Stantec

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April 17, 2018
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Revision 0

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

RE: Initial Structural Stability Assessment
Stilling Pond
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Kingston Fossil Plant
Roane County, Tennessee

1.0 PURPOSE

This letter documents Stantec's certification of the initial structural stability assessment for the TVA Kingston Fossil Plant's (KIF) Stilling Pond. Based on this assessment, the Stilling Pond 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 Stilling Pond 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 100-year storm event based upon a hazard potential classification of "low."

3.0 SUMMARY OF FINDINGS

The attached report presents the initial structural stability assessment of the Stilling Pond. 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, Don W. Fuller II, 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**
Stilling Pond
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Kingston Fossil Plant
Roane County, Tennessee

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

SIGNATURE ______________________ DATE 4/17/2018

ADDRESS: Stantec Consulting Services Inc.
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TELEPHONE: (859) 422-3000

ATTACHMENTS: Initial Structural Stability Assessment Report

Initial Structural Stability Assessment

Kingston Fossil Plant – Stilling Pond
Roane County, Tennessee

Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:
Stantec Consulting Services Inc.
Lexington, Kentucky

April 17, 2018
Revision 0

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1.0 PROJECT BACKGROUND

On April 17, 2015, the Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities (RIN-2050AE81; FRL-9149-4) (EPA Final CCR Rule) was published in the Federal Register. A Direct Final Rule in response to a partial vacatur became effective on October 4, 2016. This revision eliminated the exemption for inactive surface impoundments to meet the same requirements as active surface impoundments. An extended timeline was given to inactive surface impoundments with an NOI that complied with §257.105(i)(1), §257.106(i)(1) and §257.107(i)(1). The Stilling Pond at Kingston Fossil (KIF) Plant is an Inactive CCR Surface Impoundment as defined by the EPA Final CCR Rule that meets the requirements for an extended timeline under the Direct Final Rule and is in the process of being closed. Stantec Consulting Services, Inc. (Stantec) was contracted by the Tennessee Valley Authority (TVA) to determine whether the Stilling Pond at KIF meets the initial structural integrity criteria for existing CCR surface impoundments as defined in §257.73(d) of the Environmental Protection Agency (EPA) Final CCR Rule.

2.0 UNIT DESCRIPTION

Kingston Fossil Plant (KIF) is a coal-fired, electric generating plant. The plant is located in Roane County, Tennessee, approximately 2.5 miles southeast of Harriman, Tennessee. The Stilling Pond is located to the northeast of the plant and is 0.6 miles east of Swan Pond Road near the confluence of the Emory and Clinch Rivers on Watts Bar Lake.

Active ash sluicing operations into the pond ceased in October 2015. TVA is in the process of closing the pond with closure anticipated to be completed in May 2018. The Stilling Pond closure consists of an engineered cap system over the 700,000 cubic yards of CCR material within the Stilling Pond, and fill placement in the pond to promote positive drainage and establish vegetation. New stormwater culverts were installed within the eastern segment of Dike C, while the previous spillway pipe and riser structure were decommissioned. Stormwater runoff from the capped area will drain to the new stormwater culverts which will discharge to Watts Bar Lake.

The subsections under §257.73(d) set forth criteria for the periodic structural stability assessment of the appurtenances. Sections 2.1 to 2.3 below provide descriptions of the individual unit elements that fall within the appurtenance categories: embankments, spillways, or hydraulic structures. Figure 2 provides an overview of the Stilling Pond.

Figure 1 Aerial Photograph of KIF Stilling Pond Closure (February 27, 2018)

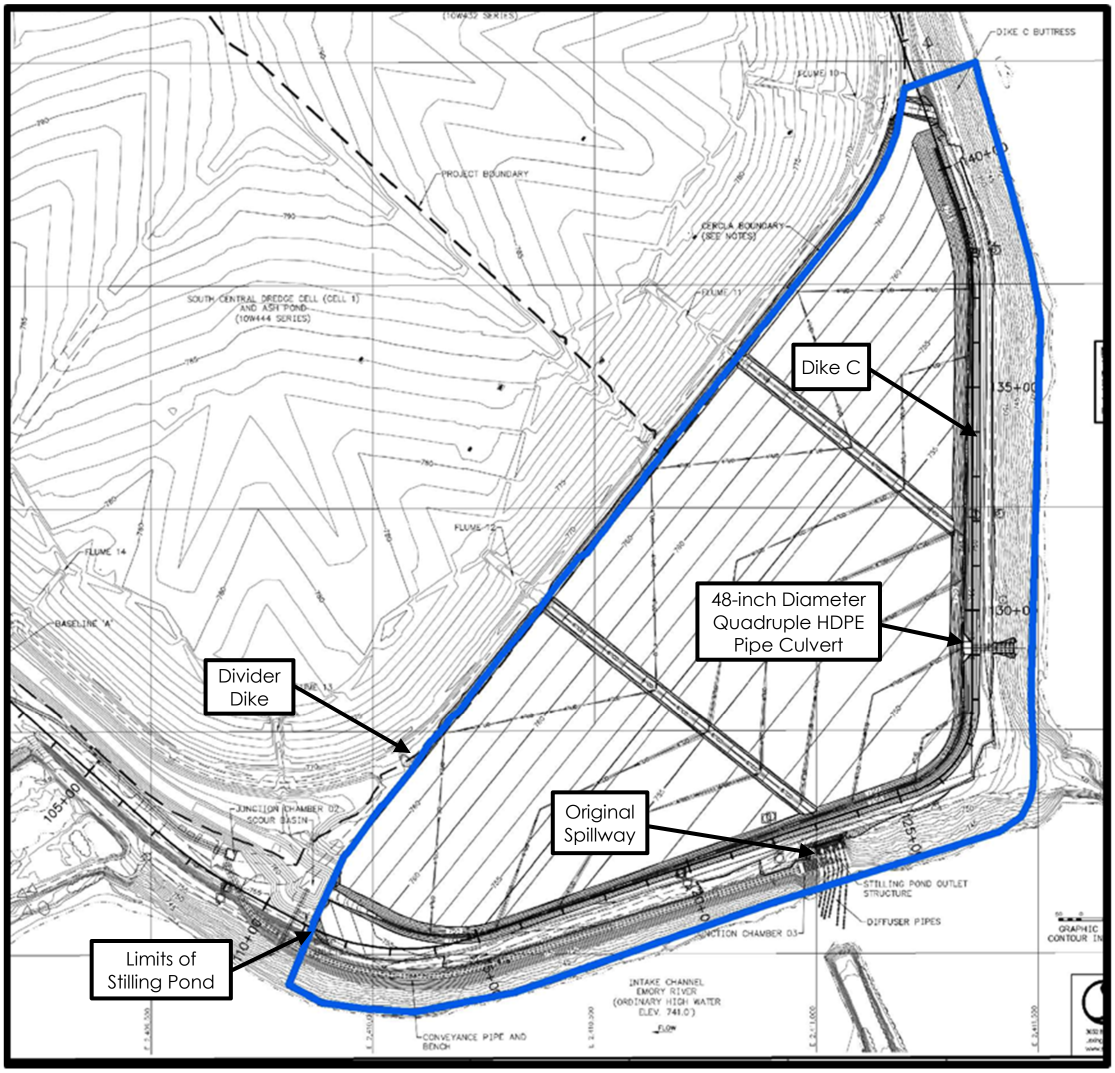

Figure 2 KIF Stilling Pond – Project Location Map

2.1 EMBANKMENTS

2.1.1 Dike C

The Stilling Pond limits shown in Figure 1 encompasses an approximate area of 40.8 acres. The Stilling Pond is contained by Dike C on the south and east sides and by the Divider Dike to the northwest. Dike C separates the Stilling Pond from the Emory River and is approximately 2,716 feet in total length along the border of the Stilling Pond. The overall constructed height of Dike C is approximately 28 feet. Dike C side slopes are approximately 4H:1V to 6H:1V along the exterior. In general, the Dike C crest elevation ranges between approximately 754 and 756 feet.

Dike C was originally constructed as a starter dike in the 1950s to an elevation of approximately 748 feet. The dike crest was raised by upstream construction between 1974 to 1978 to an elevation of 765 feet (raised dike). Portions of the raised dike were excavated with final elevations ranging between 754.5 to 756 feet (Stantec, 2017d). The starter dike is constructed of compacted clay with a rock buttress on the exterior slope (Stantec, 2009b).

2.1.2 Divider Dike

The Divider Dike was constructed within the original limits of the historic Ash Pond that has since been capped. The original Divider Dike was approximately 2,163 feet long and connects the east and west sides of Dike C (Stantec, 2014a). The Divider Dike was constructed between 1976 and 1978 to allow the Stilling Pond to operate at a higher pool elevation while the main ash pond could operate at a lower elevation (Stantec, 2009b).

The Divider Dike was constructed of bottom ash underlying a riprap cap as shown on TVA drawings 10N420 (TVA, 1976) and 10W421 (TVA, 1976 (Revised 2004)). The top of the dike was constructed to elevation 763 feet to provide additional freeboard for the ash pond (Stantec, 2017a). The dike was constructed with a slope ranging from 3H:1V to 4H:1V and with a uniform top width throughout of 16 feet.

Following the 2008 failure and as part of the Kingston Recovery Project (KRP), Cement-bentonite shear walls were constructed along the Divider Dike (Segments 3 & 4 of the KRP). These shear walls are approximately 4 feet thick by 60 feet long along the Divider Dike alignment from elevation 762 feet to 4 feet below bedrock. The spacing between these shear walls is approximately 19 feet (center to center). The purpose of constructing the cement-bentonite shear walls was to provide lateral containment of retained ash in the dredge cells during the design earthquake event. The cement-bentonite shear wall design configuration assumed long term lateral support from the backfilled Stilling Pond. On top of the shear walls, a 5-foot tall earthen berm was constructed to a top elevation of approximately 767 feet (Stantec, 2015a).

Modifications and changes to hydraulic structures were incorporated into the closure design (see Section 2.2). The Agridrain Structure that penetrated the Divider Dike, originally constructed as part of the KRP, was removed as part of the Drainage and Flow Management Project (AECOM, 2016).

2.2 SPILLWAYS

2.2.1 Original Spillway

The original spillway of the Stilling Pond consisted of six 48-inch diameter stacked concrete risers connected to six 36-inch reinforced concrete pipe (RCP). Those RCP outlet pipes connected to a concrete headwall built into Dike C. At the headwall outlet a steel flange was attached and 36-inch diameter steel pipes were connected. These steel pipes in turn were connected to six 24-inch diameter high density polyethylene (HDPE) pipes (diffuser pipes) that discharged into waters of the State of Tennessee (Emory River, in Watts Barr Lake) via the National Pollutant Discharge Elimination System (NPDES) permitted Outfall 001. As part of the closure project, the spillway structure was decommissioned by disconnecting and removing the steel pipes/valves, removing the six 48-inch diameter stacked concrete risers and removing portions of the 36-inch diameter concrete pipes (and grouting the remaining portions) downstream to the headwall structure in 2017 (Stantec, 2017d). A portion of the HDPE diffuser pipes were left open and used to convey process water flows from the Polishing Pond in the Ballfield area, located to the northwest of the Stilling Pond, as a part of the Drainage and Flow Management Project (AECOM, 2016).

2.3 HYDRAULIC STRUCTURES

2.3.1 48-Inch Quadruple Pipe Culvert

After closure, the surface stormwater runoff for the Stilling Pond will be discharged through four 48-inch diameter HDPE pipe culverts bedded and backfilled with flowable fill with concrete headwalls on the inlet and outlet sides on either side of Dike C. The pipes will convey surface runoff from the Stilling Pond closure through Dike C to the Emory River. The stormwater structure was installed in 2017 as part of the Stilling Pond closure. The pipes are approximately 94.5 feet long with an inlet invert of 745.4 feet and an outlet invert of 744.9 feet. There are flap gates at the downstream end to protect against backwater during high flow events on the Emory River.

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 Stilling Pond unit has the following features that fall within this requirement:

- Dike C
- Divider Dike

Assessment of the foundations and abutments associated with these features was completed 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 factors of safety (i.e. FS for piping greater than or equal to 3.0).

3.1 DIKE C

3.1.1 Background

The Stilling Pond is retained by Dike C on the eastern and southern sides. Dike C was built in three stages (Stantec, 2017a):

- The "starter dike" (lower portion) was constructed in the 1950s. The clay embankment was constructed over a base layer of rocks placed on the lakebed. The lakebed served as the foundation for the embankment and consisted of a layer of natural alluvial soils.
- The "raised dike" (upper portion) was completed in the 1970s, with an upstream method of construction comprising of clay embankment built on a sluiced bottom ash subgrade.
- In 2009 and 2010, a "rock buttress" consisting of filter layers and riprap armor was built on the outboard slopes along the length of Dike C.
- In 2017, the dike was modified to tie in the Stilling Pond cover by excavating portions of the raised dike.

The closure design for the KIF Stilling Pond included dewatering the pond, excavating and removing portions of the raised Dike C, backfilling the pond and constructing a cap system. The cap includes a flexible membrane liner, a geocomposite, an infiltration collection system and two feet of cover soil. Ash was left in place within the bottom of the closed facility, beneath the fill and within the boundaries of the perimeter dikes.

3.1.2 Assessment

Annual site inspections for the Stilling Pond were conducted and documented regularly from 1967 to 2014. Some of the inspection reports in the late 1980s and early 1990s are not readily available. However, over 40 years of inspections are available and document the operation and maintenance practices implemented for this facility. Daily, weekly, monthly, and quarterly inspections of the Stilling Pond (including Dike C) are conducted by qualified TVA personnel; seepage areas are monitored on a quarterly basis.

No indications of foundation issues (i.e. cracking, settlement, depressions, and/or deformation) have been noted on historic inspection reports. Recent inspections of Dike C, performed by Stantec (2010, 2012 and 2014) note no significant signs of tension cracking, settlement, deformations or similar instabilities.

Seepage analysis for the original dike construction is not available. Following the failure of the dredge cell on December 22, 2008, a seepage analysis was performed on Dike C (Stantec, 2009b). These analyses were performed by Stantec and provided in *Report of Geotechnical Exploration* (Stantec, 2009b). USACE (United States Army Corps of Engineers (USACE), 1993) minimum recommended value of 3.0 was included as design criteria against piping.

Analysis indicated Dike C did not meet criteria for piping conditions due to seepage. Based on recommendations provided, the Dike C Buttress was constructed for seepage control with some additional stability for the lower dike. The buttress consisted of a graded filter while the exposed surface consisted of TDOT 'Class B' machined riprap for scour protection.

Slope stability of Dike C was calculated for the closed configuration and presented in the *Basis of Design Report* (Stantec, 2017a). A static, pseudo-static and post-earthquake slope stability, and deformation analysis was performed to evaluate the performance of Dike C after closure is complete. Based on analysis performed, computed factors of safety are 2.0 and 2.6 which exceed a minimum 1.5 factor of safety.

Based on pseudo-static and post-earthquake slope stability analyses, the closed Stilling Pond will be subject to slope deformation under seismic conditions. For a 2475-year earthquake event, liquefaction is predicted within the saturated ash deposits. With the gentle surface slopes (1% to 2%) across the finished cover, the closed Stilling Pond will be subject to liquefaction-induced lateral spreading (Stantec, 2017a). Engineering calculations using multiple, simplified methods predict lateral movements in the range of 0.2 to 35 feet. A more robust computer simulation in *FLAC* indicated movements of 7 feet. This is much less than the minimum 120 feet distance between the retained CCRs and the Emory River water line. Lateral spreading may cause cracks in the perimeter dike, but the retained ash is unlikely to escape through these fissures. The sand and rock filter buttress on the outside of the dike provides an additional defense to prevent the discharge of CCRs to the river.

The analyses show that the CCR material in the bottom of the closed Stilling Pond will remain within the current facility footprint during and after a large earthquake. Based on these results, combined with the relatively low seismicity of the region, there is little risk for an uncontrolled release of CCRs from the closed Stilling Pond.

3.1.3 Conclusion

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

3.2 DIVIDER DIKE

3.2.1 Background

At the northwestern boundary of the Stilling Pond is the Divider Dike which separated the Ash Pond from the Stilling Pond prior to closure of the Ash Pond during the KRP. The original alignment of the Divider Dike was constructed between 1976 and 1978. The Divider Dike was buttressed as part of the KRP Segment 3 & 4 work to provide lateral support for the construction of the KRP perimeter stabilization.

3.2.2 Assessment

As part of a detailed geotechnical study, Stantec performed an evaluation of the Divider Dike in 2009. Six exploratory borings and CPTs were performed along the dike. Based on results of SPT and CPT borings, approximately 19 to 38 feet of alluvial deposits underlie the dike. Shale bedrock conditions were encountered below alluvial deposits.

The foundation of the Divider Dike was assessed to have isolated zones of soft to very soft intermittent clayey layers defined by extremely low SPT blowcounts, where the weight of hammer was sufficient to sink the soil hammer. Cement-bentonite shear walls were constructed to stabilize the foundation of the Divider Dike. A rock buttress was also constructed along the interior slope of the Divider Dike within the Stilling Pond for increased structural support for the Segment 3 cement-bentonite shear wall construction during the KRP.

During closure, the Stilling Pond was backfilled and will be capped to approximate elevation 763 feet along the Divider Dike.

3.2.3 Conclusion

Based on the assessment of the foundation and abutments for the Divider 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 Stilling Pond has the following features that fall within this requirement:

- Dike C

Assessment of the slope protection associated with these features was completed 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 DIKE C

4.1.1 Background

Dike C was designed with a riprap buttress on the exterior slope between 2009 and 2011. The buttress was originally designed using US Army Corps of Engineers Filter Criteria and consideration of wave erosion protection. A filter layer was constructed between the existing Dike C slope and the riprap buttress. The riprap buttress was left in place and lowered to an elevation of 754 feet. The revised buttress configuration houses pipes that were installed to convey flows from the polishing pond to Outfall 001 (AECOM, 2016).

4.1.2 Assessment

The riprap buttress was inspected annually prior to the start of the closure construction with no reported deficiencies.

The riprap buttress of Dike C was designed with a multi-layered filter as documented in the *Closure/Post-Closure Plan* (Stantec, 2017d).

4.1.3 Conclusion

Based on the assessment of the slope protection for Dike C, 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 Stilling Pond has the following features that fall within this requirement:

- Dike C
- Divider 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 may be used to assess compaction of the dike.

5.1.1 Background

Construction records related to the starter dike (1950s) and raised dike (1970s) were not available. The *Design Report for the Dike C Rockfill Buttress* was reviewed (Stantec, 2009a) for evidence of adverse subsurface soil properties. The subsurface exploration included borings along Dike C. Soil samples were collected using Standard Penetration Testing (SPT) methodology. SPT blowcounts in the raised clay dike, lean clay foundation soil and at depth sandy silt and silty sand soil were obtained and primarily utilized for slope stability studies.

TVA Drawings 10W229, pages 01 through 29 (Stantec, 2009b) provide documentation of the slope stability analysis along with a demonstration of the soil profile. These schematics also present elevation details of the various structural members of the dike system along with profiles of pre-construction (1940) as well as intermediate constructed surface elevations. Pre- and post-rockfill buttress construction stability is detailed in the *Design Report for Dike C Buttress* (Stantec, 2011a).

5.1.2 Assessment

SPT samples were obtained 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 at-depth recorded SPT blowcounts indicated soft soil conditions (Stantec, 2011a). The soft soils were identified with those placed within the raised clay dike, lean clay foundation soil and at-depth sandy silt and silty sand soil layers having SPT blowcount numbers as low as zero blows per foot (sampler immersed in soil under self-weight). Based on these conditions, compaction at the embankment was deemed inadequate. As a part of the study, the soft soil conditions found in the embankment and underlying foundation soils were used as the basis of design and implemented for a stabilizing rockfill buttress with a graded filter (Stantec, 2011a). The buttress provides sufficient mass to attain satisfactory safety factors for slope stability and the graded filter provides protection from exit gradients and potential piping modes of failure for the conditions at the Stilling Pond prior to closure. The removal of the water and backfilling of the Stilling Pond as part of the closure project (Stantec, 2017d) also improves conditions for slope stability and seepage.

In summary, although compaction of Dike C at the time of initial construction has been deemed inadequate, construction of the rockfill buttress with graded filter and filling of the Stilling Pond provides the necessary conditions for Dike C to meet stability requirements.

5.1.3 Conclusion

Based on the assessment of the Dike C structure, the CCR Rule-related criteria listed above have been met.

5.2 DIVIDER DIKE

5.2.1 Background

The original alignment of the Divider Dike was constructed between 1976 and 1978. The Divider Dike was further stabilized during the KRP by constructing cement-bentonite shear walls.

The Divider Dike was constructed of bottom ash underlying a riprap cap as shown on TVA drawings 10N420 (TVA, 1976) and 10W421 (TVA, 1976 (Revised 2004)).

The top of the dike was constructed to elevation 763 feet to provide additional freeboard for the ash pond (Stantec, 2017a). The dike was constructed with a slope ranging from 3H:1V to 4H:1V and with a uniform top width throughout of 16 feet.

5.2.2 Assessment

Based on review of geotechnical exploration data, soft soil conditions were encountered at the Divider Dike.

The purpose of constructing the cement-bentonite shear wall and rock buttress was to improve the KRP perimeter which was satisfactorily demonstrated by Stantec in 2015. The shear walls transfer lateral pressures from the KRP to the bedrock foundation which improves safety factors for the stability of the Divider Dike. The buttress adjacent to the Divider Dike also enhances stability.

In summary, although compaction of the Divider Dike at the time of construction has been deemed inadequate, the construction of the cement-bentonite shear walls and the rock buttress provide the necessary lateral support for the Divider Dike to meet stability requirements. The Stilling Pond has been drained and backfilled (Stantec, 2017d) which also reduces differential pressures on the Divider Dike.

5.2.3 Conclusion

Based on the assessment of the Divider Dike structure, the CCR Rule-related criteria listed above have been met.

6.0 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 is to be designed, constructed, operated, and maintained to adequately manage flow during and following the peak discharge from the event specified in this section. The Stilling Pond has the following features that fall within this requirement:

- Original Spillway

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 combined capacity of all spillways based off 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.]

6.1 ORIGINAL SPILLWAY

6.1.1 Background

The Stilling Pond is classified as a low hazard structure requiring the combined capacity of all spillways have adequate capacity to manage the flow during and following the peak discharge from a 100-year flood.

6.1.2 Assessment

6.1.2.1 Spillway Capacity

The *Initial Inflow Design Flood Control System Plan* for the Stilling Pond (Stantec, 2017f) documents the assessment of the capacity requirements outlined in §257.73(d)(1)(v) of the CCR Rule. Due to the removal/abandonment of the original spillway structure, the assessment for spillway capacity has been negated and capacity requirements are governed by the hydraulic structures in Section 7.0.

6.1.2.2 Structural Stability

CCTV inspections of the retired 36-inch diameter steel pipes were completed prior to grout injection and earthfill placement for the capped system within the Stilling Pond in accordance with the Construction Technical Specifications (Stantec, 2017e) and CQC Plan (Stantec, 2017c). No remedial actions were required as a result of observations made during the CCTV inspections.

6.1.3 Conclusion

Based on the assessment of the spillway condition and capacity, the CCR Rule-related criteria listed above have been met.

7.0 HYDRAULIC STRUCTURES CONDITIONS

Per §257.73(d)(1)(vi), the initial structural stability assessment must document whether the unit has been designed, constructed, operated and maintained with hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit that maintain structural integrity and are free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris which may negatively affect the operation of the hydraulic structure. The Stilling Pond has the following features that fall within this requirement:

- 48-inch Diameter Quadruple HDPE Pipe Culvert

Assessment of the hydraulic structures condition associated with these features was completed considering the following criteria related to the CCR rule:

1. Must be able to manage the required flows. [Estimate size of pipes based on 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).]
2. 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.]
3. 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 48-INCH QUADRUPLE HDPE PIPE CULVERT

7.1.1 Background

The Stilling Pond is classified as a low hazard structure requiring the combined capacity of all spillways be adequate to manage the flow during and following the peak discharge from a 100-year flood. As part of the closure design, the Stilling Pond is being capped and covered to a relatively flat grade across the site in addition to installation of a drainage system consisting of ditches and flumes to convey runoff to the 48-inch Diameter Quadruple HDPE Pipe Culvert and ultimately conveying outflows to the Emory River through Dike C (Stantec, 2017d).

7.1.2 Assessment

The *Inflow Design Flood Control System Plan* for the Stilling Pond (Stantec, 2017f) documents the assessment of the Stilling Pond related to the capacity requirements outlined in §257.73(d)(1)(v) of the CCR Rule. The assessment demonstrates that the 48-inch Diameter Quadruple HDPE Pipe Culvert located on the east perimeter of the Stilling Pond does meet the capacity requirements.

7.1.3 Conclusion

Based on the assessment of the hydraulic structure condition, the CCR Rule-related criteria 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. The Stilling Pond has the following features that fall within this requirement:

- Dike C

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 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 USACE (2003) recommends a required minimum factor of safety of 1.1 for maximum surcharge pool under rapid drawdown conditions.

8.1 BACKGROUND

The Stilling Pond has a potential sudden drawdown loading from the Emory River and the intake channel along the southern and eastern toes of Dike C. A sudden drawdown slope stability analysis of the downstream slope is required under the CCR Rule §257.73(d)(1)(vii).

8.2 ASSESSMENT

8.2.1 Material Properties

An overview of the subsurface conditions of Dike C of the Stilling Pond is summarized in Table 1. A more in-depth review is found in (Stantec, 2009b).

Table 1 Generalized Subsurface Conditions – Stilling Pond Dike C

Approximate Elevation (feet)	Materials	General Consistency/Density
El. 748 to El. 765 (operational configuration)	Raised Clay Dike – lean clay with sand, sandy lean clay, fat clay with sand, and sandy fat clay	Very soft to very stiff
Native Ground to El. 748	Starter Clay Dike – sandy lean clay and clayey sand with gravel	Soft to medium stiff
El. 748 to El. 750	Ash Subgrade – constructed bottom ash layer	Loose to dense
Native Ground to El. 745	Hydraulically Placed Ash – silty sand with gravel	Very loose to dense
Native Ground to 3 feet above ground surface	Gravel to Clayey Gravel (discontinuous)	Medium dense to medium stiff
Native Ground to one foot above ground surface	Sensitive Silt/Clay – low plasticity silt or silty clay	Very soft to soft
Native Ground to 3-12 feet below ground surface	Lean Clay Foundation Soil – sandy lean clay and lean clay with sand	Very soft to medium stiff
El. 717 to El. 703	Alluvial Sand – silty sand to sandy silt, silty sand with gravel	Very loose or very soft to medium dense or medium stiff

As part of the closure design calculations of the Stilling Pond, material properties developed for the Stilling Pond were documented in Stantec (2017d). The derivation of strength parameters can be found in Stantec (2017d) and are summarized in Table 2. For modeling purposes, the shale bedrock was characterized as impenetrable. The rockfill buttress was built on the exterior slopes of Dike C around the Stilling Pond in 2009 and 2010 and is also represented in the model.

Table 2 Strength Parameters for Stability Analysis – Stilling Pond Dike C

Soil Horizon	Moist Unit Weight (pcf)	Saturated Unit Weight (pcf)	Effective Stress Strength Parameters		Total Stress Strength Parameters		
			c' (psf)	ϕ' (degrees)	c (psf)	ϕ (degrees)	Stress Range
Starter Clay Dike	125	128	0	28	0	23	
Raised Clay Dike	125	128	0	28	0	23	
Ash Subgrade	109	111	0	30	0	30	σ < 4,700 psf
					1000	20	$\sigma \geq$ 4,700 psf
Hydraulically Placed Ash	100	107	0	25	0	10	
Sensitive Silt/Clay	100	107	0	25	0.24 σ_v'	-	
Lean Clay Foundation Soil	-	130	0	32	0	24	
Silty Sand to Sandy Silt	-	128	0	30	0	30	σ < 2,740 psf
Silty Sand with Gravel					1,000	20	$\sigma \geq$ 2,740 psf
Gravel to Clayey Gravel	115	127	0	30	0	30	
Rockfill Buttress	115	128	0	38	0	38	

8.2.2 Critical Cross-Section Selection

Slope stability analyses for the closed system geometry were developed as a part of the calculation package for Closure (Stantec, 2017d). Two cross-sections along the Stilling Pond perimeter alignment (Figure 3), Stations 119+69 and 132+37, were used as the critical profile geometries for modeling conditions of Dike C.

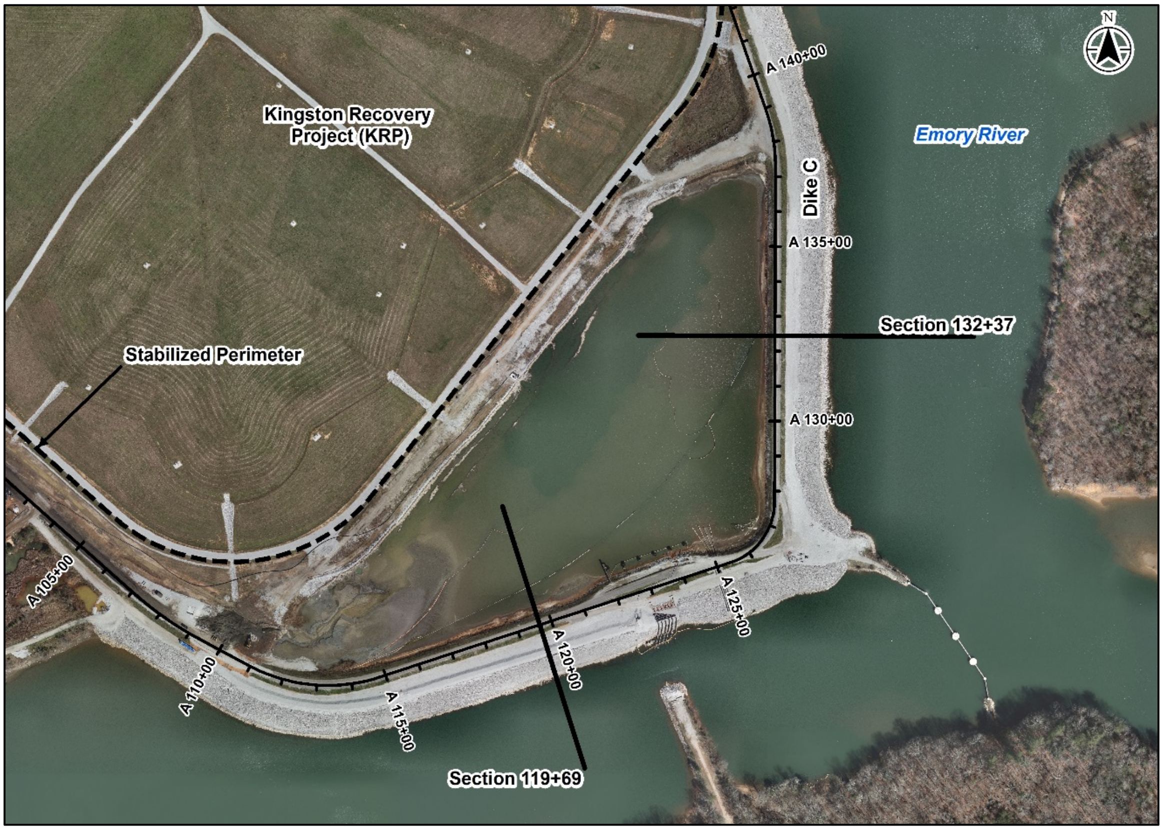

Figure 3 Aerial Photograph of KIF Stilling Pond Prior to Closure

Slope stability results are listed below in Table 3. The lowest factor of safety was calculated at the cross-section of Section 119+69. A sudden drawdown stability analysis is required based on the proposed water levels discussed in Section 8.2.3.

Table 3 Slope Stability Results

Cross-section	Factor of Safety	Condition	Reference
119+69	2.0	Long-term, static	(Stantec, 2017)
132+37	2.6	Long-term, static	(Stantec, 2017)

8.2.3 Water Levels

The sudden drawdown slope stability analyses require assessment of changes in headwater and tailwater levels. The Stilling Pond has been dewatered, backfilled and is in the process of being capped for closure. Therefore, a pool elevation located at the base of the clay cover system was conservatively selected as the operational high water level within the Stilling Pond even though the actual maximum water table elevation will be lower for the closed configuration than what was modelled. Operational normal pool, or the maximum storage pool elevation prior to closure, was selected as the low water level for the facility. The water table within the closed Stilling Pond is anticipated to be significantly lower than the modeled elevations under each scenario. Headwater elevations are listed in Table 4.

The tailwater corresponds to the Emory River or intake channel, which are both controlled by Watts Bar Lake. The 100-year flood level for the Emory River was used for the tailwater flood pool elevation (Stantec, 2017f). Low pool for the Emory River was based on (Stantec, 2017d), using the winter pool elevation. Tailwater elevations are listed in Table 4.

Table 4 KIF Water Elevations for Stability Modeling

CCR Rule Criteria	Headwater Stilling Pond Elevation (feet, NGVD29)	Tailwater Emory River Elevation (feet, NGVD29)
Maximum surcharge pool loading condition	(base of clay cover)	748.0
Long-term maximum storage pool loading condition	755.0	737.0

8.2.4 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).

8.2.5 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 Background section, the USACE Design Manual for Slope Stability (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).

8.2.6 Analysis Results

The slope stability assessment presented in this report is focused on the potential for slope failures of significant mass, which could directly impact potential release of CCR materials from the Stilling 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. Table 5 summarizes the sudden drawdown safety factor evaluation results of the Stilling Pond.

Table 5 Factor of Safety Assessment Results

Plant	Facility	Critical Cross-section	EPA Criteria	Recommended Factor of Safety Criteria	Calculated Factor of Safety
KIF	Stilling Pond	119+69	Sudden Drawdown	1.1	2.0

8.3 CONCLUSION

Based on the assessment of the sudden drawdown for the Stilling Pond perimeter, Dike C, the CCR Rule-related criteria listed above has been met.

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APPENDIX A
SUDDEN DRAWDOWN ASSESSMENT