EPA Comments

SUBJECT: Comments on “DRAFT REPORT - Dam Safety Assessment of CCW Impoundments: TVA Gallatin Power Plant”

DATE: September 5, 2012

COMMENTS:

1. On page 2-3, section 2.2.3: TVA should provide this information in their response to the draft report, if not, please follow up with them. Slag is probably handled similarly to bottom ash.
2. The report does not seem to account for flood conditions in the Cumberland River, which immediately abuts the Stilling Pond D and Fly Ash Pond E. Is there concern for impacts from flood in the Cumberland River affecting the impoundment embankments which directly abut the river?
3. In Section 7.3 “Assessment of Structural Stability,” the issue of non-global failure factors of safety being below minimum accepted factors of safety, i.e., K-section of Divider Dike E., H-section of Divider Dike., should be noted and considered in the overall assessment of the structural stability of the impoundments.
4. In Appendix a, Document 2, “Aerial Photograph,” it may be advantageous to provide, via highlight, the approximate perimeter’s of the impoundments, as cureently it is somewhat difficult to discern from the aerial photograph.
5. Appendix B, Documents 17 and 18, page 4, please indicate presence or absence of liner. N/A is an inappropriate response.

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October 3, 2012 let_008_gaf_175551015_rev_0

Mr. John C. Kammeyer
Vice President
Tennessee Valley Authority
1101 Market Street, LP 5G
Chattanooga, Tennessee 37402

Re: Response to Recommendations
USEPA CCR Impoundment Assessment DRAFT Report
Gallatin Fossil Plant (GAF)
Gallatin, Tennessee

Dear Mr. Kammeyer:

As requested, Stantec has reviewed the DRAFT report *Coal Combustion Residue Impoundment Dam Assessment Report, Gallatin Fossil Plant, Tennessee Valley Authority, Gallatin, Tennessee,* dated September 2012 prepared by Dewberry and Davis, LLC (Dewberry) for the United States Environmental Protection Agency (USEPA). The purpose of this letter is to address Dewberry's conclusions and recommendations pertaining to structural stability, hydrologic/hydraulic (H&H) capacity, and technical documentation; and to provide additional supporting information relative to ongoing plant improvements, further analysis, and planned activities where applicable. Dewberry's recommendations and corresponding responses are listed below.

Dewberry Report Section 1.2.2 – Stilling Ponds and Pond A: *Continue the project to replace the Pond A spillway; when available, provide final H & H analyses documenting that the CCR Complex will safely pass the design flood once the spillway project is completed.*

Response: The Pond A spillway improvement/replacement project is currently being designed by URS. Its purpose is to increase the H&H capacity of Pond A's conveyance system to accommodate the design storm. With regards to the H&H analysis for the stilling ponds, URS has been charged with the task of performing analysis to determine/design improvements needed and to address the stilling ponds hydrologic/hydraulic capacity issues.

Dewberry Report Section 1.2.3 2) – Stilling Ponds: *Perform slope stability analyses for all credible static and seismic loading conditions, as well as piping potential analyses, for the stilling pond complex saddle dikes (Ponds C and D) to verify and document that these dikes have adequate structural stability.*

Response: Stantec has performed the additional analysis recommended by Dewberry including 1) seepage analysis, and 2) pseudostatic (seismic) and long-term (static) slope stability analysis for Sections M (Pond C saddle dike) and N (Pond D saddle dike). The results indicate that the target factors of safety are satisfactory. The results are attached.

Dewberry Report Section 1.2.1 – Ponds A and E: *Implement Stantec's recommended remedial measures for increasing the factor of safety against non-global (shallow) slope failures to the minimum factor of safety criterion for the Bottom Ash Pond A and Fly Ash Pond E containment dikes.*

Response: A project to increase the non-global slope stability factors of safety is currently in the design phase. This project is being designed by URS.

Dewberry Report Section 1.2.3 1) – Ponds A and E: *Perform a quantitative liquefaction analysis of dike raise embankment sections overlying sluiced ash at the Bottom Ash Pond A and Fly Ash Pond E; evaluate the impact of liquefaction on the sluiced-ash supported sections of the containment dikes, if liquefaction is indicated; and evaluate the consequences of liquefaction failure of these sections of the containment dikes.*

Response: Stantec performed a liquefaction potential assessment based on ground motion estimates for the 2,500-year earthquake scenarios, Standard Penetration Test borings, and corresponding laboratory test results. A description of the methodology and the results (ground response analysis and factor of safety against liquefaction versus elevation plots) are attached. Consistent with previously submitted seismic stability analyses, Section K was analyzed for Pond A and Section B was analyzed for Pond E. The saturated bottom ash dike materials and the saturated sluiced ash materials are anticipated to undergo liquefaction for the 2,500-year earthquake.

Based on the results of the liquefaction potential assessment, residual strengths were assigned to the liquefied materials and post-earthquake static stability analysis was performed. A description of the methodology and the results (slope stability cross sections, including table of material parameters) are attached. The results indicate that Pond A Section K and Pond E Section B both have factors of safety greater than or equal to the target threshold value of 1.0; thus, the dikes will remain stable and will not undergo significant liquefaction-induced deformations due to the 2,500-year earthquake.

Dewberry Report Section 1.2.4 – Maintenance:

1) Repair minor erosion observed at various locations during the site visit; use cohesive soil cover on the eroded slopes and improve the vegetation growth. 2) Continue to inspect/monitor the dikes for new and existing seeps for changes that might affect the dikes' integrity. Closely inspect for new sinkholes that could impact the integrity and function of the dikes, particularly after heavy rainfalls or flooding.

Response: TVA's Routine Handling, Operations and Maintenance (RHO&M) group will continue the ongoing maintenance program to repair eroded areas, improve vegetative cover, and address other items. Improvements made in 2012 included overseeding of sparsely vegetated areas; wave wash protection for Ponds A, C and D; and crushed stone road/dike crest covering for Ponds E, C and D. TVA will also continue its ongoing inspection program, which includes frequent observations to monitor known seeps, and to look for changed conditions or new features.

Summary: Based on the results of Dewberry's report and the Stantec responses provided, there are no immediate, compelling, or urgent actions necessary at the GAF CCP facilities.

Ponds A and E: Considering that TVA plans to address the non-global stability issues in the near future, and based on the acceptable results of seismic stability analysis provided herein, it is Stantec's opinion that the final rating for GAF Ponds A and E should be upgraded to Satisfactory.

Stilling Ponds: Based on the acceptable results of the additional stability and seepage analysis for the saddle dikes provided in this letter, and considering that TVA plans to address the H&H issues in the near future, it is Stantec's opinion that the rating for GAF Stilling Pond Complex can be upgraded to Fair. Upon completion of Stilling Pond improvements to address the H&H issues, the rating should be upgraded to Satisfactory.

We appreciate the opportunity to provide these responses. If you have any questions or need additional information, please call.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Stephen H. Bickel, PE
Senior Principal

Randy L. Roberts, PE
Principal

/rr/cmp

Cc: Roberto L. Sanchez, PE
Michael S. Turnbow

Attachments

lope Stability Analysis
CP Storage Facilities - Existing Conditions
ennessee Valley Authority Fossil Plants

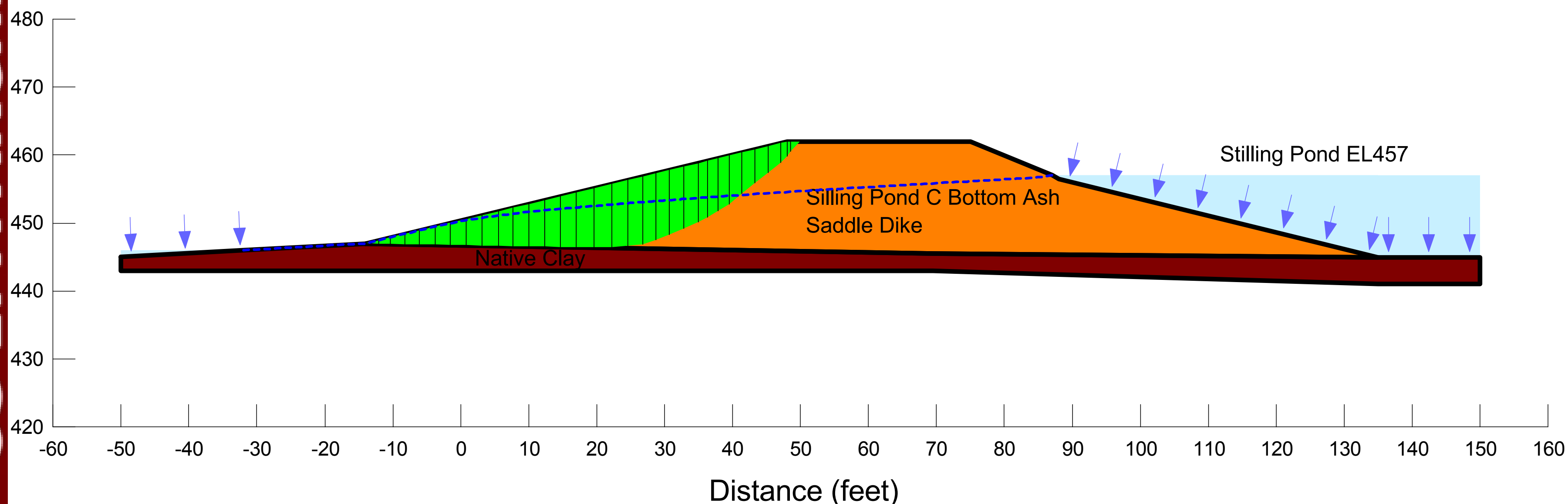
ection M - Stilling Pond C
allatin Fossil Plant
allatin, Tennessee

Stantec

Note:
The results of analysis shown here are based on available subsurface information, aboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Unit Weight	Cohesion	Friction Angle
Stilling Pond C Bottom Ash Saddle dike	105 pcf	0 psf	30 °
Native Clay	125 pcf	200 psf	27 °

Long Term Factor of Safety: 1.8



Date of Assessment - 9/20/2012

Project No. 175551015

Pseudostatic Slope Stability Analysis
CCP Storage Facilities - Existing Conditions
Tennessee Valley Authority Fossil Plants

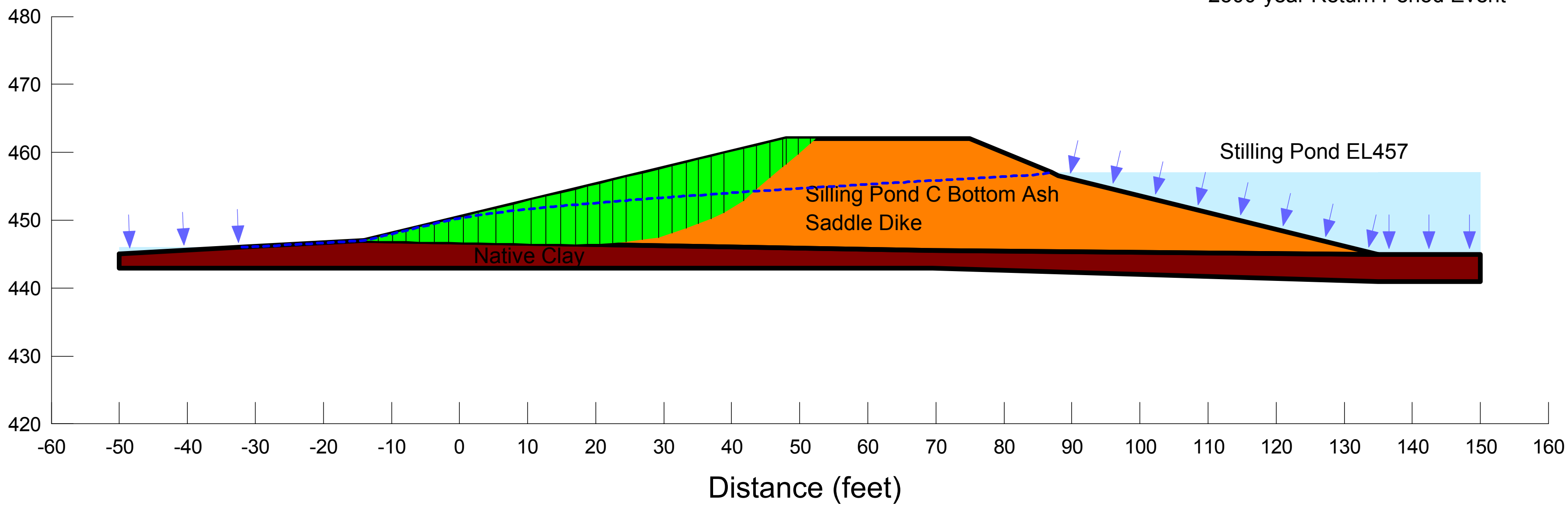
Section M - Stilling Pond C
Gallatin Fossil Plant
Gallatin, Tennessee

Stantec

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Unit Weight	Cohesion	Friction Angle
Stilling Pond C Bottom Ash Saddle dike	105 pcf	0 psf	30 °
Native Clay	125 pcf	550 psf	13 °

Factor of Safety: 1.2
Horizontal Seismic Coefficient Kh = 0.108g
2500-year Return Period Event



Seepage Analysis
CCP Storage Facilities - Existing Conditions
Tennessee Valley Authority Fossil Plants

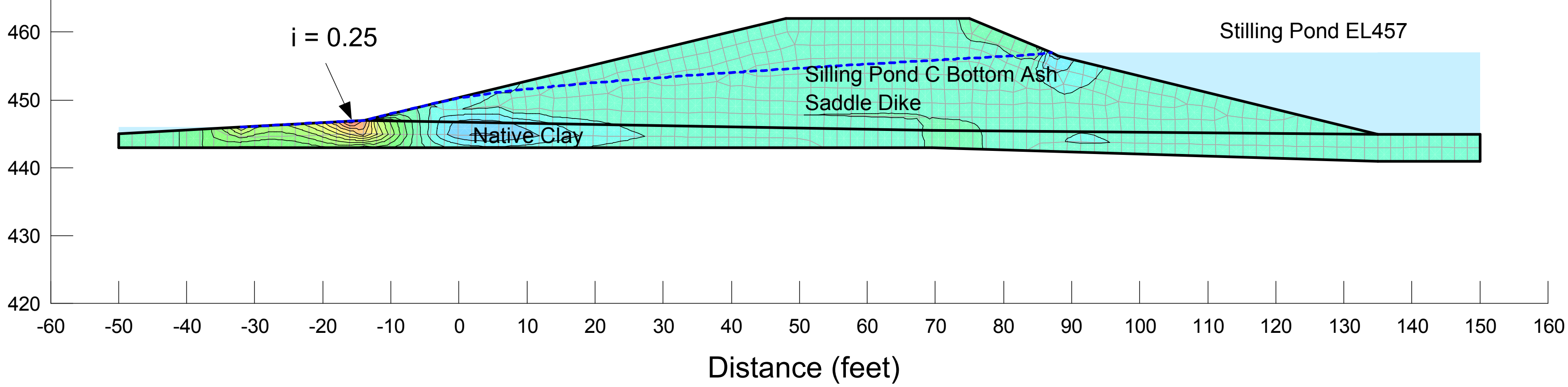
Section M - Stilling Pond C
Gallatin Fossil Plant
Gallatin, Tennessee

Piping Potential
Maximum occurs at (-16, 446.89)
Total Head = 446.89 ft
At (-16.03, 444.93)
Total Head = 447.38 ft
dH = 0.49 ft   dL = 1.96
i = 0.25 i(criticial) = 1.00
FSpiping = 4.0

Stantec

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Ksat	Kratio	Wsat
Stilling Pond C Bottom Ash Saddle dike	3.28e-006	1	0.15
Native Clay	3.2e-007	0.1	0.4
Limestone	0.000328	0.1	0.15



Date of Assessment - 9/20/2012

Project No. 175551015

Slope Stability Analysis
CCP Storage Facilities - Existing Conditions
Tennessee Valley Authority Fossil Plants

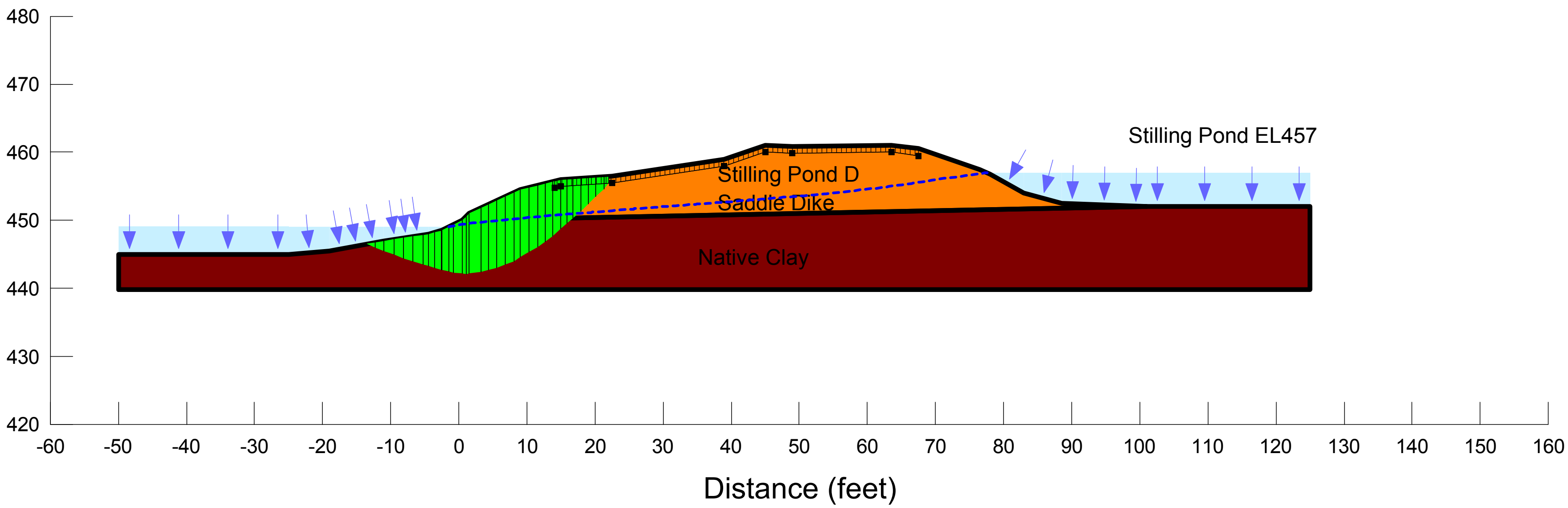
Section N - Stilling Pond D
Gallatin Fossil Plant
Gallatin, Tennessee

Stantec

Material Type	Unit Weight	Cohesion	Friction Angle
Stilling Pond D Saddle Dike	125 pcf	200 psf	22 °
Native Clay	125 pcf	200 psf	27 °

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Factor of Safety: 2.6



Date of Assessment - 9/20/2012

Project No. 175551015

Pseudostatic Slope Stability Analysis
CCP Storage Facilities - Existing Conditions
Tennessee Valley Authority Fossil Plants

Section N - Stilling Pond D
Gallatin Fossil Plant
Gallatin, Tennessee

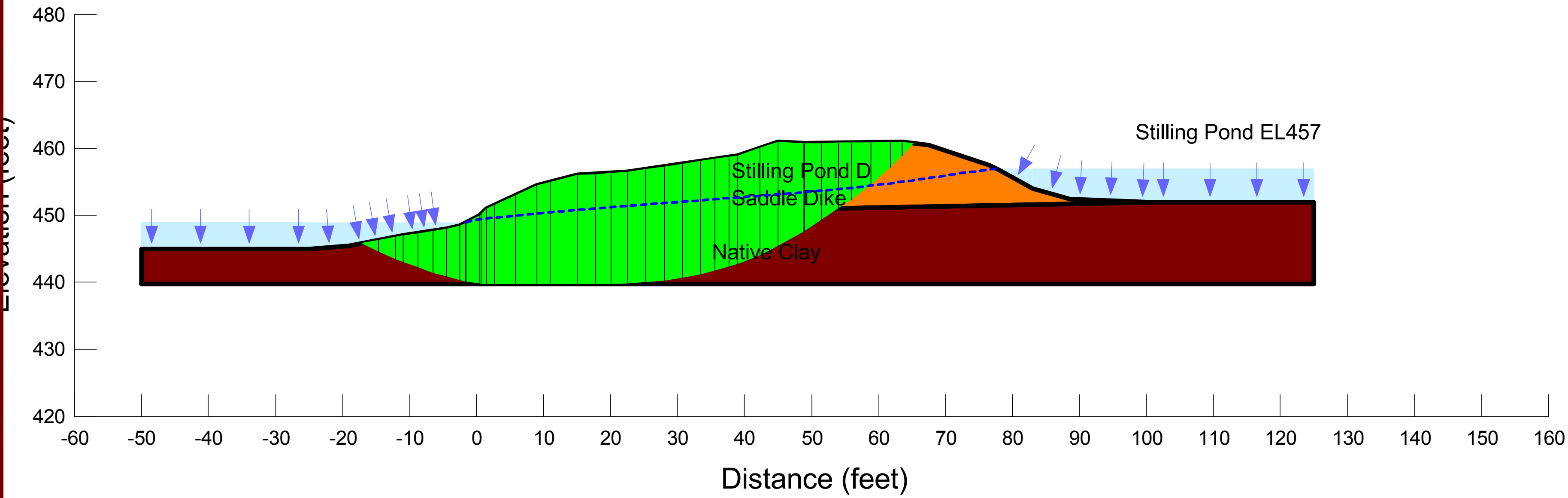
Stantec

Material Type	Unit Weight	Cohesion	Friction Angle
Stilling Pond D Saddle Dike	125 pcf	400 psf	15 °
Native Clay	125 pcf	550 psf	13 °

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Factor of Safety: 2.2

Horizontal Seismic Coefficient Kh = 0.108g
2500-year Return Period Event



Date of Assessment - 9/20/2012

Project No. 175551015

Seepage Analysis
CCP Storage Facilities - Existing Conditions
Tennessee Valley Authority Fossil Plants

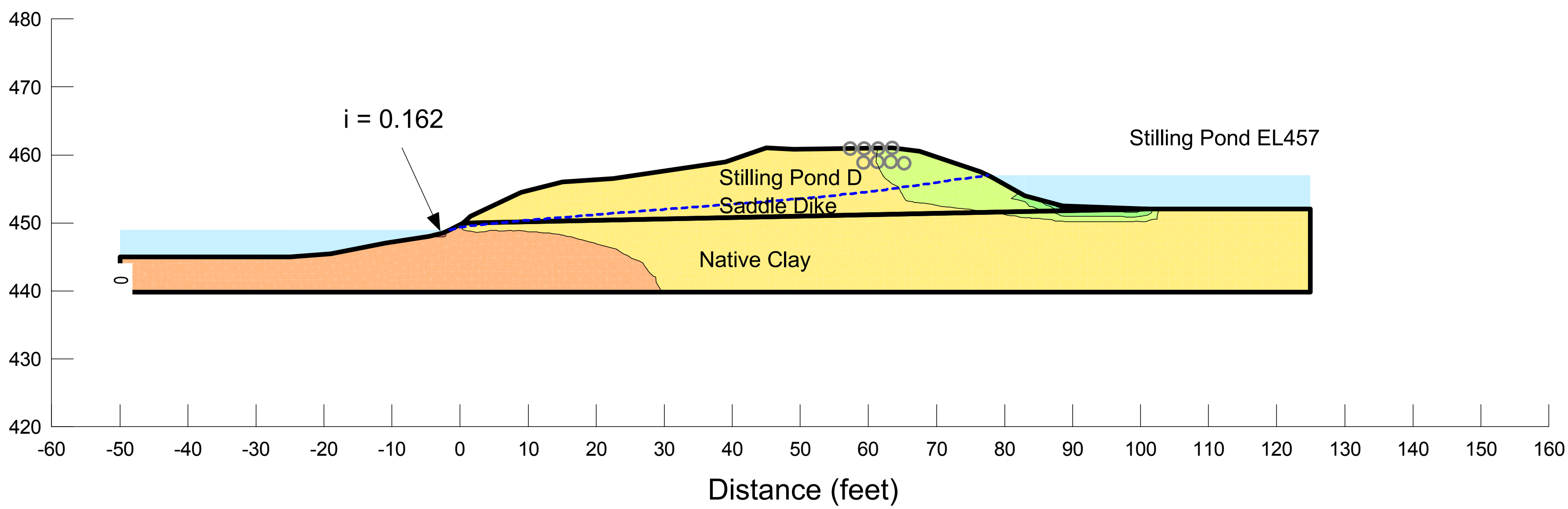
Section N - Stilling Pond D
Gallatin Fossil Plant
Gallatin, Tennessee

Piping Potential
Maximum occurs at (-2.5, 448.5)
Total Head = 449 ft
At (-2.14, 444.01)
Total Head = 449.73 ft
dH = 0.73 ft dL = 4.5
i = 0.162 i(criticial) = 1.04
FSpiping = 6.4

Stantec

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Ksat	Kratio	Wsat
Stilling Pond D Saddle Dike	1.64e-008	0.2	0.15
Native Clay	3.3e-007	0.1	0.4



Date of Assessment - 9/20/2012

Project No. 175551015

MATCHLINE (See Sheet 02)

LEGEND

- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling
- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling And Rock Core
- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling And Piezometer Location
- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling And Rock Core And Piezometer Location
- A — A' Cross Section

NOTES

1. Topographic and survey information provided by the Tennessee Valley Authority.
2. The boring logs and related information shown on this drawing depict approximate subsurface conditions only at the specific boring locations noted and at the time of drilling. Conditions at other locations may differ from those occurring at the boring locations. Also, the passage of time may result in a change in the subsurface conditions at the boring locations. Any correlations shown between borings are generally based on straight line interpolation. Actual conditions between borings are unknown and may differ from those shown.

BORING LOCATION TABLE

BORING	NORTHING	EASTING	ELEVATION (ft.)
STN-A-1	707,019.68	1,879,799.57	472.8
STN-A-2	706,994.16	1,879,810.94	473.3
STN-A-3	707,510.75	1,880,731.90	472.9
STN-A-4	707,498.65	1,880,758.47	473.8
STN-A-5	708,368.74	1,881,417.01	473.7
STN-A-6	708,353.42	1,881,433.71	474.0
STN-A-7	708,921.58	1,881,894.55	474.5
STN-A-8	708,907.06	1,881,914.61	474.8
STN-A-9	709,132.64	1,882,470.74	472.4
STN-A-10	709,085.67	1,882,461.16	474.1
STN-C-1	707,402.48	1,879,680.01	462.0

FOR INFORMATION ONLY
This Record Drawing which has been previously submitted to TVA is provided for Information Only.

RECORD DRAWING

100 0 200 400 FEET
GRAPHIC SCALE: 1"=200'

PLOT DATE: 05/20/2010 USER: BRADSHAW, STEVEN
V:\1755\ACTIVE\175559013\GEOTECHNICAL\DRAWING\REV0_RECORD\10W504-03-R0.DWG

For Supporting Design Calculations see FPGGAFFESCDX00000020100001

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R –	–	–	–	–	–	–	–	–	–	–	–
R 0	05/27/10	PC	RP	PC	RLR	RLR	RLR	TJ	–	–	–

R 0: RECORD DRAWING

DISCIPLINE INTERFACE: 1, 2, 3, 4

SCALE: 1'=200' EXCEPT AS NOTED

YARD
ASH POND/STILLING POND COMPLEX

GEOTECHNICAL EXPLORATION
BORING LAYOUT

RANDY LEE ROBERTS REGISTERED ENGINEER AGRICULTURE COMMERCE No. 113825 STATE OF TENNESSEE
Randy L. Roberts 5/27/10

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
P. COOPER	R. PETTY	P. COOPER	R. ROBERTS	R. ROBERTS	R. ROBERTS	T. JOHNSON

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GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

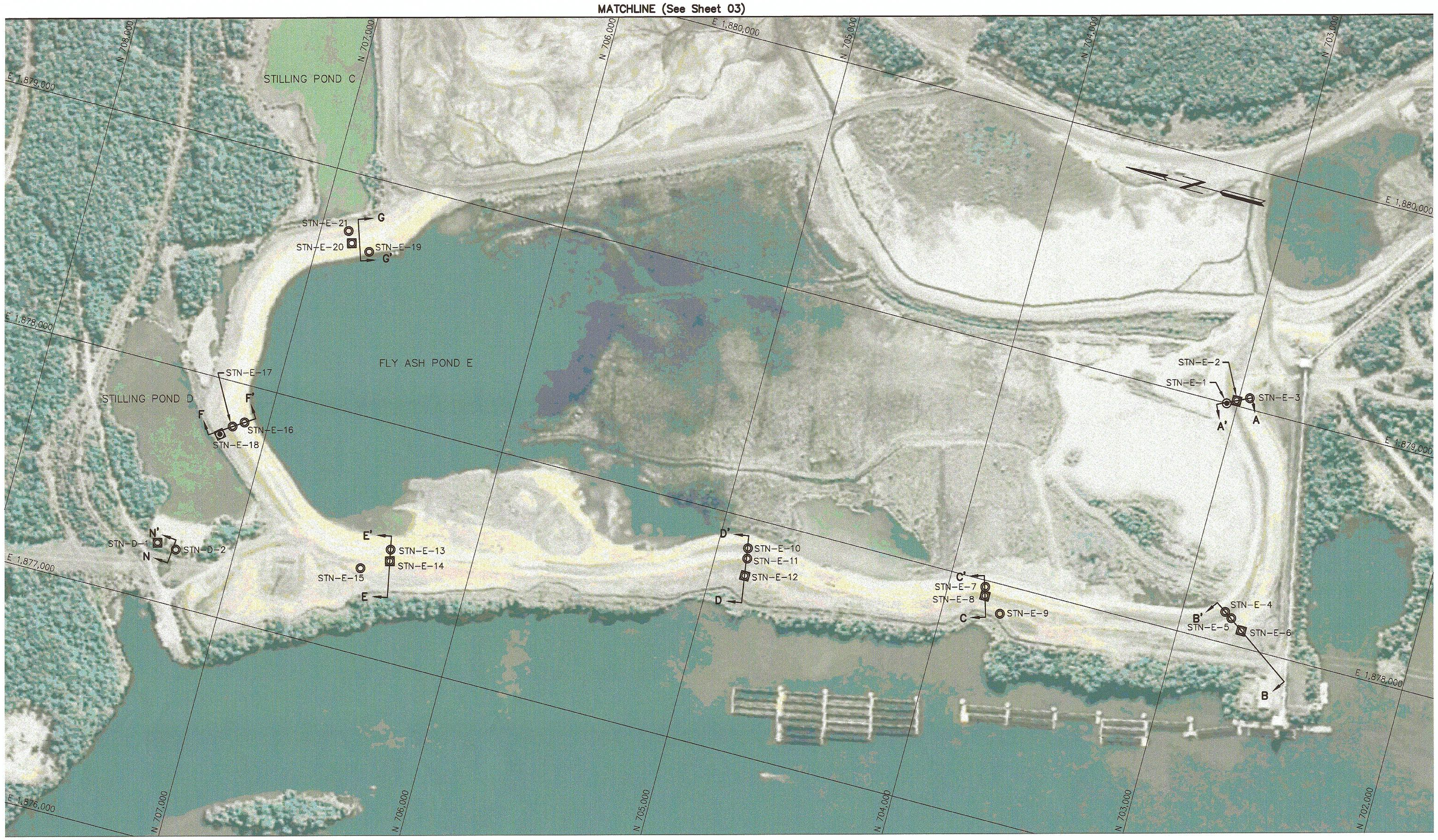
AUTOCAD R 2000 | DATE 05/27/10 | 39 | C | 10W504-03 | R 0

STANTEC | 0
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

MATCHLINE (See Sheet 03)



LEGEND

- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling
- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling And Rock Core
- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling And Piezometer Location
- Soil Boring With Continuous Standard Penetration Tests And/Or Shelby Tube Piston Sampling And Rock Core And Piezometer Location
- A A' Cross Section

NOTES

1. Topographic and survey information provided by the Tennessee Valley Authority.
2. The boring logs and related information shown on this drawing depict approximate subsurface conditions only at the specific boring locations noted and at the time of drilling. Conditions at other locations may differ from those occurring at the boring locations. Also, the passage of time may result in a change in the subsurface conditions at the boring locations. Any correlations shown between borings are generally based on straight line interpolation. Actual conditions between borings are unknown and may differ from those shown.

BORING LOCATION TABLE

BORING	NORTHING	EASTING	ELEVATION (ft.)
STN-D-1	707,328.99	1,877,246.92	460.8
STN-D-2	707,245.18	1,877,237.96	460.4
STN-E-1	703,045.88	1,879,000.10	474.1
STN-E-2	703,007.37	1,879,022.21	475.7
STN-E-3	702,955.21	1,879,046.66	459.6
STN-E-4	702,820.82	1,878,131.27	474.3
STN-E-5	702,788.65	1,878,111.48	476.1
STN-E-6	702,733.38	1,878,070.14	459.6
STN-E-7	703,843.80	1,877,971.87	475.1
STN-E-8	703,835.47	1,877,934.64	476.5
STN-E-9	703,753.39	1,877,876.25	451.8
STN-E-10	704,870.32	1,877,862.37	474.9
STN-E-11	704,863.36	1,877,828.40	476.1
STN-E-12	704,854.47	1,877,754.46	455.3
STN-E-13	706,353.41	1,877,474.21	474.3
STN-E-14	706,343.79	1,877,425.50	477.0
STN-E-15	706,458.09	1,877,364.00	463.4
STN-E-16	707,101.38	1,877,842.04	474.9
STN-E-17	707,146.54	1,877,811.85	475.4
STN-E-18	707,190.77	1,877,765.92	461.6
STN-E-19	706,774.43	1,878,687.08	472.8
STN-E-20	706,856.53	1,878,704.54	476.0
STN-E-21	706,883.00	1,878,751.72	461.6

RECORD DRAWING

100 0 200 400 FEET
GRAPHIC SCALE: 1"=200'

FOR INFORMATION ONLY
This Record Drawing which has been previously submitted to TVA is provided for Information Only.

For Supporting Design Calculations see FPGGAFFESCDX00000020100001

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0	05/27/10	PC	RP	PC	RLR	RLR	RLR	TJ	–	–	–

RECORD DRAWING

SCALE: 1'=200' EXCEPT AS NOTED

YARD
ASH POND/STILLING POND COMPLEX

GEOTECHNICAL EXPLORATION
BORING LAYOUT

RANDY LEE ROBERTS REGISTERED ENGINEER AGRICULTURE COMMERCE No. 113825 STATE OF TENNESSEE
5/27/10

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
P. COOPER	R. PETTY	P. COOPER	R. ROBERTS	R. ROBERTS	R. ROBERTS	T. JOHNSON

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GALLATIN FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R 2000 | DATE 05/27/10 | 39 | C | 10W504-02 | R 0

STANTEC | 0
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

DISCIPLINE INTERFACE

GENERAL METHODOLOGY
SEISMIC STABILITY ANALYSIS
TVA FOSSIL PLANTS

1. Seismic Hazards

1.1. Regional Seismic Sources

Seismicity in the TVA service area is attributed to the New Madrid fault and smaller, less concentrated crustal faults. Located in the western region, along the borders of Tennessee, Kentucky, Missouri, and Arkansas, the New Madrid source zone is capable of producing large magnitude earthquakes (M > 7). Events of this size would produce relatively long durations of strong ground shaking across the entire Tennessee River Valley. Fortunately, large magnitude New Madrid events are infrequent. Other source zones that may represent significant seismic risks for TVA facilities include those in eastern Tennessee, along the Wabash River Valley, and less significant sources throughout the region. While the maximum earthquake magnitudes associated with these other sources are smaller, compared to the New Madrid events, larger site accelerations can result from the closer proximity of TVA facilities.

These two earthquake scenarios generate significantly different seismic hazards at each locality and were considered independently in the analysis. To appropriately capture the influence of each, the assessments were completed independently for:

1. New Madrid events, and

2. events from “All Other Sources”.

1.2. Site-Specific Hazards

Site-specific seismic hazards were characterized for the seismic stability assessments. AMEC Geomatrix, Inc. (Oakland, California) used the 2004 TVA “Valley-wide” seismic hazard model (Geomatrix 2004) to generate seismic inputs for each of TVA’s fossil plants. Geomatrix documented their efforts in a report (AMEC Geomatrix Inc. 2011); excerpts are included herein.

The key data sets generated by Geomatrix and utilized by Stantec are:

1. Peak ground accelerations at top of hard rock (PGA_{rock}) for two different seismic sources (New Madrid Source and All Other Sources), for the 2,500-year return period, for each fossil plant location.

2. Seismic hazard deaggregation for PGA_{rock} for the 2,500-year return period. The hazards were deaggregated into appropriately sized bins of magnitude and epicentral distance.

1.3. PGA at Ground Surface

The peak horizontal accelerations obtained from the seismic hazard study represent accelerations at the top of hard bedrock (PGA_{rock}). For the assessment of liquefaction potential, the cyclic loads on natural soils and ash deposits were estimated using the simplified method described in Youd et al. (2001). This method requires estimates of the peak horizontal acceleration at the ground surface (PGA_{soil}).

Depending on the site and ground motion characteristics, peak accelerations may be amplified or attenuated (deamplified) as the energy propagates upward through the soil profile. Numerical ground response analyses can be used to model the propagation of ground motions and compute the cyclic stresses at various locations in the soil profile. One-dimensional, equivalent-linear elastic codes like ProShake can be used for this purpose if ground motion time histories are available.

To support sophisticated analyses at sites subject to higher seismic loads (i.e., large magnitudes and large accelerations), AMEC Geomatrix developed ground motion time histories for four TVA plants: Allen (ALF), Cumberland (CUF), Gallatin (GAF), and Shawnee (SHF). Relevant excerpts of the AMEC Geomatrix deliverable are provided herein. For these sites, Geocomp and Prof. Steve Kramer (University of Washington) performed ground response analyses using ProShake. These results, including profiles of acceleration and shear stress versus depth, were used for these four facilities. Compared to the more simplified method outlined below, the ProShake results allow for a more detailed representation of the ground response, particularly for facilities with extremely deep soils such as ALF and SHF.

Given the large portfolio of facilities that were considered, a simpler approach was used for the remaining facilities in this assessment. Developed for TVA by Dr. Gonzalo Castro and GEI Consultants, and implemented by Stantec in a spreadsheet, the method approximates what would be performed via one-dimensional, equivalent-linear elastic methods. For a representative soil profile, unit weights and groundwater conditions are applied to calculate total and effective stresses in the soil column. Soil stiffness (small-strain shear modulus or shear wave velocity), modulus reduction, and damping parameters are assigned based on estimated properties and published correlations. An iterative process is then used to estimate the PGA_{soil} at the top of ground, resulting from the PGA_{rock} for a given earthquake. The GEI method does not require a ground motion time history, but yields a result that appropriately considers the thickness and properties of the site-specific foundation soils. Instead of using acceleration time histories, this method utilizes response spectra for various levels of damping, which were generated by AMEC Geomatrix for use in these analyses. Relevant excerpts of the AMEC Geomatrix deliverable are provided herein. This method is more site-specific than using generic published correlations, and is judged to give reasonable results when compared to ProShake output.

2. Liquefaction Potential Assessment

2.1. Soil Loading from Earthquake Motions

The magnitude of the cyclic shear stresses induced by an earthquake is represented by the cyclic stress ratio (CSR). The simplified method proposed by Seed and Idriss (1971) and adopted by Youd et al. (2001) was used to estimate CSR. The cyclic stresses imparted to the soil were estimated from the earthquake parameters described above, representing earthquakes on the New Madrid fault and local crustal events.

2.2. Soil Resistance from Correlations with Penetration Resistance

The resistance to soil liquefaction, expressed in terms of the cyclic resistance ratio (CRR), was assessed using the empirical NCEER methodology (Youd et al. 2001). Updates to the procedure from recently published research were used where warranted. The analyses were based on the blowcount value (N) measured in the Standard Penetration Test (SPT) or the tip resistance (q_c) measured in the Cone Penetration Test (CPT).

The NCEER procedure involves a number of correction factors. Based on the site-specific conditions and soil characteristics, engineering judgment was used to select appropriate correction factors consistent with the consensus recommendations of the NCEER panel (Youd et al. 2001). To avoid inappropriately inflating the CRR, the NCEER fines content adjustment was not applied where zero blowcounts are recorded. The magnitude scaling factor (MSF) is used in the procedure to normalize the representative earthquake magnitude to a baseline 7.5M earthquake. The earthquake magnitude (M) most representative of the liquefaction risk was determined by applying the MSF to the de-aggregation data for the 2,500-year earthquakes (New Madrid and All Other Sources).

2.3. Factor of Safety Against Liquefaction

The factor of safety against liquefaction (FS_{liq}) is defined as the ratio of the liquefaction resistance (CRR) over the earthquake load (CSR). Following TVA design guidance and the precedent set by Seed and Harder (1990), FS_{liq} is interpreted as follows:

- Soil will liquefy where $FS_{liq} \leq 1.1$.
- Expect substantial soil softening where $1.1 < FS_{liq} \leq 1.4$.
- Soil does not liquefy where $FS_{liq} > 1.4$.

Using these criteria for guidance, values of FS_{liq} computed throughout a soil deposit or cross section (at specific CPT-q_c and SPT-N locations) were reviewed in aggregate. Occasional pockets of liquefied material in isolated locations are unlikely to induce a larger failure, and are typically considered tolerable. Instead, problems associated with soil liquefaction are indicated where continuous zones of significant lateral extent exhibit low values of FS_{liq}. Engineering judgment, including consideration for the likely performance in critical areas, was used in the overall assessment for each facility.

3. Post-Earthquake Slope Stability

3.1. Characterize Post-Earthquake Soil Strengths

The post-earthquake shearing resistance of each soil and coal combustion product (CCP) was estimated with consideration for the specific characteristics of that material. Specifically:

- Full static, undrained strength parameters were assigned to unsaturated soils, where significant excess pore pressures are not anticipated to develop under seismic loading.
- In saturated clays and soils with $FS_{liq} > 1.4$, 80% of the static undrained strength was assumed. These reduced strengths account for the softening effects of pore pressure buildup during an earthquake.
- In saturated, low-plasticity, granular soils with $1.1 < FS_{liq} \leq 1.4$, a reduced strength was assigned, based on the excess pore pressure ratio, r_u (Seed and Harder 1990). Typical relationships between FS_{liq} and r_u have been published by Marcuson and Hynes (1989).
- In saturated, low-plasticity, granular soils with $FS_{liq} \leq 1.1$, a residual (steady state) strength (S_r) was estimated for the liquefied soil.

3.2. Estimate Residual Strengths in Liquefied Deposits

Estimates of S_r can be obtained from empirical correlations published by various researchers. Typically, residual strength (or the ratio of residual strength over vertical effective stress) is correlated to corrected SPT blowcounts or corrected CPT tip resistance, based on back analysis of liquefaction case histories. For this evaluation, a new "hybrid" model developed by Kramer and Wang (in press) was used. Their hybrid model expresses mean residual strength as a function of both corrected SPT blowcounts and vertical effective stress:

$$\overline{\ln(S_r)} = -8.444 + 0.109(N_1)_{60} + 5.379(\sigma'_{vo})^{0.1}$$

Where S_r = residual strength in atmospheres, $(N_1)_{60}$ = normalized and corrected SPT N-value, and σ_{vo}' = initial vertical effective stress in atmospheres. A representative value of $(N_1)_{60}$ was selected for each liquefiable soil layer from a detailed review of the boring logs. SPT blowcounts judged to be erroneous or nonrepresentative of the in situ conditions were discarded. For example, excessively high blowcounts resulting from the SPT sampler hitting a cobble or boulder and excessively low blowcounts associated with borehole heave were discarded. The remaining blowcounts (in terms of $(N_1)_{60}$) were then averaged to arrive at the representative value.

SPT blowcounts and the correlation above tend to yield lower-bound estimates of steady state strength for saturated fly ash. Compared to the sandy soils considered in the correlation for S_r, a typical fly ash has a much higher fines content (>80% passing the No. 200 sieve) and a significantly lower permeability. During an SPT test at conventional rates, the excess pore pressure generated in one SPT blow cannot dissipate before the subsequent blows. The first few SPT blows may even liquefy the ash around the sampler, resulting in very low blowcounts, or even penetration under the static weight of the drill rods. Hence, SPT blowcounts in uncemented, saturated fly ash may not correlate to density and residual strengths in the same manner as sands and silty sands.

At some facilities, where CPT data were available, estimates of residual strength in saturated fly ash were obtained from the CPT sleeve friction (f_s). Where the fly ash is liquefied due to advancement of the cone probe, the sleeve friction provides a direct measurement of the residual shear strength. Liquefaction during advancement was judged by calculating the penetration pore water pressure ratio, defined as the increase in measured pore pressure above the static pore pressure (excess pore pressure), divided by the initial vertical effective stress. Penetration pore pressure ratios of one (or greater) indicate liquefaction in the material being penetrated, such that the sleeve friction data can be used as a measurement of S_r. This approach was not considered in sands or bottom ash, where the materials would be unlikely to liquefy due to advancement of the cone probe.

3.3. Analyze Slope Stability

The next step in the evaluation considered slope stability for post-earthquake conditions, including liquefied strengths where appropriate. Slope stability was evaluated using two-dimensional, limit equilibrium, slope stability methods and reduced soil strengths (from above), representing the loss of shearing resistance due to cyclic pore pressure generation during the earthquake. The analyses were accomplished using Spencer's method of analysis, as implemented in the SLOPE/W software, considering both circular and translational slip mechanisms. The analyses represent current operating conditions (geometry and phreatic levels).

If extensive liquefaction is indicated, stability was evaluated for the static conditions immediately following the cessation of the earthquake motions. Residual or steady state strengths were assigned in zones of liquefied soil, with reduced strengths that account for cyclic softening and pore pressure build up assumed in unliquefied soil. Failure (large, unacceptable displacements) is indicated if the safety factor (FS_{slope}) computed in this step is less than one. Slopes exhibiting $FS_{slope} \geq 1$ with liquefaction are assumed stable with tolerable deformations.

Within SLOPE/W, the residual strength model described previously was implemented with a cohesion (equal to S_r) that varies spatially. Based on the representative $(N_1)_{60}$ value and the initial vertical effective stress, S_r was calculated and assigned at key locations within the liquefied soil layer. The strength at any other point in the deposit was interpolated in SLOPE/W, thereby recognizing the increasing strength at higher vertical effective stress.

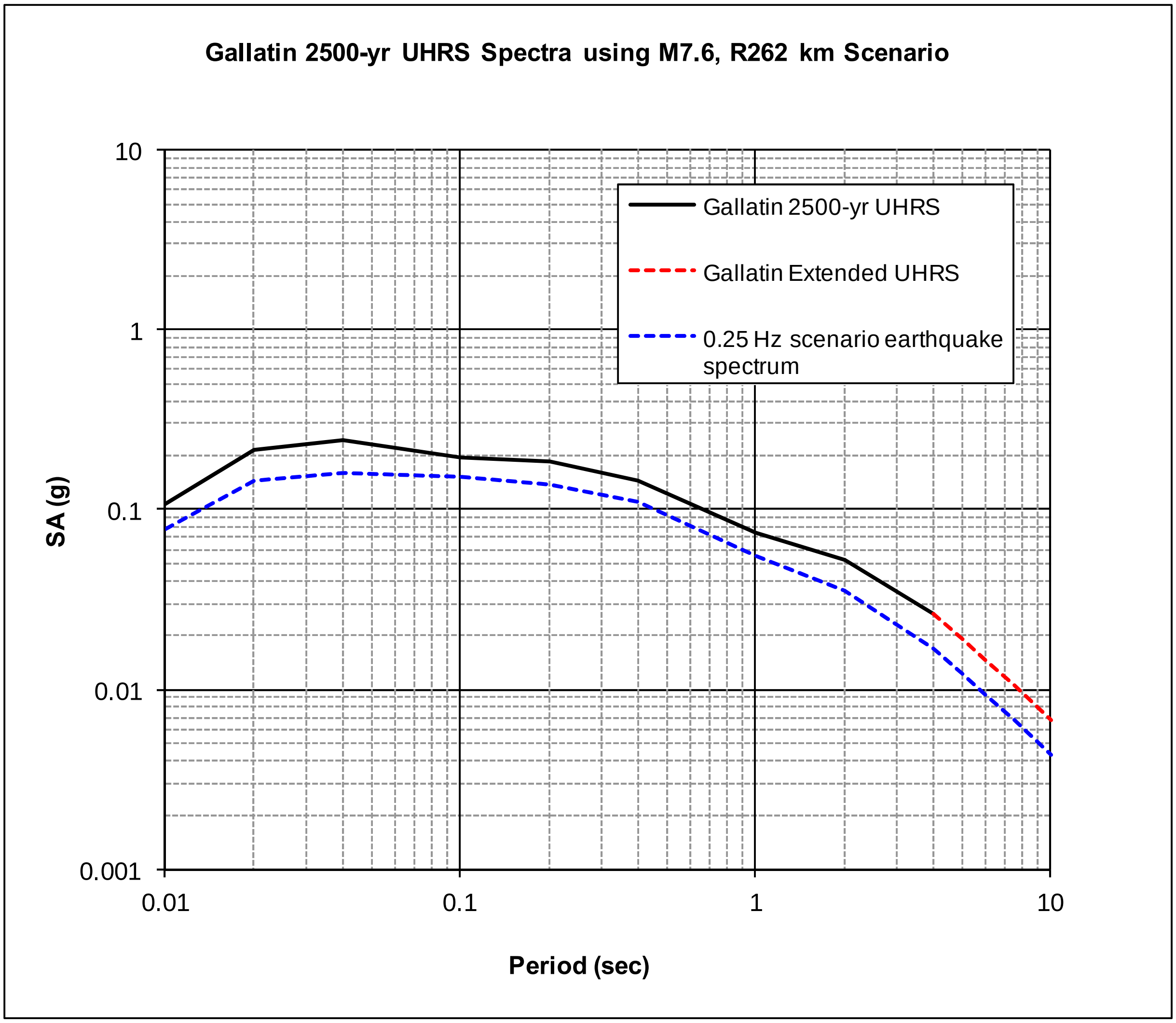
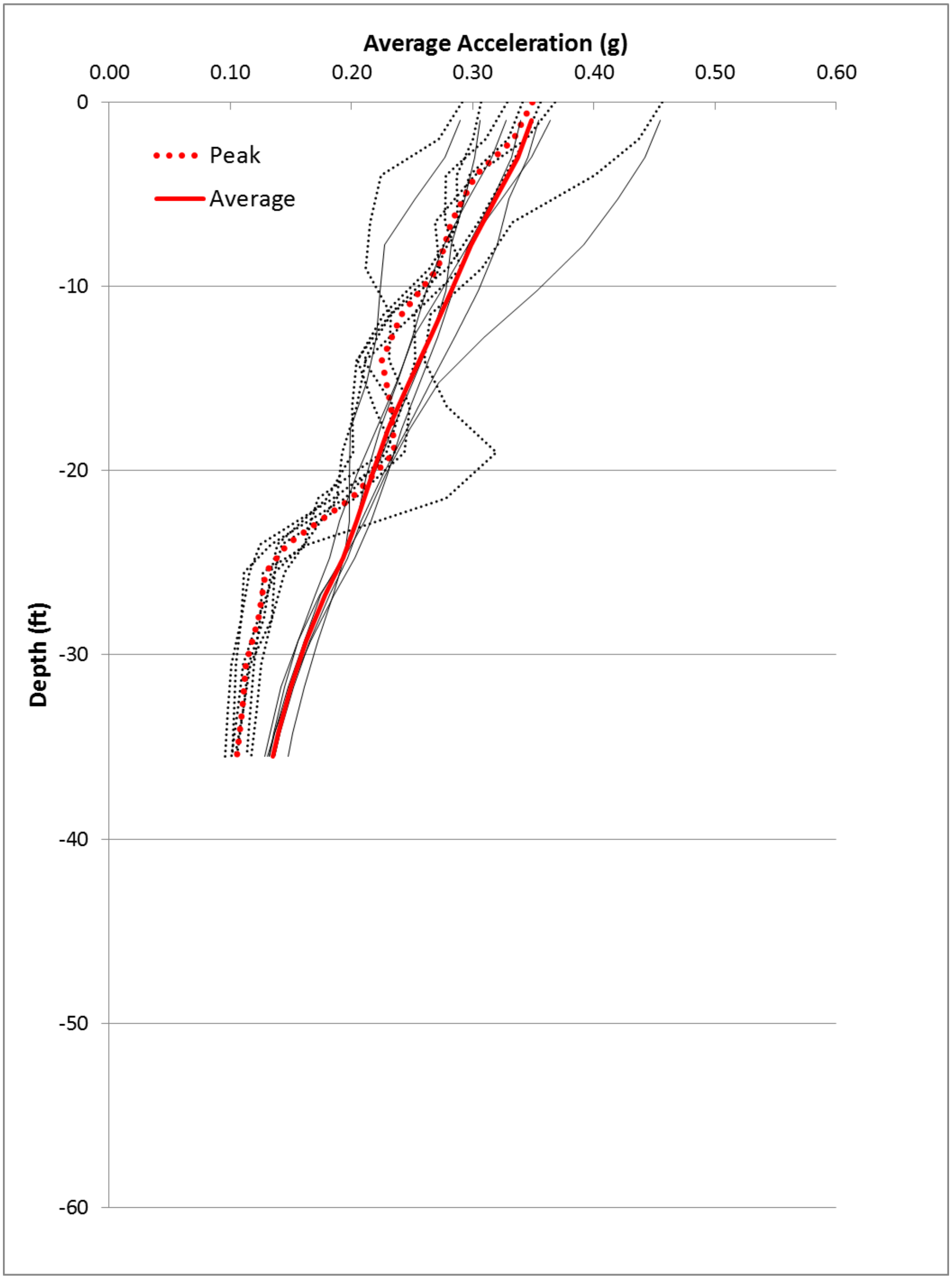
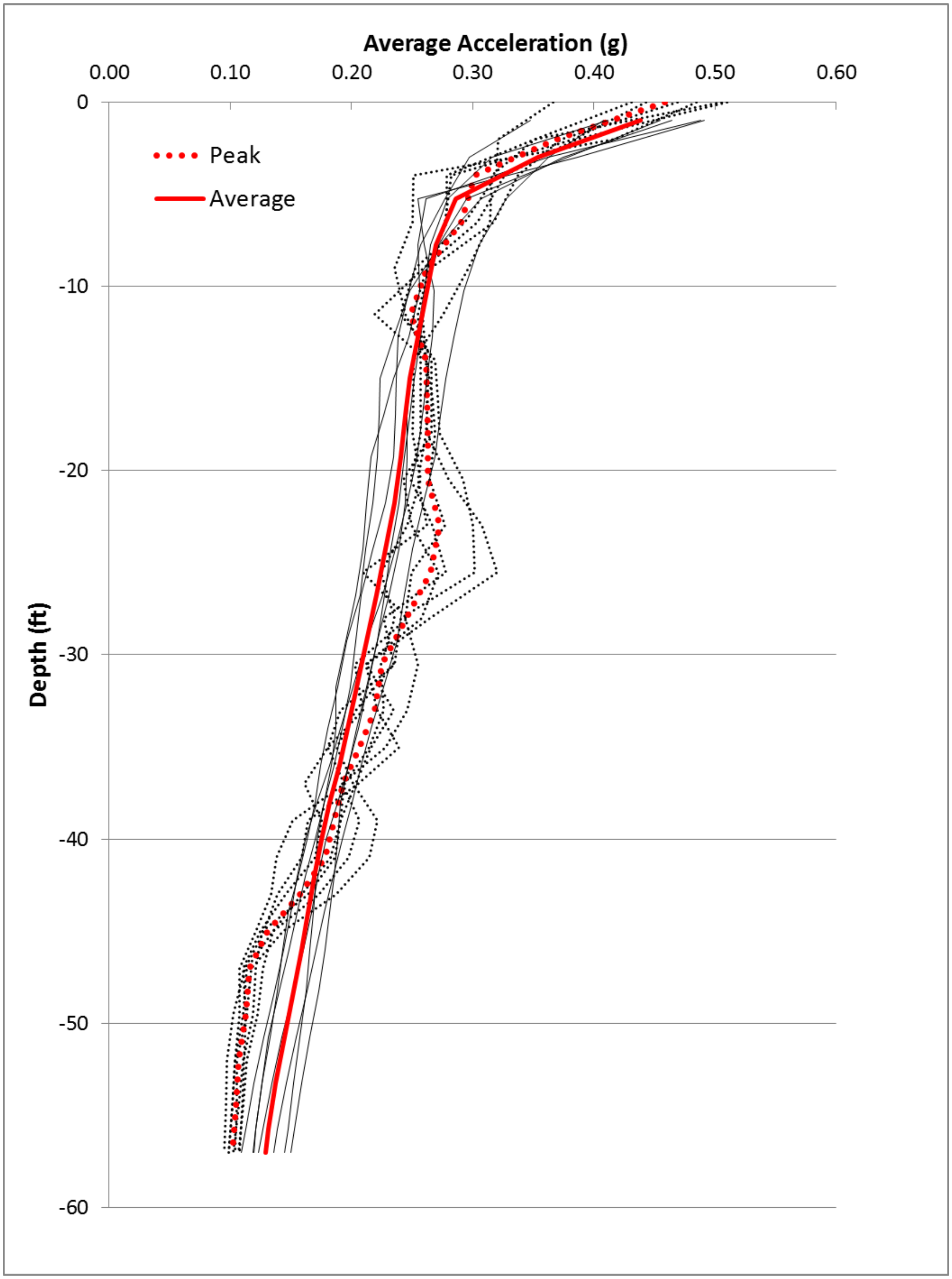


Figure 1: Horizontal Target 2500-yr UHRS (5% Damping) for the Gallatin Fossil Plant site

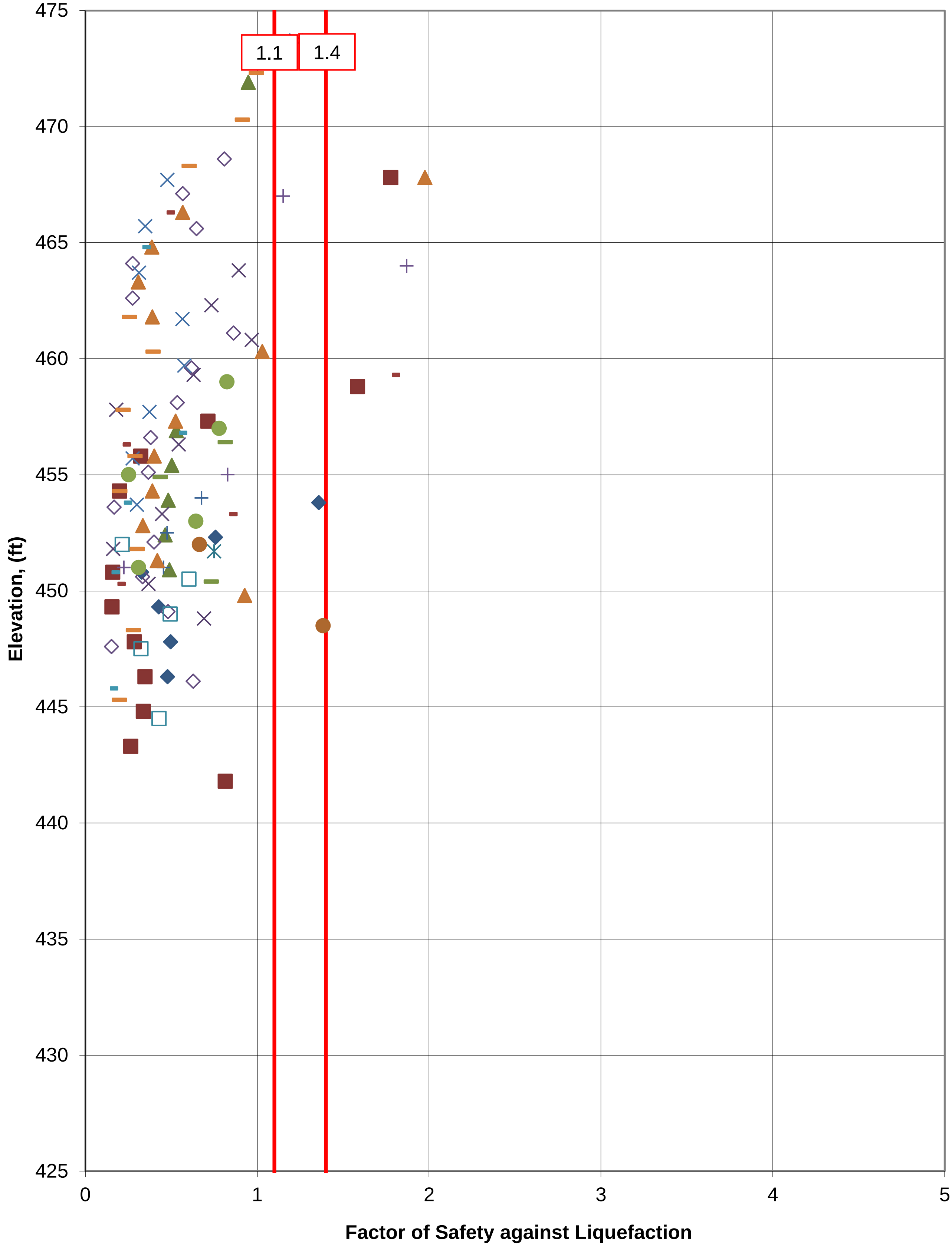
Acceleration versus depth profile at GAF Ash Pond A, Section K. Results are derived from one-dimensional ground response analysis.



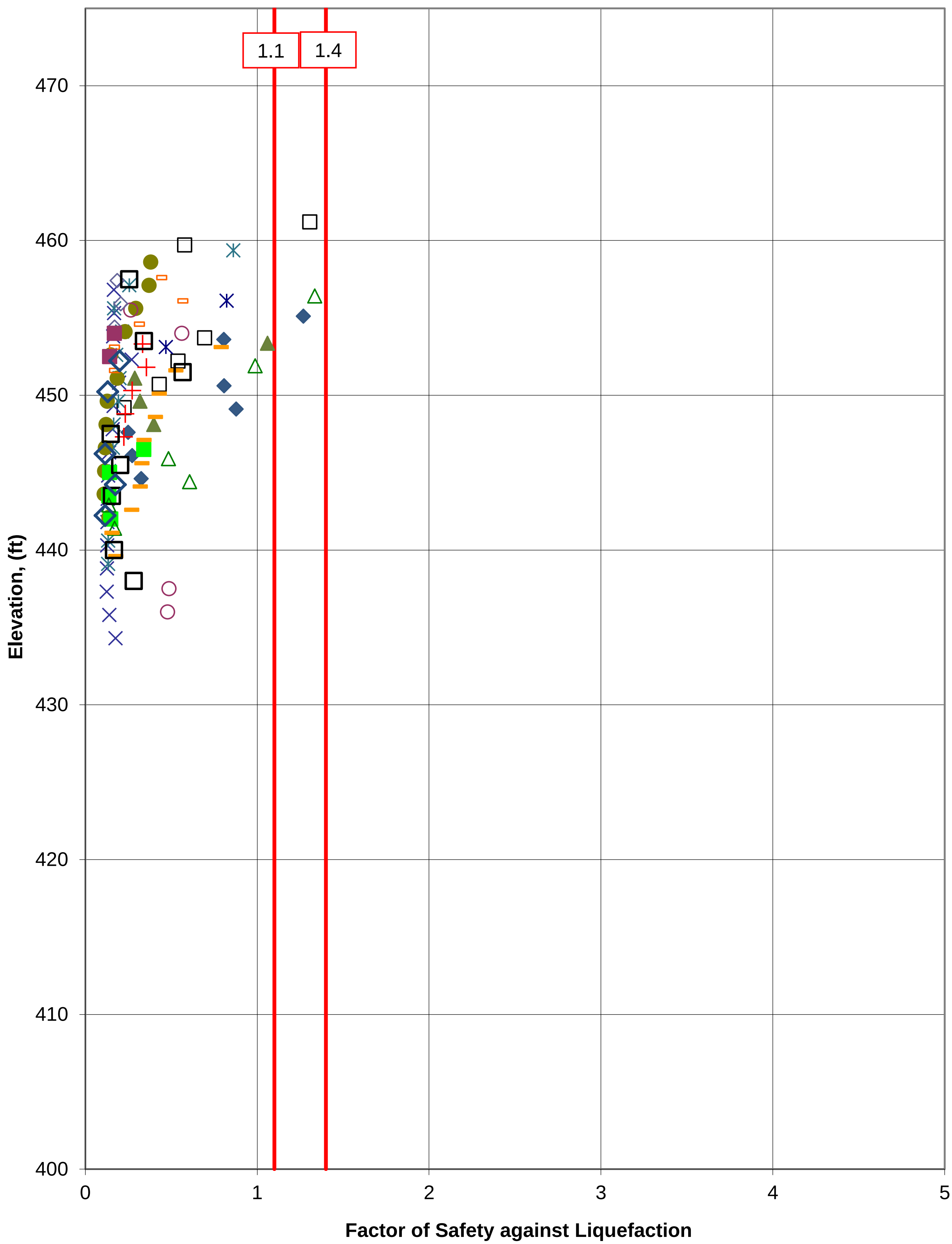
Acceleration versus depth profile at GAF Ash Pond E, Section B. Results are derived from one-dimensional ground response analysis.



TVA GAF Bottom Ash Pond A, Source = UHRS, Mw = 7.6, PGAsoil = 0.35 g, Return Period = 2500 years, SPT Data, NCEER Simplified Method, No Fines Correction if Zero Blowcounts, No Fines Correction if Fly Ash (ML)



TVA GAF Fly Ash Pond E, Source = UHRS, Mw = 7.6, PGAsoil = 0.44 g, Return Period = 2500 years, SPT Data, NCEER Simplified Method, No Fines Correction if Zero Blowcounts, No Fines Correction if Fly Ash (ML)



Section K - Bottom Ash Pond A
Gallatin Fossil Plant
Gallatin, Tennessee

Stantec

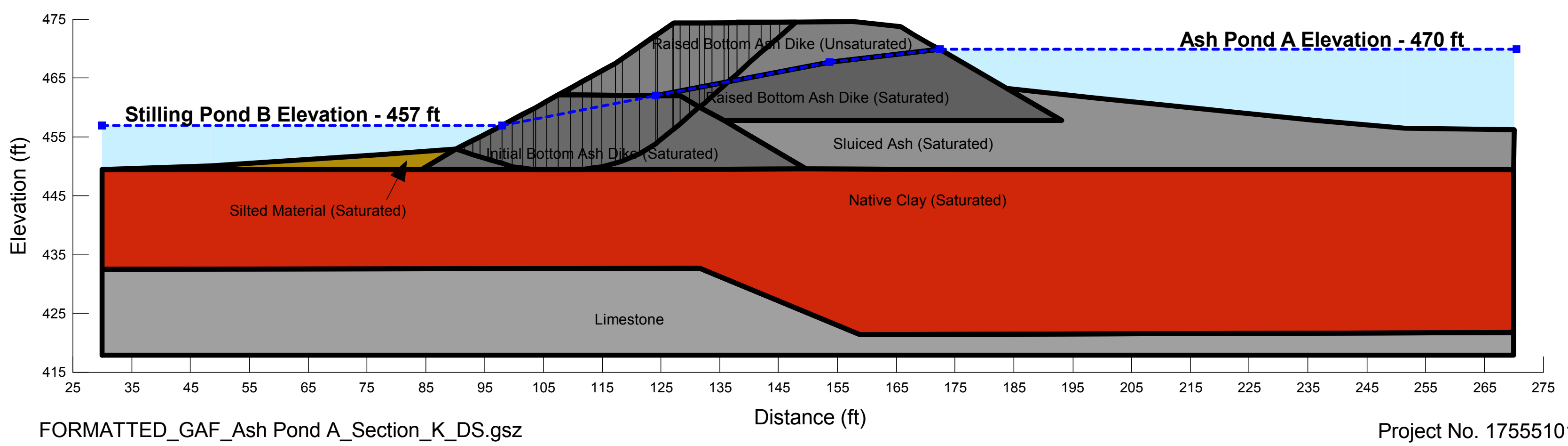
Existing Conditions - Post Earthquake

Liquefied Materials: Silted Material, Raised Bottom Ash Dike, Sluiced Ash, Initial Bottom Ash Dike

Material	Unit Weight	Cohesion	Friction Angle
Native Clay (Saturated)	125 pcf	440 psf	10.5 °
Silted Material (Saturated)	85 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=1	0 °
Raised Bottom Ash Dike (Unsaturated)	105 pcf	0 psf	34 °
Raised Bottom Ash Dike (Saturated)	105 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=22	0 °
Initial Bottom Ash Dike (Saturated)	105 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=17	0 °
Sluiced Ash (Saturated)	85 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=7	0 °

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Factor of Safety: 1.0



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Project No. 175551015

Section K - Bottom Ash Pond A
Gallatin Fossil Plant
Gallatin, Tennessee

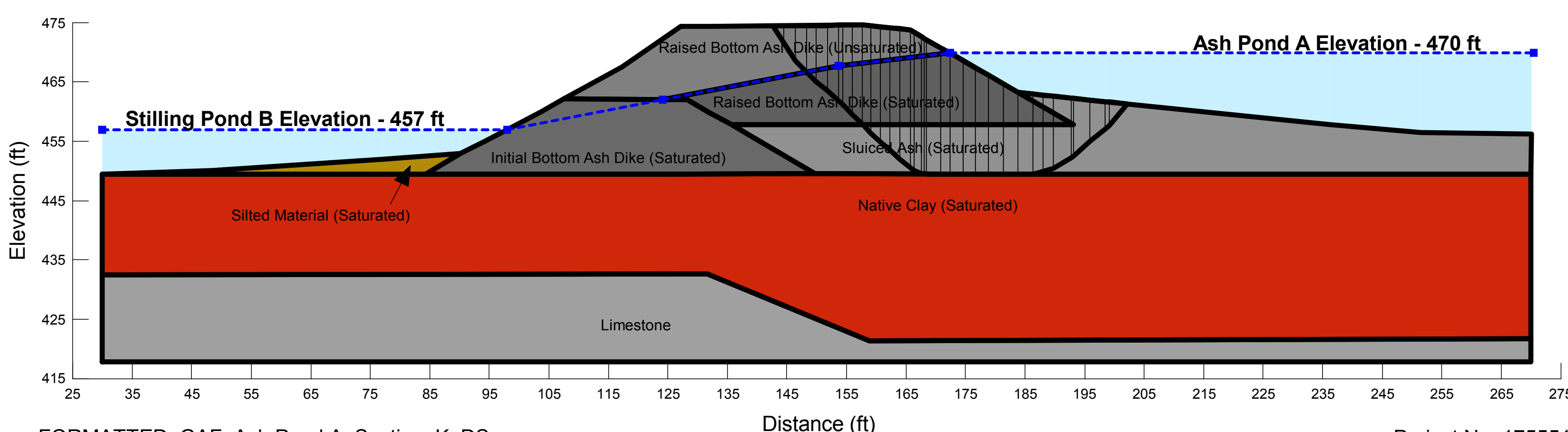
Existing Conditions - Post Earthquake

Liquefied Materials: Silted Material, Raised Bottom Ash Dike, Sluiced Ash, Initial Bottom Ash Dike

Material	Unit Weight	Cohesion	Friction Angle
Native Clay (Saturated)	125 pcf	440 psf	10.5 °
Silted Material (Saturated)	85 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=1	0 °
Raised Bottom Ash Dike (Unsaturated)	105 pcf	0 psf	34 °
Raised Bottom Ash Dike (Saturated)	105 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=22	0 °
Initial Bottom Ash Dike (Saturated)	105 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=17	0 °
Sluiced Ash (Saturated)	85 pcf	Sr=exp(-8.444+0.109N1(60)+5.379σ'^0.1), N1(60)=7	0 °

Note:
The results of analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Factor of Safety: 1.2



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Project No. 175551015

Section B - Fly Ash Pond E
Gallatin Fossil Plant
Gallatin, Tennessee

Existing Conditions - Post Earthquake

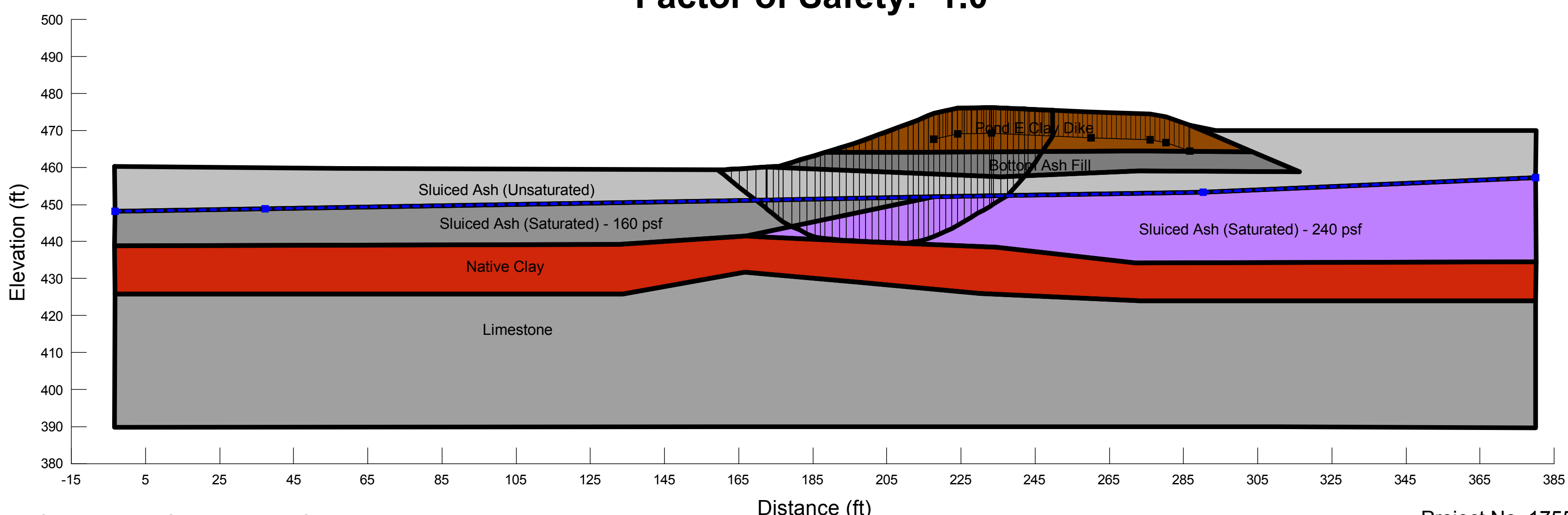
Stantec

Liquefied Materials: Sluiced Ash

Note:
The results of analysis shown here are based on available subsurfae information, laboratory test results and appoximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Unit Weight	Cohesion	Friction Angle
Native Clay	125 pcf	440 psf	10.5 °
Pond E Clay Dike	125 pcf	400 psf	15 °
Bottom Ash Fill	105 pcf	0 psf	34 °
Sluiced Ash (Unsaturated)	85 pcf	400 psf	10 °
Sluiced Ash (Saturated)	85 pcf	160 psf / 240 psf	0 °

Factor of Safety: 1.0



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Project No. 175551015

Section B - Fly Ash Pond E
Gallatin Fossil Plant
Gallatin, Tennessee

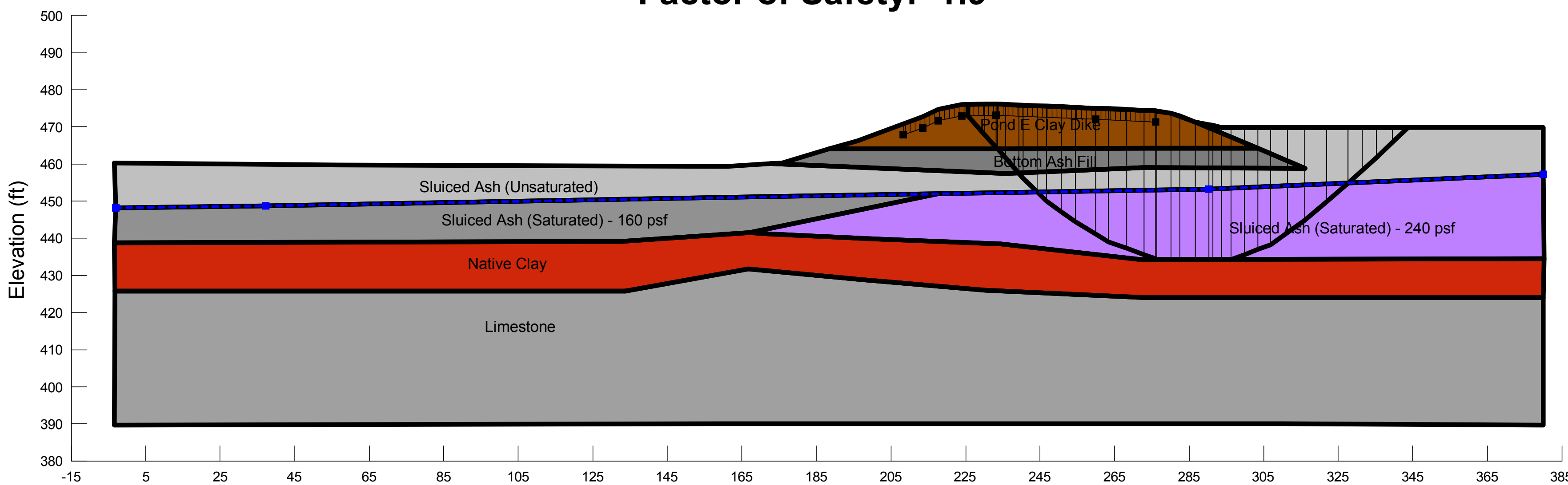
Existing Conditions - Post Earthquake

Liquefied Materials: Sluiced Ash

Note:
The results of analysis shown here are based on available subsurfae information, laboratory test results and appoximate soil properties. No warranties can be made regarding the continuity of subsurface conditions between the borings.

Material Type	Unit Weight	Cohesion	Friction Angle
Native Clay	125 pcf	440 psf	10.5 °
Pond E Clay Dike	125 pcf	400 psf	15 °
Bottom Ash Fill	105 pcf	0 psf	34 °
Sluiced Ash (Unsaturated)	85 pcf	400 psf	10 °
Sluiced Ash (Saturated)	85 pcf	160 psf / 240 psf	0 °

Factor of Safety: 1.9



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Project No. 175551015

Tennessee Valley Authority, 1101 Market Street, BR4A, Chattanooga, Tennessee 37402

October 19, 2012

Mr. Stephen Hoffman
US Environmental Protection Agency (EPA) (5304P)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

TENNESSEE VALLEY AUTHORITY (TVA) – COMMENTS ON COAL ASH SITE ASSESSMENT ROUND 11 DRAFT REPORTS FOR ALLEN (ALF), BULL RUN, (BRF) COLBERT (COF), CUMBERLAND (CUF), GALLATIN (GAF), JOHN SEVIER (JSF), JOHNSONVILLE, (JOF) KINGSTON (KIF), PARADISE (PAF), SHAWNEE (SHF), WATTS BAR (WBF), AND WIDOWS CREEK (WOF) FOSSIL PLANTS

Dear Mr. Hoffman:

Tennessee Valley Authority (TVA) appreciates the opportunity to provide responses to the recommendations outlined in the Draft Coal Ash Site Assessment Round 11 Draft Reports for TVA's fossil plants. The Draft Reports were attached to EPA's September 5, 2012 email from Jana Englander to TVA's Susan Kelly. This EPA review process has provided TVA a public forum to confirm that our coal ash facilities meet current state requirements.

TVA has contracted with Stantec Consulting Services Inc., to assist in the technical review and responses to the EPA draft reports. The draft report responses are attached for your consideration in finalizing the Coal Ash Site Assessment Round 11 Reports. The following is a summary of our responses;

Allen: A seismic stability analysis and liquefaction analysis have been completed indicating acceptable performance under seismic loading. TVA recommends the Allen East Ash Pond be upgraded from Poor to Satisfactory.

Bull Run: TVA has no additional comments to EPA's analysis.

Colbert: TVA has no additional comments to EPA's analysis.

Cumberland: The operating pool level for the Ash Pond has been lowered 6.2 feet and the seepage analysis has been revised. Piping factors of safety are now satisfactory. TVA recommends the final rating for the Ash Pond be upgraded from Fair to Satisfactory.

A liquefaction potential assessment was performed for the Gypsum Disposal Area and showed the saturated ash materials are anticipated to undergo liquefaction for the 2,500-year earthquake. Therefore, a higher level of slope stability analysis was completed demonstrating that the factor of safety is satisfactory. TVA recommends the final rating for the Gypsum Disposal Area be upgraded from Poor to Satisfactory.

Additional seismic analysis and field investigation is underway for the Dry Fly Ash Stack. The results are indicating the possibility of a favorable response. However, the analysis is not complete. We anticipate its completion during EPA's review of these comments.

Gallatin: A seismic stability analysis for Ponds A and E has been completed with acceptable results. TVA recommends the final rating be upgraded from Fair to Satisfactory.

An additional stability and seepage analysis for the saddle dikes on the stilling ponds has been completed and a project to increase the hydrologic/hydraulic capacity of the ponds is underway. Based on the analysis and improvement plans underway, TVA recommends the Gallatin Stilling Ponds rating be upgraded from Poor to Fair and from Fair to Satisfactory once the project is completed.

John Sevier: The static and seismic slope stability analysis were reviewed and deemed to be appropriate for the soil materials present.

Johnsonville: A quantitative liquefaction analysis and a post-earthquake static slope stability analysis were performed. Results showed the slope to remain stable. As a result, TVA recommends that final rating for Ash Disposal Area 2 be upgraded from Fair to Satisfactory.

Kingston: TVA has no additional comments to EPA's analysis.

Paradise: A liquefaction analysis was performed and the hydrologic/hydraulic capacity was evaluated. The liquefaction analysis indicated that the materials would remain stable and not liquefy during a 2,500 year event. The H&H analysis confirmed that the ponds safely pass the 100-year 24-hour storm. However, they do not pass the Probable Maximum Flood. TVA has plans to design and construct features to correct this issue at the ponds. TVA recommends that the facilities at Paradise be upgraded from Fair to Satisfactory once the H&H issues have been addressed.

Shawnee: A liquefaction analysis and post-earthquake static stability analysis were performed with acceptable results. TVA recommends that the rating for Ash Pond No. 2 be upgraded from Poor to Satisfactory.

Watts Bar: A hydrologic/hydraulic analysis was performed for the design storm and the new spillway system currently under design and in construction. Based on the satisfactory outcome of the analysis; TVA recommends the final rating be upgraded from Fair to Satisfactory.

Widows Creek: TVA has no additional comments to EPA's analysis.

The following is a summary of the draft facility ratings and TVA's proposed final ratings.

EPA Draft Report Results				
Plant	**Facility**	**Draft Rating**	**Driver for Rating**	**Stantec Proposed Final Rating**
ALF	East Pond	**Poor**	Seismic	**Sat**
BRF	FA Pond	**Sat**		**Sat**
	BA Pond	**Fair**	Liquefaction	**Fair**
	Gyp Pond	**Fair**	Liquefaction	**Fair**
COF	Dry Stack	**Sat**		**Sat**
	BA Pond	**Fair**	Liquefaction	**Fair**
CUF	Ash Pond	**Fair**	Piping	**Sat**
	Dry Stack	**Poor**	Seismic	**Poor**
	Gyp	**Poor**	Seismic	**Sat**
GAF	Ash Ponds	**Fair**	Liquefaction	**Sat**
	Stilling Ponds	**Poor**	H&H and static	**Fair**
JSF	Dry Stack	**Sat**		**Sat**
	Ash pond	**Sat**		**Sat**
JOF	Island	**Fair**	Liquefaction	**Sat**
KIF	Ash/stilling	**Fair**	Liquefaction	**Fair**
	GDA	**Sat**		**Sat**
PAF	Scrubber sludge	**Fair**	H&H - overtopping	**Fair**
	Ash Pond	**Fair**	H&H - overtopping	**Fair**
	Slag Ponds	**Fair**	H&H - overtopping	**Fair**
SHF	Ash Pond	**Poor**	Seismic	**Sat**
WBF	Pond	**Fair**	H&H	**Sat**
WCF	Gyp stack	**Sat**		**Sat**
	Ash Pond	**Fair**	Liquefaction	**Fair**

TVA takes its environmental responsibilities very seriously and appreciates EPA's efforts to verify the quality of our impoundments. We would like to arrange a conference call once your staff has received this letter and briefly reviewed the attached reports so we can answer any immediate questions or concerns. Please contact Susan Kelly at (423)-751-2058 or sjkelly0@tva.gov to arrange this conference call.

Sincerely,

Cynthia M. Anderson for

Brenda E. Brickhouse
Vice President
Compliance Interface and Permits

Enclosures

SJK:LMB
Enclosures
cc (electronic distribution with enclosures):
C. M. Anderson, BR 4A-C
D. L. Bowling, Jr., WT 7D-K
B. E. Brickhouse, BR 4A-C
A. S. Cooper, OMA 1A-WDC
D. M. Hastings, WT 6A-K
J. C. Kammeyer, LP 5D-C
G.A. Kelley, LP 3D-C
S.J. Kelly, BR 4A-C
A.A. Ray, LP3K-C
M. S. Turnbow, LP 5G-C
EDMS (Leslie Bailey), BR 4A-C