Stantec Consulting Services Inc.
1409 North Forbes Road, Lexington KY 40511-2024

October 12, 2016
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Revision 0

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

RE: Initial Structural Stability Assessment
Active Ash Pond 2
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Johnsonville Fossil Plant
New Johnsonville, Tennessee

1.0 PURPOSE

This letter documents Stantec's certification of the initial structural stability assessment for the TVA Johnsonville Fossil Plant's (JOF) Active Ash Pond 2. Based on this assessment, the Active Ash Pond 2 is in compliance with the structural stability requirements in the EPA Final CCR Rule at 40 CFR 257.73(d).

2.0 INITIAL STRUCTURAL STABILITY ASSESSMENT

As described in 40 CFR 257.73(d), documentation is required on how the Active Ash Pond 2 has been designed, constructed, operated, and maintained according to the structural stability requirements listed in the section. The combined capacity of all spillways must also be designed, constructed, operated, and maintained to adequately manage flow from the 1000-year storm event based upon a hazard potential classification of "significant."

3.0 SUMMARY OF FINDINGS

The attached report presents the initial structural stability assessment of the Active Ash Pond 2. The results show that the impoundment meets the structural stability requirements set forth in 40 CFR 257.73(d)(1)-(2).

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

Re: **Initial Structural Stability Assessment**
Active Ash Pond 2
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Johnsonville Fossil Plant
New Johnsonville, Tennessee

3. that the initial structural stability assessment for the TVA Johnsonville Fossil Plant's Active Ash Pond 2 meets the requirements specified in 40 CFR 257.73(d)(1)-(2).

SIGNATURE [signature] DATE 10/12/2016

ADDRESS: Stantec Consulting Services Inc.
10509 Timberwood Circle, Suite 100
Louisville, Kentucky 40223-5308

TELEPHONE: (502) 212-5075

ATTACHMENTS: Initial Structural Stability Assessment Report

Initial Structural Stability Assessment

Johnsonville Fossil Plant – Active Ash Pond 2
New Johnsonville, Tennessee

Stantec

Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:
Stantec Consulting Services Inc.
Lexington, Kentucky

October 12, 2016
Revision 0

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1.0 PROJECT BACKGROUND

On April 17, 2015 the "Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" (EPA Final CCR Rule) was published in the Federal Register. Stantec Consulting Services, Inc. (Stantec) was contracted by the Tennessee Valley Authority (TVA) to analyze the Structural Stability of the Active Ash Pond 2 associated with the Johnsonville Fossil Plant (JOF) CCR surface impoundments (SI) and evaluate compliance with §257.73 of the CCR Rule.

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 structural stability 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.

2.0 UNIT DESCRIPTION

The Johnsonville Fossil Plant (JOF), formerly known as the Johnsonville Steam Plant, is located on a 748-acre reservation owned by TVA in west-central Tennessee. The plant site is in the community of New Johnsonville, which is in Humphreys County. It is on the east bank of the Kentucky Lake reservoir, which was created on the Tennessee River in the mid-1940s. The plant is located approximately 12 miles west of Waverly, Tennessee, and approximately 65 miles west of Nashville, Tennessee.

Active Ash Pond 2 is situated on the west side of the reservation. The Ash Pond is bounded by Kentucky Lake to the west, and the Condenser Water Intake Channel and Boat Harbor to the east. The Ash Pond was created by building a perimeter dike to enclose an area of approximately 90 acres. TVA has determined that the Active Ash Pond 2 is a CCR Surface Impoundment and therefore subject to the CCR rule.

The subsections under §257.73(d) address conditions of appurtenances categorized as embankments, spillways, or hydraulic structures. Sections 2.1 to 2.3 below provide descriptions of the individual unit elements that fall within these appurtenance categories. Figure 1 provides an overview of the Active Ash Pond 2 and appurtenances.

Note that all elevations included in this document and appendices are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

2.1 EMBANKMENTS

2.1.1 Perimeter Dike

The perimeter dike was built in several stages at various times. The dike encompasses the entire ash pond. The current perimeter dike configuration has a height ranging from 25 to 30 feet, a total length of approximately 2 miles, and slopes on the order of 2.5H:1V to 3H:1V.

2.2 SPILLWAYS

2.2.1 Primary Spillway System

The configuration of the primary spillway system for Ash Disposal Area No. 2 is documented in an Operations and Maintenance Plan prepared by Stantec (Stantec, 2011b) and Record Drawings (Stantec, 2010b). Construction of the primary spillway system for Ash Disposal Area No. 2 was completed in November 2009. The spillway system consists of six (6) pre-cast concrete inlet boxes. Each inlet structure has five (5) six-inch high by seven (7) foot-long removable fiberglass-covered stoplogs for controlling the pool elevation of Ash Disposal Area No. 2. A 4-foot-tall steel skimmer surrounds the spillway inlet structures and is attached to the faces of the inlet boxes. The skimmer prevents cenospheres and other floating debris from passing over the stoplogs and into

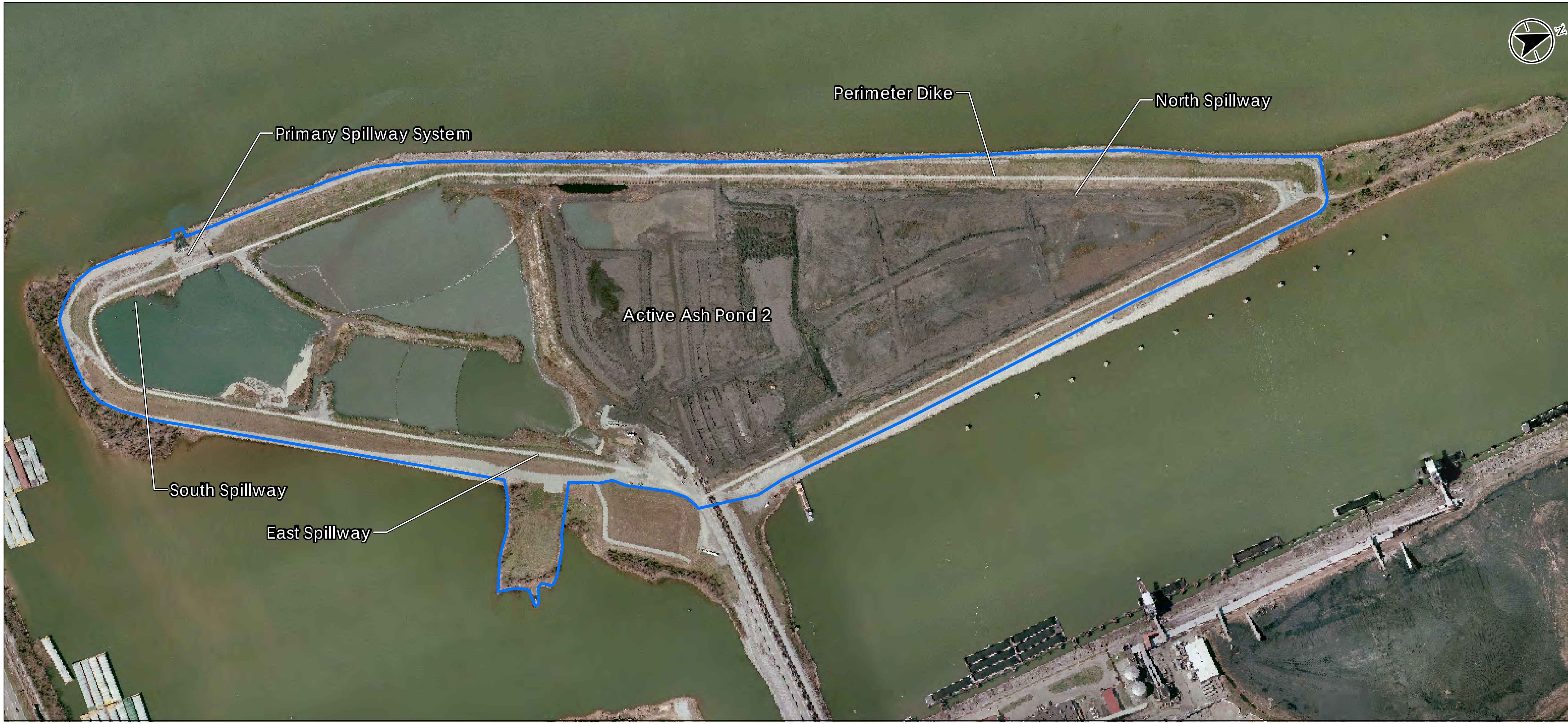
Kentucky Lake. Each inlet structure discharges to a 30-inch-diameter DR-17 high density polyethylene (HDPE) pipe that discharges to Kentucky Lake through a single headwall equipped with a concrete sill for energy dissipation.

2.2.2 North, South, and East Spillways

The three sets of spillways were located on the northwest dike (North Spillways), southwest dike (South Spillways), and southeast dike (East Spillways)(see Figure 2 for approximate locations) . Each spillway riser structure consists of 48-inch inside diameter (ID) stacked concrete pipe sections above a reinforced concrete base structure. Each outlet pipe consists of a 36-inch ID reinforced concrete pipe placed horizontally in a trench beneath the perimeter dike to discharge into Kentucky Lake (South and North Spillways) or into the plant Condenser Water Inlet Channel (East Spillways). As documented in a Construction Certification Report (Stantec, 2011a), TVA permanently ceased operation and closed the North, South, and East Spillways in 2011, as described further in Section 8.1.

2.3 HYDRAULIC STRUCTURES

Other than the spillways described above, there are no hydraulic structures underlying or passing through the Perimeter Dike of Active Ash Pond 2.



Legend

Disposal Area Approximate Limits

0 200 400 Feet

1:4,800 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided By Client (Dated May, 2015)

Stantec

TVA

Project Location
New Johnsonville
Humphreys County, Tennessee

175555008
Prepared by WSW on 2016-08-31
Independent Review by TG on 2016-08-31

Client/Project
Tennessee Valley Authority
Johnsonville Fossil Plant

Figure No.
1

Title
Active Ash Pond 2

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3.0 FOUNDATIONS AND ABUTMENTS (§257.73(d)(1)(i))

Per §257.73(d)(1)(i), the initial structural stability assessment must document whether the unit has been designed, constructed, operated and maintained with stable foundations and abutments. The Active Ash Pond 2 has the following features that fall within this requirement:

- Perimeter Dike

Assessment of the foundations and abutments associated with this feature was performed considering the following criteria related to the CCR rule:

- Review inspection reports of the facility, considering frequency of inspections, and if the inspections included review and/or assessment of features including cracking, settlement, deformation or erosion of the foundations/abutments. Inspections should indicate that there are no significant signs of tension cracking, settlement, depressions, erosion, and/or deformations at the crest, slope and toe of the structure.

- Confirm that an assessment of seepage conditions of the foundation, with considerations for heave and vertical exit gradient, has been performed. Verify that the seepage assessment follows appropriate methodologies (such as USACE EM 1110-2-1901) and that the foundations exhibit acceptable performance (e.g. FS for piping greater than or equal to 3.0).

3.1 PERIMETER DIKE

3.1.1 Background

The Active Ash Pond 2 is formed by a ring dike system; therefore, there are no natural abutments. Based on previous geotechnical work ((TVA, 1969), (TVA, 1977), (Stantec, 2010a), (Stantec, 2012)), the foundation of the perimeter dike generally consists of Pleistocene age alluvial lean clay to sand with silt and gravel deposits that vary in thickness from 60 to 100 feet. Fill was also observed in eastern portions of the area, reportedly sluiced from dredging operations during construction of the plant. The fill is described as lean and sandy lean clay, to lean clay with gravel, silt and sand. The alluvium is described as lean clay with sand, to silty sand and sand with silt and gravel. The alluvial deposits are underlain by bedrock described as limestone and generally encountered approximately 100 feet below the top of the alluvium (Stantec, 2012).

3.1.2 Assessment

Annual site inspections for the Active Ash Pond 2 area, including the Perimeter Dike, were conducted and documented regularly from 1969 to 2015 (TVA, 1969 - 2015) and (Stantec, 2010 and 2011). A formal 5-year site inspection was conducted in 2013 (Stantec, 2014). As reported by the EPA (Dewberry, 2013), daily, weekly, monthly, and quarterly inspections of the Active Ash Pond 2 area are conducted by TVA personnel. Seepage areas are reported on an annual basis as part of TVA's Seepage Action Plan (SAP), and are conducted separate from the annual site inspections. A seepage collection system, consisting of a gravel trench drain and perforated pipe network, was installed along the Southeast dike in 2009 to address the previously observed seepage in the area.

No indications of global foundation issues (i.e. cracking, settlement, depressions, and/or deformation) have been noted on historic inspection reports. Recent inspections of the Perimeter Dike (Stantec, 2010 and 2011), (Stantec, 2014), and (Dewberry, 2013)) note no significant signs of tension cracking, settlement, deformations or similar instabilities.

Seepage analyses of the Perimeter Dike were available for review. These analyses were performed by Stantec (Stantec, 2010a). A portion of the seepage analysis performed by Stantec evaluated factors of safety with respect to heave and exit gradient within the foundation materials. The analysis followed methodology presented in USACE (USACE, 2003). Results from the analysis indicated that the dike had factors of safety for piping/heave as low as 2.5, to greater than 3.0. As reported by Stantec, the planned closure of the Ash Pond No.2 included improvements to the Perimeter Dike that were designed and constructed in phases to achieve a minimum factor of safety of 3.0 for piping/heave. The closure phases included the Northeast and Southeast Dike Improvement Projects that were completed in 2010 and 2011.

3.1.3 Conclusion

Based on the assessment of the foundation and abutments for the Perimeter Dike, the CCR Rule-related criteria listed above have been met.

4.0 SLOPE PROTECTION (§257.73(d)(1)(ii))

Per §257.73(d)(1)(ii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated and maintained with adequate slope protection to protect against surface erosion, wave action, and adverse effects of sudden drawdown. The Active Ash Pond 2 has the following features that fall within this requirement:

- Perimeter Dike

Assessment of the slope protection associated with this feature was performed considering the following criteria related to the CCR rule:

1. Regular (weekly) inspections for erosion. Inspections should show there are no significant signs of deterioration in the slope protection configuration of the Item.

2. Appropriate slope protection shall be provided based on anticipated flow velocities. [Hydrologic / hydraulic calculations of flow velocities on the slope of the Item for the appropriate erosive forces. Some common slope protection measures include: Rip rap, Gabions, Paving (concrete or asphalt), or appropriate vegetative cover.]

3. If slope protection is rip rap, filter layer(s) under the rip rap shall be designed according to established filter criteria. However, existing Rip rap cover may be evaluated based on performance and observations during inspections.

4.1 PERIMETER DIKE

4.1.1 Background

Slope protection for the Perimeter Dike consists of a combination of grass vegetation cover or rip rap. The exterior slope has rip rap wave protection along the lower portion with grass cover above extending to the crest. The interior slope has rip rap wave protection along the majority of the dike within the open water portion of the ash pond. The immediate area around the Primary Spillway System includes rip rap slope protection on both the interior and exterior slope. Original design calculations for the rip rap slope protection used for the Perimeter Dike are not available.

4.1.2 Assessment

Annual site inspection reports from 1969 to 2015 generally indicate appropriate maintenance of slope protection features of the dike, in accordance with the procedures outlined in TVA's Operations Support Document (TVA, July, 2011). See Section 6.0 for details about vegetated slopes.

The use of rip rap as erosion and wave wash protection along the dike slopes appears appropriate to address concerns of erosive wave action and anticipated flows. Significant repairs associated with slope protection issues at Active Ash Pond 2 have been documented and include a series of rip rap protection areas constructed along the western Perimeter Dike adjacent to the Kentucky Lake. These repairs occurred from 1994 through 1997, in 2004, and again in 2005 (each year represented an additional section of dike undergoing repair). The repairs were constructed to address erosion caused by wave and currents from Kentucky Lake water level fluctuations. Details of the repairs are provided below.

According to TVA Construction Drawing 10W527-1, rip rap used for the exterior slope protection consisted of at least 50 % by weight, durable stones weighing a minimum of 230 pounds each. The minimum thickness of the rip rap was specified to be 3 feet. The drawings also indicate that rip rap areas are to be underlain by a 12-inch thick filter blanket, consisting of crushed stone or gravel. The filter blanket is underlain by Class C non-woven filter fabric. The drawing indicates that shorter portions of the exterior western slope used a rip rap protection consisting of a 24-inch thick layer of rip rap (stones between 80 to 120 pounds), and underlain by crushed stone and Class B non-woven filter fabric. This rip rap protection layer extends from the northwest corner of the dike to the south approximately 1,600 linear feet.

As observed in the February 2016 site visit by Stantec personnel, the rip rap slope protection that was observed above the water surface was continuous and performing well. The crest of the dike was observed to be covered with crushed stone.

4.1.3 Conclusion

Based on the assessment of the slope protection for the Active Ash Pond 2, the CCR Rule-related criteria listed above have been met.

5.0 EMBANKMENT DIKE COMPACTION (§257.73(d)(1)(iii))

Per §257.73(d)(1)(iii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated and maintained with dikes mechanically compacted to a density sufficient to withstand the range of loading conditions in the CCR unit. The Active Ash Pond 2 has the following features that fall within this requirement:

- Perimeter Dike

Assessment of the dike compaction associated with these features was completed considering the following criteria related to the CCR rule:

1. Documentation showing the dike was mechanically compacted. Acceptable documentation may include construction drawings, field notes, construction photographs, correspondences, or any evidence showing the dike was mechanically compacted during construction.

2. If no construction documentation is available specific data from geotechnical explorations of dike may be used. Geotechnical borings with continuous SPTs may be used to assess compaction of the dike. Appropriate methodology correlating blow counts and compaction (Density) should be used.

5.1 PERIMETER DIKE

5.1.1 Background

Construction records related to dike material placement and compaction for the initial perimeter dike were not available during this review. Certain TVA design drawings provide proposed dike construction and compaction methods and were referenced in the assessment discussed below. A subsurface exploration of the dike was also available that provided SPT data used in the assessment.

5.1.2 Assessment

TVA Drawings 10W272 R5, 10N527 R5, and 10W527 R15 provide documentation of specific compaction requirements related to the construction of the Perimeter Dike. Construction criteria related to dike embankment materials and dike compaction as noted on these drawings include:

- Prior to placement of new dike foundation materials surfaces were to be scarified, and new fill rolled to blend with existing fill material.

- Dike embankments were to be compacted using sheepsfoot rollers. Construction monitoring was to include use of standard penetrometer to achieve approximately 95 percent of Standard maximum dry density. Field moisture was specified to be controlled to achieve optimum compaction for materials used in the raised dikes.

Stantec completed a geotechnical exploration and slope stability evaluation of the Active Ash Disposal Area for TVA in April, 2010. The geotechnical exploration program included drilling and sampling locations around the Perimeter Dike of the Active Ash Pond 2. Continuous Standard Penetration (SP) Testing was performed at each boring location. The SPT data from this study was used to estimate relative density of dike embankment materials, referencing NAVFAC DM-7.1.

The SP data reviewed shows an average N-value for the upper dike embankment (above approximate Elevation 378, representing the raised portion of the dike) of 16 blows per foot (bpf). An average N-value for the lower dike embankment (below Elevation 378) was indicated to be 9 bpf. The Stantec geotechnical exploration also evaluated the dike embankment materials using moisture-density testing. This evaluation showed that the in-situ dry densities of the dike materials vary from 95 to 100 percent of standard Proctor. Correlating the SP and moisture-density test results using NAVFAC DM-7.1 indicate that appropriate compaction exists within the embankment of the Perimeter Dike.

5.1.3 Conclusion

Based on the assessment of the embankment dike compaction for the Perimeter Dike, the CCR Rule-related criteria listed above have been met.

6.0 VEGETATED SLOPES (§257.73(d)(1)(iv))

Per §257.73(d)(1)(iv), the initial structural stability assessment must document whether the unit has been designed, constructed, operated and maintained with vegetated slopes of dikes and surrounding areas except for slopes which have an alternate form or forms of slope protection.

The Active Ash Pond 2 has the following features that fall within this requirement:

- Perimeter Dike

Assessment of the vegetated slopes associated with these features was completed considering the criteria related to the CCR rule:

1. Regular inspection records showing vegetative cover sufficient to prevent surface erosion while allowing an unobstructed view to visually inspect the slope.

6.1 BACKGROUND

The Perimeter Dike is vegetated above the rip rap armoring on the interior and exterior slopes.

6.2 ASSESSMENT

Annual site inspections were conducted and documented regularly following construction of the perimeter dike. Annual inspection reports for over 40 years are available and document the vegetative cover over the dike structures. The vegetative cover of the dike exterior slopes is typically mowed twice annually as reported by TVA maintenance personnel. TVA Engineering also performs annual inspections and prepares reports addressing site conditions and directives for needed repairs and maintenance activities.

In February 2016, Stantec personnel visited the site to observe existing conditions. The vegetation along the slopes of the dikes of Active Ash Pond 2 was 6 inches or less in height, and there was good coverage.

6.3 CONCLUSION

Based on the assessment of the vegetated slopes for the Active Ash Pond 2, the CCR Rule-related criteria listed above have been met.

7.0 SPILLWAY CONDITION AND CAPACITY (§257.73(d)(1)(v))

Per §257.73(d)(1)(v), the initial structural stability assessment must document whether the unit has been designed, constructed, operated and maintained with a single spillway or combination of spillways that meet the condition and capacity requirements as outlined in this section of the CCR Rule. The combined capacity of all spillways are to be designed, constructed, operated, and maintained to adequately manage flow during and following the peak discharge from the event specified in this section. Ash Disposal Area No. 2 has the following features that fall within this requirement:

- Primary Spillway System
- North, South, and East Spillways

Assessment of the spillway condition and capacity associated with these features was completed considering the following criteria related to the CCR Rule:

1. Outlet channel must be of non-erodible material designed to carry sustained flow velocities based on the required flood events. [Estimate flow velocities and select appropriate material using hydraulic analysis for the following flood events: PMF (high hazard potential unit), 1000-year flood (Significant hazard unit), 100-year flood (low hazard potential unit).]

2. Must adequately manage flow during and following the peak discharge. [Estimate size of outlet structure based of hydraulic analysis for the following flood events: PMF (High hazard potential unit), 1000-year flood (Significant hazard potential unit), and 100-year flood (low hazard potential unit).]

3. Must be structurally stable. [Assess stability of structure using stability and stress analyses according to an appropriate methodology. Some acceptable methodologies may include: EM 1110-2-2400, EM 1110-2-2100, ACI 350, etc.]

4. Must maintain structural integrity. [Structural integrity may be warranted by periodic inspections of existing conduits. Inspections must show no significant presence of deformation, distortions, cracks, joint separation, etc.]

5. Must be free from significant amounts of obstruction and anomaly which may affect the operation of the hydraulic structure [Perform periodic pipe inspections to detect deterioration, deformation, distortion, bedding deficiencies, and sediment, and debris accumulations.]

7.1 PRIMARY SPILLWAY SYSTEM

7.1.1 Background

The Active Ash Pond 2 is classified as a significant hazard structure requiring the combined capacity of all spillways be adequate to manage the flow during and following the peak discharge from a 1000-year flood.

The Primary Spillway System is located in the southwest corner of Ash Pond 2 (See Figure 2 for approximate location). The spillway was constructed in 2009 to convey flows from the Ash Pond 2 to Kentucky Lake. Refer to Section 2.2 for a detailed description of the Primary Spillway System.

7.1.2 Assessment

7.1.2.1 Spillway Capacity

The Initial *Inflow Design Flood Control System Plan* for Ash Disposal Area No. 2 (Stantec 2016a) documents the assessment of the Primary Spillway System related to the capacity requirements outlined in §257.73(d)(1)(v) of the CCR Rule. The assessment demonstrates that the Primary Spillway meets capacity requirements.

7.1.2.2 Structural Stability

Johnsonville Fossil Plant (JOF) Ash Disposal Area 2 Drawdown and Permanent Spillway Installation report (Stantec 2009) documents (Appendix B.3) acceptable levels of structural stability for overturning, eccentricity, and sliding.

7.1.3 Conclusion

Based on the assessment of the spillway condition and capacity for the Primary Spillway System at Active Ash Pond 2, the CCR Rule-related criteria listed above have been met.

7.2 NORTH, SOUTH, AND EAST SPILLWAYS

7.2.1 Background

The three sets of spillways were located on the northwest dike (North Spillways), southwest dike (South Spillways), and southeast dike (East Spillways) (See Figure 2 for approximate locations and Section 2.3 for a detailed description).

As discussed in Stantec (2011a), the North Spillway risers were reportedly inspected and videotaped on September 13, 2003 and then filled with grout. Grout is visible in the exposed tops of the risers; however, there is no available documentation on the method of execution of this work. The North Spillway barrels were later grouted in 2011 as part of the Existing Spillway Closure Project described in Section 7.2.2.

7.2.2 Assessment

As documented in a Construction Certification Report (Stantec, 2011a), TVA permanently closed the North, South, and East Spillways in 2011 during the Existing Spillway Closure Project. Detailed descriptions of the abandonment work for each spillway are provided in Stantec (2011a). In their current condition, the North, South, and East Spillways can no longer convey flow from Active Ash Pond 2 to Kentucky Lake.

7.2.3 Conclusion

Based on the assessment of the spillway condition and capacity for the North, South, and East Spillways at Active Ash Pond 2, the CCR Rule-related criteria listed above have been met.

8.0 SUDDEN DRAWDOWN ASSESSMENT (§257.73(d)(1)(vii))

Per §257.73(d)(1)(vii), the initial structural stability assessment must document whether the unit has been designed, constructed, operated, and maintained with downstream slopes that can be inundated by an adjacent water body (such as a river, stream, or lake) to determine if structural stability is maintained during low pool or sudden drawdown of the adjacent water body. Active Ash Pond 2 has the following feature that falls within this requirement:

- Perimeter Dike

Assessment of the sudden drawdown associated with these features was completed considering the following criteria related to the CCR rule:

1. Maintain slope stability during sudden drawdown of adjacent water body.

Guidance provided by the USEPA (2015) described the basis of the CCR Rule's factor of safety criteria and methodology as EM 1110-2-1902 (USACE, 2003) or other appropriate methodologies. Table 3-1 of EM 1110-2-1902 (USACE, 2003) recommends a required minimum factor of safety of 1.1 for maximum surcharge pool under rapid drawdown conditions.

8.1 PERIMETER DIKE

8.1.1 Background

Active Ash Pond 2 has a potential sudden drawdown loading from Kentucky Lake along the toe of its perimeter dike. A sudden drawdown slope stability analysis of the downstream slope is required under the CCR Rule §257.73(d)(1)(vii). The sudden drawdown slope stability analysis was performed in conjunction with the static safety factor assessment discussed in Stantec (2016b).

8.1.2 Assessment

8.1.2.1 Material Properties

An overview of the subsurface conditions of the perimeter dike of Active Ash Pond 2 is summarized in Table 1. A more in-depth review is found in Stantec (2010a).

Table 1 Generalized Subsurface Conditions – Active Ash Pond 2 Perimeter Dike

Approximate Elevation (feet)	Materials	General Consistency/Density
El. 378 to El. 390	Upper Clay Dike – lean clay, lean clay with sand, and lean clay with gravel	Medium stiff to very stiff
Below Upper Clay Dike (depth of 15 feet)	Ash - silty sand with gravel and silt	n/a
El. 370 to El. 378	Lower Clay Dike – lean clay, lean clay with sand, lean clay with gravel, and silt	Medium stiff to very stiff
El. 334 to El. 370	Fill - lean clay, sandy lean clay, lean clay with gravel, silt, and silt with sand	Soft to medium stiff
El. 320 to El. 334	Alluvial Clay and Silt – lean clay, lean clay with sand, lean clay with gravel, sandy lean clay, silt, and silt with gravel	Very soft to medium stiff
Below El. 320	Alluvial Sand and Gravel – silty sand, silty sand with gravel, poorly graded sand with or without silt and gravel, well graded sand with or without silt and gravel, and poorly graded gravel with or without silt and sand	Medium dense to dense

During the 2009 geotechnical explorations (Stantec, 2010a), Stantec performed a laboratory testing program consisting of natural moisture content determinations, sieve and hydrometer analyses, Atterberg limits, specific gravity determinations, and consolidated-undrained triaxial compression tests. The results of this laboratory testing program were used to derive soil parameters used for seepage and slope stability analyses in conjunction with instrumentation data installed during the geotechnical exploration. The soil parameters derived for the seepage analysis are presented in Table 2, and the strength parameters derived for slope stability evaluation are presented in Table 3. The results of the laboratory testing and derivation of the soil parameters can be found in Stantec (2010a). Total strength parameters were developed in Stantec (2011d).

Table 2 Soil Parameters for Seepage Analysis

Soil Horizon	k_v (cm/s) range	k_h / k_v range	G_s	Void Ratio, e	Volumetric Water Content	
					Saturated (%)	Residual (%)
Upper Clay Dike	1.0 x 10^{-6} to 3.0 x 10^{-6}	1 to 10	2.66	0.51	34	2
Lower Clay Dike	1.0 x 10^{-6} to 2.0 x 10^{-3}	1 to 10	2.66	0.51	34	2
Fill	1.0 x 10^{-5} to 1.0 x 10^{-4}	3 to 5	2.73	0.42	30	2
Ash	1.0 x 10^{-6} to 1.0 x 10^{-5}	20	2.64	0.65	39	2
Alluvial Clay and Silt	1.0 x 10^{-2}	20	2.68	0.34	25	1
Alluvial Sand and Gravel	1.0 x 10^{-4} to 2.0 x 10^{-4}	5 to 10	2.43	0.68	41	3
Rip rap	1.0	1	2.60	1.66	62	0

Table 3 Soil Parameters for Stability Analysis

Soil Horizon	Unit Weight (pcf)	Effective Stress Strength Parameters		Total Stress Strength Parameters	
		c' (psf)	ϕ' (degrees)	c (psf)	ϕ (degrees)
Upper Clay Dike	125	200	29	521	16.2
Lower Clay Dike	125	100	29	211	19
Fill	124	50	29	470	16.7
Ash	100	0	22	0	10
Alluvial Clay and Silt	124	100	30	522	16.7
Alluvial Sand and Gravel	120	0	30	0	30
Rip rap	100	0	38	0	38

8.1.2.2 Critical Cross Section Selection

Slope stability analyses were available from the Stantec (2010a). Fourteen cross sections from Active Ash Pond 2 were developed based on geotechnical boring locations as shown in Figure 2. Nine representative cross sections were selected for analyses (A-A', B-B', C-C', C1-C1', D-D', E-E', F-F', I-I', K-K', and M-M'). These representative sections were analyzed under static, long-term, steady-state conditions. Historical rapid drawdown analyses have not been performed on Active Ash Pond 2.

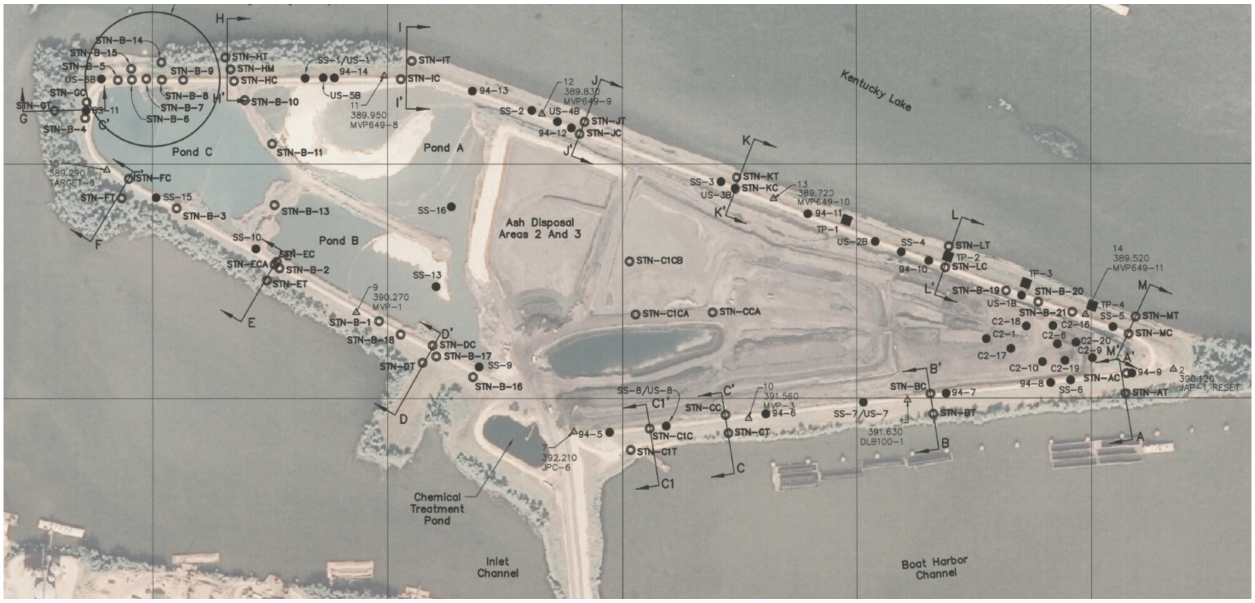

Figure 2 JOF Active Ash Pond 2 – Plan View of Cross Sections (Stantec, 2010a)

The initial slope stability analysis in Stantec (2010a) used geometry and pool levels that were current at the time of the exploration. The exploration took place between February and April in 2009. The results of this initial analysis are presented in Table 4. The report also includes an overview and stability analyses for each of the four stages of the closure plan for Active Ash Pond 2. The four stages of the closure plan include the following improvements as outlined in Stantec (2010a):

- Closure Plan Stage 1 was the construction of new spillways and lowering pool levels. The spillways were completed in November 2009. The improvements decreased the pool level 2.4 feet to an elevation of 384.6 feet.
- Closure Plan Stage 2 included relocating the sluice channel to flow in an east to west direction across Active Ash Pond 2. This work was completed in 2010. The abandoned sluice channel that ran inside the northeast dike was excavated to Elevation 378 and maintained in a dewatered condition by pumping.
- Closure Plan Stage 3 involved the improvement of the slope stability of the northeast dike by installing an internal seepage filter and flattening the exterior slope. A rock buttress was also constructed along the toe of the lower bench. This work was completed in 2010

- Closure Plan Stage 4 was a slope stability improvement project on the southeast dike. The improvements are similar to Closure Plan Stage 3. This work was completed in 2011.

Slope stability analyses were completed for each of the closure plan stages. Cross-section geometry was changed as necessary using design drawings for the closure plan stages. Long-term, steady-state seepage conditions were used using the soil parameters outlined in Section 8.1.2.1. The results of the analyses are summarized in Table 4 assuming a deep-seated failure through the dike.

Table 4 Historical Slope Stability Analysis Results

Section	Dike Section	Factor of Safety				
		Existing	Closure Plan Stage			
			1	2	3	4
A-A'	Northeast	1.5	1.5	1.5	1.8	1.8
B-B'	Northeast	1.4	1.4	1.6	1.8	1.8
C-C'	Northeast	1.2	1.4	1.4	1.6	1.6
C1-C1'	Northeast	1.3	1.3	1.5	1.7	1.7
E-E'	Southeast	1.4	1.5	1.5	1.5	1.8
F-F'	Southeast	1.4	1.4	1.4	1.4	1.8
I-I'	Southwest	1.7	1.8	1.8	1.8	1.8
K-K'	Northwest	1.5	1.5	1.5	1.5	1.5
M-M'	Northwest	1.5	1.5	1.5	1.5	1.5

The results of the 2010 analyses indicate that the slope stability of the southeast and northeast dikes significantly improved from construction activities associated with Closure Plan Stages 3 and 4. The west dike did not see significant improvements from construction activities associated with any of the closure plan stages.

To determine if these analyses of the closure plan stages are representative of field conditions, a review of recent construction activities and topographic information was performed. The following observations were made from the review:

- The construction activities of Closure Plans 1 and 2 only influence pool levels and not the geometry in any of the sections.

- Closure Plan Stage 3 was completed as Work Plan 6 (Stantec, 2010a). The construction activities of Work Plan 6 changed the geometry of sections A-A', B-B', C-C', and C1'-C1'. Minor differences in geometry between design and record drawings are anticipated. Threshold analyses done in Stantec and URS (2014) were performed using the record geometric conditions from Work Plan 6. The geometry found in the 2014 threshold analyses are considered to be representative of field conditions for sections A-A', B-B', C-C', and C1'-C1'.

- Closure Plan Stage 4 was completed as Work Plan 7 (Stantec, 2011c). The construction activities of Work Plan 7 changed the geometry of sections D-D', E-E', F-F', and G-G' and is reflected in Stantec (2010a).

- The geometry of the section on the western dike (H-H' through M-M') did not change as part of the four closure plan stages. However, topographic information (Tuck Mapping Solutions, 2015) indicates that the slopes of the toe of these sections are flatter and extend further into Kentucky Lake than the original sections in Stantec (2010a). The change in geometry is likely due to accumulated sediment at the toe of these sections.

From Stantec (2010a) and Stantec and URS (2014), the baseline condition produced the lowest factors of safety in sections C1-C1', J-J', K-K', and M-M'. However, Stantec and URS (2014) used straight-line approximations of the piezometric line instead of using seepage analyses. Stantec (2010a) compared the field piezometer measurements and calibrated seepage models to determine a reasonable prediction of the phreatic surface as opposed to a straight-line piezometric assumption. The seepage models were therefore incorporated into this analysis.

Preliminary slope stability analyses were performed on existing conditions for sections C1'-C1', J-J', K-K', and M-M'. The current geometry was used for the four sections, including the sediment accumulation shown in topographic information (Tuck Mapping Solutions, 2015) at the toes of sections J-J', K-K', and M-M'. A seepage analysis was performed to determine the pore water pressures for the steady state, long-term normal pool elevations for Active Ash Pond 2 and Kentucky Lake discussed in Section 8.1.2.3. These analyses indicate that section K-K' is the critical cross section.

8.1.2.3 Water Levels

The sudden drawdown slope stability analyses require assessment of changes in headwater and tailwater levels. In Stantec (2016a), the water elevations for Active Ash Pond 2 were redefined to meet the requirements of the EPA CCR Rule inflow design flood cases. The maximum surcharge pool elevation was selected as the high water level within the ash pond. The 1000-year flood elevation was used for the flood pool elevation of Active Ash Pond 2 (Stantec, 2016a). Normal pool or the maximum storage pool elevation was selected as the low water level for the facility. Headwater elevations are listed in Table 5.

The tailwater for Active Ash Pond 2 corresponds to the Kentucky Lake pool elevation. The 100-year flood level for Kentucky Lake was used for the tailwater flood pool elevation (Stantec, 2016a). Low pool for Kentucky Lake was based on the summer pool elevation (Stantec and URS, 2014). Previous analyses determined that summer pool conditions were more critical than winter pool. This was verified in the preliminary slope stability analysis. Tailwater elevations are listed in Table 5.

Table 5 JOF Water Elevations for Stability Modeling

CCR Rule Criteria	Headwater Active Ash Pond 2 Elevation (feet, NGVD29)	Tailwater Kentucky Lake Elevation (feet, NGVD29)
Maximum surcharge pool loading condition	385.9	375.1
Long-term maximum storage pool loading condition	384.3	359.0

8.1.2.4 Analysis Methodology

Stantec performed the sudden drawdown 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 recommendations and criteria outlined in the USACE Design Manuals EM 1110-2-1902 "Slope Stability" (USACE, 2003) and in the Stantec Engineer's Certification of Safety Factor Assessment Report (Stantec, 2015c).

Seepage models using SEEP/W were created to determine the distribution of pore water pressures. The pore water pressures that resulted from the seepage analyses were used for the sudden drawdown analyses. The determination to use seepage modeling instead of manually inputting pore water pressures was made due to historical seepage model results. The selection of the soil parameters used for the seepage models is discussed in Section 8.1.2.1.

8.1.2.5 Acceptance Criteria

A minimum factor of safety is not explicitly specified within the EPA Final CCR Rule §257.73(d)(1)(vii). In the CCR Rule discussion, USACE (2003) is considered the basis for the slope stability analyses. Table 3-1, Minimum Required Factors of Safety: New Earth and Rock-Fill Dams, requires a factor of safety of 1.1 for a rapid drawdown condition from maximum surcharge pool (USACE, 2003).

8.1.2.6 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 Active Ash Pond 2. 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 ten feet vertically below the ground surface. Table 6 summarizes the sudden drawdown safety factor evaluation results at Active Ash Pond 2.

Table 6 JOF Factor of Safety Assessment Results

Plant	Facility	Critical Cross Section	EPA Criteria	Recommended Factor of Safety Criteria	Calculated Factor of Safety
JOF	Active Ash Pond 2	K-K'	Sudden Drawdown	1.1	1.5

8.1.3 Conclusion

Based on the assessment of the sudden drawdown for Active Ash Pond 2, the CCR Rule-related criteria listed above have been met.

9.0 REFERENCES

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APPENDIX A
SUDDEN DRAWDOWN ASSESSMENT

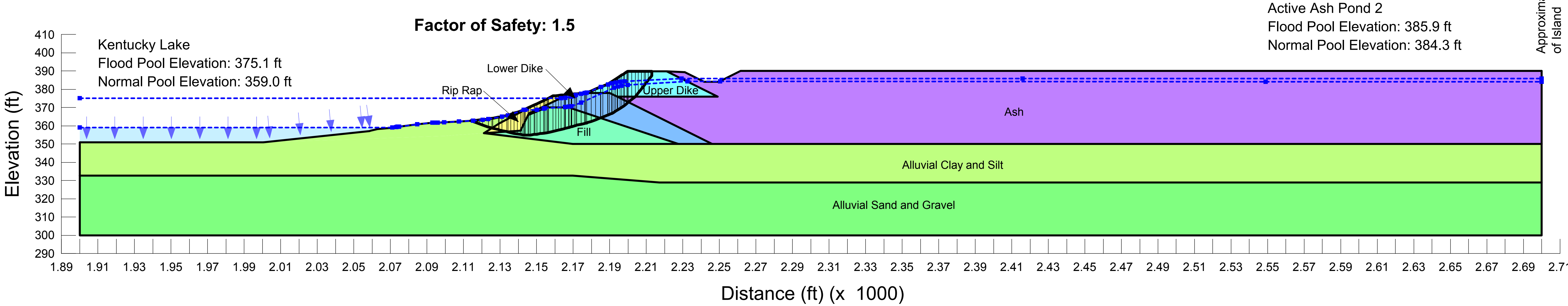
Tennessee Valley Authority
Johnsonville Fossil Plant - Active Ash Pond 2
New Johnsonville, Tennessee
Section K-K'

Sudden Drawdown Analysis

Existing Geometry
Sudden Drawdown
Undrained, SDD Strengths

Material Type	Unit Wt.	Effective - c'	Effective - phi'	Total - c	Total - phi
Upper Dike	125 pcf	200 psf	29 °	521 psf	16.2 °
Lower Dike	125 pcf	100 psf	29 °	211 psf	19 °
Ash	100 pcf	0 psf	22 °	0 psf	10 °
Fill	124 pcf	50 psf	29 °	470 psf	16.7 °
Alluvial Clay and Silt	124 pcf	100 psf	30 °	522 psf	16.7 °
Alluvial Sand and Gravel	120 pcf	0 psf	30 °	0 psf	30 °
Riprap	100 pcf	0 psf	38 °	0 psf	38 °

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.



Tennessee Valley Authority
Johnsonville Fossil Plant - Active Ash Pond 2
New Johnsonville, Tennessee
Section K-K'

Sudden Drawdown Analysis

Existing Geometry
Sudden Drawdown
Undrained, SDD Strengths

Material Type	Unit Wt.	Effective - c'	Effective - phi'	Total - c	Total - phi
Upper Dike	125 pcf	200 psf	29 °	521 psf	16.2 °
Lower Dike	125 pcf	100 psf	29 °	211 psf	19 °
Ash	100 pcf	0 psf	22 °	0 psf	10 °
Fill	124 pcf	50 psf	29 °	470 psf	16.7 °
Alluvial Clay and Silt	124 pcf	100 psf	30 °	522 psf	16.7 °
Alluvial Sand and Gravel	120 pcf	0 psf	30 °	0 psf	30 °
Riprap	100 pcf	0 psf	38 °	0 psf	38 °

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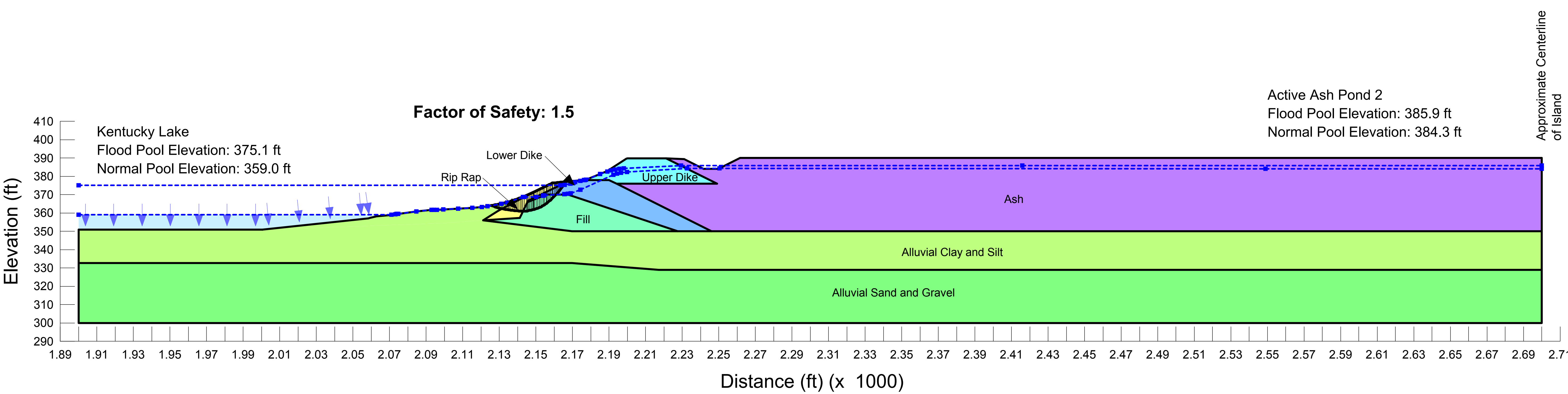


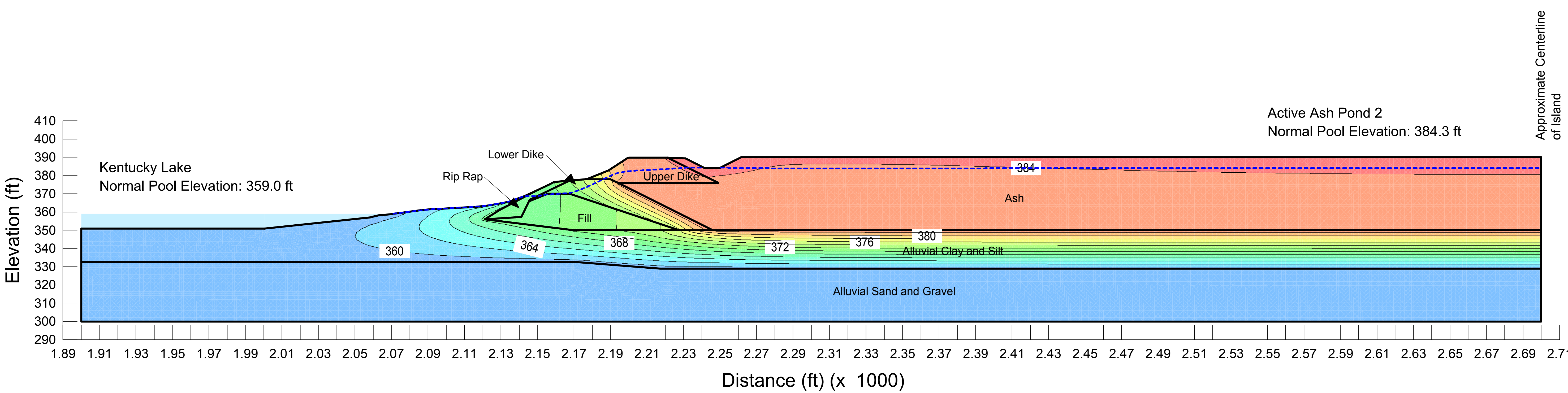
Tennessee Valley Authority
Johnsonville Fossil Plant - Active Ash Pond 2
New Johnsonville, Tennessee
Section K-K'

Seepage Analysis

Existing Geometry
Seepage - Normal Pool
Long-Term, Steady-State
Contours of Total Head (feet)

Material Type	Ksat (ft/sec)	Kratio (kv/kh)	Wsat
Upper Dike	9.84e-008	1	0.34
Lower Dike	2.95e-007	0.333	0.34
Ash	3.28e-005	0.1	0.41
Fill	4.92e-006	0.333	0.3
Alluvial Clay and Silt	6.56e-007	0.05	0.39
Alluvial Sand and Gravel	0.00656	0.05	0.25
Riprap	0.0328	1	0.62

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.



![TVA]

Tennessee Valley Authority
Johnsonville Fossil Plant - Active Ash Pond 2
New Johnsonville, Tennessee
Section K-K'

Seepage Analysis

Existing Geometry
Seepage - Normal Pool
Long-Term, Steady-State
Pore Water Pressure Contours (psf)

Material Type	Ksat (ft/sec)	Kratio (kv/kh)	Wsat
Upper Dike	9.84e-008	1	0.34
Lower Dike	2.95e-007	0.333	0.34
Ash	3.28e-005	0.1	0.41
Fill	4.92e-006	0.333	0.3
Alluvial Clay and Silt	6.56e-007	0.05	0.39
Alluvial Sand and Gravel	0.00656	0.05	0.25
Riprap	0.0328	1	0.62

Note:
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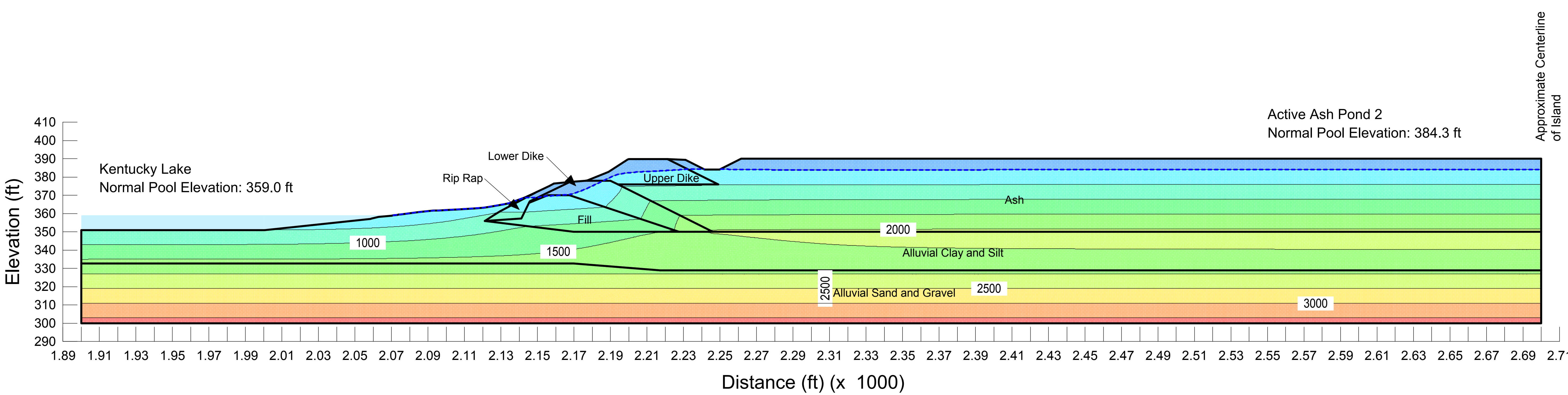

Tennessee Valley Authority
Johnsonville Fossil Plant - Active Ash Pond 2
New Johnsonville, Tennessee
Section K-K'

Seepage Analysis

Existing Geometry
Seepage - Flood Pool
Long-Term, Steady-State
Contours of Total Head (feet)

Material Type	Ksat (ft/sec)	Kratio (kv/kh)	Wsat
Upper Dike	9.84e-008	1	0.34
Lower Dike	2.95e-007	0.333	0.34
Ash	3.28e-005	0.1	0.41
Fill	4.92e-006	0.333	0.3
Alluvial Clay and Silt	6.56e-007	0.05	0.39
Alluvial Sand and Gravel	0.00656	0.05	0.25
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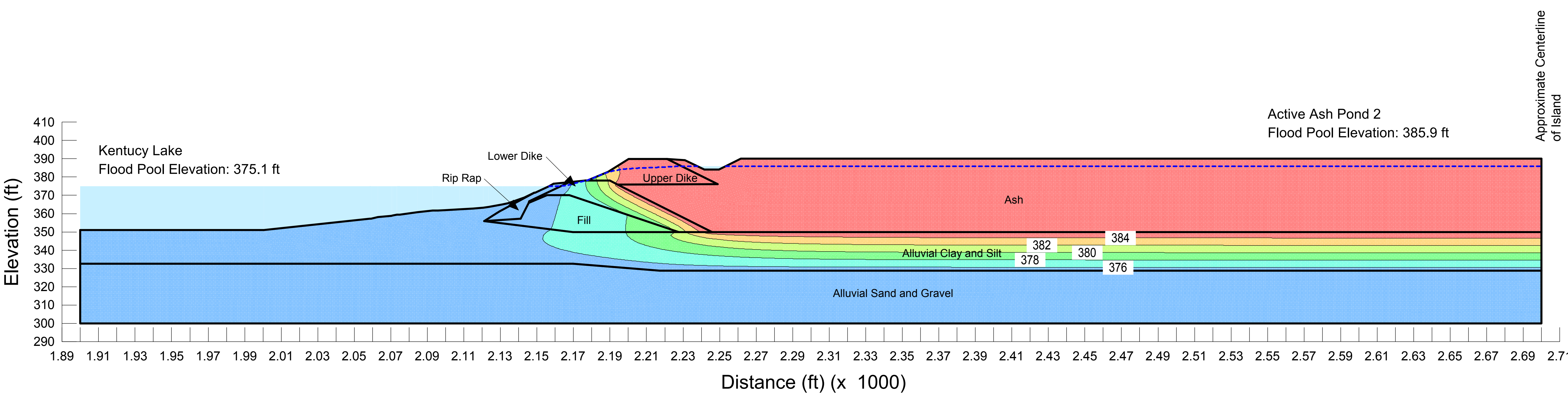

Tennessee Valley Authority
Johnsonville Fossil Plant - Active Ash Pond 2
New Johnsonville, Tennessee
Section K-K'

Seepage Analysis

Existing Geometry
Seepage - Flood Pool
Long-Term, Steady-State
Pore Water Pressure Contours (psf)

Material Type	Ksat (ft/sec)	Kratio (kv/kh)	Wsat
Upper Dike	9.84e-008	1	0.34
Lower Dike	2.95e-007	0.333	0.34
Ash	3.28e-005	0.1	0.41
Fill	4.92e-006	0.333	0.3
Alluvial Clay and Silt	6.56e-007	0.05	0.39
Alluvial Sand and Gravel	0.00656	0.05	0.25
Riprap	0.0328	1	0.62

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.