Memorandum from the Office of the Inspector General

September 23, 2010

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

FINAL REPORT – INSPECTION 2009-12910-02 – PEER REVIEW OF DIKE C BUTTRESSING

Attached is the subject final report for your review and action. Your written comments, which addressed your management decision and/or actions taken, have been included in the report. No further action is needed.

The Office of the Inspector General (OIG) contracted with Marshall Miller & Associates Inc., 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 in 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 Gregory 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.

Robert E Martin

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
Tom D. Kilgore, WT 7B-K
William R. McCollum, Jr., LP 6A-C
Stephen H. McCracken, KFP 1T-KST
Annette L. Moore, LP 3K-C
Richard W. Moore, ET 4C-K
David R. Mould, WT 7B-K
Anda A. Ray, WT 11A-K
Emily J. Reynolds, OCP 1L-NST
Joyce L. Shaffer, WT 9B-K
John M. Thomas III, MR 3A-C
Robert B. Wells, WT 9B-K
Wendy Williams, WT 9B-K
OIG File No. 2009-12910-02

Peer Review of Stantec Consulting Services, Inc.
Dike C Buttress, Stage 1 Construction – Segment "D"
Dated September 23, 2010

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

September 23, 2010

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

5900 Triangle Drive
Raleigh, NC 27617
Tel (919) 786-1414 • Fax (919) 786-1418
www.mma1.com

Item 1: TITLE PAGE

Title of Report

Peer Review of Stantec Consulting Services, Inc. (Stantec)
Dike C Buttress, Stage 1 Construction – Segment "D"
Supporting Stability Calculations, Drawings, Technical Specifications, and Quality Control Plan
Tennessee Valley Authority Kingston Fossil Plant (KIF) – Harriman, Roane County, TN

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.

Effective Date of Report

September 23, 2010

Qualified Persons

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

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

EDMUNDO JOSE LAPORTE
PROFESSIONAL ENGINEER
AGRICULTURE
COMMERCE
No. 111870
STATE OF TENNESSEE
09/23/10

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

Aaron J. Antell, P.E.
Project Engineer
D'Appolonia, Engineering Division of Ground Technology, Inc.

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 ***Stantec Consulting Services, Inc.*** **(Stantec)** stability calculations and construction documents for the Stage 1 Construction – Segment "D" portion of the Dike C Buttress at the Kingston Fossil Plant. It is Marshall Miller's opinion that the planned Stage 1 Construction – Segment "D" portion of the Dike C Buttress does produce stability enhancements that are sufficient based on Stantec's drained slope stability analyses. Marshall Miller also believes that the Stage 1 Construction will satisfactorily address issues of "piping"/internal erosion, surface erosion, and scour over those Dike C areas that will be covered with an aggregate filter and be buttressed. However, Marshall Miller found that the specific design bases/criteria, relative improvement in stability, and reasoning for certain variations in the buttress configuration were not well documented within the materials that were supplied for review.

Marshall Miller's key observations from reviewing the documents related to the Segment "D" portion of the Dike C Buttress at the Kingston Fossil Plant are as follows:

1. A direct comparison of slope stability factors of safety for the existing and buttressed dike configurations at critical sections was not performed, so the relative improvement in stability afforded by the Stage 1 Buttress Construction is not clearly documented.

2. The design shows a transition to steeper configuration of the outslope of the buttress between two points that will diminish the stabilization benefits of the buttress.

3. The Stage 1 Buttress Construction was only evaluated presuming drained conditions, so the stability situation under possible load cases that could prompt undrained behavior of the dike and foundation materials (rate of construction, rapid drawdown, and earthquake/seismic cases) is unknown at this time.

Marshall Miller believes that the planned Stage 1 Buttress Construction does produce stability enhancements and also addresses issues of “piping”/ internal erosion, surface erosion, and scour in buttressed areas. Therefore, the significance of the above Marshall Miller observations and recommendations is dependent on the approach and conservatism that is applied in the design of the final closure plan.

Management’s Response to Draft Report

To address this report, TVA management had Stantec review and respond to the findings of this report. TVA management and its contractor provided addition information on the findings and recommendations in this report. For complete responses, please see appendices A – TVA Transmittal Memo and B – Stantec’s Response.

Marshall Miller Assessment of Management’s Comments to Draft Report

Marshall Miller concluded that the additional information provided adequately addressed the concerns and recommendations identified in the report.

Item 3: TABLE OF CONTENTS

APPENDICIES

Item 4: INTRODUCTION

The TVA OIG retained Marshall Miller to conduct a peer review of the slope stability analyses and construction documents for the Stage 1 Construction – Segment "D" portion of the Dike C Buttress at the Kingston Fossil (KIF) Plant, Harriman, Roane County, Tennessee. Stantec of Lexington, Kentucky designed the stabilization plan and developed the corresponding construction documents. The Stage 1 Construction is divided into four segments designated Segments A, B, C and D. Segment "D" was selected for review because it is the first buttress segment under construction. The buttress segments are similar in configuration, materials, and purpose, so findings related to Segment "D" apply to all segments of the Stage 1 Construction.

Marshall Miller reviewed the Stantec stability calculations, Drawings (i.e., "*Plans for Construction*"), Technical Specifications, and Quality Control Plan (including Addendum 001) for the Stage 1 Construction – Segment "D" portion of the Dike C Buttress. Marshall Miller understands that Stantec did not prepare a formal engineering or design report to document the assumptions and methods for designing the Dike C buttress, and to present a direct comparison of slope stability factors of safety for the existing and buttressed dike configurations at critical sections (pre- and post-construction configurations). Regardless, we were able to rely on the above-mentioned construction documents and Stantec slope stability analyses to formulate our findings and recommendations.

This report presents the following:

- Marshall Miller Project Team;
- Description of Marshall Miller's scope of service;
- Background information for the Kingston Fossil Plant and Dike C; and
- Findings and recommendations from Marshall Miller's peer review of the slope stability analyses and construction documents prepared by Stantec.

Item 5: MARSHALL MILLER PROJECT TEAM

Marshall Miller, an employee-owned and Engineering News-Record Magazine (ENR) top 500 company, began offering geologic services to the mining industry in 1975. Marshall Miller provides a range of services to the mining, utility, financial, governmental, and legal industries. Marshall Miller employs nearly 200 engineers, geologists, scientists and other professionals who work from regional offices in ten states.

Marshall Miller retained 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

Marshall Miller was engaged by OIG to provide a technical peer review of the construction documents and supporting slope stability analyses developed by Stantec for the Stage 1 Construction – Segment "D" portion of the Dike C Buttress at the KIF Plant. Marshall Miller also performed a cursory review of electronic files for stability calculations performed by Stantec. Marshall Miller did not perform a parallel study or confirmatory design calculations for the Stage 1 stabilization plan developed by Stantec. The specific Dike C Buttress, Stage 1 Construction – Segment "D" documents reviewed by Marshall Miller included:

- Plans for Construction (Drawing Package – Issued for Construction), dated November 18, 2009;
- Quality Control Plan, dated November 18, 2009;
- Addendum 1 to Quality Control Plan, dated February 16, 2010; and
- Technical Specifications, dated November 18, 2009.

In providing the professional services to compile this report, Marshall Miller used generally accepted engineering principles and practices to develop findings and recommendations. Marshall Miller reserves the right to amend and supplement this report based on additional information. If OIG, TVA, TVA's consultants, or others discover additional information pertinent to the engineering performance of the existing Dike C or the planned buttress at the KIF fossil plant, Marshall Miller requests the opportunity to review the information for relevance to Marshall Miller's findings and recommendations herein.

Item 7: BACKGROUND

Dike C at the KIF plant 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 byproducts 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 above mean sea level (AMSL). 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.

TVA engaged Stantec to develop a stabilization plan for Dike C in response to slope stability concerns identified in the report by Stantec titled: "*Report of Geotechnical Exploration and Slope Stability for Dike C [existing conditions], Tennessee Valley Authority Kingston Fossil Plant (KIF)*," (KIF Dike C Report) dated August 3, 2009. Stantec developed a staged/phased stabilization plan that generally consists of constructing an aggregate buttress against the riverside (downstream slope) of Dike C. Stage 1 of the stabilization plan includes buttress construction below El. 754, which is slightly above the lower-most downstream bench on Dike C. The Stage 1 Construction is divided into four segments designated Segments A, B, C and D. Buttress construction commenced with Segment D, which consists of the northern-most 2,200 feet of Dike C, from STA 138+00 to STA 160+00.

Item 8: REVIEW

Marshall Miller reviewed the Stantec slope stability calculations, Drawings (i.e., "*Plans for Construction*"), Technical Specifications, and Quality Control Plan (including Addendum 001) applicable to the Stage 1 Construction – Segment "D" portion of the Dike C Buttress. In general, it is Marshall Miller's opinion that the planned Stage 1 Construction – Segment "D" portion of the Dike C Buttress does produce stability enhancements and also addresses issues of "piping"/ internal erosion, surface erosion, and scour in buttressed areas. However, Stantec did not supply information that clearly indicates the design bases/criteria, relative improvement in stability, and reasoning for certain variations in the buttress configuration.

8.1. FINDINGS

In Marshall Miller professional opinion the Stantec, slope stability analyses presuming drained conditions indicate that the Stage 1 Construction will satisfactorily enhance the static stability of Dike C. In addition, the filter, drainage, and erosion-resistant materials specified by Stantec for the planned aggregate buttress address issues of "piping"/ internal erosion, surface erosion, and scour in buttressed areas. However, Marshall Miller did note that the specific design bases/criteria, relative improvement in stability, and reasoning for certain variations in the buttress configuration were not well documented within the materials that were supplied for review. Specifically they noted that:

- Stantec did not prepare a direct comparison of slope stability factors of safety for the existing and buttressed dike configurations at critical sections, so the relative improvement in stability afforded by the Stage 1 Buttress Construction is not clearly documented.

- The proposed buttress configuration includes a transition from an outslope at 6H:1V at STA 147+00 to an outslope of 4H:1V at STA 145+50. It is unclear why the outslope of the buttress is transitioned to a steeper configuration at this location. Based on Marshall Miller's review of the subsurface conditions, there is no appreciable improvement in the existing conditions from STA 147+00 to STA 145+50 that would justify this change in configuration.

- Based on the Plans for Construction prepared by Stantec, Marshall Miller overlaid the proposed buttress configuration at STA 138+00 and STA 149+00 onto the stability cross-sections at STA 138+27 and STA 149+14, respectively, which were taken from the Stantec "*Report of Geotechnical Exploration and Slope Stability for Dike C [existing conditions]*" dated August 3, 2009. The planned buttress at STA 138+27 (4H:1V outslope) does not extend beyond the deep-seated failure surface below the toe of the existing dike; whereas, the buttress at STA 149+14 (6H:1V outslope) does extend beyond the deep-seated failure surface below the toe of the dike. Based on this simplistic comparison, it does not appear that the change in buttress configuration is justified based on stability considerations.

- Stantec did not perform an undrained slope stability analysis for the buttress construction case, or other load cases that could prompt undrained behavior of the dike and foundation materials (rapid drawdown and earthquake/seismic cases). With regard to the construction case and associated rate of loading issues, the starter dike is constructed of clayey materials and, in Marshall Miller's professional opinion, is subject to undrained loading during buttress construction. Also, subsurface profiles in the previously referenced Stantec geotechnical report indicate zones and layers of clayey material within the foundation, which could impede drainage and contribute to undrained loading of even the silty sand to sandy silt foundation soils.

8.2. RECOMMENDATIONS

Based on the findings described above, Marshall Miller recommends that Stantec consider:

- Documenting the relative improvement in stability afforded by the Stage 1 Buttress Construction, based on a direct comparison of slope stability factors of safety for the existing and buttressed dike configurations at critical sections.

- Reconfigure the outslope from STA 147+00 to STA 145+50 to a consistent 6H:1V.

- Performing an undrained evaluation of the end-of-construction conditions and applicable rapid drawdown scenarios.

August 31, 2010

Robert E. Martin, ET 3C-K

TVA COMMENTS - DRAFT INSPECTION 2009-12910-02 - PEER REVIEW OF DIKE C BUTTRESSING

Attached, please find TVA comments in response to your draft inspection regarding subject Peer Review. We appreciate the opportunity to provide comments on this draft report. Please direct any questions to John Kammeyer at (423) 751-4077.

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

JAR:
Attachment
Cc (Attachment)
Peyton T. Hairston, Jr. WT 7B-K
John Kammeyer, LP 5D-C
William R. McCollum, Jr., LP 6A-C
Annette L. Moore, LP 3K-C
John M. Thomas III, MR 3S 120
Joyce L. Shaffer, WT 9B-K
Robert B. Wells, WT 9B-K
Wendy Williams, WT 9B-K
OIG File No. 2009-12910-02

Stantec Consulting Services Inc.
1409 North Forbes Road
Lexington, KY 40511-2050
Tel: (859) 422-3000
Fax: (859) 422-3100

Stantec

August 26, 2010 let_010_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 –August 17, 2010
Stantec Dike C Buttress, Stage 1 Construction – Segment "D" (November 18, 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. Dike C Buttress, Stage 1 Construction – Segment "D", November 18, 2009*, dated August 17, 2010. Marshall Miller's comments and Stantec's responses are provided below. Please note the format of the referenced Marshall Miller document does not numerate specific findings. Stantec has enumerated the findings based on the Marshall Miller sequence of recommendations presented.

Comment 1:

Stantec did not prepare a direct comparison of slope stability factors of safety for the existing and buttressed dike configurations at critical sections, so the relative improvement in stability afforded by the Stage 1 Buttress Construction is not clearly documented.

Response 1:

The two critical sections analyzed within segment D (Sta 138+00 to Sta 160+00) are located at station 138+27 and station 149+14. Each critical section along with existing (pre-buttressed condition) and current (buttressed condition) long term slope stability factors of safety are discussed below.

1.1 Stability Section Station 138+27

For the drained shear strength parameter case, the slope stability results for the stability section at station 138+27 are shown on Drawing XXWXXX-11 in Appendix A. With the stage 1 buttress in place the lower toe potential slip surface B has an estimated factor of safety of

1.53 with the buttress in place, an increase of 0.40 from the factor of safety of 1.13 for a similar potential slip surface for the existing conditions. The overall potential slip surface C has an estimated factor of safety of 1.76 with the buttress in place, or an increase of 0.24 over the existing stability condition.

1.2 Stability Section Station 149+14

For the drained shear strength parameter case, the slope stability results for the stability section at station 149+14 are shown on Drawing XXWXXX-12 in Appendix A. With the stage 1 buttress in place the lower toe potential slip surface B has an estimated factor of safety of 1.94 with the buttress in place, an increase of 0.79 from the factor of safety of 1.15 for a similar potential slip surface for the existing conditions. The overall potential slip surface C has an estimated factor of safety of 1.95 with the buttress in place, or an increase of 0.46 over the existing stability condition.

Comment 2:

The proposed buttress configuration includes a transition from an outslope at 6H:1V at STA 147+00 to an outslope of 4H:1V at STA 145+50. It is unclear why the outslope of the buttress is transitioned to a steeper configuration at this location. Based on Marshall Miller's review of the subsurface conditions, there is no appreciable improvement in the existing condtions form STA 147+00 to STA 145+50 that would justify this change in configuration.

Response 2:

The transition from a buttress oustlope of 6H:1V at Sta 147+00 to a buttress outslope of 4H:1V at Sta 145+50 was completed to better match the existing outslope conditions of Dike C while continuing to meet the slope stability factor of safety criteria of 1.50. Stantec was able to achieve a more economical design that meets all project criteria by utilizing this approach. Refer to Response 1 for the buttressed slope stability factors of safety at critical section station 138+27 which is considered representative of the subsurface condions from Sta 138+00 to Sta 147+00. The transition from the 6H:1V outslope to the 4H;1V outslope was therefore performed entirely within the section of the dike requiring the 4H;1V buttress outslope.

Comment 3:

Stantec did not perform an undrained slope stability analysis for the buttress construction case, or other load cases that could prompt undrained behavior of the dike and foundation materials (rapid drawdown and earthquake/seismic cases). With regard to the construction case and associated rate of loading issues, the starter dike is constructed of clayey materials and, in Marshall Miller's professional opinion, is subject to undrained loading during buttress construction. Also, subsurface profiles in the previously referenced Stantec geotechnical report indicate zones and layers of clayey material within the foundation, which could impede drainage and contribute to undrained loading of even the silty sand to sandy silt foundation soils.

Response 3:

3.1 Undrained Loading

Stantec has completed undrained slope stability analysis for the buttress construction case for segment D. The results of this analysis are presented in Stantec's letter; Response to Final Marshall Miller Review - August 2, 2010, dated August 5, 2010. For clarioty purposes, the contents of Stantec's August 5, 2010 letter have been reproduced here and are as follows (Appendix references have been updated and accurately reflect the attached appendix to this letter):

The stability conditions for the period during and immediately following construction of the buttress has been reviewed for Segments C and D utilizing undrained shear strength parameters. Outlined below is a summary of the material parameters that have been used, the analysis methods and results, along with a review of the existing instrumentation monitoring performed to date.

Material Parameters

For the short term loading condition assessment with the buttress in place, the following soil layers were assumed to exhibit undrained behavior;

- Starter Clay Dike
- Raised Clay Dike
- Hydraulically Placed Ash
- Sensitive Silt/Clay
- Lean Clay Foundation Soil
- Silty Clay

The remaining soil layers modeled within the stability cross sections have been taken to be coarse grained, with rapid dissipation of excess pore water pressures. Therefore effective strength parameters have been assumed to continue to apply.

For the starter clay dike, raised clay dike, lean clay foundation soil, and silty clay materials, the undrained shear strength behavior was assumed to follow an R-Envelope model. The undrained shear strength parameters were derived from representative consolidated undrained (CU) Triaxial tests performed on samples retrieved during the field drilling program conducted for the original Dike C stability assessment report (August 3, 2009).

For the undrained shear strength parameters of the hydraulically placed ash, Stantec has utilized the consolidated undrained Triaxial testing performed by AECOM as a part of their "Root Cause Analysis Report".

As the sensitive silt/clay layer that has been assumed to exist beneath the hydraulically placed ash and the clay starter dike, is “soft”, the undrained shear strength for this material has been assumed to follow a c/p ratio relationship. The value of the c/p ratio has been derived from direct simple shear tests performed on material from this zone. The samples from the direct shear tests were first consolidated to a known pressure and then simply sheared undrained.

Based on available information, the parameters used in the evaluation of Dike C under short term stability with the buttress construction are outlined in Table 1 below. These parameters are a hybrid of the various models that may be used, and in our opinion best characterize the behavior of the materials of the site under undrained conditions.

Table 1. Selected Undrained Strength Parameters for Short Term Stability Analysis

Soil Horizon	Unit Weight (pcf)	Total Stress Strength Parameters	
		c (psf)	ϕ' (degrees)
Starter Clay Dike	129	300	26
Raised Clay Dike	125	65	23
Constructed Ash	93	0	30
Hydraulically Placed Ash	96	0	10
Gravel to Clayey Gravel	120	0	32
Sensitive Silt/Clay	127	S_u/σ'_v=0.32	0
Lean Clay Foundation Soil	129	200	15
Silty Clay	129	200	15
Sandy Silt to Silty Sand	105 to 113	0	27 to 29
Fine Grained Sand to Sand with Silt	118 to 128	0	31 to 36

Analysis Methods

For the short term loading case with the buttress construction and using the applicable drained and undrained strength parameters as outlined above, we have utilized the software UTEXAS4 as well as SLOPE/W. The UTEXAS4 model was used to incorporate the $\varphi_u \neq 0$ undrained shear strength models, while the SLOPE/W model was used as an overall calibration utilizing an equivalent $\varphi_u = 0$ shear strength model for the appropriate materials. Both models utilized the SEEP/W output for the pore water pressure regime that was outlined in our August 3, 2009 stability report.

The UTEXAS4 model was developed by Stephen G. Wright (Shinoak Software, Austin, Texas). The porewater pressures derived from the SEEP/W nodal points were used in UTEXAS4 to interpolate the pore water pressure at the bottom of each slice along a potential failure surface. The model utilizes a three stage stability computation. The first stage is performed to compute the effective normal stresses along the shear surface (on the base of each slice) before undrained loading. The stresses computed from the first stage are used to estimate undrained shear strengths, which are then used in the second set of stability computations. The second stage stability evaluation then uses the undrained shear stresses from the first stage to estimate the factors of safety for the potential undrained loading case of the buttress construction. The third stage computations are performed for cases where the drained strengths may be lower than the undrained strengths.

The UTEXAS4 slope program has inherent conservatisms within the model, namely the loading from the rockfill is assumed to occur instantaneously and the rockfill used for the buttress has zero shear strength.

Analysis Results

Sta. 149+14

For the stability section at Sta. 149+14, the slope stability output plots are included on Figures 1B and 2B in Appendix B. Figure 1B shows the UTEXAS4 output assuming the Stage 1 buttress has been constructed to 6H:1V. Using the drained and undrained strength parameters as outlined above on Table 1, the critical slip surface for this cross section corresponds to an overall deep seated surface with an estimated factor of safety of 2.10 as shown on Figure 1B in Appendix B.

As a further check on the slope stability using undrained strength parameters, SLOPE/W was also used by converting the undrained shear strength parameters for the hydraulically placed ash, the starter and raised clay dike materials and the sensitive silt and clay material to equivalent undrained strengths assuming φ_u=0. This was done by determining the average effective stress within the various materials prior to the buttress construction and then estimating the equivalent average undrained shear strength value assuming φ_u=0. The material strengths for all other materials follow that given on Table 1. By using this conversion method, the estimated undrained strength of the hydraulically placed ash was 315 psf, the starter and raised clay dike undrained strength was 525 psf, and the sensitive silt and clay undrained strength was 250 psf. For this scenario using SLOPE/W, the critical slip surface is shown on Figure 2B in Appendix B and has an estimated factor of safety of 1.93.

Sta. 138+27

For the stability section at Sta. 138+27, the slope stability output plots are included on Figures 3B and 4B in Appendix B. Figure 3B shows the UTEXAS4 output assuming the Stage 1 buttress has been constructed to 4H:1V. Using the drained and undrained strength parameters as outlined above on Table 1, the critical slip surface for this cross section corresponds to a lower toe relatively shallow surface with an estimated factor of safety of 1.19 as shown on Figure 3B in Appendix B.

Similar to the analysis outlined above for the cross section at Sta. 149+14, the undrained slope stability for this cross section was reviewed using SLOPE/W and equivalent undrained shear strengths assuming φ_u=0 for the sensitive silt and clay and the underlying silty clay materials. Using average normal effective stresses prior to the buttress construction, the equivalent undrained shear strength of the sensitive silt and clay was estimated to be 250 psf, and 375 psf for the silty clay material. For these conditions and using SLOPE/W, the critical slip surface is shown on Figure 4B in Appendix B and has an estimated factor of safety of 1.41.

The exact reasons why these two slope models are giving substantially different results for the factor of safety for very similar slip surfaces using similar material properties is not known, but it is suspected that the inherent conservatisms in the UTEXAS4 model are influencing the model output.

Instrumentation Monitoring Results

As outlined in our August 3, 2009 report on the Dike C slope stability, there are numerous piezometers and slope inclinometers located along the dike. Standpipe piezometers are located within the raised and starter dike at approximate Stations 143+00 and 155+00, with slope inclinometers located at Stations 149+14 and 138+27. During the construction of the buttress, daily piezometer measurements were taken to review potential pore water pressure increases with the buttress fill loading. Slope inclinometer measurements were taken bi-weekly to review potential downslope movements.

The piezometers located at Sta. 155+00 were monitored on a daily basis from December 16, 2009 to April 20, 2010 (PZ-1), January 19, 2010 to April 20, 2010 (PZ-2U), and January 19, 2010 to June 14, 2010 (PZ-3L and PZ-4). All piezometers located at Sta. 143+00 have been monitored on a daily basis from April 21, 2010 to June 18, 2010. The summary graph of this daily monitoring is shown on Figure 1C in Appendix C. As shown on Figure 1C, there have been no significant increases in the level of any of the piezometers (beyond increases related to the seasonal lake level rise) that would suggest excess pore water pressure increases with the buttress fill loading. This would imply that any excess pore water pressures that are generated with the buttress fill loading are dissipated very rapidly.

The slope inclinometers located at STN-08 (Sta. 149+14) and STN-18 (Sta. 138+27) have also shown insignificant downslope movements since their installation. Summary output plots showing the results of these two inclinometers (Figure 2C and 3C in Appendix C) to July 12, 2010 is included in Appendix C.

3.2 Rapid Drawdown

Stantec has completed analyses to characterize the stability of Dike C (with the rock buttress) in a rapid drawdown event. The results of this analysis are presented in Stantec's letter; Response to October 29, 2009 AECOM Review of Stantec's August 3, 2009 Dike C Report, dated February 19, 2010. For practicality purposes, the contents of Stantec's February 19, 2010 letter have been reproduced here and are as follows (Appendicie references have been updated and accurately reflect attached appendicies to this letter):

Stantec has completed additional analyses to characterize the stability of Dike C (with the rock buttress) in a rapid drawdown event. The critical condition was assumed to be a drop in Watts Bar Lake from the 100-year flood elevation (748 feet) to the normal winter pool elevation (737 feet). Each of the stability sections with the rockfill buttress as outlined above was evaluated for this drawdown event. Graphical results from the stability analyses are given in Appendix D.

Steady-state seepage analyses were first performed using the finite element program SEEP/W, developed by the GEO-SLOPE International, Ltd (Calgary, Alberta, Canada). For each cross section, two steady-state seepage analyses, corresponding respectively to water levels before and after the drawdown, were conducted. The computed pore water pressure at each finite element nodal point was extracted for the subsequent stability analyses. The parameters used for the analyses can be found on the rapid drawdown graphical outputs included in Appendix D.

The rapid drawdown stability analyses were performed using the computer program UTEXAS4, developed by Stephen G. Wright (Shinoak Software, Austin, Texas). The pore water pressures extracted from the SEEP/W nodal points were used in UTEXAS4 to interpolate the pore water pressure at the bottom of each slice along a potential failure surface. The three-stage stability analysis method, developed by Duncan, Wright, and Wong (1990), was used for calculating the rapid drawdown factors of safety. The three-stage method of analysis is described in EM 1110-2-1902 (USACE 2003) and Duncan and Wright (2005).

The three-stage computations consist of three complete sets of stability calculations. The first stage involves stability analysis of the slope using the high water level for Watts Bar Lake (elevation 748.0 feet) and assuming the pore water pressures in the soils are in a steady-state condition. Both the effective normal stresses and shear stresses along the potential failure surface are calculated. These stresses represent the anisotropic consolidation stresses prior to drawdown, and are used to calculate the undrained shear strength for soils without free drainage. The second stage involves an analysis of the slope immediately after the rapid drawdown. Undrained shear strengths are estimated based on the consolidation stresses calculated in the first state. The third stage computation compares the drained and undrained strengths at each slice base along the potential failure surface. Steady-state pore water pressures corresponding to the low water level (elevation 737 feet) are used to calculate the drained strength in the third stage calculation. The undrained strength is estimated in the second stage. The smaller of the drained and undrained strengths is chosen to compute the final factor of safety.

In the second stage of the computations, UTEXAS4 uses an interpolation scheme to determine the undrained shear strength of anisotropically consolidated soils. The interpolation is based on two limiting strength envelopes, representing a fully drained strength and the undrained strength of an isotropically consolidated soil sample. Both of these input envelopes represent a relationship between the shear strength and the effective normal consolidation stress on the failure plane. The envelopes correspond to effective principal stress ratios ($K_c=\sigma'_1/\sigma'_3$) at consolidation of K_f and 1, respectively, and are defined by an intercept and a slope. The envelope corresponding to $K_c=K_f$ is identical to the conventional effective stress shear strength envelope. Thus, its intercept ($d_{Kc=Kf}$) is the same as the effective stress cohesion value (c') and its slope ($\psi_{Kc=Kf}$) is the same as the effective stress friction angle (ϕ'). The K_c=1 envelope can be derived from the total stress cohesion value (c) and the total stress friction angle (ϕ), as determined from conventional CU triaxial compression tests. When c and ϕ are obtained from a line drawn tangent to the total stress Mohr's circles, the relationships among the intercept ($d_{Kc=1}$) and slope ($\psi_{Kc=1}$) of the K_c=1 envelope, the total stress c and ϕ, and the effective stress ϕ' are:

$$d_{k_c=1} = c\left(\frac{\cos\phi\cos\phi'}{1-\sin\phi}\right) \quad \textbf{Eqn.3.1}$$

$$\psi_{k_c=1} = \tan^{-1}\left(\frac{\sin\phi\cos\phi'}{1-\sin\phi}\right) \quad \textbf{Eqn.3.2}$$

These parameters are given for each soil on the UTEXAS4 output plots in Appendix D.

TVA criteria for stability in a rapid drawdown event is established in the "Draft TVA Coal Combustion Products Management Program" (prepared by URS and dated October 23, 2009). The criteria, taken from USACE guidance for new earth dams (EM 1110-2-1902, Table 3-1), requires a safety factor of 1.1 (drawdown from a maximum surcharge pool) to 1.3 (drawdown from a maximum storage pool). The philosophy in this recommended range is that lower safety factors should be acceptable for unusual events, while higher safety factors should be required for frequent events. For Dike C, a rapid drawdown of Watts Bar Lake from the 100-year flood stage be considered an expected and likely event. Hence, it would appear reasonable to require FSslope $\geq$ 1.3 for rapid drawdown along Dike C.

Graphical output from the UTEXAS4 rapid drawdown analyses are presented in Appendix D. The computed factors of safety for slope stability are summarized in Table 2. With the buttress in place, the computed safety factors for all five sections exceed the design guidelines of FS $\geq$ 1.3 for sudden drawdown.

Table.2. Stability Assessment for Dike C with the Rock Buttress, Following a Drop in Watts Bar Lake from the 100-year Flood Pool (Elev. 748 feet) to the Normal Winter Pool (Elev. 737 feet)

Cross Section	Factor of Safety for Slope Stability
108+93	1.93
119+69	1.63
132+37	1.75
138+27	1.36
149+14	1.92

3.3 Seismic Loading

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. Due to the size of this report, it has not been reproduced in this letter or as an appendicie.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Thomas Crilly
Stantec Quality Assurance

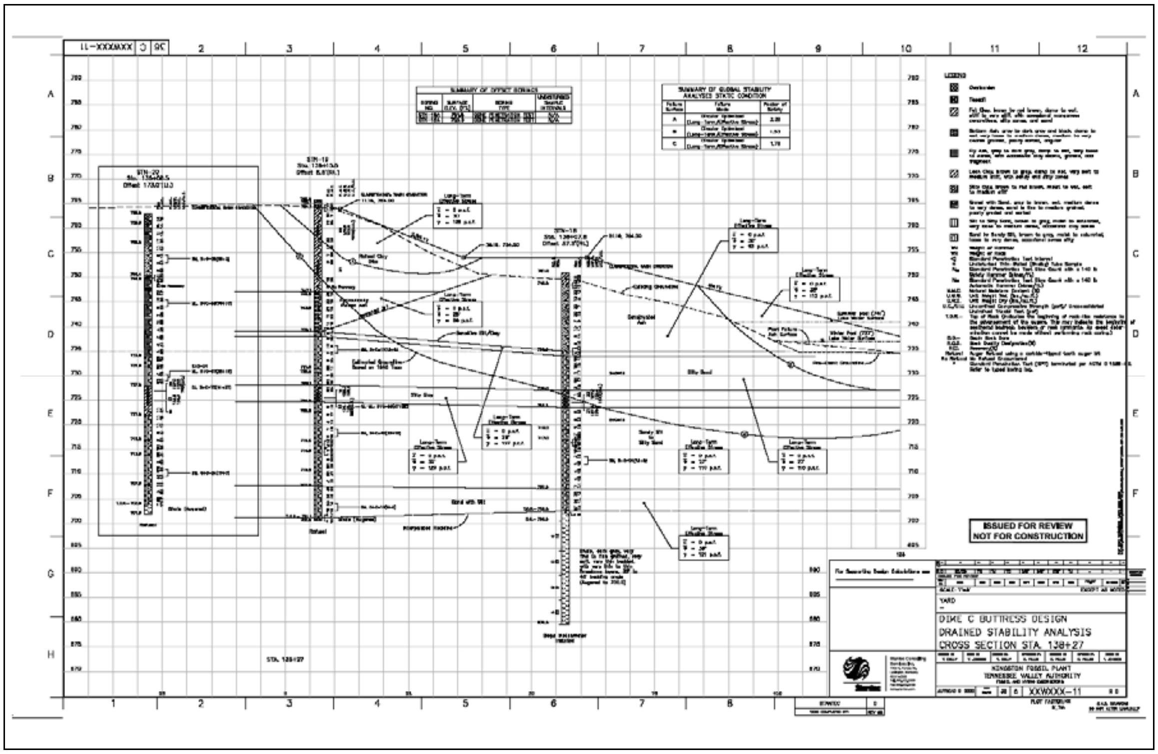
Don W. Fuller II, PE
Principal

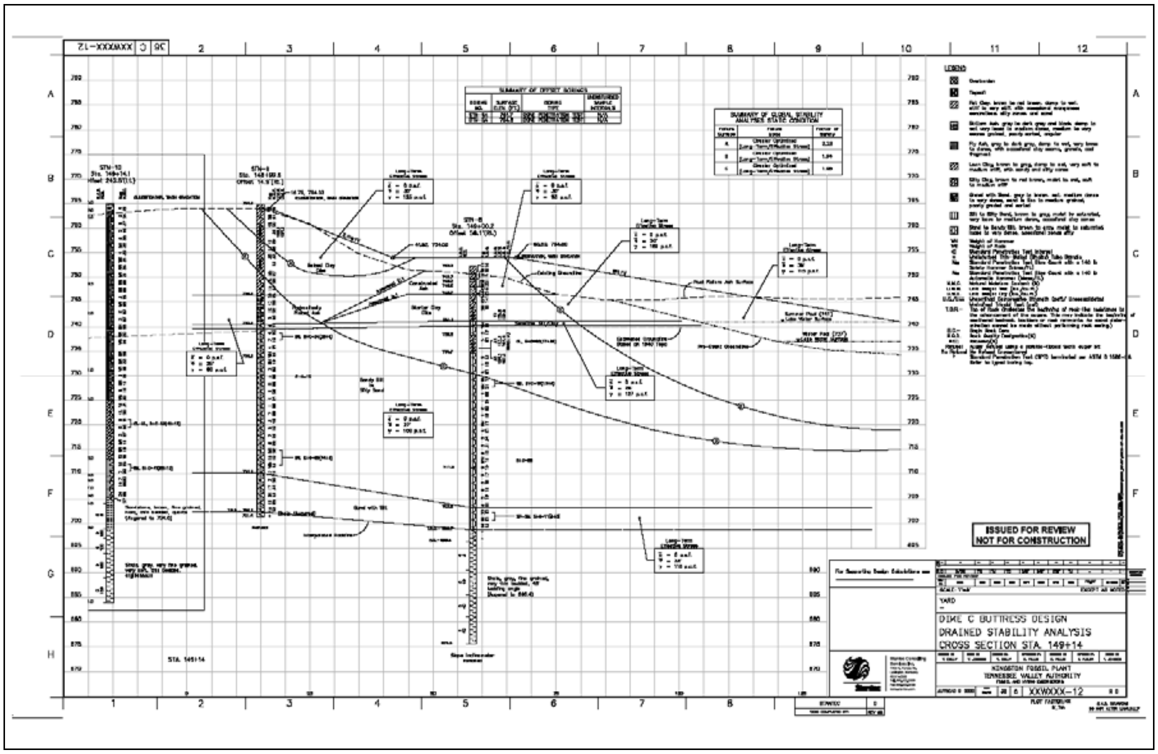
jp/tc/cmw

Appendix A: Slope Stability Output – Drained Buttress Condition
Appendix B: Slope Stability Output – Undrained Buttressed Condition
Appendix C: Piezometer and Slope Inclinometer Summary Graphs
Appendix D: Slope Stability Output – Rapid Drawdown Scenario

Appendix A

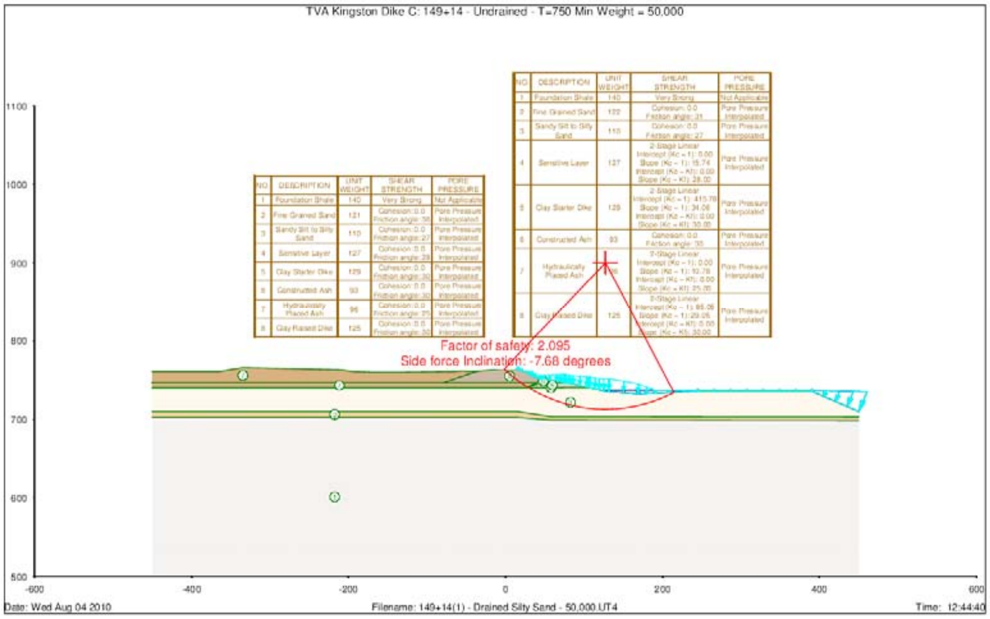
Slope Stability Drawings - Drained Buttressed Condition

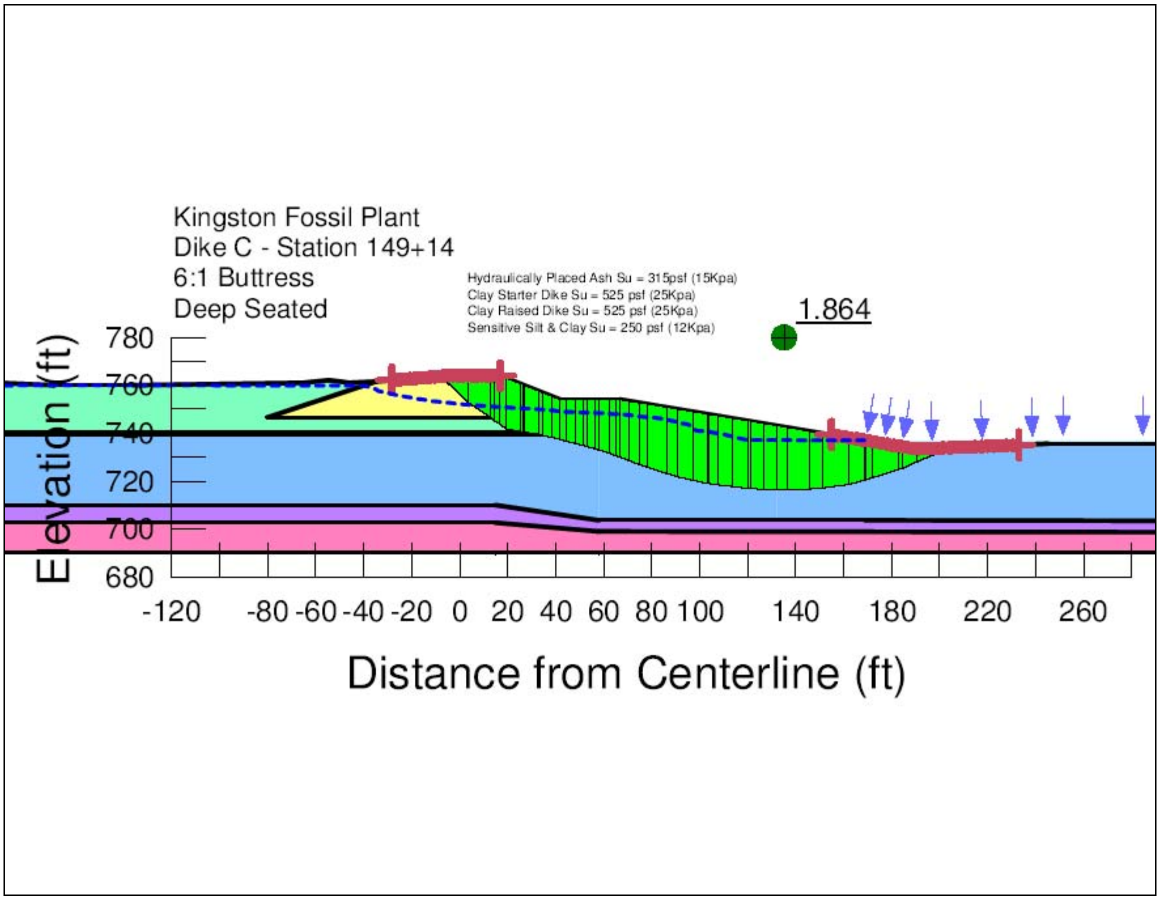

ISSUED FOR REVIEW
NOT FOR CONSTRUCTION
DIKE C BUTTRESS DESIGN
DRAINED STABILITY ANALYSIS
CROSS SECTION STA. 138+27
KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
STA. 138+27

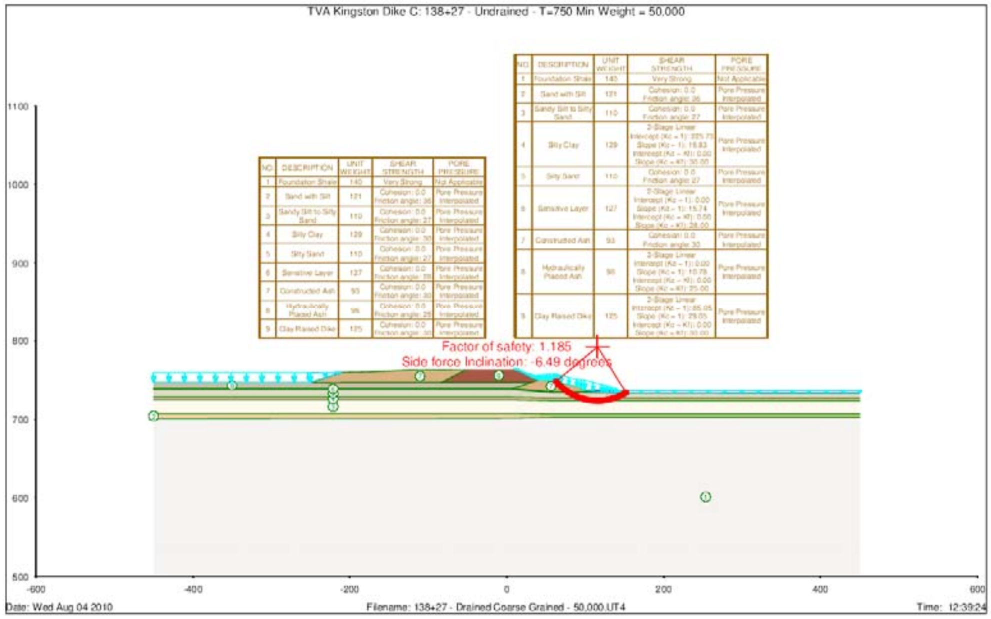

ISSUED FOR REVIEW
NOT FOR CONSTRUCTION
YARD
DIKE C BUTTRESS DESIGN
DRAINED STABILITY ANALYSIS
CROSS SECTION STA. 149+14
KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
XXWXXX-12
STA. 149+14

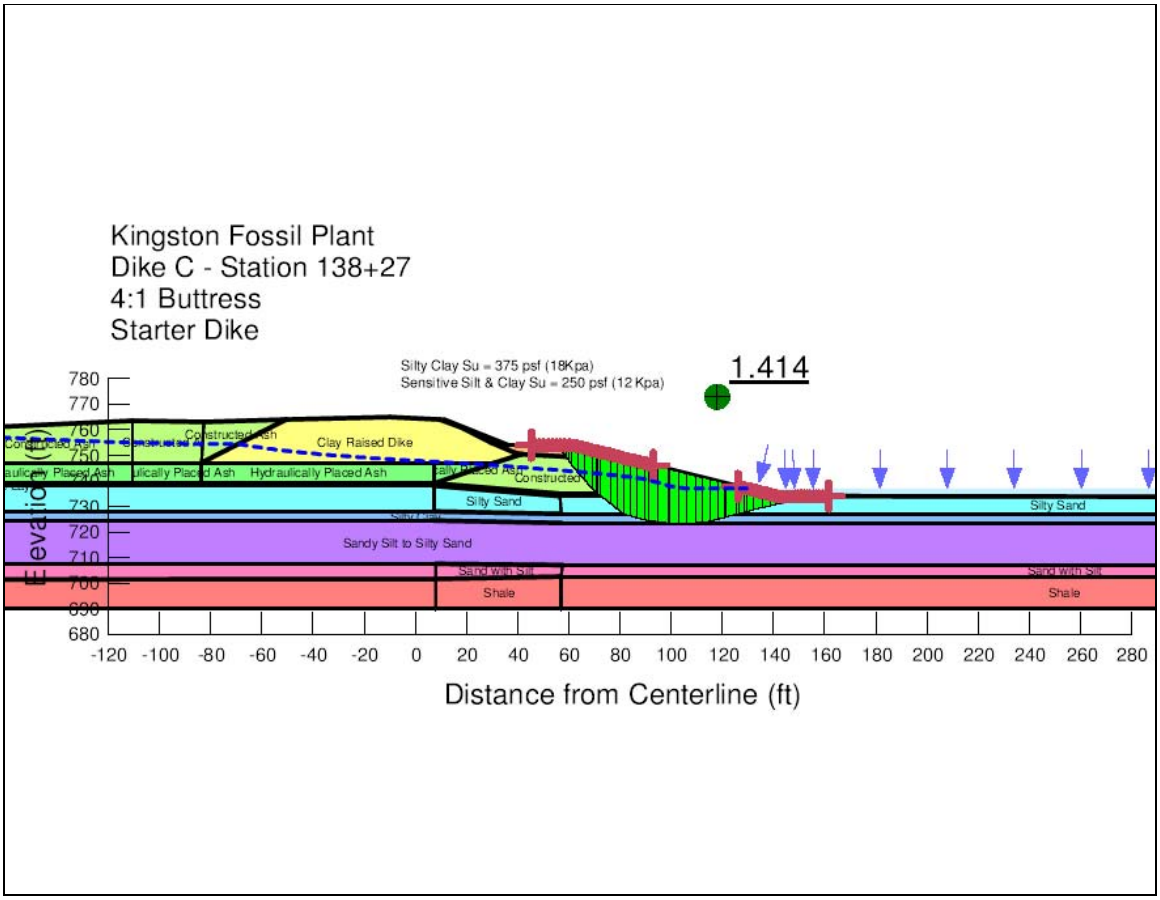
Appendix B

Slope Stability Output - Undrained Buttressed Condition


TVA Kingston Dike C: 149+14 - Undrained - T=750 Min Weight = 50,000
Factor of safety: 2.095
Side force Inclination: -7.68 degrees
1100
1000
900
800
700
600
500
-600
-400
-200
0
200
400
600
Date: Wed Aug 04 2010
Filename: 149+14(1) - Drained Silty Sand - 50,000.UT4
Time: 12:44:40

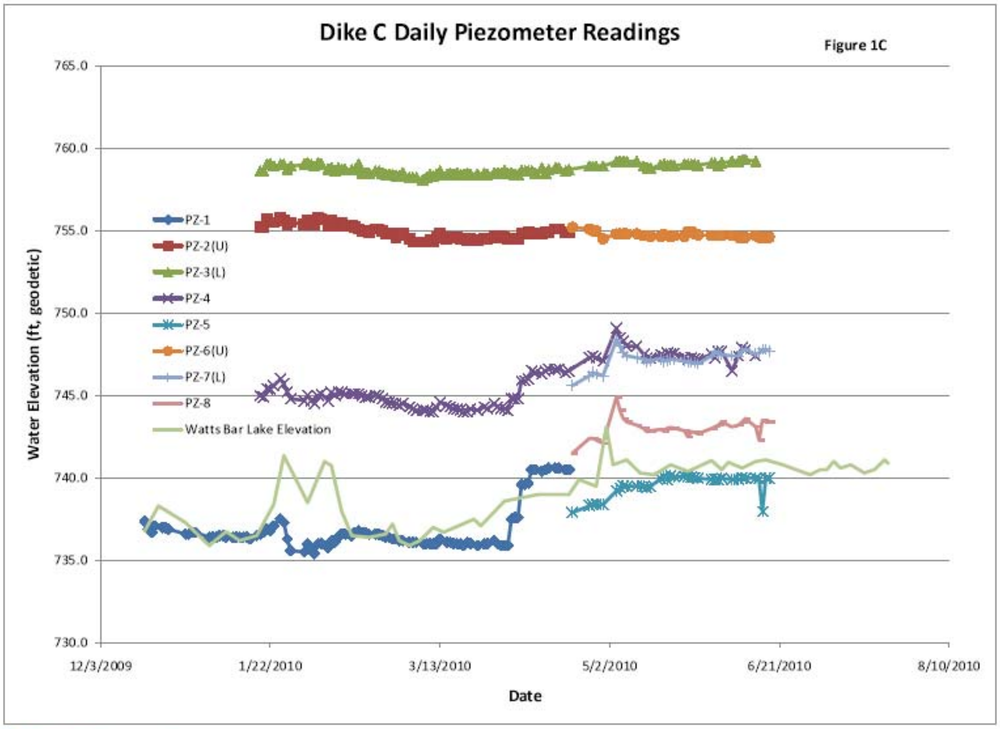

Kingston Fossil Plant
Dike C - Station 149+14
6:1 Buttress
Deep Seated
Hydraulically Placed Ash Su = 315psf (15Kpa)
Clay Starter Dike Su = 525 psf (25Kpa)
Clay Raised Dike Su = 525 psf (25Kpa)
Sensitive Silt & Clay Su = 250 psf (12Kpa)
1.864
780
760
740
720
700
680
Elevation (ft)
-120
-80 -60 -40 -20 0 20 40 60 80 100
140
180
220
260
Distance from Centerline (ft)


TVA Kingston Dike C: 138+27 - Undrained - T=750 Min Weight = 50,000
Factor of safety: 1.185
Side force Inclination: -6.49 degrees
Date: Wed Aug 04 2010
Filename: 138+27 - Drained Coarse Grained - 50,000.UT4
Time: 12:39:24


Kingston Fossil Plant
Dike C - Station 138+27
4:1 Buttress
Starter Dike
Silty Clay Su = 375 psf (18Kpa)
Sensitive Silt & Clay Su = 250 psf (12 Kpa)
1.414
Clay Raised Dike
Constructed Ash
Hydraulically Placed Ash
Silty Sand
Sandy Silt to Silty Sand
Sand with Silt
Shale
Elevation (ft)
Distance from Centerline (ft)

Appendix C

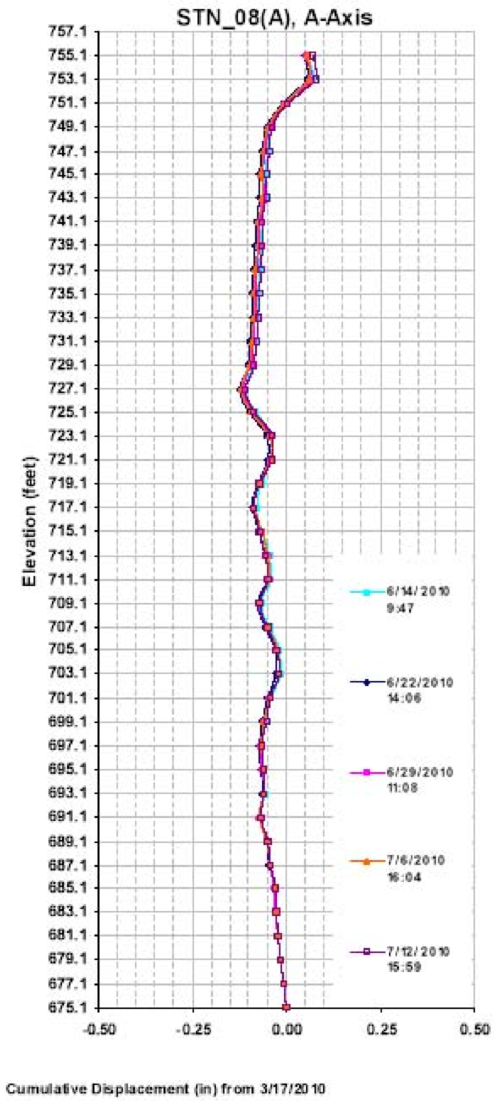
Piezometer and Slope Inclinometer Summary Graphs

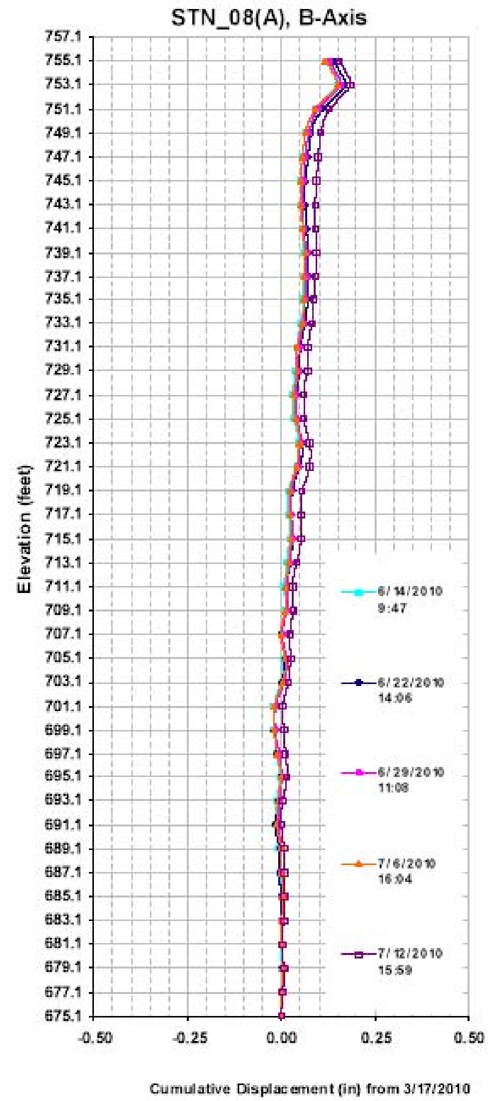


Stantec

Kingston Fossil Plant
Kingston, TN
175669093

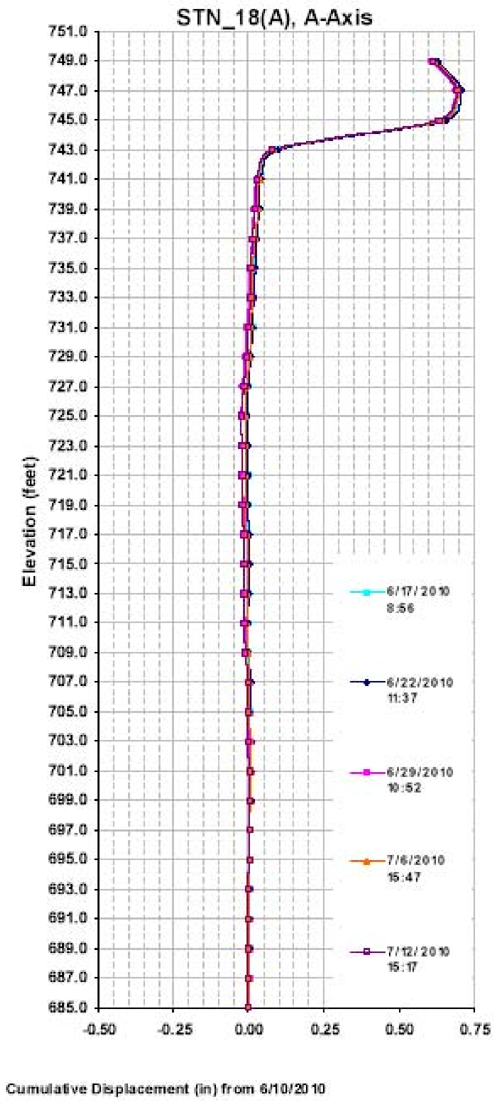
8/5/2010

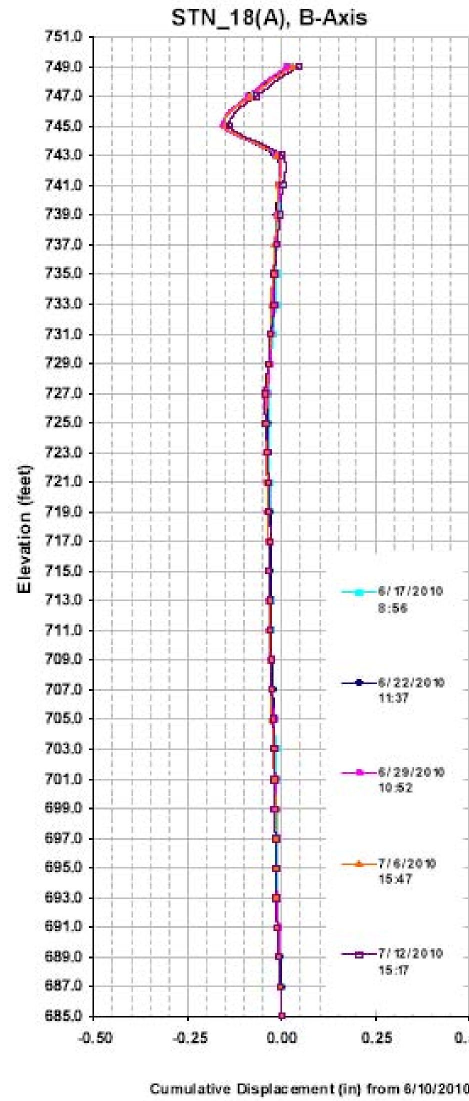




Stantec

Kingston Fossil Plant
Ash Pond Stability
Kingston, TN
175569042
7/20/2010



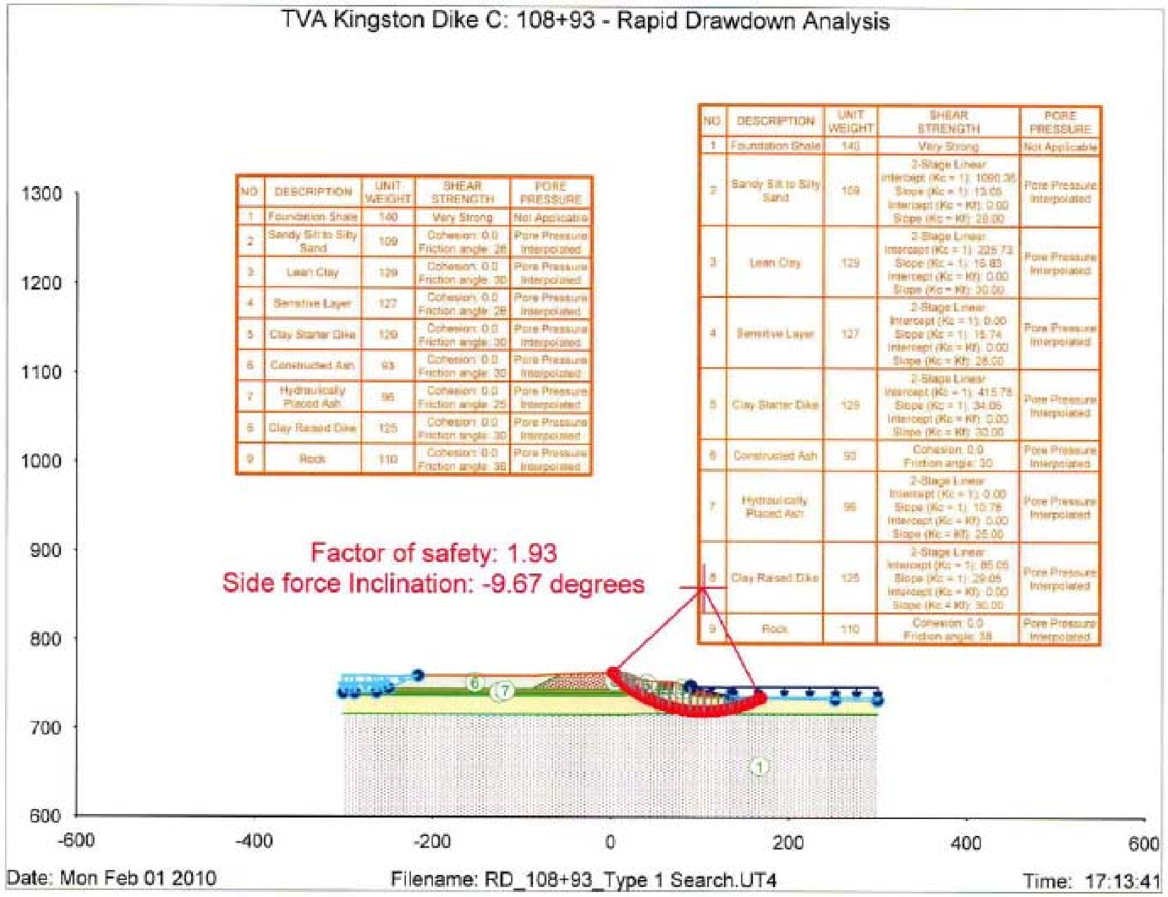


Stantec

Kingston Fossil Plant
Ash Pond Stability
Kingston, TN
175569042
7/20/2010

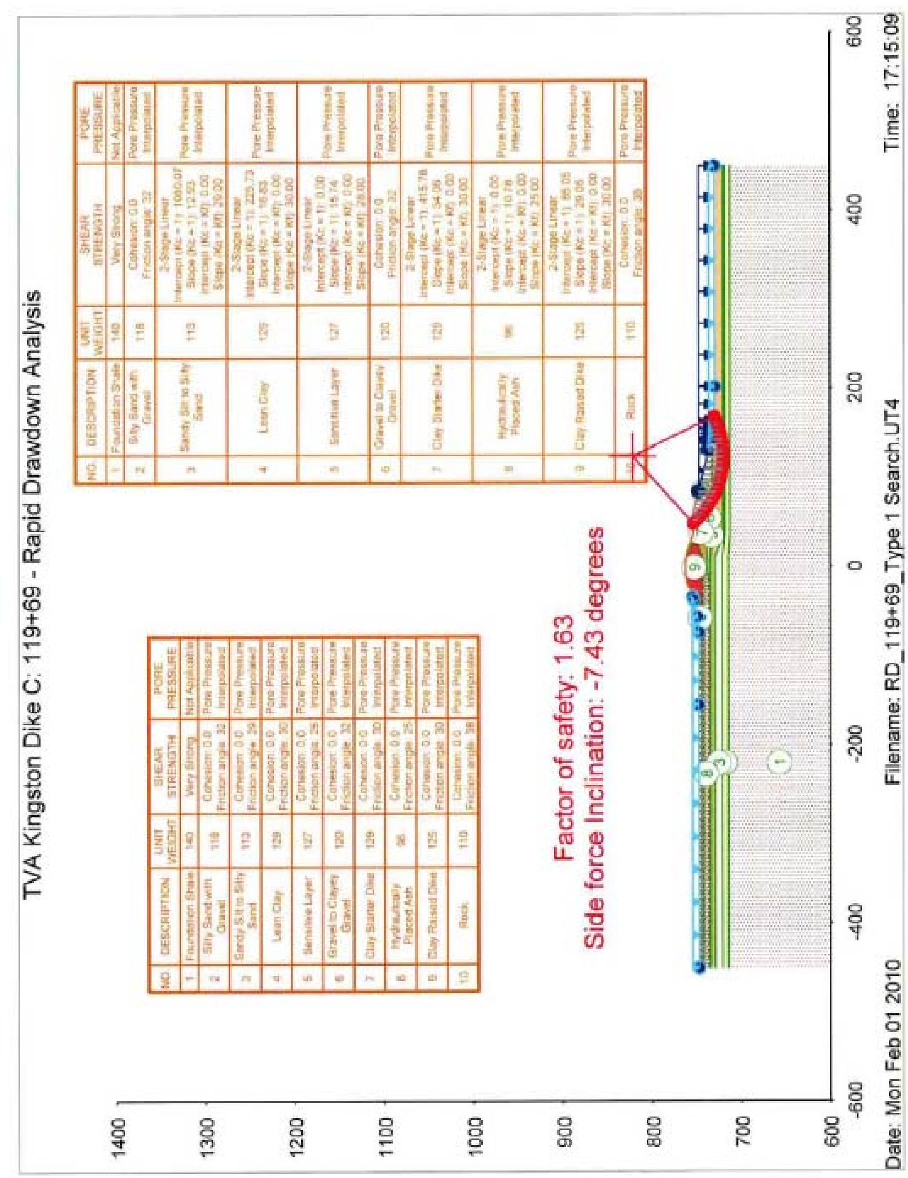
Appendix D

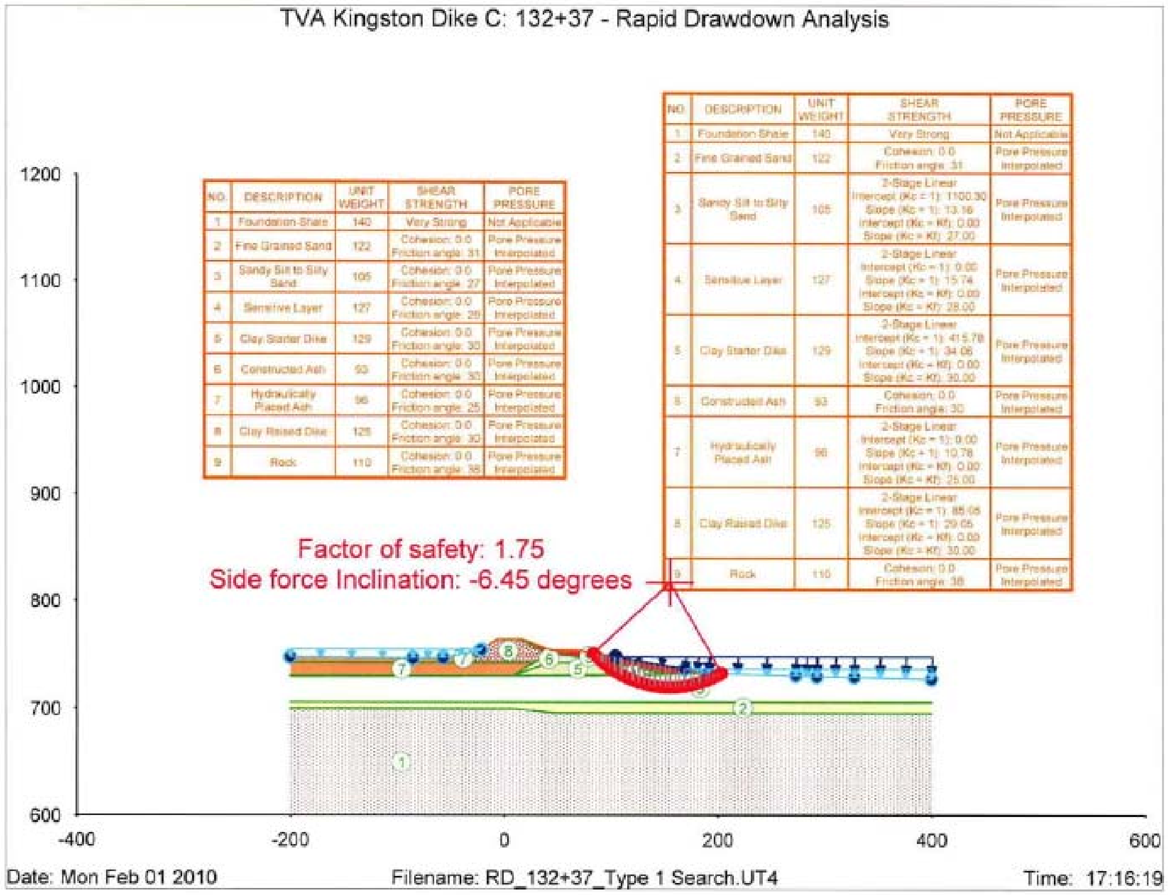
Slope Stability Output -
Rapid Drawdown
Scenario



NO	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sandy Silt to Silty Sand	109	Cohesion: 0.0 Friction angle: 28	Pore Pressure Interpolated
3	Lean Clay	129	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
4	Sensitive Layer	127	Cohesion: 0.0 Friction angle: 28	Pore Pressure Interpolated
5	Clay Starter Dike	129	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
6	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
7	Hydraulically Placed Ash	96	Cohesion: 0.0 Friction angle: 25	Pore Pressure Interpolated
8	Clay Raised Dike	125	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
9	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated

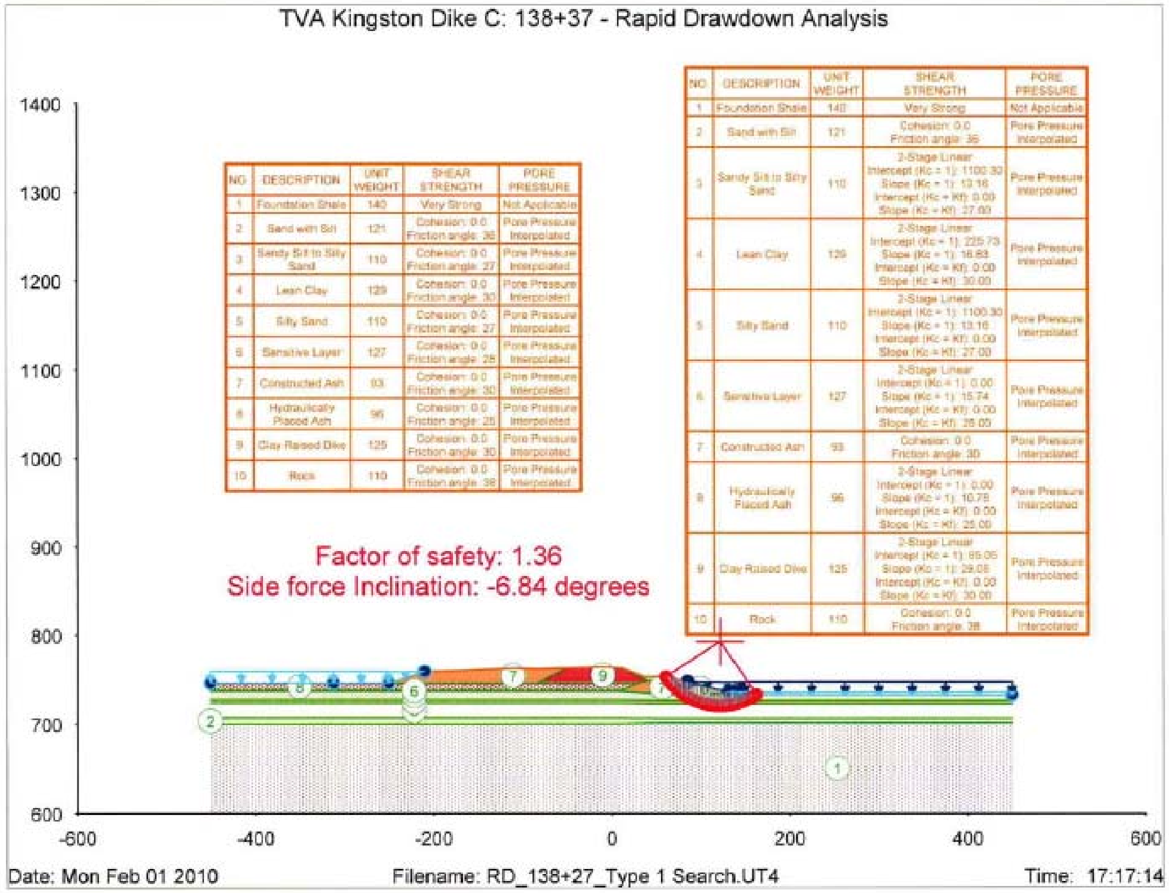
NO	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sandy Silt to Silty Sand	109	2-Stage Linear Intercept (Kc = 1): 1090.36 Slope (Kc = 1): 13.05 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 28.00	Pore Pressure Interpolated
3	Lean Clay	129	2-Stage Linear Intercept (Kc = 1): 225.73 Slope (Kc = 1): 16.83 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
4	Sensitive Layer	127	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 15.74 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 28.00	Pore Pressure Interpolated
5	Clay Starter Dike	129	2-Stage Linear Intercept (Kc = 1): 415.78 Slope (Kc = 1): 34.06 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
6	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
7	Hydraulically Placed Ash	96	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 10.78 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 25.00	Pore Pressure Interpolated
8	Clay Raised Dike	125	2-Stage Linear Intercept (Kc = 1): 85.05 Slope (Kc = 1): 29.05 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
9	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated


TVA Kingston Dike C: 119+69 - Rapid Drawdown Analysis
Factor of safety: 1.63
Side force Inclination: -7.43 degrees
Date: Mon Feb 01 2010
Filename: RD_119+69_Type 1 Search.UT4
Time: 17:15:09



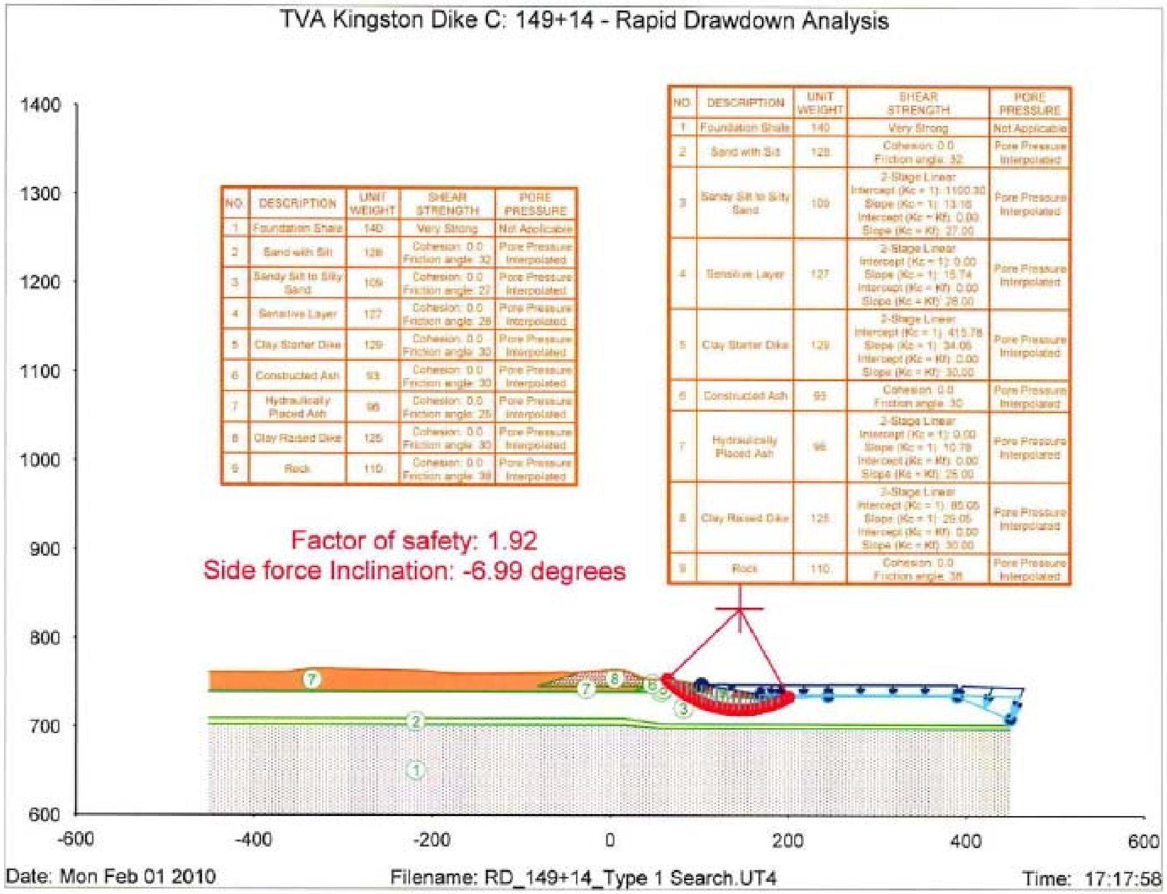
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Fine Grained Sand	122	Cohesion: 0.0 Friction angle: 31	Pore Pressure Interpolated
3	Sandy Silt to Silty Sand	105	Cohesion: 0.0 Friction angle: 27	Pore Pressure Interpolated
4	Sensitive Layer	127	Cohesion: 0.0 Friction angle: 29	Pore Pressure Interpolated
5	Clay Starter Dike	129	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
6	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
7	Hydraulically Placed Ash	96	Cohesion: 0.0 Friction angle: 25	Pore Pressure Interpolated
8	Clay Raised Dike	125	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
9	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Fine Grained Sand	122	Cohesion: 0.0 Friction angle: 31	Pore Pressure Interpolated
3	Sandy Silt to Silty Sand	105	2-Stage Linear Intercept (Kc = 1): 1100.30 Slope (Kc = 1): 13.16 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 27.00	Pore Pressure Interpolated
4	Sensitive Layer	127	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 15.74 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 28.00	Pore Pressure Interpolated
5	Clay Starter Dike	129	2-Stage Linear Intercept (Kc = 1): 415.78 Slope (Kc = 1): 34.06 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
6	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
7	Hydraulically Placed Ash	96	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 10.78 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 25.00	Pore Pressure Interpolated
8	Clay Raised Dike	125	2-Stage Linear Intercept (Kc = 1): 85.05 Slope (Kc = 1): 29.05 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
9	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated



NO	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sand with Silt	121	Cohesion: 0.0 Friction angle: 36	Pore Pressure Interpolated
3	Sandy Silt to Silty Sand	110	Cohesion: 0.0 Friction angle: 27	Pore Pressure Interpolated
4	Lean Clay	129	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
5	Silty Sand	110	Cohesion: 0.0 Friction angle: 27	Pore Pressure Interpolated
6	Sensitive Layer	127	Cohesion: 0.0 Friction angle: 28	Pore Pressure Interpolated
7	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
8	Hydraulically Placed Ash	96	Cohesion: 0.0 Friction angle: 25	Pore Pressure Interpolated
9	Clay Raised Dike	125	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
10	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated

NO	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sand with Silt	121	Cohesion: 0.0 Friction angle: 36	Pore Pressure Interpolated
3	Sandy Silt to Silty Sand	110	2-Stage Linear Intercept (Kc = 1): 1100.30 Slope (Kc = 1): 13.16 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 27.00	Pore Pressure Interpolated
4	Lean Clay	129	2-Stage Linear Intercept (Kc = 1): 225.73 Slope (Kc = 1): 16.83 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
5	Silty Sand	110	2-Stage Linear Intercept (Kc = 1): 1100.30 Slope (Kc = 1): 13.16 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 27.00	Pore Pressure Interpolated
6	Sensitive Layer	127	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 15.74 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 28.00	Pore Pressure Interpolated
7	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
8	Hydraulically Placed Ash	96	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 10.78 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 25.00	Pore Pressure Interpolated
9	Clay Raised Dike	125	2-Stage Linear Intercept (Kc = 1): 85.05 Slope (Kc = 1): 29.08 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
10	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sand with Silt	128	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
3	Sandy Silt to Silty Sand	109	Cohesion: 0.0 Friction angle: 27	Pore Pressure Interpolated
4	Sensitive Layer	127	Cohesion: 0.0 Friction angle: 28	Pore Pressure Interpolated
5	Clay Starter Dike	129	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
6	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
7	Hydraulically Placed Ash	96	Cohesion: 0.0 Friction angle: 25	Pore Pressure Interpolated
8	Clay Raised Dike	125	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
9	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sand with Silt	128	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
3	Sandy Silt to Silty Sand	109	2-Stage Linear Intercept (Kc = 1): 1100.30 Slope (Kc = 1): 13.16 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 27.00	Pore Pressure Interpolated
4	Sensitive Layer	127	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 15.74 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 28.00	Pore Pressure Interpolated
5	Clay Starter Dike	129	2-Stage Linear Intercept (Kc = 1): 415.78 Slope (Kc = 1): 34.06 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
6	Constructed Ash	93	Cohesion: 0.0 Friction angle: 30	Pore Pressure Interpolated
7	Hydraulically Placed Ash	96	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 10.78 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 25.00	Pore Pressure Interpolated
8	Clay Raised Dike	125	2-Stage Linear Intercept (Kc = 1): 85.05 Slope (Kc = 1): 26.05 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Pore Pressure Interpolated
9	Rock	110	Cohesion: 0.0 Friction angle: 38	Pore Pressure Interpolated