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October 11, 2021

Tennessee Valley Authority
1101 Market Street
Chattanooga
Tennessee, 37402-2801

Subject: Engineer's Certification of 2021 Periodic Safety Factor Assessment
Ash Pond A
Tennessee Valley Authority Gallatin Fossil Plant
Gallatin, Tennessee

1.0 PURPOSE

The purpose of this document is to certify that the Tennessee Valley Authority (TVA) Gallatin Fossil Plant (GAF) Ash Pond A is in compliance with the factors of safety specified in 40 CFR § 257.73(e) of the United States Environmental Protection Agency (USEPA) Coal Combustion Residuals Rule (CCR Rule). According to 40 CFR § 257.73(f)(3), a periodic safety factor assessment is required five years from the posting of the initial safety factor assessment in the unit's Operating Record. The initial safety factor assessment was placed in the facility's operating record on October 12, 2016.

2.0 SUMMARY OF FINDINGS

AECOM compiled and reviewed available topographic and geotechnical data for the TVA Gallatin Fossil Plant's Ash Pond A and reviewed the initial safety factor assessments performed in 2016 by AECOM and Geocomp. Based upon its review of the available documents, revisions were made to the critical cross-section, designated Section Q-Q', to reflect current conditions. The primary change involved revising the water levels assumed for Ash Pond A due to the discontinued use of siphon spillways that are no longer required following the cessation of CCR and non-CCR waste streams to the unit. The critical section was analyzed for the loading conditions specified in 40 CFR 257.73(e)(1)(i) through (iv).

The attached calculation package presents the safety factor assessment for Section Q-Q' for the loading conditions specified in 40 CFR 257.73(e)(1)(i) and (iv). The calculated factors of safety are shown in the following table. The results show that the calculated factors of safety for Section Q-Q' exceed the minimum safety factors required under 40 CFR 257.73(e)(1)(i) through (iv).

Plant	Facility	Critical Cross Section	EPA Criteria	EPA Required Factor of Safety (FOS)	Calculated FOS
GAF	Ash Pond A	Q-Q'	Long-term maximum storage pool loading condition	1.50	1.85
			Maximum surcharge pool loading condition	1.40	1.74
			Seismic factor of safety loading condition	1.00	1.10
			Liquefaction factor of safety loading condition	1.20	1.64

3.0 CERTIFICATION

I, David Skeggs, being a Professional Engineer in good standing in the State of Tennessee, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this certification has been prepared in accordance with the accepted practice of engineering; that the information contained herein is accurate as of the date of my signature below; and that Ash Pond A meets the requirements of the factors of safety specified in 40 CFR 257.73(e).

SIGNATURE: ______________________ **DATE:** October 11, 2021
David Skeggs, PE

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ATTACHMENTS: *AECOM (2021), Tennessee Valley Authority – 2021 Periodic Safety Factor Assessment 40 CFR 257.73(e); Existing CCR Surface Impoundment – Ash Pond A; TVA Gallatin Fossil Plant (Rev 0, October 11, 2021)*

DAVID ERIC SKEGGS
No. 124294

10/11/2021

COAL COMBUSTION PRODUCT DISPOSAL PROGRAM
Gallatin Fossil Plant
SUMNER COUNTY, TENNESSEE

2021 Periodic Safety Factor Assessment
40 CFR 257.73(e)
Existing CCR Surface Impoundment-
Ash Pond A
TVA Gallatin Fossil Plant

Prepared for

Tennessee Valley Authority
1101 Market St.
Chattanooga, TN 37402-2801

October 11, 2021 – Rev 0

Prepared by

AECOM

DAVID ERIC SKEGGS
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10/11/2021

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 OBJECTIVE

This assessment presents the results of AECOM's analysis of the existing surface impoundment, Ash Pond A, at Gallatin Fossil Plant (GAF) in Gallatin, Tennessee. AECOM was contracted by the Tennessee Valley Authority (TVA) to perform static and seismic safety factor assessment of the GAF Ash Pond A based on the requirements of the published United States Environmental Protection Agency (EPA) Coal Combustion Residual (CCR) Rule 40 Code of Federal Regulations (CFR) §257.73(e). An initial safety factor assessment for an existing CCR surface impoundment was completed in October 2016. The CCR Rule requires a periodic static safety factor assessment every five years.

1.2 OUTLINE OF RULE REQUIREMENTS

As required by 40 CFR §257.73(b), a safety factor assessment (§257.73(e)) is required for each existing CCR surface impoundment that:

1. Has a height of five feet or more and a storage volume of 20 acre-feet or more; or
2. Has a height of 20 feet or more.

The Gallatin Ash Pond A perimeter dike qualifies under the CCR Rule because this impoundment either (1) has a height of five feet or more and a storage volume of 20 acre-feet or more, (2) or has a height of 20 feet or more. The safety factor assessment requirements under the CCR Rule are explicitly outlined below, with specific sections of the CCR Rule cited as appropriate:

- §257.73(e)(1)(i): The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
- §257.73(e)(1)(ii): The calculated static factor of safety under maximum surcharge pool loading condition must equal or exceed 1.40.
- §257.73(e)(1)(iii): The calculated seismic factor of safety must equal or exceed 1.00.
- §257.73(e)(1)(iv): For dikes constructed of soils that have susceptibility to liquefaction, the calculated factor of safety must equal or exceed 1.20.
- §257.73(e)(2): The owner or operator of the CCR unit must obtain certification from a qualified professional engineer stating that the initial assessment and each subsequent periodic assessment specified in paragraph (e)(1) of this section meets the requirements of this section.
- §257.73(f)(3) [Part]: The owner or operator of the CCR unit must conduct and complete the assessments required by paragraphs (a)(2), (d), and (e) of this section every five years.

This assessment is intended to address the above described slope stability requirements from the CCR Rule and to demonstrate compliance regarding completion of the periodic assessment.

1.3 DESCRIPTION OF THE STRUCTURE

The TVA Gallatin Fossil Plant (GAF) is a coal-fired electric generating plant located in Sumner County, Tennessee on the north bank of the Cumberland River. The GAF plant has been in operation since 1959, and currently consists of four coal-fired electric generating units.

Ash Pond A is located in the northeast corner of the GAF complex and was commissioned in 1970. Ash Pond A is located within the Ash Pond Complex, which is comprised of Ash Pond A, Ash Pond E, Bottom Ash Pond, and Middle Pond A. Ash Pond A is situated northeast of Ash Pond E, with Stilling Ponds B, C, and D located to the north of both Ash Ponds A and E. Divider dikes separate Ash Pond A from Ash Pond E. Middle Pond A and Bottom Ash Pond are located east and southeast of Ash Pond E, respectively. The Ash Pond Complex is shown in **Figure 1**.

Figure 1: Aerial View of Ash Pond Complex

The perimeter dike which forms Ash Pond A is approximately 4,830 feet in length and varies in height from 19.5 to 28 feet. The dike was originally constructed of bottom ash to a crest elevation (El.) of approximately 461.5 feet Mean Sea Level (MSL) but was later raised to approximately El. 474 feet MSL. The raised portion was completed to the upstream of the original crest. Part of the raised bottom ash dike is founded on the original dike and partially on sluiced ash. The crest of the dike is approximately 35 feet in width.

The upstream dike slope is inclined approximately 1.5H:1V (horizontal:vertical). The downstream slope of the dike is inclined approximately 2.5H:1V. The toe of the downstream slope of the dike contains a rip rap stone bench. The bench has a slope inclined approximately 2H:1V. The rip rap bench was constructed to provide access along the downstream side of the Ash Pond A perimeter dike. The crest elevation of the rip rap bench varies, ranging from approximately El. 460.0 to El. 462.5 feet MSL. It has a minimum crest width of 10 feet. The upper portion of the downstream slope consists of well maintained, grassy vegetation.

2.0 PROJECT RECONNAISSANCE

2.1 REVIEW OF EXISTING DATA

As part of the CCR Rule assessment for Ash Pond A, AECOM reviewed available historical information and assessment reports. The existing data review included the following documents:

- AECOM (2016a). *Initial Safety Factor Assessment Geotechnical Exploration Report, Existing Surface Impoundment - Ash Pond A, TVA Gallatin Fossil Plant, Rev0.* October 7, 2016.
- AECOM (2016b). *Basis of Design Ash Pond Lowering and Flow Diversion, Gallatin Fossil Plant, Sumner County, Tennessee, Revision 0.* January 21, 2016.
- MACTEC Engineering and Consulting, Inc. (2004). *Report of Geotechnical Exploration, Ash Disposal Area and Potential On-site and Off-site Borrow Areas, Gallatin Fossil Plant, Gallatin, Tennessee.* October 14, 2004.
- Stantec Consulting Services Inc. (2010). *Report of Geotechnical Exploration and Slope Stability Evaluation, Ash Pond/ Stilling Pond Complex, Gallatin Fossil Plant – Gallatin, Tennessee*. May 27, 2010.
- TVA (2021), *2021 Annual Inspection of CCR Facilities, Gallatin Fossil Plant, Gallatin, Sumner County, Tennessee,* July 29, 2021.
- TVA (2019). LiDAR topographic survey flight. May 30, 2019.
- Quantum Spatial, Inc. (2017). LiDAR topographic survey flight and photography topographic survey flight. February 14, 2017. Prepared for Tennessee Valley Authority.
- URS (2014). *Ash Pond A and E Dikes Geotechnical Site Evaluation Report (Rev. 0).* February 21, 2014.
- Geocomp (2016). Initial Seismic Safety Factor Assessment, TVA Gallatin Fossil Plant Ash Pond A, October 14, 2016.

2.2 DATA GAPS

During the existing data review, AECOM did not identify data gaps that would require additional geotechnical drilling/ sampling, in-situ tests, instrumentation, laboratory testing or field surveying.

2.3 SUMMARY OF CHANGES FROM INITIAL ASSESSMENT

Based on the review of available data, the primary change to the analyses of Pond A when compared to the initial safety factor assessments include the following:

- A slight increase in the normal water level (maximum storage pool) of the unit from 463 to 464.4. This increase was due to the cessation of CCR and non-CCR waste streams to the unit and the discontinued use of siphon spillways previously used to manage normal flows.
- More accurate modeling of the rock buttress located at the toe of Ash Pond A in the seismic and liquefaction analyses.

3.0 SUMMARY OF FIELD INVESTIGATIONS AND LABORATORY TESTING

In 2012, URS completed a geotechnical exploration and analysis on the divider and perimeter dikes of Ash Pond A (URS, 2014). The geotechnical exploration was performed along the crest and near the exterior toe of the Ash Pond A dikes. The exploration work on the dikes of Ash Pond A included six (6) Hollow Stem Auger (HSA) Standard Penetration Test (SPT) soil borings, disturbed and undisturbed soil sampling, in-situ testing activities that included four (4) Marchetti dilatometer testing (DMT) and seven (7) cone penetration testing (CPT), laboratory testing, and the installation and monitoring of five (5) open stand-pipe piezometers and six (6) vibrating wire piezometers. Exploration activities were conducted between April 24 and May 3, and May 14, 15, and 17, 2012. Subsurface data gathered by URS in 2012 was used to supplement historical data previously gathered at Ash Pond A. Historic boring logs, in-situ test results, piezometer installation records, and laboratory testing results have been compiled by AECOM and are presented in the *Initial Safety Factor Assessment Geotechnical Exploration Report, Existing Surface Impoundment - Ash Pond A, TVA Gallatin Fossil Plant, Rev0* report (AECOM, 2016a). The geotechnical explorations, laboratory testing, and conclusions presented in this report were used as the basis for this analysis. No new explorations have been performed since the initial assessment.

LiDAR and photography flight topographic survey data gathered by both TVA and Quantum Spatial was provided by TVA. The LiDAR and photography survey was completed February 14, 2017 and May 30, 2019 and the data was used to update the Gallatin site topography basemap from which the stability cross sections were developed. Bathymetry topographic survey data for the Ash Pond and Stilling Ponds was provided to AECOM by TVA in October, 2017.

The initial seismic stability analyses were performed by another consultant as part of the 40 CFR §257.73(e)(1)(iii) and (iv) (Geocomp, 2016). Data from the initial seismic stability analyses was used to determine the 2021 periodic safety factors for the seismic (pseudostatic) and liquefaction (post-earthquake) conditions.

4.0 DETAILED TASK ANALYSIS CRITERIA

4.1 MATERIAL PROPERTIES

Based upon the results of historical subsurface explorations, the subsurface conditions encountered at Ash Pond A generally consist of initial and raised bottom ash dikes underlain by hydraulically sluiced fly ash and residual clay. Soil deposits at Ash Pond A are underlain by limestone bedrock. A summary of the subsurface conditions encountered at the Ash Pond A perimeter dike are summarized in **Table 1.** A detailed description of the subsurface profile is presented in AECOM (2016a). Soil classifications provided are based on the Unified Soil Classification System (USCS).

Table 1: Generalized Subsurface Conditions

Materials	Approximate Elevation (feet MSL)	Apparent Density / Consistency
Bottom Ash Fill – Consists of moist, black and dark brown, silty sand (SM) and sand with silt (SP-SM, and SW-SM).	Elevation 474.7 to Elevation 443.8	Loose to Dense
Sluiced Fly Ash - Hydraulically placed fly ash deposits classified as wet, gray and black silty sand (SM), clayey sand (SC), and sandy silt (ML).	Elevation 462.1 to Elevation 444.2	Very Loose to Medium Dense
Residual Clay - Moist, light gray and brown lean clay (CL) and fat clay (CH).	Elevation. 450.7 to Elevation 421.8	Medium Stiff to Stiff
Limestone Bedrock	Elevation 451.2 to Elevation 421.5 (refusal elevation)	--

The strength properties used in the stability models were developed during the URS Geotechnical Site Evaluation (URS, 2014) by comparing SPT, CPT, DMT, and laboratory test results, and employing engineering judgment and local experience. Values for shear strength, unit weight, and angle of internal friction were estimated for each soil horizon using empirical correlations or laboratory test results and then each parameter was selected by comparing the results. A summary of the engineering parameters used in the static safety factor modeling is provided in **Table 2**.

Table 2: Material Properties for Slope Stability Analysis

Material	Unit Weight (pcf)	Drained (Effective Stress) Strength Parameters		Undrained (Total Stress) Strength Parameters	
		c' (psf)	Φ' (deg.)	c (psf)	Φ (deg.)
Pond A Raised Bottom Ash Dike-High	105	0	38	0	38
Pond A Raised Bottom Ash Dike-Low	105	0	30/ 33[1]	0	30/ 33[1]
Pond A Initial Bottom Ash Divider Dike	105	0	35	0	35
Bottom Ash Fill	110	0	36	0	36
Sluiced Ash	85	0	26	400	0
Residual Clay	125	200	27	1,000	0
Silted Material	85	0	24	0	24
Rip Rap Stone Bench	115	0	40	0	40
Gravel Road Surface	115	0	37	0	37
Limestone Bedrock	Impenetrable				

[1] Friction angle of Bottom Ash Fill material varies by location, based upon SPT N-Values measured in subsurface borings.

The results of the strength parameter correlations and derivation can be found in the *Initial Safety Factor Assessment Geotechnical Exploration Report, Existing Surface Impoundment - Ash Pond A, TVA Gallatin Fossil Plant, Rev0* report (AECOM, 2016a).

Based on the initial seismic safety factor assessment (Geocomp, 2016), only the sluiced ash and native clay under the initial dike are susceptible to liquefaction. For the liquefied condition (post-earthquake condition), the sluiced ash was shown to have an undrained residual shear strength ratio of 0.39 and the clay was shown to have an undrained shear strength of 800 psf.

4.2 SELECTION OF CRITICAL CROSS SECTIONS

Historic steady state slope stability models were available from URS (URS, 2014). A total of six (6) stability cross sections were previously developed using the site geometry, material properties, and boundary conditions determined from the field explorations, laboratory testing, and review of historical data. The design cross sections were selected to be representative of the most critical dam geometries, such as the maximum embankment height, the steepest embankment slopes, the thickest interval of ash in the foundation, and the least resisting force at and beyond the downstream toe. At Ash Pond A, the cross sections which met these criteria were located along the northern leg of the perimeter dike, at cross sections H-H', I-I', J-J', K-K', L-L', and Q-Q'. The existing stability cross sections have been reviewed and revised based upon the latest topography and bathymetry data provided by TVA. The location of the cross sections is shown in **Figure 2**.

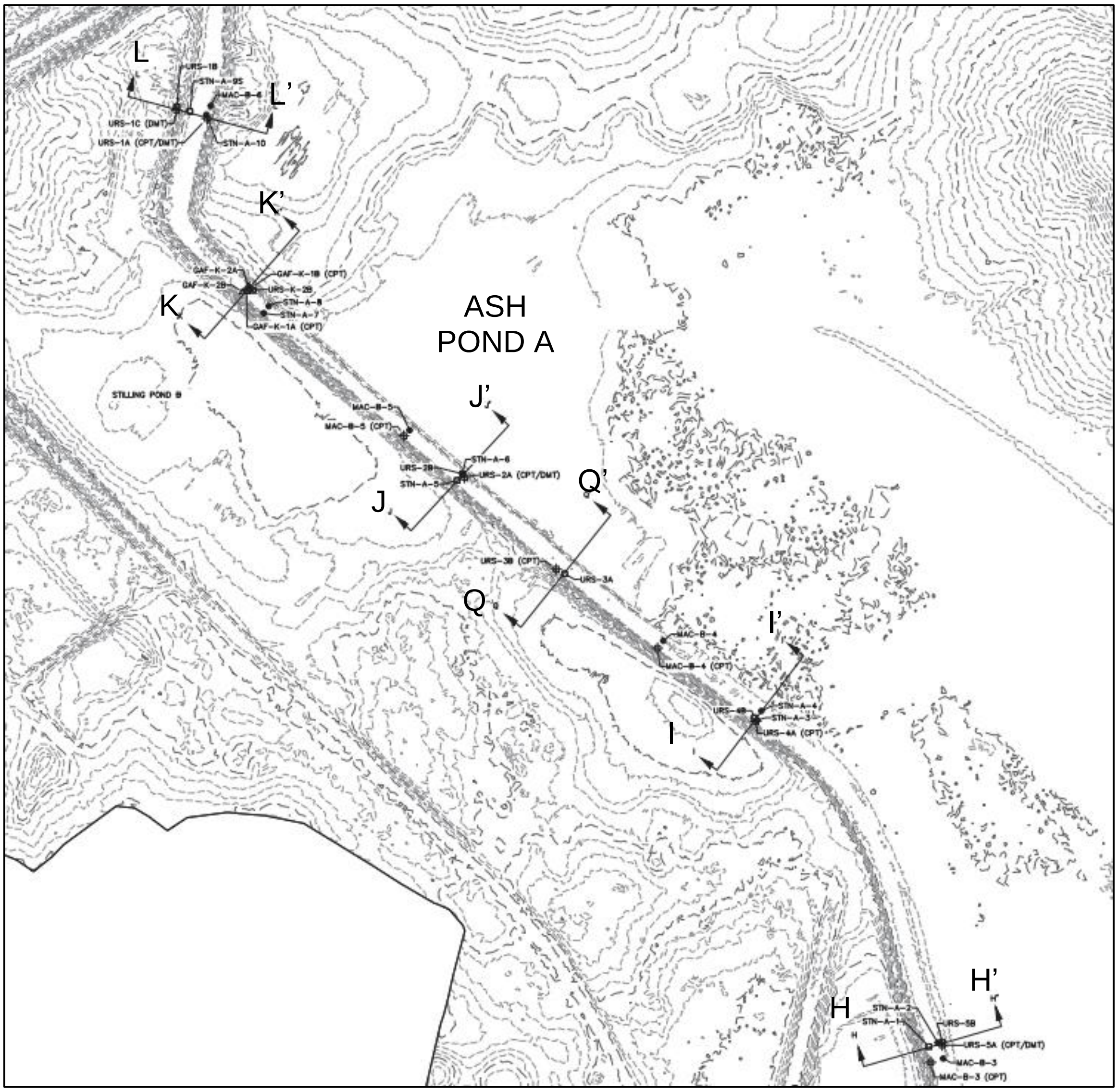

Figure 2: Location of Cross Sections

As demonstrated in the initial safety factor assessment, Section Q-Q' resulted in the lowest factors of safety when analyzed for Seismic, Liquefaction, and Long-term Maximum Storage Pool loading conditions and was determined to be the critical cross section under these loading condition. Section I-I' resulted in the lowest factor of safety with respect to the Maximum Surcharge Pool loading condition and was selected as the critical cross section.

4.3 WATER LEVELS

The long-term maximum storage pool loading condition specified in §257.73(e)(1)(i) is the pond operating water surface elevation obtained from automated pond level indicator instruments installed at the unit.

The maximum surcharge pool loading condition specified in §257.73(e)(1)(ii) is the pool level determined based on hydraulic analyses conducted for the 1,000-year, 6-hour storm event. Further discussion of the upstream and downstream inflow water level selection is provided in AECOM, 2021 [3].

Pond water levels utilized in the slope stability models are summarized in **Table 3**.

Table 3: Summary of Headwater and Tailwater Pool Elevations

Body of Water	Long-Term Maximum Storage Pool Elevation (feet MSL)	Maximum Surcharge Pool Elevation (feet MSL)
Ash Pond A	464.4	468.5
Stilling Pond B	456.0	458.3
Stilling Pond C	456.0	458.3

4.4 ANALYSIS METHODOLOGY

The stability analyses were performed using limit equilibrium methods through the computer software GeoStudio 2019 (Version 10.0.1.17733) by GEOSLOPE International, Ltd. (GEO-SLOPE, 2019). The GeoStudio software includes the SLOPE/W module which performs 2-dimensional limit equilibrium analysis based on the method of slices according to Spencer's Method.

The stability cross sections were analyzed for global stability, defined as a slip surface that would pass from the far half of the top of dike (crest nearest the Ash Pond) to the downstream toe of the dike. The resulting factor of safety slip surface encompasses the majority of the dike and represents a failure which would likely result in the release of impounded ash. Circular failure geometries were evaluated by defining entry/exit limits to develop the failure surface. The following stability analysis conditions were analyzed for the Gallatin Ash Pond A perimeter dike.

4.4.1 LONG TERM MAXIMUM STORAGE POOL §257.73(e)(1)(i)

This analysis considers Ash Pond A and the downstream stilling ponds under normal operating conditions. The phreatic surface was modeled using a piezometric line developed based upon piezometer and pond level indicator data presented in the 2021 annual inspection report. The long-term maximum storage pool water elevations listed in **Table 3** were input for the ash pond and downstream stilling ponds. The phreatic surface passing through the dike was set equal to historical piezometer data representative of steady state operating conditions. Peak drained (effective stress) strength parameters were used for all materials.

4.4.2 MAXIMUM SURCHARGE POOL §257.73(e)(1)(ii)

The maximum surcharge pool load condition is created by a rapid pool level rise during a flood. It is a temporary water level, higher than the normal pool, which does not last long enough to develop steady-state seepage within the impoundment embankment and foundation (USACE, 2003). The pool is assumed to rise faster than water can flow in or out of fine-grained soils, and the surcharge pressure may cause shear-induced, excess pore pressures in the saturated zones. This assumption is based on the significance of the surcharge pressure with respect to the size of the dike. During the maximum surcharge pool loading analysis, the tailwater elevation was conservatively maintained at the ordinary high water elevation, neglecting potential added resistance at the toe resulting from short term, surcharge loading conditions.

Performed as an undrained analysis, materials below the phreatic surface were considered saturated and modeled using undrained shear strength parameters. The partially saturated zones above the phreatic surface were modeled using drained material properties. The headwater and tailwater levels were assumed to be at the long term maximum storage pool elevations provided in **Table 3**.

The phreatic surface passing through the dike was modeled by drawing a piezometric line. A surcharge pressure reflecting the increased loading due to pool level rise from the maximum storage pool elevation to the 1,000-year, 6-hour storm event was applied to the ground surface on the inboard side of the dike. Surcharge pressures are discussed further in **Section 5.0**.

The slope stability in the downstream direction was evaluated. The required minimum factor of safety corresponds to the entry for “maximum surcharge pool” in **Table 4**.

4.4.3 PSEUDOSTATIC LOADING CONDITION §257.73(e)(1)(iii)

The seismic stability safety factor was evaluated under pseudostatic loading conditions using maximum storage pool levels and piezometric surfaces determined by instrumentation and survey data. The horizontal seismic coefficient is based on values developed for Middle Pond A and Bottom Ash Pond (AECOM, 2016). Undrained (total stress) strength parameters were used for all materials.

4.4.4 POST-EARTHQUAKE LOADING CONDITION §257.73(e)(1)(iv)

The liquefaction safety factor was evaluated under post-earthquake conditions using maximum storage pool levels and piezometric surfaces determined by instrumentation and survey data. Sand-like materials that are potentially susceptible to liquefaction (the sluiced ash and native clay under the initial dike as described in Section 4.1) are modeled using undrained strength ratios and clay-like materials are modeled using reduced undrained shear strengths.

4.5 ACCEPTANCE CRITERIA

The following summary is taken from the EPA’s CCR Rule §257.73(e). The factor of safety assessment criteria is outlined in **Table 4** below.

Table 4: Required Factors of Safety

Loading Condition	CCR Rule Required Factor of Safety	CCR Rule Reference
Long-Term, Maximum Storage Pool	1.50	§257.73(e)(1)(i)
Maximum Surcharge Pool	1.40	§257.73(e)(1)(ii)
Seismic (pseudostatic loading condition)	1.00	§257.73(e)(1)(iii)
Liquefaction (post-earthquake loading condition)	1.20	§257.73(e)(1)(iv)

5.0 ANALYSIS ASSUMPTIONS

The following assumptions were made when performing the safety factor assessment.

- The analyses are intended to identify failures which would likely result in the loss of impounded ash. Therefore, circular slip surfaces in the downstream direction were considered. Upstream directional failures were not included.
- Global failure surfaces were defined using either an entry/exit circular slip surface or block failure geometry. The global (deep seated) failure surfaces were modeled by setting slip surface boundary conditions which limit the program to analyzing only global failure surfaces. The failure surface was defined with boundary limits behind the centerline of the dike crest and beyond the downstream toe of the dike. These criteria limit the program to analyzing only global (deep seated) failure surfaces, as specified in the CCR Rule.
- The long-term maximum storage pool elevation for Ash Pond A and the tailwater stilling ponds is the normal pool operating elevation determined from automated pond level indicators.
- The maximum surcharge pool elevations were applied to the model based on the flood pool level determined for the 1,000-year, 6-hour storm event. The surcharge pool was assumed to not last long enough for steady-state conditions to develop. Therefore, the phreatic surface determined for the long-term maximum storage pool was utilized within the embankment. A surcharge pressure was applied to the slow-draining soils along the ground surface, reflecting the difference in elevation between the flood pool and normal pool.
- Significant changes to the subsurface materials have not occurred since the initial safety factor assessment. Therefore, material parameters developed by URS (2014) were used in the slope stability modeling.
- The horizontal seismic coefficient of 0.119g was developed in the initial safety factor assessment for Middle Pond A and Bottom Ash Pond (AECOM, 2016c). This value was assumed for the dikes impounding Ash Pond A.
- Potential liquefied (post-earthquake) materials were determined in the initial seismic safety factor assessment for Ash Pond A (Geocomp, 2016). The post-earthquake strength parameters for sluiced ash and native clay under the initial dike were used for these analyses.

6.0 ANALYSIS RESULTS

The existing dike configuration at Ash Pond A was analyzed at critical cross sections I-I’ and Q-Q’ in conjunction with the strength parameters presented in **Table 2**, and phreatic conditions modeled based upon piezometer water level readings. Result output plots from the SLOPE/W module can be found in **Appendix A**. **Table 5** below summarizes the factors of safety calculated for static, seismic, and liquefaction loading conditions considered at stability cross section I-I’ and Q-Q’ for GAF Ash Pond A.

Table 5: 2021 Periodic Static Safety Factor Assessment Results

Plant	Facility	Critical Cross Section	Loading Condition	CCR Rule Required Factor of Safety	Calculated Factor of Safety
GAF	Ash Pond A	Q-Q’	Long-Term, Maximum Storage Pool Loading Condition [§257.73(e)(1)(i)]	1.50	1.85
			Maximum Surcharge Pool Loading Condition [§257.73(e)(1)(ii)]	1.40	1.74
			Seismic (Pseudostatic Loading Condition) [§257.73(e)(1)(iii)]	1.00	1.10
			Liquefaction (Post-Earthquake Loading Condition) [§257.73(e)(1)(iv)]	1.20	1.64
		I-I’	Long-Term, Maximum Storage Pool Loading Condition [§257.73(e)(1)(i)]	1.50	2.03
			Maximum Surcharge Pool Loading Condition [§257.73(e)(1)(ii)]	1.40	2.03
			Seismic (Pseudostatic Loading Condition) [§257.73(e)(1)(iii)]	1.00	1.32
			Liquefaction (Post-Earthquake Loading Condition) [§257.73(e)(1)(iv)]	1.20	2.03

7.0 CONCLUSIONS

The 2021 periodic static, seismic, and liquefaction safety factor assessments have been completed for the Gallatin Fossil Plant Ash Pond A in accordance with the EPA 40 CFR §257.73(e). Computed factors of safety for slope stability at the critical cross sections meet or exceed the CCR Rule requirement under long-term, maximum storage pool loading condition [§257.73(e)(1)(i)], maximum surcharge pool loading condition [§257.73(e)(1)(ii)], seismic (pseudostatic loading condition) [§257.73(e)(1)(iii)], and liquefaction (post-earthquake loading condition) [§257.73(e)(1)(iv)]. The updated analyses indicates that Section Q-Q’ is the critical cross-section for all cases evaluated. These results demonstrate that the Gallatin Fossil Plant Ash Pond A meets the requirements of EPA 40 CFR §257.73(e) for slope stability.

8.0 REFERENCES

1. AECOM (2016a). *Initial Safety Factor Assessment Geotechnical Exploration Report, Existing Surface Impoundment Ash Pond A, TVA Gallatin Fossil Plant, Rev0.* October 7, 2016.
2. AECOM (2016b). *Basis of Design Ash Pond Lowering and Flow Diversion, Gallatin Fossil Plant, Sumner County, Tennessee, Revision 0.* January 21, 2016.
3. AECOM (2021), Inflow Design Flood Control Plan 40 CFR §257.82, Existing Surface Impoundment, Ash Pond A, Gallatin Fossil Plant Revision 0. October 11, 2021.
4. GEO-SLOPE International, Ltd. (2019). GeoStudio 2019, Version 10.0.1.17733. Calgary, Alberta, Canada. www.geo-slope.com.
5. MACTEC Engineering and Consulting, Inc. (2004). *Report of Geotechnical Exploration, Ash Disposal Area and Potential On-site and Off-site Borrow Areas, Gallatin Fossil Plant, Gallatin, Tennessee.* October 14, 2004.
6. Stantec Consulting Services Inc. (2010). *Report of Geotechnical Exploration and Slope Stability Evaluation, Ash Pond/ Stilling Pond Complex, Gallatin Fossil Plant – Gallatin, Tennessee*. May 27, 2010.
7. Stantec Consulting Services Inc., and AECOM (2016). *Annual Instrumentation and Monitoring Program Final Report (Rev. 2) Fiscal Year 2015.* Prepared for Tennessee Valley Authority. February 19, 2016.
8. Tuck Mapping Solutions, Inc. (2015a). LiDAR topographic survey flight. March 16, 2015. Big Stone Gap, Virginia. Prepared for Tennessee Valley Authority.
9. Tuck Mapping Solutions, Inc. (2015a). Photography topographic survey flight. April 19, 2015. Big Stone Gap, Virginia. Prepared for Tennessee Valley Authority.
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11. URS (2014). *Ash Pond A and E Dikes Geotechnical Site Evaluation Report (Rev. 0).* February 21, 2014.
12. URS (2015). *Pond A Dike Remediation Construction Record Documentation Report (Rev.0).* January 16, 2015.
13. Geocomp (2016). *Initial Seismic Safety Factor Assessment, EPA Final CCR Rule, TVA Gallatin Fossil Plant Ash Pond A, Gallatin, Tennessee (Rev. 0)*. October 14, 2016.
14. AECOM (2016c). *Initial Safety Factor Assessment, 40 CFR 257.73(e), Existing Surface Impoundment-Middle Pond A and Bottom Ash Pond, TVA Gallatin Fossil Plant (Rev. 0)*. October 7, 2016.

APPENDIX A

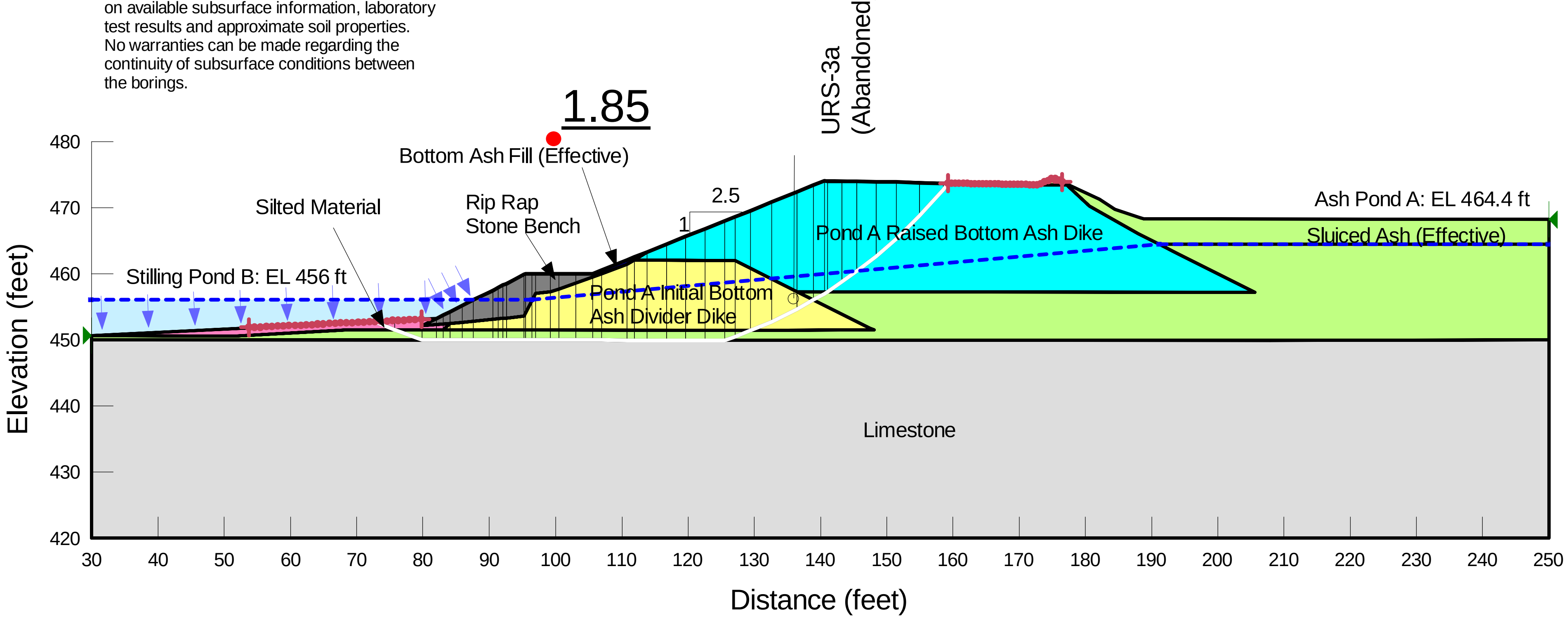
SLOPE STABILITY ANALYSIS

Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section Q-Q'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill (Effective)	Mohr-Coulomb	110	0	34
🟨	Initial Bottom Ash Divider Dike	Mohr-Coulomb	105	0	35
⬜	Limestone	Bedrock (Impenetrable)			
🟦	Raised Bottom Ash Dike	Mohr-Coulomb	105	0	38
⬛	Rip Rap Bench	Mohr-Coulomb	115	0	40
🟪	Silted Material	Mohr-Coulomb	85	0	24
🟩	Sluiced Ash (Effective)	Mohr-Coulomb	85	0	26

Slope Stability Long-term Maximum Storage Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_Q.gsz

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

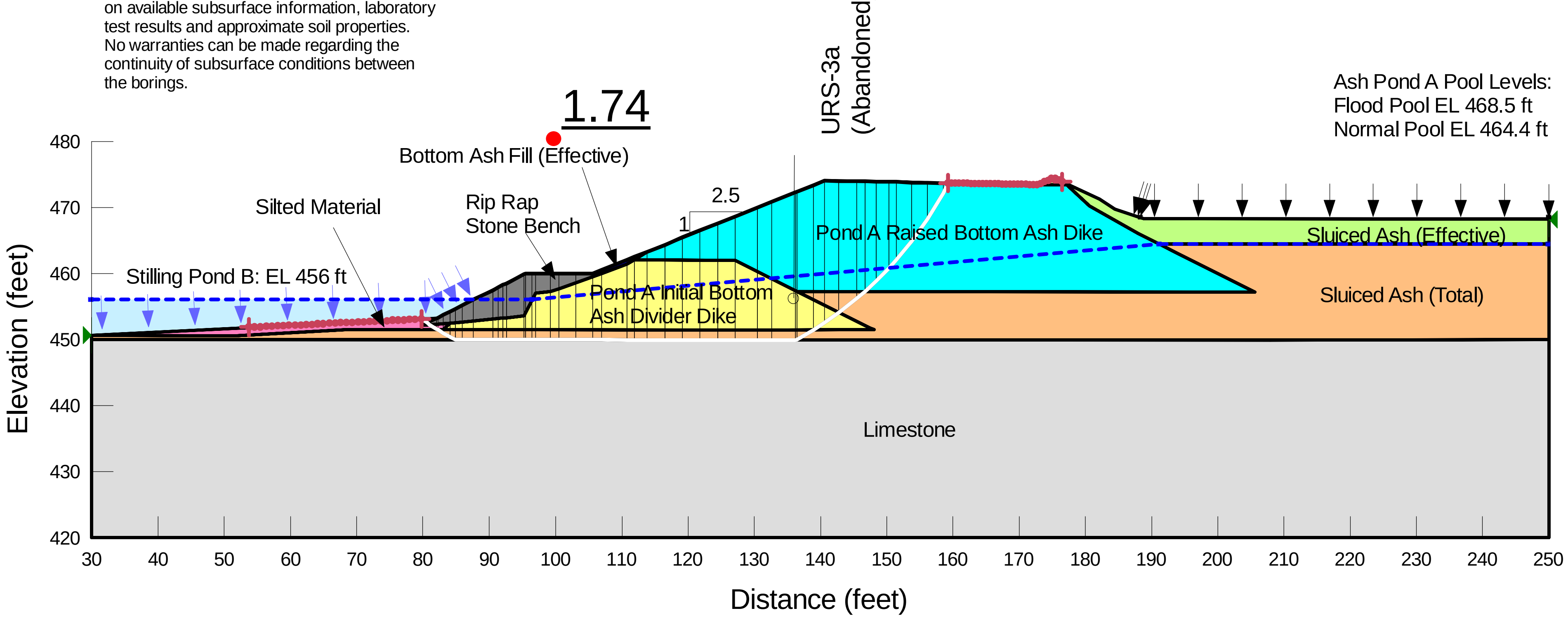


Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section Q-Q'

Slope Stability Maximum Surcharge Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_Q.gsz

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill (Effective)	Mohr-Coulomb	110	0	34
🟨	Initial Bottom Ash Divider Dike	Mohr-Coulomb	105	0	35
⬜	Limestone	Bedrock (Impenetrable)			
🟦	Raised Bottom Ash Dike	Mohr-Coulomb	105	0	38
⬛	Rip Rap Bench	Mohr-Coulomb	115	0	40
🟪	Silted Material	Mohr-Coulomb	85	0	24
🟩	Sluiced Ash (Effective)	Mohr-Coulomb	85	0	26
🟧	Sluiced Ash (Total)	Mohr-Coulomb	85	400	0

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.



Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section Q-Q'

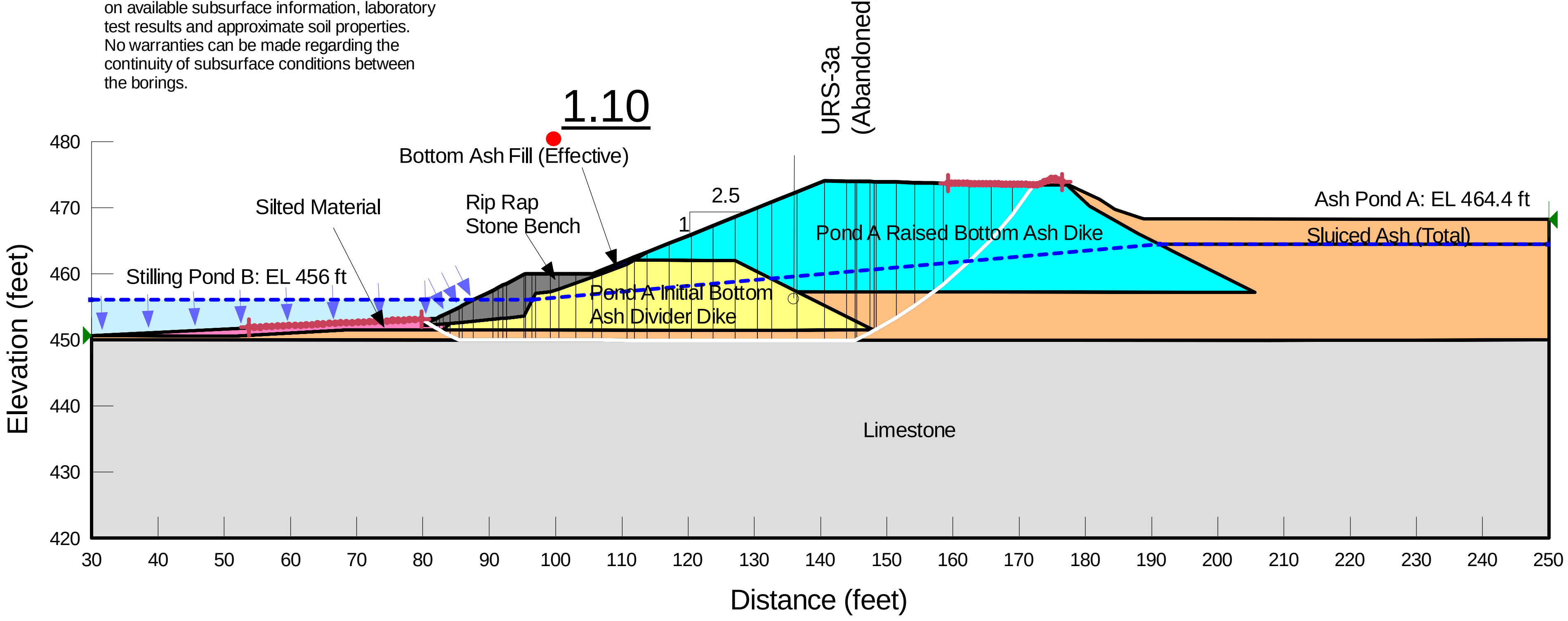
Factor of Safety: 1.10

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill (Effective)	Mohr-Coulomb	110	0	34
🟨	Initial Bottom Ash Divider Dike	Mohr-Coulomb	105	0	35
⬜	Limestone	Bedrock (Impenetrable)			
🟦	Raised Bottom Ash Dike	Mohr-Coulomb	105	0	38
⬛	Rip Rap Bench	Mohr-Coulomb	115	0	40
🟥	Silted Material	Mohr-Coulomb	85	0	24
🟧	Sluiced Ash (Total)	Mohr-Coulomb	85	400	0

Slope Stability Pseudostatic Maximum Storage Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_Q.gsz

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Horz Seismic Coef.: 0.119

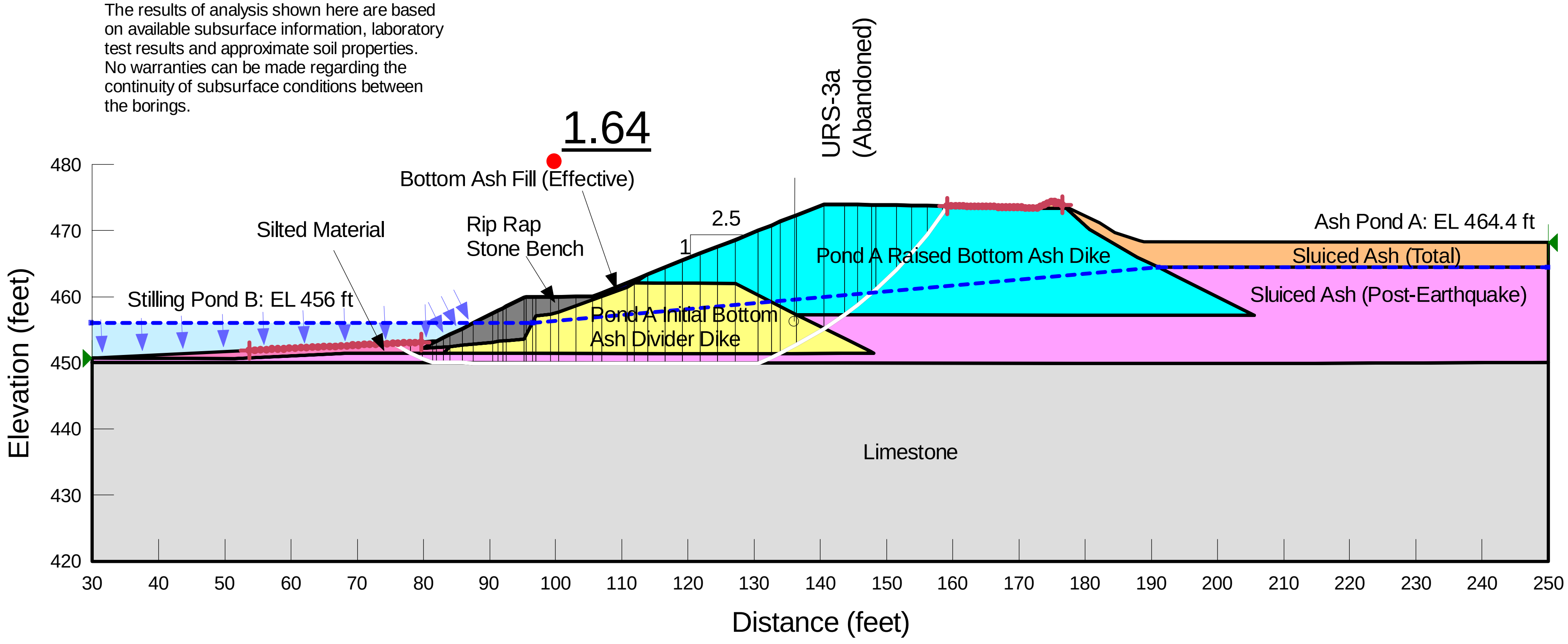


Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section Q-Q'

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill (Effective)	Mohr-Coulomb	110			0	34
🟨	Initial Bottom Ash Divider Dike	Mohr-Coulomb	105			0	35
⬜	Limestone	Bedrock (Impenetrable)					
🟦	Raised Bottom Ash Dike	Mohr-Coulomb	105			0	38
⬛	Rip Rap Bench	Mohr-Coulomb	115			0	40
🟥	Silted Material	Mohr-Coulomb	85			0	24
🟪	Sluiced Ash (Post-Earthquake)	SHANSEP	85	50	0.39		
🟧	Sluiced Ash (Total)	Mohr-Coulomb	85			400	0

Slope Stability Post-Earthquake Maximum Storage Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_Q.gsz

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

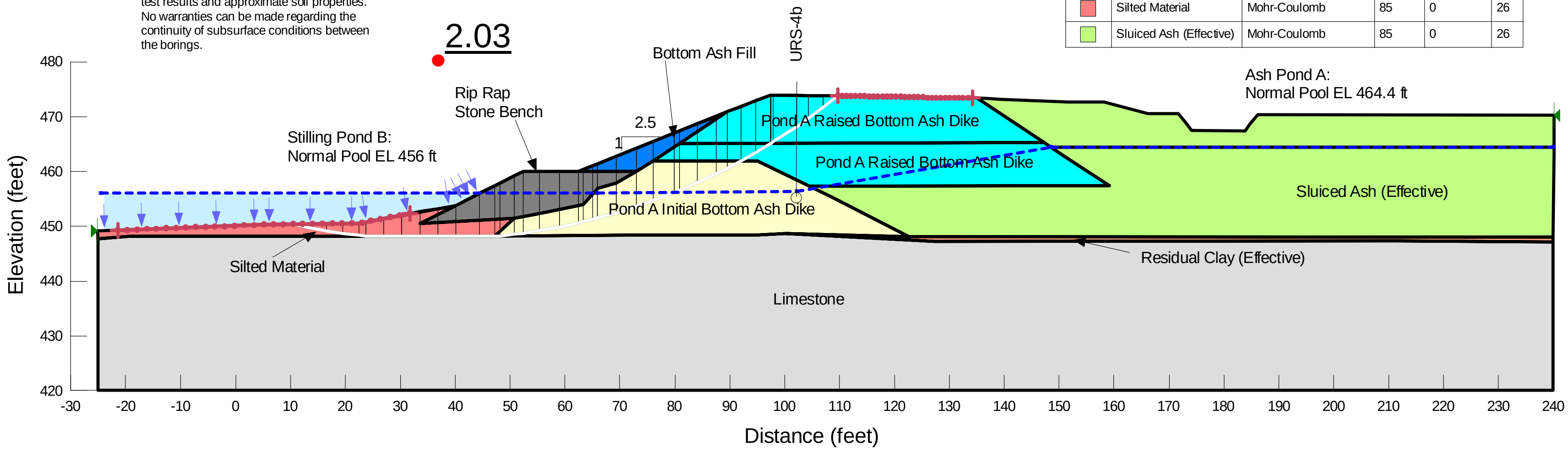


Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section I-I'

Slope Stability Long-term Maximum Storage Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_I.gsz

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill	Mohr-Coulomb	105	0	34
⬜	Limestone	Bedrock (Impenetrable)			
🟨	Pond A Initial Bottom Ash Dike	Mohr-Coulomb	105	0	35
🟦	Pond A Raised Bottom Ash Dike - High	Mohr-Coulomb	105	0	38
🟦	Pond A Raised Bottom Ash Dike - Low	Mohr-Coulomb	105	0	38
🟧	Residual Clay (Effective)	Mohr-Coulomb	125	200	27
⬛	Rip Rap Bench	Mohr-Coulomb	115	0	40
🟥	Silted Material	Mohr-Coulomb	85	0	26
🟩	Sluiced Ash (Effective)	Mohr-Coulomb	85	0	26

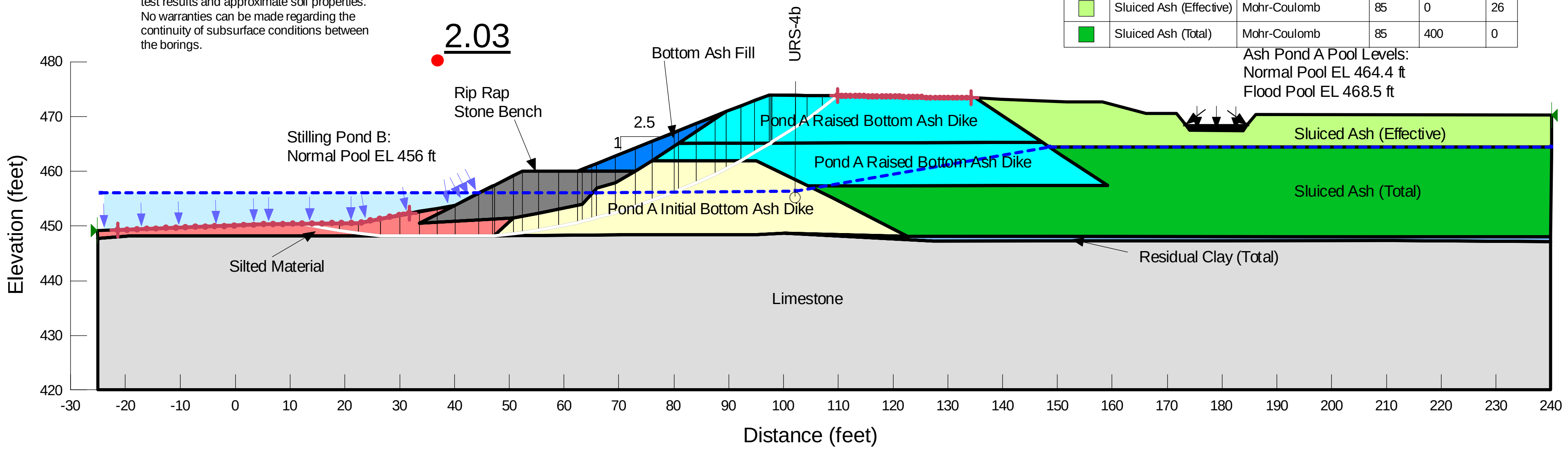


Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section I-I'

Slope Stability Maximum Surcharge Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_I.gsz

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill	Mohr-Coulomb	105	0	34
⬜	Limestone	Bedrock (Impenetrable)			
🟨	Pond A Initial Bottom Ash Dike	Mohr-Coulomb	105	0	35
🟦	Pond A Raised Bottom Ash Dike - High	Mohr-Coulomb	105	0	38
🟦	Pond A Raised Bottom Ash Dike - Low	Mohr-Coulomb	105	0	38
🟦	Residual Clay (Total)	Mohr-Coulomb	125	1,000	0
⬛	Rip Rap Bench	Mohr-Coulomb	115	0	40
🟥	Silted Material	Mohr-Coulomb	85	0	26
🟩	Sluiced Ash (Effective)	Mohr-Coulomb	85	0	26
🟩	Sluiced Ash (Total)	Mohr-Coulomb	85	400	0



Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section I-I'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill	Mohr-Coulomb	105	0	34
⬜	Limestone	Bedrock (Impenetrable)			
🟨	Pond A Initial Bottom Ash Dike	Mohr-Coulomb	105	0	35
🟦	Pond A Raised Bottom Ash Dike - High	Mohr-Coulomb	105	0	38
🟦	Pond A Raised Bottom Ash Dike - Low	Mohr-Coulomb	105	0	38
🟦	Residual Clay (Total)	Mohr-Coulomb	125	1,000	0
⬛	Rip Rap Bench	Mohr-Coulomb	115	0	40
🟥	Silted Material	Mohr-Coulomb	85	0	26
🟩	Sluiced Ash (Total)	Mohr-Coulomb	85	400	0

Slope Stability Pseudostatic Maximum Storage Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_I.gsz

Horz Seismic Coef.: 0.119

Note:
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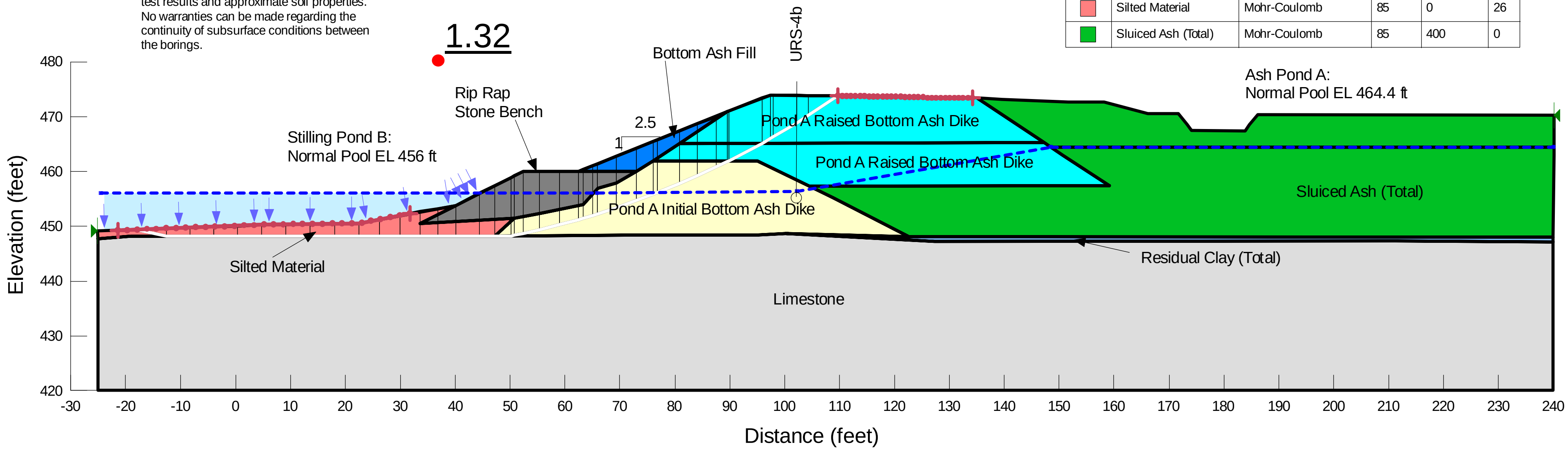

Tennessee Valley Authority
Gallatin Fossil Plant
Ash Pond A
Cross Section I-I'

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)
🟦	Bottom Ash Fill	Mohr-Coulomb	105			0	34
⬜	Limestone	Bedrock (Impenetrable)					
🟨	Pond A Initial Bottom Ash Dike	Mohr-Coulomb	105			0	35
🟦	Pond A Raised Bottom Ash Dike - High	Mohr-Coulomb	105			0	38
🟦	Pond A Raised Bottom Ash Dike - Low	Mohr-Coulomb	105			0	38
🟦	Residual Clay (Post-Earthquake)	Mohr-Coulomb	125			800	0
⬛	Rip Rap Bench	Mohr-Coulomb	115			0	40
🟥	Silted Material	Mohr-Coulomb	85			0	26
🟩	Sluiced Ash (Post-Earthquake)	SHANSEP	85	50	0.38		
🟩	Sluiced Ash (Total)	Mohr-Coulomb	85			400	0

Slope Stability Post-Earthquake Maximum Storage Pool
Method: Spencer
Slip Surface: Entry and Exit
File Name: GAF_Section_I.gsz

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.