Memorandum from the Office of the Inspector General

August 2, 2010

Robert M. Deacy, Sr., LP 5D-C

FINAL REPORT – INSPECTION 2009-12910-01– PEER REVIEW OF STABILITY ANALYSIS OF DIKE C AT KINGSTON FOSSIL PLANT

Attached is the subject final report for your review and action. Your written comments, which address your management decision and/or actions taken, have been included in the report. We note in the report that some unresolved issues remain. Specifically:

- Marshall Miller & Associates (Marshall Miller) states that existing riprap placements are indicative of repairs to existing slopes and need to be identified on record drawings. We deem that further consideration should be given to updating the existing-condition drawings.
- Please provide final action notification regarding installation of additional piezometers at or near STA 138+27 and STA 149+14 as agreed to by TVA and Stantec.
- Please provide Stantec's staged-construction analysis considering undrained shear strengths with the Stage 1 Construction – Segment "C" or "D" Dike C Buttress documents for Marshall Miller's review.

The Office of the Inspector General (OIG) contracted with Marshall Miller to conduct this review. All work pertaining to this review was conducted by Marshall Miller. The OIG relied on Marshall Miller's processes and procedures for quality control of the attached report. Information contained in this report may be subject to public disclosure. Please advise us of any sensitive information in this report that you recommend be withheld.

If you have any questions, please contact Greg R. Stinson, Project Manager, at (865) 633-7367 or Gregory C. Jaynes, Deputy Assistant Inspector General, Inspections, at (423) 785-4810. We appreciate the courtesy and cooperation received from your staff during this review.

Gregory C. Jaynes

(for) Robert E. Martin
Assistant Inspector General
(Audits and Inspections)
ET 3C-K

GRS:NLR
Attachment
cc: See page 2

cc (Attachment):
Robert J. Fisher, LP 3K-C
Peyton T. Hairston, Jr., WT 7B-K
John C. Kammeyer, LP 5D-C
Tom D. Kilgore, WT 7B-K
William R. McCollum, Jr., LP 6A-C
Annette L. Moore, LP 3K-C
Richard W. Moore, ET 4C-K
David R. Mould, WT 7B-K
Emily J. Reynolds, OCP 11-NST
Joyce L. Shaffer, WT 9B-K
John M. Thomas III, MR 3A-C
Robert B. Wells, WT 9B-K
OIG File No. 2009-12910-01

Mr. John Montgomery, Stantec

Letter Report

Technical Rebuttal to May 11, 2010 TVA Response to OIG Draft Inspection 2009-12910-01 – Peer Review of Stability Analysis of Dike C at Kingston Fossil Plant

Tennessee Valley Authority Kingston Fossil Plant (KIF)
Harriman, Tennessee

Prepared for:

TVA Office of the Inspector General
Knoxville, Tennessee

Prepared by:

Project No.: TVA106-08

August 2, 2010

Marshall Miller & Associates, Inc.
ENERGY/ENVIRONMENTAL/ENGINEERING/CARBON MANAGEMENT

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Item 1: TITLE PAGE

Title of Report

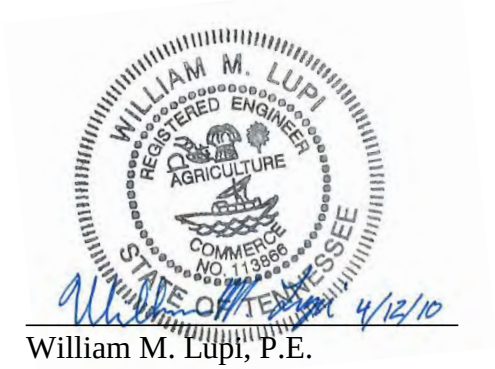
Peer Review of Stantec Consulting Services, Inc.
Report of Geotechnical Exploration and Slope Stability for Dike C
Tennessee Valley Authority Kingston Fossil Plant (KIF)

Project Location

The project site is located in Harriman, Roane County, Tennessee, and is situated on a peninsula formed by the confluence of the Emory River and the Clinch River.

Qualified Persons

William S. Almes, P.E.
TVA OIG Contract Manager
Senior Engineer & Director of Geotechnical Services
Marshall Miller & Associates, Inc.



William M. Lupi, P.E.
Project Engineer
Marshall Miller & Associates, Inc.

Edmundo J. Laporte, P.E.
Senior Engineer
Marshall Miller & Associates, Inc.

Christopher J. Lewis, P.E.
Principal Engineer
D'Appolonia, Engineering Division of Ground Technology, Inc.

Effective Date of Report

August 2, 2010

Item 2: EXECUTIVE SUMMARY

The Tennessee Valley Authority (TVA) Office of the Inspector General (OIG) retained Marshall Miller & Associates, Inc. (Marshall Miller) to conduct a peer review of the report entitled "Report of Geotechnical Exploration and Slope Stability for Dike C" (Dike C Report) prepared by Stantec Consulting Services, Inc. (Stantec) of Lexington, Kentucky. In summary, it is Marshall Miller's opinion that Stantec generally performed a reasonable scope of investigation for the portion of Dike C covered by its report and applied appropriate investigative methods and evaluation techniques. However, Stantec applied site-wide characterization and application of shear strength parameters even though areas of significantly weaker material were identified. In addition, there is a lack of information on seepage and material conditions nearer the downstream toe of Dike C, which causes additional uncertainty about the Stantec study and its associated conclusions and opinions about the Dike C conditions.

The in-situ and laboratory testing programs applied appropriate and complementary suites of laboratory tests to characterize the dike fill, native foundation soils, and ash materials in the primary areas of interest for Dike C. The available body of site-specific data is considerable; however, Stantec applied a site-wide perspective in the characterization and application of shear strength properties for their analyses of the five evaluated slope stability sections along thousands of feet of containment dike. The Stantec approach underutilized the exploration data and may have masked the existence and/or diminished the significance of weak soil layers in particularly critical reaches of the dike system. Consequently, Marshall Miller believes that Stantec's evaluations overstate the factor of safety for global slope stability along more critical reaches of the dike system and are more a representation of the site-wide average conditions. Marshall Miller is not suggesting that a stability failure is imminent under the existing conditions, but rather that the margin of safety along certain sections of the dike system is less than suggested by the Stantec calculated factor of safety of around 1.5 for deep-seated failures. The significance of this observation is dependent on the approach and conservatism that is applied in the design of more immediate stability enhancements to the dike system (i.e., the interim stability enhancements that might be designed based on drained analyses). TVA and Stantec believe the planned remediations are sufficient to address all concerns regardless of

differences in opinion on methodology used for slope stability evaluations. Marshall Miller has not evaluated the planned remediations at this time but will conduct a peer review of the Dike C remediations in the near future.

Management's Response to Draft Report

To address this report, TVA management had Stantec and AECOM review and respond to the findings of this report. TVA management and its contractors disagreed with many of the findings and recommendations in this report. Stantec responded that, "It is Stantec's professional opinion that the scope of geotechnical exploration, laboratory testing program, and subsequent stability analysis were performed in accordance with standard industry practice using the degree of care and skill normally exercised by competent members of the engineering profession. In addition, it is our opinion that the results adequately characterize the structural stability of Dike C." AECOM noted that, "Stantec selected the appropriate number of cross-sections and used, in our opinion standard design drained friction angles of safety for this structure." Both Stantec and AECOM responded in detail to each finding and recommendation. For complete responses please see appendices A – TVA Transmittal Memo, B – Stantec's Response, & C –AECOM's Response.

OIG and Marshall Miller Assessment of Management's Comments to Draft Report

Marshall Miller provided additional comments in response to AECOM and Stantec responses. In summary, Marshall Miller stands by the findings in the report and disagrees with some of the methodologies used by Stantec to evaluate Dike C. However, they feel that the Dike C improvement planned actions, referenced in the Stantec and AECOM responses, address or will address most of their findings and recommendations (Marshall Miller is completing an evaluation of the Dike C remediations which will be addressed in a separate report). The remaining findings and recommendations not fully addressed are not considered substantial and should not affect the stability of the dike. For Marshall Miller's complete response please see appendix D.

TVA management requested two engineering consultants respond to Marshall Miller's report. Stantec performed the Dike C study that Marshall Miller was tasked by the OIG to peer review.

AECOM was also asked to respond to Marshall Miller's peer review. It is important to note that AECOM performed the root cause analysis study of the Kingston failure. Some of the opinions included in their response were also rendered in the root cause analysis study. A change in those opinions could have raised questions about the accuracy of the root cause analysis study.

Item 3: TABLE OF CONTENTS

Item 4: INTRODUCTION AND BACKGROUND

The Tennessee Valley Authority (TVA) Office of the Inspector General (OIG) retained Marshall Miller & Associates, Inc. (Marshall Miller) to conduct a peer review of the report entitled "Report of Geotechnical Exploration and Slope Stability for Dike C" (Dike C Report) prepared by Stantec Consulting Services, Inc. (Stantec) of Lexington, Kentucky. At the request of TVA, this work was performed by Stantec following the ash dredge cell failure which occurred at the TVA Kingston Fossil Plant (Kingston) near Harriman, Tennessee, on December 22, 2008.

During its engagement, Marshall Miller met with and participated in teleconferences with various representatives of the OIG, TVA, Stantec, and AECOM, among others, and was provided access to various documents, including subsurface exploration data, laboratory testing results, engineering calculations and analyses, engineering design drawings, photographs, aerial maps, and other pertinent documentation which were reviewed during the peer review.

This report presents the following:

- Marshall Miller Project Team;
- Description of Marshall Miller's scope of work and background on Stantec's evaluations;
- Findings and recommendations related to Marshall Miller's review of Stantec's slope stability and seepage analyses; and
- Comments and suggestions regarding the Kingston facility's Dike C Embankment Remediation Work Plan.

Item 5: MARSHALL MILLER PROJECT TEAM

Marshall Miller, an employee-owned Engineering News-Record Magazine (ENR) Top 500 company, began offering geologic services to the mining industry in 1975 and has provided a full range of related services to the mining, utility, financial, governmental, and legal industries for 33 years. Today, Marshall Miller employs nearly 200 engineers, geologists, scientists, and other professionals working from regional offices in ten states.

Marshall Miller subcontracted with D'Appolonia, Engineering Division of Ground Technology, Inc., of Monroeville, Pennsylvania, for their additional expertise with tailings impoundments and dams, problem ground conditions, and forensic investigations.

The Marshall Miller Project Team is comprised of the following professionals:

- Mr. Peter Lawson – Executive Vice President & Principal-in-Charge.
- Mr. William S. Almes, P.E. – Director of Geotechnical Services & Contract Manager for TVA OIG.
- Mr. Edmundo J. Laporte, P.E. – Senior Engineer.
- Mr. William M. Lupi, P.E. – Project Engineer.
- Mr. Richard G. Almes, P.E. – Principal Geotechnical Engineer.
- Mr. Christopher J. Lewis, P. E. – Principal Geotechnical Engineer[1].
- Mr. Aaron J. Antell, P.E. – Project Engineer[1].

[1] Christopher J. Lewis, P.E. and Aaron J. Antell, P.E. are Geotechnical Subconsultants of Marshall Miller and are employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

Item 6: SCOPE OF SERVICE & BACKGROUND

6.1. SCOPE OF SERVICE

Marshall Miller was engaged to provide a technical peer review of the stability analyses of Dike C at the TVA Kingston Fossil Plant. Marshall Miller did not conduct a parallel study (field investigation, laboratory testing, and engineering analyses) to the Stantec study of the existing Dike C conditions, but rather, Marshall Miller largely relied on the Stantec field investigation and test data to formulate the findings presented in this report. However, for comparison with the Stantec study and to support the findings of this report, Marshall Miller did evaluate a sampling of the geotechnical data to independently characterize the properties of the alluvial foundation soils. Marshall Miller also conducted comparative slope stability analyses for a selected reach of the dike system as described under Item 7 below. Stantec and TVA consulted with other qualified geotechnical engineering consultants during the evaluation of Dike C.

Marshall Miller completed a thorough peer review of Stantec's "Report of Geotechnical Exploration and Slope Stability for Dike C" (Dike C Report). If more current versions of these documents exist, Marshall Miller was not aware of such changes. As such, Marshall Miller's professional opinions are based principally on the review of the above-referenced documents and discussions with TVA, Stantec, AECOM, and other TVA consultants.

In preparing this report, the professional services of Marshall Miller have been utilized, findings obtained, and conclusions made per generally accepted engineering principles and practices. Marshall Miller reserves the right to amend and supplement this report based on new or additional information that might be obtained or become known. If OIG, TVA, TVA's consultants, or others discover additional information pertinent to the Kingston ash pond failure or related studies, Marshall Miller requests the opportunity to review the information for significance relative to Marshall Miller's findings and conclusions as presented herein.

6.2. BACKGROUND

The portion of Dike C reviewed by Stantec consists of the existing, approximately 5,600-foot long, two-tiered dike embankment (upstream staged configuration) located at the southern and southeastern limit of the coal combustion by-products disposal facility. This embankment consists of an initial starter clay dike constructed on alluvial foundation soils, in most sections raised slightly with constructed ash, and a raised clay dike constructed by upstream techniques over impounded, hydraulically placed/sluiced ash. The initial starter dike was constructed in the 1950s, which provided an embankment crest at approximately Elevation (El.) 748 feet. Past TVA drawings and reports indicate that portions of the Dike C starter embankment are founded over a layer of broken shale within the Watts Bar Reservoir. The shale was encountered during the subsurface exploration phase of the Stantec study and these findings are depicted in two of the geotechnical cross-sections.

The raised clay dike, reportedly constructed in the 1970s, increased the Dike C crest to El. 765. The raised dike was constructed of clayey soils, partly on the upstream face of the starter dike and out over hydraulically placed ash. According to available design drawings, neither dike stage contains regular internal drains, relief wells, or other specific features for seepage control.

Stantec's field investigation program was performed along the remaining Dike C embankment. This included the portion of Dike C east and south of Dike D that remained following the December 22, 2008 failure (refer to Figure 1 of the referenced Stantec Dike C Report). The exploratory drilling work was performed between March 17 and May 28, 2009. Stantec's subsurface investigation and instrumentation program included the following:

Borings and Instrumentation:

- Completion of 74 hollow-stem soil borings at 54 locations;
- Installation of 6 slope inclinometers; and
- Installation of 20 standpipe piezometers.

Geotechnical Testing and Sampling:

- Performance of 1,844 Standard Penetration Tests;
- Collection of 131 undisturbed Shelby-tube samples;
- Collection of 20 feet of rock cores (per boring)at 9 locations; and
- Performance of 20 cone penetrometer tests.

Item 7: SLOPE STABILITY ANALYSES

Marshall Miller reviewed the results of Stantec's Dike C slope stability analyses, including subsurface investigation results, soil laboratory test data, and material shear strength properties. In general, it is Marshall Miller's opinion that the in-situ and laboratory testing programs applied appropriate and complementary suites of tests to characterize the dike fill, native foundation soils, and ash materials in the primary areas of interest for Dike C. However, Stantec applied a site-wide perspective in the characterization and application of shear strength properties that led to an overstatement of the factor of safety for global slope stability along more critical reaches of the dike system.

7.1. FINDINGS

In Marshall Miller's opinion, the slope stability analyses methodology applied by Stantec led to an overstatement of the factor of safety for global slope stability along more critical reaches of the dike system. Specifically, Marshall Miller noted the following items of concern during the peer review:

- Stantec developed site-wide shear strength parameters based on site-specific exploration and laboratory data. The characterization and application of site-wide shear strength parameters underutilizes the exploration data and risks masking (or discounting) the existence and significance of particularly critical reaches of the containment dike system. The Stantec approach does not fully capture the variations in the factors of safety due to potential variability in the soil shear strengths.

- It is Marshall Miller's professional opinion that in some instances Stantec selected shear strengths/friction angles that were higher than should have been used. This led to an overstated minimum factor of safety. Instances where the selected shear strengths were too high include:

    - At Station 132+37, Stantec used a friction angle of 27 degrees for most of the alluvial foundation soils and 28 degrees for a thin, sensitive silt/clay layer within the foundation. The alluvial foundation soils (i.e., soil below the estimated pre-

existing ground line) through this area consist of (1) silty sand to sandy silt (as shown in Table 9 of the Dike C Report) and (2) high and low plasticity clay with relatively low standard penetration tests blow counts (N-values) to no measureable blow count (i.e., standard penetration tests blow counts equivalent to weight of hammer (WOH) or weight of rods (WOR)) and low cone penetrometer test correlated friction angles (significantly lower than 27 degrees). These findings raise questions about the applicability and reliability of such a correlation, as it is most pertinent to coarse-grained soils with a measurable blow count. In the professional opinion of Marshall Miller, the 27 to 29 degree range of drained friction angle for the foundation soils does not encompass representative values along more critical reaches of the dike system, where the drained friction angle could be significantly lower. Based on Marshall Miller's review of the exploration data, particularly within the subject weaker link reach of the dike containment system, zones of cohesive (CL[2], CH[3], and ML[4]) soil exist in the foundation. Consistent with typical practice, standard penetration tests correlations are applicable to non-cohesive soils.

Due to the overall weakness of this section of the dike, Marshall Miller recalculated the factor of safety at Station 132+37. Stantec calculated a minimum factor of safety for failure through the foundation soils equal to 1.47 at Station 132+37. As noted above, Stantec used a drained friction angle of 27 degrees for the alluvial foundation soils and 28 degrees for a thin, sensitive silt/clay layer within the foundation. Marshall Miller determined a representative range of 23 to 25 degrees drained friction angle for the foundation soils was appropriate. Subsequently, Marshall Miller recalculated the factor of safety for the section at Station 132+37 and determined it to be 1.26 to 1.35. Lower drained friction

2 Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. Das, Braja M. *Principles of Geotechnical Engineering*, Boston: PWS Publishers, 1985, p. 70.

3 Inorganic clays of high plasticity, fat clays. Braja M. Das, p. 70.

4 Inorganic silts, very fine sands, rock flour, silty or clayey fine sands. Braja M. Das, p. 70.

angles are justified for more critical reaches of the dike system and result in a lower factor of safety than is customarily accepted.

Marshall Miller is not suggesting that a stability failure is imminent under the existing conditions, but rather that the margin of safety along certain sections of the dike system are less than a factor of safety of 1.47 suggests. The significance of this observation is dependent on the approach and conservatism that is applied in the design of more immediate stability enhancements to the dike system (i.e., the interim stability enhancements that might be designed based on drained analyses).

- While Stantec classified the foundation zones between and proximate to Station 125+70 and Station 134+30 as sandy, roughly one-half of the laboratory test results indicated the material was silty sand with greater than 40 percent fines content. The fines content of the sandy material and the prevalence of standard penetration tests blow counts equivalent to WOH or WOR indicate that the effective friction angle could be quite low. Correlations used to determine effective friction angle based on standard penetration tests blow counts generally indicate a lower-bound friction angle of about 25 degrees. Figure 5.7 from Duncan and Wright (2005), a reference from the Stantec report, is an example correlation that indicates a lower-bound friction angle of about 25 degrees for coarse-grained soils. The applicability of this correlation is questionable, especially given the overall fineness of the foundation deposit between Station 125+70 and Station 134+30, the absence of a measurable blow count in many instances, and the consistency reflected by the cone penetrometer test profiles.

- The Stantec report states that past shallow sliding of the downstream face of Dike C was reported in the project records; however, the locations of the past slide(s) were not provided.

- The Kingston Dike C site is located within a region with known moderate seismic risk. However, no seismic stability evaluations were included in the Stantec Dike C

Report. It is Marshall Miller's professional opinion that seismic issues warrant more thorough consideration.

- Stantec used a bathymetric survey that did not reflect current conditions. The survey was dated March 10, 2009. Due to changes in river hydraulics and dredging activities, the March 2009 survey may not accurately reflect current conditions.

7.2. RECOMMENDATIONS

Based on the findings described above, Marshall Miller has developed the following list of recommendations for consideration:

- Marshall Miller advocates the use of location-specific shear strength parameters for the key material layers, based on data obtained at and proximate to the dike sections that are more critical with respect to (1) geometric configuration, (2) seepage conditions, (3) material classification, and (4) the relative consistency of the materials as indicated by the in-situ testing, particularly for the highly variable foundation soils. It is important to characterize the shear strengths (drained and undrained) of key materials from a more local or discrete perspective, rather than a site-wide perspective, such that the more critical reaches of the dike system are identified and appropriately stabilized.

- Stantec should establish shear strength properties with the degree of confidence/conservatism normally applied from a design perspective.

- TVA should document the areas where slides occur on record drawings, such that the information is part of the pre-inspection documentation reviewed by inspectors of the KIF wet ash disposal facility.

- TVA has developed a methodology for TVA's seismic assessments of closed coal combustion products facilities. TVA should take appropriate actions to apply these methodologies.

- The existing ground surface (exposed or submerged) downstream of the dike system should be verified and potential changes related to dredging activities in the Watts Bar Lake area be evaluated and accounted for.

Item 8: SEEPAGE ANALYSES

Marshall Miller reviewed the results of Stantec's Dike C seepage analyses, including the material properties, boundary conditions, and pool elevations that were analyzed for each of the generalized subsurface/geotechnical cross-sections. In general, it is Marshall Miller's opinion that Stantec performed a reasonable scope of investigation to support the seepage analyses for the portion of Dike C covered by its report, and applied appropriate investigative methods and evaluation techniques. More specifically, however, with regard to the available test boring and cone penetrometer test information, there is a lack of information on seepage and material conditions nearer the downstream toe of Dike C. Marshall Miller recognizes that access on the downstream slope and along the toe of the starter dike is restrictive and might have impeded exploration of the area. Nevertheless, the lack of information on seepage and material conditions nearer the downstream toe causes uncertainty with the study and its associated conclusions and opinions about the Dike C conditions.

8.1. FINDINGS

In Marshall Miller's opinion, the seepage analyses methodology applied by Stantec was appropriate and reasonable, based on a review of the Dike C Report and supporting documentation. However, Marshall Miller noted the following seepage modeling aspects and areas that might contribute to more severe seepage conditions than reflected by the Stantec evaluations:

- The starter dike was reported to have been raised on different occasions, which is supported by the multiple layers of ash and clay materials shown in the test boring logs. However, the seepage models did not incorporate this layering in the dike system cross section. The variability of the materials comprising the dike system introduce considerable uncertainty into the seepage modeling, and reinforces the need to compare the modeling results with the subsurface data (piezometric data, moisture content profiles, cone penetrometer test pore pressure profiles, visual descriptions of recovered samples, geotechnical index data, etc.)

- There were multiple instances where piezometer readings indicated higher phreatic surfaces and porewater pressure contours than reflected by the seepage modeling results. These included the following:
    - The piezometer readings for PZ-10(U).
    - The piezometer readings for PZ-14(U).
    - The piezometer readings for PZ-18(U).
- The calculated exit gradient and factor of safety against piping were higher and lower, respectively, than recommended in the USACE Engineering Manual EM 1110-2-1901. Stantec did not provide recommendations to address the high exit gradient or the low factors of safety against piping.
- Piezometers were not installed at the geotechnical cross-sections at Station 138+27 and Station 149+14; therefore, there is no way to verify the accuracy of the Seep/W model analyses at these locations. Stantec's report does not explain why piezometers were not installed at these slope stability sections, nor how the predicted seepage conditions were validated absent this piezometric data.

8.2. RECOMMENDATIONS

Based on the findings described above, Marshall Miller has developed the following list of recommendations for consideration:

- The seepage model for each section should be adjusted to represent the actual piezometer readings. As a general principle, whenever field data is available, it should be used to produce models that better reflect the actual site conditions.
- According to Stantec, the exit gradient and corresponding factor of safety against piping will be addressed in the buttressing plan. Stantec should follow through and evaluate the exit gradient and corresponding factor of safety against piping in the buttressing plan.

- Additional piezometers should be installed at cross-sections located at Station 138+27 and Station 149+14 to provide site-specific data for calibration and validation of the predicted seepage conditions at these cross-sections.

Item 9: DIKE C EMBANKMENT REMEDIATION WORK PLAN

Marshall Miller reviewed Stantec's preliminary analyses of a slope buttress system for Dike C. While a formal peer review of the slope buttress system design was not performed, findings from the peer review of the Dike C slope stability should be considered during the development of the phases comprising the final buttressing configuration. The preliminary Dike C buttress system reviewed by Marshall Miller did not include the final buttress system configuration, the slope stability calculations prepared to evaluate the preliminary or final buttress design, or the methods for improving the low factor of safety against seepage piping through the embankment.

9.1. COMMENTS AND SUGGESTIONS

Based on our review of the preliminary information supplied by Stantec, Marshall Miller offers the following comments and suggestions:

- The process and rate of constructing an embankment buttress system to stabilize the raised portion of Dike C could inadvertently decrease (temporarily or otherwise) the stability of the Dike C embankment under certain failure modes. Accordingly, the construction sequence and the evolving buttress configuration may warrant the evaluation of interim construction conditions, and not just the planned final (stabilized) configuration.

- The lack of subsurface information near the downstream toe of the starter dike, which is within the Watts Bar Reservoir, should be recognized by Stantec as an area of uncertainty that could affect the stability of the slope buttress system itself, especially if the rate of the buttress system construction prompts increased pore pressures within the loose finer-grained foundation soils.

- The weaker links in the dike containment system (i.e., location-specific approach) should be specifically identified and evaluated when assessing stabilization plans to ensure that the more marginal reaches of the dike system are stabilized to an appropriate margin of safety.

May 11, 2010

Robert E. Martin, ET 3C-K

RESPONSE TO OIG DRAFT INSPECTION, 2009-12910-01 – PEER REVIEW OF STABILITY ANALYSIS OF DIKE C AT KINGSTON FOSSIL PLANT

Attached, please find two documents in response to your draft inspection regarding the Peer Review of Stability Analysis of Dike C at Kingston Fossil Plant. Both AECOM and Stantec have provided written response to all conclusions and recommendations provided by OIG's consultant Marshall Miller & Associates.

One action has been taken as a result of MM&A report, and that is the installation of the two new Piezometers at Kingston Dike C; at locations STA 149+14 and STA 138+27. These two instruments will be installed by June 3rd, 2010.

Robert M. Deacy
Senior Vice President
Fossil Generation Development & Construction
LP 5D-C

JAR:
Attachment
Cc (Attachment)
William R. McCollum, Jr., LP 6A-C
Peyton T. Hairston, Jr., WT 7B-K
John C. Kammeyer, LP 5D-C
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OIG File No. 2009-12910-01

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May 5, 2010 lel_006_175669093

Mr. John Kammeyer, PE
Vice President
Tennessee Valley Authority
1101 Market Street, LP 5G
Chattanooga, Tennessee 37042

Re: Response to Comments
Marshall Miller Review - April 12, 2010
Stantec Report of Geotechnical Exploration and Slope Stability for Dike C (August 3, 2009)

Dear Mr. Kammeyer:

As requested, Stantec has completed a review of Marshall Miller and Associates (Marshall Miller) report: Peer Review of Stantec Consulting Services, Inc. Report of Geotechnical Exploration and Slope Stability for Dike C Dated August 3, 2009, dated April 2010. Marshall Miller's comments and Stantec's responses are enumerated below. Please note the format of the referenced Marshall Miller document does not numerate specific comments. Stantec has attempted to group general comments and provide a consolidated response based on the nature of the comment.

Comment 1 A:

Marshall Miller advocates the use of location-specific shear strength parameters for the key material layers, based on data obtained at and proximate to the dike sections that are more critical with respect to (1) geometric configuration, (2) seepage conditions, (3) material classification, (4) the relative consistency of the materials as indicated by the in-situ testing, particularly for the highly variable foundations soils. It is important to characterize the shear strengths (drained and undrained) of key materials from a more local or discrete perspective, rather than a site-wide perspective, such that the more critical reaches of the dike system are identified and appropriately stabilized.

Comment 1 B:

Stantec developed site-wide shear strength parameters based on site-specific exploration and laboratory data. The characterization and application of site-wide shear strength parameters underutilizes the exploration data and risks masking (or discounting) the

existence and significance of particularly critical reaches of the containment dike system. The Stantec approach does not fully capture the variations in the factors of safety due to the potential variability in the soil shear strengths.

Comment 1 C:

At station 132+37, Stantec used a friction angle of 27 degrees for most of the alluvial foundation soils and 28 degrees for a thin, sensitive silt/clay layer within the foundation. The alluvial foundation soils (i.e., soil below the estimated pre-existing ground line) through this area consist of (1) silty sand to sand silt (as shown in Table 9 of the Dike C Report) and (2) high and low plasticity clay with relatively low standard penetration test blow counts (N-values) to no measurable blow count (i.e., standard penetration tests blow counts equivalent to weight of hammer (WHO) or weight of rods (WOR)) and low cone penetrometer test correlated friction angles (significantly lower than 27 degrees). Based on Marshall Miller's review of the exploration data, particularly within the subject weaker link reach of the dike containment system, zones of cohesive (CL, CH, and ML) soil exist in the foundation. Consistent with typical practice, standard penetration tests correlations are not applicable to non-cohesive soils. Marshall Miller determined a representative range of 23 to 25 degrees drained friction angle for the foundation soils was appropriate.

Comment 1 D:

While Stantec classified the foundation zones between and proximate to Station 125+70 and Station 134+30 as sandy, roughly one-half of the laboratory test results indicate the material was silty sand with greater than 40 percent fines content. The fines content of the sandy material and the prevalence of standard penetration test blow counts equivalent to WOH or WOR indicate that the effective friction angle could be quite low. Correlations used to determine effective friction angle based on standard penetration tests blow counts generally indicate a lower-bound friction angle of about 25 degrees. Figure 5.7 from Duncan and Wright (2005), a reference from the Stantec report, is an example correlation that indicates a lower-bound friction angle of about 25 degrees for coarse-grained soils. The applicability of this correlation is questionable, especially given the overall fineness of the foundation deposit between Station 125+70 and Station 134+30, the absence of a measureable blow count in many instances, and the consistency reflected by the cone penetrometer test profiles.

Comment 1 E:

The weaker links in the dike containment system (i.e., location-specific approach) should be specifically identified and evaluated when assessing stabilization plans to ensure that the more marginal reaches of the dike system are stabilized to an appropriate margin of safety.

Comment 1 F:

The lack of subsurface information near the downstream toe of the starter dike, which is within the Watts Bar Reservoir, should be recognized by Stantec as an area of uncertainty that could affect the stability of the slope buttress system itself, especially if the rate of buttress system construction prompts increased pore pressures within the loose finer grained foundation soils.

Response 1 A through F:

It is Stantec's professional opinion that the scope of geotechnical exploration, laboratory testing program and subsequent stability analysis were performed in accordance with standard industry practice using that degree of care and skill normally exercised by competent members of the engineering profession. In addition, it is our opinion that the results adequately characterize the structural stability of Dike C. It should be noted that TVA has proactively implemented an overall Dike C Risk Mitigation Plan based on the results of the geotechnical exploration. The plan includes hazard classification of the structure, a dike mitigation construction-emergency action plan, continued instrumentation monitoring and dam safety inspections as well as structured construction quality control plans. In order to implement the plan quickly and facilitate on-going recovery from the December, 2008 dredge cell incident, the design and construction efforts are being executed on parallel paths with designated linear buttress segments and two stages of construction. Parametrically, the buttress design addresses any foreseeable localized variability in existing dike material properties and maintains adequate short-term and long term factors of safety for slope stability and seepage failures.

Comment 2:

The Stantec report states that past shallow sliding of the downstream face of Dike C was reported in the project records; however, the locations of the past slide(s) were not provided.

Response 2:

Documented failures are presented in AECOM's Root Cause Analysis Report. It should be noted that all documented events appear to have occurred within the limits of failure of the 2008 incident and those elements are no longer present on-site.

Comment 3:

The Kingston Dike C site is located within a region with known moderate seismic risk. However, no seismic stability evaluations were included in the Stantec Dike C Report.

Response 3:

The scope of the subject stability analysis was focused on characterizing Dike C stability under static conditions. Stantec has completed additional analyses to evaluate the probability that an earthquake would fail Dike C during the remaining service life. Reference Stantec's report; TVA Kingston Fossil Plant Ash Pond Dike C Seismic Risks during Remaining Service Life Revision 1, dated April 9, 2010 for seismic analyses completed to date.

Comment 4:

Stantec used a bathymetric survey that did not reflect current conditions. The survey was dated March 10, 2009. Due to changes in river hydraulics and dredging activities, the March 2009 survey may not accurately reflect current conditions.

Response 4:

The base map for Dike C including the bathymetric data was initially developed using the information made available by TVA. The topographic data was obtained from various LIDAR and hydrographic surveys; refer to Table 4.1 below for a list of all surveys used.

Table 4.1: LIDAR and Hydrographic Survey Sources

Filename	Content
Kingston Ash Pond 1' Contours NAD27 02-25-09.dwg	1' Contours based on LIDAR data from 2-25-09
Kingston Regional NAD27 2' Contours.dwg	2' Contours of the larger area based on data from 12-30-08
TBK776.SND	Hydrographic survey of intake channel and Emory River from 12-23-09 to 1-8-09
TBK77V.SND	Hydrographic survey of inlet of intake channel 1-30-09
TBK776AA.SND	Hydrographic survey of the ash and stilling ponds 2-10-09
TBK776AD.SND	Hydrographic survey of the Emory River adjacent to the spill 2-23-09
TBK776AE.SND	Hydrographic survey of the Emory River adjacent to the spill 3-10-09
TBK776W.SND	Hydrographic survey of Emory and Clinch River 1-31-09

The topographic and bathymetric information is considered adequate to support the analysis and conclusions.

In association with on-going December, 2008 incident recovery and buttress engineering design, additional bathymetric and vibracore surveys have been completed. Stantec continues to evaluate this data and provide engineering support to both initiatives. This support includes development of engineering recommendations related to ash dredging within the proximity of Dike C and evaluation of river bottom geometry following dredging. To further reduce the risk of over-excavation of ash into the native foundation soils at the toe of Dike C, Stantec has recommended that hydraulic dredging should not occur within 60 feet of the rockfill buttress (between 200 and 260 feet from the dike centerline). Dredging of ash near the toe of Dike C is being accomplished using mechanical means, where better control of the exaction limits can be maintained.

For the buttress construction along the northern portion of segment D, complete cross section surveys of the native lake bottom have been conducted at 100' intervals. At each 100' interval, cross section surveys were taken along the actual excavated river bottom subgrade, at the top of each filter layer, and finally along the top of the completed buttress.

The northern half of segment D of the buttress construction is within an area of significant ash deposition following the breach, and therefore possible to have discrepancies between the assumed and actual lake bottoms. Geometry discrepancies have been noted for the 1000 feet +/- of the buttress that has been constructed from Sta 160+00 to Sta150+00, but over this length the actual as surveyed lake bottom geometry is typically very similar to the geometry as assumed for the analysis. The most significant discrepancy between the as analyzed and actual geometries occurred at Sta 154+00. In this case, the actual lake bottom extended to elevation 730 feet +/-, or approximately 5 feet lower than was originally assumed. The actual surveyed lake bottom for this section along with the previously assumed lake bottom is shown on Drawing 2 in Comment 4 Appendix. During the excavation of the ash material and the subsequent buttress construction within this area, Stantec noted the discrepancy and performed additional stability evaluation to ensure the buttress design still satisfies the project requirements.

The stability evaluation for the section at Sta 154+00 using the as-surveyed lake bottom geometry and with the buttress in place is shown on Figures 1 to 3 in Comment 4 Appendix with the results summarized in Table 4.2 below. This stability section was developed based on as-built surveyed ground geometry with subsurface soil conditions from the previously analyzed stability section at Sta 149+14. Using the same shear strength parameters and SEEP/W input file as outlined in Stantec's August 3, 2009 stability report, and under steady state conditions, the buttress design at this critical section satisfies the slope stability requirements, with Table 4.2 listing the estimated factors of safety for the various slip surfaces. The cross section at this location was also reviewed to ensure that the filter will provide an adequate factor of safety against piping. With the filter and buttress in place, the estimated factor of safety against piping is estimated to be 18.6 (Table 4.2) which is acceptable as per USACE 1110-2-1901.

Table 4.2: Summary of Estimated Factors of Safety for Buttressed Conditions at station 154+00

Cross Section	Slope Stability Safety Factors			FS Against Piping
	Raised Dike	Starter Dike	Overall Deep Seated	
154+00	2.28	1.91	1.82	18.6

To further refine the data obtained from the Table 4.1 sources, two vibracore studies have been completed, dated November 2009 and April 2010, respectively. The vibracore work has been completed to evaluate the thickness of spilled ash and confirm the elevation of the native lake bottom along the toe of Dike C. The location of the vibracore holes is shown on Drawing 1 in Comment 4 Appendix. The vibracore hole locations have been concentrated near the southern half of segment D and along the entirety of segments A through C. Also shown on Drawing 1 is a summary table of the lake bottom surface elevation based on the vibracore data, the lake bottom surface based on the original LIDAR and bathymetric surveys, and the discrepancy between the two.

Discrepancies have been identified in areas of the existing Dike C toe. Between stations 141+00 to 148+00 the vibracore results indicate the river bottom elevation to be between 4 and 10 feet below the LIDAR and bathymetric survey results. A similar discrepancy exists between stations 126+00 to 127+00 and between stations 116+00 to 117+00.

Based on the referenced vibracore/bathymetric survey data, and results of the additional analyses performed for section 154+00, Stantec will continue to review as-built survey information as it becomes available and will continue to assess the adequacy of the designed mitigative measures against the actual conditions encountered. Further, Stantec will be completing an As-Built report upon the completion of the Dike C buttress construction to document that target factors of safety are maintained through implementation of the Risk Mitigation Plan.

Comment 5:

The starter dike was reported to have been raised on different occasions, which is supported by the multiple layers of ash and clay materials shown in the test boring logs. However, the seepage models did not incorporate this layering dike system cross section. The variability of the materials comprising the system introduce considerable uncertainty into the seepage modeling, and reinforces the need to compare the modeling results with subsurface data (piezometric data, moisture content profiles, cone penetrometer test pore pressure profiles, visual descriptions of recovered samples, geotechnical index data, etc.)

Response 5:

Noted. The starter dike was originally constructed to an elevation of approximately 748 ft using residual clay and ash materials. In 1974, the starter dike underwent an interim raise of approximately 1.5 ft to provide additional freeboard capacity. From the borehole drilling, there was significant layering of various materials that makes up the starter dike as a whole, however, these layered materials showed reasonable similarity.

There were a total of 11 Atterberg Limit tests and 13 grain site tests performed on the constructed ash and clay materials that make up the starter dike. These tests were performed on samples taken from 11 boreholes along the top of the starter dike and are labeled as "Starter Clay Dike" or "Constructed Ash" materials in Table 5-1 in Comment 5 Appendix. From the Atterberg Limit Tests performed on starter dike materials, the liquid limit ranged from 23 – 44% (average 33%) with the plastic limit ranging from 14 – 26% (average 19%). The grain size of the material was similarly consistent and generally contained 0-30% gravel sized particles, approximately 30% sand-sized particles, 15 – 30% silt-sized particles, and 10 – 25% clay-sized particles. Moisture content tests from all soil samples taken from the starter dike materials are shown in Figure 5-1 in Comment 5 Appendix and show very consistent moisture content values at between 10 – 30%.

Based on the consistent nature of the materials found within the starter dike, the seepage modeling that was performed for all cross sections generally utilizing a constructed ash layer overlaying a residual clay layer to make up the starter dike. To be consistent with the layering of the constructed ash layer versus the residual clay layer, the constructed ash layer was assigned a horizontal to vertical hydraulic conductivity ratio of 2.5 times greater than the residual clay. When the seepage analysis was performed, a parametric evaluation was also performed on material properties of all materials to best match the monitored piezometer levels.

The piezometers that were installed at the site were placed at five zones generally corresponding to the locations of the stability sections. At each zone, there was one piezometer installed within the starter dike, and three nested piezometers within the raised dike. The raised dike piezometers consisted of a deep screen tip zone (elevation range 710 – 725 ft), an intermediate screen tip zone (elevation range 735 – 751 ft) and a shallow screen tip zone (elevation range 750 – 762 ft). Each of the piezometers has been monitored since installation to the current date, with all piezometer reading up to the beginning of March included in Figure 5-2 to 5-6 in Comment 5 Appendix. In general, all piezometers have decreased with the lowering of Watts Bar Lake during the fall of 2009, suggesting a direct hydraulic link with the piezometer tips and the lake, especially with the starter dike piezometers. There is also a general decrease in the piezometer level readings within the raised dike piezometers from the shallow screen tip to the deep screen tip, suggesting an overall downward hydraulic gradient from the dike fill soils down to the native soils.

For the one year (approximate) monitoring period of the piezometers to date, there appears to be a distinct groundwater regime with the lake at its regulated summer level (elevation 741 ft) versus when the lake is at its regulated winter level (elevation 737 ft). As anticipated, the

groundwater level regime with the lake at the summer level is higher than the groundwater regime with the lake at its winter level. The approximate water levels within the piezometers for the summer and winter lake levels are shown in Table 5-2 in Comment 5 Appendix. Also shown in Table 5-2 is the equivalent total head at the piezometer locations as estimated from the SEEP/W assessment. The seepage assessment was performed using the winter lake level as a boundary condition and material seepage parameters to match the known levels within the piezometers at the time of the analysis, which corresponded to the groundwater regime at the summer lake level.

Using the information as stated above, Stantec offers the following conclusions:

- The starter dike materials (i.e. clay fill and ash) are relatively consistent throughout the majority of the dike length based upon index and moisture content testing.
- In known areas of constructed ash used as part of the starter dike, the horizontal to vertical hydraulic conductivity ratio of the ash material was appropriately modeled as several times greater than that of the clay materials to match the observed layered nature of the ash.
- The seepage modeling that was performed as part of the August 3, 2009 Dike C stability report utilized a winter lake level boundary condition and matched the water level within the piezometers that had been monitored up to that time. With subsequent monitoring of the piezometers through the fall and winter of 2009/2010, the actual groundwater regime with the lake at its winter level is generally lower than what was originally modeled resulting in a conservative pore water pressure regime for most of the modeled cross sections. The monitored water levels within the starter dike piezometers are in particular significantly lower with the lake at its winter level than the modeled total head from the seepage assessment at the same location.

It is Stantec's professional opinion that the variability of the materials comprising the dike system has been adequately incorporated into the modeling, and that the seepage modeling performed matches well with the actual piezometer monitoring results.

Comment 6:

There were multiple instances where piezometer readings indicated higher phreatic surfaces and porewater pressure contours than reflected by the seepage modeling results. These include the following:

- *The piezometer readings for PZ-10(U)*
- *The piezometer readings for PZ-14(U)*
- *The piezometer readings for PZ-18(U).*

Response 6:

Noted. There were several instances where piezometer readings seemed to indicate a higher phreatic surface and corresponding pore water pressures than reflected by the seepage modeling. Piezometers PZ-10(U), PZ-14(U), and PZ-18(U) were given as examples.

The piezometers PZ-14(U) and PZ-18(U) have piezometer screen tips at elevation 752.9 ft and 756.7 ft, respectively. The monitored water levels within these two piezometers have been consistently at the bottom of the screen tip since the monitoring began. It appears that subsequent monitoring since installation has detected the water level to be between the bottom of the capped piezometer tube and the bottom of the screened zone and not corresponding to a true groundwater level at these locations. Nested piezometers adjacent to PZ-14(U) and PZ-18(U) with deeper screened zones have been monitored at much lower levels. This would imply the actual pore water pressure regime at depth is more consistent with the deeper piezometer screen tips. Water elevations within the deeper piezometers adjacent to PZ-14(U) and PZ-18(U) are in general agreement with the phreatic surface as determined from the seepage modeling.

Piezometer PZ-10 has been monitored at a relatively consistent elevation of 755 ft since its installation. The screen tip for this piezometer is at elevation 752.2 ft, and below the monitored level. The piezometer monitored level is also very consistent with the Stilling Pond level (755 ft), therefore a direct hydraulic connection between the piezometer tip and the Stilling Pond is suspected. Water levels with the deeper screen tip piezometers adjacent to PZ-10(U), specifically PZ-11(L) and PZ-12 have both indicated a significantly lower level than PZ-10(U). Piezometer PZ-11(L) has been monitored at Elev. 750 to 751 ft and piezometer PZ-12 has been monitored at Elev. 746 ft with the lake at the summer level and Elev. 743 ft with the lake at the winter level, as shown on Figure 5-4 in Comment 5 Appendix. The two deeper piezometers are considered more representative of the actual pore water pressure at depth and are therefore more influential for the overall stability. These two piezometers have been monitored at or below the total head as generated from the seepage model (seepage total head at elevation 751.6 ft at this location). It is Stantec's professional opinion that the pore water pressure regime at depth is modeled correctly in the analyses. As noted previously, the buttress design addresses the noted potential variances in the material seepage related properties.

Comment 7:

The calculated exit gradient and factor of safety against piping were higher and lower, respectively, than recommended in the USACE Engineering Manual EM 1110-2-1901. Stantec did not provide recommendations to address the high exit gradient or the low factor of safety against piping.

Response 7:

Noted. Stantec has addressed the issue of calculated high exit gradients and associated low factors of safety against piping via implementation of graded filter components developed during the detailed design of the mitigative rockfill buttress.

For Dike C, a graded filter has been designed to increase the factor of safety against piping. The design of the graded filter has been completed using the US Corp of Engineers (USACE) Filter Design (EM 1110-2-2300) as a basis for design criteria.

For the analysis of the rockfill buttress from a seepage prospective, the downstream toe of the buttress was placed at a distance from the toe of the existing starter dike where acceptable vertical exit gradients were achieved downstream of the toe of the buttress. In all cases, the location of the rockfill buttress has been set based on controlling seepage forces.

With the proposed filter and buttress in place, the estimated critical vertical exit gradients along with the factor of safety against piping are shown on Table 7.1. In all cases, the graded filter and the rockfill buttress provide appropriate factor of safety values.

Table 7.1: Summary of Computed Exit Gradients and Factors of Safety against Piping with Buttress in Place

Cross Section	Vertical Gradient (i_v) at Critical Exit Point	Location of Critical Exit Point	Material	FS_{piping}
108+93	0.17	Toe	Silty Sand to Sandy Silt	20.9
119+69	0.37	Toe	Lean Clay	14.5
132+37	0.66	Toe	Clay Starter Dike	6.1
138+27	0.28	Toe	Constructed Ash	12.7
149+14	0.26	Toe	Silty Sand to Sandy Silt	18.6

Comment 8:

Piezometers were not installed at the geotechnical cross-sections at Station 138+27 and Station 149+14; therefore, there is no way to verify the accuracy of the Seep/W model analyses at these locations. Stantec's report does not explain why piezometers were not installed at these slope stability sections, nor how the predicted seepage conditions were validated absent this piezometric data.

Additional piezometers should be installed at cross sections located at station 138+27 and 149+14 to provide site specific data for calibration and validation of the predicted seepage conditions at these cross sections

Response 8:

Noted. Although no piezometers exist at the specific locations of cross-sections 138+27 and 149+14, they were installed at Sta 143+05 and Sta 154+82. These piezometers were originally installed at the same time as the borehole drilling at locations suspected to be used for the critical slope stability sections. Upon review of all subsurface and laboratory data, the cross sections at Sta 149+14 and 138+27 were deemed to be critical for their representative zones. Based on this, the piezometer monitoring results at Sta 154+82 have been assumed to be representative of the stability section at Sta 149+14, representing segment D between Sta 160+00 to Sta 147+00, and the monitoring results from Sta 143+05 representative of the stability section 138+27, representing segment D between Sta 147+00 to Sta 138+00.

Each grouping of piezometers has been taken to be representative of a segment of the dike, or a portion of a segment of the dike, in the same manner that the stability cross sections have been taken to be representative of a segment of the dike. The segments have been divided into their respective limits based on the dike geometry, subsurface soil horizons and similarities in head and tail water conditions. It is Stantec's opinion that this approach is reasonable and generally consistent with acceptable industry standards. The installation of additional piezometers at Sta 149+14 and Sta 138+27, however, would serve as complimentary validation of the groundwater levels and seepage conditions at these two cross sections. In consideration of the subject comment, the planning of the installation of the additional piezometers has been initiated, and will be installed as soon as practicle.

Comment 9:

The process and rate of constructing an embankment buttress system to stabilize the raised portion of Dike C could inadvertently decrease (temporarily or otherwise) the stability of the Dike C embankment under certain failure modes. Accordingly, the construction sequence and the evolving buttress configuration may warrant the evaluation of interim construction conditions, and not just the planned final (stabilized) configuration.

Response 9:

Stantec has completed a detailed analysis considering undrained soil conditions for the Dike C stability for the period immediately following the construction of the buttress. The analysis has been completed using the software UTEXAS4, a slope stability software package, available from ENSOFT. UTEXAS4 has been utilized to perform 3-stage analyses of each of the five representative cross sections with the design buttress in place. The UTEXAS4 software allows for the evaluation of ‚instant' loading due to the buttress construction yet does not consider the strength that the buttress materials will add. Resulting calculated factors of safety determined for the period immediately following construction will be presented in the Dike C Buttress Design Report.

Additionally, Stantec has monitored piezometers on a daily basis that were installed within areas of the dike where the buttress has been completed. These monitored results have not shown an increase in water level, suggesting that the pore water pressure in the fill and native soils is not being influenced by the buttress loading.

Sincerely,

STANTEC CONSULTING SERVICES INC.

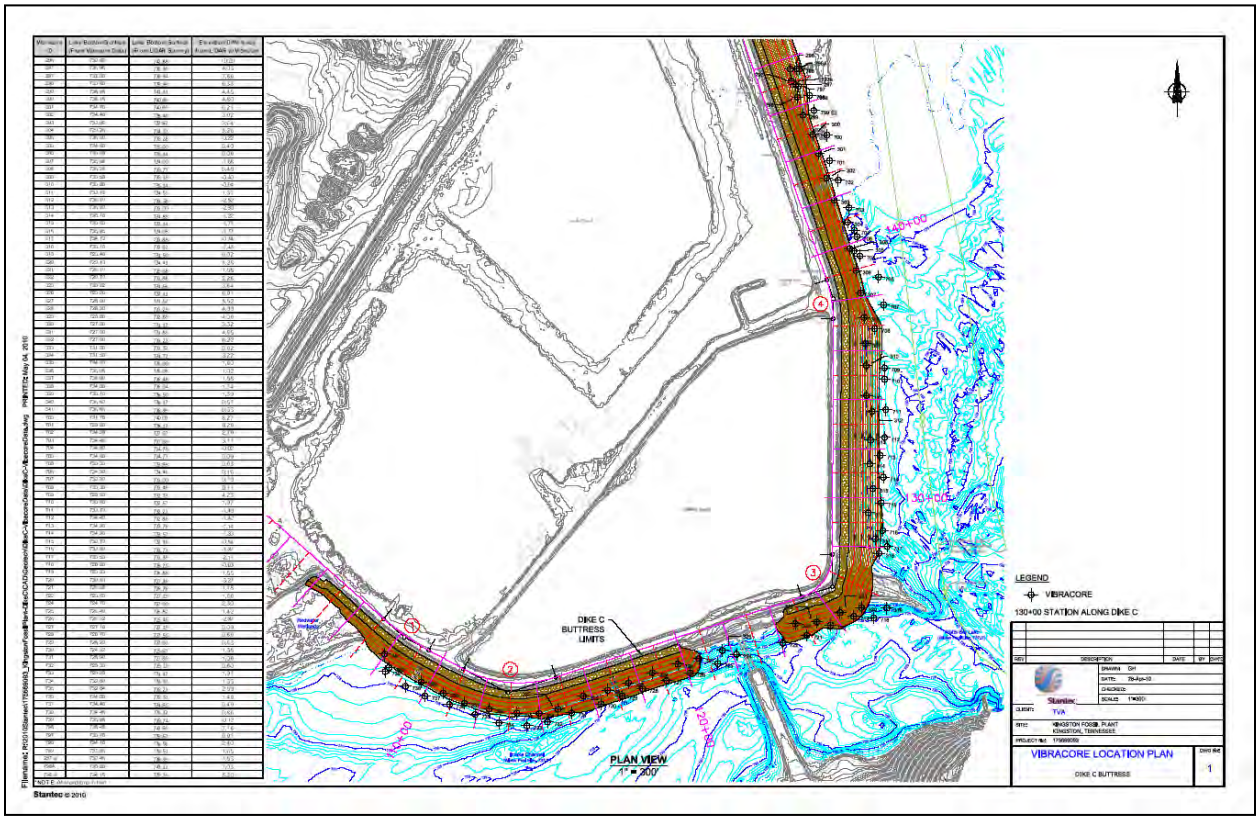
Thomas Crilly
Stantec Quality Assurance

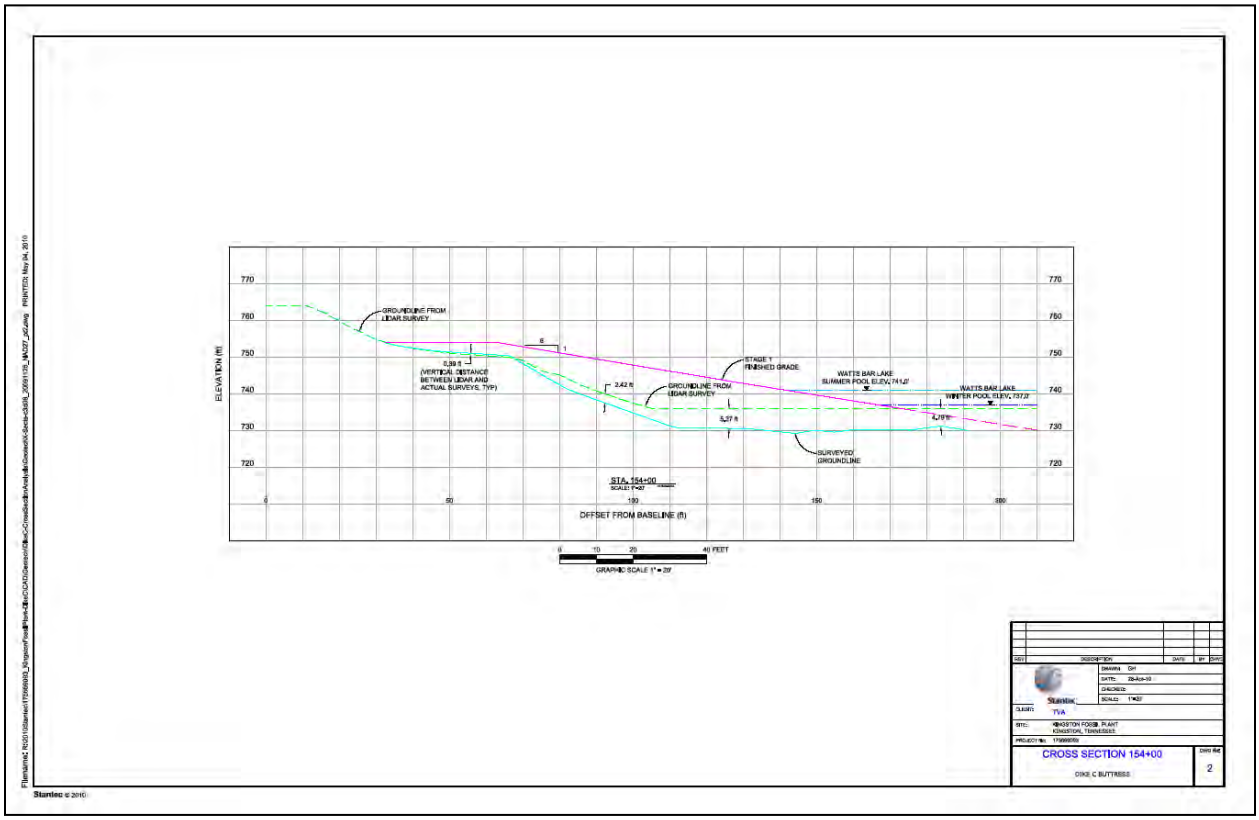
Don W. Fuller II, PE
Principal

jp/tc/cmw

Comment 4 Appendix
Comment 5 Appendix

Comment 4 Appendix


DIKE C BUTTRESS LIMITS
PLAN VIEW
1" = 200'
LEGEND
VIBRACORE
130+00 STATION ALONG DIKE C
VIBRACORE LOCATION PLAN
DIKE C BUTTRESS
Stantec © 2016


770
760
750
740
730
720
ELEVATION (ft)
GROUNDLINE FROM LIDAR SURVEY
6
1
0.39 ft
(VERTICAL DISTANCE BETWEEN LIDAR AND ACTUAL SURVEYS, TYP)
STAGE 1 FINISHED GRADE
WATTS BAR LAKE SUMMER POOL ELEV. 741.0'
WATTS BAR LAKE WINTER POOL ELEV. 737.0'
3.42 ft
GROUNDLINE FROM LIDAR SURVEY
5.27 ft
4.70 ft
SURVEYED GROUNDLINE
STA. 154+00
SCALE: 1"=20'
0
50
100
150
200
DIFFSET FROM BASELINE (ft)
0
10
20
40 FEET
GRAPHIC SCALE 1" = 20'
Stantec
TVA
KINGSTON FOSSIL PLANT
KINGSTON, TENNESSEE
CROSS SECTION 154+00
COKE C BUTTRESS
2
Stantec © 2016

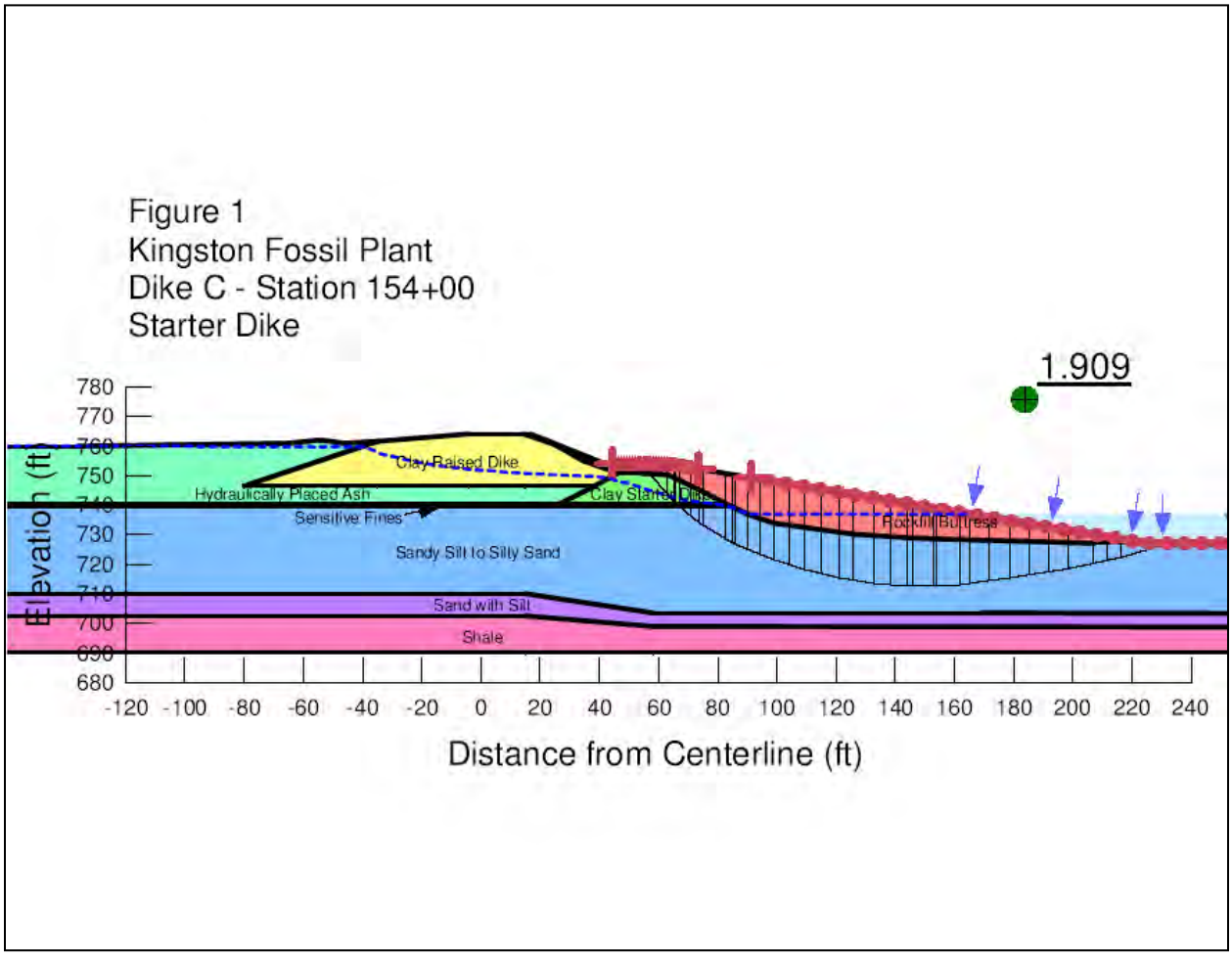


Figure 1
Kingston Fossil Plant
Dike C - Station 154+00
Starter Dike
1.909
Clay Raised Dike
Hydraulically Placed Ash
Sensitive Fines
Clay Starter Dike
Rockfill Buttress
Sandy Silt to Silty Sand
Sand with Silt
Shale
Elevation (ft)
780
770
760
750
730
720
700
690
680
-120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240
Distance from Centerline (ft)

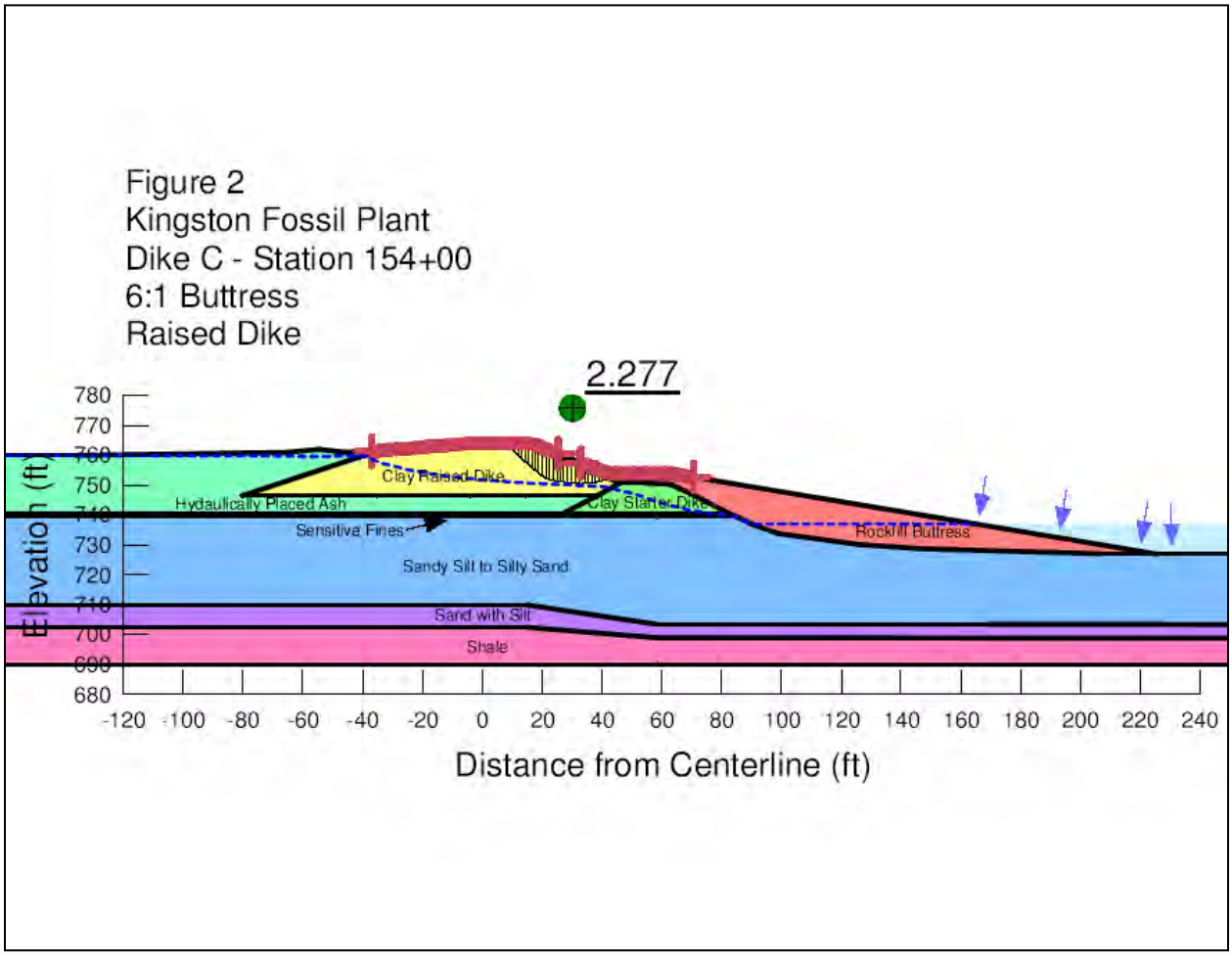


Figure 2
Kingston Fossil Plant
Dike C - Station 154+00
6:1 Buttress
Raised Dike
2.277
Elevation (ft)
780
770
760
750
740
730
720
710
700
690
680
Clay Raised Dike
Hydraulically Placed Ash
Clay Starter Dike
Sensitive Fines
Rockfill Buttress
Sandy Silt to Silty Sand
Sand with Silt
Shale
-120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240
Distance from Centerline (ft)

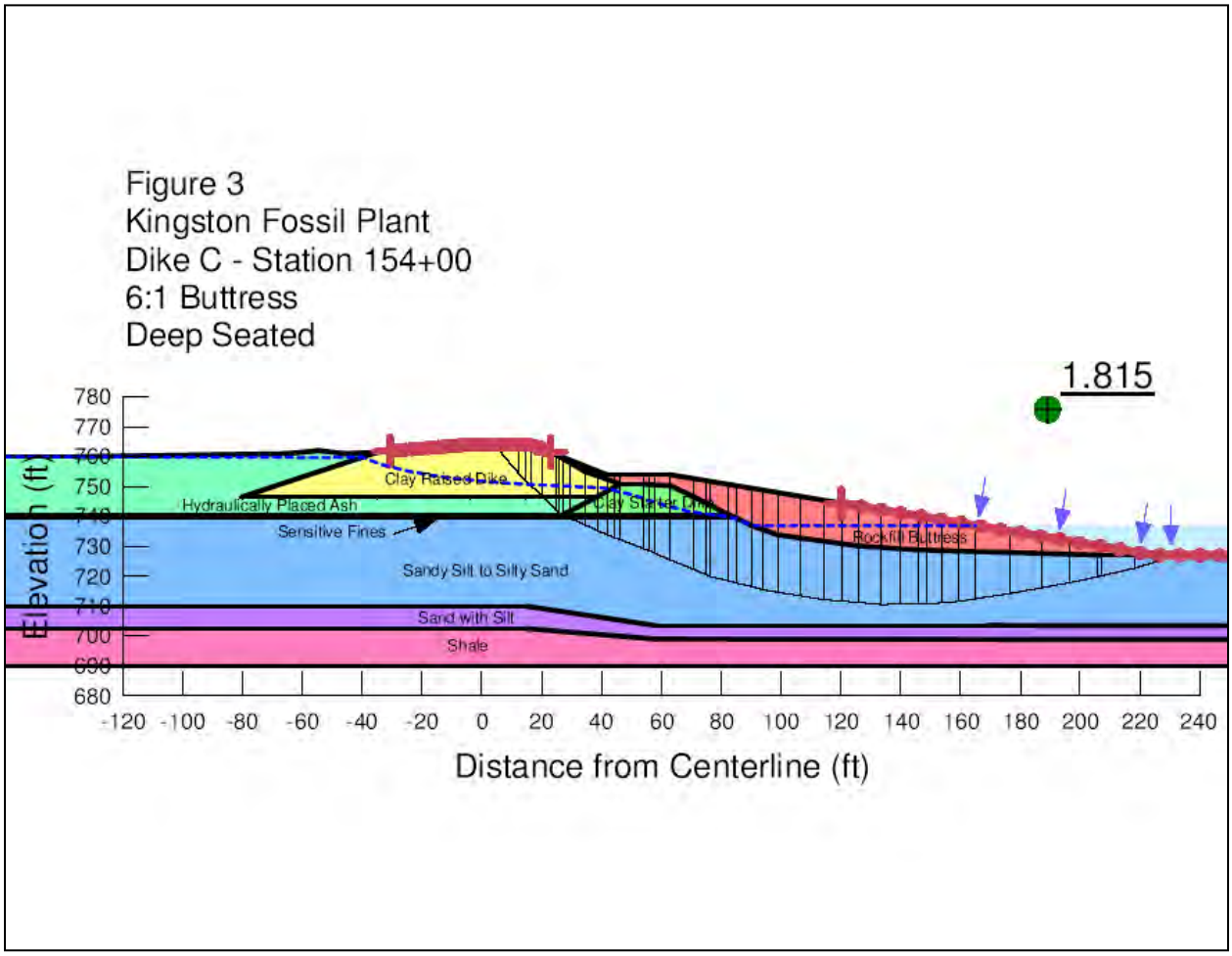


Figure 3
Kingston Fossil Plant
Dike C - Station 154+00
6:1 Buttress
Deep Seated
1.815
Elevation (ft)
780
770
760
750
730
720
700
680
Clay Raised Dike
Hydraulically Placed Ash
Sensitive Fines
Sandy Silt to Silty Sand
Sand with Silt
Shale
Rockfill Buttress
-120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240
Distance from Centerline (ft)

Comment 5 Appendix

Table 5-1
Atterberg Limit and Grain Size Testing Data
Starter Dike Boreholes

							Grain Size Data			
Segment	Location	Elevation	Assumed Soil Layer Description	Moisture Content	LL	PL	% Gravel	% Sand	% Silt	% Clay
A	STN-52	745.7-748.7	Starter Clay Dike	27	40	26	33.4	37.5	18.7	10.4
	STN-71	744.5-747.5	Starter Clay Dike	19	36	20	19.8	46.8	16.2	17.2
	STN-69	746.3-749.3	Starter Clay Dike	29	44	26	29.2	39	14.6	17.2
B	STN-36	744.4-748.9	Starter Clay Dike	15	35	14	21.8	39.6	19.4	19.2
C	STN-64	743.4-746.4	Constructed Ash	20	28	15	13.4	62.1	16.4	11.4
	STN-65	741.1-744.1	Starter Clay Dike	20			20.1	58.2	16.7	5
	STN-62	740.8-743.8	Starter Clay Dike	8			23.6	61.8	13.2	1.4
	STN-65	734.6-735.1	Starter Clay Dike	19	30	22	0	29.2	45.7	25.1
	STN-64	737.4-740.4	Starter Clay Dike	23	28	15	1	34.6	36.3	28.1
	STN-26	731.5-736	Starter Clay Dike	20	26	16	0.4	43.3	30.7	25.6
D	STN-14	748.6-751.6	Constructed Ash	19	41	21	5.2	37.2	27.5	30.1
	STN-60	735.5-738.5	Constructed Ash	20	31	18	0	31.9	38.1	30
	STN-8	746.2-746.7	Starter Clay Dike	20.6	23	15	0.2	36.7	37.2	25.9

Table 5-2

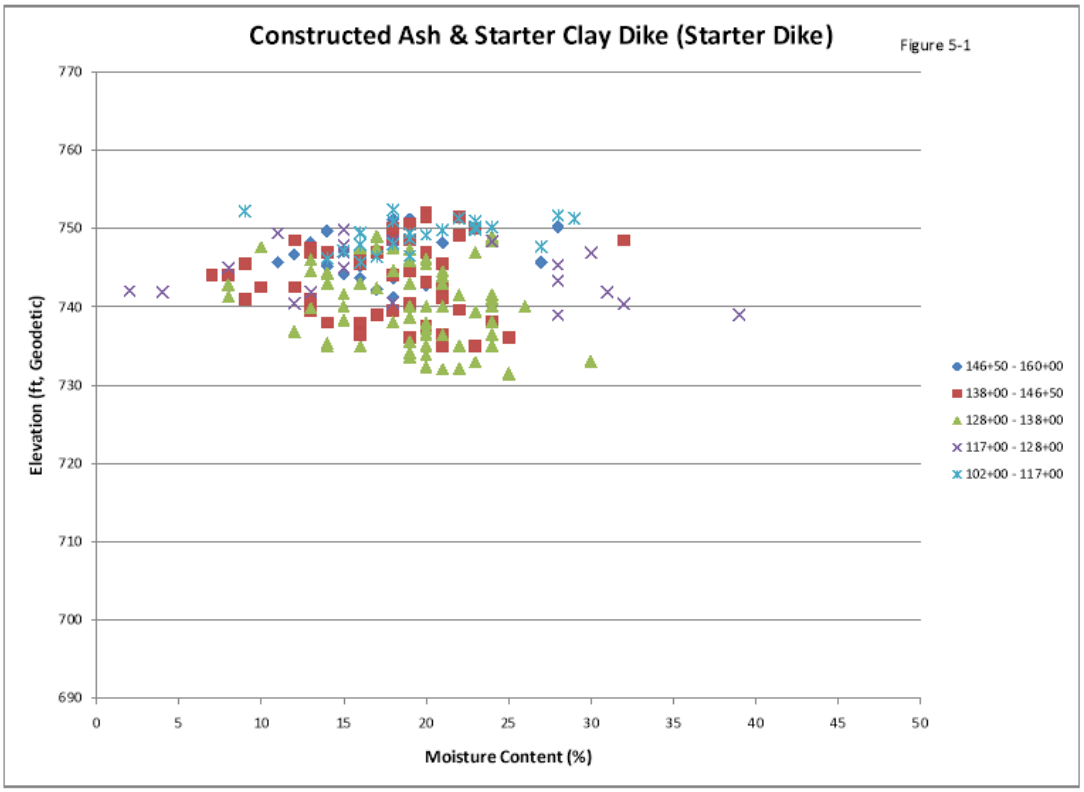
Zone 102+00 – 117+00						
	Starter Dike		Raised Dike			
Lake Level	PZ-17	Total Head from Seepage Assessment	Shallow Screen Zone PZ-18	Intermediate Screen Zone PZ-19	Deep Screen Zone PZ-20	Total Head from Seepage Assessment
Summer (741 ft)	749	N/A	–	752	747.5	N/A
Winter (737 ft)	749	750.9	–	749	745	753.9

Zone 117+00 – 127+00						
	Starter Dike		Raised Dike			
Lake Level	PZ-13	Total Head from Seepage Assessment	Shallow Screen Zone PZ-14	Intermediate Screen Zone PZ-15	Deep Screen Zone PZ-16	Total Head from Seepage Assessment
Summer (741 ft)	741	N/A	–	741	747	N/A
Winter (737 ft)	739.5	737.7	–	738	745	738

Zone 127+00 – 138+00						
	Starter Dike		Raised Dike			
Lake Level	PZ-9	Total Head from Seepage Assessment	Shallow Screen Zone PZ-10	Intermediate Screen Zone PZ-11	Deep Screen Zone PZ-12	Total Head from Seepage Assessment
Summer (741 ft)	741	N/A	755	751	746	N/A
Winter (737 ft)	738	747.9	755	750	743	751.6

Zone 138+00 – 146+50						
	Starter Dike		Raised Dike			
Lake Level	PZ-5	Total Head from Seepage Assessment	Shallow Screen Zone PZ-6	Intermediate Screen Zone PZ-7	Deep Screen Zone PZ-8	Total Head from Seepage Assessment
Summer (741 ft)	743	N/A	755 – 760	747	744	N/A
Winter (737 ft)	741	744	755 – 760	745	741	747.5

Zone 146+50 – 160+00						
	Starter Dike		Raised Dike			
Lake Level	PZ-1	Total Head from Seepage Assessment	Shallow Screen Zone PZ-2	Intermediate Screen Zone PZ-3	Deep Screen Zone PZ-4	Total Head from Seepage Assessment
Summer (741 ft)	745	N/A	756	759	750	N/A
Winter (737 ft)	737	748.4	755	758	745	751.1


Constructed Ash & Starter Clay Dike (Starter Dike)
Figure 5-1
Elevation (ft, Geodetic)
770
760
750
740
730
720
710
700
690
0
5
10
15
20
25
30
35
40
45
50
Moisture Content (%)
146+50 - 160+00
138+00 - 146+50
128+00 - 138+00
117+00 - 128+00
102+00 - 117+00

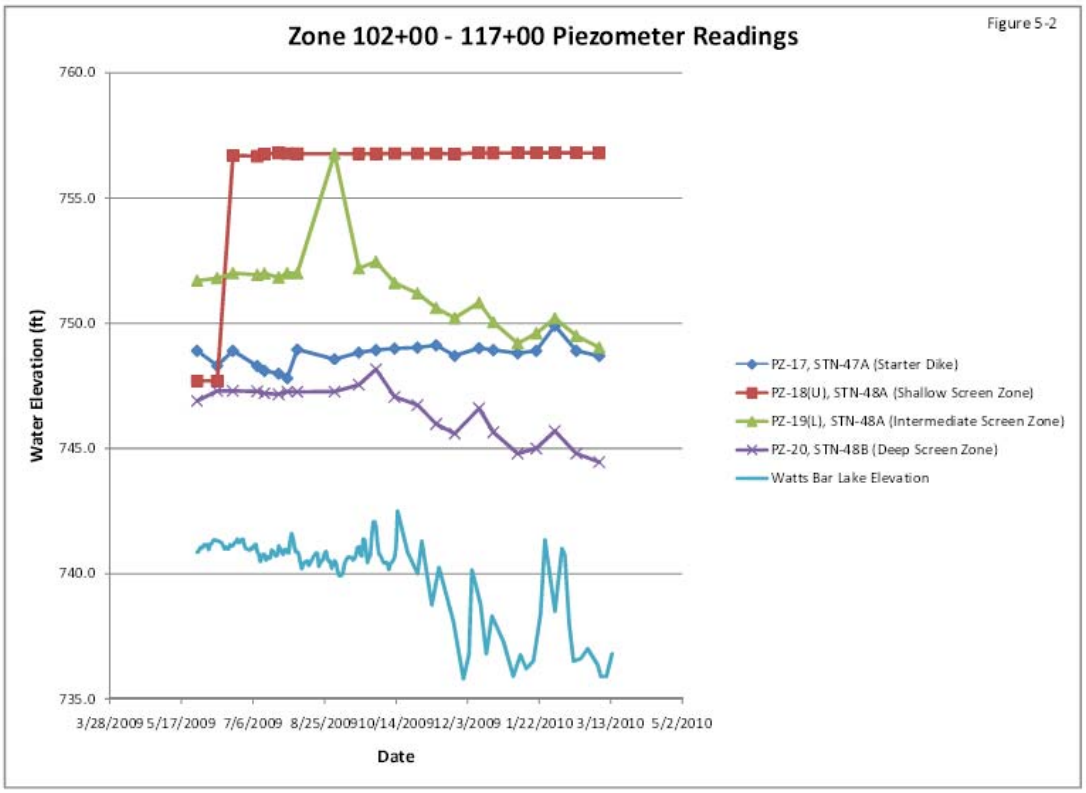
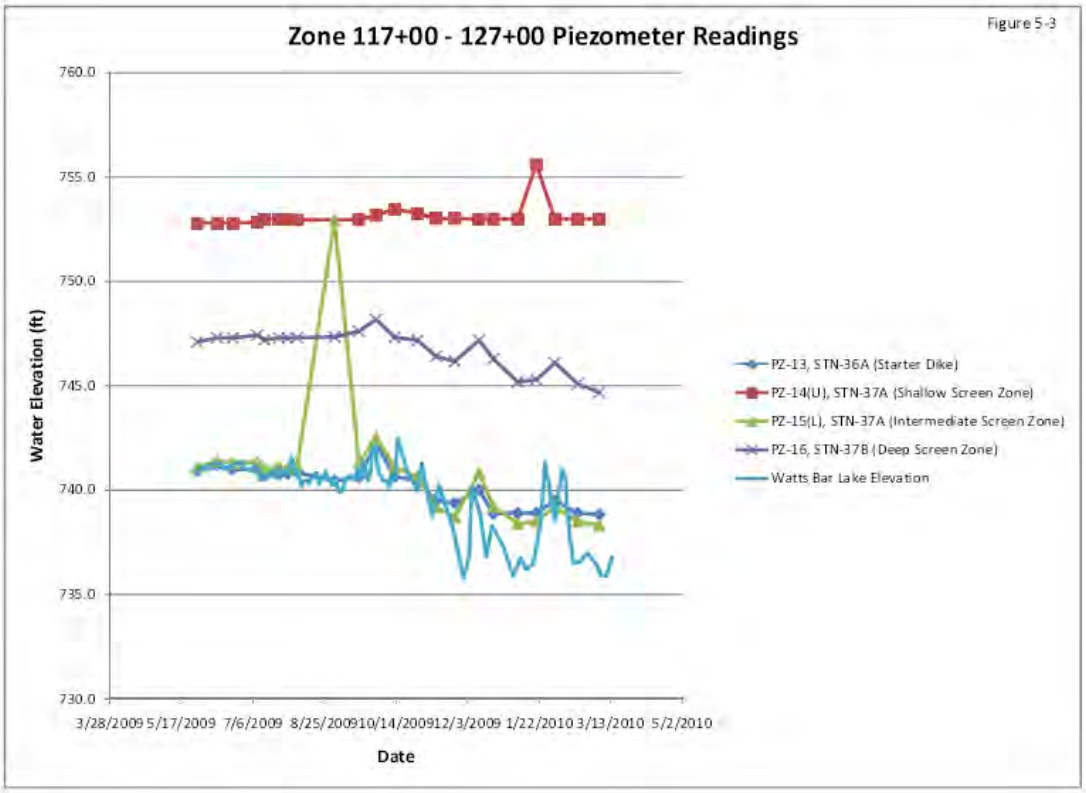
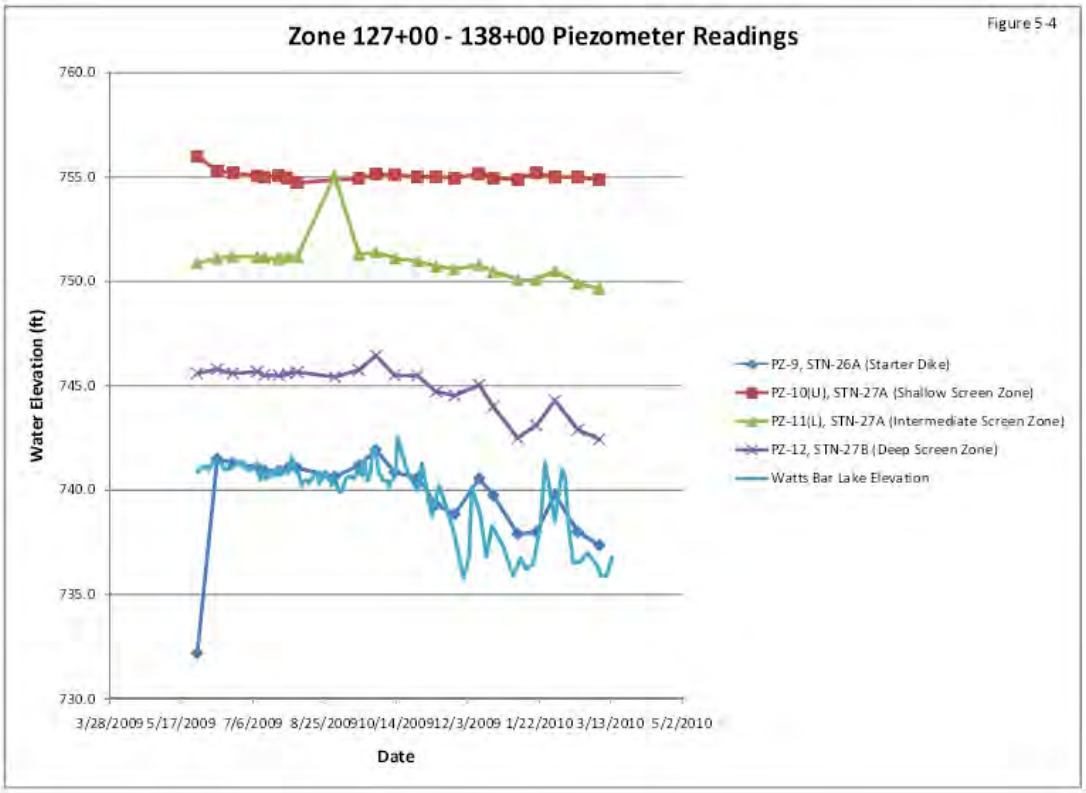


Figure 5-2
Zone 102+00 - 117+00 Piezometer Readings
760.0
755.0
750.0
745.0
740.0
735.0
Water Elevation (ft)
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010
5/2/2010
Date
PZ-17, STN-47A (Starter Dike)
PZ-18(U), STN-48A (Shallow Screen Zone)
PZ-19(L), STN-48A (Intermediate Screen Zone)
PZ-20, STN-48B (Deep Screen Zone)
Watts Bar Lake Elevation


Zone 117+00 - 127+00 Piezometer Readings
Figure 5-3
760.0
755.0
750.0
745.0
740.0
735.0
730.0
Water Elevation (ft)
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010
5/2/2010
Date
PZ-13, STN-36A (Starter Dike)
PZ-14(U), STN-37A (Shallow Screen Zone)
PZ-15(L), STN-37A (Intermediate Screen Zone)
PZ-16, STN-37B (Deep Screen Zone)
Watts Bar Lake Elevation


Zone 127+00 - 138+00 Piezometer Readings
Figure 5-4
760.0
755.0
750.0
745.0
740.0
735.0
730.0
Water Elevation (ft)
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010
5/2/2010
Date
PZ-9, STN-26A (Starter Dike)
PZ-10(U), STN-27A (Shallow Screen Zone)
PZ-11(L), STN-27A (Intermediate Screen Zone)
PZ-12, STN-27B (Deep Screen Zone)
Watts Bar Lake Elevation

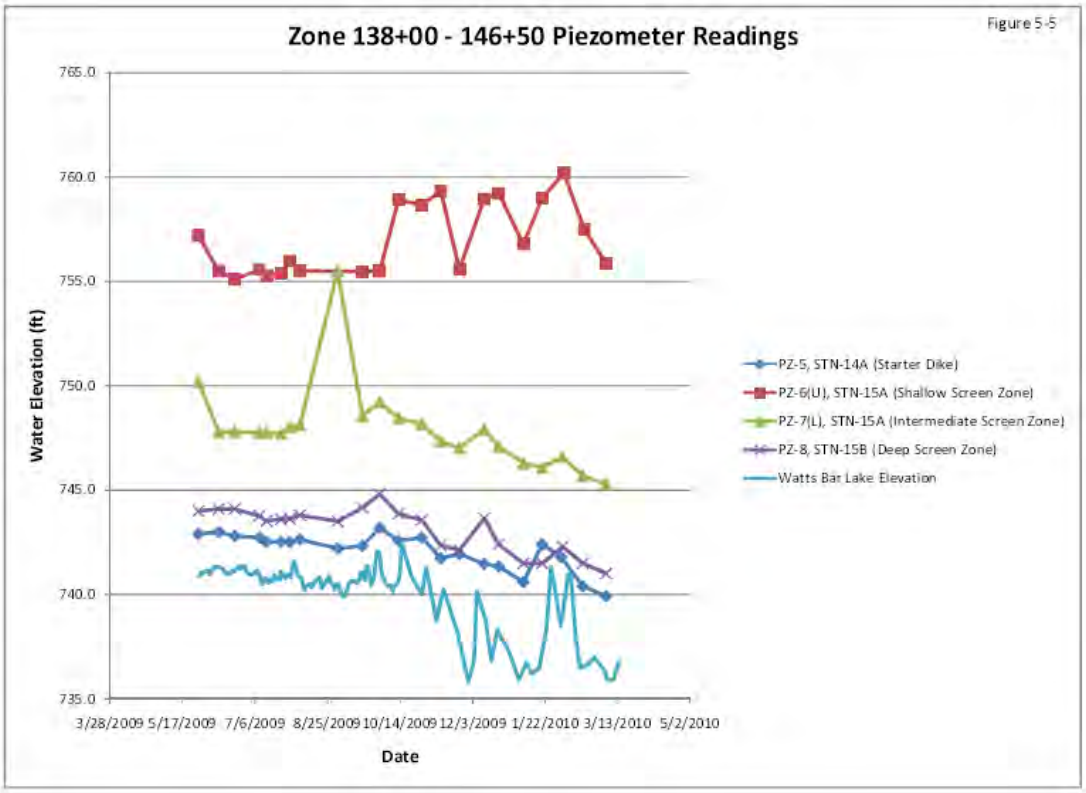


Figure 5-5
Zone 138+00 - 146+50 Piezometer Readings
765.0
760.0
755.0
750.0
745.0
740.0
735.0
Water Elevation (ft)
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010
5/2/2010
Date
PZ-5, STN-14A (Starter Dike)
PZ-6(U), STN-15A (Shallow Screen Zone)
PZ-7(L), STN-15A (Intermediate Screen Zone)
PZ-8, STN-15B (Deep Screen Zone)
Watts Bar Lake Elevation

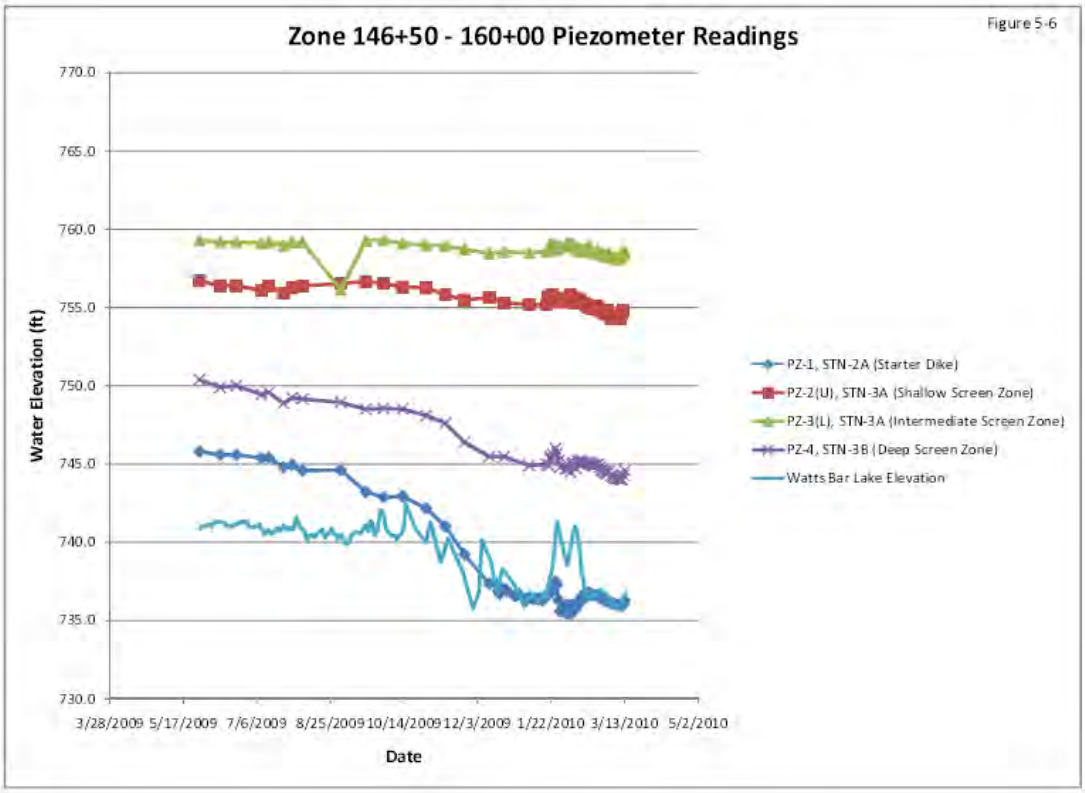


Figure 5-6
Zone 146+50 - 160+00 Piezometer Readings
Water Elevation (ft)
770.0
765.0
760.0
755.0
750.0
745.0
740.0
735.0
730.0
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
1/22/2010
3/13/2010
5/2/2010
Date
PZ-1, STN-2A (Starter Dike)
PZ-2(U), STN-3A (Shallow Screen Zone)
PZ-3(L), STN-3A (Intermediate Screen Zone)
PZ-4, STN-3B (Deep Screen Zone)
Watts Bar Lake Elevation

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April 30, 2010

Mr. John Kammeyer, P.E.
Vice President
Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

Subject: AECOM Review of Marshall Miller Peer Review of Stantec Report of Geotechnical Exploration and Slope Stability for Dike C, Kingston Fossil Plant, Harriman, Tennessee -- AECOM Project No. 60140251, Task 400

Dear Mr. Kammeyer:

As requested, AECOM reviewed Marshall Miller & Associates, Inc. April 12, 2010, peer review letter report addressing their concerns and comments on Stantec's August 3, 2009, Report of Geotechnical Exploration and Slope Stability for Dike C.

Documents Reviewed

As preparation to do this assignment we reviewed the following documents:

- Stantec Report titled Report of Geotechnical Exploration and Slope Stability for Dike C, Kingston Fossil Plant, Harriman, Tennessee, dated August 3, 2009.
- Stantec Technical Specifications, Dike C Buttress, Phase 1 Segment C Construction, Kingston Fossil Plant, Harriman, Roan County, Tennessee, Issued for Construction, R1, dated November 18, 2009.
- Stantec Quality Control Plan, Dike C Buttress, Phase 1 Segment C Construction, Kingston Fossil Plant, Harriman, Roan County, Tennessee, Issued for Construction, R1, data March 19, 2010.
- Stantec letter titled Seismic Risks during Remaining Service Life (Revision 1), Ash Pond Dike C, TVA Kingston Fossil Plant, dated April 9, 2010
- Marshall Miller & Associates, Inc. Report, dated April 12, 2010, and titled Peer review of Stantec's August 3, 2009, report cited above.
- TVA Bathometry for Watts Bar Reservoir, Dwg. file dated April 15, 2010.
- Stantec Table titled Drained SEEP and SLOPE Files for KIF Dike C Buttress Design Report, Kingston Dike C Ash Pond Buttress Stability Analyses, undated.
- Stantec Table titled Factor of Safety with Proposed Works Completed – Preliminary – Work in Progress, April 9, 2010.

Review Summary

We highlighted several of Marshall Miller's report comments and then followed up with our responses to three items in their report:

Item 7: Slope Stability Analyses

Excerpts from Marshall Miller's comments on slope stability findings after reviewing Stantec's Dike C slope stability analyses were:

- *"Stantec applied a site-wide shear strength parameters based on site specific exploration and laboratory data… The Stantec approach does not fully capture the variations in the factors of safety due to potential variability in the soil shear strengths."*
- *"It is Marshall Miller's professional opinion that in some instances Stantec selected shear strengths/friction angles that were higher than should have been used. This led to an overstated minimum factor of safety."*
- *"In the professional opinion of Marshall Miller, the 27 to 29 degree range of drained friction angle for the foundation soils does not encompass the representative values along the more critical reaches of the dike system, where the drained angle could be significantly lower. Based on Marshall Miller's review of exploration data, particularly within the subject weaker link reach of the dike containment system, zones of cohesion (CL, CH, and ML) soil exist in the foundation."*

AECOM Response:

Current Dike C Stabilization Efforts by TVA

There is no active upstream filling, expansion upstream or changes in active pool elevations behind the intact portions of Dike C.

The only short-term loading impacting intact Dike C is the ongoing downstream fill and annual fall drawdown and storm surge drawdown. The dike and its foundation have been subject to more than 50 years of annual fall drawdown and numerous tropical storm surcharge pools. There has been documented shallow seepage related sloughs on the former west end of Dike C that was sweep away by the Dredge Cell 2 failure. There are no recorded deep foundation slides on intact portions of Dike C retaining the ash collection pond and settling basin.

TVA is currently constructing a downstream buttress along the intact portion of Dike C. This buttress includes a sand filter placed against downstream slope of Dike C. This slope has been prepared by removal of surface vegetation, along with dredging any fly ash found at the dike toe. The placement of the buttress stone fill has not caused buttress fill movement. There has been no movement in the Stantec monitored Dike C inclinometers or excess pore water pressure build-up in the Casagrande-type piezometers placed under the crest and starter dike of Dike C. This buttress fill could be considered a rapid filling event; however, no distress has been observed by Stantec who are the full-time inspectors at the site.

AECOM Discussion on Drained Shear Strengths in the Alluvium

In our opinion the Marshall Miller's comment that the weight of hammer alluvium (WOH) should have been assigned a drained effective stress friction angle of 23 to 25 degrees is unwarranted and not supported by the literature or site-specific data under Dike C. We disagree with this comment for the reasons discussed below.

AECOM has reviewed the RCA direct shear testing on samples alluvium from the RCA 200, 700 and 800 series holes and noted Plasticity Indices (PI) for sampled ML, CL, CL-ML, OL and CH soil types to have PI ranging from 5 to 23 indicative, with the 33 percentile (PI) equal to 8. The drained direct shear tests in the alluvium showed friction angles of 27.3 to 33.6 degrees, with the 33 percentile friction angle to be approximately 29 degrees. This compares well to moderate plasticity natural soils shown on Figure 21.4 in Lambe and Whitman (1969) titled, "Soil Mechanics" that references the work of Kenney (1959) that indicates for PI's of 8 and 20, the lowest drained friction angle would be 30 and 27 degrees, respectively. This correlation is similar to the peak friction angle versus PI chart in Terzaghi, Peck and Mesri (1996) titled, "Soil Mechanics in Engineering Practice" (see Figure 19.7). Therefore AECOM believes that the Stantec drained friction of 27 degrees is appropriate for this analysis.

AECOM recommends a drained friction angle of 28 degrees for alluvial layer and 29 degrees for the soft clay alluvium and loose fly ash and clayey silt slimes. We know Stantec focused their efforts to obtain continuous SPT and tube sampling at the expected contact between Dike C and the foundation soils to detect slimes. AECOM did not see any evidence from Stantec's borings that slimes were present under Dike C.

AECOM Responses to Marshal Miller Slope Stability Recommendations

- *"Marshall Miller advocates the use of location-specific shear strength parameters for the key material layers, based on data obtained at and proximate to the dike sections that are more critical with respect to (1) geometric configuration, (2) seepage conditions, (3) material classification, and (4) the relative consistency of the materials as indicated by the in-situ testing, particularly for the high variable foundation soils. It is important to characterize the shear strengths (drained and undrained) of key materials from a more local or discrete perspective, rather than a site wide perspective, such a that the more critical reaches of the dike system are identified and approximately stabilized."*

AECOM Response: Stantec selected the appropriate number of cross-sections and used, in our opinion, standard design drained friction angles and computed factors of safety for this structure. This structure is currently being buttressed with a fill comprised of ASTM C33 fine aggregate concrete sand placed over the prepared subgrade, covered with ASTM No. 57 crushed stone, with TDOT Class B riprap armor to achieve a 4H:1V and 6H:1V fill extending into the dredged reservoir. The buttress fill details are clearly shown on Stantec's "for construction" TVA Drawing Nos. 10W229-40 through 10W220-66.

AECOM agrees with Stantec's drained shear strength properties for the reasons outlined above in the section AECOM Discussion on Drained Shear Strengths in the Alluvium of this letter. This agreement is based on our RCA testing program on Kingston soils and on collaborating classic Soil Mechanics text books that are the industry standard correlations for low plasticity clays that were found at the Kingston site and compared to similar low plasticity clays published in peer reviewed text books.

- *"Stantec should establish shear strength properties with the degree of confidence/conservative normally applied from a design perspective."*

AECOM Response: AECOM supports the Stantec's drained shear strength parameters, as we would use the USACE EM 1110-2-2300 criteria for using the 33 percentile of the data. Stantec's selection of friction angle are more conservative than the standard of practice and are less than what AECOM used in the RCA analysis. Therefore, we concur with Stantec selection of design parameters.

- *"TVA should document the areas where slides occur on record drawings, such the information is part of pre-inspection documentation reviewed by inspectors of KIF wet ash disposal facility."*

AECOM Response: TVA has records of the slide locations in their annual reports and AECOM documented the slides in the RCA report dated June 25, 2009. This is an unnecessary task as Dike C will be buttressed with riprap, covering a reversed filter comprised of crushed stone over sand placed over the prepared native

subgrade with all fly ash removed. Currently, the first stage Dike C downstream buttress construction is in progress along Segments C and D.

- *"TVA has developed a methodology for TVA's seismic assessments of closed coal combustion products facilities. TVA should take appropriate actions to apply these methodologies."*

AECOM Response: Stantec has addressed this issue in their letter to TVA titled, Seismic Risks during Remaining Service Life (Revision 1), Ash Pond Dike C, TVA Kingston Fossil Plant, dated April 9, 2010. We understand TVA is currently assessing risk versus time of exposure and various closure options.

- *"The existing ground surface (exposed or submerged) downstream of the dike system should be verified and potential change so dredging activities in the Watts Bar Lake areas be evaluated and accounted."*

AECOM Response: In accordance with the Stantec's design and QA plan, the TVA contractors are required to place the buttress on a native soil subgrade cleared of the failed fly ash flow slide. AECOM has seen the post dredging bathometry to define subgrade topography on which the buttress fill is being placed.

Item 8: Seepage Analyses

In Marshall Miller's opinion, the seepage analyses methodology applied by Stantec was appropriate and reasonable, based on a review of the Dike C Report and supporting documentation. However, Marshall Miler noted the several issues that might contribute to more severe seepage conditions than reflected by Stantec evaluation.

Excerpts from the Marshall Miller opinions were:

- *"There were multiple instances where piezometer readings indicated higher phreatic surface and porewater pressure contours than reflected by the seepage modeling results." These include the following: The piezometer readings for PZ-10(U), PZ-14 (U), and PZ-18(U)."*

- *"The calculated exit gradient and factor of safety against piping were higher and lower, respectively, than recommended to address the high exit gradient or the low factors of safety against piping."*

- *"Piezometers were not installed at Station 138+27 and Station 149+14; therefore, there is no way to verify the accuracy of the SEEP/W model analyses at these locations."*

AECOM Responses to Marshall Miller Slope Stability Recommendations

- *"The seepage model for each section should be adjusted to represent the actual piezometer readings. As a general principle, whenever field data is available, it should be used to produce models that better reflect the actual site conditions."*

AECOM Response: AECOM recommends actual piezometer data and field and laboratory permeability be used to model seepage through Dike C. We acknowledge that Stantec has used conservative $100K_h$:$1K_v$ ratio for sluiced ash in their analyses and therefore their seepage analyses are conservative. However, after the completion of the downstream buttress, the seepage will be intercepted with an ASTM C33 concrete sand filter to collect the seepage reducing the potential for piping. The sand filter will be covered with crushed stone and riprap.

- *"According to Stantec, the exit gradient and corresponding factor of safety against piping will be addressed in the buttressing plan. Stantec should follow through and evaluate the exit gradient and corresponding factor of safety against piping in the buttress plan."*

AECOM Response: We acknowledge that Stantec used a conservative $100K_h$:$1K_v$ ratio for sluiced ash in their SEEP/W analyses and therefore their seepage analysis results are conservative. However, seepage through Dike C will be intercepted with ASTM C33 concrete sand filter layer to collect the seepage and prevent piping or reduce the potential for piping. The filter sand layer will be covered with crushed stone and riprap.

Stantec computed seepage exit gradients for Dike C before and after the buttress fill with sand filter blanket placed over the prepared Dike C subgrade. The following table summarizes Stantec's computed factor of safety against piping.

TVA Station	FS Against Piping prior to Stabilization 8/3/09	FS Against Piping with Downstream Buttress/Filter Fill (Stage 1 and 2)	Final Buttress Details / History
108+93	2.7	20.9 > 3 per UASCE 1110-2-1901	4H:1V, Intake Channel
119+69	1.4	14.5 > 3	4H:1V, Intake Channel
132+37	1.3	6.1 > 3	6H;1V, Watts Bar Reservoir, 1985 seepage area with FS=1.2, Historic toe scour
138+27	1.7	12.7 > 3	4H:1V, Watts Bar Reservoir
149+14	2.1	18.6 > 3	6H:1V, Watts Bar Reservoir

The buttressed Dike C will meet the new TVA Programmatic rules and US Army Corps of Engineer standards.

- *"Additional piezometers should be installed at cross-sections located at Station 138+27 and Station 149+14 to provide site-specific data for calibration and validation of the predicted seepage condition at these cross-sections."*

AECOM Response: We concur with Marshall Miller that adding performance monitoring piezometers at Stations 138+27 and 149+14 will allow confirmation of future performance at these stations.

Item 9: Dike C Embankment Remediation Work Plan

Marshall Miller indicated they reviewed the preliminary Dike C buttress system. However, the plan did not include the final buttress configuration, the slope stability calculations prepared to evaluate the preliminary or final buttress design, or the methods for improving the low factor of safety against seepage piping through the embankment.

AECOM Responses to Marshall Miller Dike C Embankment Remediation Comments and Suggestions

- *"The process and rate of constructing an embankment buttress system to stabilize the raised portion of Dike C could inadvertently decrease (temporary or otherwise) the stability of Dike C embankment under certain failure modes. Accordingly, the construction sequence and the evolving buttress configuration may warrant the evaluation of interim construction conditions, and not just the planned final (stabilized) configuration."*

AECOM Response: Construction of the buttress fill will be done in two stages. Stage 1 will place fill upward from the submerged toe within the limits of Watts Bar Reservoir up to the El. 754 feet which is just above the Dike C starter dike to form an initial 30-foot wide bench. Once Stage 1 fill is completed, the Stage 2 fill will be placed from El. 754 feet up to El. 765 feet to match the existing Dike C crest elevation. No fill will be placed upstream of the existing Dike C, and Dike C will not be raised above its current freeboard elevation.

- *"The lack of subsurface information near the downstream toe of the starter dike, which is within the Watts Bar Reservoir, should be recognized by Stantec as an area of uncertainty that could affect the*

stability of the slope buttress system itself, especially if the rate of the buttress system construction prompts increased pore water pressures within the loose finer-grained foundation soils."

AECOM Response: AECOM has reviewed Stantec's filling plan and understands the benefit of a two phase filling program. The first phase is to form the base of the fill in the reservoir, cover seepage breakouts, provide interim slope stability and protect against scour and wave erosion. The second phase will begin after Stage 1 filling is complete for the four segments (e.g., A through D). Stage 1 was done not to overload the fill and foundation soils by decreasing the rate of filling. Stage 2 filling will not commence until four segments of the Stage 1 filling are complete.

As of the date of this letter, there is active Stage 1 filling along the toe of Dike C at Segments C and D adjacent to Watts Bar Reservoir. The dredging of spilled ash from the Reservoir is complete along Dike C and the bottom of the lake has been surveyed. Stantec is monitoring inclinometers and piezometers within Dike C to confirm downstream slope stability. According Stantec, the Stage 1 filling to date shows no visible signs of shallow slippage and no measurable excess pore water pressure in the Dike C piezometers or downstream movements in the inclinometers along the crest of Dike C and along the Starter Dike. Buttress filling to establish a filter blanket and stabilization fill in two vertical stages is inherently a stabilizing activity and protects the dike from known high water scour, and also provides a reverse filter blanket to protect against internal piping and uncontrolled exit gradients.

According to Stantec, the lowest computed FS for Stage 1 filling up to the top of the Starter Dike is 1.53 which is greater than 1.3 for an interim stability condition per the TVA 2009 Master Programmatic Document.

- *"The weaker links in the dike containment system (i.e., location-specific approach) should be specifically identified and evaluated when assessing stabilization plans to ensure that the more marginal reaches of the dike system are stabilized to an appropriate margin of safety."*

AECOM Response: Stantec has analyzed five dike cross-sections and we agree with Marshall Miller to add piezometers at buttressed Stations 138+27 and 149+14. The Stantec cross-section at Station 132+37 matches the TVA reported March 1985 seepage break-out and computed low factor of safety (FS = 1.2) area, which was also the zone of maximum reported Emory River scour that impacted Dike C. The other wet area at the west side of Dike C was lost when Dredge Cell 2 breached on December 22, 2008.

Below is a table that was developed from Stantec's August 3, 2009, report and recent deep seated downstream embankment and foundation stability analysis results dated April 9, 2010, (Work in Progress) for Dike C using the computer program SLOPE/W.

TVA Station	FS Prior to Stabilization 8/3/09	FS with Downstream Buttress Fill (Stage 1 and 2)	Final Buttress Details / History
108+93	1.66	1.93 > 1.5 per USACE EM 1110-2-1902	4H:1V, Intake Channel
119+69	1.48	1.86 > 1.5	4H:1V, Intake Channel
132+37	1.47	1.88 > 1.5	6H;1V, Watts Bar Reservoir, 1985 seepage area with FS=1.2, Historic toe scour
138+27	1.52	1.76 > 1.5	4H:1V, Watts Bar Reservoir
149+14	1.49	1.95 > 1.5	6H:1V, Watts Bar Reservoir

The lowest computed FS for Stage 1 filling up to the tip of the Starter Dike is 1.53 which greater than 1.3 for an interim stability condition. The buttressed Dike C will meet the new TVA Master Programmatic Document guidelines and US Army Corps of Engineers standard for static stability.

Closing

AECOM recommends the construction of the Dike C downstream stabilization fill be completed without delay with full-time over-sight and testing by Stantec, the engineer of record for the project.

AECOM understands and endorses the containment of the ash collection pond, former dredge cells and loose foundation soils to preclude deep seated liquefaction failure. Stantec's design involves deep soil mixing around the perimeter of the dredge cell and ash collection pond to preclude the loss of wet ash and foundational failures. Only the stilling pond will stay active, and will undergo the Seismic Phase A screening process. After the Seismic Phase A screening process, the TVA will determine the risks of Dike C failure, the consequence and cost to mitigate, and make a future decision at that time to stabilize, dredge, remove, or accept the risk.

Please contact us if you have any comments or questions.

Very truly yours,

AECOM

William H. Walton, P.E., S.E.
Senior Principal Engineer
Vice President

William Butler, P.E.
Senior Geotechnical Engineer

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July 23, 2010

Mr. Gregory C. Jaynes
Deputy Assistant Inspector General, Inspections
Tennessee Valley Authority
Office of the Inspector General
1101 Market Street EB 2G-C
Chattanooga, TN 37402-2801

Re: ***Technical Rebuttal to May 11, 2010 TVA Response to OIG Draft Inspection, 2009-12910-01 – Peer Review of Stability Analysis of Dike C at Kingston Fossil Plant***
TVA Response Consists of Two Separate Documents:

1. ***April 30, 2010, Letter from W. Walton, P.E., S.E. and W. Butler, P.E. of AECOM to J. Kammeyer, P.E. of TVA (7 pages)***
2. ***May 5, 2010, Letter from D. Fuller, P.E. and T. Crilly of Stantec to J. Kammeyer, P.E. of TVA (12 pages plus Appendices)***

Dear Mr. Jaynes:

In respective letters dated April 30, 2010, and May 5, 2010, AECOM[1] and Stantec Consulting Services, Inc. (Stantec) provided responses, on behalf of the Tennessee Valley Authority (TVA), to a draft technical peer review report prepared by Marshall Miller & Associates, Inc. (Marshall Miller) on April 12, 2010. Marshall Miller's peer review was developed based on a technical peer review of Stantec's report entitled *Report of Geotechnical Exploration and Slope Stability for Dike C* [Existing Conditions] for TVA's Kingston Fossil Plant (KIF) located in Harriman, Tennessee, dated August 3, 2009, hereinafter referred to as the Kingston Report. Pursuant to the request of the TVA Office of the Inspector General (TVA OIG), Marshall Miller has prepared this technical rebuttal to the responses presented by AECOM and Stantec.

[1] AECOM had previously participated, on TVA's behalf, in projects related to the Kingston Fossil Plant (KIF). More specifically, in January 2009, TVA contracted with AECOM to prepare a Root Cause Analysis of the ash spill at KIF. AECOM's findings and analyses were presented in a report entitled "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008."

AECOM Responses

The April 30, 2010 response prepared by Mr. William H. Walton, P.E., S.E., and Mr. William Butler, P.E., of AECOM highlighted several items in Marshall Miller's comments and provided responses to three items in Marshall Miller's peer review report. Marshall Miller's rebuttal to the AECOM responses is provided below.

AECOM's Response to Item 7: Current Dike C Stabilization Efforts by TVA

In Marshall Miller's review of the Kingston Report, the findings and recommendations pertain to slope stability evaluations of existing conditions by Stantec, not evaluations of the downstream buttress. Marshall Miller acknowledges AECOM's characterization (in its response letter) of historical seepage and hydraulic loading on the dike and documentation of past shallow sloughs. However, additional data and newer, presumably better, information is presently available for assessing the margin of safety under the existing conditions. In Marshall Miller's opinion, the presumption that past performance is a reliable indicator of future performance does not negate the need to evaluate short-term loading conditions using representative shear strengths for the more critical dike sections.

AECOM's Response to Item 7: AECOM Discussion on Drained Shear Strengths in the Alluvium

In Marshall Miller's opinion, the effective shear strength parameters used for foundation soils in Stantec's slope stability analyses of existing conditions misrepresent the foundation conditions between dike Station 125+70 and Station 134+30. Based on the boring and cone penetration tests (CPTs) logs, and test data, the foundation soils are highly variable, consisting of a random mix of zones of varying compositions. The variability of the foundation soils is also evident in the varying approaches that have been applied to characterizing the generalized foundation conditions. In the Kingston Report, Stantec treated the foundation soils as coarse-grained soils and established the effective shear strength using correlations between standard penetration test (SPT) N-values and effective friction angle. In contrast, AECOM's response cites results from the direct shear testing and accompanying index testing on fine-grained soils presented in its June 25, 2009 Root Cause Analysis (RCA) report. The shear strength of the foundation soils has a significant effect on the results of the stability analyses, so the significant variability of the foundation soils warrants targeted consideration of the site-specific data for the weaker foundation zones beneath more critical dike sections.

AECOM's response does not address the site-specific data collected from the particular section of Dike C questioned by Marshall Miller. Also, some of the RCA data cited by AECOM is not

representative of the foundation soils at issue and AECOM's use of the bottom 33th percentile Plasticity Indices (PI) is questionable. Regardless, the site-specific data clearly indicates that foundation soils between Station 125+70 and Station 134+30 are weaker than foundation soils below other sections of the dike system, and that an effective friction angle lower than 27 degrees should be considered. In addition to the SPT-N data, the following information from the Kingston Report supports Marshall Miller's opinion:

- Results from CPTs advanced in this section of Dike C indicate an effective friction angle ranging from 20 to 28 degrees.
- Direct simple shear and consolidated undrained triaxial tests performed on samples of foundation soils from borings STN-27B and STN-29 indicate an effective friction angle ranging from 23 to 29 degrees, respectively.
- This location is one of the few reaches of Dike C where SPTs indicate no measurable blow count through substantial thicknesses of the foundation soils in different soil types including silt, sand, silty sand, sandy silt, and clay materials and through zones of relatively high overburden stress/confinement.

Marshall Miller acknowledges that data indicating an effective friction angle of 27 degrees is appropriate for foundation soils below some sections of Dike C. However, in Marshall Miller's opinion, site-specific testing between Station 125+70 and Station 134+30 indicates effective friction angles lower than 27 degrees in pertinent zones of the dike foundation.

AECOM's Response to Marshall Miller Slope Stability Recommendations

Marshall Miller accepts that installation of the buttress will help mitigate slope stability concerns and address variability in the foundation soils. However, the installation of the buttress has no bearing on the characterization and evaluation of existing conditions, including documentation of past slides. The locations of past slides are pertinent to evaluating existing site conditions and assessing the level of safety corresponding to those conditions. As described in the previous response, Marshall Miller stands by its original findings and recommendations.

AECOM's Response to Item 8: Seepage Analyses

Marshall Miller acknowledges that the remedial buttress and associated aggregate filter layers will reduce the potential for piping. Furthermore, Marshall Miller's comment is satisfactorily addressed by Stantec's explanation and the additional information in the Comment 5 Appendix to Stantec's response.

AECOM's Response to Item 9: Dike C Embankment Remediation Work Plan
Marshall Miller's comment has been satisfactorily addressed by AECOM's and Stantec's responses to comments related to the Dike C embankment remediation work plan. Based on Marshall Miller's review of the Stage 1 Construction – Segment "D" portion of the Dike C Buttressing plan, Marshall Miller accepts Stantec's opinion that the buttressing plan satisfactorily addresses the potential variances in the seepage conditions and improves slope stability conditions.

Stantec Responses

Mr. Thomas Crilly and Mr. Don W. Fuller, II, P.E., of Stantec reviewed Marshall Miller's peer review report and provided responses in a May 5, 2010, letter report. Marshall Miller's rebuttal to the Stantec responses is provided below.

Stantec Response 1 A through F
Marshall Miller's comments pertaining to notably looser/softer foundation soils at Station 132+37, and between and proximate to Station 125+70 and Station 134+30 are not specifically addressed in Stantec's response; therefore, Marshall Miller stands by its original findings. Nevertheless, as indicated above in Marshall Miller's reply to AECOM's response to Item 9, Marshall Miller accepts Stantec's opinion that the buttressing plan will satisfactorily address the potential variability in the shear strength properties identified by Marshall Miller.

Stantec's Response 2
Stantec's response is acknowledged. Note that Marshall Miller's review of the existing-condition drawings identified existing riprap placements that are indicative of repairs to the existing slopes. Marshall Miller recommends that any past slides/slope repair areas be identified on record drawings, especially if such areas lie above the planned stabilization buttress.

Stantec's Response 3
Stantec's response is acknowledged and accepted.

Stantec's Response 4
Marshall Miller's comment is satisfactorily addressed by the additional information supplied with Stantec's response and the description of Stantec's and TVA's efforts to identify and address differing conditions during implementation of the Risk Mitigation Plan.

Stantec's Response 5
Marshall Miller's comment is satisfactorily addressed by Stantec's explanation and the additional information in the Comment 5 Appendix to Stantec's response.

Stantec's Response 6
Marshall Miller's comment is satisfactorily addressed by Stantec's explanation and the additional information in the Comment 5 Appendix to Stantec's response. Also, based on Marshall Miller's review of the Stage 1 Construction – Segment "D" portion of the Dike C Buttressing plan, Marshall Miller accepts Stantec's opinion that the buttressing plan satisfactorily addresses the potential variances in the seepage conditions.

Stantec's Response 7
Marshall Miller concurs with Stantec that the graded filter components of the Dike C Buttressing Plan address this comment.

Stantec's Response 8
Marshall Miller acknowledges the TVA's plan to install additional piezometers at or near STA 138+27 and STA 149+14, which will resolve this comment.

Stantec's Response 9
Marshall Miller acknowledges Stantec's response. However, Marshall Miller did not receive Stantec's staged-construction analysis considering undrained shear strengths with the Stage 1 Construction – Segment "C' or "D" Dike C Buttress documents.

Thank you for the opportunity to review and comment on Stantec's and AECOM's responses. Should you have any questions or need additional clarification, please contact Bill Almes at (919) 786-1414.

Respectfully submitted,

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