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Coal Combustion Residuals - Factor of Safety Assessment -

Virginia Electric and Power Company
Possum Point Power Station
Surface Impoundment D
Dumfries, Virginia

GAI Project Number: C150132.00

October 2016

Prepared by: GAI Consultants, Inc.
Richmond Office
4198 Cox Road, Suite 114
Glen Allen, Virginia 23060

Prepared for: Virginia Electric and Power Company
5000 Dominion Boulevard
Glen Allen, Virginia 23060-3308

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Certification/Statement of Professional Opinion

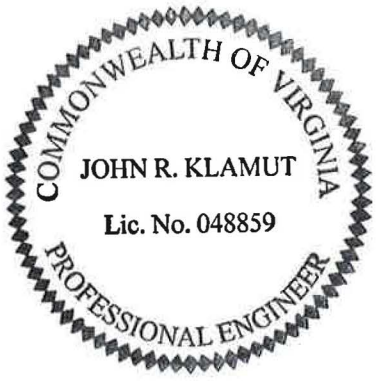
The Factor of Safety Assessment (Assessment) for the Possum Point Power Station Surface Impoundment D was prepared by GAI Consultants, Inc. (GAI). The Assessment was based on certain information that, other than for information GAI originally prepared, GAI has relied on but not independently verified. This Certification/Statement of Professional Opinion is therefore limited to the information available to GAI at the time the Assessment was written. 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 the Assessment 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 Assessment was prepared consistent with the requirements of section 257.73 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 Code of Federal Regulations (CFR) Subpart D).

The use of the words "certification" and/or "certify" 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.

GAI Consultants, Inc.

John R. Klamut, P.E.
Engineering Manager

Date: 10/13/2016



Acronyms

Assessment	Coal Combustion Residuals Factor of Safety Assessment
CCR	Coal Combustion Residuals
CCR Rule	"Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" 40 CFR 257 Subpart D (2015)
CFR	Code of Federal Regulations
DCR	Virginia Department of Conservation and Recreation
Dominion	Virginia Electric and Power Company d/b/a Dominion
EPA	United States Environmental Protection Agency
GAI	GAI Consultants, Inc.
MSL	Mean sea level
N/A	Not Applicable
Station	Dominion Possum Point Power Station
USGS	United States Geological Survey
VPDES	Virginia Pollutant Discharge Elimination System

1.0 Introduction

The Possum Point Power Station (Station) is owned by Virginia Electric and Power Company d/b/a Dominion Virginia Power (Dominion) and is located in Prince William County, Virginia. The Station includes Surface Impoundment D, which is being used for the long term storage of coal combustion residuals (CCR).

Surface Impoundment D is located on Dominion property at the Possum Point Power Station in Prince William County, Virginia (coordinates 38° 32′ 05″ North and 77° 16′ 57″ West)

Purpose Surface Impoundment D is regulated as an existing CCR surface impoundment under the Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" [40 CFR 257 Subpart D] published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (CCR Rule). Surface Impoundment D is also regulated as a dam by the Virginia Department of Conservation and Recreation (DCR) and has an approved Operation and Maintenance Certificate with Inventory Number 15320.

2.0 Purpose

This Factor of Safety Assessment is prepared pursuant to § 257.73(e)(1) of the CCR Rule [40 CFR § 257.73(e)(1)].

3.0 Factor of Safety Assessment Requirements

In accordance with § 257.73(e)(1), a CCR surface impoundment owner or operator "must conduct 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…for the critical cross section of the embankment."

§ 257.73(e)(1) requires that safety assessments be conducted for the following conditions of the impoundment and that the safety factor assessments be supported by appropriate engineering calculations:

- 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 are susceptible to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

This Assessment will document the factors of safety for the Surface Impoundment D embankment as required by § 257.73(e)(1).

4.0 Factor of Safety Assessment

Surface Impoundment D consists of an earthen embankment and stored CCR contained behind the embankment. Surface Impoundment D includes a single engineered embankment that was constructed across a natural valley. The embankment is approximately 1,700 feet long at the crest, 20 feet wide at the top and has a top elevation of 150 feet MSL. The cross-section selected to represent the critical slope associated with the existing conditions is illustrated in Appendix A. The material properties used to represent the in-place embankment soils, foundation, and drainage blanket were obtained from slope stability analyses previously completed for Surface Impoundment D as part of the Final Design Report completed by Virginia Power, Engineering and Construction, Civil Engineering department

(Virginia Power, 1986a). The phreatic surface used in the analyses was dependent on the condition being assessed and is discussed for each analysis.

The factors of safety calculated for each condition are summarized in Table 1 and are summarized below.

Table 1. -
Calculated Factors of Safety. -

Factor of Safety Condition	Minimum Factor of Safety	Calculated Factor of Safety
Long-term, maximum storage pool loading	1.50	1.70
Maximum surcharge pool loading	1.40	1.62
Seismic factor of safety	1.00	1.27

Calculations are included in Appendix A.

4.1 Long-Term Maximum Storage Pool Loading Condition

According to the preamble of the CCR Rule, Section E.3.b.ii.b, the maximum storage pool loading is "the maximum water level that can be maintained that will result in full development of a steady-state seepage condition". The Rule goes on to state that "the maximum storage pool loading needs to consider a pool elevation in the CCR unit that is equivalent to the lowest elevation of the invert of the spillway, i.e., the lowest overflow point of the perimeter of the embankment".

The normal pool in Surface Impoundment D, as determined by the principle spillway outlet structure, is at elevation 142.00 feet (Virginia Power, 2014); therefore, the long term maximum storage pool loading condition will have a phreatic surface elevation of 142.00 feet. The phreatic surface at the centerline of the embankment is conservatively estimated at elevation 142 feet. A straight line was used to connect elevation 142.00 feet and the elevation of the drainage blanket at the critical cross section.

The calculated static factor of safety is 1.70 for the embankment and meets the requirement for the long term maximum storage pool condition (1.50).

4.2 Maximum Surcharge Pool Loading Conditions

The Surface Impoundment D spillways and inflow control systems have been designed to pass the Probable Maximum Flood (PMF) while maintaining a minimum design freeboard of two feet (Virginia Power, 1986a). Therefore, a maximum pool elevation of 148.00 feet (2 feet below the crest of the embankment), was used for the phreatic surface for the maximum surcharge pool loading condition. The inflow design flood is the 1,000-year flood (GAI, 2016c) for a significant hazard dam (GAI, 2016b). The PMF is greater than the 1,000 year flood, so the PMF phreatic surface used for the analysis is more conservative than the inflow design flood phreatic surface. The calculated static factor of safety is 1.62 for the embankment and meets the requirement for the maximum surcharge pool condition (1.40).

4.3 Seismic Factor of Safety

The seismic factor of safety was analyzed with a seismic loading event with a 2% probability of exceedance in 50 years, based on United States Geological Survey (USGS) seismic hazard maps. A peak ground acceleration of 0.1g was used in the analyses (Appendix A).

The long term maximum storage pool loading condition was evaluated under seismic conditions. The calculated factor of safety of 1.27 for the embankment meets the requirement for a seismic event (1.00).

4.4 Liquefaction Factor of Safety

To evaluate liquefaction resistance of soils, the site stratigraphy must be understood with respect to material classification, groundwater conditions, and age of the soil deposits. A review of available published literature, in conjunction with in-situ data from previously completed subsurface investigations, was used to evaluate the site conditions (GAI, 2016a).

According to the Geologic Map of the Quantico Quadrangle, the area was mapped as the Potomac Group consisting of clay, clayey sand, and sandy silt likely of the Cretaceous age. Therefore, the alluvial soils encountered beneath the containment dikes are not anticipated to be susceptible to liquefaction. In addition, the embankment is not susceptible to liquefaction because it was placed as a compacted fill (GAI, 2016a) as described in Appendix A.

Because neither the soils underlying the Surface Impoundment D embankment nor the embankment itself are susceptible to liquefaction, no further documentation is required to demonstrate compliance with § 273.73(e)(1)(iv).

5.0 Conclusion

In GAI's opinion, the analyses show that Possum Point Power Station Surface Impoundment D meets or exceeds the factors of safety required by § 257.73(e)(1).

6.0 References

GAI Consultants, Inc. (GAI). 2016a.
Solid Waste Disposal Facility, Part B Permit Application, Possum Point Power Station, Coal Combustions Residual Surface Impoundment Closures, Dumfries, Virginia. July.

GAI Consultants, Inc. (GAI). 2016b.
Coal Combustion Residuals Initial Hazard Potential Classification Assessment, Possum Point Power Station, Dumfries, Virginia. October.

GAI Consultants, Inc. (GAI). 2016c.
Coal Combustion Residuals Inflow Design Flood Control System Plan, Possum Point Power Station, Dumfries, Virginia. October.

United States Environmental Protection Agency (EPA). 2015.
40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. April 17.

Virginia Power (Dominion). 1986a.
Final Design Report, Possum Point Power Station, Ash Pond 'D' Dam, DCR Inventory #15320, October.

Virginia Power (Dominion). 1986b.
Final Design Drawings, Possum Point, Ash Pond "D" Expansion Project, Possum Point Power Station.

Virginia Power (Dominion). 2014.
Operating Plan and Schedule, Ash Pond 'D' Dam and Impoundment, Possum Point Power Station, Prince William County, Virginia. April.

Virginia Department of Conservation and Recreation (DCR), Soil and Water Conservation Board. 2016.
Dam Safety Alteration Permit 15320. Effective April 30, 2016; Expires April 30, 2018. May 3.

Virginia Department of Environmental Quality (VDEQ), Northern Regional Office. 2016.
Virginia Pollutant Discharge Elimination System (VPDES) Permit No. VA0002071. Effective April 3, 2013; Expires April 2, 2018. January 19

APPENDIX A
Supporting Calculations

SUBJECT: POSSUM POINT POWER STATION – SAEFTY FACTOR ASSESSMENT

BY TIM DATE 09/12/16 PROJ. NO. C150132.00

CHKD. BY BWB/KLS DATE 09/23/16 SHEET NO. 1 OF 12

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OBJECTIVE:

To evaluate the stability of the Dominion Surface Impoundment D embankment at the Possum Point Power Station, Prince William County, Virginia. The analysis will address the requirements outlined in 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 (CCR Rule), §257.73(e)(1).

METHODOLOGY:

Evaluate stability using two-dimensional limit equilibrium analysis with the software program SLOPE/W and the Morgenstern-Price Method. The analysis will be run based on conditions outlined in the CCR Rule (Reference 1).

REFERENCES:

1. United States Environmental Protection Agency, 2015. *40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule.* April 17, 2015.
2. GAI Consultants, Inc., *2015 Solid Waste Disposal Facility Part B Permit Application, Possum Point Power Station, Prince William County, Virginia.* September 2015
3. Virginia Power, *Final Design Report, Possum Point Power Station, Ash Pond 'D' Dam, DCR Inventory #15320*. Submitted 1986
4. Virginia Power, *Operating Plan and Schedule, Maintenance Plan and Schedule, Inspection Schedule, Emergency Action Plan Schedule, Ash Pond 'D' Dam and Impoundment, Possum Point Power Station, Prince William County, Virginia.* April 2014
5. Virginia Power, *Final Design Drawings, Possum Point Power Station, Ash Pond 'D' Dam, DCR Inventory #15320*. Submitted 1986
6. GAI Consultants Inc., 2016. *DRAFT Coal Combustion Residuals Inflow Design Flood Control System Plan, Pond D, Possum Point Power Station, Prince William County, Virginia.* August 2016.
7. Harr, Milton Edward. *Groundwater and Seepage*. New York: McGraw-Hill, 1962. Print.

BACKGROUND:

In accordance with § 257.73(e)(1), a CCR surface impoundment owner or operator "must conduct 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…for the critical cross section of the embankment."

§ 257.73(e)(1) requires that safety assessments be conducted for the following conditions of the impoundment and that the safety factor assessments be supported by appropriate engineering calculations:

- 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 are susceptible to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

ANALYSIS:

Factor of Safety analyses were performed along the perimeter embankment of Pond D pursuant to §257.73(e)(1), shown above. One cross-section was selected to represent the most critical slope condition and the location of this section is shown on the figure presented in Attachment 1. Additionally, detailed information regarding the cross section geometry of the section is included in the slope stability software output presented in Attachment 2.

The soil parameters used in the factor of safety analyses are summarized below. The material properties used to represent the in-place embankment soils, clay foundation and drainage blanket were obtained from the slope stability analyses previously completed for Pond D as part of the Final Design Report completed by Virginia Power, Engineering and Construction, Civil Engineering department (originally submitted October, 1986).

Soil Type	γ_T (pcf)	c=c' (psf)	$\varphi=\varphi'$ (Degrees)
Embankment Soil	120	0	33
Clay Foundation	125	0	25
Ash	90	0	36
Drainage Blanket	125	0	37

The phreatic surface used in the analyses was dependent on the condition being assessed and is discussed for each analysis.

Long-Term Maximum Storage Pool Loading Condition

According to the CCR Rule preamble, the maximum storage pool loading is “the maximum water level that can be maintained that will result in full development of a steady-state seepage condition.” The Rule goes on to state that “the maximum storage pool loading needs to consider a pool elevation in the CCR unit that is equivalent to the lowest elevation of the invert of the spillway, *i.e.*, the lowest overflow point of the perimeter of the embankment.”

Pond D operating level is controlled by a principle spillway outlet structure located at the southeast corner. The outlet structure utilizes manually operated valves from 116 to 142 feet of elevation. Normal pool in Pond D as determined by an orifice in the outlet structure is at elevation 116.00 feet (Reference 5); therefore, the long term maximum storage pool loading condition will have a phreatic surface elevation of 116.00 feet. Reference 7 provides information on where the phreatic surface enters the drainage blanket and the elevation at the beginning of the drainage blanket. For the phreatic surface at the centerline of the embankment, historical data for monitoring wells near the centerline of the embankment show the phreatic surface staying somewhat consistent or decreasing over time. From January 2001 to April 2014, observation well W-3 recorded the highest phreatic surface through the embankment. Based on the information, the phreatic surface will be set at El. 100 feet to be conservative. Straight lines were used to connect the above points.

The calculated factor of safety is 1.89 for the embankment and meets the requirement for the long term maximum storage pool condition (1.50).

Maximum Surcharge Pool Loading Condition

As per the final design report (Reference 3) the Pond D impoundment was designed to adequately convey the probable maximum flood (PMF) with a minimum freeboard of 2 feet. Utilizing the PMF as the design flood in lieu of the 1000-year flood exceeds the requirements set forth by § 257.82 for a significant hazard dam (Reference 6). Based on the design flood, the phreatic surface will be at elevation 148.00 feet. The phreatic surface is determined based on the information in Reference 7.The calculated factor of safety is 1.62 for the embankment and meets the requirement for the maximum surcharge pool condition (1.40).

Seismic Factor of Safety

The seismic factor of safety is run with a seismic loading event with a 2% probability of exceedance in 50 years, based on United States Geological Survey (USGS) 2014 seismic hazard map. Based on the information in Reference 2, a peak ground acceleration of 0.1g was used in the analysis. The seismic hazard map is included as Attachment 3.

The long term maximum storage pool loading condition was evaluated under seismic conditions. The calculated factor of safety of 1.40 for the embankment meets the requirement for a seismic event (1.00).

Liquefaction Factor of Safety

According to Reference 3, the central portions of the Pond D embankment contained loose, saturated ash and soft alluvial clays. Design of the embankment was based on removal of these materials and replaced with compacted embankment fill. The embankment fill consisted of soils classified as USCS soil types CL, SC, or SM.

The technical specifications as part of the original design report outline the compaction requirements for the embankment fill. Embankment fill material were to be placed in lifts not to exceed 12 inches and compacted to a minimum 95 percent of the maximum dry density as defined by ASTM D698. The as-built drawings indicate that the embankment was constructed per the technical specifications contained in the original design report.

A liquefaction analysis was done as part of the Solid Waste Disposal Facility Part B Application (Reference 2). The analysis identified the foundation soils were not anticipated to be susceptible to liquefaction and identified the saturated impounded ash as the critical layer. The liquefaction analysis determined that the saturated ash was not susceptible to liquefaction. Based on the analysis in Reference 2, the embankment fill is also not susceptible to liquefaction.

Based on the information provided, the embankment soil is not considered to be susceptible to liquefaction. Pursuant to § 257.73(e)(1)(iv) - which requires that the liquefaction factor of safety be calculated only for dikes constructed on soils that are susceptible to liquefaction. Thus, a liquefaction analysis is not required.

SUMMARY:

Based on the conditions in the CCR Rule, Pond D meets or exceeds the required factors of safety required by § 273.73(e)(1). A summary of the results are listed below:

Loading Condition	Target FS	FS
Long Term Maximum Storage	1.50	1.89
Maximum Surcharge	1.40	1.62
Seismic	1.00	1.40
Liquefaction	N/A	N/A

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ATTACHMENT 1

PLAN VIEW

MAPPING REFERENCE:

EXISTING TOPOGRAPHY PREPARED BY KEDDAL AERIAL MAPPING. PHOTOGRAPHY DATED 02-13-2015. VA-N NAD83 (2011) NAVD88 (GEOID 12A) 1 FT. CONTOUR INTERVALS

SUPPLEMENTED BY GROUND SURVEY PERFORMED BY GAI CONSULTANTS, INC. AND FROM INFORMATION PROVIDED BY DOMINION.

ROW AND BOUNDARY SURVEY INFORMATION SHOWN BY GAI CONSULTANTS DATED, 7-27-2015

NO.:	DATE:	DWN:	CHK:	APV:	DESCRIPTION:

REVISION RECORD

DRAWING TITLE
STABILITY ANALYSIS SECTION - POND D CLOSURE

CLIENT
VIRGINIA ELECTRIC AND POWER COMPANY
GLEN ALLEN, VA

PROJECT
POSSUM POINT POWER STATION
COAL COMBUSTION RESIDUAL SURFACE IMPOUNDMENT CLOSURES
DUMFRIES, VA

gai consultants
ISSUING OFFICE: Richmond | 4198 Cox Road, Suite 114, Glen Allen, VA 23060

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ATTACHMENT 2

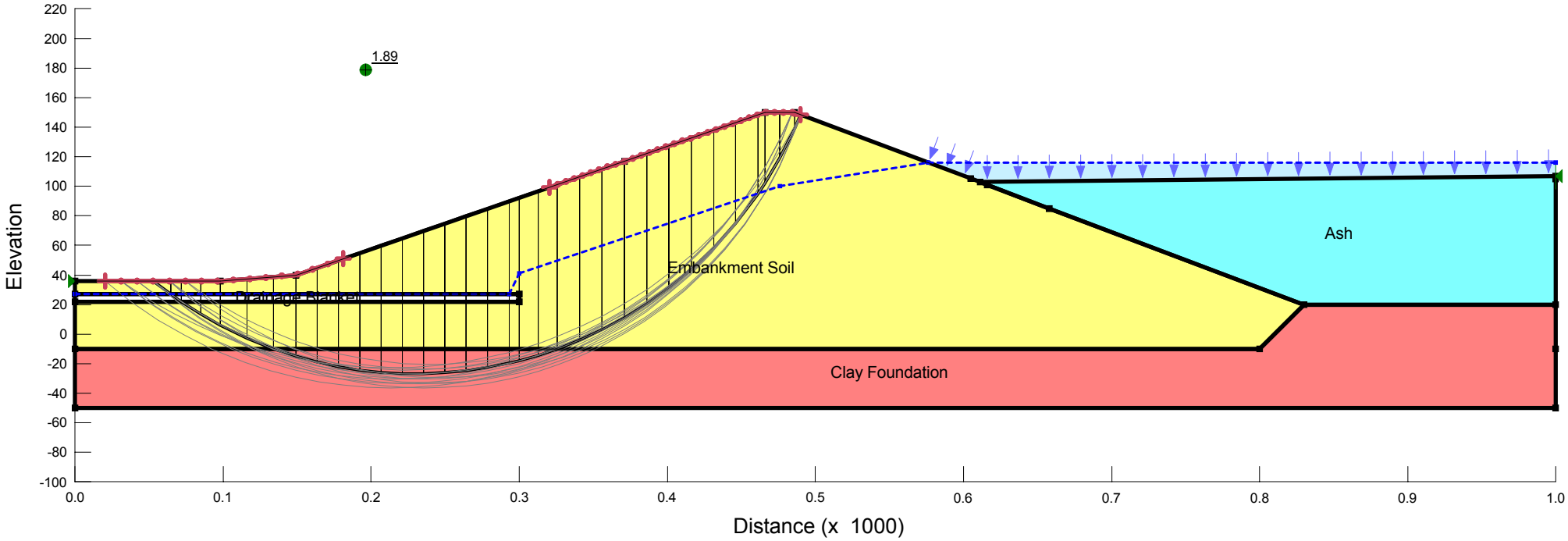
SLOPE STABILITY OUTPUT FILES

GAI Project: C150132.00

By: TIM 9/9/16
Ck: KLS 9/23/16

Dominion Possum Point Safety Factor Assessment
Drained - Section 1
Long-Term Maximum Storage Pool Loading Condition

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Drainage Blanket Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 37 ° Piezometric Line: 1

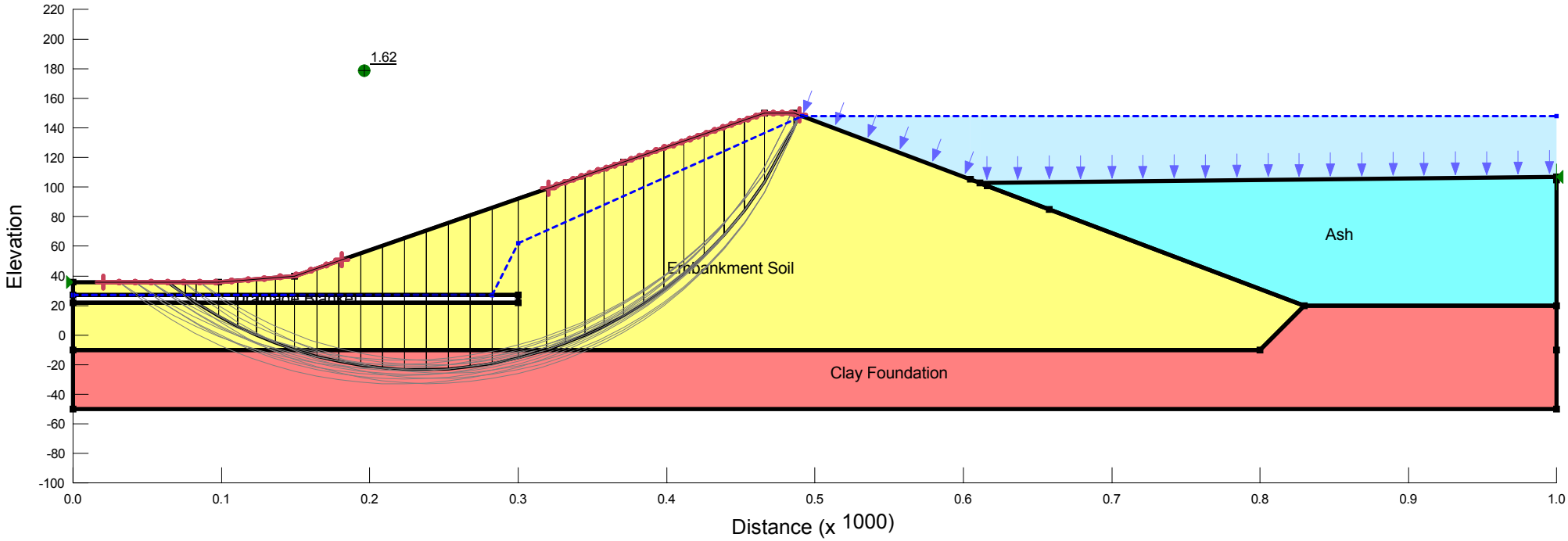


GAI Project: C150132.00

By: TIM 9/9/16
Ck: KLS 9/23/16

Dominion Possum Point Safety Factor Assessment
Drained - Section 1
Maximum Surcharge Pool Loading Condition

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Drainage Blanket Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 37 ° Piezometric Line: 1



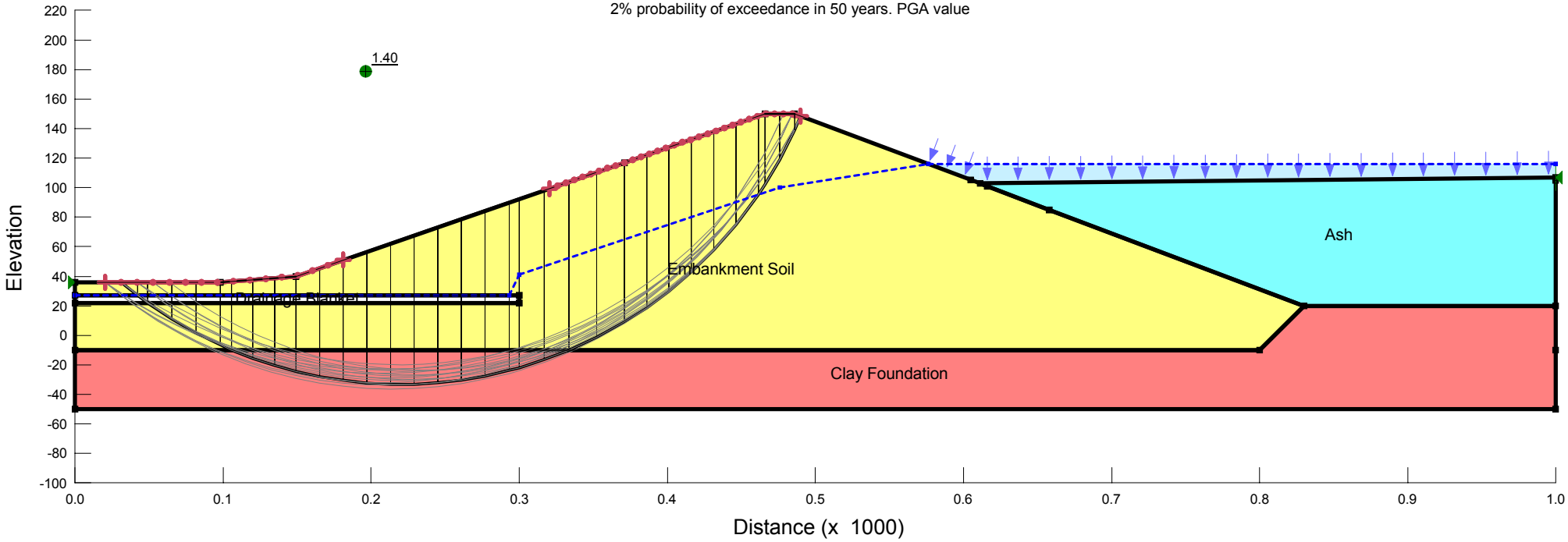
GAI Project: C150132.00

By: TIM 9/9/16
Ck: KLS 9/23/16

Dominion Possum Point Safety Factor Assessment
Drained - Section 1
Seismic Factor of Safety

Soil Parameters:
Name: Embankment Soil Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 200 psf Phi: 25 ° Piezometric Line: 1
Name: Ash Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 36 ° Piezometric Line: 1
Name: Drainage Blanket Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 37 ° Piezometric Line: 1

Seismic Value: 0.1
2% probability of exceedance in 50 years. PGA value



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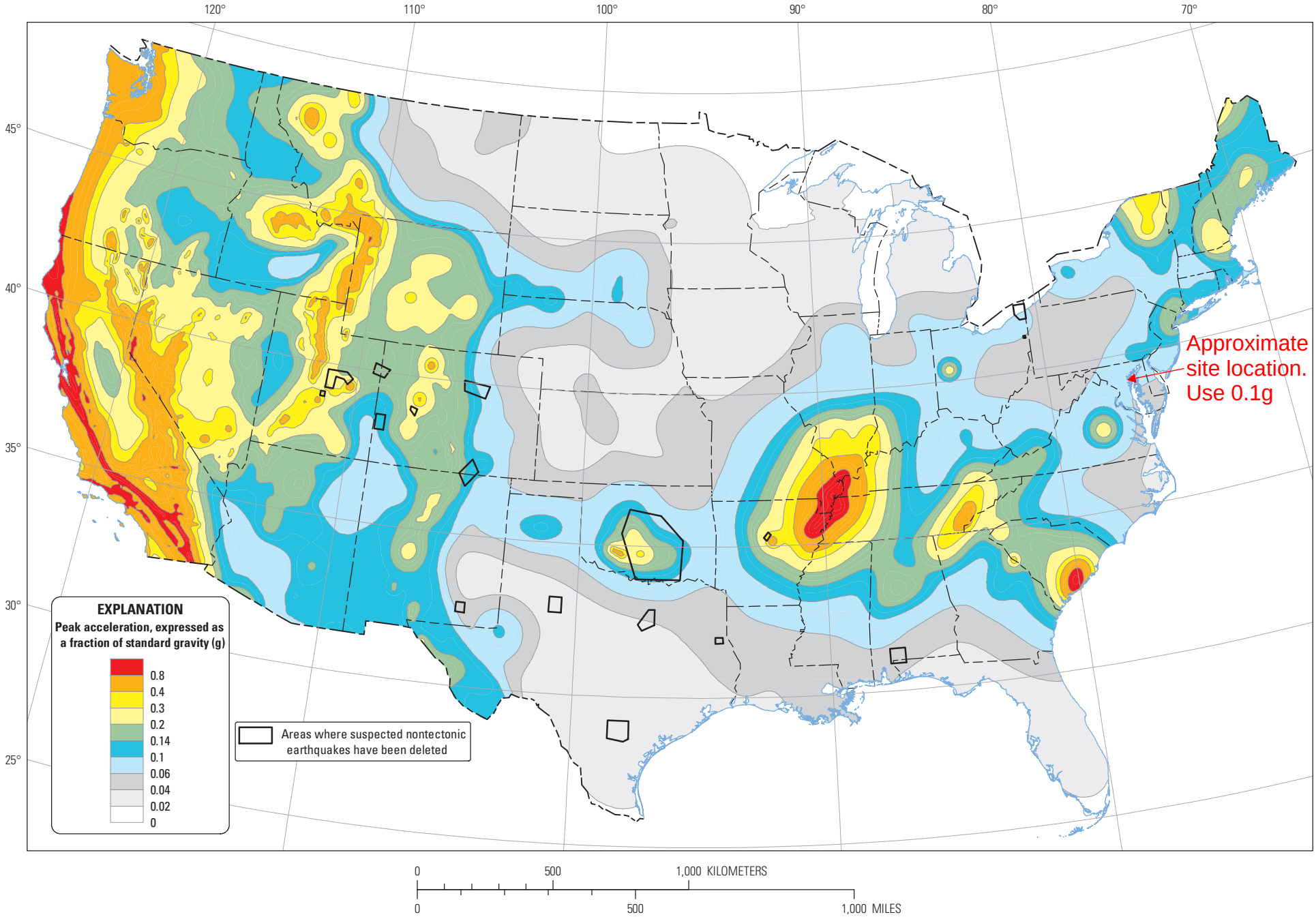
ATTACHMENT 3

SEISMIC HAZARD MAP



Two-percent probability of exceedance in 50 years map of peak ground acceleration