INITIAL SAFETY FACTOR ASSESSMENT

EXISTING CCR IMPOUNDMENTS

CCR Rule Section 257.73(e)

ASBURY POWER PLANT

21133 Uphill Lane
Asbury, Missouri 64832

October 17, 2016

EMPIRE

SERVICES YOU COUNT ON

EMPIRE DISTRICT ELECTRIC COMPANY

Prepared by:

PPI PALMERTON & PARRISH, INC.

STATE OF MISSOURI
RACHEL JEANNE GOEKE
NUMBER PE-2007020268
PROFESSIONAL ENGINEER

10/17/16

Rachel J. Goeke, P.E.
MO P.E. 2007020268

October 17, 2016

Empire District Electric Company
Asbury Power Plant
21133 Uphill Lane
Asbury, Missouri 64832

RE: **Initial Safety Factor Assessment** – CCR Rule Section 257.73(e)
Empire District Electric Company – Asbury Power Plant
Asbury, Missouri
PPI Project Number 231518

To Whom it May Concern:

This document summarizes the **Initial 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 Empire's operating records. In accordance with Section 257.107(f)(11), a copy of this document should also be posted to Empire's 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.
By:

Rachel J. Goeke

Rachel J. Goeke, P.E.
MO P.E. 2007020268

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CCR RULE SECTION 257.73(e)

EMPIRE DISTRICT ELECTRIC COMPANY – ASBURY POWER PLANT

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 (Empire) 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.

For the purposes of this Report, PPI performed a detailed review of our previously completed studies, and compared current field conditions and CCR Impoundment operating conditions to conditions at the time of our previously completed studies.

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.

PPI reviewed existing field conditions for the purposes of this Report. The condition of the perimeter levee embankments at the Asbury CCR Impoundment has not changed appreciably since completion of our previous studies. A considerable volume of additional coal combustion residuals (CCR) has been placed in the interior of the Lower Pond since completion of our most recent Report in 2014. The additional CCR volume does not affect the perimeter levee embankments. Other changes include a significant reduction in the ponded operating level of the South Pond, and an ongoing reduction in the ponded operating level of the Upper Pond.

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. The geometry, composition of the levee embankment and underlying foundation conditions, and general piezometric surface has not changed since 2014. The location of the Critical Cross Section is 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 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. 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 below, including effective and total stress shear strength parameters for each stratum.

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

		Shear Strength Parameters			
		Effective Stress		Total Stress	
Strata	γ_m (pcf)	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 Clay, stiff to very stiff, shaley	126	200	27	500	15
Shale	135	5,000	35	5,000	35

The geologic cross section is illustrated graphically on the slope stability analysis result output included in Appendix II.

3.1.1 Piezometric Surface

The 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. The maximum surcharge elevation for the Upper Pond is controlled by a 10-inch overflow pipe, with a top of pipe elevation of 953 feet. The historical normal operating level elevation for the Upper Pond is about 4.5 inches above the bottom of the overflow pipe, at approximately elevation 952.54 feet. Empire is in the process of lowering the normal operating pool elevation of the Upper Pond, which should increase the calculated Factors of Safety published in this Report.

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 Empire 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 modelled 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 Cooling Tower 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. Based on information provided by Empire, the ditch primarily carries discharge water from the Cooling Tower. The flow elevation and volume of water in the ditch is relatively consistent. The ditch geometry is shown on the Critical Cross Section. The ditch is modelled 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 utilized Probabilistic Seismic Hazard Analysis (PSHA) methods as outlined in USACE ER 1110-2-1806 for completion of seismic slope stability analysis. The PSHA was performed using the 2008 Interactive Deaggregation Program available on the United State Geological Survey (USGS) Earthquake Hazards Mapping website (http://earthquake.usgs.gov). PSHA output for the 2,475-year recurrence interval event is included in Appendix I and summarized in the table below.

Table 3.2-1: PSHA Output	
Earthquake Return Period	Peak Horizontal Ground Acceleration (pga) for BC rock
2,475-year (2% PE in 50 yr.)	0.052g[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	Calculated FS
End of Construction	257.73(e)(1)(i)	1.3	NA[1]
Static, Maximum Storage Pool	257.73(e)(1)(ii)	1.5	1.5
Static, Maximum Surcharge Pool	257.73(e)(1)(iii)	1.4	1.5
Seismic	257.73(e)(1)(iv)	1.0	1.1
Liquefaction	257.73(e)(1)(v)	1.2[1]	NA[2]

[1] The Asbury CCR Impoundment levees have been in place for decades. 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 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. 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 initial 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: 2007020268

Name: Rachel Jeanne Goeke, P.E.

Signature: Rachel J. Goeke

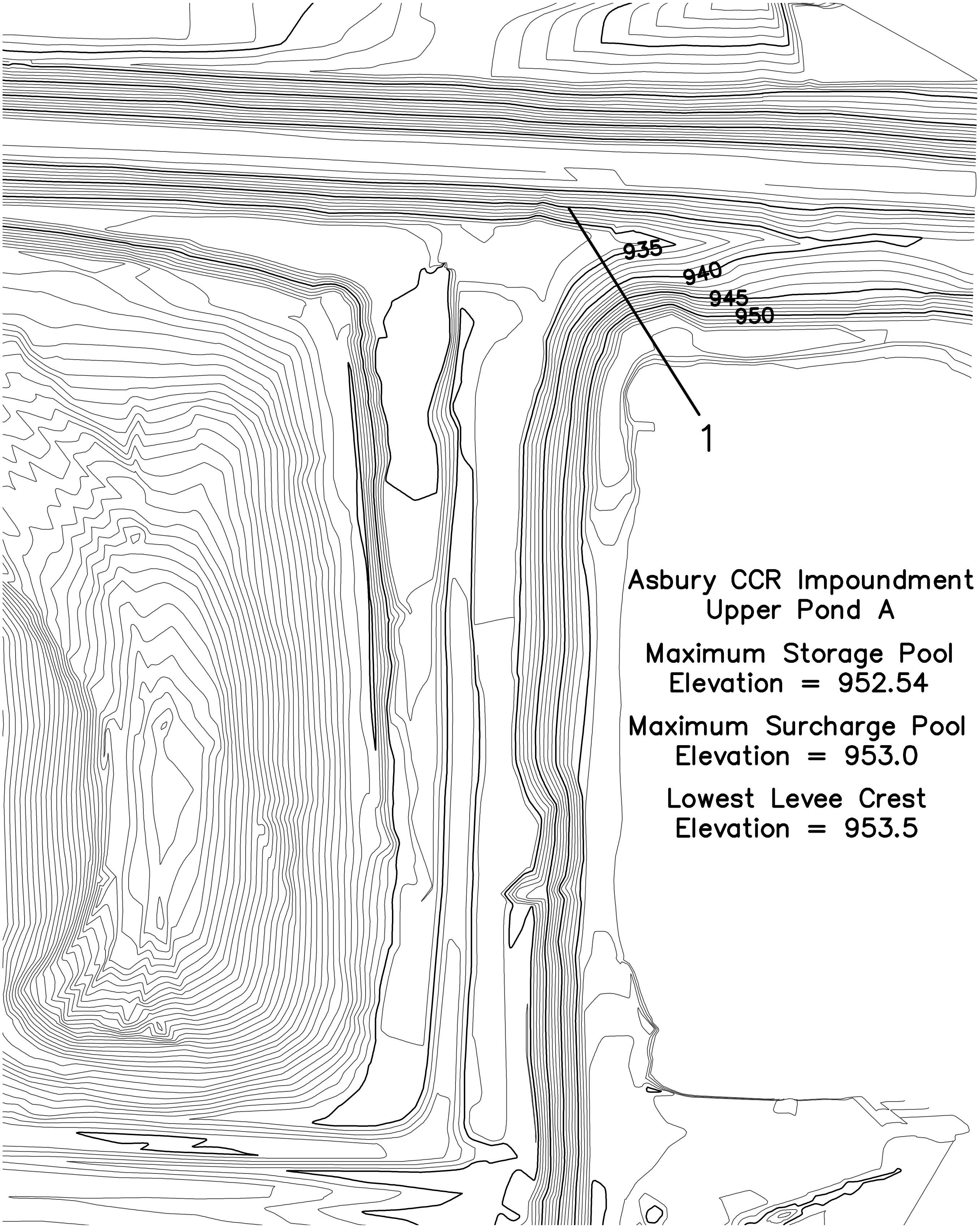
Date: October 17, 2016

Seal:

STATE OF MISSOURI
RACHEL
JEANNE GOEKE
NUMBER
PE-2007020268
PROFESSIONAL ENGINEER

Rachel J. Goeke
10/17/16

FIGURE



SCALE
1"=100'

Project: Asbury Power Plant, 21133 Uphill Lane, Asbury, MO
Client: Empire District Electric Company

Cross Section Location Plan

DATE: October 17, 2016

Project Number: 231518

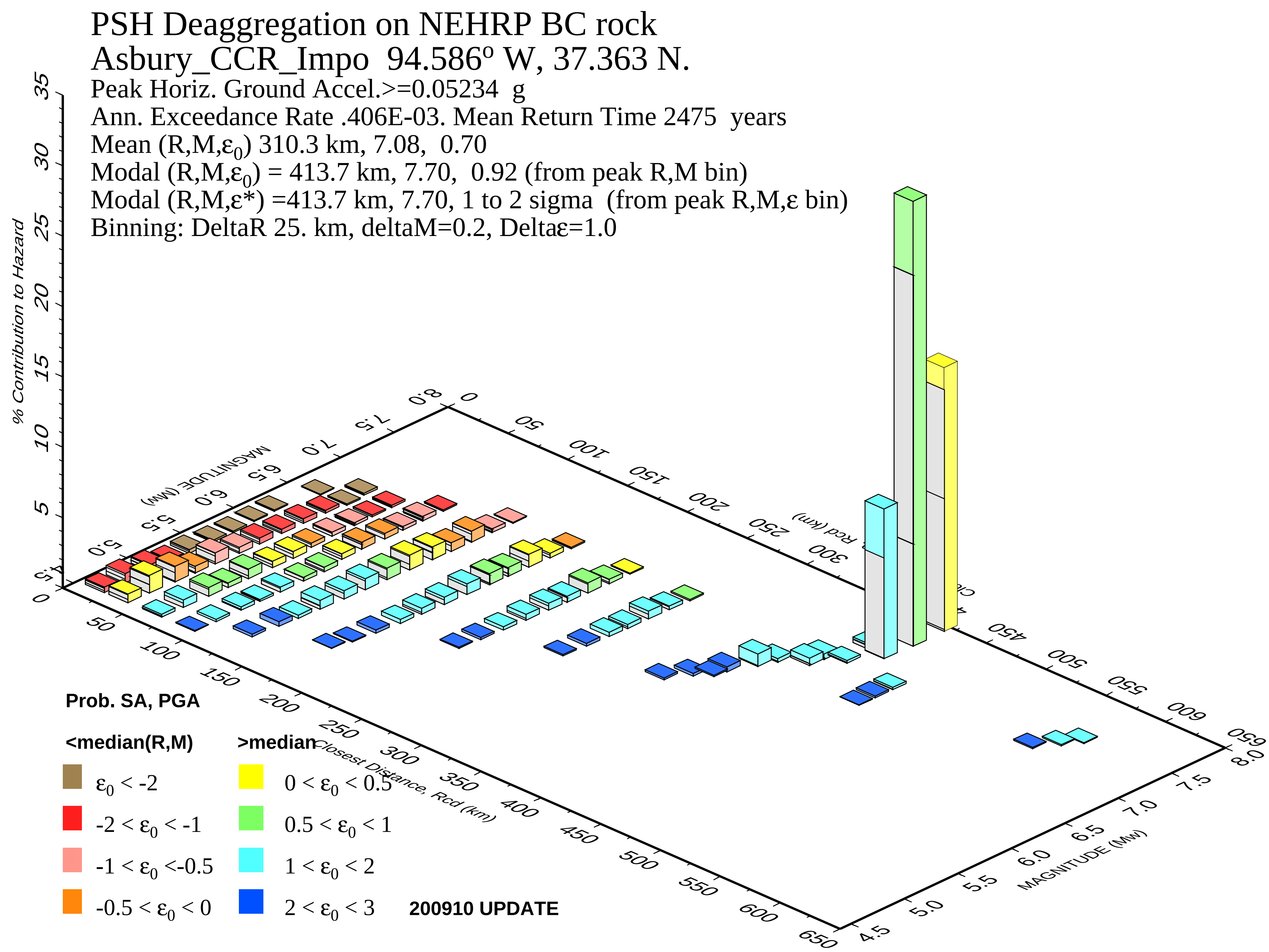
PPI PALMERTON & PARRISH, INC.
GEOTECHNICAL AND MATERIALS ENGINEERS/MATERIALS TESTING LABORATORIES/ENVIRONMENTAL SERVICES

FIGURE 1

S:_MASTER PROJECT FILE\2015\E\EDE-231518-Asbury CCR Rule Compliance-Sub\2016\2016-10-17 - Initial Structural Stability\Cross Sections.dwg

APPENDIX I

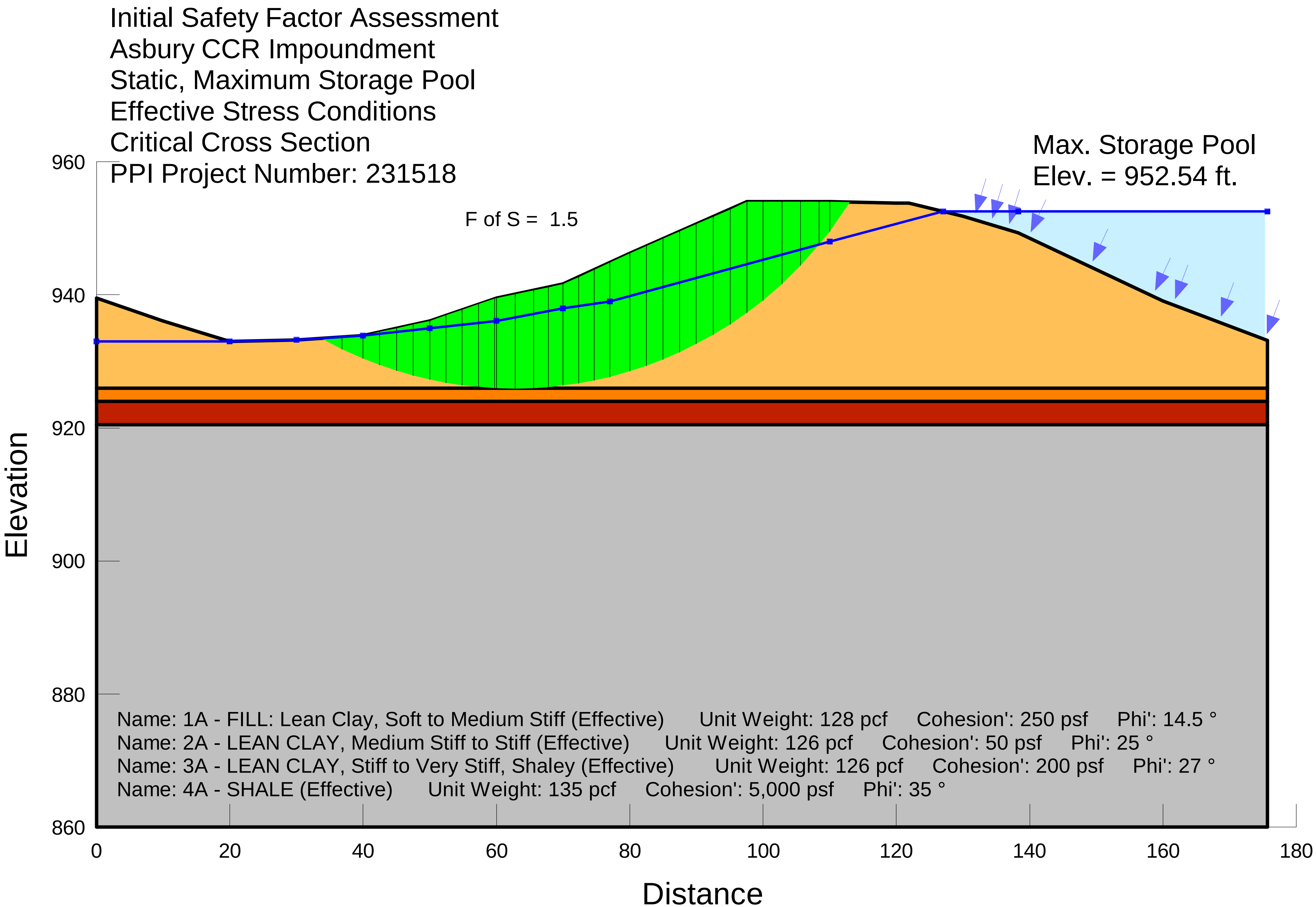
PROBABILISTIC SEISMIC HAZARD ANALYSIS (PSHA) DEAGGREGATION OUTPUT

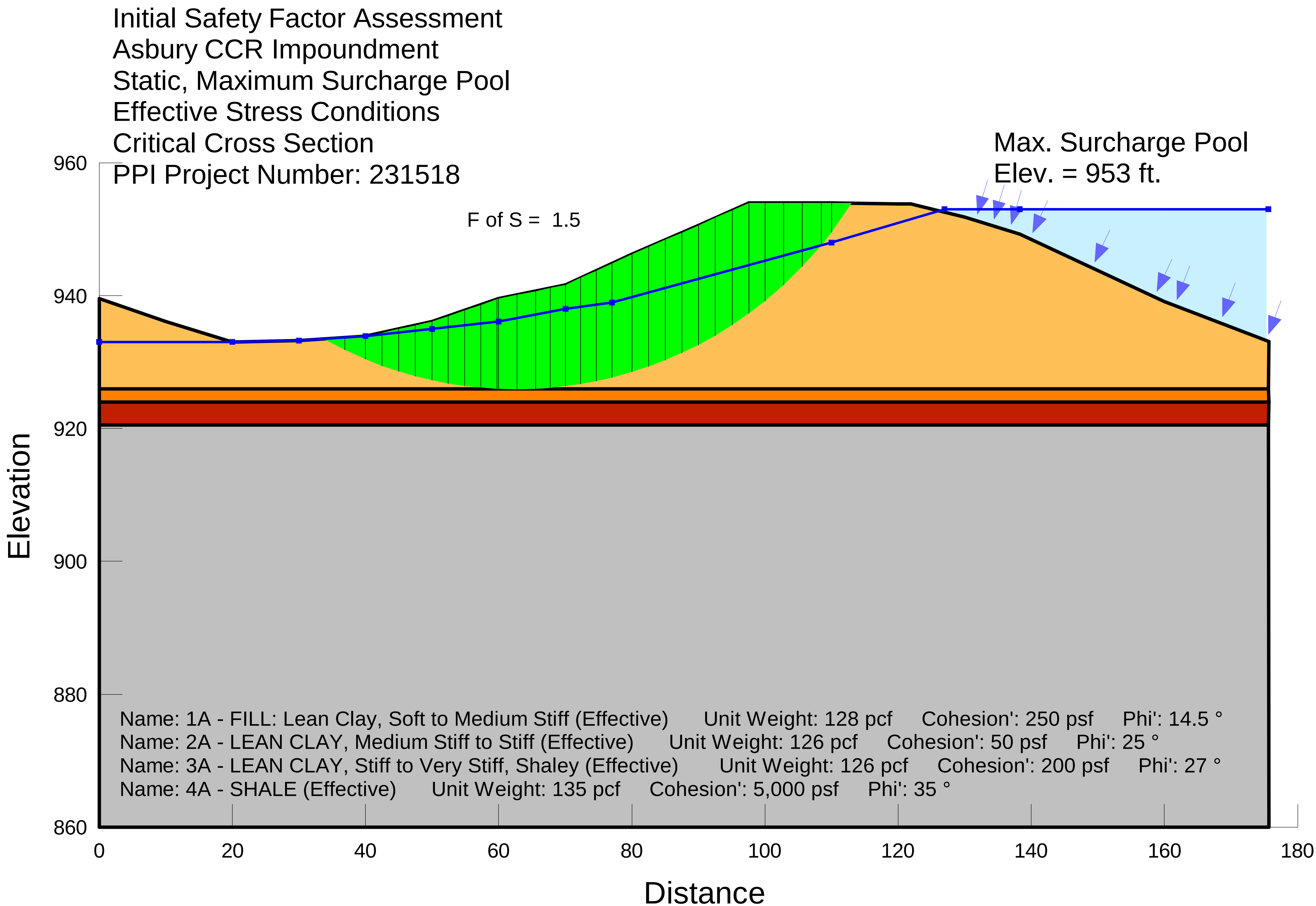


GMT 2016 Oct 6 18:08:00 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

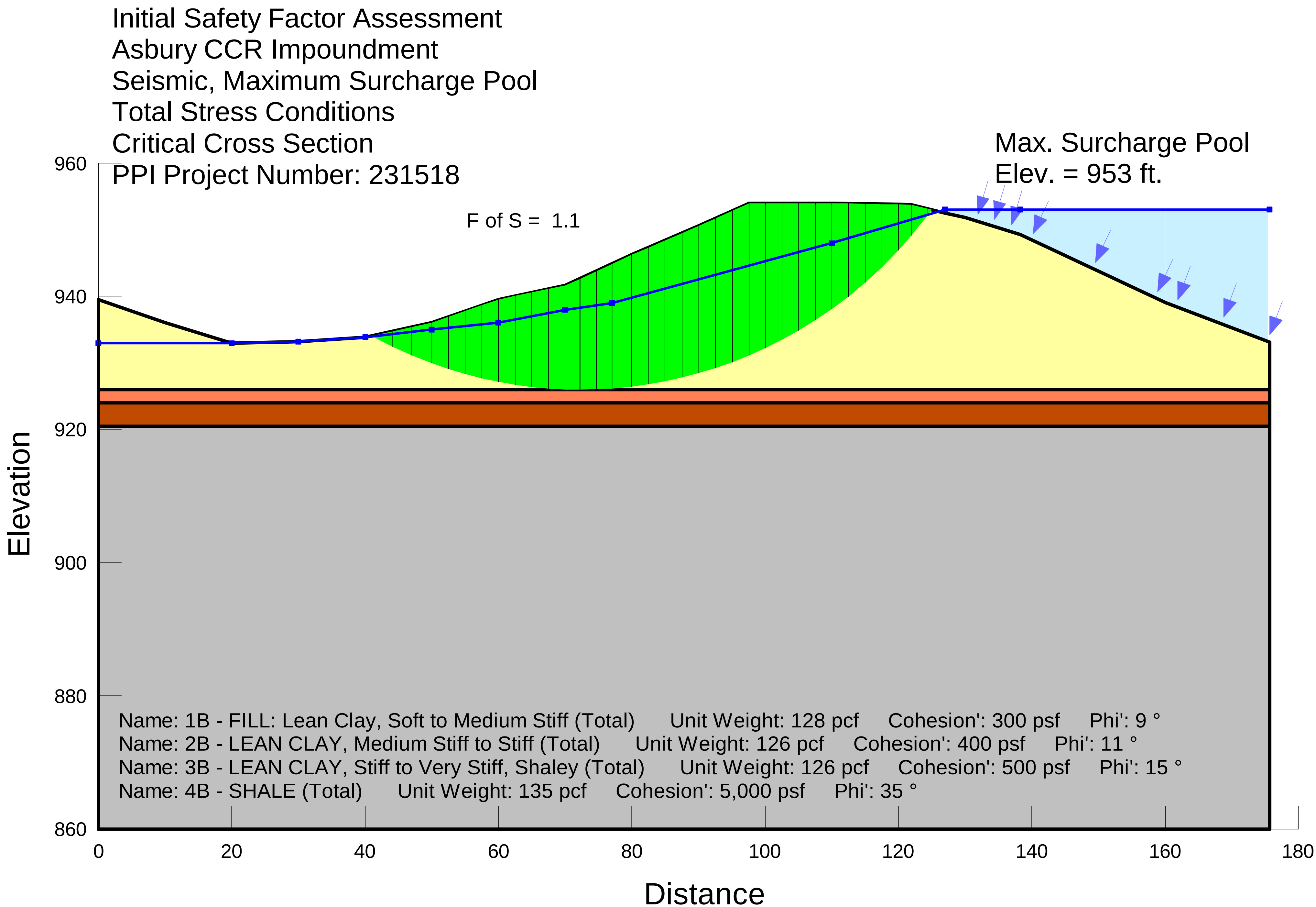
APPENDIX II

SLOPE STABILITY ANALYSIS RESULTS


Initial Safety Factor Assessment
Asbury CCR Impoundment
Static, Maximum Storage Pool
Effective Stress Conditions
Critical Cross Section
PPI Project Number: 231518
Max. Storage Pool
Elev. = 952.54 ft.
F of S = 1.5
960
940
920
900
880
860
Elevation
0
20
40
60
80
100
120
140
160
180
Distance
Name: 1A - FILL: Lean Clay, Soft to Medium Stiff (Effective) Unit Weight: 128 pcf Cohesion': 250 psf Phi': 14.5 °
Name: 2A - LEAN CLAY, Medium Stiff to Stiff (Effective) Unit Weight: 126 pcf Cohesion': 50 psf Phi': 25 °
Name: 3A - LEAN CLAY, Stiff to Very Stiff, Shaley (Effective) Unit Weight: 126 pcf Cohesion': 200 psf Phi': 27 °
Name: 4A - SHALE (Effective) Unit Weight: 135 pcf Cohesion': 5,000 psf Phi': 35 °



Initial Safety Factor Assessment
Asbury CCR Impoundment
Static, Maximum Surcharge Pool
Effective Stress Conditions
Critical Cross Section
PPI Project Number: 231518
Max. Surcharge Pool
Elev. = 953 ft.
F of S = 1.5
Name: 1A - FILL: Lean Clay, Soft to Medium Stiff (Effective) Unit Weight: 128 pcf Cohesion': 250 psf Phi': 14.5 °
Name: 2A - LEAN CLAY, Medium Stiff to Stiff (Effective) Unit Weight: 126 pcf Cohesion': 50 psf Phi': 25 °
Name: 3A - LEAN CLAY, Stiff to Very Stiff, Shaley (Effective) Unit Weight: 126 pcf Cohesion': 200 psf Phi': 27 °
Name: 4A - SHALE (Effective) Unit Weight: 135 pcf Cohesion': 5,000 psf Phi': 35 °
Elevation
960
940
920
900
880
860
Distance
0
20
40
60
80
100
120
140
160
180



Initial Safety Factor Assessment
Asbury CCR Impoundment
Seismic, Maximum Surcharge Pool
Total Stress Conditions
Critical Cross Section
PPI Project Number: 231518
Max. Surcharge Pool
Elev. = 953 ft.
F of S = 1.1
Name: 1B - FILL: Lean Clay, Soft to Medium Stiff (Total) Unit Weight: 128 pcf Cohesion': 300 psf Phi': 9 °
Name: 2B - LEAN CLAY, Medium Stiff to Stiff (Total) Unit Weight: 126 pcf Cohesion': 400 psf Phi': 11 °
Name: 3B - LEAN CLAY, Stiff to Very Stiff, Shaley (Total) Unit Weight: 126 pcf Cohesion': 500 psf Phi': 15 °
Name: 4B - SHALE (Total) Unit Weight: 135 pcf Cohesion': 5,000 psf Phi': 35 °
960
940
920
900
880
860
Elevation
0
20
40
60
80
100
120
140
160
180
Distance