REPORT

Periodic Safety Factor Assessment

Bremo Power Station CCR Surface Impoundment: North Ash Pond

Submitted to:

Bremo Power Station

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Submitted by:

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Project No. 21466315

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1.0 CERTIFICATION

This periodic Safety Factor Assessment for the Bremo Power Station's North Ash Pond was prepared by Golder Associates Inc. (Golder). The document and Certification/Statement of Professional Opinion are based on and limited to information that Golder has relied on from Dominion and others, but not independently verified, as well as work products produced by Golder.

On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that this document has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the document was prepared consistent with the requirements in §257.73(e) of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015, with an effective date of October 19, 2015 [40 CFR §257.73(e)].

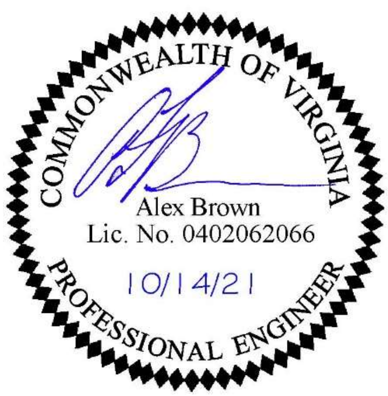
The use of the word "Certification" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

Alex Brown, PE
Print Name

Senior Project Geotechnical Engineer
Title

Signature

10/14/2021
Date



2.0 INTRODUCTION

This periodic Safety Factor Assessment (Assessment) was prepared for the Bremo Power Station's (Station) existing Coal Combustion Residuals (CCR) surface impoundment known as the North Ash Pond (NAP). This Safety Factor Assessment was prepared in accordance with 40 CFR Part §257, Subpart D and is consistent with the requirements of 40 CFR §257.73(e).

The Station, owned and operated by Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion), is located in Fluvanna County at 1038 Bremo Road, east of Route 15 (James Madison Highway) and north of the James River. The Station includes an existing CCR surface impoundment, the NAP, as defined by the Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule (40 CFR §257; the CCR rule). The NAP is also regulated as a dam by the Virginia Department of Conservation and Recreation (DCR) with Inventory Number 065020 (DCR Dam Permit).

3.0 PURPOSE

This periodic Assessment is prepared pursuant to § 257.73(e)(1) of the CCR Rule [40 CFR § 257.73(e)(1)]. The initial Safety Factor Assessment was completed on October 17, 2016, and is required to be updated every five (5) years pursuant to 40 CFR 257.73(f)(3).

4.0 SAFETY FACTOR ASSESSMENT REQUIREMENTS

In accordance with § 257.73(e)(1), the owner or operator of a CCR surface impoundment must conduct periodic safety factor assessments and document whether the calculated factors of safety achieve the minimum safety factors specified for the critical cross section of the embankment. The safety factor assessments must be supported by appropriate engineering calculations. The minimum safety factors specified in § 257.73(e)(1)(i) through(iv) include:

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

5.0 SAFETY FACTOR ASSESSMENT

A slope stability analysis of the NAP embankment was conducted to determine whether the calculated factors of safety for the critical cross section of the embankment meet or exceed the minimum safety factors specified in 40 CFR §257.73(e)(1).

5.1 Methodology

Stability safety factors were evaluated using a general limit equilibrium (GLE) method and the computer program SLIDE2 Version 9.008. Specifically, the method developed by Morgenstern and Price (1965) was used in SLIDE to evaluate the stability of potential failure surfaces associated with the critical cross section. For each surface, the method calculates the shear strengths that would be required to maintain equilibrium and then calculates a factor of safety by dividing the available shear strength by the shear strength required to maintain stability. The slip surface producing the minimum factor of safety is reported as the critical slip surface. Golder evaluated slip surfaces using Rocscience's Cuckoo Search, which is a global optimization method. This method typically yields more conservative safety factors than methods assuming either block or circular failure geometries. Material properties and slope geometry for the NAP embankment were taken from previous Golder investigations, analyses, and reports included in Golder's February 2017 Geotechnical Design Report (Golder, 2017) and are presented in Table 1 below.

Table 1: Summary of Geotechnical Strength Properties

Material	Total Unit Weight *(pound per cubic foot, pcf)*	Strength Properties[1]	
		Peak φ' (°)	Cohesion (*pound per square foot, psf*)
Dike Fills	125	31	50
New Dike Fill	120	31	50
CCR Fill	110	34	0
Sluiced CCR	90	EL. > 280 ft amsl: 28	0, *SHANSEP*[2]
		EL. < 280 ft amsl: 24, *SHANSEP*[2]	
Ponded Water	62.4	No Strength	
Alluvium	115	28, *0*	50, *2000*
Alluvium > 75 ft	*120*	*0*	*3500*
Residuum	125	31	50
Disintegrated Rock	140	31	1000

Notes:
1. Seismic strength properties are italicized.
2. SHANSEP Strength Parameters: A = 200 psf, S = 0.22, m = 0.

The four loading scenarios required by the CCR rule are discussed in the following sections.

5.2 Critical Cross Sections and Geometry

The critical cross section determined from the Geotechnical Design Report is Section NP-B, which runs perpendicular to the southern embankment (Golder, 2017; Appendix A). This section is critical for all conditions analyzed. Since the initial 5-year Safety Factor Assessment was performed, CCR material has been completely removed from the East Ash Pond (EAP) and placed within the NAP. This new geometry is reflected in the critical cross section analyzed. Additionally, the CCR material in the NAP has been protected by a rain cover. This rain cover minimizes surface water within the limits of the NAP from infiltrating the CCR or embankment. Water levels within the embankment have consistently decreased over the past 5 years, thus the groundwater table (GWT) modeled within the embankment for each loading scenario is based on Summer 2021 GWT levels observed in piezometers located within the impoundment and embankment.

5.3 Long-Term Maximum Storage Pool Conditions

In accordance with the CCR Rules, the long-term maximum storage pool elevation was set equal to the NAP's emergency spillway elevation [330.7 feet above mean sea level (ft amsl)], as the principal spillway mechanism is currently serviced by pumps that manages non-contact stormwater collected in the NAP below elevation 328 ft amsl. The emergency spillway, located on the west side of the NAP, is available for discharge should water accumulate to the crest of the spillway. The existing emergency spillway is a trapezoidal-shaped, broad-crested spillway that is built into the road surface along the top of the NAP embankment. It has a width of 200 feet and a crest elevation of 330.7 ft amsl. The spillway has an effective depth of 3.3 feet and is predominantly vegetated with an existing access road along its length that is surfaced with well-compacted gravel. The size and capacity of the emergency spillway are adequate to convey the runoff from the inflow design flood without overtopping the embankment. The analysis of the spillway capacity is included in Appendix A of the Periodic Inflow Design Flood Control System Plan (Golder, 2021). Due to the rain cover, the maximum pool storage is modeled as a lined pond above the ash.

The calculated static factor of safety is 1.69 for the long-term, maximum storage pool loading condition, therefore meeting the requirement for the long-term maximum storage pool condition.

5.4 Maximum Surcharge Pool Conditions

The maximum surcharge pool elevation was conservatively calculated based on 90% of the probable maximum flood (PMF) in accordance with DCR regulations, Section 4VAC50-20-50 for impounding structures. The evaluation of the NAP's hydraulic performance using the DCR's requirements for a Spillway Design Flood has been used in-lieu of the 1,000-year flood which provides a more conservative approach. The maximum surcharge pool condition corresponds to a water level at elevation 331.7 ft amsl. Due to the rain cover, the maximum surcharge pool is modeled as a pond above the ash. The analysis of the hydraulic and hydrologic conditions is included in Appendix A of the Periodic Inflow Design Flood Control System Plan (Golder, 2021).

The calculated static factor of safety is 1.69 for the maximum surcharge pool loading condition, therefore meeting the requirement for the maximum surcharge pool condition.

5.5 Seismic Loading Conditions

Factors of safety for stability under seismic loading conditions were calculated based on the earthquake hazard corresponding to a probability of exceedance of 2% in 50 years (2,475-year return period). The Bray and Travasarou displacement-based seismic slope stability screening method, as described in Golder 2017, was used. For this method, a pseudo-static coefficient (0.1011; USGS, 2014) corresponding to one-half the Peak Ground Acceleration (PGA) for a seismic event having a probability of occurrence of 2% in 50 years was used in the analysis. For further details on the site seismic hazard and/or the application of the Bray and Travasarou method, refer to Golder 2017. The long-term maximum storage pool loading condition was evaluated under seismic conditions.

The calculated seismic factor of safety is 1.07 for the long-term, maximum storage pool loading condition, therefore meeting the requirement for the maximum storage pool seismic condition.

5.6 Post-Seismic Liquefaction Loading Conditions

Golder completed an evaluation of the liquefaction susceptibility of the site soils and CCR materials (Golder, 2017). Based on the liquefaction evaluations, the foundation and embankment materials of the NAP dam were calculated to not be susceptible to liquefaction under the design earthquake hazard. Because the dam/dikes of the NAP are not constructed of materials or on foundation materials calculated to be susceptible to liquefaction, no post-liquefaction demonstration is required in the CCR rule.

5.7 Results

The table below presents the results of the Safety Factor Assessments for the NAP analysis cases required in 40 CFR §257.73(e)(1)(i) to (iv) of the CCR rule. For all required conditions evaluated, the calculated factors of safety meet the target factors of safety identified in the CCR rule. Stability analyses figures are included in Appendix A, and the factors of safety are summarized in Table 2 below.

Table 2: North Ash Pond - Factors of Safety

Case	Pool Elevation (ft amsl)	Target Factor of Safety (FS)	FS
Max Storage Pool	330.7	1.5	1.69
Max Surcharge Pool	331.7	1.4	1.69
Seismic	330.7	1.0	1.07
Liquefied Ash	N/A	1.2	N/A

6.0 CONCLUSION

Based on known site conditions, information referenced herein, as well as work performed by Golder for this Periodic Safety Factor Assessment, the NAP meets the minimum factors of safety as required by §257.73(e)(1) for each of the conditions analyzed.

7.0 REFERENCES

Code of Virginia, 4VAC50-20-50. Performance standards required for impounding structures; effective March 23, 2016.

Golder Associates. Safety Factor Assessment, Bremo Power Station CCR Surface Impoundment: North Ash Pond. October 2016.

Golder Associates. Bremo Power Station CCR Surface Impoundments: Appendix E – Geotechnical Design Report. Revised February 2017.

Golder Associates. Periodic Inflow Design Flood Control System Plan, Bremo Power Station CCR Surface Impoundment: North Ash Pond. October 2021.

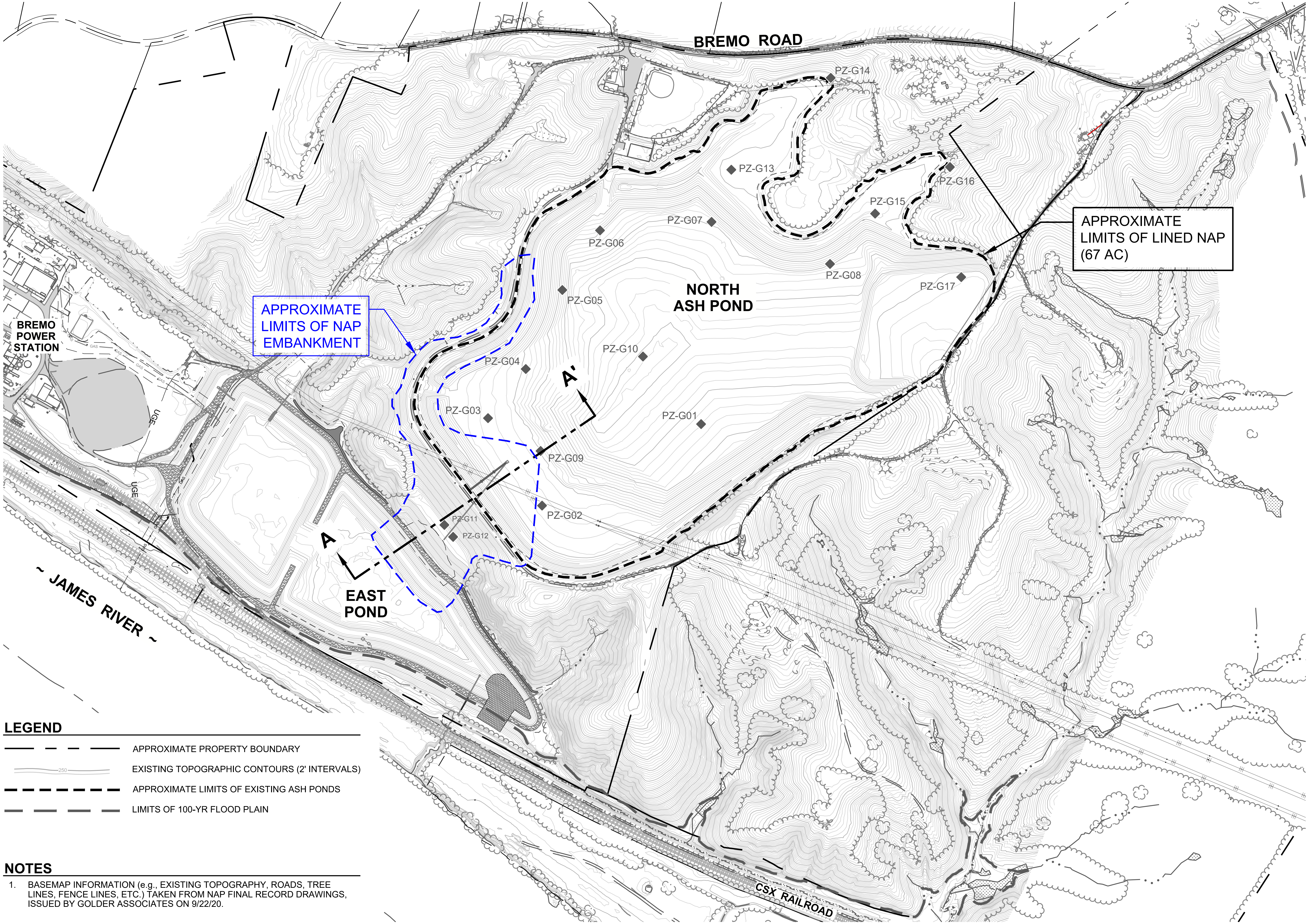
Morgenstern, N. R., and Price, V. E. (1965). "The Analysis of the Stability of General Slip Surfaces," Geotechnique Vol 15 1, p. 79.

RocScience (2021). Slide Version 9.017. Build date: June 2, 2021.

Schnabel Engineering, LLC. 2016. Geotechnical Data Report Support of Excavation Design. November 30, 2016.

United States Geological Survey (USGS). Unified Hazard Tool. Dynamic: Conterminous U.S. 2014 (update) Edition. PGA with 2% probability of exceedance in 50 years. Available online: https://earthquake.usgs.gov/hazards/interactive/

Virginia DCR Dam Permit, Inventory No. 065020.



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- LIMITS OF 100-YR FLOOD PLAIN

NOTES

1. BASEMAP INFORMATION (e.g., EXISTING TOPOGRAPHY, ROADS, TREE LINES, FENCE LINES, ETC.) TAKEN FROM NAP FINAL RECORD DRAWINGS, ISSUED BY GOLDER ASSOCIATES ON 9/22/20.

CLIENT
DOMINION ENERGY.
BREMO POWER STATION
FLUVANNA COUNTY, VIRGINIA

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-08-16
DESIGNED	ATN
PREPARED	SIB
REVIEWED	JRD
APPROVED	ATN

PROJECT
PERIODIC SAFETY FACTOR ASSESSMENT
STABILITY ANALYSIS
NORTH ASH POND

TITLE
STABILITY CROSS SECTION LOCATION

PROJECT NO. 21-466315

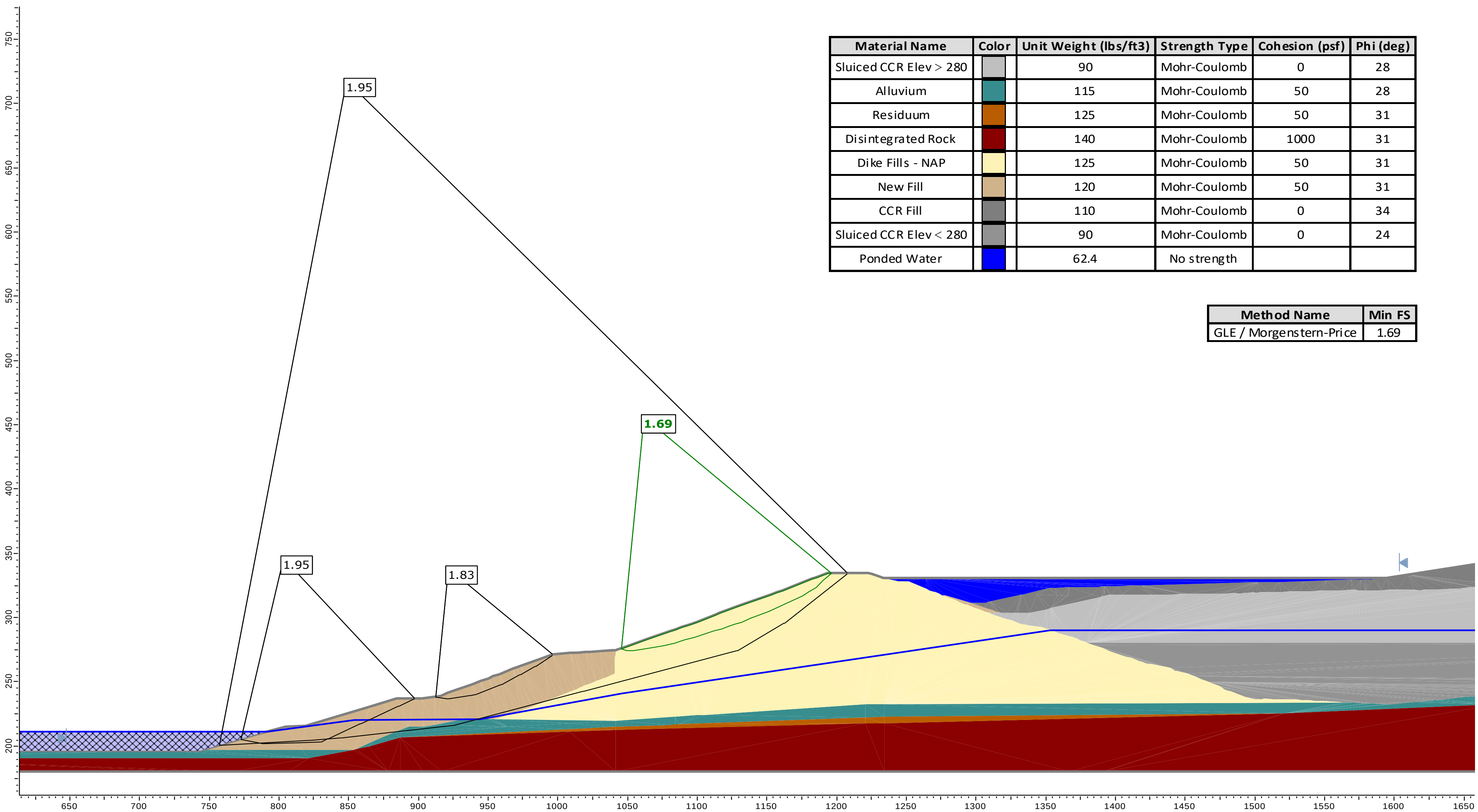
REV. 0

FIGURE 1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

APPENDIX A

North Ash Pond Stability Analysis



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Sluiced CCR Elev > 280		90	Mohr-Coulomb	0	28
Alluvium		115	Mohr-Coulomb	50	28
Residuum		125	Mohr-Coulomb	50	31
Disintegrated Rock		140	Mohr-Coulomb	1000	31
Dike Fills - NAP		125	Mohr-Coulomb	50	31
New Fill		120	Mohr-Coulomb	50	31
CCR Fill		110	Mohr-Coulomb	0	34
Sluiced CCR Elev < 280		90	Mohr-Coulomb	0	24
Ponded Water		62.4	No strength		

Method Name	Min FS
GLE / Morgenstern-Price	1.69

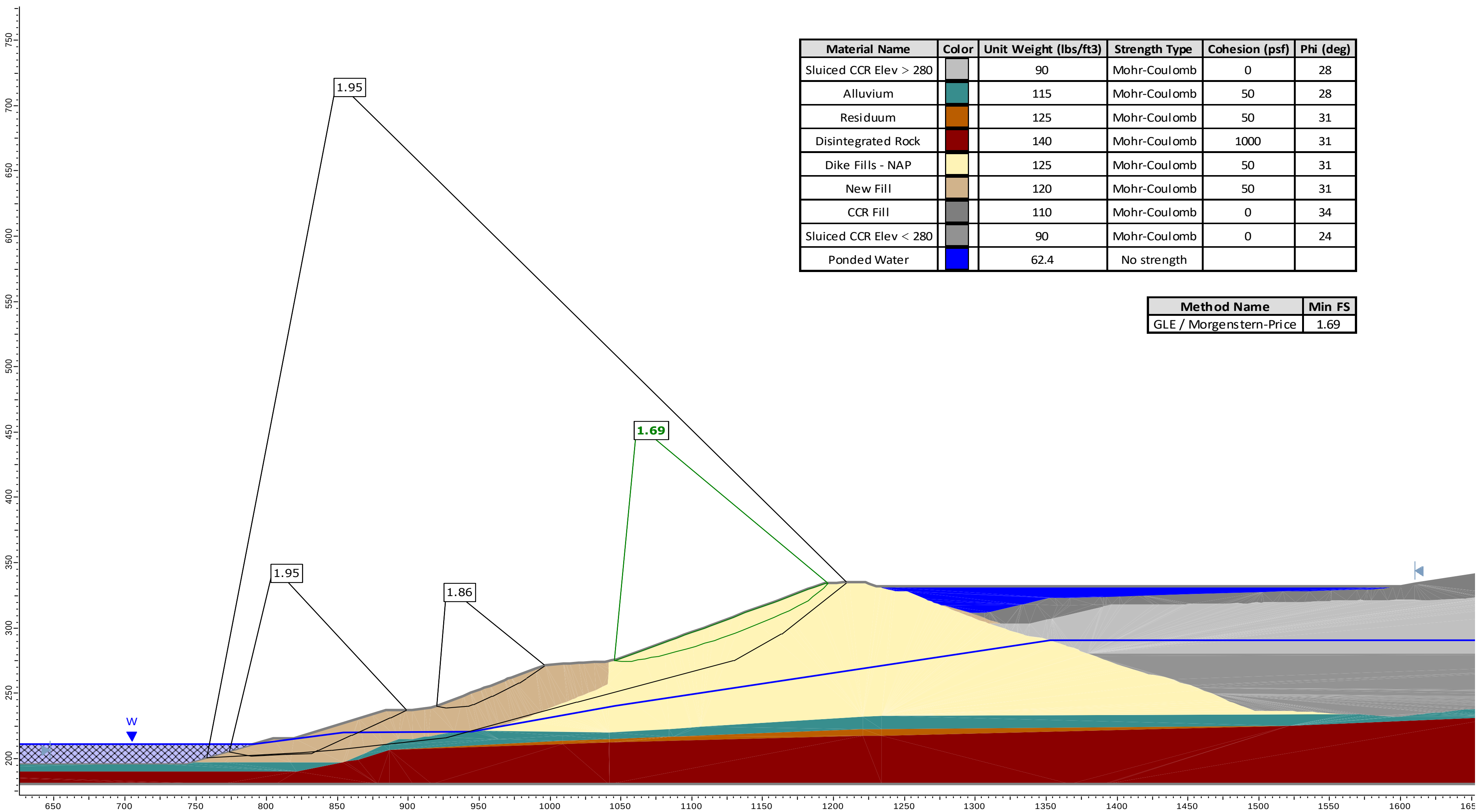
Note: GLE/Morgenstern Price method results displayed.

GOLDER
MEMBER OF WSP

SCALE	AS SHOWN	PROJECT	Bremo Power Station
DATE	Aug 2021	TITLE	North Ash Pond Maximum Pool Storage
MADE BY	SDRM		
CAD	-		
CHECK	ALB	CLIENT	Dominion Energy
REVIEW	ATN	FIGURE	1

FILE: SAFETY FACTOR ASSESSMENT

PROJECT No. 21466315 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Sluiced CCR Elev > 280		90	Mohr-Coulomb	0	28
Alluvium		115	Mohr-Coulomb	50	28
Residuum		125	Mohr-Coulomb	50	31
Disintegrated Rock		140	Mohr-Coulomb	1000	31
Dike Fills - NAP		125	Mohr-Coulomb	50	31
New Fill		120	Mohr-Coulomb	50	31
CCR Fill		110	Mohr-Coulomb	0	34
Sluiced CCR Elev < 280		90	Mohr-Coulomb	0	24
Ponded Water		62.4	No strength		

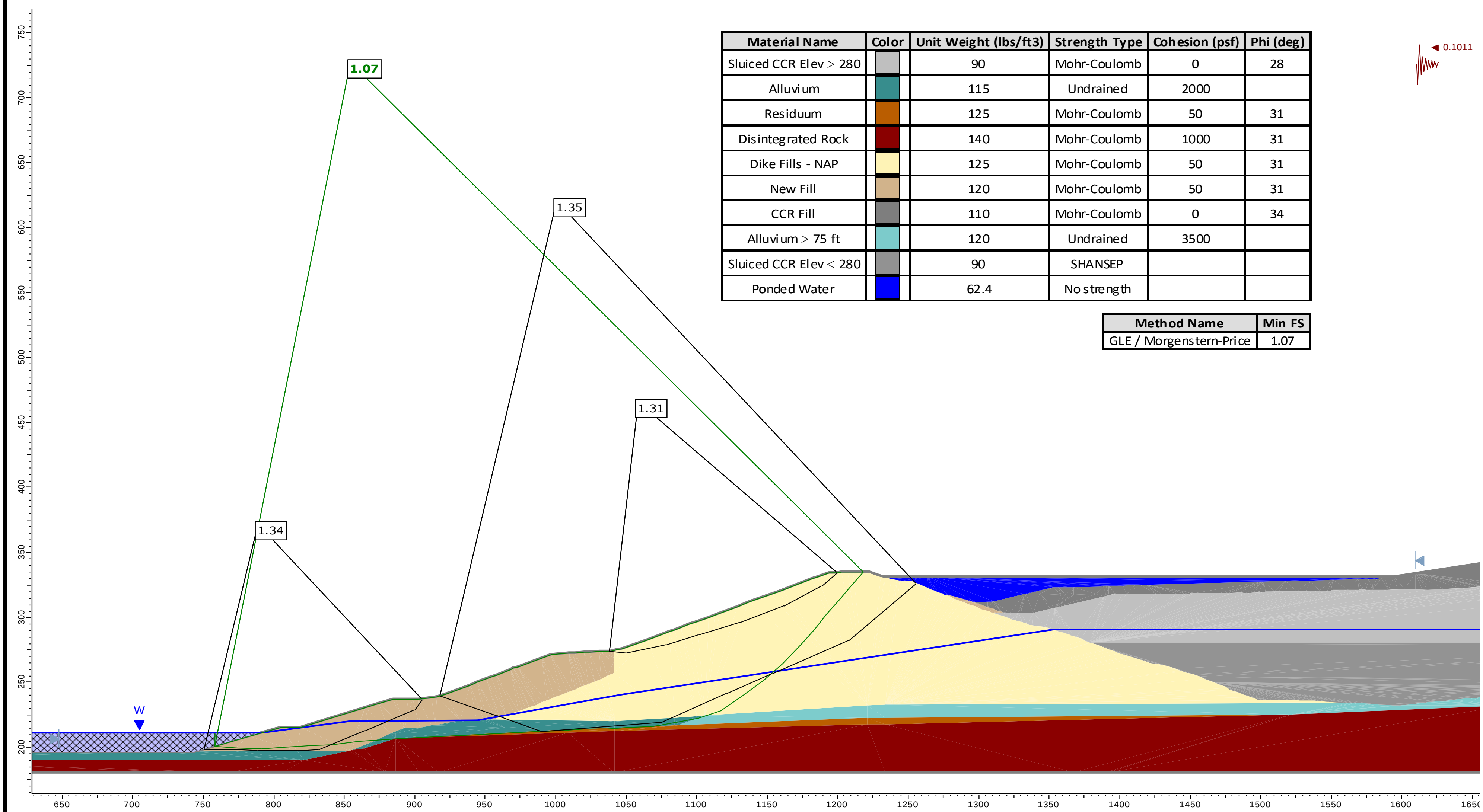
Method Name	Min FS
GLE / Morgenstern-Price	1.69

Note: GLE/Morgenstern Price method results displayed.

GOLDER
MEMBER OF WSP

SCALE	AS SHOWN	PROJECT	**Bremo Power Station**
DATE	Aug 2021	TITLE	**North Ash Pond Maximum Pool Surcharge**
MADE BY	SDRM		
CAD	-		
CHECK	ALB	CLIENT	**Dominion Energy**
REVIEW	ATN	FIGURE	2

FILE: SAFETY FACTOR ASSESSMENT
PROJECT No. 21466315 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Sluiced CCR Elev > 280		90	Mohr-Coulomb	0	28
Alluvium		115	Undrained	2000	
Residuum		125	Mohr-Coulomb	50	31
Disintegrated Rock		140	Mohr-Coulomb	1000	31
Dike Fills - NAP		125	Mohr-Coulomb	50	31
New Fill		120	Mohr-Coulomb	50	31
CCR Fill		110	Mohr-Coulomb	0	34
Alluvium > 75 ft		120	Undrained	3500	
Sluiced CCR Elev < 280		90	SHANSEP		
Ponded Water		62.4	No strength		

Method Name	Min FS
GLE / Morgenstern-Price	1.07

Note: GLE/Morgenstern Price method results displayed.

GOLDER
MEMBER OF WSP

SCALE	AS SHOWN	PROJECT	**Bremo Power Station**
DATE	Aug 2021	TITLE	**North Ash Pond Seismic**
MADE BY	SDRM		
CAD	-		
CHECK	ALB	CLIENT	**Dominion Energy**
REVIEW	ATN	FIGURE	3

FILE: SAFETY FACTOR ASSESSMENT

PROJECT No. 21466315 REV. 0

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