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October 12, 2016
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Revision 0

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

RE: Initial Structural Stability Assessment
Bottom Ash Pond
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Cumberland Fossil Plant
Cumberland City, Tennessee

1.0 PURPOSE

This letter documents Stantec's certification of the initial structural stability assessment for the TVA Cumberland Fossil Plant's (CUF) Bottom Ash Pond. Based on this assessment, the Bottom Ash 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 Bottom Ash 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 Bottom Ash 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, 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**
Bottom Ash Pond
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Cumberland Fossil Plant
Cumberland City, Tennessee

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

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

Cumberland Fossil Plant – Bottom Ash Pond
Stewart County, Tennessee

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 Cumberland Fossil Plant (CUF) 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 Cumberland Fossil Plant (CUF) is a coal-fired, electric generating plant. The plant is located in Stewart County Tennessee. The plant is located immediately west of Cumberland City, Tennessee approximately 17 miles south of the Kentucky – Tennessee border.

The Bottom Ash Pond is located immediately southwest of the plant. It is bounded by a stormwater ditch to the north, the Coal Yard Drainage Basin to the northeast, the Gypsum Disposal Area to the southeast, and the Dry Fly Ash Stack to the southwest and west. The Bottom Ash Pond encompasses approximately 7 acres. TVA has determined that the Bottom Ash Pond 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 Bottom Ash Pond 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 that forms the Bottom Ash Pond perimeter along the north side is approximately 800 feet long. The overall constructed height of the perimeter dike varies from approximately 30 to 35 feet. Dike side slopes range from approximately 2.5H:1V to 3H:1V. The crest of the dike is approximately 40 feet wide and includes a gravel access road.

The dike was originally constructed in 1969 and raised in 1979 to its current height and configuration. The dike is constructed of compacted clay.

2.1.2 Divider Dike

The Bottom Ash Pond is separated from the Dry Ash and Gypsum Stack facilities by a divider dike. The Divider Dike forms the perimeter along the west, south, and east sides and is approximately 1,500 feet in length. The overall constructed height of the perimeter dike varies from approximately 7 to 15 feet. The slopes range from approximately 1.5H:1V to 3H:1V. The crest of the dike varies in width from approximately 20 to 50 feet and includes an access road along the portion adjacent to the Gypsum Stack.

Figure No.
1

Title
Bottom Ash Pond

Client/Project
Tennessee Valley Authority (TVA)
Cumberland Fossil Plant

Project Location
Cumberland City,
Stewart County, Tennessee

175555021
Prepared by WSW on 2016-08-31
Technical Review by TG on 2016-08-31

0 200 Feet
1:2,400 (At original document size of 11x17)

Legend
Disposal Area Approximate Limits

Notes
1. Coordinate System: NAD 1927 StatePlane Tennessee FIPS 4100
2. Aerial Imagery provided by client (Dated 2015)

Stantec

TVA

V:\175\1temporary\users\NSoltes\Work IDs\regs\CumberlandFossilPlant\Fig1_BottomAshPond.mxd Revised: 2016-08-31 By: nsoltes

Based on review of the dike configuration and its role in current operations, it appears that failure of the Divider Dike would result in limited impacts to the remainder of the Bottom Ash Pond and would not lead to loss of containment of material off of TVA property. Therefore, no further assessment of the Internal Divider Dike under §257.73 of the EPA Final CCR Rule is included.

2.2 SPILLWAYS

2.2.1 Outflow Pipes

The Bottom Ash Pond Outflow Pipes consist of two 54-inch-diameter reinforced concrete pipes (RCP) that direct flow from the Bottom Ash Pond to the North Ditch and subsequently the Stilling Pond. The two pipes are located near the northern end of the pond as shown on Figure 1.

The pipes are 86 feet long with concrete headwalls located at the inlet and outlet.

2.3 HYDRAULIC STRUCTURES

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

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 Bottom Ash Pond has the following features that fall within this requirement:

- Perimeter Dike

Assessment of the foundations and abutments associated with this feature 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 performance (e.g. FS for piping greater than or equal to 3.0).

3.1 PERIMETER DIKE

3.1.1 Background

The Bottom Ash Pond is formed by a perimeter dike that ties into other dikes associated with the original ash disposal area (currently the Dry Ash/Gypsum Stack facility) on the west and south sides of the pond; therefore, there are no natural abutments. Based on previous geotechnical studies ((Stantec, 2010), (Geocomp, 2016) and (Stantec, 2016a)), the foundation of the perimeter dike generally consists of alluvial clay and alluvial sand deposits that vary in thickness from 20 to 70 feet. The alluvial deposits are underlain by bedrock consisting of Ordovician age Mannie Shale, Fernvale Limestone, and Heritage/Carters/Lebanon/Ridley/Pierce and Murfreesboro Limestone Formations.

3.1.2 Assessment

Annual site inspections for the Bottom Ash Pond area, including the Perimeter Dike, were conducted and documented regularly from 1996 to 2015. These inspections include observations related to foundation conditions with respect to observable cracking, settlement, depressions, erosion and deformation. No indication of significant signs of tension cracking, settlement, depressions, erosion, and/or deformations at the crest, slope and toe of the structure were documented.

Seepage analyses of the Perimeter Dike were not available for review. Seepage analysis does not appear to be warranted for this feature, however, due to several factors, including:

- The "Low" hazard classification of the Bottom Ash Pond (Stantec, 2015b) ;
- Effluent seeping through the Bottom Ash Pond Dikes is routed to the Stilling Pond (including Retention Pond);
- The potential impacts due to seepage related failure of the dike would be limited to the adjacent Dry Ash/Gypsum Stack facility and/or Stilling Pond (including Retention Pond) and confined internally within those units; and
- The water level within the Bottom Ash Pond is maintained at a relatively low level with respect to the surrounding topography due to operational procedures within the pond. Typical water depths of 2 to 4 feet are maintained in the pond.

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 Bottom Ash Pond has the following features that fall within this requirement:

- Perimeter Dike

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: Riprap, Gabions, Paving (concrete or asphalt), or appropriate vegetative cover.]*

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

4.1 PERIMETER DIKE

4.1.1 Background

Slope protection for the exterior slopes of the Perimeter Dike generally consists of rip rap. The interior slopes of the Perimeter Dike consist of bottom ash, excluding some isolated areas that have rip rap armoring.

4.1.2 Assessment

As reported by the EPA (Dewberry, 2013) daily, weekly, monthly, and quarterly inspections of the Perimeter Dike are conducted by qualified TVA personnel, and areas of erosion are prioritized for appropriate repairs. Annual site inspections are conducted by TVA. Site inspection reports from 1996 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).

The use of rip rap along the exterior slope of the dike appears appropriate considering the potential for erosive flows in the area. Documentation of the design of the rip rap armoring is included on Record Drawings for the Seepage Improvements Project. According to Record Drawing 10W554-06, the minimum thickness of the rip rap layer on the northern exterior slope of the dike is 12-inches, and it is underlain by a crushed stone filter. Vegetation or armoring of the interior slopes of the dike does not appear to be practical considering the current operational condition of the Bottom Ash Pond. Bottom Ash Pond operations include routine dredging of the settling basins that requires large equipment to traverse the elevated areas within the Bottom Ash Pond and excavation that causes the interior slopes to be bare. The interior slopes are routinely redressed as part of the dredging operation to maintain the integrity of the slope and address any areas of erosion.

As part of a March 2016 site visit, Stantec personnel observed the rip rap protection along the exterior slopes. The rip rap was located along the exterior slope of the northern and eastern sections of the perimeter dike between the Bottom Ash Pond and the Plant. The rip rap above the water surface was continuous and performing well.

4.1.3 Conclusion

Based on the assessment of the slope protection for the Perimeter Dike, 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 Bottom Ash Pond 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 the dike material placement and compaction for the 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. Subsurface explorations of the dike were available that provided SPT data used in the assessment.

5.1.2 Assessment

TVA Drawings 10N212 and 10N213 provide documentation of 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:

- Embankments were to be constructed from earth fill from approved borrow sources in accordance with standard TVA construction specifications,

- Dike embankments were to be compacted with sheepsfoot rollers. Construction monitoring was to include two field moisture-density tests per day to achieve a minimum 95 percent of Standard Proctor maximum density as determined by TVA Materials Laboratory. The earth fill moisture content was not to exceed 3 percent above optimum moisture content.

A previous geotechnical exploration report prepared by Law Engineering (Law, 1992) was available to review as part of this assessment. Law completed a geotechnical exploration and stability analysis of the Ash Pond in January 1992. Their exploration included drilling and sampling locations around the Perimeter Dike. SP testing was also performed at each boring location. The SP data from these studies were used to estimate relative density of dike embankment materials, referencing NAVFAC DM-7.1

The SP test data reviewed shows average N-values ranging from 6 to 22; with an average N-value of 15 for the dike embankment materials. Correlating these results using NAVFAC DM-7.1 indicate that the compacted clay embankment exhibits very stiff conditions. Hence, 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 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. The Stilling Pond has the following features that fall within this requirement:

- Outflow Pipes

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.]

6.1 OUTFLOW PIPES

6.1.1 Background

The Bottom Ash 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. The Outflow Pipes consist of two 54-inch-diameter RCP that penetrate the perimeter dike and discharge flow from the Bottom Ash Pond.

6.1.2 Assessment

The *Inflow Design Flood Control System Plan* for the Bottom Ash Pond (Stantec 2016c) documents the assessment of the Bottom Ash Pond related to the capacity requirements outlined in §257.73(d)(1)(v) of the CCR Rule. The assessment demonstrates that the Outflow Pipes in combination with the other hydraulic structures located at the Bottom Ash Pond does meet the capacity requirements.

As shown in Stantec (2016b), the subgrade was compacted prior to placing the pipe bedding for the 54-inch-diameter RCP. The pipe bedding and backfill consisted of compacted No. 57 crushed stone placed to the midline of the pipes. Compacted No. 3 crushed stone was placed from the midline of the pipes to 12 inches below the final grade line. A minimum of 12 inches of No. 57 crushed stone was placed over the No. 3 stone to establish a stone access road and the final grade line. A minimum cover of 3 feet of backfill was placed over the top of the pipes.

During the 2016 site visit by Stantec personnel, the Outflow Pipes were freely discharging with no observed deficiencies or blockages.

6.1.3 Conclusion

Based on the assessment of the Outflow Pipes condition and capacity for Bottom Ash Pond, the CCR Rule-related criteria listed above have been met.

7.0 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 may be inundated by the pool of an adjacent water body, such as a river, stream, or lake, downstream slopes that maintain structural stability during low pool of the adjacent water body or sudden drawdown of the adjacent water body. The Bottom Ash Pond has the following features that fall 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 Rapid 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.

7.1 PERIMETER DIKE

7.1.1 Background

The nearest adjacent body of water to the Bottom Ash Pond is the Cumberland River located approximately 2,500 feet to the north. The 100-year peak water surface elevation of the Cumberland River in this location is approximately 381 feet.

7.1.2 Assessment

The low point along the exterior slope toe of the perimeter dike of the Bottom Ash Pond is approximately elevation 390 feet; therefore, the exterior slope of the perimeter dike will not become inundated by the Cumberland River for the 100-year flood event.

7.1.3 Conclusion

Based on the assessment of the sudden drawdown potential for the Bottom Ash Pond perimeter dike, the CCR Rule-related criteria listed above have been met.

8.0 REFERENCES

Dewberry. (2013). "USEPA Coal Combustion Residue Impoundment Round 11 - Dam Assessment Report, Cumberland Fossil Plant, Dry Ash Storage/Ash Pond, Tennessee Valley Authority, Cumberland City, Tennessee."

Geocomp, S. &. (2016). Soil borings performed to support Seismic Safety Factor Demonstration.

Law Engineering (1991), "TVA Cumberland Ash Pond," Project 417.91199.05, December 11.

Law Engineering (1992), "TVA- Cumberland City, Cumberland City, Tennessee," Project 57401442.01, January.

Naval Facilities Engineering Command (NAVFAC). (1986). "Soil Mechanics Design Manual 7.01."

Stantec Consulting Services Inc. (Stantec). (2009, 2010, and 2013). TVA Annual Inspection Program, Cumberland Fossil Plant.

Stantec Consulting Services Inc. (Stantec). (2010). "Report of Geotechnical Exploration and Slope Stability Evaluation, Ash Pond, Cumberland Fossil Plant. Prepared for Tennessee Valley Authority."

Stantec Consulting Services Inc. (2015b). "Hazard Potential Classification Assessment, Bottom Ash Pond, Cumberland Fossil Plant." Prepared for Tennessee Valley Authority. August.

Stantec Consulting Services Inc. (Stantec). (2016a). Soil Borings (B-1 and B-2) obtained as part of a Geotechnical Exploration.

Stantec Consulting Services Inc. (Stantec). (2016b). "Record Drawings, Gypsum Disposal Complex Siphon Improvements Project, TVA Project No. 608929, Cumberland Fossil Plant, Cumberland City, Stewart County, Tennessee". Prepared for Tennessee Valley Authority. March 29.

Stantec Consulting Services Inc. (Stantec). (2016c). "Inflow Design Flood Control System Plan, Cumberland-Bottom Ash Pond, Stewart, County, Tennessee". Prepared for Tennessee Valley Authority. September 2016.

Tennessee Valley Authority (TVA). (1969, 1975, 1979). Construction Drawings (10N212-214, 10N224, 10N227), Ash Disposal Area, Cumberland Steam Plant.

Tennessee Valley Authority (TVA). (July, 2011). "TVA Operations Support Document."

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

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