

PERIODIC SAFETY FACTOR ASSESSMENT

EXISTING CCR IMPOUNDMENTS
CCR Rule Section 257.73(e)

ASBURY POWER PLANT

21133 Uphill Lane
Asbury, Missouri 64832

October 15, 2021

The Empire District Electric Company

Prepared by:



Rachel J. Goeke, P.E.
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October 15, 2021

The Empire District Electric Company
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 – Asbury Power Plant
Asbury, Missouri
PPI Project Number 231518

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's operating records. In accordance with Section 257.107(f)(11), a copy of this document should also be posted to The Empire District Electric Company'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, P.E.
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PERIODIC SAFETY FACTOR ASSESSMENT – EXISTING CCR IMPOUNDMENTS

CCR RULE SECTION 257.73(e)

THE 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 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.

For the purposes of this Periodic Safety Factor Assessment Report, PPI again reviewed previously completed studies, and compared historic Impoundment geometry and operating conditions to current conditions. As discussed later in this Report, the Asbury Power Plant last burned coal in December 2019, and was officially taken out of service on March 1, 2020.

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.

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 the Initial Safety Factor Assessment Report in 2016. The additional CCR volume does not affect the perimeter levee embankments.

The Asbury Power Plant last burned coal in December 2019 and was officially taken out of service on March 1, 2020. Residual coal from the coal pile area was disposed of in the Asbury CCR Impoundment in 2020. Various improvements were made to the former coal pile area, including construction of a sedimentation basin, in 2021. As-built information about this construction was reviewed by PPI, and it was determined that it does not affect the geometry or piezometric surface of the critical cross section. As of the date of this Report, the Asbury CCR Impoundment is inactive, insofar as no additional CCR is planned for disposal and no operating water is pumped into or out of the Impoundment.

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 2016. 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 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 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 I.

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. Since the Asbury CCR Impoundment has become inactive, the normal pool elevation in the Upper Pond is more typically around elevation 948 feet and is primarily controlled by rainfall and evaporation.

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 District Electric Company 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 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 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 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.)	0.054g 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	1.3
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 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: 2007020268

Name: Rachel Jeanne Goeke, P.E.

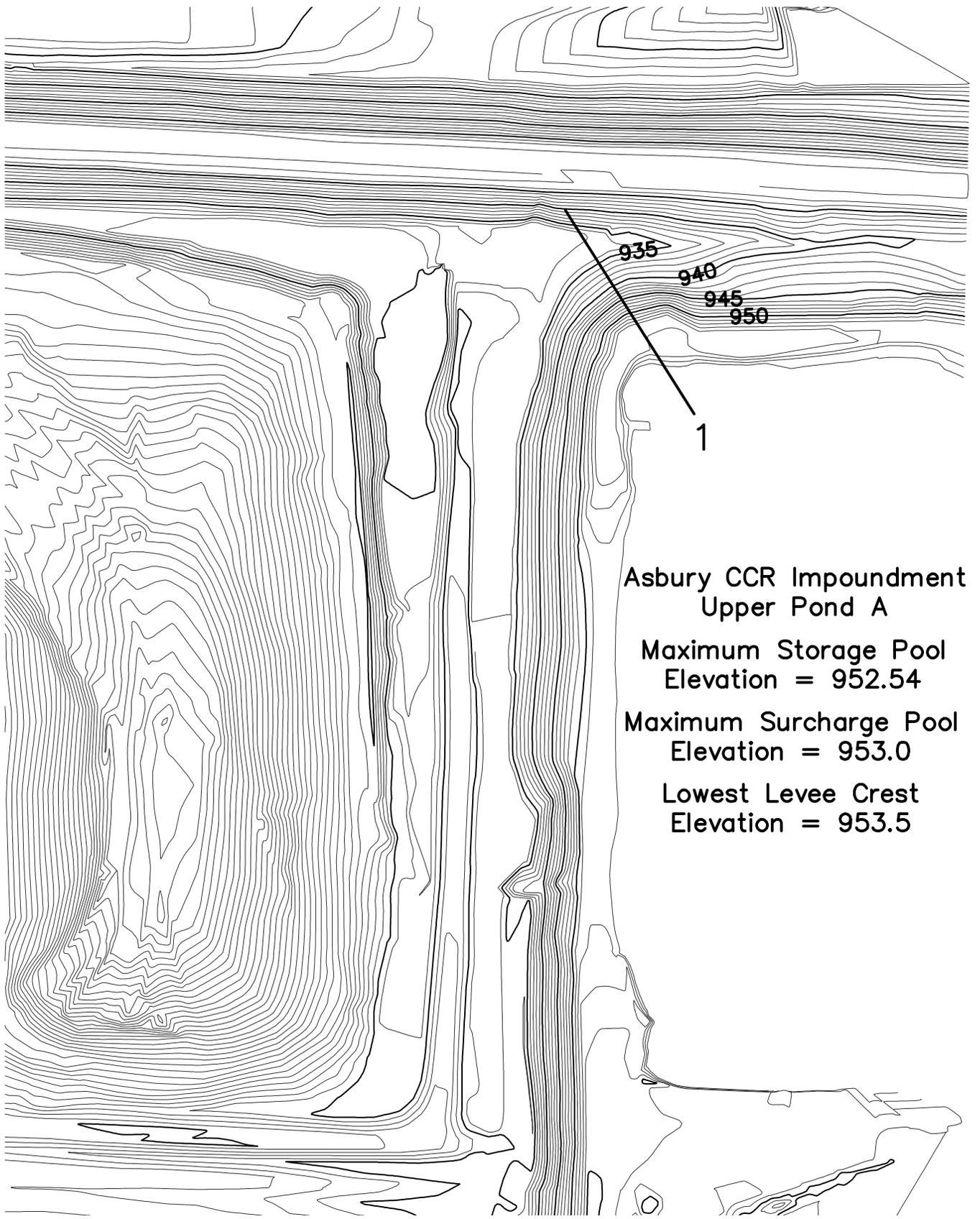
Seal:

Signature: 

Date: October 17, 2021



FIGURE



**Asbury CCR Impoundment
Upper Pond A**
Maximum Storage Pool
Elevation = 952.54
Maximum Surcharge Pool
Elevation = 953.0
Lowest Levee Crest
Elevation = 953.5



SCALE
1"=100'

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

Cross Section Location Plan

DATE: October 15, 2021

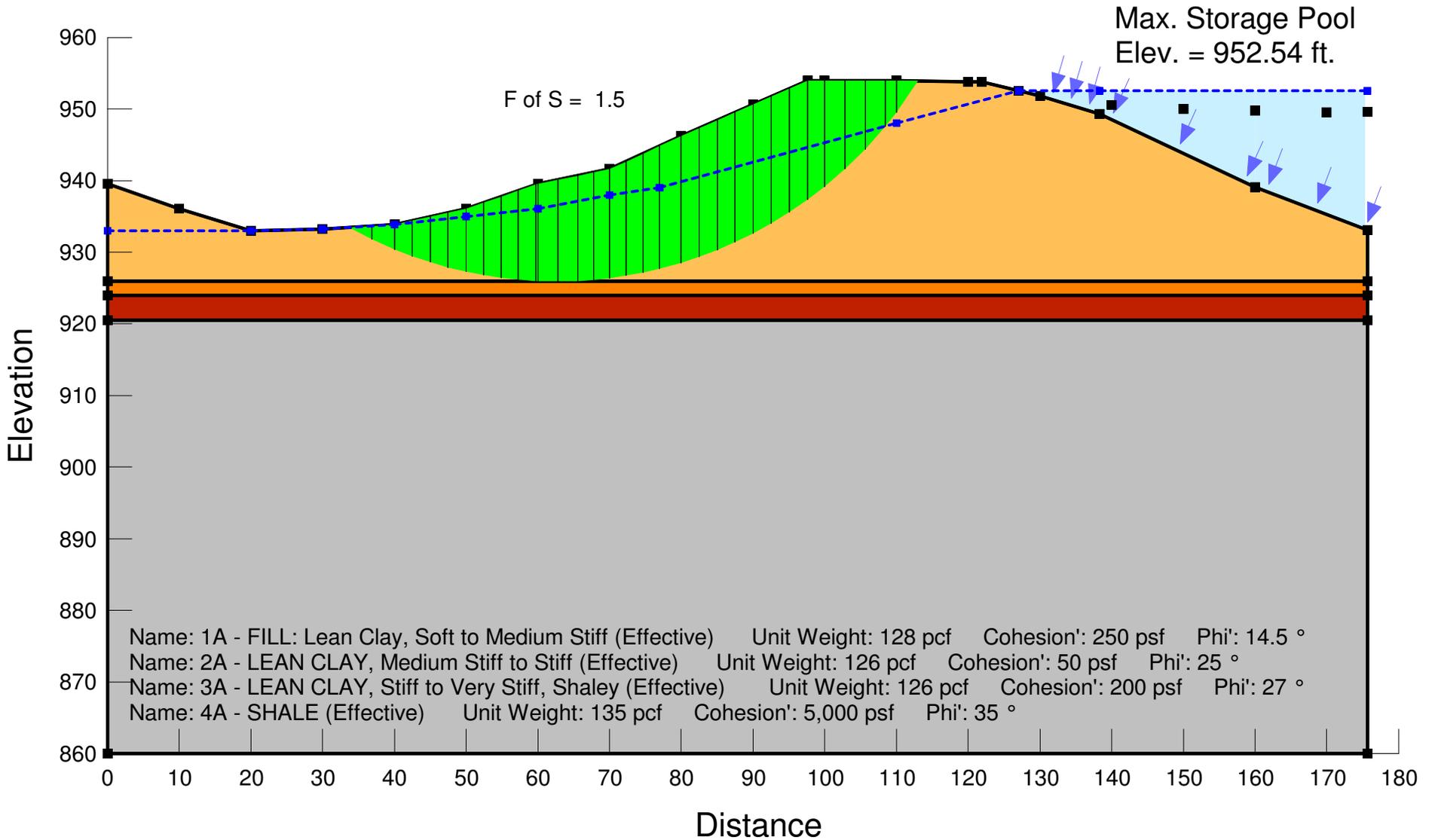
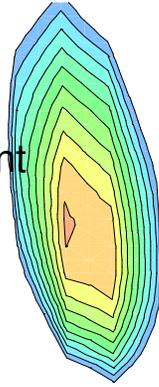
Project Number: 231518



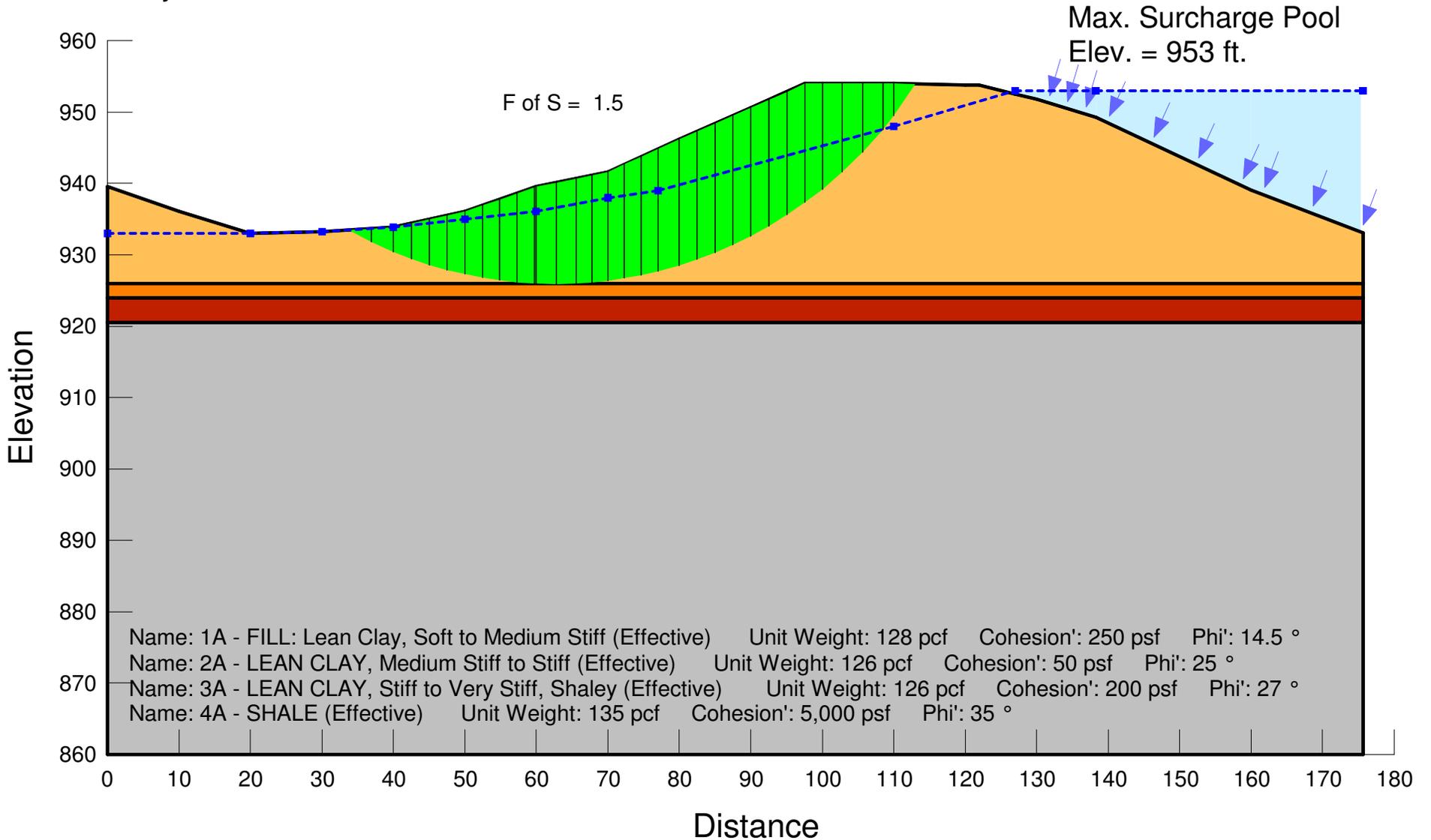
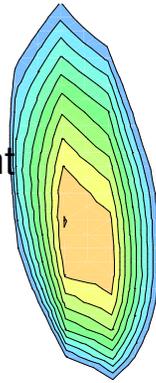
FIGURE 1

APPENDIX I
SLOPE STABILITY ANALYSIS RESULTS

Periodic Safety Factor Assessment
 Asbury CCR Impoundment
 Static, Maximum Storage Pool
 Effective Stress Conditions
 Critical Cross Section
 PPI Project Number: 231518



Periodic Safety Factor Assessment
 Asbury CCR Impoundment
 Static, Maximum Surcharge Pool
 Effective Stress Conditions
 Critical Cross Section
 PPI Project Number: 231518



Periodic Safety Factor Assessment
 Asbury CCR Impoundment
 Static, Maximum Surcharge Pool
 Total Stress Conditions
 Seismic Event: 2% PE in 50 years
 (2,475-year return period)
 PGA = 0.054g
 Critical Cross Section
 PPI Project Number: 231518

