PERIODIC SAFETY FACTOR ASSESSMENT

EXISTING CCR IMPOUNDMENTS

CCR Rule Section 257.73(e)

ASBURY POWER PLANT

21133 Uphill Lane
Asbury, Missouri 64832

December 13, 2024

The Empire District Electric Company d/b/a Liberty Utilities

Prepared by:

PALMERTON & PARRISH, INC.

STATE OF MISSOURI
BRANDON ROSS PARRISH
NUMBER PE-2010000852
PROFESSIONAL ENGINEER

12/13/24

Brandon R. Parrish, P.E.
MO P.E. 2010000852

December 13, 2024

The Empire District Electric Company d/b/a Liberty Utilities
Asbury Power Plant
21133 Uphill Lane
Asbury, Missouri 64832

RE: **Periodic Safety Factor Assessment** – CCR Rule Section 257.73(e)
The Empire District Electric Company d/b/a Liberty Utilities – Asbury Power Plant
Asbury, Missouri
PPI Project Number 231518-2024

To Whom it May Concern:

This document summarizes the **Periodic Safety Factor Assessment** of the Empire District Electric Company's CCR Impoundments at the Asbury Power Plant. This document has been prepared to meet the requirements of Section 257.73(e) of the CCR Rule.

In accordance with Section 257.105(f)(12) of the CCR Rule, a copy of this document should be maintained in The Empire District Electric Company d/b/a Liberty Utilities' operating records. In accordance with Section 257.107(f)(11), a copy of this document should also be posted to Liberty Utilities' CCR Compliance website. Notification of the availability of this document should be provided to the State Director, as required in Section 257.106(f)(11).

PALMERTON & PARRISH, INC.
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STATE OF MISSOURI
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PALMERTON & PARRISH, INC.

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ASBURY, MISSOURI

1.0 INTRODUCTION

CCR Rule Section 257.73(e): Periodic Safety Factor Assessments

(1) The owner or operator must conduct an initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in paragraphs (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessment must be supported by appropriate engineering calculations.

Palmerton & Parrish, Inc. (PPI) has been retained by The Empire District Electric Company d/b/a Liberty Utilities, since 2011 for assistance with various CCR-related compliance tasks. PPI completed a detailed Site Structural Assessment of the Asbury CCR Impoundment in 2012 and 2014. PPI's studies included field reconnaissance, a subsurface drilling program, installation of temporary piezometers, a laboratory testing program, and slope stability analysis.

PPI completed a detailed review of the previously completed studies during preparation of the Initial Safety Factor Assessment Report, published on October 17, 2016. PPI then completed a Periodic Safety Factor Assessment Report, published on October 15, 2021, in which PPI again reviewed previously completed studies and compared historic Impoundment geometry and operating conditions to current conditions. As discussed later in this Report, in March 2020, The Empire District Electric Company d/b/a Liberty stopped coal-fired power generation at the Asbury Power Plant and planned for the plant's retirement. A demolition contractor imploded the Power Plant in June 2023, removed the residual materials, and reclaimed the site by June 2024.

Closure of the Asbury Coal Combustion Residuals (CCR) Impoundment began in early June 2022 and was completed in January 2023. Free liquids were removed to the extent possible, and the existing CCR materials were sufficiently stabilized to support the placement of the final fill and final cover system. Any discharge was discharged through a NPDES permitted outfall. This discharge was in compliance with the current NPDES permit. The CCR materials were graded to provide positive drainage of stormwater. A final cover system was installed to minimize infiltration and erosion.

The chosen final cover system was the ClosureTurf system. ClosureTurf is a patented, three component system that is EPA Subtitle D landfill compliant that is specifically designed to address and solve soil erosion, slope integrity, installation and maintenance cost control, EPA regulation compliance, and longevity of structure and appearance. The anticipated design life of ClosureTurf is 100 years. ClosureTurf consists of the following components, top to bottom.

- Specialized sand infill
- Engineered artificial turf
- Flexible geomembrane liner (FML)
- Prepared CCR subgrade

The facility is now called the Asbury Renewable Operations Center (AROC), which manages operations of wind farms and solar generation.

2.0 REQUIRED FACTOR OF SAFETY VALUES

The table below summarizes the calculated Factor of Safety values required for various design loading cases in the CCR Rule.

Table 2.0-1: Required Factor of Safety Values

CCR Rule Reference	Loading Condition	Req. Min. FS
257.73(e)(1)(i)	End of Construction	1.3
257.73(e)(1)(ii)	Static, Maximum Storage Pool	1.5
257.73(e)(1)(iii)	Static, Maximum Surcharge Pool	1.4
257.73(e)(1)(iv)	Seismic	1.0
257.73(e)(1)(v)[1]	Liquefaction[1]	1.2[1]

[1] Computation of Factor of Safety required only for dikes constructed of soils susceptible to liquefaction.

3.0 CRITICAL CROSS SECTION

Numerous cross sections and various loading conditions were analyzed during PPI's previous studies. In PPI's 2012 and 2014 studies, the critical cross section was identified in the northwest corner of the Upper Pond. This location was confirmed to be the critical cross section at the time of PPI's Initial Safety Factor Assessment Report in 2016 and reviewed in the 2021 Periodic Safety Factor Assessment.

PPI reviewed existing field conditions for the purposes of this Report. The condition of the perimeter levee embankments at the Asbury CCR Impoundment have changed appreciably since completion of our previous studies with the regrading for the CCR impoundment final cap closure. Allgeier, Martin and Associates, Inc. completed a final survey of the site following installation of the "ClosureTurf" dated May 5, 2023. The updated topographic map was used in combination with the previous topographic maps to produce the cross sections used for the slope stability analysis.

Based on PPI's review and comparison of existing conditions to previously existing conditions, the critical cross section for slope stability analysis is still located at the northwest corner of the Upper Pond. Since 2021 the geometry of the slope has changed most notably by reducing the total height, and the general piezometric surface composition has been reduced and is expected to remain stable with no additional water moving in or out the geosynthetic cap material. The levee embankment and underlying foundation conditions have not changed since 2021. The location of the Cross Sections are shown on the Site Plan included as Figure 1.

3.1 Geologic Cross Section

PPI developed a geologic cross section for the Critical Cross Section located at the northwest corner of the Upper Pond during completion of previous studies. There have been no changes to underlying geology, levee embankment composition, or levee embankment geometry, other than total height reduction, since development of the geologic cross section.

The geologic cross section was developed using data from subsurface investigations and laboratory testing programs in 2012 and 2014, along with construction observations during 2022. PPI's subsurface investigation included collection of thin-walled Shelby tube samples, pushed hydraulically in advance of drilling in general accordance with ASTM D 1587. Laboratory soil shear strength testing included pocket penetrometers, unconfined compressive strength, and multi-stage consolidated undrained triaxial testing. Geologic strata are summarized in the table on the following page, including effective and total stress shear strength parameters for each stratum.

Table 3.1-1: Geologic Strata and Soil Shear Strength Parameters

Strata	γ_m (pcf)	Shear Strength Parameters			
		Effective Stress		Total Stress	
		c_{eff} (psf)	ϕ_{eff} (deg)	c_{tot} (psf)	ϕ_{tot} (deg)
FILL: Lean Clay, soft to medium stiff	128	250	14.5	300	9
Lean Clay, medium stiff to stiff	126	50	25	400	11
Lean to Fat Clay, stiff to very stiff, shaley	126	100	27	150	17
Lean to Fat Clay, stiff to very stiff, shaley, sandy	129	50	22	100	18
Lean Clay, stiff to very stiff, shaley	126	200	27	500	15
CCW	84	60	36	60	36
Coal	81	100	24	100	16
Shale	135	5,000	35	5,000	35

The geologic cross sections are illustrated graphically on the slope stability analysis results output included in Appendix I.

3.1.1 Piezometric Surface

The original piezometric surface for the Critical Cross Section was developed using groundwater elevations measured during and upon completion of drilling in 2012 and 2014, historically surveyed water elevations in the North Cell of the Upper Pond, and the water elevation in the ditch near the toe of the levee embankment. Within the 2021 update it was noted that the Asbury CCR Impoundment had become inactive since the Asbury Power Plant was taken out of service on March 1, 2020. The normal pool elevation in the Upper Pond was more typically around the elevation 948 feet and was primarily controlled by rainfall and evaporation.

Since closure of the CCR impoundment in 2023 and the use of the geosynthetic liner material, the impoundment is not affected by rainfall or evaporation and the piezometric surface within the enclosure is assumed to be fairly constant. For the purposes of the Periodic Safety Factor Assessment, the piezometric elevations within the CCR impoundment were assumed to be at a maximum elevation of 940 ft. for both cross sections representing worst case conditions.

3.1.2 Existing Timber Pile Wall

There is an existing timber pile wall around the northwest corner of the North Cell of the Upper Pond. Based on information provided by long-term Liberty Utilities employees, this timber pile wall has been in place since prior to 1986. As-built information for the timber pile wall is not available.

The Critical Cross Section passes through the existing timber pile wall. The wall was not modeled in the slope stability analysis. This is considered conservative, as it is probable that the timber pile wall was driven to refusal during original installation. The timber pile wall most likely extends to refusal near or within shale bedrock.

3.1.3 Existing Drainage Ditch

There is an existing drainage ditch that runs parallel to the toe of the levee embankment slope of the North Cell of the Upper Pond. The ditch is typically 1 to 2 feet deep and is located 10 or more feet west of the levee embankment toe. Historically, this ditch primarily carried discharge water from the Cooling Tower. Under current operations, it is more commonly dry or contains very shallow water.

The ditch geometry is shown on the Critical Cross Section. The ditch is modeled with no flow, which is a conservative assumption since it ignores the water surcharge pressure. The failure surface for the critical Factor of Safety daylights before reaching the ditch channel.

3.2 Seismic Event

Section 257.73(e)(1)(iv) requires that the Critical Cross Section be analyzed under total stress conditions during a seismic event with a 2 percent probability of exceedance in 50-years (2% P.E. in 50-yr.). This seismic event is also known as the 2,475-year recurrence interval event.

PPI researched the design earthquake event using tools available from the United States Geological Survey (USGS) and the American Society of Civil Engineers (ASCE). The design earthquake event, as determined using the online ASCE 7 Hazard Tool (https://asce7hazardtool.online), is summarized in the table below.

Table 3.2-1: PSHA Output

Earthquake Return Period	Peak Horizontal Ground Acceleration (pga) for Site Class C
2,475-year (2% PE in 50 yr.)	0.084g[1]
[1] g = gravity = 32.174 ft/sec^2	

4.0 ANALYSIS METHODOLOGY

Conventional analysis procedures were utilized for computation of structural stability factors of safety. Slope stability analysis was performed using the computer program

SLOPE/W, part of the GeoStudio software package published by GEO-SLOPE International. Within SLOPE/W, Spencer's method was specified for completion of the analysis. Spencer's method is a limit equilibrium method that utilizes the method of slices. Spencer's method satisfies both force and moment equilibrium.

5.0 RESULTS

The table below summarizes the calculated Factors of Safety required in the CCR Rule, the applicable reference to the CCR Rule, and the calculated Factor of Safety values for the critical cross section at the Asbury CCR Impoundment.

Table 5.0-1: Calculated Factors of Safety

Loading Condition	CCR Rule Reference	Req. Min. FS	NW Slope 1 Calculated FS	NE Slope 2 Calculated FS
End of Construction	257.73(e)(1)(i)	1.3	N/A[1]	N/A[1]
Static, Maximum Storage Pool	257.73(e)(1)(ii)	1.5	1.8	2.5
Static, Maximum Surcharge Pool	257.73(e)(1)(iii)	1.4	N/A[2]	N/A[2]
Seismic	257.73(e)(1)(iv)	1.0	1.3	2.0
Liquefaction	257.73(e)(1)(v)	1.2[1]	N/A[3]	N/A[3]

[1] The Asbury CCR Impoundment levees have been in place for decades and were most recently modified in 2023. End of construction analysis, as outlined in Section 257.73(e)(1(i) of the CCR Rule does not apply to the Asbury CCR Impoundment.

[2]The Asbury CCR Impoundment is capped and closed off from additional water inflow and evaporation. Piezometric level was assumed to be at a maximum worst case of 940 ft. and is expected to remain stable over time.

[3]The Asbury CCR Impoundment levees are constructed of earth fill materials that are not considered susceptible to liquefaction. The levees are underlain by natural stiff clay soils and bedrock. In some locations CCR material was placed above the levees but significant compaction effort was observed when placing the CCR resulting in a dense material. In addition, previous laboratory testing performed by PPI indicated that the CCR exhibits a fines content (minus No. 200 sieve) ranging from approximately 20 to 50 percent, resulting in negligible liquefaction potential. Section 273.73(e)(1)(iv) of the CCR Rule does not apply to the Asbury CCR Impoundment.

6.0 CERTIFICATION 257.73(e)(2)

The undersigned Professional Engineer certifies that the periodic safety factor assessment meets the requirements of 40 CFR 257.73(e)(2). As published in this Report, the Critical Cross Section of the Asbury CCR Impoundment meets the required calculated Factors of Safety.

State of Missouri Professional Engineering License Number: 2010000852

Name: Brandon Ross Parrish, P.E.

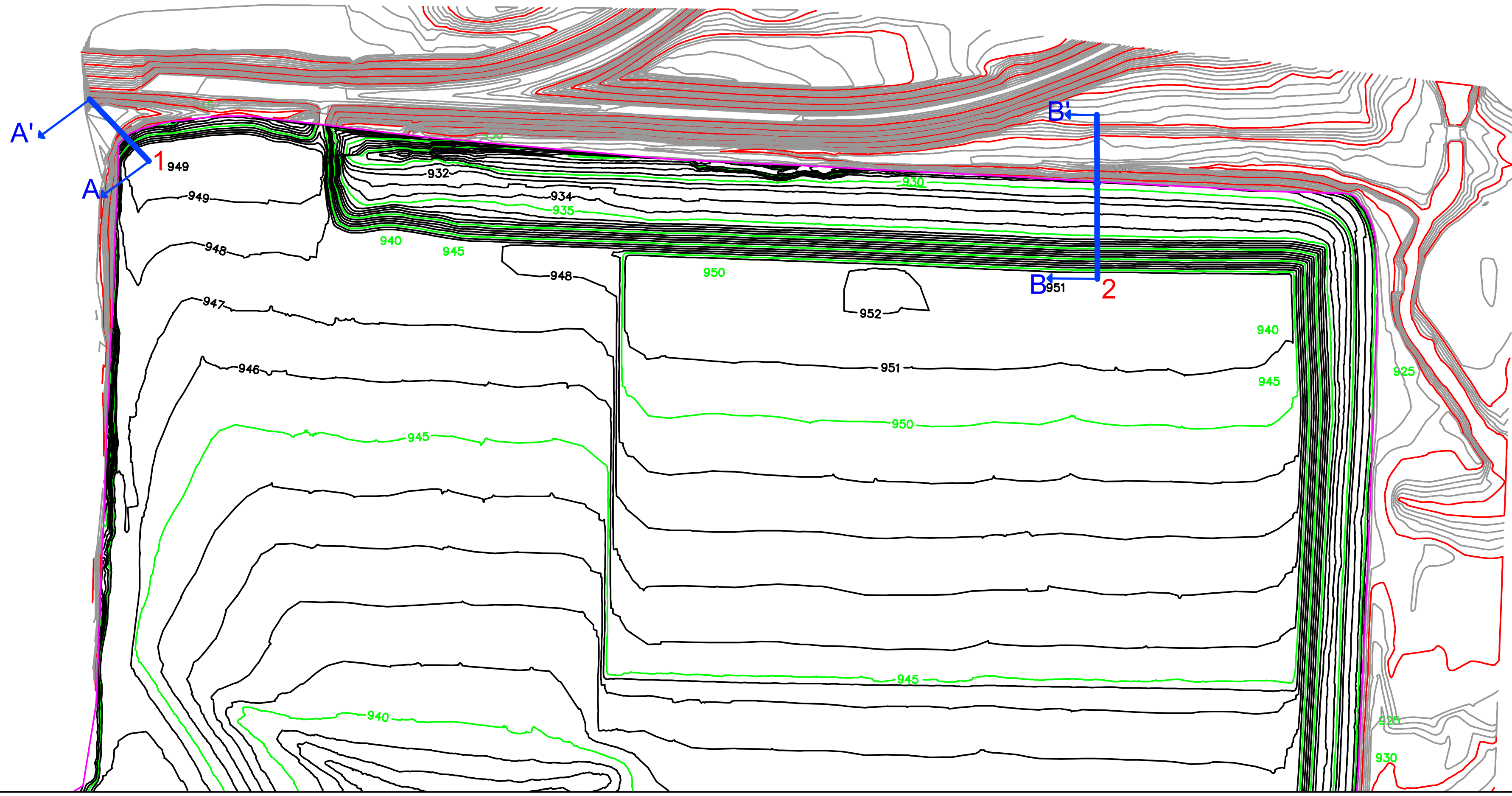
Signature: ______________________

Date: December 13, 2024

Seal:

12/13/24

FIGURE



LEGEND

Cross Section

SCALE
1" = 120'

Project: Periodic Safety Factor Assessment - Asbury Power Plant
Client: Empire District Electric Company d/b/a Liberty Utilities

Site Plan - Cross Section Location

Date: November 11, 2024

Project Number: 231518-2024

PALMERTON & PARRISH, INC.
GEOTECHNICAL AND MATERIALS ENGINEERS/MATERIALS TESTING LABORATORIES/ENVIRONMENTAL SERVICES

FIGURE 1

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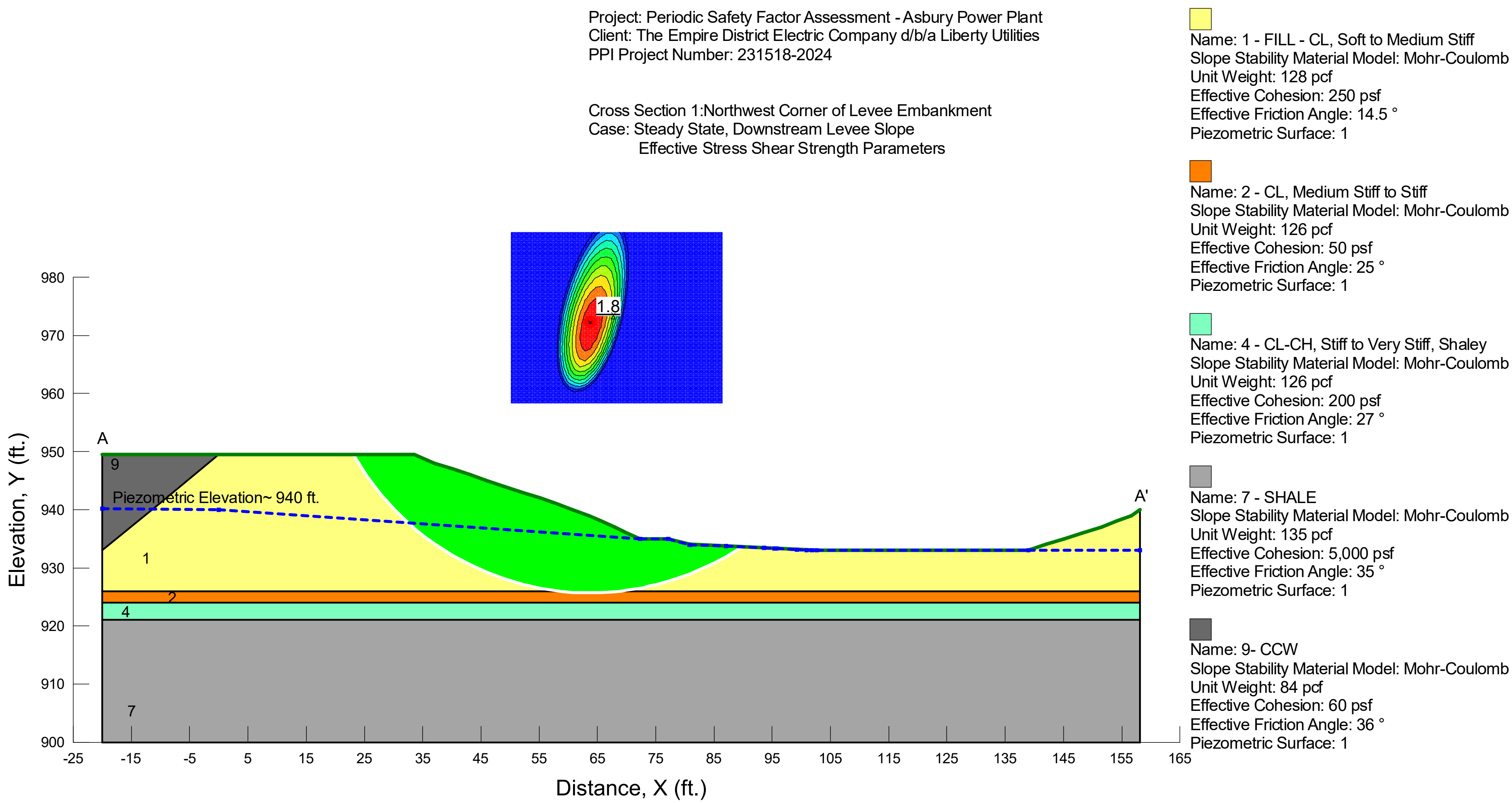
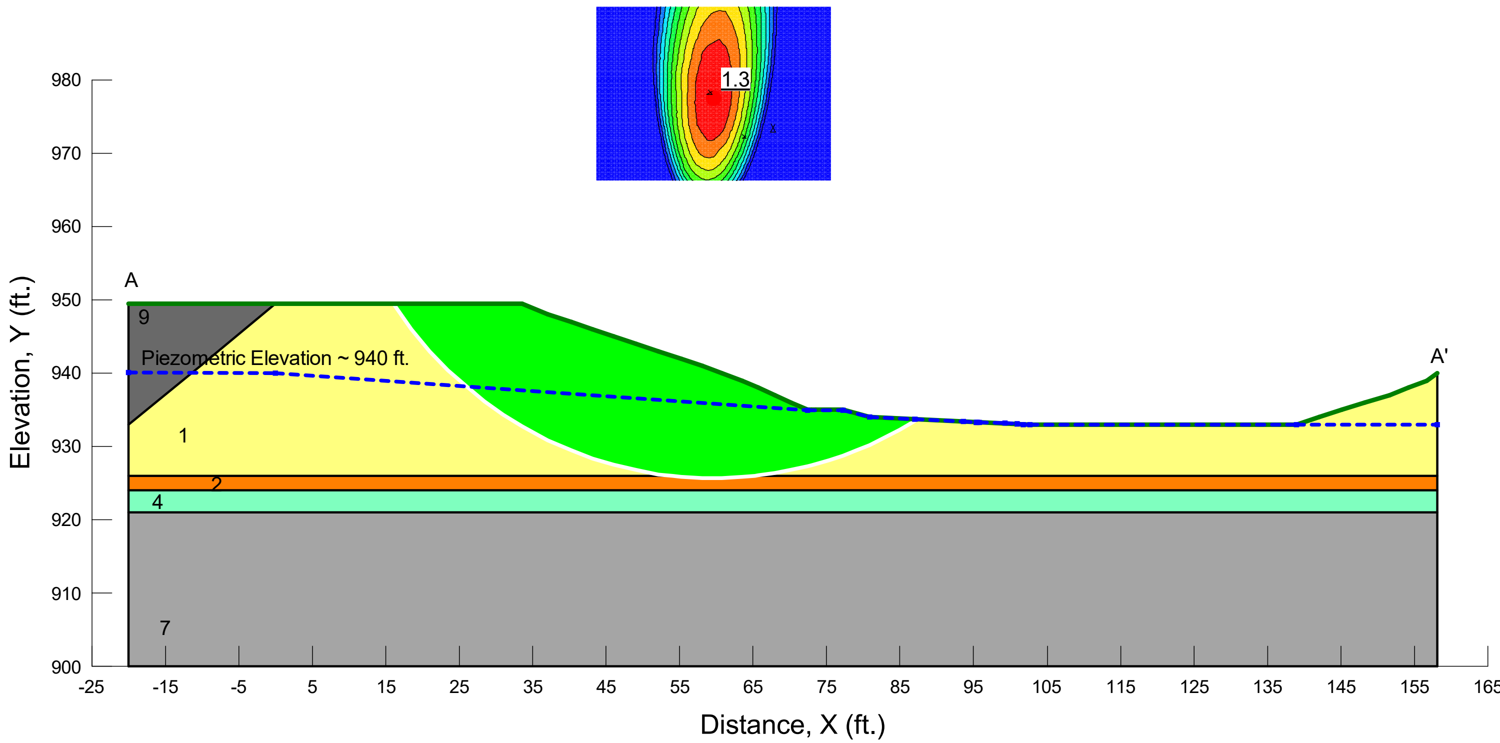
APPENDIX I

SLOPE STABILITY ANALYSIS RESULTS


Project: Periodic Safety Factor Assessment - Asbury Power Plant
Client: The Empire District Electric Company d/b/a Liberty Utilities
PPI Project Number: 231518-2024
Cross Section 1:Northwest Corner of Levee Embankment
Case: Steady State, Downstream Levee Slope
Effective Stress Shear Strength Parameters
1.8
A
A'
9
Piezometric Elevation~ 940 ft.
1
2
4
7
Elevation, Y (ft.)
980
970
960
950
940
930
920
910
900
Distance, X (ft.)
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
Name: 1 - FILL - CL, Soft to Medium Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 128 pcf
Effective Cohesion: 250 psf
Effective Friction Angle: 14.5 °
Piezometric Surface: 1
Name: 2 - CL, Medium Stiff to Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 25 °
Piezometric Surface: 1
Name: 4 - CL-CH, Stiff to Very Stiff, Shaley
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 27 °
Piezometric Surface: 1
Name: 7 - SHALE
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 5,000 psf
Effective Friction Angle: 35 °
Piezometric Surface: 1
Name: 9- CCW
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 84 pcf
Effective Cohesion: 60 psf
Effective Friction Angle: 36 °
Piezometric Surface: 1

Project: Periodic Safety Factor Assessment - Asbury Power Plant
Client: The Empire District Electric Company d/b/a Liberty Utilities
PPI Project Number: 231518-2024

Cross Section 1: Northwest Corner of Levee Embankment
Case: Steady State, Eathquake Load, Downstream Levee Slope
Seismic Event: 2% PE in 50-yr. Event
PGAm= 0.084g
Total Stress Shear Strength Parameters



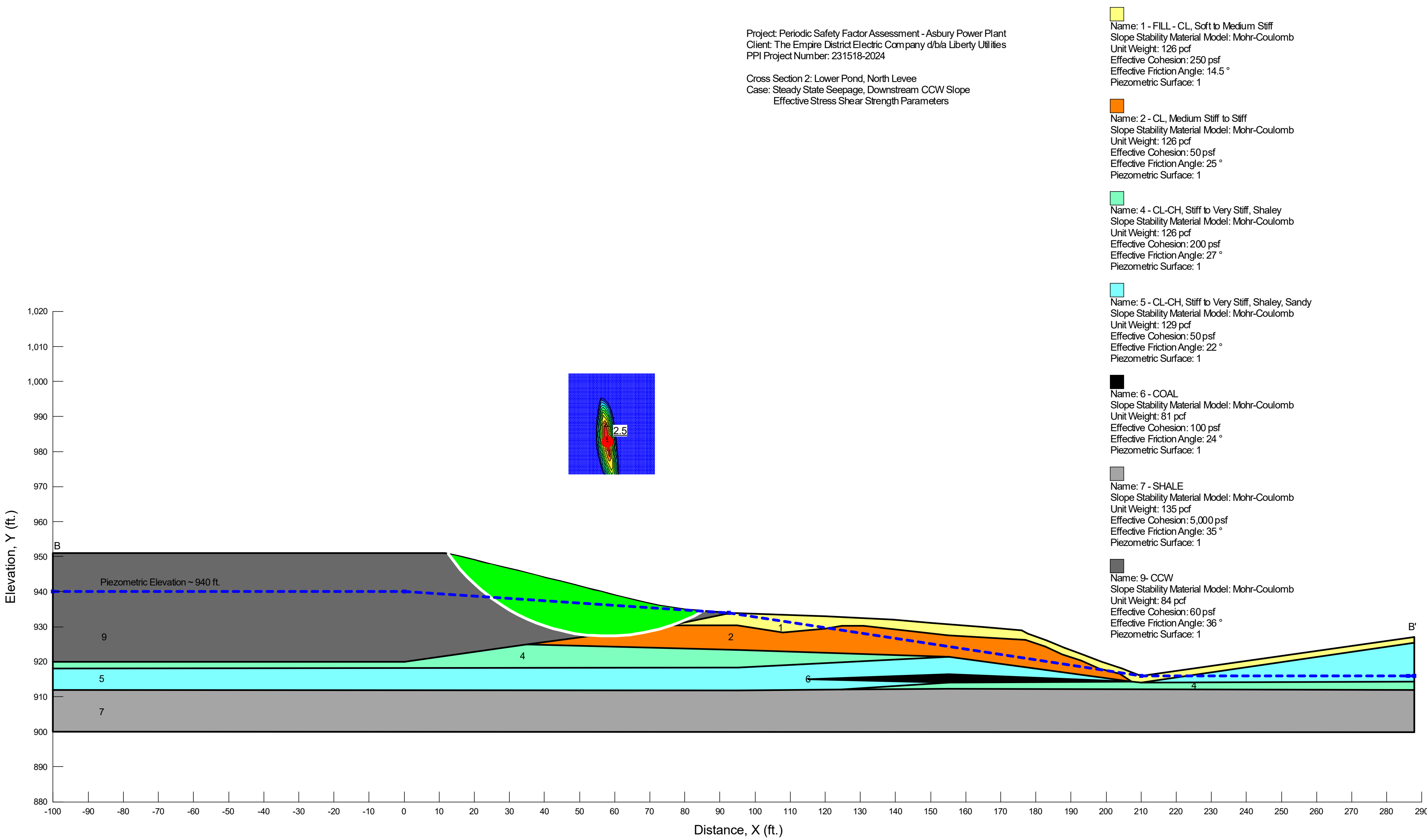
Name: 1 - FILL - CL, Soft to Medium Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 128 pcf
Effective Cohesion: 300 psf
Effective Friction Angle: 9 °
Piezometric Surface: 1

Name: 2 - CL, Medium Stiff to Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 400 psf
Effective Friction Angle: 11 °
Piezometric Surface: 1

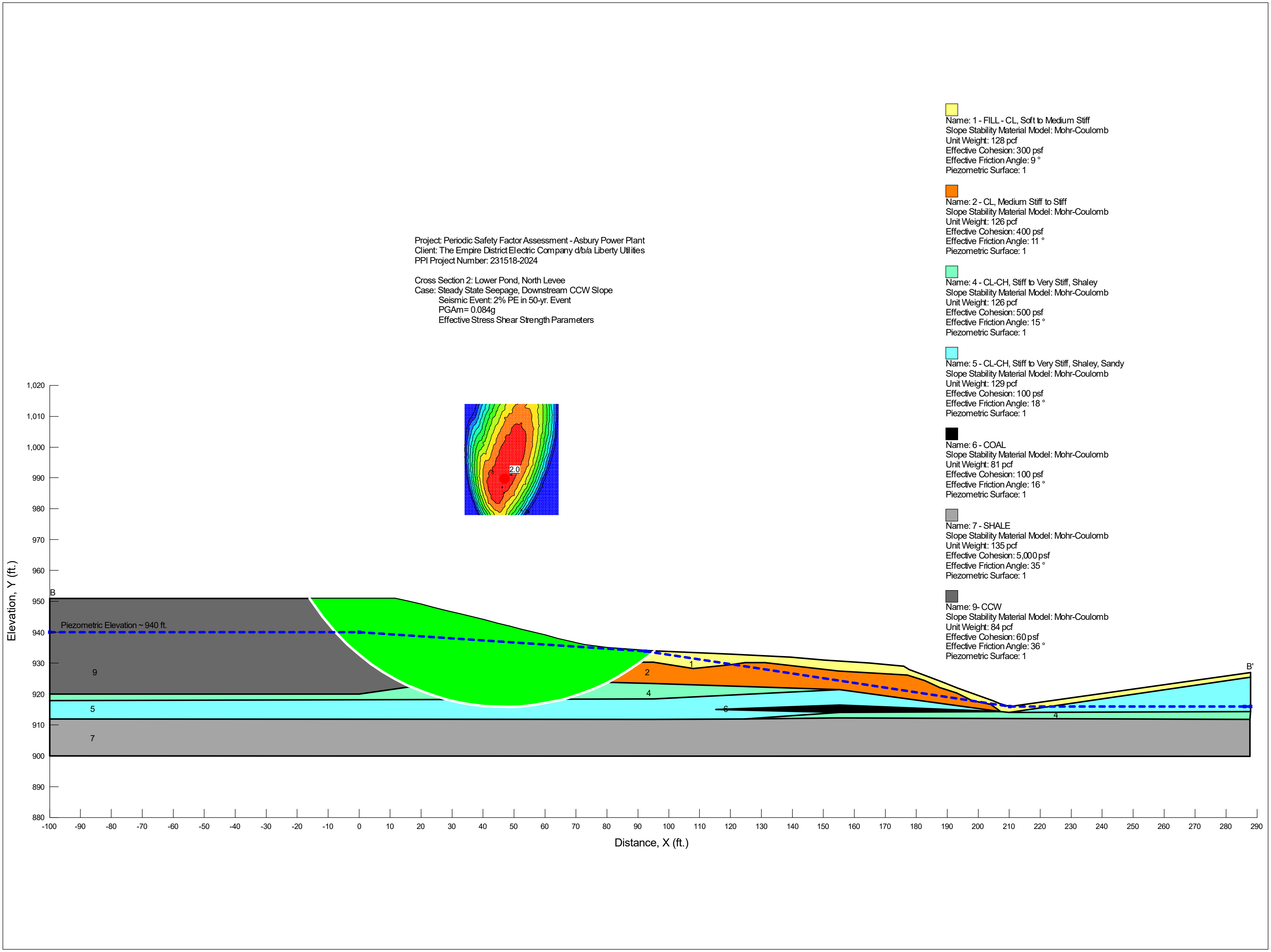
Name: 4 - CL-CH, Stiff to Very Stiff, Shaley
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 500 psf
Effective Friction Angle: 15 °
Piezometric Surface: 1

Name: 7 - SHALE
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 5,000 psf
Effective Friction Angle: 35 °
Piezometric Surface: 1

Name: 9- CCW
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 84 pcf
Effective Cohesion: 60 psf
Effective Friction Angle: 36 °
Piezometric Surface: 1



Project: Periodic Safety Factor Assessment - Asbury Power Plant
Client: The Empire District Electric Company d/b/a Liberty Utilities
PPI Project Number: 231518-2024
Cross Section 2: Lower Pond, North Levee
Case: Steady State Seepage, Downstream CCW Slope
Effective Stress Shear Strength Parameters
Name: 1 - FILL - CL, Soft to Medium Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 250 psf
Effective Friction Angle: 14.5 °
Piezometric Surface: 1
Name: 2 - CL, Medium Stiff to Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 25 °
Piezometric Surface: 1
Name: 4 - CL-CH, Stiff to Very Stiff, Shaley
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 27 °
Piezometric Surface: 1
Name: 5 - CL-CH, Stiff to Very Stiff, Shaley, Sandy
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 129 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 22 °
Piezometric Surface: 1
Name: 6 - COAL
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 81 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 24 °
Piezometric Surface: 1
Name: 7 - SHALE
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 5,000 psf
Effective Friction Angle: 35 °
Piezometric Surface: 1
Name: 9- CCW
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 84 pcf
Effective Cohesion: 60 psf
Effective Friction Angle: 36 °
Piezometric Surface: 1
2.5
B
B'
Piezometric Elevation ~ 940 ft.
9
4
5
7
2
1
6
4
Elevation, Y (ft.)
1,020
1,010
1,000
990
980
970
960
950
940
930
920
910
900
890
880
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
Distance, X (ft.)



Project: Periodic Safety Factor Assessment - Asbury Power Plant
Client: The Empire District Electric Company d/b/a Liberty Utilities
PPI Project Number: 231518-2024
Cross Section 2: Lower Pond, North Levee
Case: Steady State Seepage, Downstream CCW Slope
Seismic Event: 2% PE in 50-yr. Event
PGAm= 0.084g
Effective Stress Shear Strength Parameters
Name: 1 - FILL - CL, Soft to Medium Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 128 pcf
Effective Cohesion: 300 psf
Effective Friction Angle: 9 °
Piezometric Surface: 1
Name: 2 - CL, Medium Stiff to Stiff
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 400 psf
Effective Friction Angle: 11 °
Piezometric Surface: 1
Name: 4 - CL-CH, Stiff to Very Stiff, Shaley
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 126 pcf
Effective Cohesion: 500 psf
Effective Friction Angle: 15 °
Piezometric Surface: 1
Name: 5 - CL-CH, Stiff to Very Stiff, Shaley, Sandy
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 129 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 18 °
Piezometric Surface: 1
Name: 6 - COAL
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 81 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 16 °
Piezometric Surface: 1
Name: 7 - SHALE
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 5,000 psf
Effective Friction Angle: 35 °
Piezometric Surface: 1
Name: 9- CCW
Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 84 pcf
Effective Cohesion: 60 psf
Effective Friction Angle: 36 °
Piezometric Surface: 1
2.0
B
B'
Piezometric Elevation ~ 940 ft.
9
5
7
2
1
4
6
4
Elevation, Y (ft.)
1,020
1,010
1,000
990
980
970
960
950
940
930
920
910
900
890
880
Distance, X (ft.)
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290