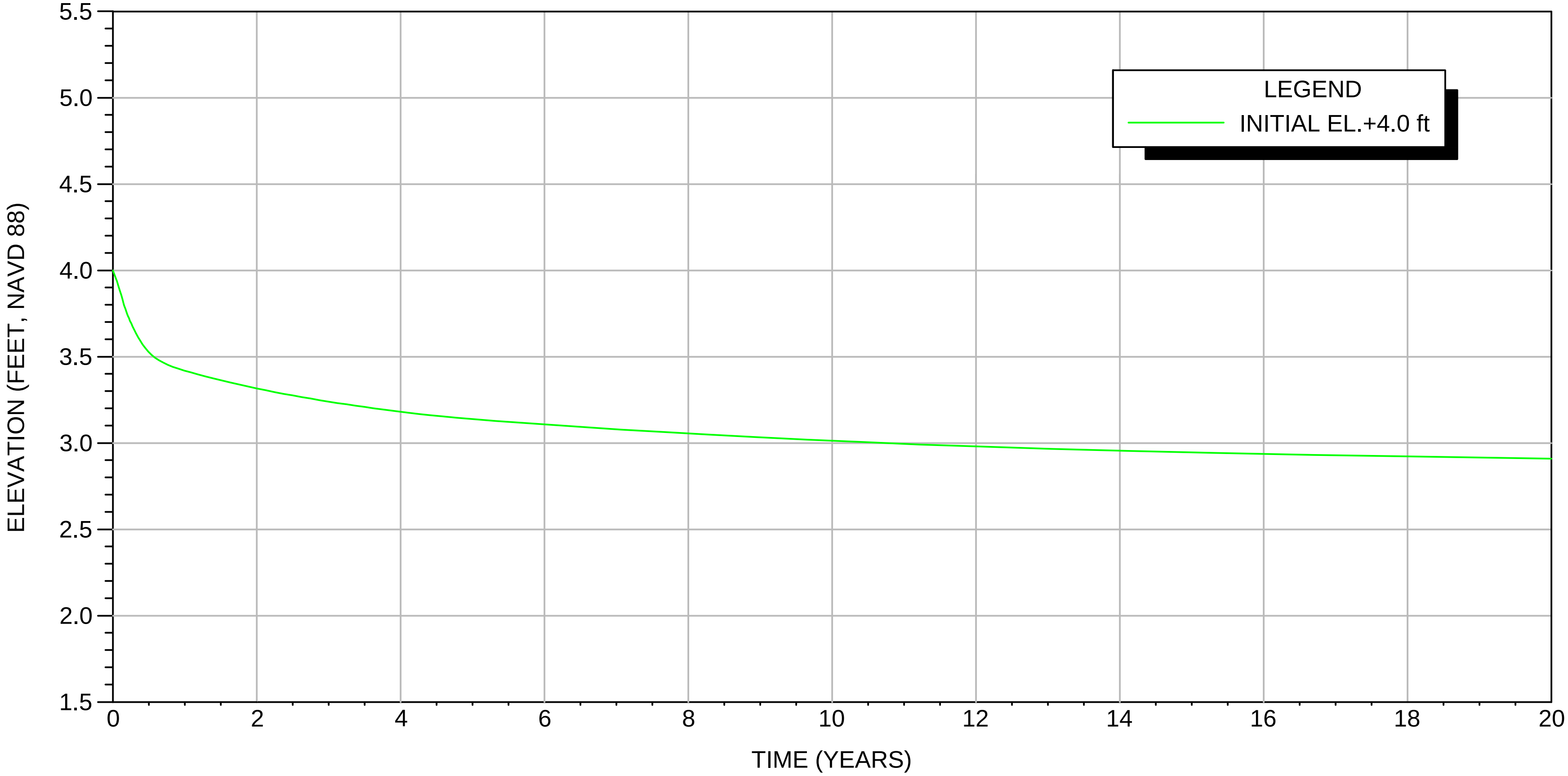
Figure II-B11

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-12 CD modified on Aug 08, 2011 - 1:10pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.49	3.41	3.31	3.13	3.00	2.91	2.82

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-12)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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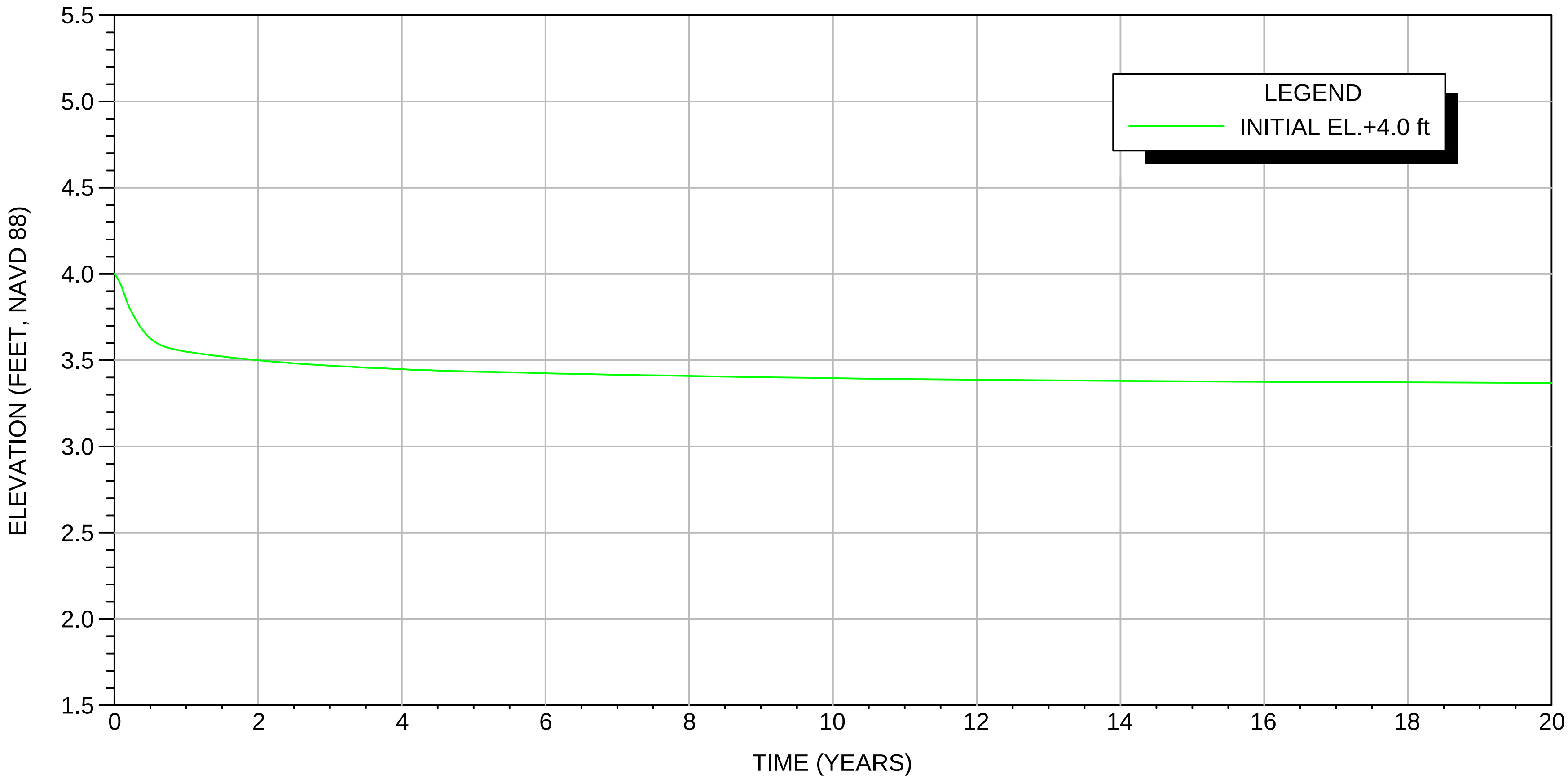
Figure II-B12

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-13 CD modified on Aug 08, 2011 - 1:10pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.59	3.55	3.50	3.43	3.39	3.37	3.36

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-13)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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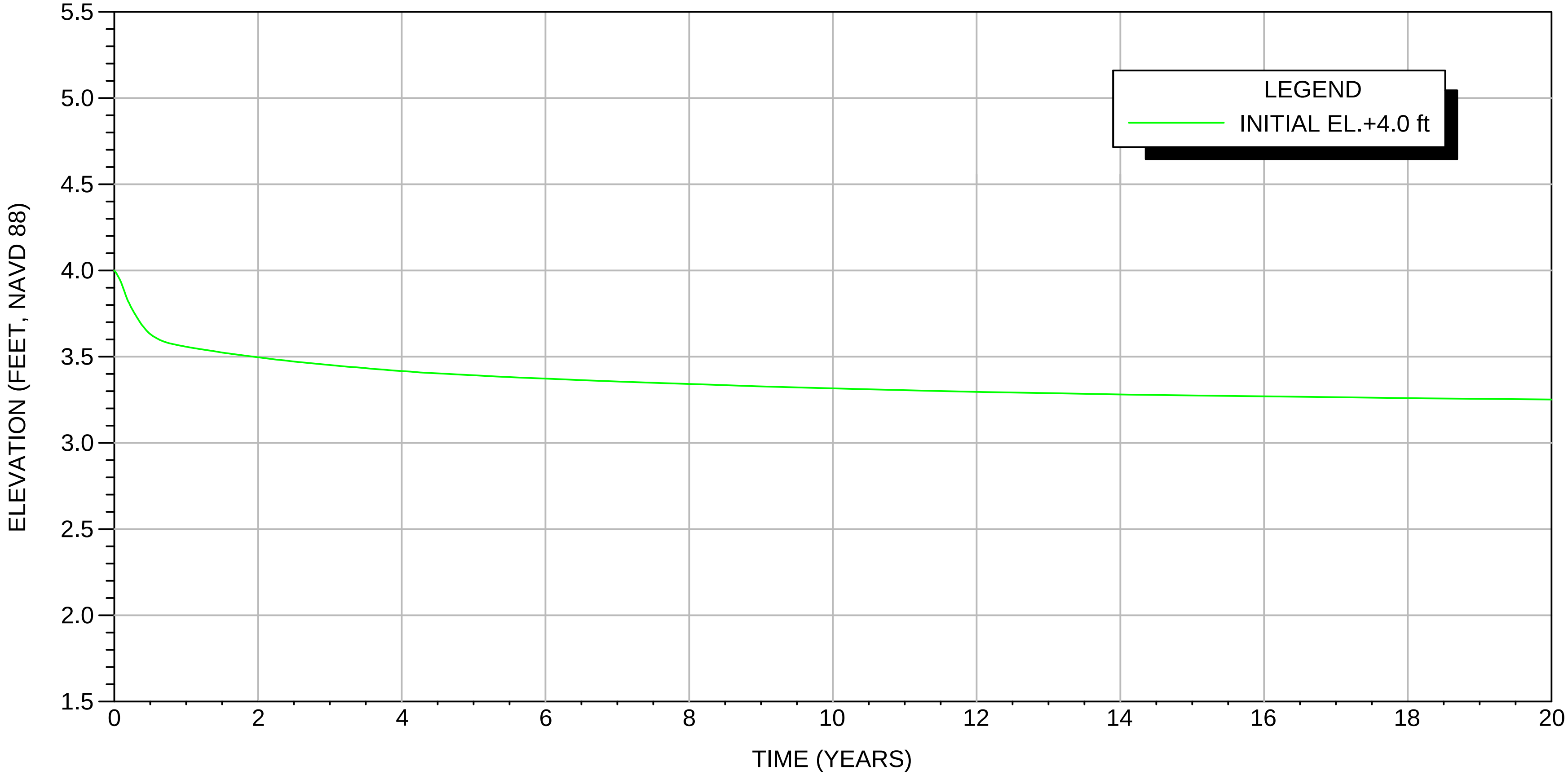
Figure II-B13

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-14 CD modified on Aug 08, 2011 - 1:10pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.60	3.55	3.49	3.39	3.31	3.25	3.22

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-14)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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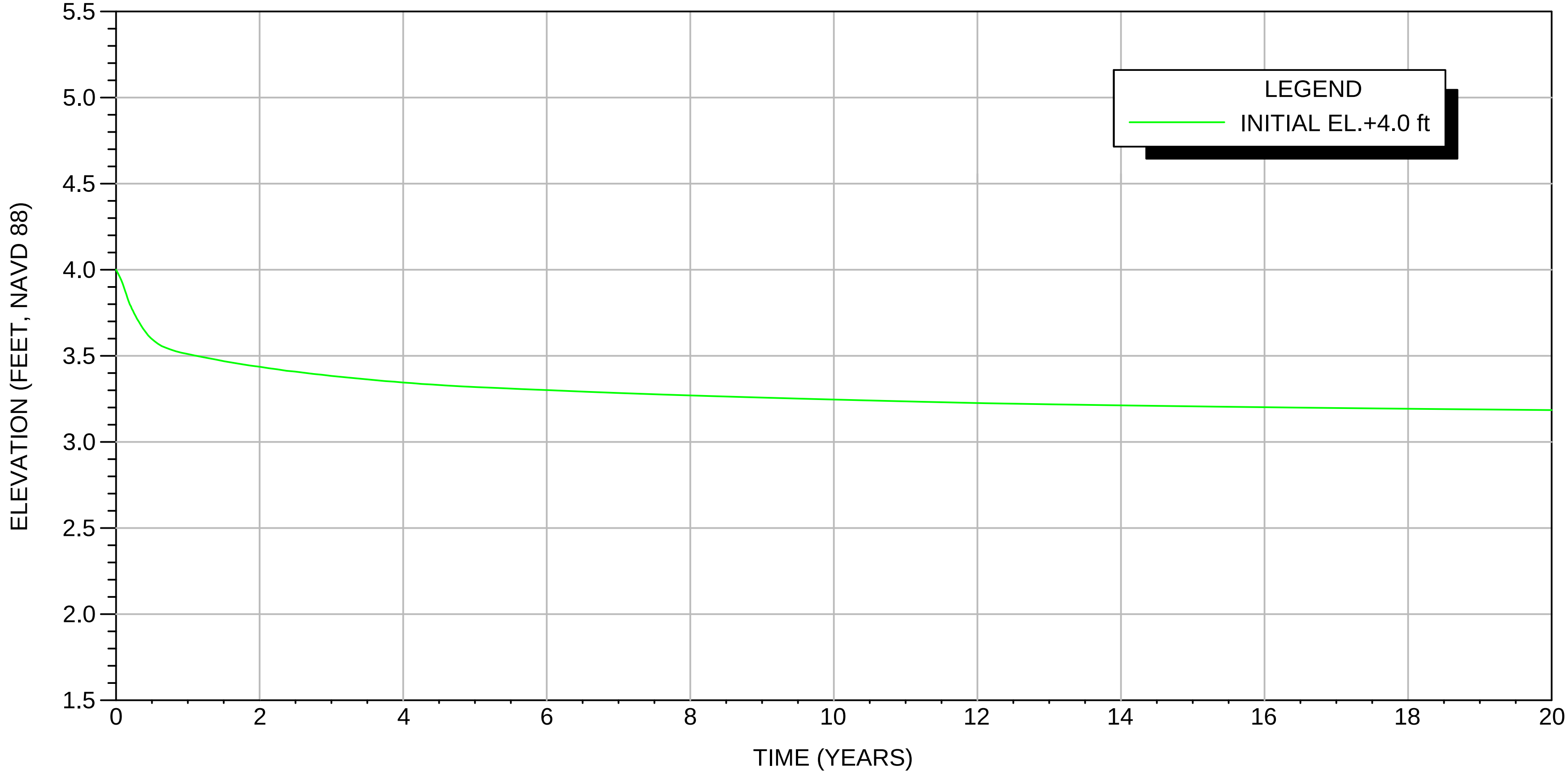
Figure II-B14

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-15 CD modified on Aug 08, 2011 - 1:10pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.56	3.51	3.43	3.31	3.24	3.18	3.14

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-15)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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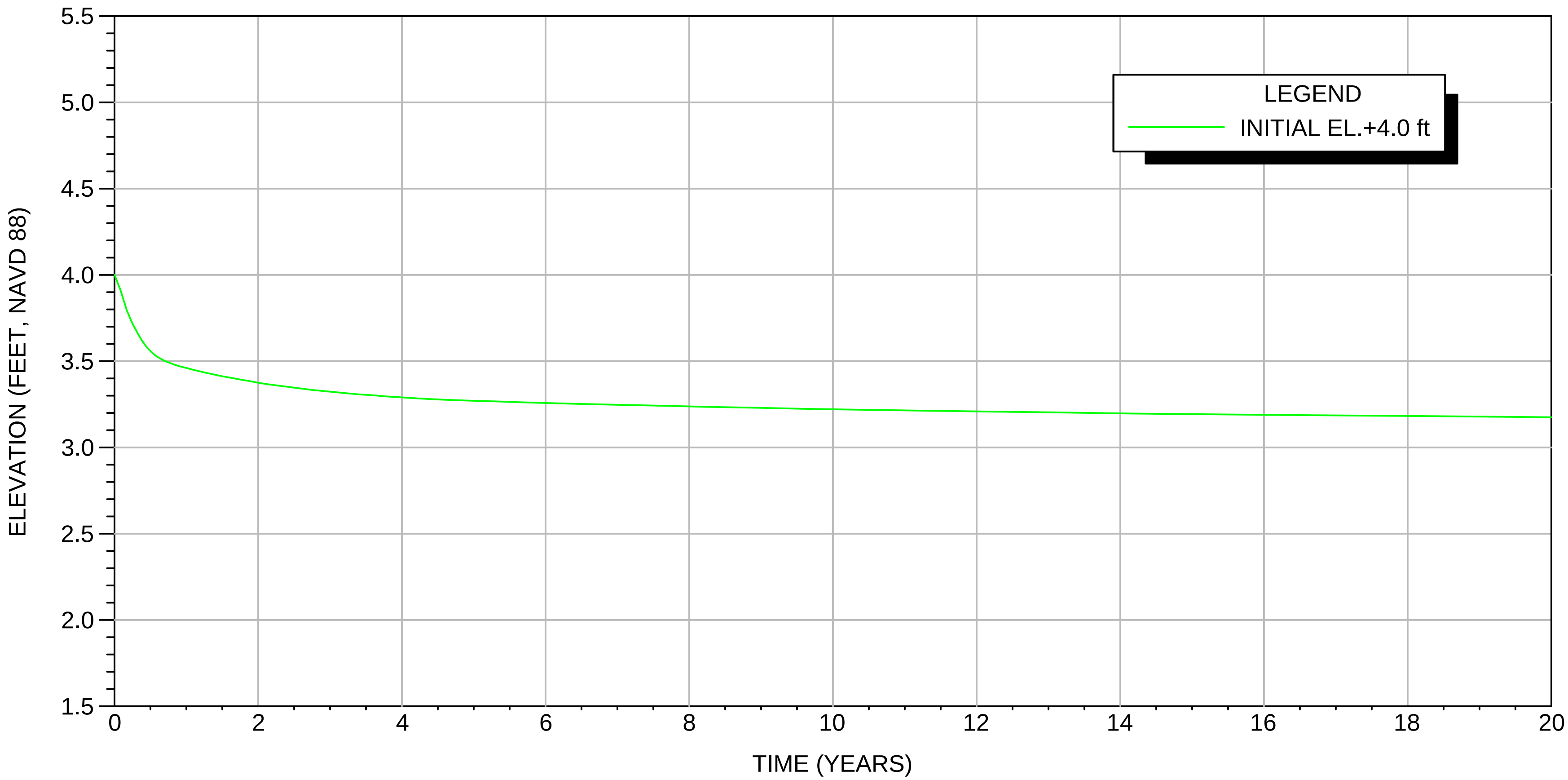
Figure II-B15

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_4384\SETTLEMENT.dwg\TAB:B-16 CD modified on Aug 08, 2011 - 1:10pm VT : KMC



ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.52	3.45	3.37	3.27	3.22	3.18	3.10

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-16)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-B16

PRELIMINARY

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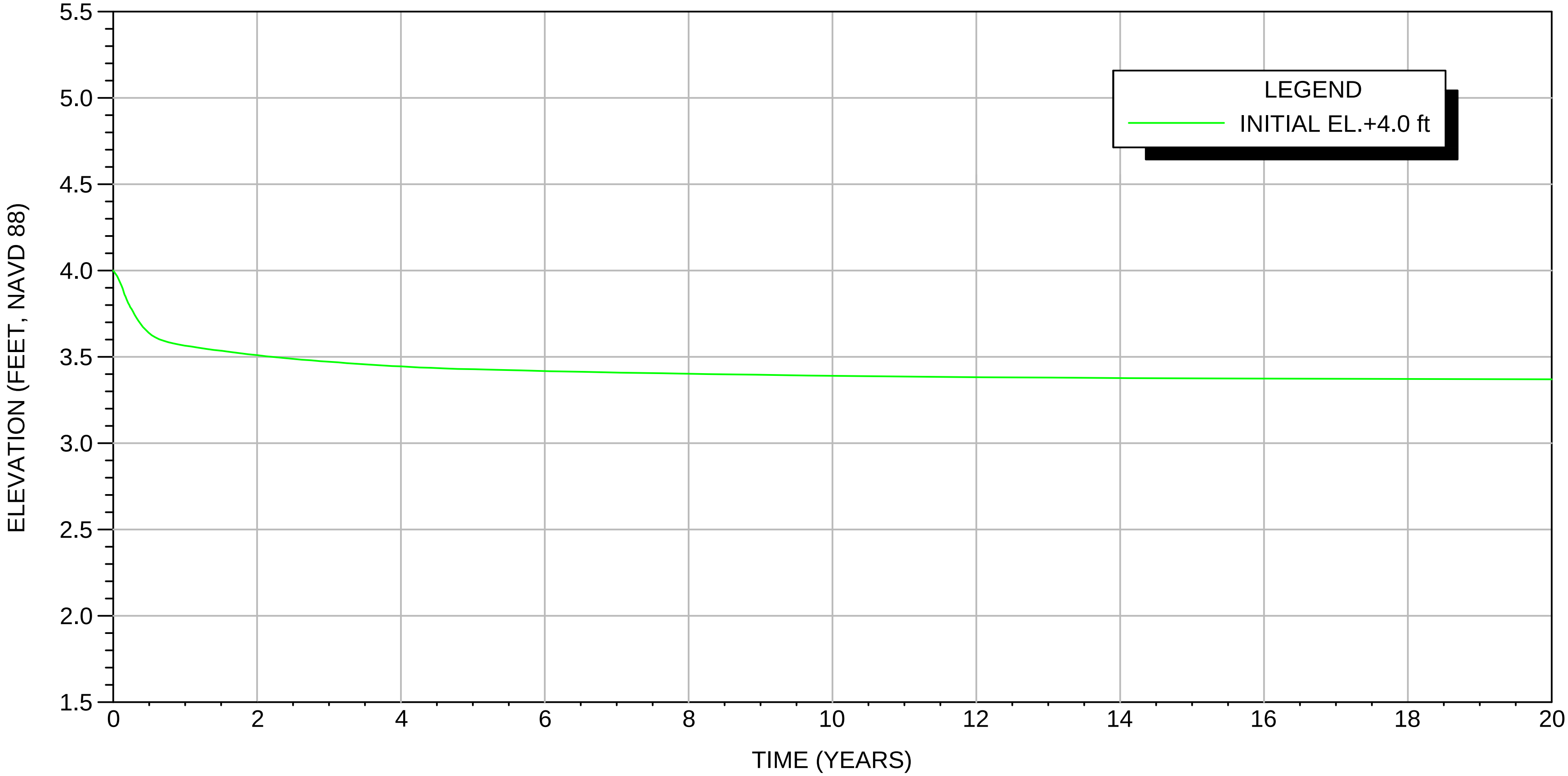

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.60	3.56	3.51	3.43	3.39	3.37	3.36

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-17)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-B17

PRELIMINARY

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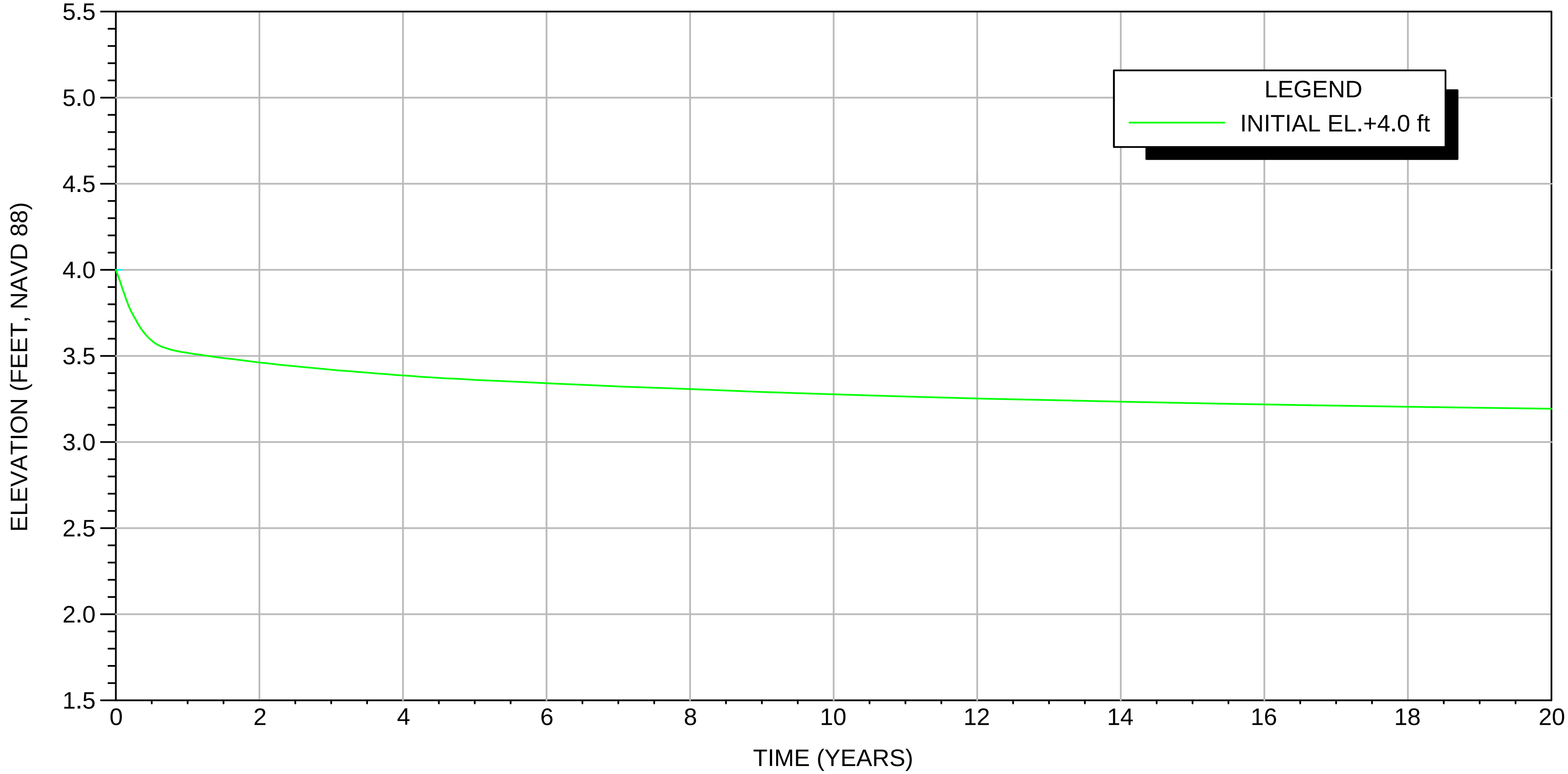

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.55	3.52	3.46	3.36	3.27	3.19	3.09

CONTAINMENT DIKE SETTLEMENT ELEVATION VS. TIME (B-18)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-B18

PRELIMINARY

Appendix C
Slope Stability and Settlement Analyses for Earthen Terrace

PRELIMINARY

Calculation Checksheet

Project No. 16715-020-00 Project Title: Lost Lake Marsh Creation

Deliverable Title: Geotechnical Engineering Report

Calculations Description: Settlement,Time Rate Settlement and Slope Stability Analyses for Terrace Fill.

Originator: S. Malla Checked by: V. Tammineni Date: August 4, 2011

Checking method (describe): Verified parameters and checked computations

Comments: Settlement calculations were performed using a settlement analysis program based on one-dimensional consolidation theory. Soil settlement characteristics were determined based on soil properties, published correlations, and correlations developed based on this and other coastal projects. Time rate of settlement was estimated using spreadsheet calculations based on published equations. Spencer's method of slope stability analyses were done by using the SLOPE/W program.

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Slope Stability Calculation Approach for the Earthen Terrace
Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)

1. A total of 3 borings (Boring 16 thru 18) were considered for checking the slope stability of the earthen terraces.

2. Subsurface profiles for each boring were developed based on shear strength, unit weight, and moisture content.

3. The following dimensions, slopes and elevations were used to start the slope stability analyses of the terraces:
    i. Terrace slopes of 3H:1V
    ii. Crown width of 10 feet
    iii. Bench width (distance between toe of the terrace and excavation access channel) of 15 feet.
    iv. Excavation slope of 3H:1V from the mudline to excavation bottom
    v. Elevations of terrace crown, phreatic surface, mudline and excavation bottom are El +4.0 feet, +1 foot, -1.5 feet and -10 feet, NAVD 88, respectively.

4. The results of our analyses indicate that the dimensions, slopes and elevation mentioned above will provide a factor of safety greater than 1.2 for the terraces in all profiles.

GeoEngineers performed stability analyses for the dikes using the computer program SLOPE/W (2007 version), developed by GEO-SLOPE International Ltd. SLOPE/W is a software product that computes factors of safety against potential failure based on limit equilibrium theory to evaluate the stability of earth slopes. Subsurface soil properties were estimated using the results of subsurface explorations and associated laboratory testing. The factor of safety for the earthen embankment for various slopes was analyzed using the Spencer method. The Spencer method considers both shear and normal interslice forces. The method involves a circular search and takes into account both moment and force equilibrium.

PRELIMINARY

Settlement Calculation Approach for the Terrace
Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)

1. Borings 16 through 18 were considered for the terrace settlement. Based on the survey transects provided by OCPR, mudline for borings 16 thru 18 was assumed to be at El -1.5 feet, NAVD 88. The terrace crown and the phreatic surface were assumed to be at El +4 feet, NAVD 88 and El +1 feet, NAVD 88, respectively.

2. Settlement parameters were developed for each soil layer of borings 16 thru 18. The following description explains how the parameters were developed.
   (a) One consolidation test was done for each soil boring and the samples for the consolidation test were selected from varying depths and materials.
   (b) A total of 9 consolidation test results were analyzed and graphs were reconstructed to determine compression (C_c), recompression (C_r) and vertical consolidation (C_v) coefficients, initial void ratios (e_0) and maximum past pressures (P_c).
   (c) Correlations presented in equations 1 through 4 (shown in the attached spreadsheets) were used to calculate e_0, C_c and C_r for the soil layers without a representative consolidation test.
   (d) C_v for all the soil layers were obtained depending upon the moisture content from a best fit curve shown herewith this calculation package. The best fit curve was drawn through the plotted C_v points obtained from the consolidation tests of this and previous coastal projects done by GeoEngineers.
   (e) Past previous pressures (P_c) for the soil layers were estimated from the equation P_c = [[C_u/ (P'_0 *0.22)]^(10/8)]* P'_0, where P'_0 is the effective overburden pressure. For the soil layers with a representative consolidation test, P_c was selected by analyzing the values obtained from the equation and the test.

3. It was assumed that the clay shear strength for a normally consolidated soil profile for this project to be approximately 22% of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles. Based on this relationship, it appears that approximately top 15 feet of the soil profile is slightly over-consolidated in all borings used for settlement analyses. This affected P_c selected for design within this zone.

4. For calculation of pressures at borings 16 thru 18, an effective terrace unit weight was calculated based on 3 feet at 85 pounds per cubic foot (pcf) and 2.5 feet at 22.6 pcf (buoyant unit weight)

5. Effective rectangular load distribution was considered for trapezoidal terraces. The stressed zone was assumed to extend below the rectangular load at 1H: 2V to El -60 feet, NAVD 88 approximately.

6. Drainage path to the phreatic surface or to the nearest granular soil layer or out of the 1H: 2V stress-zone was analyzed for all the soil layers. The presence of small sand and silt layers within clay was also considered in the drainage path evaluation. Drainage distance of a soil layer was selected such that the time it would take for the pore water to drain out following that drainage path was the least one.

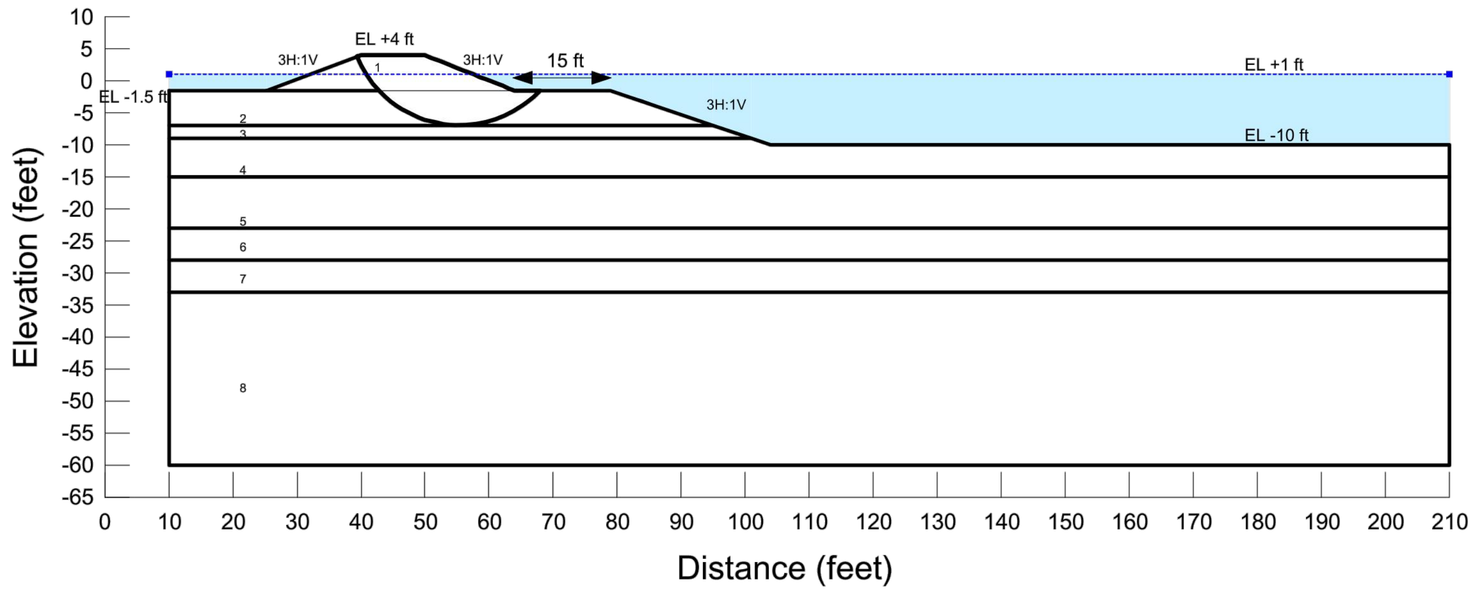
7. The SETANL program was used for the calculation of settlement of terraces based on settlement parameters mentioned above. The program calculates settlement based on Terzaghi's one dimensional linear consolidation theory and the program outputs are included with the settlement calculation package. The time rate settlements for all terraces were calculated using a spreadsheet as shown in the calculation package.

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_5820\SLOPE STABILITY.dwg\TAB:BC1 modified on Aug 05, 2011 - 2:01pm VT : KMC

Name: 1. Earthen Terrace Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Peat - 1 Unit Weight: 85 pcf Cohesion: 90 psf Phi: 0 °
Name: 3. Organic Clay - 1 Unit Weight: 92 pcf Cohesion: 190 psf Phi: 0 °
Name: 4. Clay - 1 Unit Weight: 102 pcf Cohesion: 190 psf Phi: 0 °
Name: 5. Clay-2 Unit Weight: 115 pcf Cohesion: 190 psf Phi: 0 °
Name: 6. Clay -3 Unit Weight: 102 pcf Cohesion: 190 psf Phi: 0 °
Name: 7. Peat-2 Unit Weight: 72 pcf Cohesion: 150 psf Phi: 0 °
Name: 8. Clay-4 Unit Weight: 85 pcf Cohesion: 150 psf Phi: 0 °

FOS: 1.51



EARTHEN TERRACE SLOPE STABILITY EVALUATION - B-16

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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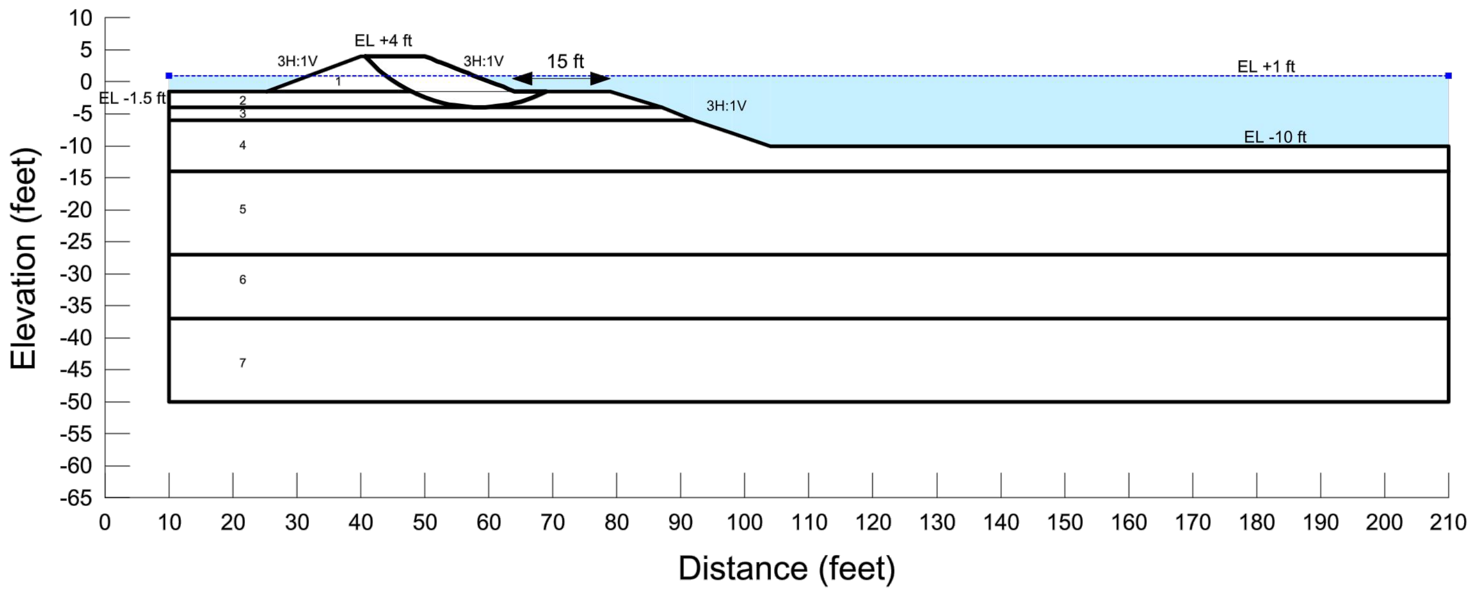
Figure II-C1

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_5820\SLOPE STABILITY.dwg\TAB:BC2 modified on Aug 05, 2011 - 2:01pm VT : KMC

Name: 1. Earthen Terrace Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Organic Clay - 1 Unit Weight: 95 pcf Cohesion: 100 psf Phi: 0 °
Name: 3. Organic Clay - 2 Unit Weight: 101 pcf Cohesion: 160 psf Phi: 0 °
Name: 4. Clay - 1 Unit Weight: 115 pcf Cohesion: 160 psf Phi: 0 °
Name: 5. Clay - 2 Unit Weight: 110 pcf Cohesion: 200 psf Phi: 0 °
Name: 6. Organic Clay -3 Unit Weight: 97 pcf Cohesion: 250 psf Phi: 0 °
Name: 7. Peat - 1 Unit Weight: 79 pcf Cohesion: 250 psf Phi: 0 °

FOS: 1.87



EARTHEN TERRACE SLOPE STABILITY EVALUATION - B-17

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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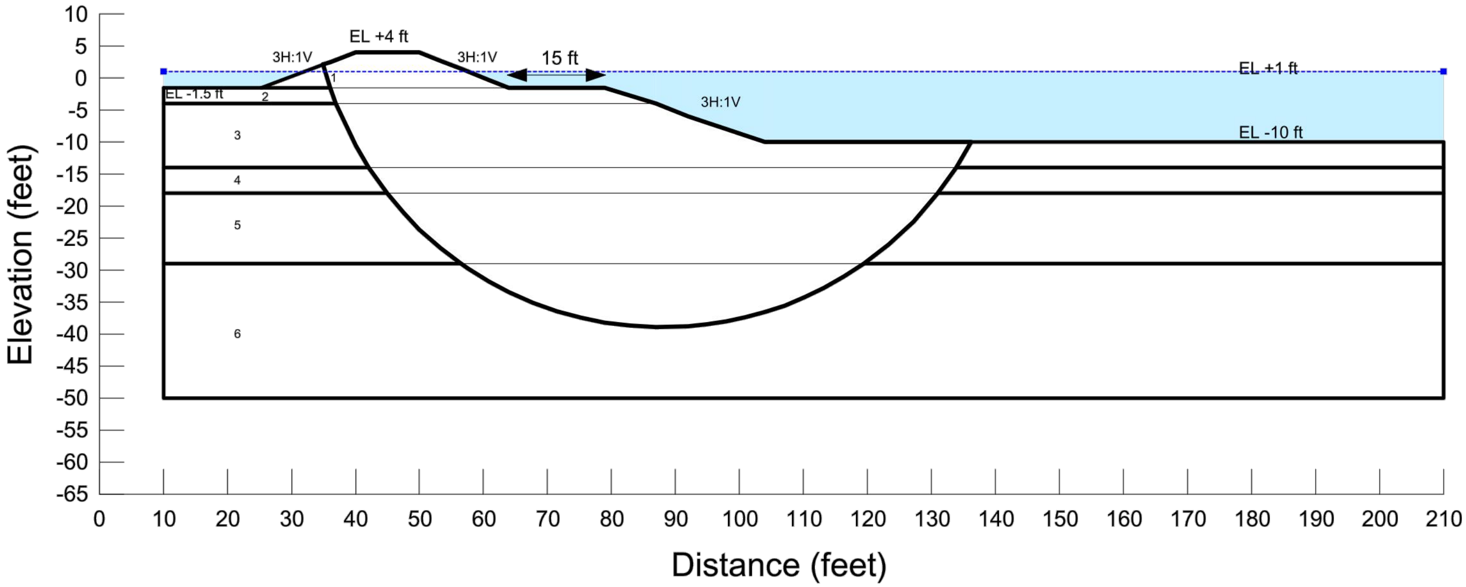
Figure II-C2

PRELIMINARY

C:\Users\kcook\appdata\local\temp\AcPublish_5820\SLOPE STABILITY.dwg\TAB:BC3 modified on Aug 05, 2011 - 2:01pm VT : KMC

Name: 1. Earthen Terrace Unit Weight: 85 pcf Cohesion: 60 psf Phi: 0 °
Name: 2. Organic Clay - 1 Unit Weight: 85 pcf Cohesion: 100 psf Phi: 0 °
Name: 3. Clay - 1 Unit Weight: 105 pcf Cohesion: 150 psf Phi: 0 °
Name: 4. Sand Unit Weight: 120 pcf Cohesion: 0 psf Phi: 20 °
Name: 5. Clay - 2 Unit Weight: 100 pcf Cohesion: 180 psf Phi: 0 °
Name: 6. Organic Clay -2 Unit Weight: 80 pcf Cohesion: 150 psf Phi: 0 °

FOS: 1.82



EARTHEN TERRACE SLOPE STABILITY EVALUATION - B-18

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-C3

PRELIMINARY

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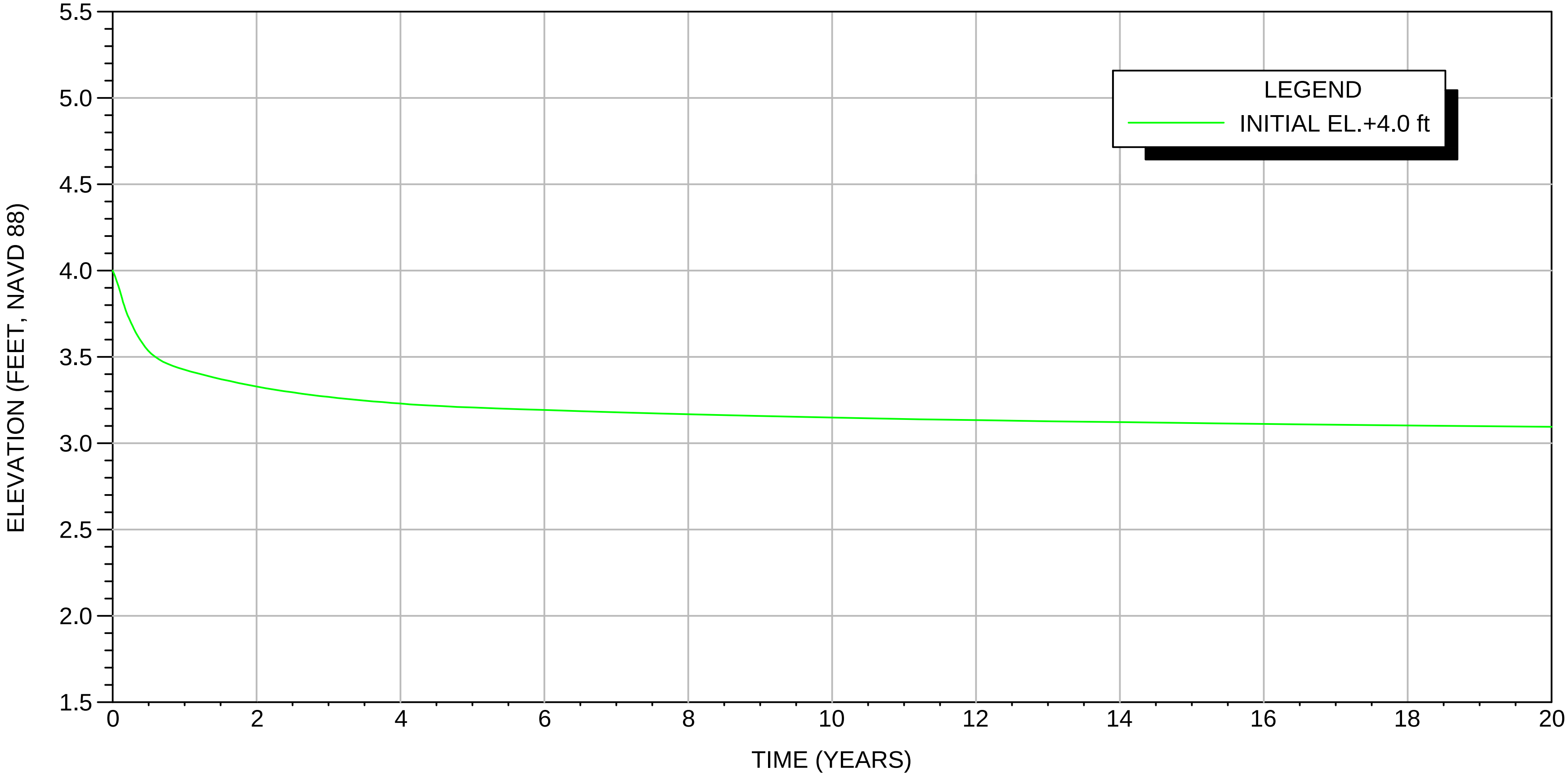

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.50	3.42	3.32	3.20	3.14	3.10	2.98

EARTHEN TERRACE SETTLEMENT ELEVATION VS. TIME (B-16)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-C4

PRELIMINARY

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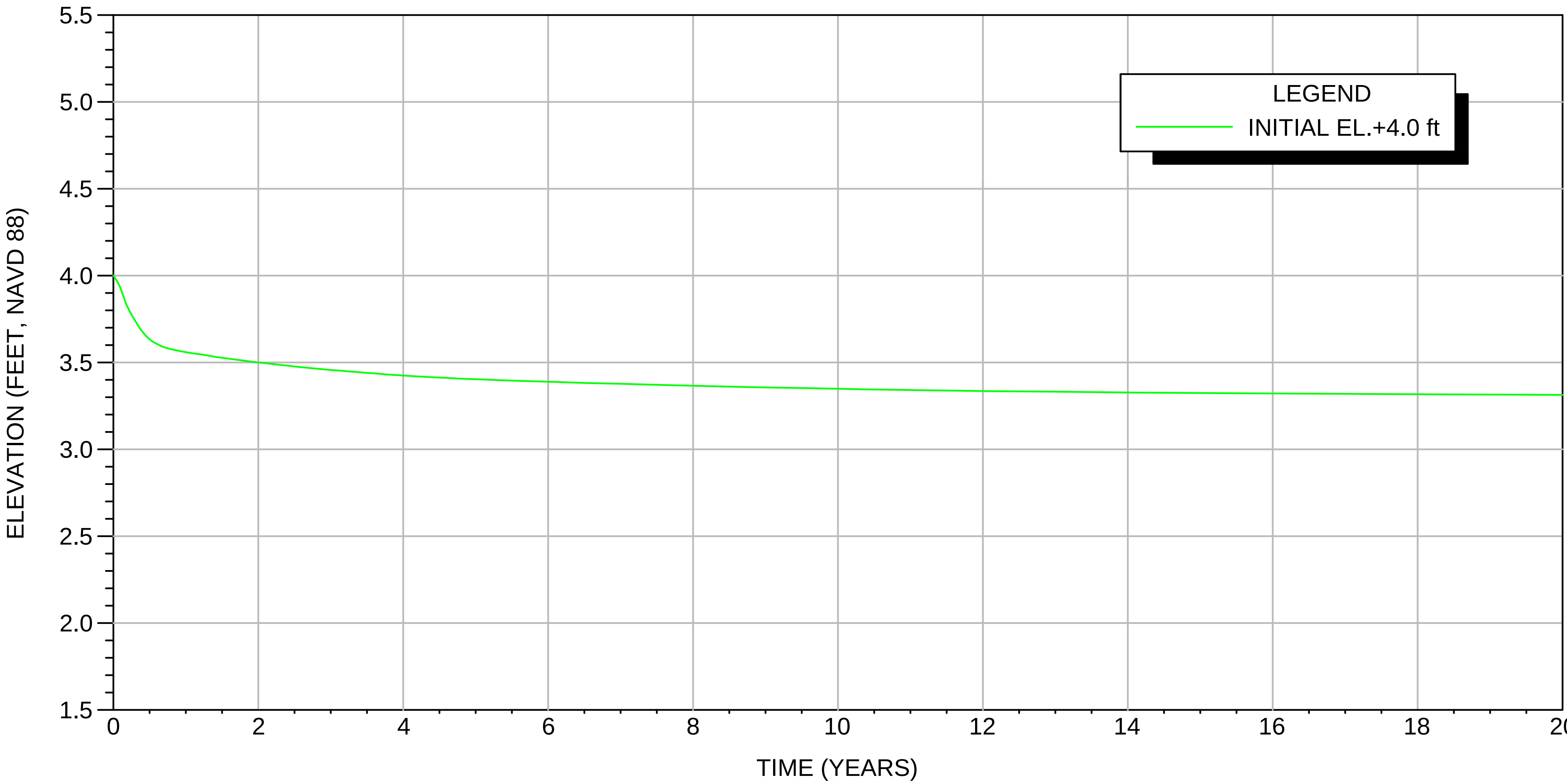

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.60	3.56	3.50	3.40	3.34	3.31	3.30

EARTHEN TERRACE SETTLEMENT ELEVATION VS. TIME (B-17)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-C5

PRELIMINARY

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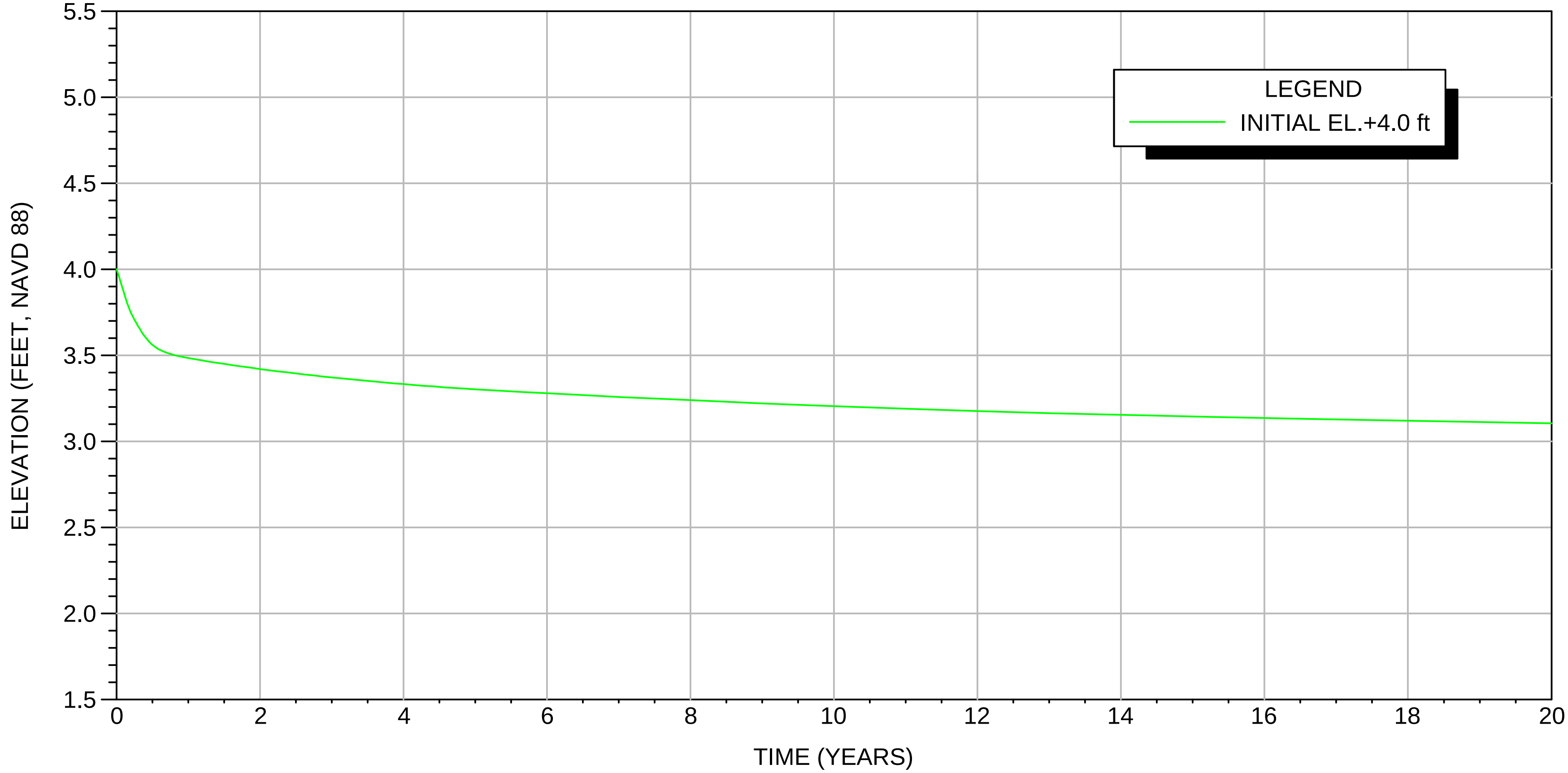

ELEVATION (FEET, NAVD 88)							
0 DAYS	6 MONTHS	1 YEAR	2 YEAR	5 YEAR	10 YEAR	20 YEAR	LONG TERM
4.0	3.53	3.48	3.42	3.30	3.19	3.11	2.96

EARTHEN TERRACE SETTLEMENT ELEVATION VS. TIME (B-18)

Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72)
Terrebonne Parish, Louisiana

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Figure II-C6

PRELIMINARY

APPENDIX II-D
Report Limitations and Guidelines for Use

APPENDIX D
REPORT LIMITATIONS AND GUIDELINES FOR USE

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Louisiana Office of Coastal Protection and Restoration (OCPR) 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 OCPR 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 Lost Lake Marsh Creation and Hydrologic Restoration Project (TE-72) located in Terrebonne Parish, Louisiana. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, we recommend that GeoEngineers be given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Most Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an informed opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

The construction recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers is unable to assume responsibility for the recommendations in this report without performing construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help prevent costly problems associated with unanticipated subsurface conditions, we recommend giving contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report's accuracy is limited. In addition, encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor’s procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) are less exact than other engineering and natural science disciplines. Without this understanding, there may be expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory “limitations” provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you need to know more how these “Report Limitations and Guidelines for Use” apply to your project or site.

Biological Pollutants

GeoEngineers’ Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term “Biological Pollutants” includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

PRELIMINARY

Have we delivered World Class Client Service?

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

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