OCTOBER 2016

CLECO POWER LLC
BRAME ENERGY CENTER

CLECO

SAFETY FACTOR ASSESSMENT:

BOTTOM ASH POND

PROVIDENCE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0   INTRODUCTION

Providence was contracted by Cleco Power LLC (Cleco) to conduct safety factor assessments of the Bottom Ash Pond at Cleco's Brame Energy Center located in Lena, Louisiana. Recent Coal Combustion Residual (CCR) regulations at 40 CFR 257.73(e)(1) established requirements for owners and operators to conduct safety factor assessments to document whether the calculated factors of safety for the Bottom Ash Pond achieve the minimum safety factors specified below:

- The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
- The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
- The calculated seismic factor of safety must equal or exceed 1.00.
- For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

The Cleco Brame Energy Center is located near Lena in Rapides Parish, Louisiana. A site location map showing the Brame Energy Center is included as **Figure 1**. This safety factor assessment pertains to the Bottom Ash surface impoundment (Pond) utilized for the Unit 2 coal-fired generation unit. A site map for the Bottom Ash Pond is included as **Figure 2**.

2.0   FACTORS OF SAFETY

Providence performed a safety factor analysis (slope stability analysis) for the levees surrounding the Bottom Ash Pond. This analysis required a review of the original permit and construction drawings for the Bottom Ash Pond, a detailed topographic survey of the perimeter levees of the Bottom Ash Pond, and installation of borings in the perimeter levees to determine the soil conditions that exist within the perimeter levee system for these ponds.

Providence mobilized to the Brame Energy Center in June of 2011 and again in April of 2016 to install geotechnical borings in the perimeter levees of the Bottom Ash Pond. Geotechnical testing Laboratory, Inc. installed 4 borings spaced approximately 500 feet apart along the center line of the levee in 2011 and 3 additional borings in 2016. Soil profiles were generated for sections along the Bottom Ash Pond that shows the results of the geotechnical borings and the laboratory analysis. **Table 1** shows the soil profiles for each section and the characteristics used for the safety factor modeling.

Table 1 Subsurface Soil Classification and Parameters

	Soil	Depth (ft)	Unit Wt. (lb/ft³)	Cohesion (lb/ft²)	Friction Angle(Φ)
Bottom Ash Pond Section 1 B-13	CL	1.5	120	1,100	-
	CL-CH	2.0	120	550	-
	CH	9.5	106	250	-
	SP-SM	19.5	115	0	30
	SM	23.5	115	0	30
	CL	16.5	120	1,760	-
	SP-SM	6.5	115	0	30
Bottom Ash Pond Section 2 B-12	Soil	Depth (ft)	Unit Wt. (lb/ft³)	Cohesion (lb/ft²)	Friction Angle(Φ)
	SM	4.0	115	0	30
	CL	2.0	115	1,500	-
	SM	6.0	115	0	30
	SP-SM	11.5	115	0	30
	SP	8.5	115	0	30
	CL-CH	6.0	120	1,500	-
	SP	24.0	115	0	30
Bottom Ash Pond Section 3 B-3	Soil	Depth (ft)	Unit Wt. (lb/ft³)	Cohesion (lb/ft²)	Friction Angle(Φ)
	Cl-ML	7.5	130	375	-
	SM-SC	9.0	115	250	24
	SP-SM	15.5	115	350	20
	CH	40.0	133	850	-
	SC	11.0	130	750	-
	CL-CH	17.0	121	1,000	-

The safety factor analysis uses the strength of the soil material of which the levee is made of and subgrade to assess levee stability in accordance to the existing conditions. The Spencer Method for slope stability was used since it is the most conservative approach. The Spencer Method is a general method of slices developed on the basis of limit equilibrium. It requires satisfying equilibrium of forces and moments acting on individual blocks. The blocks are created by dividing the soil above the slip surface by dividing planes. Deep failure analysis evaluates the potential of the levees to fail through the bottom of the levees into the existing native soils. The analysis was based upon the following assumptions and input parameters.

- The subgrade stratigraphy was modeled using soil profiles from completed soil borings at the site with the soil profile condition at each section for each pond through the entire levee system.

- The height and exterior slope of the levees were determined based on actual field surveys and previously permitted design data and the bottom elevation and the interior slope of the levees below the water line was determined based on the previously permitted design provided by Cleco.

- The input parameters used in our analyses were based upon results from geotechnical investigations conducted for this safety factor analysis. **Appendix A** includes a copy of the geotechnical results as provided by the geotechnical contractor.

- The fill material in the pond was assumed to be water for the Bottom Ash Pond. Maximum water elevation in the Bottom Ash Pond is 103.5 feet NAVD 88.

The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50

Providence modeled the pond under the long-term, maximum storage to the freeboard level for the Bottom Ash surface impoundment. Based on the results of the slope stability analysis, the following minimum factors of safety were obtained:

Table 2 Long-Term Factors of Safety

Surface Impoundment	Section Number	Soil Boring No.	Maximum Water Elevation (feet NAVD 88)	Analysis	Factor of Safety
Bottom Ash	Section 1	B-13	103.5	Spencer Method Deep Failure	1.68
Bottom Ash	Section 2	B-12	103.5	Spencer Method Deep Failure	2.32
Bottom Ash	Section 3	B-3	103.5	Spencer Method Deep Failure	1.60

The calculated long-term static factor of safety under maximum storage pool loading conditions is greater than 1.50, therefore these safety factors are adequate.

The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40

Providence modeled the pond using a scenario where the facility allows the pond to fill to the freeboard level for the Bottom Ash surface impoundment. This scenario represents the flood/heavy rainfall conditions. The new elevation was determined using 2.5 feet of freeboard from the lowest levee crown elevation for this pond.

Based on the results of the slope stability analysis, the following minimum factors of safety were obtained:

Table 3 Short-Term Factors of Safety

Surface Impoundment	Section Number	Soil Boring No.	Maximum Water Elevation (feet NAVD 88)	Analysis	Factor of Safety
Bottom Ash	Section 1	B-13	103.5	Spencer Model Deep Failure	1.52
Bottom Ash	Section 2	B-12	103.5	Spencer Model Deep Failure	1.52
Bottom Ash	Section 3	B-3	103.5	Spencer Model Deep Failure	1.54

The calculated short-term static factor of safety under maximum surcharge pool loading conditions is greater than 1.40, therefore these safety factors are adequate.

The calculated seismic factor of safety must equal or exceed 1.00

The Brame Energy Center is not located in a seismic area. The Louisiana Geological Survey and the United States Geological Survey classifies the entire state of Louisiana as a low seismic risk area. This low seismic risk classification denotes that the levels of horizontal shaking that have a 2 in 100 chance of being exceed in in a 50-year period range from 0-8% g where g is the acceleration of a falling object due to gravity. The nearest published fault system to the Brame Energy Center is approximately 100 miles away. Therefore, the calculated seismic factor of safety is not applicable to the Bottom Ash Pond.

For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.2

The clayey sands and poorly graded sands in the Bottom Ash Pond levees have greater N values to resist earthquake motions and acceleration; and the relative densities are greater than 35 to 40 percent, therefore these soils are not subject to liquefaction.

It must be noted that Cleco keeps the operating water levels in the Bottom Ash Pond at lower levels. The low operating levels for this pond will not adversely affect the structural stability of the perimeter levees around the Bottom Ash Pond. The normal operating water level in the Bottom Ash Pond ranges from 90 to 96 feet NAVD 88. These levels are significantly lower than the modeled flooded/heavy rainfall conditions.

3.0   CONCLUSIONS

Based on the results from the safety factor analysis, the existing levee design for the Bottom Ash Pond achieves the minimum safety factor requirements of the 40 CFR 257.73(e)(1) CCR regulations. Results of the safety factor analysis and model input parameters can be found in **Appendix A**. **Appendix B** contains a P.E. Certification that attests to the safety factor assessment.

FIGURE 1

SITE LOCATION MAP

Bottom Ash Pond

N

Legend

—— Property Boundary

4,000 2,000 0 4,000
Feet

Reference

Base map comprised of U.S.G.S. 7.5 minute topographic maps, "Lena, LA", "Boyce, LA", "Jericho, LA", and "Gardner, LA".

Site Location Map

Safety Factor Assessment - Bottom Ash Pond
Boyce, Rapides Parish, Louisiana

Cleco Power LLC
Brame Energy Center

Drawn By	LMM	10/04/16
Checked By	LMH	10/04/16
Approved By	CVH	10/04/16

PROVIDENCE

Project Number
002-186

Drawing Number
002-186-A013

1
Figure

FIGURE 2

SITE MAP

Legend

▭ Property Boundary

Reference

Base map comprised of Google Earth aerial imagery from 10/03/14.

Bottom Ash Pond

1,000	500	0	1,000

Feet
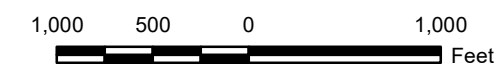
Site Map

Safety Factor Assessment - Bottom Ash Pond
Boyce, Rapides Parish, Louisiana

Cleco Power LLC
Brame Energy Center

Drawn By	LMM	10/04/16
Checked By	LMH	10/04/16
Approved By	CVH	10/04/16
Project Number		
002-186		
Drawing Number		
002-186-B014		

PROVIDENCE

002-186-B014

2

Figure

Providence Engineering and Environmental Group LLC

APPENDIX A

SAFETY FACTOR ANALYSIS

PROVIDENCE
1201 Main Street
Baton Rouge, LA 70802

Attn: Mr. Gary Leonards, P.E.

Re: **Slope Stability Analysis of Bottom Ash Pond**
                 Cleco Brame Energy Center
                 Lena, Louisiana

Dear Mr. Leonards:

APS Engineering and Testing, LLC has completed slope stability analysis of the Bottom Ash Pond located at Cleco Brame Energy Center in Lena, Louisiana. Authorization to proceed with this work was received from **Mr. Gary Leonards** via email on July 18, 2016. Our analysis was performed based on the soil boring log data provided by the client. Our scope of services included performing landside stability of the existing levee with maximum water elevation, as requested by the client. All sections were modeled and analyzed based on the survey data and soil boring data provided by the client. This report presents the results of Sections 1, 2 and 3 of the Bottom Ash Pond.

Background

The Bottom Ash Pond at the Brame Energy Center was initially constructed in 1981. The facility was expanded in 1982 when an additional coal fired boiler system (Unit #2) came on line. The bottom ash is sluiced to the Bottom Ash Pond. The Bottom Ash Pond is an existing unit that is essential for the management of solid residuals generated at the Brame Energy Center.

TABLE 1.0

Pond	Section #	Soil boring # (Report No.) *	Boring Depth (Feet)	Average Top of Levee Elevation (feet, NAVD88)	Pond Max. Water Elevation (feet, NAVD 88)
Bottom Ash	Section 1	B-13 (04-16-061)	80	109.8	103.5
	Section 2	B-12 (04-16-061)	80	123.3	103.5
	Section 3	B-3 (06-11-090)	80	107.9	103.5

*Boring data was obtained from Reports prepared by Geotechnical Testing Laboratory (GTL), Inc.

All three sections achieved the minimum desired factor of safety of 1.50. Please refer to *Attachments* of this report.

Assumptions and Observations:

- Soil layers are horizontal with uniform thickness.
- Soil layers encountered in Levee Centerline boring were used for the analysis.
- Cross section profiles limits were extended horizontally on the land side, whenever the failure plane passes the limits.

Slope Stability Analysis Results

Slope stability analysis was performed using Spencer method for both the short term and long term conditions as requested by the client. Changes in slopes, structural loadings, and other conditions may affect the results of slope stability analysis. Factors of safety (FoS) obtained from slope stability analysis results do meet 1.50 according to HSDRRS guidelines for Steady Water Level conditions.

TABLE 2.0

Soil Type	Phi	Cohesion (psf)
Silt (ML)	28°	0
Clay (CL/CH)	28°	0
Sand (SP / SM)	37°	0

TABLE 3.0

Pond	Section #	Condition	Flood Side Water Elevation (feet, NAVD88)	Factor of Safety Obtained	Notes
Bottom Ash Pond	1	Short Term	103.5	1.53	--
	1	Long Term	103.5	1.68	--
	2	Short Term	103.5	2.27	--
	2	Long Term	103.5	2.32	--
	3	Short Term	103.5	1.58	--
	3	Long Term	103.5	1.60	--

Based on the results presented in the above table, all three sections of the Bottom Ash Pond meet minimum required factor of safety with the projected maximum water elevation as shown in above table for both short term and long term conditions. This is based on the soil boring data provided by the client.

Liquefaction

Clayey sands and poorly graded sands present at the bottom ash project site have greater N values to resist the earthquake motions and acceleration. Also, the relative densities are more than 35 to 40 percent and therefore do not present susceptibility to liquefaction.

If you have any questions pertaining to this report, or if we may be of further service, please contact our office.

Respectfully submitted,
APS ENGINEERING AND TESTING, LLC

Sairam Eddanapudi, P.E.   Sergio Aviles, P.E.
Project Manager   President

Attachments

Boring Location Plan
Slope stability Analysis Results

LA Highway 121

B-8
B-9
B-10
B-11

B-7

B-6

Interstate 49

LA Highway

B-5

Fly Ash Pond

B-4

Leachate & Contact Storm Water Pond

B-3

B-15

THREE

Ash Management Area

B-2

Bottom Ash Pond

B-1

ONE

B-14

TWO

B-12

B-13

Image USDA Farm Service Agency

CLECO BRAME ENERGY CENTER
BOTTOM ASH POND - SECTION 1
SHORT TERM SLOPE STABILITY ANALYSIS
SOIL BORING B-13 (FROM GTL REPORT NO.: 04-16-061)

1.526

CL

CL/CH

CH

SP-SM

SM

CL (2)

SP-SM (2)

EXTENDED HORIZONTALLY
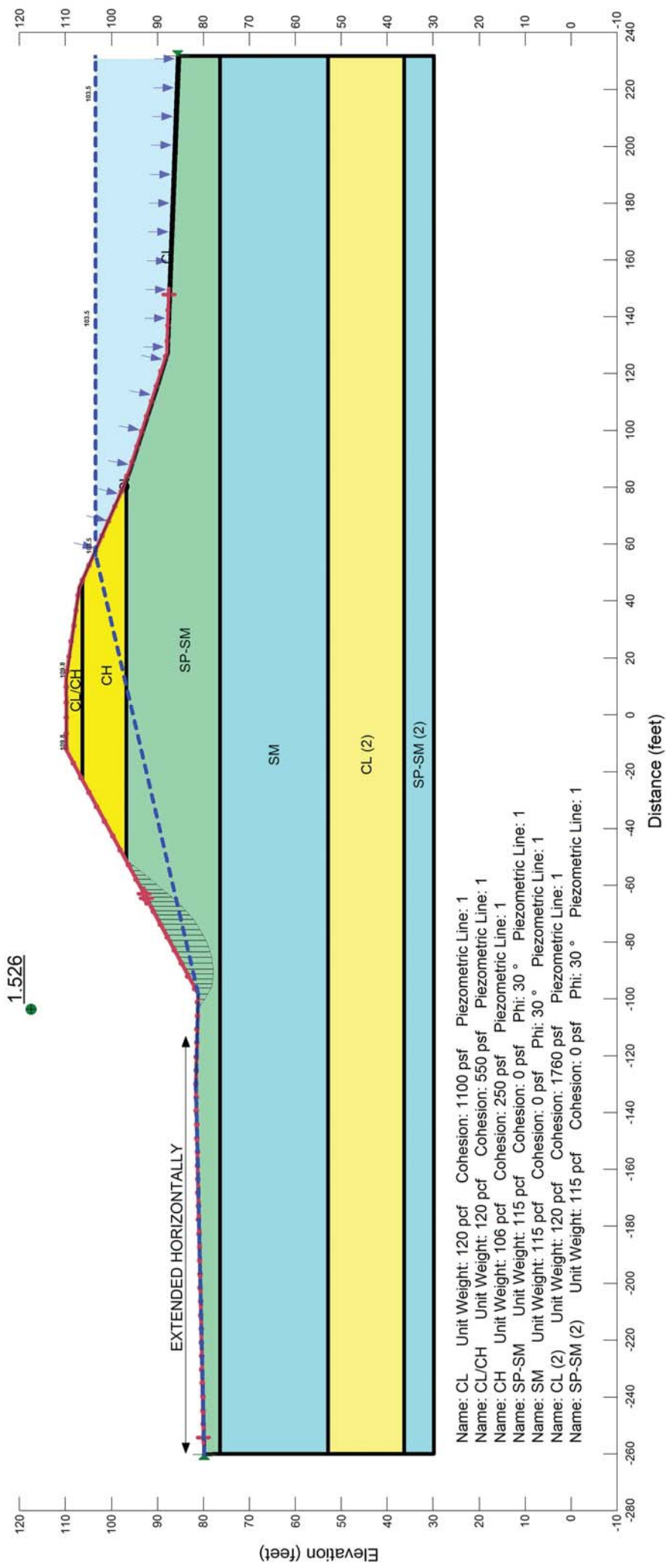
Name: CL   Unit Weight: 120 pcf   Cohesion: 1100 psf   Piezometric Line: 1
Name: CL/CH   Unit Weight: 120 pcf   Cohesion: 550 psf   Piezometric Line: 1
Name: CH   Unit Weight: 106 pcf   Cohesion: 250 psf   Piezometric Line: 1
Name: SP-SM   Unit Weight: 115 pcf   Cohesion: 0 psf   Phi: 30 °   Piezometric Line: 1
Name: SM   Unit Weight: 115 pcf   Cohesion: 0 psf   Phi: 30 °   Piezometric Line: 1
Name: CL (2)   Unit Weight: 120 pcf   Cohesion: 1760 psf   Piezometric Line: 1
Name: SP-SM (2)   Unit Weight: 115 pcf   Cohesion: 0 psf   Phi: 30 °   Piezometric Line: 1

Distance (feet)

Elevation (feet)

CLECO BRAME ENERGY CENTER
BOTTOM ASH POND - SECTION 1
LONG TERM SLOPE STABILITY ANALYSIS (S-CASE)
SOIL BORING B-13 (FROM GTL REPORT NO.: 04-16-061)

1.68

EXTENDED HORIZONTALLY

Name: CL   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 23 °   Piezometric Line: 1
Name: CL/CH   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 23 °   Piezometric Line: 1
Name: CH   Unit Weight: 106 pcf   Cohesion: 0 psf   Phi: 23 °   Piezometric Line: 1
Name: SP-SM   Unit Weight: 115 pcf   Cohesion: 0 psf   Phi: 33 °   Piezometric Line: 1
Name: SM   Unit Weight: 115 pcf   Cohesion: 0 psf   Phi: 33 °   Piezometric Line: 1
Name: CL (2) Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 23 °   Piezometric Line: 1
Name: SP-SM (2) Unit Weight: 115 pcf Cohesion: 0 psf   Phi: 33 °   Piezometric Line: 1

LONGTERM SOIL PROPERTIES WERE OBTAINED FROM HSDRRS GUIDELINES UPDATED ON 14JUN12.
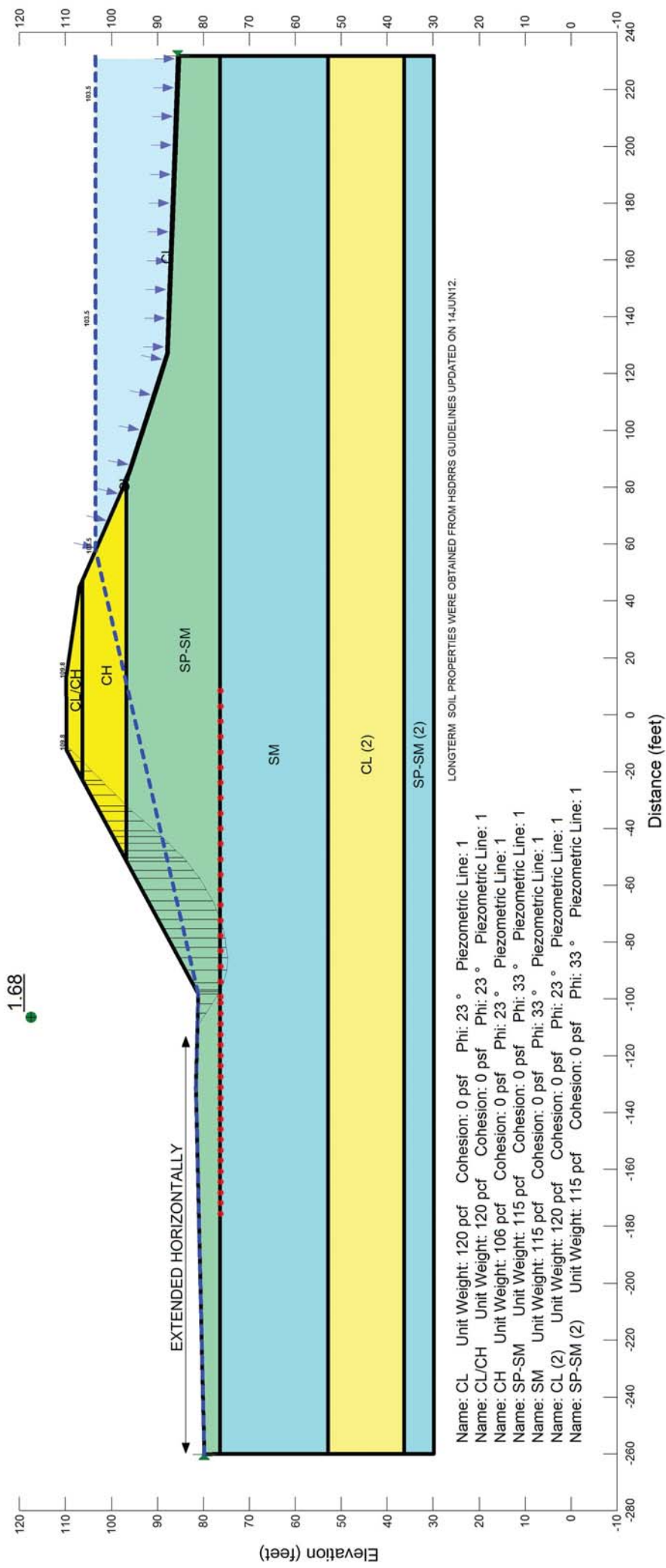
Distance (feet)

Elevation (feet)

CLECO BRAME ENERGY CENTER
BOTTOM ASH POND - SECTION 2
SHORT TERM SLOPE STABILITY ANALYSIS
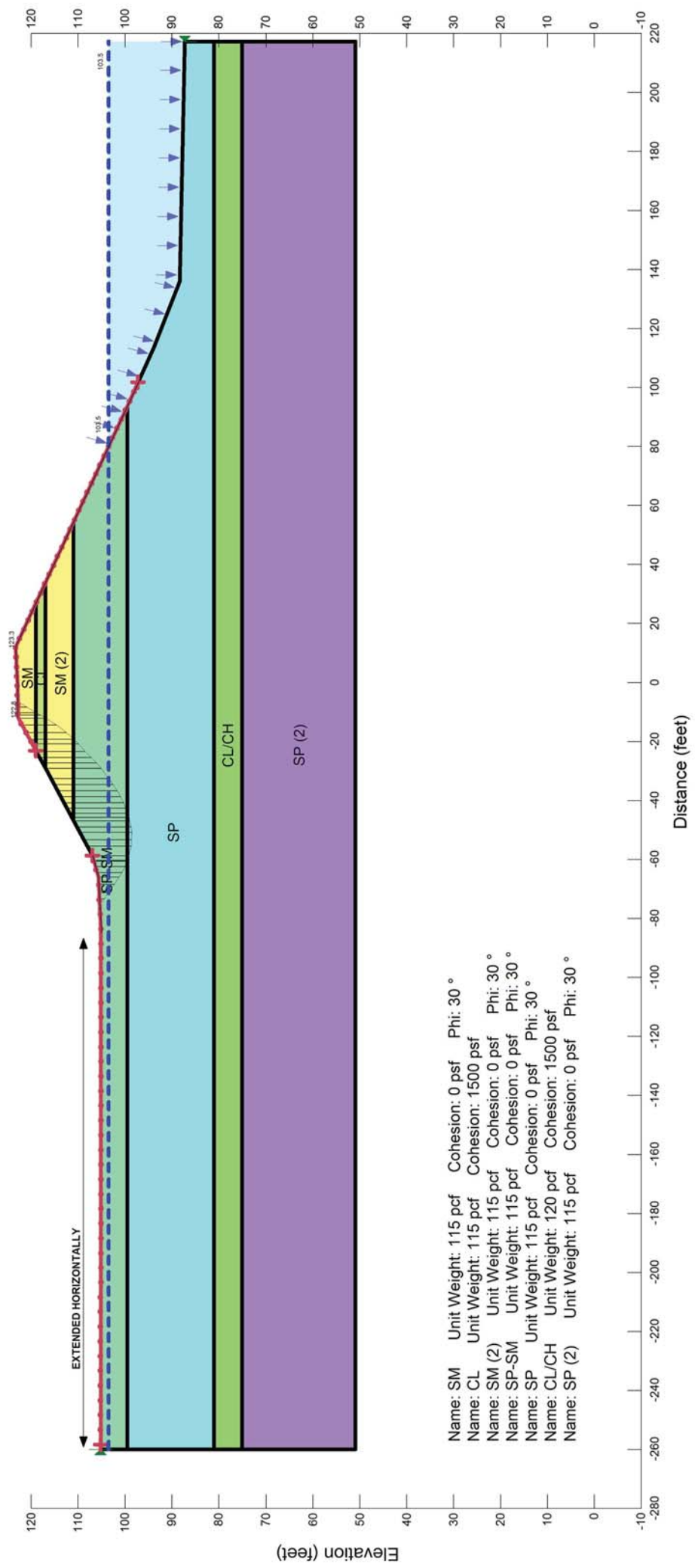SOIL BORING B-12 (FROM GTL REPORT NO.: 04-16-061)

2.270

Name	Unit Weight	Cohesion	Phi
Name: SM	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 30 °
Name: CL	Unit Weight: 115 pcf	Cohesion: 1500 psf	
Name: SM (2)	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 30 °
Name: SP-SM	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 30 °
Name: SP	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 30 °
Name: CL/CH	Unit Weight: 120 pcf	Cohesion: 1500 psf	
Name: SP (2)	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 30 °

Distance (feet)

Elevation (feet)

CLECO BRAME ENERGY CENTER
BOTTOM ASH POND - SECTION 2
LONG TERM SLOPE STABILITY ANALYSIS (S-CASE)
SOIL BORING B-12 (FROM GTL REPORT NO.: 04-16-061)

2.32

Name: SM	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 33 °
Name: CL	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 23 °
Name: SM (2)	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 33 °
Name: SP-SM	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 33 °
Name: SP	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 33 °
Name: CL/CH	Unit Weight: 120 pcf	Cohesion: 0 psf	Phi: 23 °
Name: SP (2)	Unit Weight: 115 pcf	Cohesion: 0 psf	Phi: 33 °

EXTENDED HORIZONTALLY

Elevation (feet)

Distance (feet)

SM
CL
SM (2)
SP-SM
SP
CL/CH
SP (2)

CLECO BRAME ENERGY CENTER
BOTTOM ASH POND - SECTION 3
SHORT TERM SLOPE STABILITY ANALYSIS
SOIL BORING B-3 (FROM GTL REPORT NO.: 06-11-090)

1.578

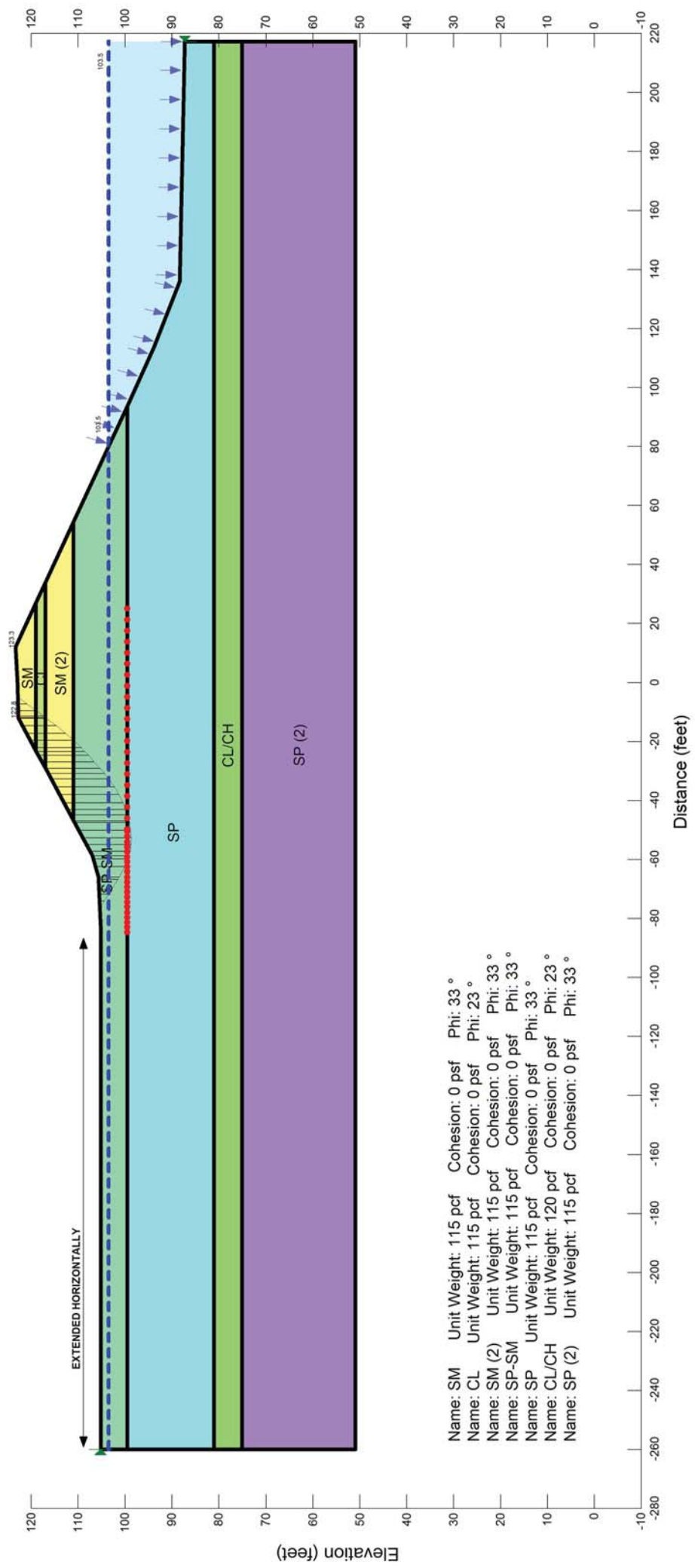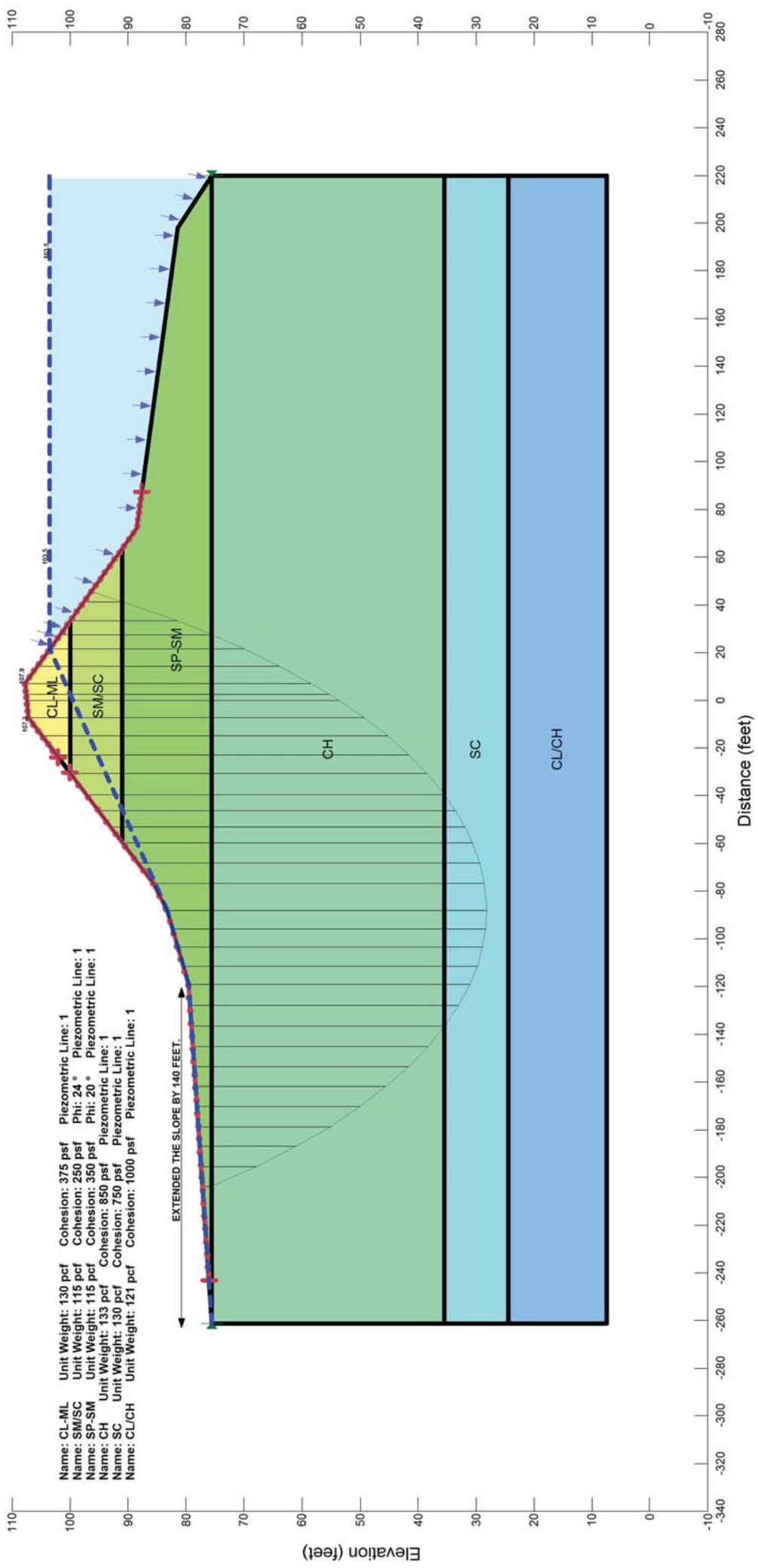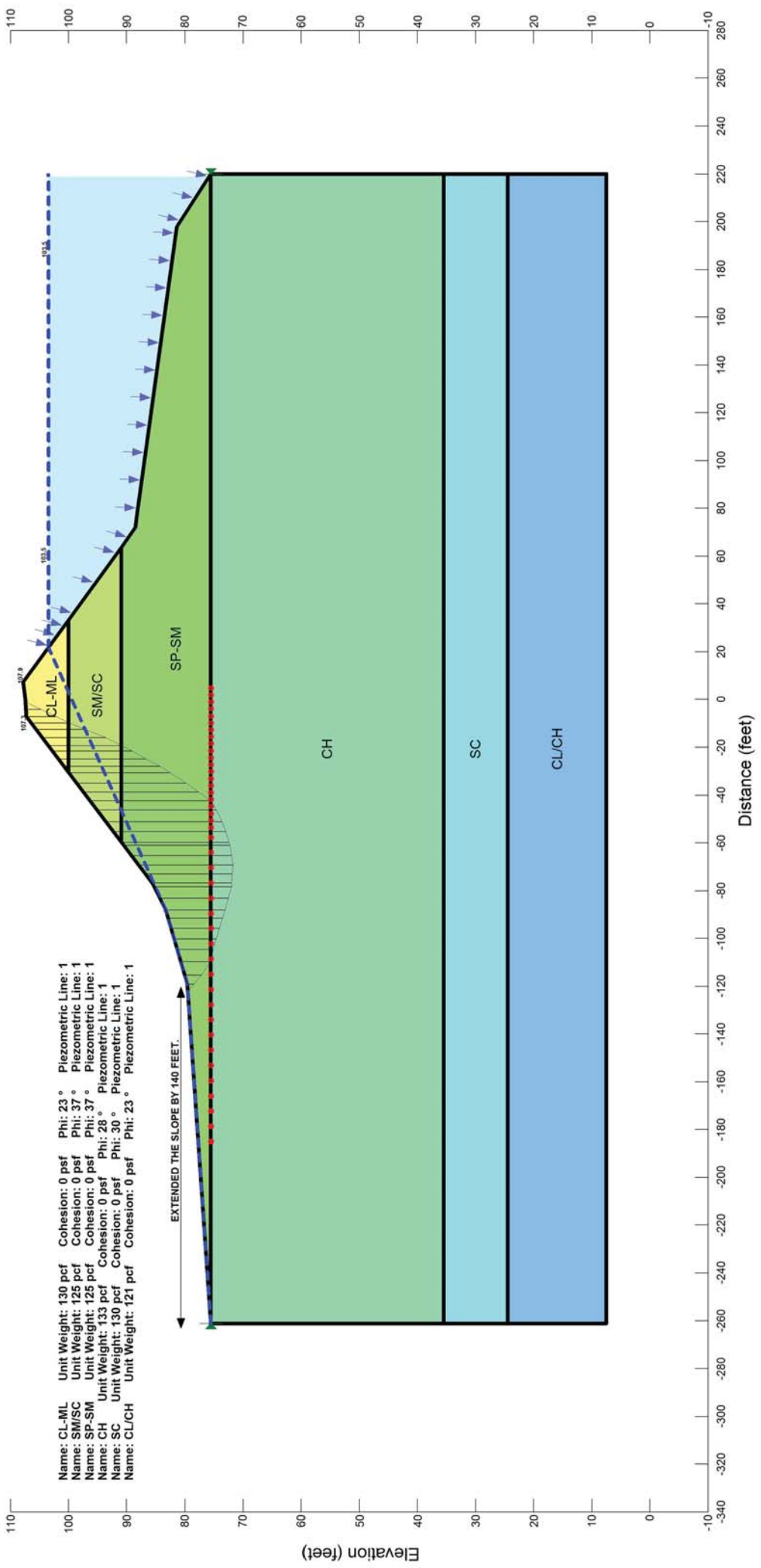| Name: CL-ML | Unit Weight: 130 pcf | Cohesion: 375 psf | | Piezometric Line: 1 |
Name: SM/SC	Unit Weight: 115 pcf	Cohesion: 250 psf	Phi: 24°	Piezometric Line: 1
Name: SP-SM	Unit Weight: 115 pcf	Cohesion: 350 psf	Phi: 20°	Piezometric Line: 1
Name: CH	Unit Weight: 133 pcf	Cohesion: 850 psf		Piezometric Line: 1
Name: SC	Unit Weight: 130 pcf	Cohesion: 750 psf		Piezometric Line: 1
Name: CL/CH	Unit Weight: 121 pcf	Cohesion: 1000 psf		Piezometric Line: 1

EXTENDED THE SLOPE BY 140 FEET.

Distance (feet)

Elevation (feet)

CLECO BRAME ENERGY CENTER
BOTTOM ASH POND - SECTION 3
LONG TERM SLOPE STABILITY ANALYSIS (S-CASE)
SOIL BORING B-3 (FROM GTL REPORT NO.: 06-11-090)

1.6

Name:				
Name: CL-ML	Unit Weight: 130 pcf	Cohesion: 0 psf	Phi: 23 °	Piezometric Line: 1
Name: SM/SC	Unit Weight: 125 pcf	Cohesion: 0 psf	Phi: 37 °	Piezometric Line: 1
Name: SP-SM	Unit Weight: 125 pcf	Cohesion: 0 psf	Phi: 37 °	Piezometric Line: 1
Name: CH	Unit Weight: 133 pcf	Cohesion: 0 psf	Phi: 28 °	Piezometric Line: 1
Name: SC	Unit Weight: 130 pcf	Cohesion: 0 psf	Phi: 30 °	Piezometric Line: 1
Name: CL/CH	Unit Weight: 121 pcf	Cohesion: 0 psf	Phi: 23 °	Piezometric Line: 1

EXTENDED THE SLOPE BY 140 FEET.

Distance (feet)

Elevation (feet)

CL-ML
SM/SC
SP-SM
CH
SC
CL/CH

APPENDIX B

P.E. CERTIFICATION

**CLECO BRAME ENERGY CENTER
BOTTOM ASH POND
CCR SAFETY FACTOR ASSESSMENT**

PROFESSIONAL ENGINEER CERTIFICATION

I hereby certify that I have performed a safety factor assessment for Cleco's Brame Energy Center Bottom Ash Pond in accordance with the 40 CFR 257.73(e)(1) CCR requirements. This safety factor assessment has determined that the Bottom Ash Pond has met the following requirements:

- The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
- The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

And that these requirements were not applicable based on the findings:

- The calculated seismic factor of safety must equal or exceed 1.00.
- For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

James C. Van Hoof

Name

24630   **LA**

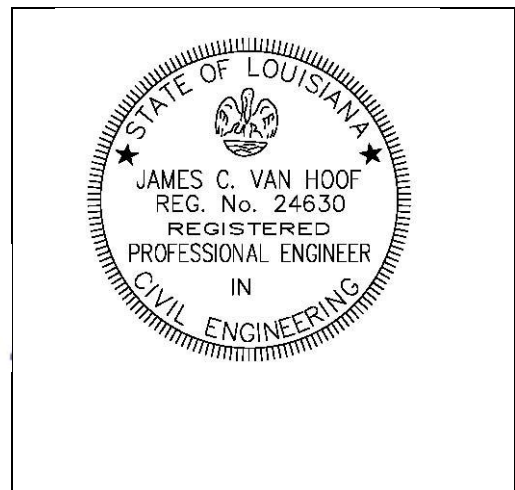Registration No.   State

James C. Van Hoof, P.E.

Signature

10/17/2016

Date   *(Seal)*