TVA

Anda A. Ray
Senior Vice President
Environment and Technology

October 27, 2011

Mr. Richard Kinch
U.S. Environmental Protection Agency
Two Potomac Yard
2733 South Crystal Drive
5th Floor: N-5783
Arlington, Virginia 22202-2733

Dear Mr. Kinch:

On October 22, 2010, the Tennessee Valley Authority (TVA) provided hazard rating updates for our five wet coal combustion impoundments originally designated as "high hazard". At that time, our consultant had completed a more detailed assessment of our impoundments and reduced four of the five impoundments classified as "high hazard" to "significant hazard". Due to continued physical work and assessments at the final impoundment, TVA is now able to reduce this classification from "high hazard" to "significant hazard". A copy of the internal memo is attached to this letter for your review.

As of the end of September 2011, TVA has no impoundments with greater than "significant hazard" classification. We continue to work to ensure and maintain the stability of all of our impoundments.

If you have questions, please do not hesitate to contact me at (865) 632-8511.

Sincerely,

Anda A. Ray

Enclosures

Coal Combustion Products Engineering

TVA

September 28, 2011 *Memo No: CUF 11-0001*

Dam Safety Officer, Michael T. Scott, LP 3D-C

CUMBERLAND FOSSIL PLANT ASH POND HAZARD CLASSIFICATION "SIGNIFICANT"

The Cumberland Fossil Plant is located at the confluence of Wells Creek and the Cumberland River in Stewart County, Tennessee. The fly ash pond has a footprint of approximately 50 acres with a dike crest elevation of approximately 394 feet.

In 2010, TVA contracted Stantec to perform a detailed analysis using recently developed topographic data to determine the limit of impact caused by a breach of the Cumberland Fly Ash Pond dike. The report titled, "Dam Breach Analysis and Inundation Mapping - Cumberland Fly Ash Pond," summarizes the additional study of the breach impacts using HEC-HMS, a hydrologic routing software, and HEC-RAS, a hydraulic modeling software capable of performing unsteady flow routing.

The analysis was performed for two basic failure scenarios: (1) A "Sunny Day" breach, which consists of a piping failure assumed to occur during normal operational inflows. The impoundment water surface elevation is normally assumed to be at the top of the lowest non-clogging spillway; and (2) A Probable Maximum Precipitation (PMP) event, which consists of an overtopping failure during a PMP event. The results revealed that no external buildings were located within the inundation limits. However, scour protection for the Cumberland City Road Bridge was a concern. Underwater inspections confirmed that there was inadequate armoring of the bridge foundations and abutments.

Working with TDOT (Tennessee Department of Transportation), construction plans were developed to address the scour protection deficiencies. Construction activities began in August 2011 and were completed on September 16, 2011. Construction activities were verified by Stantec via construction observation and the record survey. The attached Stantec memo recommends that the hazard classification be lowered from "High Hazard" to "Significant Hazard." TVA CCP Engineering has reviewed the report and concurs with the methodology of analysis and the subsequent results. Therefore, CCP Engineering is sending this memo to Dam Safety to document the lowering of the Hazard Classification of the Cumberland Ash Pond to "Significant."

Scott Turnbow

Scott Turnbow
Senior Manager, CCP Engineering
LP 5E-C

MST:MST
Attachment: Stantec 175631002 and 175639026
cc (Attachment):

J. C. Kammeyer, LP 5D-C
J. T. Barton, LP 3D-C
K. L. Mullinax, CUF 1A-CCT
S. E. Bennett, LP 5E-C

Stantec

Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati OH 45241-2012
Tel: (513) 842-8200
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September 27, 2011
File: 175631002

Shannon Bennett, PE
Program Manager - CUF
Tennessee Valley Authority – CCP Engineering
1101 Market Street, LP5E-C
Chattanooga, Tennessee 37402

Reference: Cumberland Fossil Plant Ash Pond Hazard Classification

Dear Ms. Bennett:

In 2010, Stantec Consulting Services Inc. (Stantec) performed a breach analysis and mapped the inundation zones for the Cumberland Fly Ash Pond. Results of this analysis and mapping were presented in the *Dam Breach Analysis and Inundation Mapping – Cumberland Fly Ash Pond* dated September 2010. The report evaluated potential failure scenarios of the Fly Ash Pond Dam for use in Emergency Action Planning and Dam Safety Hazard Classification. The analysis determined that no external (non-TVA) buildings were located within the inundation limits. However, the breach analysis identified possible scour impacts to the Cumberland City Road Bridge that crosses Wells Creek. As a result, Stantec recommended that the Dam Safety Hazard Classification remain at High Hazard until confirmation of existing scour protection or further action was taken to protect the bridge.

Underwater inspections determined inadequate armoring of the bridge foundations and abutments was present. Stantec subsequently developed construction drawings for scour countermeasures. The drawing set was titled *Wells Creek Bridge Scour Protection Work Plan 13* (CUF-110504-WP-13), dated May 4, 2011. The scour countermeasure design included the placement of a riprap blanket along the channel bottom and pre-cast concrete scour protection features at the four deepest bridge piers. Construction began on the project in August, 2011 and was substantially complete on September 16, 2011.

Based on Stantec's construction observation and the record survey performed by TVA, it appears that sufficient scour protection has been provided to reduce the risk to the bridge foundations for the Cumberland City Road Bridge over Wells Creek. Construction of the scour countermeasures was in general accordance with the Construction Drawings and Specifications. As a result, it is Stantec's opinion that the Dam Safety Hazard Classification for the Cumberland Ash Pond can be reduced from High Hazard to Significant Hazard. Record Drawings have been prepared and submitted to TVA under separate cover.

**Reference: Cumberland Fossil Plant Ash Pond
Hazard Classification**

If the ash pond is modified (i.e. berm crest elevation raised) or development occurs within the impact zone, the hazard classification should be re-evaluated.

We appreciate the opportunity to assist Tennessee Valley Authority on this project. If you have any questions, please call our office.

Sincerely,

STANTEC CONSULTING SERVICES INC.

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Stantec

Dam Breach Analysis and Inundation Mapping

Cumberland Fly Ash Pond
Cumberland Fossil Plant
Stewart County, Tennessee

September, 2010

Stantec Consulting Services Inc.
11687 Lebanon Road
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September 2, 2010
File: 175639026

Daniel G. Stephens, PE
Program Manager - CUF
Tennessee Valley Authority – CCP Engineering
1101 Market Street, LP5E-C
Chattanooga, Tennessee 37402

Reference: Cumberland Fossil Plant Ash Pond Breach Inundation Analysis

Dear Mr. Stephens:

Enclosed is our report of the breach inundation analysis for the Cumberland Fossil Plant Ash Pond. This report summarizes Stantec Consulting Services Inc.'s analysis, methodologies, modeling results and hazard classification recommendation. We appreciate the opportunity to assist Tennessee Valley Authority on this project. If you have any questions, please call our office.

Sincerely,

STANTEC CONSULTING SERVICES INC.

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Table of Contents

1.0 Study Description

The Cumberland Fossil Plant is located at the confluence of Wells Creek and the Cumberland River in Stewart County, Tennessee. The fly ash pond has a footprint of approximately 50 acres with a dike crest elevation of approximately 394 feet.

Stantec had previously performed breach analyses of the fly ash pond at the Cumberland Fossil Plant using approximate methods. The results of this study were included in the summary titled, "Preliminary Dam Breach Approximate Limits of Impact – Methodology" and submitted to the TVA on July 24, 2009 (Reference 1).

Stantec has been requested to perform a detailed analysis using recently developed topographic data to determine the limit of impact caused by a breach of the ash pond dike. The following report summarizes the additional study of the breach impacts using HEC-HMS, a hydrologic routing software, and HEC-RAS, hydraulic modeling software capable of performing unsteady flow routing.

2.0 Breach Hydrograph Development

2.1 FAILURE SCENARIOS

Stantec developed breach hydrographs for the ash pond using the U.S. Army Corps of Engineers (USACE) HEC-HMS computer modeling software, Version 3.4. Breach analyses were performed for two failure scenarios: (1) A "Sunny Day" breach which consists of a piping failure that is assumed to occur during normal operational inflows. The impoundment water surface elevation is normally assumed to be at the top of the lowest non-clogging spillway. (2) A Probable Maximum Precipitation (PMP) event which consists of an overtopping failure during a PMP event. Specific assumptions for the two scenarios are outlined below:

For a piping failure, HEC-HMS simulates a trapezoidal breach that begins at the bottom elevation of the breach and has a gradually increasing breach orifice height and width, until the dam crest is reached. Likewise, for a PMP failure, HEC-HMS simulates a trapezoid failure that begins at the top of the embankment and has gradually increasing breach width and decreasing weir elevation until the bottom elevation is reached.

2.1.1 "Sunny Day" Scenario

Since the Cumberland Ash Pond does not have an emergency spillway, the water surface elevation at the time of the breach was assumed to be equal to the perimeter dike crest elevation of 394.0 feet. Inflow to the ash pond was neglected and the water surface elevation of the Cumberland River assumed to be 359.0 feet which is the summer normal pool of Lake Barkley (Reference 2). The resulting water surface elevation at likely breach locations along Wells Creek was estimated at 359.3 feet. Piping failures were assumed to occur along Wells Creek or the Cumberland Fossil Plant Discharge Channel as shown in Figure A1 of Appendix A. The impounded water and fly ash within the pond was assumed to be lost down to elevation 359.3 feet since the surrounding water would act as tailwater and limit outflow. Conservatively, all sluiced ash above elevation 359.3 feet was assumed to mobilize and be lost through the breach. Figure A2 in Appendix A is a schematic cross section through the ash pond showing the "Sunny Day" failure configuration.

2.1.2 PMP Scenario

The water surface in the ash pond at the beginning of the PMP event was assumed at normal pool elevation, 384.3 feet. Overtopping failures were to occur along Wells Creek or the Cumberland Fossil Plant Discharge Channel as shown in Figure A1 of Appendix A. The water surface elevation on Wells Creek and the Cumberland River was assumed at the level of the 100-year flood event, an elevation of 381.0 feet at the breach location. This assumption is reasonable since some level of flooding of the surrounding waterways would be expected during a PMP event of the ash pond but the water surface elevations of the surrounding waterways would be expected to be less than the PMP elevations since Wells Creek and the Cumberland

River have much larger drainage areas and lag times. The overtopping failure was assumed to begin when the ash pond water surface reached the crest of the dike, elevation 394.0 feet. Figure A3 in Appendix A is a schematic cross section through the ash pond showing the PMP failure configuration.

The inflow consisted of the 6-hour PMP event precipitation (35.4 inches) obtained from the National Oceanic and Atmospheric Administration (NOAA) Hydrometeorological Report No.56 (HMR-56) (Reference 3). Three different hyetograph shapes were evaluated: (1) SCS Type-B 6-hour hyetograph, (2) “Early Peak” 6-hour hyetograph, and (3) “Late Peak” 6-hour hyetograph. The SCS Type-B 6-hour hyetograph is a standard shape currently being used for spillway design at various TVA fossil plants (Reference 4). The "Early Peak" and "Late Peak" hyetographs were developed using a procedure outlined in HMR-56. The 1-, 2-, 3-, 4-, 5-, and 6-hr PMP depths were taken from Figure 16 in HMR-56 and arranged sequentially. Incremental depths were determined for each hour and then rearranged to develop the two hyetographs according to rules presented in HMR-56.

2.2 ESTIMATION OF DAM BREACH PARAMETERS

Many empirical equations have been developed from case studies to predict average breach width and breach development time based on the height of the dam, depth of the water, volume impounded, and type of breach. Since there is great uncertainty in predicting dam breach parameters, Stantec used different empirical equations and based final breach parameters on the range of the estimates obtained and engineering judgment.

Estimates for breach development time and average breach parameters for the “Sunny Day” scenario are summarized in Table 1. The predicted average breach width (B_{av}) ranged from 85.9 feet to 146.8 feet and breach development time (t_f) ranged from 0.2 hours to 1.1 hours. These estimates are based on the assumed failure conditions, height of the breach (35 feet), and impoundment water volume of 1141 acre-feet in the ash pond above the breach elevation. While the total volume of both water and sluiced ash above the breach elevation is 1762 acre-feet, for use in determination of the dam breach parameters, ash volume is excluded.

Table 1. Estimate of Dam Breach Parameters Based on “Sunny Day” Scenario

Equation Name	B_{av} (feet)	t_f (hours)
Froehlich (1987)[5]	95.8	0.7
Froehlich (1995)[6]	85.9	0.6
USBR (1988)[7]	104.1	0.3
Von Thun and Gillette (1990)[8]	146.8	0.2-1.1
Average	**108.1**	**0.5**

The selected parameters for the "Sunny Day" Scenario are summarized below:

(1) The average breach width along Wells Creek is 108.1 feet, which is the average of the breach widths from the equations referenced. For the breach along the Discharge Channel, an average breach width of 65.7 feet was selected because the lined spillway would restrict the bottom width of the breach to just 36.0 feet at this location.

(2) The breach development time is 0.5 hours.

(3) The piping initiates at the Wells Creek normal pool elevation of 359.3 feet at the location of the breach, which is also the bottom elevation of the breach, and progresses linearly. This elevation was used for both breach analyses as a conservative assumption.

(4) The top of breach is the dike crest elevation of 394.0 feet.

(5) The piping coefficient is 0.8, a common orifice coefficient value.

Estimates for breach development time and average breach parameters for the PMP event scenario are summarized in Table 2. For the overtopping failure of the PMP event scenario, only the Froehlich equations were utilized because of their incorporation of a correction factor specifically for overtopping failures. The predicted average breach width (B_{av}) ranged from 81.2 feet to 89.3 feet and breach development time (t_f) ranged from 0.1 hours to 1.2 hours. These estimates are based on the assumed failure conditions, height of the breach (13.0 feet), and impoundment volume of water of 598 acre-feet in the ash pond above the breach elevation. While the total volume of both water and sluiced ash above the breach elevation is 631 acre-feet, for use in determination of the dam breach parameters, only the water volume is used.

Table 2. Estimate of Dam Breach Parameters Based on PMP Scenario

Equation Name	B_{av} (feet)	t_f (hours)
Froehlich (1987)(5)	89.3	1.2
Froehlich (1995)(6)	81.2	0.9
USBR (1988)(7)	Not Considered	0.1
Von Thun and Gillette (1990)(8)	Not Considered	0.1-1.0
Average	**85.2**	**0.6**

The selected parameters for the PMP Scenario are summarized below:

(1) The average breach width is 85.2 feet, which is the average of the average breach widths from the equations referenced.

(2) The breach development time is 0.6 hours.

(3) The bottom elevation of the breach is at the Wells Creek 100-year flood elevation of 381.0 feet.

(4) The overtopping failure initiates at the dike crest elevation, 394.0 feet and progresses linearly.

The empirical calculations that served as the basis for the dam breach parameters estimation are included in Figures A4 and A5 of Appendix A, for the "Sunny Day" and PMP Scenarios, respectively.

2.3 "SUNNY DAY" SCENARIO HYDROLOGIC MODELING

A dam breach outflow hydrograph for the "Sunny Day" scenario was estimated using the dam break capabilities of HEC-HMS Version 3.4. The data required for the model included (1) an elevation-storage relationship for the ash pond impoundment, (2) starting water surface elevation, and (3) dam breach parameters. Hydrologic inputs are described as follows:

(1) The stage storage curve, shown in Figure A6 of Appendix A, was developed using three sources provided by TVA:

  a. Hydrographic survey dated September, 2008 (Reference 9)
  b. Aerial survey dated April, 2009 (Reference 10)
  c. Design drawings dated January,1969 (Reference11)

(2) The starting water surface was set to the dike crest elevation of 394.0 feet.

(3) The dam breach parameters described in Section 2.2 were applied to the model.

The computed outflow hydrograph for the "Sunny Day" scenario resulted in a peak outflow of 44,363 cfs which occurred 22 minutes after the start of the breach when the failure occurred along Wells Creek. The computed outflow hydrograph for the "Sunny Day" scenario resulted in a peak outflow of 22,522 cfs which occurred 24 minutes after the start of the breach when the failure occurred along the Discharge Channel. The hydrographs are included as Figure A7 of Appendix A.

2.4 PRE-FAILURE HYDROLOGIC MODEL DEVELOPMENT FOR PMP EVENT

The purpose of the pre-failure hydrologic model was to establish the time during the PMP event that the ash pond water surface would reach the top of embankment elevation and overtopping would begin to occur. Stantec used available data to develop a hydrologic model of the ash pond in HEC-HMS Version 3.4. Hydrologic information and outlet geometry information was taken from "Cumberland Fossil Plant – Design Support Calculations for Spillway Replacement Project" by Stantec dated 2010 (Reference 12). The data required for the model included (1) an elevation-storage relationship for the impoundment, (2) a starting water surface elevation, (3) an outflow rating curve, (4) watershed parameters, and (5) an inflow hydrograph. Hydrologic inputs are described as follows:

(1) The stage-storage curve, shown in Figure A8 of Appendix A, was developed for the PMP pre-failure modeling from a hydrographic survey provided by TVA and dated September, 2008 (Reference 9).

(2) The starting water surface was set to the normal pool elevation of 384.3 feet. The normal operating pool elevation was selected because it would be unlikely for the pool elevation to be at the crest elevation at the start of the PMP event.

(3) The ash pond outlet consists of four circular riser structures. A rating curve for these structures was developed based on a construction detail drawing (Reference 13) assuming inlet control for the PMP breach scenario and is included in Figure A9 of Appendix A.

(4) Watershed parameters input to the model included:

a. Composite Curve Number = 89
b. Lag Time = 9.2 min
c. Watershed Area = 467 acres

(5) The inflow hydrograph was computed in HEC-HMS based on the watershed parameters and the 6-hour SCS Type-B PMP event, 6-hour "Early Peak" PMP event or 6-hour "Late Peak" PMP event. An additional inflow of 57 cfs, which is the maximum expected plant flow pumped to the pond, was also applied as a constant baseflow.

The model showed that overtopping would be expected to begin 2 hours and 40 minutes after the start of the 6-hour SCS Type-B PMP event, 1 hour and 20 minutes after the start of the 6-hour "Early Peak" PMP event and 5 hours and 26 minutes after the start of the 6-hour "Late Peak" PMP event. The computed PMP hydrographs are included in Figure A10 of Appendix A.

2.5 PMP SCENARIO HYDROLOGIC MODELING

A dam breach outflow hydrograph for the PMP scenario was calculated using the dam break capabilities of HEC-HMS Version 3.4. The simulation was run from the time of overtopping, until 24-hours after the start of the PMP. The data required for the model included (1) an elevation-storage relationship for the ash pond impoundment, (2) starting water surface elevation, (3) dam breach parameters, and (4) an inflow hydrograph for PMP event. These inputs are described below:

(1) The stage storage curve, shown in Figure A6 of Appendix A, was developed using three sources provided by TVA:

   a. Hydrographic survey dated September, 2008 (Reference 9)
   b. Aerial survey dated April, 2009 (Reference 10)
   c. Design drawings dated January, 1969 (Reference 11)

(2) The starting water surface was set to the top of embankment elevation of 394 feet.

(3) The dam breach parameters described in Section 2.2 were applied to the model.

(4) The inflow hydrograph for the remaining PMP event after the water surface elevation in the fly ash pond reaches an elevation of 394.0 feet was obtained from the pre-failure hydrologic model for a PMP event described in Section 2.4. This remaining PMP event hydrograph was included as an inflow during the breach.

The peak outflow computed for the three PMP scenarios are summarized in Table 3. The hydrographs are included as Figure A11 of Appendix A.

Table 3. Summary of Peak Outflow for PMP Breach Scenarios

PMP Event Description	Time of Peak (Hour:Min After Start of PMP Event)	Peak Outflow (cfs)
6-Hour SCS Type-B Hyetograph	3:16	12,055
6-Hour “Early Peak” Hyetograph	1:56	10,521
6-Hour “Late Peak” Hyetograph	6:02	14,381

3.0 Hydraulic Model Development

An unsteady flow hydraulic model was developed in USACE HEC-RAS Version 4.1.0 software to calculate maximum water surface elevations for the postulated breach scenarios.

3.1 MODEL GEOMETRY

The HEC-RAS model was developed using cross sections with an average spacing of less than 1000 feet for Wells Creek and an average spacing of less than 5000 feet for the Cumberland River in the vicinity of the Cumberland Fossil Plant. Cross section overbank geometry was developed from 1-foot contour interval aerial mapping provided by TVA and dated March 2010 (Reference 14) where available. Wells Creek and the Cumberland River channel geometry for the underwater portion of the cross sections was developed from a hydrographic survey of Wells Creek and the Cumberland River Channel performed by TVA in January 2010 (Reference 15). Channel geometry for the Cumberland Fossil Plant Discharge Channel underwater portion of the cross sections and structures was developed from channel design drawings provided by TVA (Reference 16)

In areas where aerial mapping along the Cumberland River was not available, cross section information was developed from USGS 10-Meter Digital Elevation Map data (Reference 17).

The Cumberland City Road bridge over Wells Creek was added to the hydraulic model based on field survey performed by TVA in January 2010 (Reference 15) and design drawings provided by the Tennessee Department of Transportation (Reference 18). The Cumberland City Road bridge over the Discharge Channel was based on design drawings provided by TVA (Reference 16)

3.2 HEC-RAS UNSTEADY HYDRAULIC MODELING

The "Sunny Day" breach was assumed to occur during a non-flood condition. The approximate baseflow for Wells Creek of 14 cfs was obtained from "Tennessee Streamstats" (Reference 19) and applied as an inflow to Wells Creek in the HEC-RAS model. Baseflow in the Discharge Channel was set at approximately 59 cfs (Reference 12). Baseflow in the Cumberland River was approximated as 24,520 cfs based on average annual flow rates recorded at USGS Gage 03437000 near Dover, Tennessee from 1938 to 1965 (Reference 20). A downstream boundary condition was applied to the Cumberland River reach such that the initial water surface elevation was 359.0 feet, which is the Cumberland River summer normal pool elevation (Reference 2). The downstream boundary condition represents a backwater effect from Lake Barkley. The appropriate "Sunny Day" breach hydrograph was applied as a lateral inflow to Wells Creek upstream of the Cumberland City Road bridge and as an inflow to the Discharge Channel at the locations shown on Figure A1 of Appendix A during separate simulations. The simulations used a 24-hour duration time and a computation interval of 20-seconds.

The PMP breach was assumed to occur during a 100-year flood of Wells Creek and the Cumberland River. Detailed flood information was not available for Wells Creek. The approximate 100-year peak discharge for Wells Creek of 13,600 cfs was obtained from "Tennessee Streamstats" (Reference 19) and applied as an inflow to Wells Creek in the HEC-RAS model. Baseflow in the Discharge Channel was approximately 59 cfs because the majority of the contributing drainage area is regulated through the ash ponds to be breached (Reference 12).The approximate 100-year peak discharge of the Cumberland River, 300,000 cfs, was obtained from a USGS gage on the Cumberland River near Dover, Tennessee, approximately 15 miles downstream from the Cumberland Fossil Plant at river mile 88 (Reference 21). A downstream boundary condition was applied to the Cumberland River reach such that the 100-year water surface elevation was 380.1 feet based on data developed by the USACE from the Cumberland River gage at Cumberland Fossil Plant at river mile 104 (Reference 22). Each of the PMP breach hydrographs was applied as a lateral inflow to Wells Creek upstream of the Cumberland City Road bridge as shown in Figure A1 of Appendix A. The simulation used a 24-hour duration time and a computation interval of 20-seconds.

3.3 BRIDGE SCOUR ANALYSIS

During the "Sunny Day" breach simulation, flow velocities beneath the Cumberland City Road bridge over Wells Creek reach a peak of 13.2 feet per second. During the "PMP" breach simulation flow velocities beneath the bridge reach a peak of 9.7 feet per second. While these flows occur only briefly, their magnitude makes failure of the bridge by scour a concern.

To estimate the depth of potential scour in the vicinity of the bridge foundation, the hydraulic design functions of the HEC-RAS software were utilized. HEC-RAS performs scour analysis based on the methodology outlined in HEC-18 (Reference 23). Bridge scour calculations were performed for only the "Sunny Day" simulation due to the higher velocities. Figure B1 and B2 of Appendix B summarize the HEC-RAS bridge scour input parameters as well as support calculations.

According to construction drawings provided by TDOT, the existing bridge abutments, extending 40 feet upstream and downstream, are protected by a riprap blanket (Reference 18). At the time of this study, the presence of scour protection along the Wells Creek channel bottom was not confirmed. As such, the channel bottom was assumed to be free of rip rap and scour projection.

For purposes of the scour analysis, the riprap was assumed to have a D50 of 150.0 mm and D95 of 300.0 mm based on field observations. For the bed material within the channel, Stantec assumed the material properties of fine sediments. The entered properties were based on lab analysis of soil boring B-49 (Reference 24) located approximately 5000 feet upstream of the bridge and taken at the estimated depth of the original stream bed. This sample was selected to provide what is thought to be a conservative estimate of the channel properties in the absence of specific data.

4.0 Results and Inundation Mapping

The inundation limits for each scenario were mapped to determine which structures/roadways would be impacted. The primary areas of concern were the Cumberland City Road bridges at the mouth of Wells Creek and crossing the Discharge Channel. The bridge impact elevations, defined as the top of deck elevation, were determined based on field survey data. The peak water surface elevations at each of the bridges are provided in Table 4. Based on the base flood elevations provided by USACE and routing model results, the Cumberland City Road bridge over Wells Creek overtops during the 100-year event. The model results indicate that the PMP breach outflows result in an increase of water surface elevation of 0.4 feet. No additional structures or bridges were identified within the potential impact zone of the “Sunny Day” or PMP scenarios. For each scenario, the breach was applied upstream of the Cumberland City Road bridges. These locations correspond to the locations at which a breach produces the most severe rise in water surface elevation at each of the bridges.

The individual PMP events modeled produced slightly different breach hydrographs. The model indicated that the 6-hour “Late Peak” PMP event produces the greatest water surface elevations along both Wells Creek and the Cumberland River. The PMP event impact elevations are based on values produced by the 6-hour “Late Peak” PMP event.

Inundation mapping was developed for each of the breach scenarios and is included as Figures B3 and B4 of Appendix B for the “Sunny Day” and PMP scenarios, respectively. The inundation limits were delineated using the hydraulic model outputs and the imagery and topographic data described in Section 3.2.

Table 4. Dam Breach Modeling Impact Summary

Facility	Base Sunny Day WS (feet)	Base 100-Year WS (feet)	Impact Elevation (feet)	Max. Post-Breach WS (feet)	
				Sunny Day Breach	PMP Breach
Cumberland City Road Bridge at Mouth of Wells Creek	359.3	380.9	380.9	363.0	381.3
Cumberland City Road Bridge Over Discharge Channel	359.3	380.6	381.2	359.6	380.7

According to model results, the combination of pier and contraction scour, at the Cumberland City Road bridge over Wells Creek, could cause scour to a depth of 322.3 feet within the channel for the grain sizes taken from the boring sample. In the areas covered by the riprap blanket, no significant scour occurred. Table 5 summarizes the maximum scour depth within the channel based on the assumed sediment properties. According to design drawings provided by the Tennessee Department of Transportation (Reference 18) the top of the pile cap within the channel is at an elevation of 326.6 feet and extends down to an elevation of 323.6 feet. The scour depth calculations assume sustained flow conditions and thus provide a conservative value for this simulation because peak flow velocities are sustained for only minutes. The maximum scour depth is below the base of the pile cap and could undermine the piers, potentially causing bridge failure.

Table 5. Dam Breach Bridge Scour Summary

	Grain Size
Channel D50 (mm)	0.009
Channel D95 (mm)	1.00
Starting Channel Elevation (ft)	344.6
Max Scour Depth (ft)	22.3
Max Scour Elevation (ft)	322.3
Impact Elevation (ft)	323.6
Difference Between Scour and Impact Elevations (ft)	-1.3

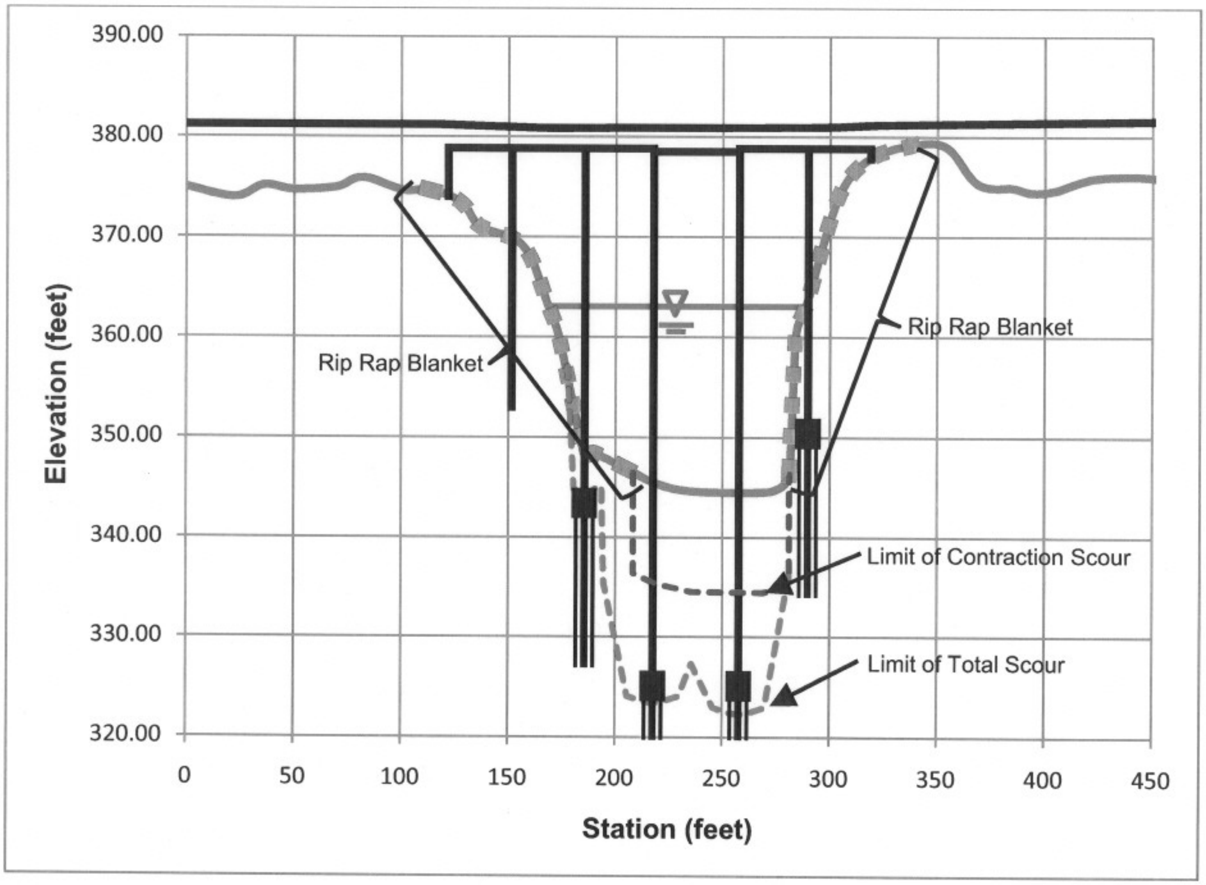

Figure 1. Bridge Scour Depth Results During "Sunny Day" Simulation

5.0 Hazard Classification

The Cumberland City Road bridge at the mouth of Wells Creek was identified within the dam breach impact zone where maximum computed water surface elevations exceed the defined impact elevation during the PMP event; however, the model indicates that the bridge overtops prior to the breach event and the subsequent rise in water surface elevations at the bridge during the PMP event is less than 0.5 feet. This small rise in water surface elevations caused by the breach event is unlikely to result in additional risk of loss of life at the bridge.

Additionally, the analysis indicates that scour is a potential risk to the Cumberland City Road bridge over Wells Creek during a dam breach event. It is recommended that the hazard classification remain at High Hazard until confirmation of existing scour protection or action is taken to protect the bridge. The confirmation of the existing presence or the placement of a riprap blanket through the bridge cross section would reduce the risk that scour poses to the Cumberland City Road bridge during a dam breach event and allow the hazard classification of the ash pond to be reduced from High Hazard to Significant Hazard.

If additional scour protection is required, the design and construction of the scour protection should be in accordance with requirements and specifications of the Tennessee Department of Transportation.

If the ash pond is modified (i.e. berm crest elevation raised) or development occurs within the impact zone, the hazard classification should be re-evaluated. Additionally, if the Cumberland City Road bridges across Wells Creek or the discharge channel are significantly modified, the hazard classification could be affected, since the maximum water surface elevations upstream of the bridge could increase.

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