Stantec

Stantec Consulting Services Inc.
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October 6, 2016
File: rpt_001_let_17555021
Revision 0

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

RE: Initial Safety Factor Assessment
Stilling Pond (including Retention Pond)
EPA Final CCR Rule
TVA Cumberland Fossil Plant
Stewart County, Tennessee

1.0 PURPOSE

This letter documents Stantec's certification of the initial safety factor assessment for the TVA Cumberland Fossil Plant's (CUF) Stilling Pond (including Retention Pond). Based on this assessment, the Stilling Pond (including Retention Pond) is in compliance with the static factors of safety specified in the EPA Final CCR Rule at 40 CFR 257.73(e)(1)(i) and (ii).

2.0 SAFETY FACTOR ASSESSMENT

The safety factor assessment conducted pursuant to 40 CFR 257.73(e) addresses the following static factors of safety:

- Long-term, maximum storage pool loading condition,
- Maximum surcharge pool loading condition.

Stantec compiled and reviewed available historical site, topographic, and geotechnical data as of December 11, 2015. A complete listing of documents reviewed is included in the attached references.

Based upon its review of these available documents, Stantec identified two cross sections as the most critical. The cross sections are designated Section P-P' and Section Q-Q', and they were analyzed for the loading conditions specified in 40 CFR 257.73(e)(1)(i) and (ii).

3.0 SUMMARY OF FINDINGS

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

Plant	Facility	Critical Cross Section	EPA Final CCR Rule Criteria	EPA Final CCR Rule Required Factor of Safety	Calculated Factor of Safety
CUF	Stilling Pond (including Retention Pond)	P-P'	Long-term maximum storage pool loading condition	1.50	2.16
			Maximum surcharge pool loading condition	1.40	1.89
CUF	Stilling Pond (including Retention Pond)	Q-Q'	Long-term maximum storage pool loading condition	1.50	1.98
			Maximum surcharge pool loading condition	1.40	1.74

4.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Stephen H. Bickel, being a Professional Engineer in good standing in the State of Tennessee, do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this certification is prepared in accordance with the accepted practice of engineering;
2. that the information contained herein is accurate as of the date of my signature below; and
3. that the initial static safety factor assessment for the TVA Cumberland Fossil Plant's Stilling Pond (including Retention Pond) presented in the table above meets the requirements of the static factors of safety specified in 40 CFR 257.73(e)(1)(i) and (ii).

SIGNATURE Stephen H. Bickel

DATE 10/6/2016

STEPHEN H. BICKEL
No. 113134

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Louisville, Kentucky 40223-5308

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ATTACHMENTS: Safety Factor Assessment Calculation Package

Safety Factor Assessment

Cumberland Fossil Plant –
Stilling Pond
(including Retention Pond)
Stewart County, Tennessee

Stantec

Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:
Stantec Consulting Services Inc.
Louisville, Kentucky

October 6, 2016
Revision 0

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1.0 INTRODUCTION

1.1 OBJECTIVE

On April 17, 2015 the "Final Rule: Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" (Environmental Protection Agency, 2015) was published in the Federal Register. Stantec Consulting Services, Inc. (Stantec) was contracted by the Tennessee Valley Authority (TVA) to analyze the Structural Integrity Criteria for the Cumberland Fossil Plant (CUF) CCR surface impoundments and to evaluate compliance with §257.73 of the EPA Final CCR Rule.

1.2 OUTLINE OF RULE REQUIREMENTS

As required by §257.73 of the EPA Final CCR Rule, an initial structural integrity evaluation is required by October 17, 2016 and must include an initial safety factor assessment for each existing CCR surface impoundment that meets the conditions of paragraph (b) as follows:

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 safety factor assessment must document whether the calculated factors of safety for each existing CCR surface impoundment perimeter dike demonstrate the minimum static safety factors specified in paragraphs (e)(1)(i) and (e)(1)(ii) of the EPA Final CCR Rule for the critical cross section of the embankment.

Table 1 Factor of Safety Criteria

EPA Final CCR Rule Criteria	EPA Final CCR Rule Required FOS	EPA Final CCR Rule Reference
Long-term, maximum storage pool loading condition	1.50	§257.73(e)(1)(i)
Maximum surcharge pool loading condition	1.40	§257.73(e)(1)(ii)

In addition, in accordance with paragraph (f)(2), the owner or operator of the existing CCR surface impoundment may elect to use a previously completed assessment to serve as the initial assessment required by paragraph (e) of the EPA Final CCR Rule provided that the previous assessment(s) was completed no earlier than 42 months prior to October of 2016 and meets the applicable requirements of paragraph (e) of the EPA Final CCR Rule. Note that only the static slope stability analyses load cases are covered in this assessment.

1.3 DESCRIPTION OF STRUCTURE

Cumberland Fossil Plant (CUF) is a coal-fired, electric-generating plant located in Stewart County, Tennessee south of the Cumberland River and approximately 60 miles northwest of Nashville. Wells Creek flows around the western and southwestern perimeter of CUF. TVA has determined that the Stilling Pond (including Retention Pond) is a CCR surface impoundment and, therefore, is subject to the CCR rule. Figure 1 shows an overview of Cumberland Fossil Plant and the location of the Stilling Pond (including Retention Pond).

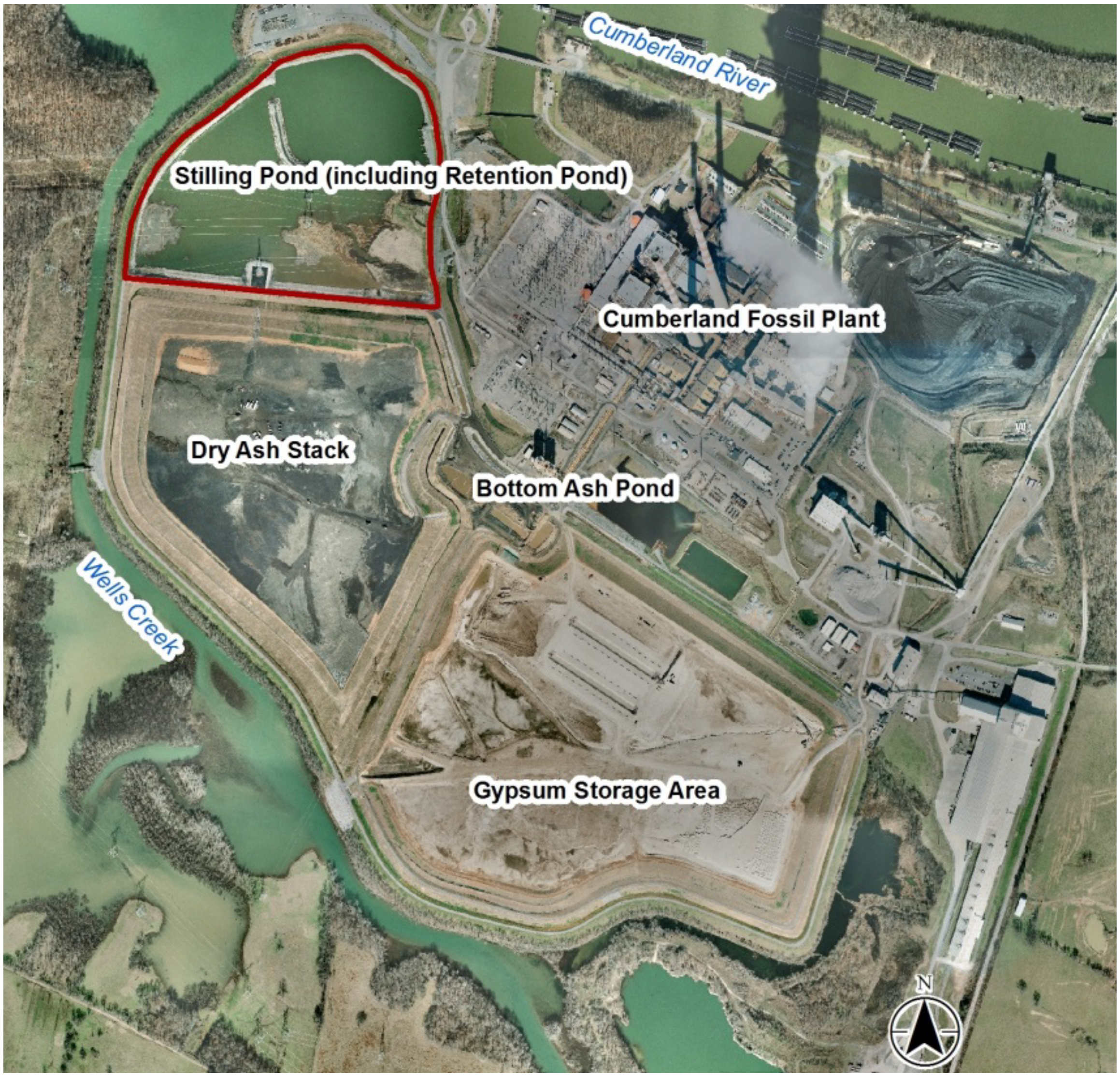

Figure 1 Cumberland Fossil Plant - Overview Map

2.0 PROJECT RECONNAISSANCE

2.1 REVIEW OF EXISTING DATA

The existing data review included the following documents:

- Stantec Consulting Services Inc. (2016). *Inflow Design Flood Control System Plan, Cumberland – Stilling Pond (including Retention Pond), Stewart County, Tennessee*. Prepared for Tennessee Valley Authority, February 2 (DRAFT).

- Stantec Consulting Services Inc. (2015). *2015 Formal (5 Year) Inspection of CCR Facilities and Ponds, Cumberland Fossil Plant, Cumberland City, Stewart County, Tennessee*. Prepared for Tennessee Valley Authority, April 29.

- Stantec Consulting Services Inc. (2013). *Instrumentation Installation and Updated Seepage Analyses, Ash Pond, Cumberland Fossil Plant, Cumberland City, Tennessee*. Prepared for Tennessee Valley Authority, January 9.

- Stantec Consulting Services Inc. (2012). *Basis of Design Report, Cumberland Fossil Plant, Ash Stilling Pond, Spillway Improvement Project, Work Plan 7 (CUF-110311-WP-7)*. Prepared for Tennessee Valley Authority, Calculation Package FPGCUFFESCDX0000002010008, March 21.

- Stantec Consulting Services Inc. (2011). Letter to Michael S. Turnbow, Tennessee Valley Authority, from Randy Roberts, Stantec. Re: Results of Seismic Slope Stability Analysis, Active CCP Disposal Facilities, Cumberland Fossil Plant. September 22.

- Stantec Consulting Services Inc. (2010). *Report of Geotechnical Exploration and Slope Stability Evaluation, Ash Pond, Cumberland Fossil Plant, Stewart County, Tennessee.* Prepared for Tennessee Valley Authority, March 29.

- Stantec Consulting Services Inc. and URS Corporation (2014). *Instrumentation and Monitoring Plan (Rev. 2), Tennessee Valley Authority, Instrumentation Monitoring Program, Coal Combustion Product Storage Facilities, Various Plants, Alabama, Kentucky and Tennessee*. Prepared for Tennessee Valley Authority, September 30.

- The RLS Group LLC (2015). 15019T.dwg. *Hydrographic Survey, Cumberland Fossil Plant, Main Ash and Stilling Pond*. Prepared for Tennessee Valley Authority, August 4 (last revision). Date of Survey June 16, 2015, Hixson, Tennessee.

- Tuck Mapping Solutions, Inc. (2015). *Cumberland 2015 Mapping.dwg*. *CUF Topographic Data*. Prepared for Tennessee Valley Authority, July 30. LiDAR flight date: April 11, 2015. Photography flight date: March 23, 2015.

2.2 DATA GAPS

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

3.0 SUMMARY OF FIELD INVESTIGATIONS AND LABORATORY TESTING

Two geotechnical explorations were performed to characterize the perimeter dikes of the Stilling Pond (including Retention Pond). Stantec performed drilling and sampling of 20 soil test borings at the crest and toe of the pond dikes in 10 locations around the Stilling Pond and Retention Pond in July and August of 2009 (Stantec, 2010). Three additional soil test borings were performed near the southwest portion of the Retention Pond in October 2012 (Stantec, 2013). The geotechnical explorations, laboratory testing, and conclusions were used as the basis for this analysis and are found in Stantec (2010 and 2013).

Recent topographic (Tuck Mapping Solutions, Inc., 2015) and bathymetric (The RLS Group LLC, 2015) data were provided for the Stilling Pond (including Retention Pond).

Note that a supplemental geotechnical exploration and seismic stability analyses are being performed by Geocomp as part of the EPA Final CCR Rule compliance effort for §257.73(e)(1)(iii) and (iv). The seismic work is being performed concurrently with this stability analysis, and its data is not available for use in this report.

4.0 DETAILED TASK ANALYSIS CRITERIA

4.1 MATERIAL PROPERTIES

An overview of the subsurface conditions of the perimeter dike at the Stilling Pond (including Retention Pond) is summarized in Table 2. A more in-depth review is found in Stantec (2010).

Table 2 Generalized Subsurface Conditions – Stilling Pond (including Retention Pond) Perimeter Dike

Materials	Approximate Elevation	General Consistency/Density
Dike 1 – original perimeter dike, lean clay (CL) with areas of sand or gravel, limited areas classified as fat clay (CH), just above natural ground in most borings surrounding the Retention and Stilling Ponds	Top of dike 380 feet	Very soft to very stiff
Dike 2 (lean clay) – raised dike uphill of original perimeter dike, along outside perimeter of Retention and Stilling Ponds, lean clay to lean clay with gravel (CL)	Top of dike 395 feet	Soft to very stiff
Dike 2 (fat clay) – raised dike uphill of original perimeter dike, along outside perimeter of Retention and Stilling Ponds, fat clay to fat clay with gravel (CH), near the top of Dike 2 or may compose complete Dike 2 zone	Top of dike 395 feet	firm to very stiff
Fly ash (sluiced) – silt (ML), silty sand with gravel (SP), silty sand (SM), and sandy lean clay (CL)	Various	Very soft to medium stiff
Alluvial (clay) – lean clay (CL), silty to sandy with rock fragments	Various	Soft to very stiff
Alluvial (granular) – silty sand with gravel (SM), gravel with clay to silt and sand (GP-GC or GM)	Various	Very loose to very dense
Bedrock – interbedded limestone and shale	El. 280-371 feet	Moderately hard to hard

During the 2009 geotechnical explorations, Stantec performed a laboratory testing program consisting of natural moisture content determinations, sieve and hydrometer analyses, Atterberg limits, specific gravity determinations, unit weight and moisture-density (Proctor) testing, consolidated-undrained triaxial compression tests, and falling head permeability tests. The strength parameters derived using the laboratory data and used in this static slope stability evaluation are presented in Table 3. The results of the laboratory testing and derivation of the strength parameters can be found in Stantec (2010 and 2011) and Stantec and URS (2014).

Table 3 Strength Parameters for Stability Analysis – Stilling Pond (including Retention Pond) Perimeter Dike

Soil Horizon	Unit Weight (pcf)	Effective Stress Strength Parameters		Total Stress Strength Parameters	
		c' (psf)	ϕ' (degrees)	c (psf)	ϕ (degrees)
Dike 1 (Lean Clay)	123	200	22	800	20
Dike 2 (Lean Clay)	123	200	32	500	21
Dike 2 (Fat Clay)	119	200	29	200	18
Fly Ash (Sluiced)	100	0	22	140	11
Alluvial Clay	124	200	33	450	20
Alluvial Granular	130	0	32	100	20
Bedrock	Impenetrable				

4.2 CRITICAL CROSS SECTION SELECTION

Historic steady-state slope stability analyses were available from Stantec (2010) and Stantec and URS (2014). Stantec (2013) discussed additional piezometer installation and updated the seepage analyses following facility improvements around the Ash Pond; static slope stability analyses were not performed for this report.

Figure 2 shows a plan view of the Stilling Pond (including Retention Pond) and the cross sections previously analyzed. The Dry Ash Stack lies to the south of the Stilling Pond (including Retention Pond).

In Stantec (2010), eight cross sections were analyzed under steady-state conditions. The eight sections analyzed were P-P', Q-Q', R-R', S-S', T-T', U-U', V-V', and W-W'. These analyses used pore water pressures developed from seepage modeling with a headwater elevation of 384.23 feet and a tailwater elevation for Wells Creek/Cumberland River of 359.5 feet. For Sections V-V' and W-W', tailwater elevation reflects the invert of the surface ditch leading to the outlet channel at an elevation of 375 feet.

In Stantec and URS (2014), instrumentation threshold analyses were performed for the Stilling Pond (including Retention Pond). Three cross sections within the facility were analyzed: Q-Q', S-S', and U-U'. The results of the baseline conditions were updated with the pond pool level at elevation 378.2 feet (following the Work Plan 7 construction (Stantec, 2012) described below). Tailwater elevation was 360 feet. These analyses used piezometric lines to define water levels within the embankment.

To determine if cross sections along the perimeter dike of the Stilling Pond (including Retention Pond) were still representative of field conditions, a review of recent construction activities, topographic, and bathymetric information was performed. The following modifications were made since the 2009 geotechnical exploration:

- The Stilling Pond (including Retention Pond) pool level was lowered from the Spillway Improvements Project (Work Plan 7) completed in March of 2012 (Stantec, 2012 and Stantec, 2013).
- A second geotechnical exploration was performed near Section P-P' in October of 2012 (Stantec, 2013) to facilitate the installation of supplemental piezometers.

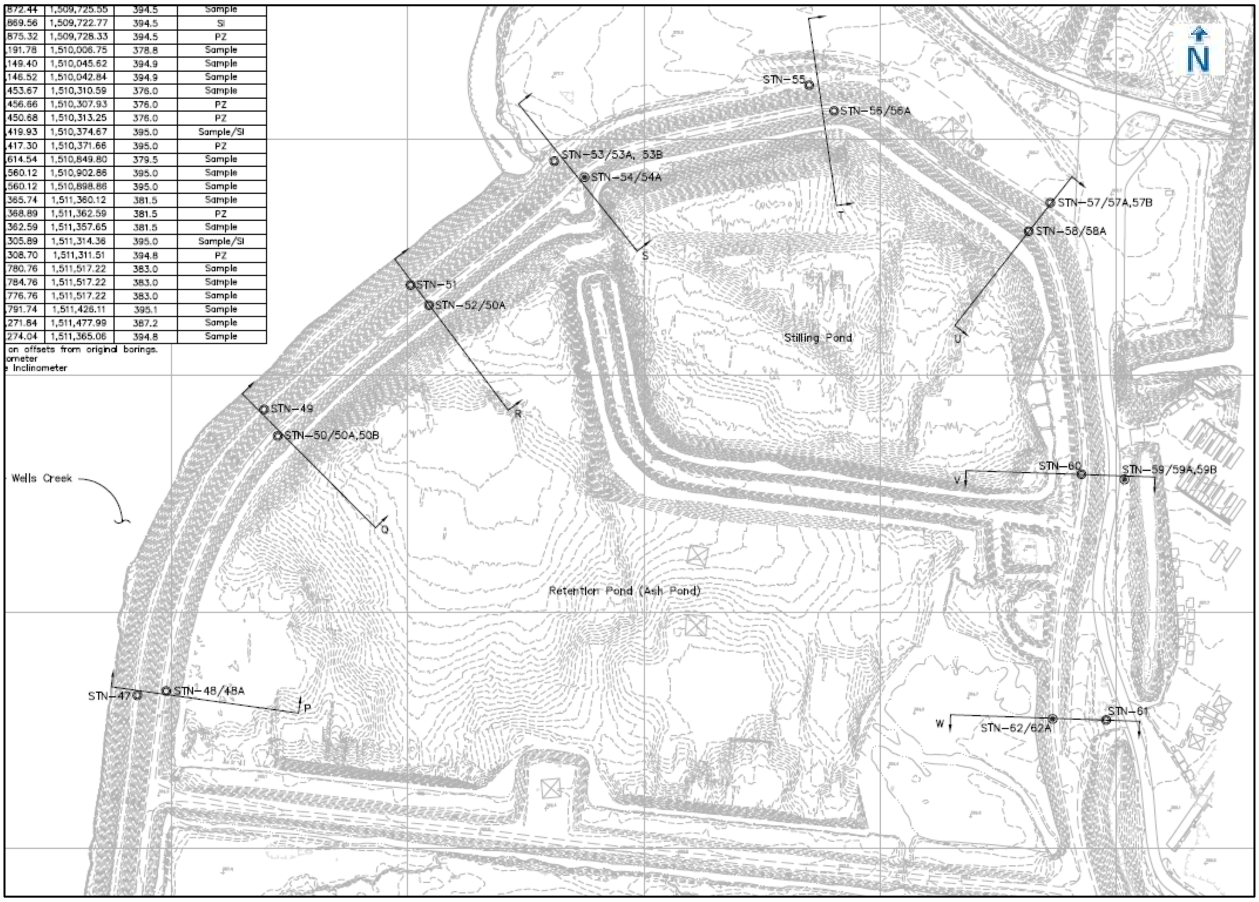

Figure 2 CUF Stilling Pond (including Retention Pond) – Plan View of Cross Sections

The additional geotechnical exploration performed in October of 2012 refined the subsurface soil geometry in Section P-P', confining the alluvial granular layer with alluvial clay. The threshold analysis performed in Stantec and URS (2014) reflects this refinement in subsurface geometry. No additional changes to cross section geometry have occurred. Recent topographic data (Tuck Mapping Solutions, 2015) and bathymetric data (The RLS Group, 2015) indicate no changes in the cross section geometry. The model surface geometry and material properties provided in the historical reports were used in this slope stability assessment.

A summary of the historic slope stability factors of safety from Stantec (2010) and Stantec and URS (2014) are listed in Table 4. As discussed above, the water level of the pond was lowered in 2012 as part of Work Plan 7 (Stantec, 2012 and Stantec, 2013).

Table 4 Historic Static Slope Stability Results

Cross Section	Static Long-Term Factor of Safety[3]	Reference
P-P'	1.7[1]	Stantec, 2010
Q-Q'	1.9	Stantec, 2010
Q-Q'	1.75[2]	Stantec and URS (2014)
R-R'	2.0	Stantec, 2010
S-S'	2.5	Stantec, 2010
S-S'	2.47[2]	Stantec and URS (2014)
T-T'	2.9	Stantec, 2010
U-U'	2.6	Stantec, 2010
U-U'	2.83[2]	Stantec and URS (2014)
V-V'	2.8	Stantec, 2010
W-W'	7.2	Stantec, 2010

[1] Prior to modified subsurface geometry from 2012 exploration.

[2] Lowered water table due to spillway improvement project (WP7).

[3] Factors of safety shown are as reported.

Based on the results shown above, Sections P-P' and Q-Q' displayed the lowest factors of safety and are considered critical cross sections for this analysis.

4.3 WATER LEVELS

Referring to Stantec (2016), the water elevations for the Stilling Pond (including Retention Pond) were redefined to meet the requirements of the EPA CCR Rule inflow design flood cases [§257.82(a)]. The long-term maximum storage pool elevation is the normal pool elevation as determined from the basis of design report for Work Plan 7 (Stantec, 2012). The maximum surcharge pool elevation is the pool level determined for the "Late Storm Peak" 1,000-year, 6-hour storm.

The tailwater corresponds to Wells Creek, which is controlled by the Cumberland River. For both the long-term maximum storage and maximum surcharge analyses, the tailwater elevation was set at elevation 359.0 feet, the normal summer pool for the Cumberland River (Stantec, 2012). Headwater and tailwater elevations are listed in Table 5.

Table 5 CUF Water Elevations for Stability Modeling

CCR Rule Criteria	Headwater Stilling Pond (including Retention Pond) Elevation (feet, NGVD29)	Tailwater Cumberland River Elevation (feet, NGVD29)
Long-term maximum storage pool loading condition	378.0	359.0
Maximum surcharge pool loading condition	385.1	359.0

4.4 ANALYSIS METHODOLOGY

Stantec performed the static slope stability analyses using the GeoStudio 2007, Version 7.23 software package developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada (GEO-SLOPE International, Ltd, 2007). This package includes the SLOPE/W module for slope stability analysis. The analyses were performed in accordance with the guidelines in USACE Design Manual EM 1110-2-1902 "Slope Stability" (United States Army Corps of Engineers, 2003).

4.4.1 Long-Term Maximum Storage Pool

A drained, effective stress analysis was performed for this load case to evaluate slope stability in the downstream direction. The headwater level is the "long-term maximum storage pool" level for the Stilling Pond (including Retention Pond), and the tailwater level is the Cumberland River's normal pool provided in Table 5.

The phreatic surface and steady-state pore pressures are based on the static piezometric line of the dike at this pool level. The piezometric line is a straight-line assumption within the embankment correlated with instrumentation data over time. The required minimum factor of safety corresponds to the entry for "long-term maximum storage pool" in **Error! Reference source not found.**. The referenced instrumentation data is included in Appendix A.

4.4.2 Maximum Surcharge Pool

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 dam 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.

Performed as an undrained analysis, materials below the phreatic surface are considered saturated and modeled using undrained material properties. The partially saturated zones above the phreatic surface are modeled using drained material properties.

The headwater level is the "long-term maximum storage pool" level provided in Table 5. Tailwater level is also defined in Table 5. The piezometric line is a straight-line assumption within the embankment between the headwater and tailwater pool elevations. A surcharge pressure is applied to the ground surface reflecting the additional pressure load from the maximum surcharge pool loading condition. Surcharge pressures are discussed further in Section 5.0.

The slope stability in the downstream direction is evaluated. The required minimum factor of safety corresponds to the entry for "long-term maximum surcharge pool" in Table 6.

4.5 ACCEPTANCE CRITERIA

The following summary is taken from the EPA's CCR Rule §257.73(e). The factor of safety assessment criteria are explicitly outlined in Table 1.

5.0 ANALYSIS ASSUMPTIONS

The following assumptions apply to this analysis.

- Historical strength parameters were assumed to be appropriate for the analysis (Section 4.1).
- Sections P-P’ and Q-Q’ are the critical cross sections for static slope stability (Section 4.2).
- The piezometric line for the long-term maximum storage case is defined by a straight-line assumption within the embankment between the pool level and the tailwater (Section 4.4.1).
- The surcharge pool is assumed to not last long enough to develop steady-state seepage within the dam embankment and foundation.
    - The piezometric line is a straight-line assumption within the embankment between the headwater (maximum storage) and tailwater pool elevations.
    - A surcharge pressure is applied to the slow-draining soils along ground surface, reflecting the difference in the elevation between the surcharge pool and the maximum storage pool.
    - The surcharge pressure is assumed not to apply to fully drained surficial soils. The pore pressures will be computed using a second piezometric line that corresponds to the maximum surcharge pool condition.
    - Materials below the phreatic surface are assumed to be saturated and modeled using undrained material properties. The partially saturated zones above the phreatic surface are modeled using drained material properties.

6.0 ANALYSIS RESULTS

The slope stability assessments presented in this report are focused on the potential for slope failures of significant mass, which could directly impact potential release of water and CCR materials from CUF's Stilling Pond (including Retention Pond). The search for a critical slip surface in the slope stability assessments is thus restricted to consider only potential surfaces where the depth (measured at the base of at least one slice) is more than 10 feet vertically below the ground surface. A summary of the static safety factor evaluation results at the Stilling Pond (including Retention Pond) is summarized in Table 6. Appendix A includes the results of the slope stability analyses referenced below.

Table 6 Factor of Safety Assessment Results

Plant	Facility	Critical Cross Section	EPA Final CCR Rule Criteria	EPA Final CCR Rule Required Factor of Safety	Calculated Factor of Safety
CUF	Stilling Pond (including Retention Pond)	P-P'	Long-term maximum storage pool loading condition	1.50	2.16
			Maximum surcharge pool loading condition	1.40	1.89
CUF	Stilling Pond (including Retention Pond)	Q-Q'	Long-term maximum storage pool loading condition	1.50	1.98
			Maximum surcharge pool loading condition	1.40	1.74

7.0 CONCLUSIONS

This report documents the static safety factor evaluation of Cumberland Fossil Plant's Stilling Pond (including Retention Pond). The evaluation was performed in accordance with section §257.73(e) of the EPA Final CCR Rule.

For Section P-P', the static safety factor evaluation resulted in safety factors of 2.16 for the maximum storage pool loading condition [§257.73(e)(1)(i)] and 1.89 for the maximum surcharge pool [§257.73(e)(1)(ii)] loading condition. For Section Q-Q', the static safety factor evaluation resulted in safety factors of 1.98 for the maximum storage pool loading condition and 1.74 for the maximum surcharge pool loading condition. These results are greater than the required safety factors of 1.50 and 1.40 for the long-term maximum storage pool and maximum surcharge pool loading conditions, respectively.

8.0 REFERENCES

Environmental Protection Agency (2015). "Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities." Federal Register, Vol. 80, No. 74, April 17.

GEO-SLOPE International, Ltd (2007). GeoStudio 2007, Version 7.23, Build 5099. Calgary, Alberta, Canada. www.geo-slope.com.

Stantec Consulting Services Inc. (2016). *Inflow Design Flood Control System Plan, Cumberland – Stilling Pond (including Retention Pond), Stewart County, Tennessee*. Prepared for Tennessee Valley Authority, February 2 (DRAFT).

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Stantec Consulting Services Inc. (2013). *Instrumentation Installation and Updated Seepage Analyses, Ash Pond, Cumberland Fossil Plant, Cumberland City, Tennessee*. Prepared for Tennessee Valley Authority, January 9.

Stantec Consulting Services Inc. (2012). *Basis of Design Report, Cumberland Fossil Plant, Ash Stilling Pond, Spillway Improvement Project, Work Plan 7 (CUF-110311-WP-7)*. Prepared for Tennessee Valley Authority, Calculation Package FPGCUFFESCDX0000002010008, March 21.

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Stantec Consulting Services Inc. and URS Corporation (2014). *Instrumentation and Monitoring Plan (Rev. 2), Tennessee Valley Authority, Instrumentation Monitoring Program, Coal Combustion Product Storage Facilities, Various Plants, Alabama, Kentucky and Tennessee*. Prepared for Tennessee Valley Authority, September 30.

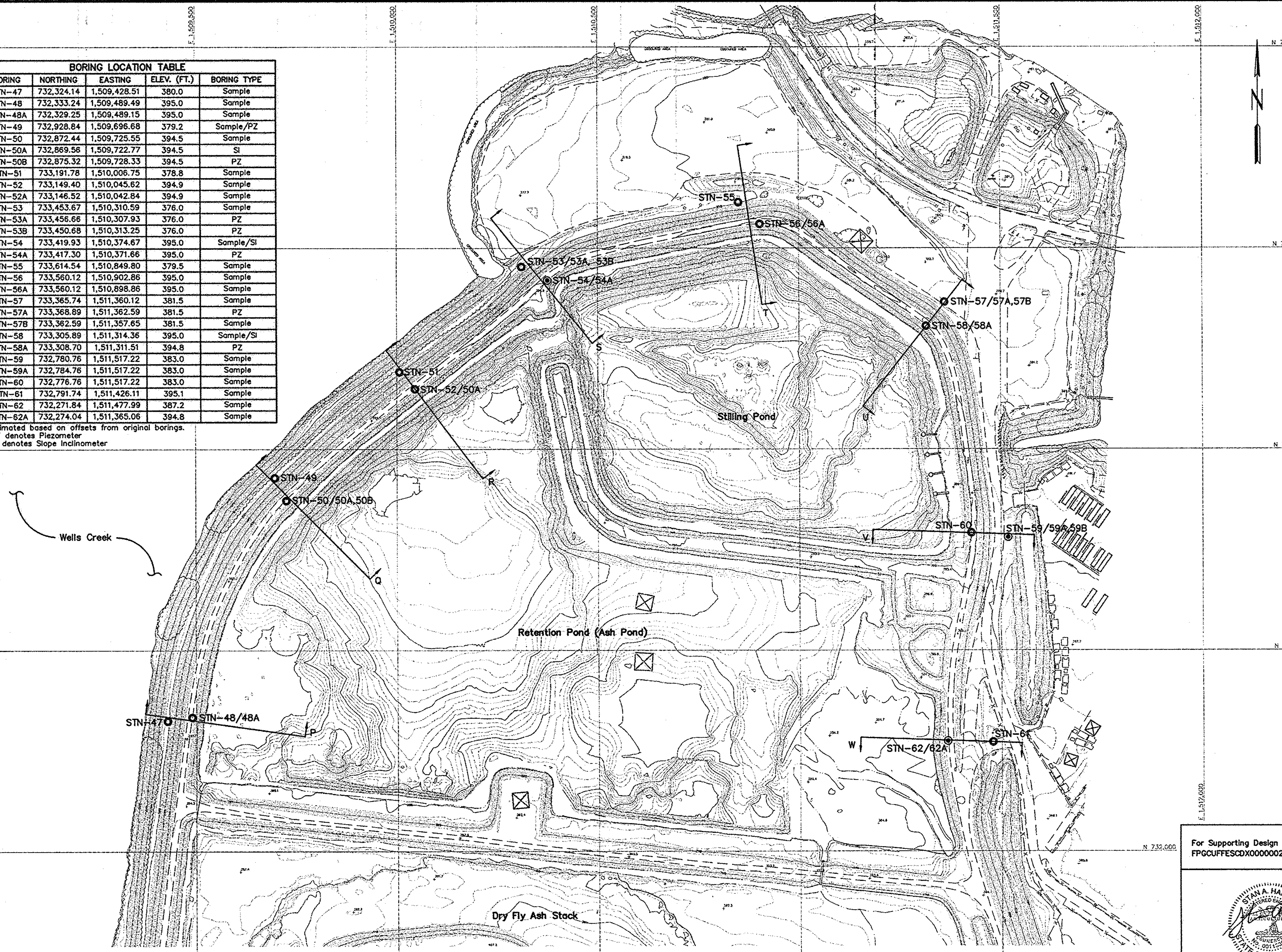
The RLS Group LLC (2015). 15019T.dwg. *Hydrographic Survey, Cumberland Fossil Plant, Main Ash and Stilling Pond*. Prepared for Tennessee Valley Authority, August 4 (last revision). Date of Survey June 16, 2015, Hixson, Tennessee.

Tuck Mapping Solutions, Inc. (2015). *Cumberland 2015 Mapping.dwg*. *CUF Topographic Data*. Prepared for Tennessee Valley Authority, July 30. LiDAR flight date: April 11, 2015. Photography flight date: March 23, 2015.

United States Army Corps of Engineers (USACE) (2003). Engineering and Design. *Slope Stability. Engineering Manual EM 1110-2-1902, Department of the Army*. October 31.

APPENDIX A
SLOPE STABILITY ANALYSIS

NOT TO SCALE



BORING LOCATION TABLE

BORING	NORTHING	EASTING	ELEV. (FT.)	BORING TYPE
STN-47	732,324.14	1,509,428.51	380.0	Sample
STN-48	732,333.24	1,509,489.49	395.0	Sample
*STN-48A	732,329.25	1,509,489.15	395.0	Sample
STN-49	732,928.84	1,509,696.68	379.2	Sample/PZ
STN-50	732,872.44	1,509,725.55	394.5	Sample
*STN-50A	732,869.56	1,509,722.77	394.5	SI
*STN-50B	732,875.32	1,509,728.33	394.5	PZ
STN-51	733,191.78	1,510,006.75	378.8	Sample
STN-52	733,149.40	1,510,045.62	394.9	Sample
*STN-52A	733,146.52	1,510,042.84	394.9	Sample
STN-53	733,453.67	1,510,310.59	376.0	Sample
*STN-53A	733,456.66	1,510,307.93	376.0	PZ
*STN-53B	733,450.68	1,510,313.25	376.0	PZ
STN-54	733,419.93	1,510,374.67	395.0	Sample/SI
*STN-54A	733,417.30	1,510,371.66	395.0	PZ
STN-55	733,614.54	1,510,849.80	379.5	Sample
STN-56	733,560.12	1,510,902.86	395.0	Sample
*STN-56A	733,560.12	1,510,898.86	395.0	Sample
STN-57	733,365.74	1,511,360.12	381.5	Sample
*STN-57A	733,368.89	1,511,362.59	381.5	PZ
*STN-57B	733,362.59	1,511,357.65	381.5	Sample
STN-58	733,305.89	1,511,314.36	395.0	Sample/SI
*STN-58A	733,308.70	1,511,311.51	394.8	PZ
STN-59	732,780.76	1,511,517.22	383.0	Sample
*STN-59A	732,784.76	1,511,517.22	383.0	Sample
STN-60	732,776.76	1,511,517.22	383.0	Sample
STN-61	732,791.74	1,511,426.11	395.1	Sample
STN-62	732,271.84	1,511,477.99	387.2	Sample
*STN-62A	732,274.04	1,511,365.06	394.8	Sample

*Estimated based on offsets from original borings.
"PZ" denotes Piezometer
"SI" denotes Slope Inclinometer

BORING LAYOUT

SCALE: 1"=100'

50 0 100 200 FEET
GRAPHIC SCALE: 1" = 100'
CONTOUR INTERVAL = 1'

LEGEND

○ Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests

◉ Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests and Rock Core

NOTE:

The topographic mapping provided is based on horizontal datum NAD27 and vertical datum NGV29 using State Plane Tennessee coordinate system. The site photography was performed on 4/17/2009.

RECORD DRAWING

For Supporting Design Calculations see
FPGCUFFESCDX00000020100002

STAN A. HARRIS
No. 00115308
3/25/10

Stantec Consulting
Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241-2012
Tel. 513.842.8200
Fax 513.842.8250
www.stantec.com

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R –	–	–	–	–	–	–	–	–	–	–	–
R 0	03/29/10	DBR	CW	DBR	SAH	SAH	SAH	TJ	–	–	–
RECORD DRAWING											

SCALE: 1"=100' EXCEPT AS NOTED

YARD
RETENTION AND STILLING PONDS

GEOTECHNICAL EXPLORATION
BORING LAYOUT

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
D. ROGERS	C. WITHERS	D. ROGERS	S. HARRIS	S. HARRIS	S. HARRIS	T. JOHNSON

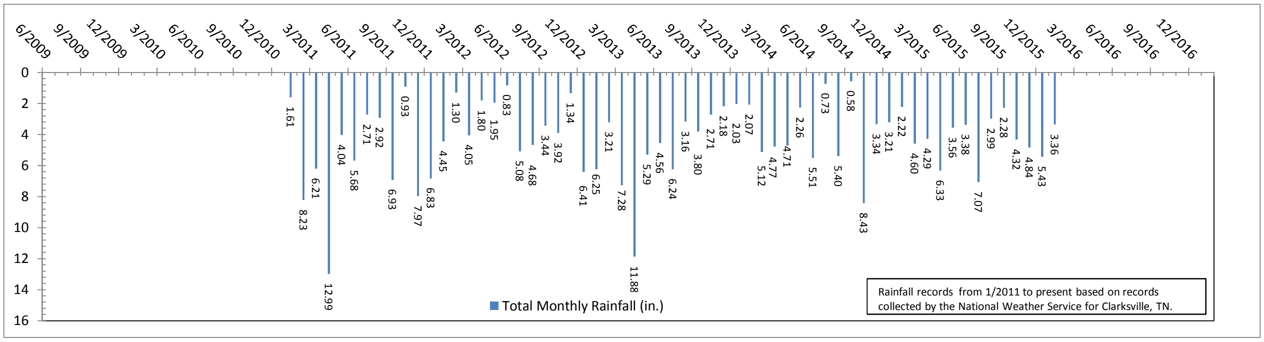
CUMBERLAND FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000	DATE 03/29/10	46	C	10W544-01	R 0

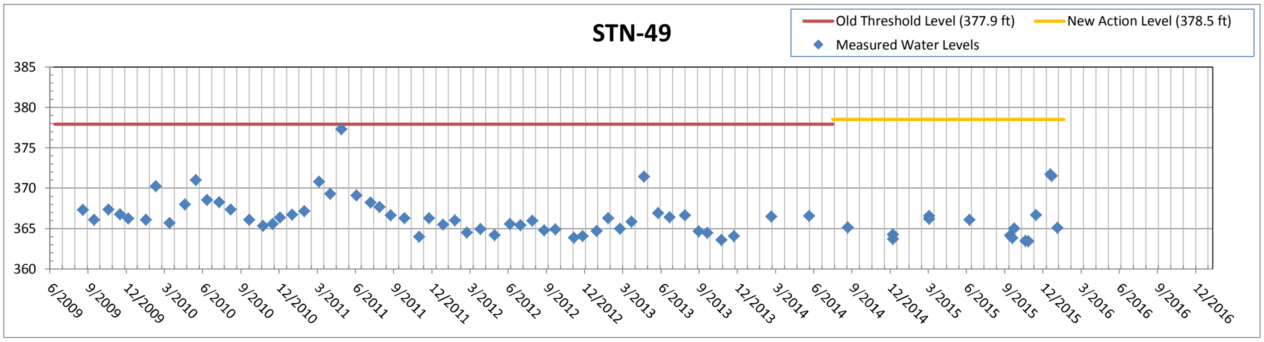
STANTEC	0
TASK COMPLETED BY:	REV NO.

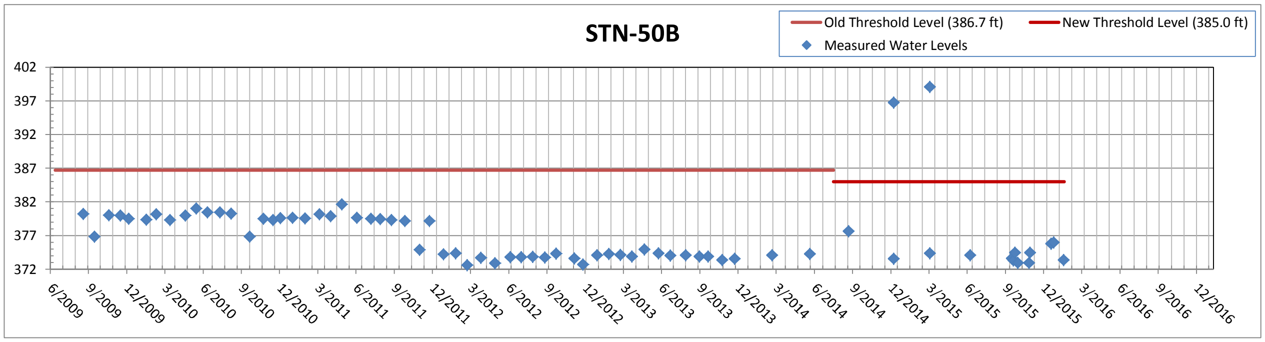
PLOT FACTOR:XX
W_TVA

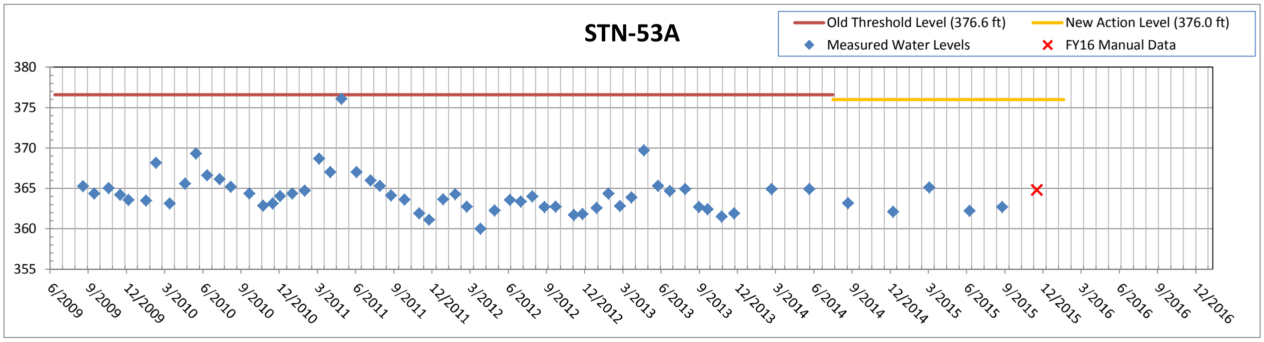
C.A.D. DRAWING
DO NOT ALTER MANUALLY

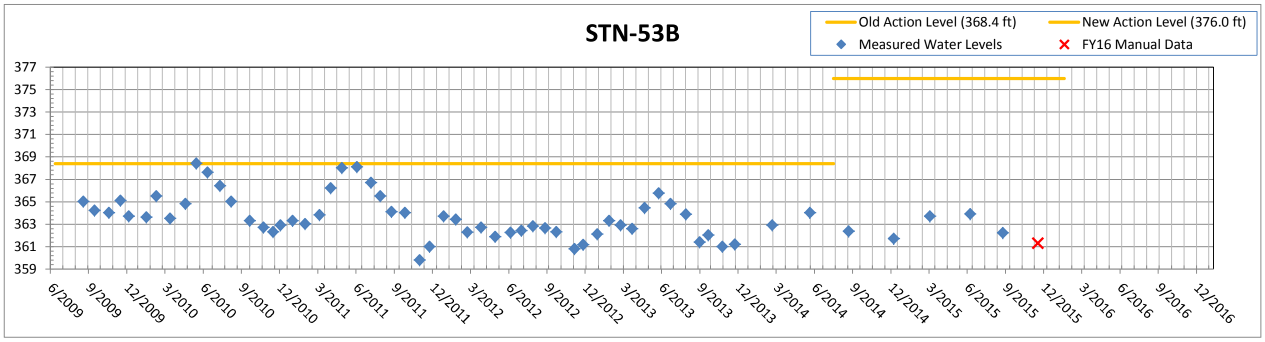


Rainfall records from 1/2011 to present based on records collected by the National Weather Service for Clarksville, TN.









Tennessee Valley Authority
Cumberland Fossil Plant
Stilling Pond (including Retention Pond)
Cumberland City, Tennessee
Section P-P'

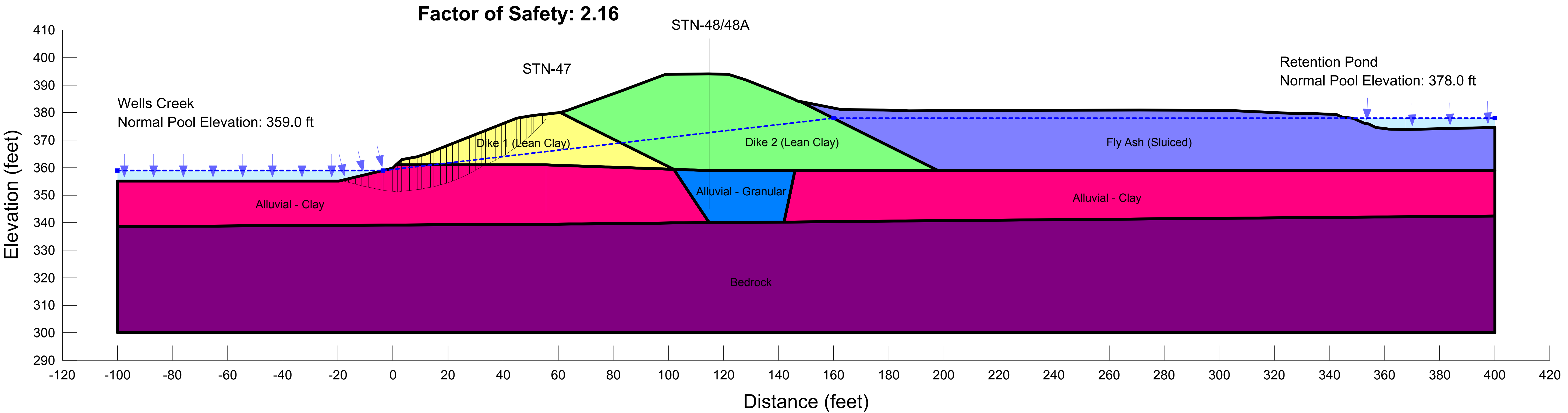
Static Slope Stability Analysis

Material Type	Unit Wt.	Effective Cohesion	Effective Friction Angle
Dike 1 (Lean Clay)	123 pcf	200 psf	22 °
Dike 2 (Lean Clay)	123 pcf	200 psf	32 °
Fly Ash (Sluiced)	100 pcf	0 psf	22 °
Alluvial - Clay	124 pcf	200 psf	33 °
Alluvial - Granular	130 pcf	0 psf	32 °
Bedrock	Impenetrable		

Existing Geometry
Long-Term, Maximum Storage Pool Loading
Effective Stress Analysis;
Drained Strengths

Note:

The results of this analysis are based on available subsurface information, field and laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions between the borings.



Project No. 175555021, 203.10

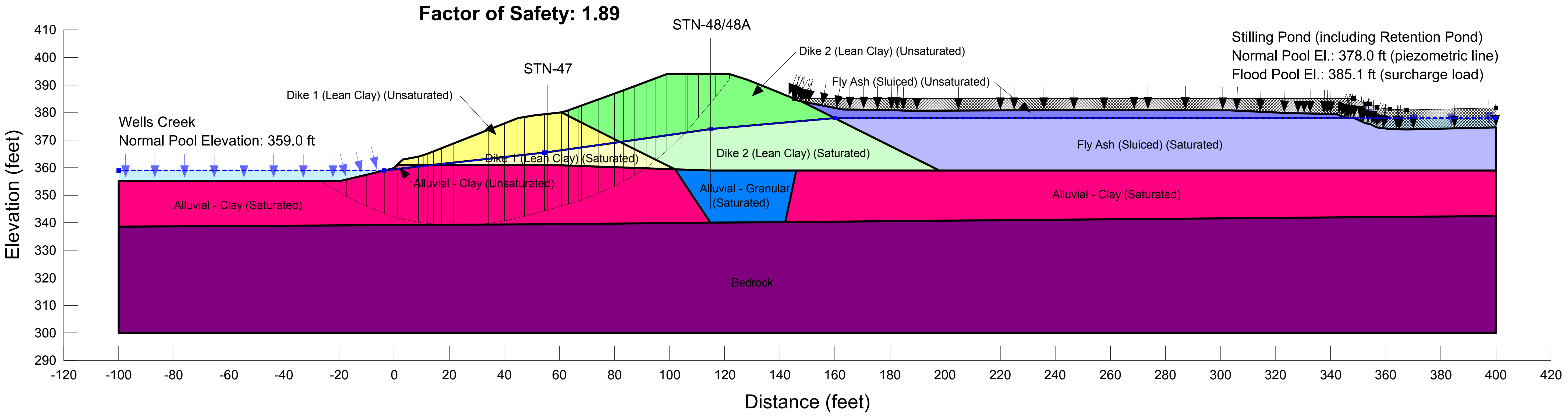
Tennessee Valley Authority
Cumberland Fossil Plant
Stilling Pond (including Retention Pond)
Cumberland City, Tennessee
Section P-P'

Static Slope Stability Analysis

Existing Geometry
Maximum Surcharge Pool Loading
Total Stress Analysis;
Drained Strengths - above phreatic surface
Undrained Strengths - below phreatic surface

Note:
The results of this analysis are based on available subsurface information, field and laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Unit Wt.	Effective Cohesion	Effective Friction Angle	Total Cohesion	Total Friction Angle
Dike 1 (Lean Clay) (Unsaturated)	123 pcf	200 psf	22 °	-	-
Dike 2 (Lean Clay) (Unsaturated)	123 pcf	200 psf	32 °	-	-
Fly Ash (Sluiced) (Unsaturated)	100 pcf	0 psf	22 °	-	-
Alluvial - Clay (Unsaturated)	124 pcf	200	33	-	-
Dike 1 (Lean Clay) (Saturated)	123 pcf	-	-	800 psf	20 °
Dike 2 (Lean Clay) (Saturated)	123 pcf	-	-	500 psf	21 °
Fly Ash (Sluiced) (Saturated)	100 pcf	-	-	140 psf	11 °
Alluvial - Clay (Saturated)	124 pcf	-	-	450 psf	20 °
Alluvial - Granular (Saturated)	130 pcf	-	-	100 psf	20 °
Bedrock	Impenetrable				



Project No. 175555021, 203.10

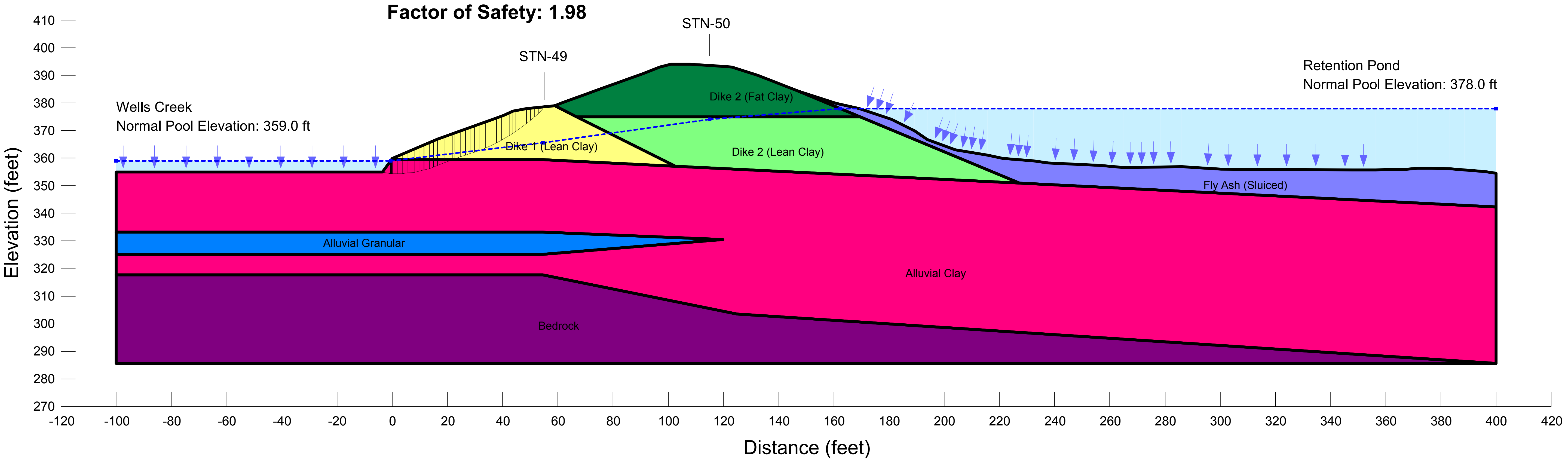
Tennessee Valley Authority
Cumberland Fossil Plant
Stilling Pond (including Retention Pond)
Cumberland City, Tennessee
Section Q-Q'

Static Slope Stability Analysis

Material Type	Unit Wt.	Effective Cohesion	Effective Friction Angle
Dike 1 (Lean Clay)	123 pcf	200 psf	22 °
Dike 2 (Lean Clay)	123 pcf	200 psf	32 °
Dike 2 (Fat Clay)	119 pcf	200 psf	29 °
Fly Ash (Sluiced)	100 pcf	0 psf	22 °
Alluvial Clay	124 pcf	200 psf	33 °
Alluvial Granular	130 pcf	0 psf	32 °
Bedrock	Impenetrable		

Existing Geometry
Long-Term, Maximum Storage Pool Loading
Effective Stress Analysis;
Drained Strengths

Note:
The results of this analysis are based on available subsurface information, field and laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions between the borings.



Project No. 175555021, 203.10

Tennessee Valley Authority
Cumberland Fossil Plant
Stilling Pond (including Retention Pond)
Cumberland City, Tennessee
Section Q-Q'

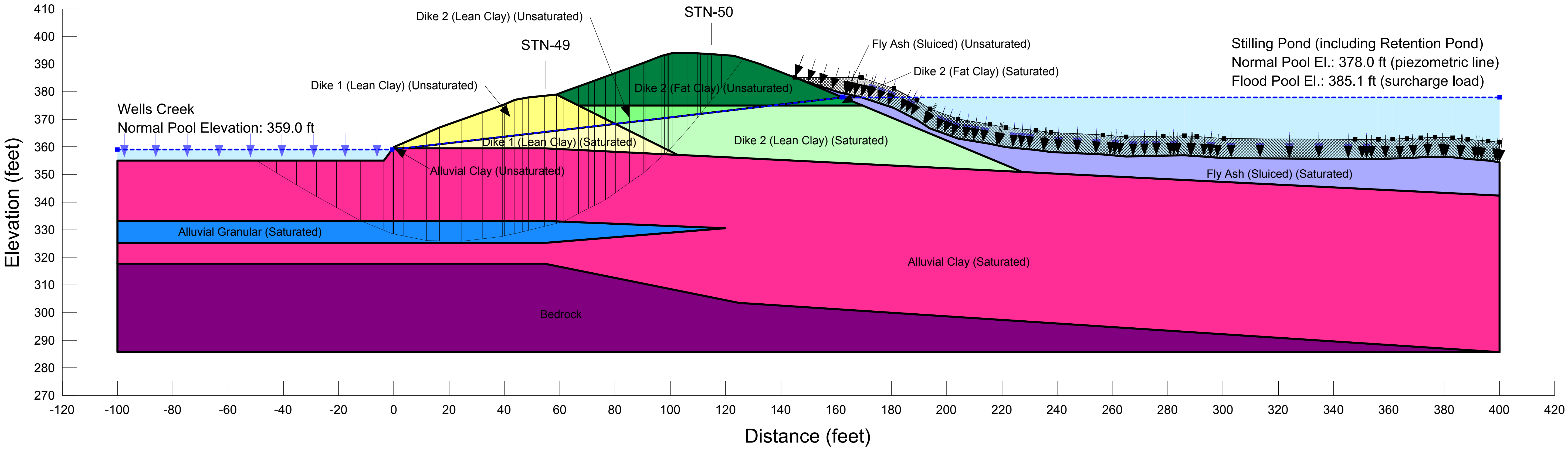
Static Slope Stability Analysis

Existing Geometry
Maximum Surcharge Pool Loading
Total Stress Analysis;
Drained Strengths - above phreatic surface
Undrained Strengths - below phreatic surface

Note:
The results of this analysis are based on available subsurface information, field and laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Unit Wt.	Effective Cohesion	Effective Friction Angle	Total Cohesion	Total Friction Angle
Dike 1 (Lean Clay) (Unsaturated)	123 pcf	200 psf	22 °	-	-
Dike 2 (Lean Clay) (Unsaturated)	123 pcf	200 psf	32 °	-	-
Dike 2 (Fat Clay) (Unsaturated)	119 pcf	200 psf	29 °	-	-
Fly Ash (Sluiced) (Unsaturated)	100 pcf	0 psf	22 °	-	-
Dike 1 (Lean Clay) (Saturated)	123 pcf	-	-	800 psf	20 °
Dike 2 (Lean Clay) (Saturated)	123 pcf	-	-	500 psf	21 °
Dike 2 (Fat Clay) (Saturated)	119 pcf	-	-	200 psf	18 °
Fly Ash (Sluiced) (Saturated)	100 pcf	-	-	140 psf	11 °
Alluvial Clay (Saturated)	124 pcf	-	-	450 psf	20 °
Alluvial Granular (Saturated)	130 pcf	-	-	100 psf	20 °
Bedrock	Impenetrable				

Factor of Safety: 1.74



Project No. 175555021, 203.10