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September 30, 2016

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

Initial Inflow Design Flood Control System Plan
Slag Ponds 2A and 2B; Slag Stilling Pond 2C
EPA Final CCR Rule
TVA Paradise Fossil Plant
Drakesboro, Kentucky

1.0 PURPOSE

This letter documents AECOM's certification of the initial inflow design flood control system plan for the TVA Paradise Fossil Plant's Slag Ponds 2A and 2B, and Slag Stilling Pond 2C. Based on the assessment, the Slag Ponds 2A and 2B, and Slag Stilling Pond 2C complies with the inflow design flood control requirements in the Final CCR Rule 40 CFR 257.82.

2.0 INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

As described in 40 CFR 257.82(c), an inflow design flood control system plan must be prepared to document how the inflow design flood control system has been designed and constructed to manage the design storm required by the hazard classification. Based on the Hazard Potential Classification, Slag Ponds 2A and 2B, and Slag Stilling Pond 2C have been assigned a significant hazard potential classification rating. Thus, the 1,000 year storm event was selected from §257.82(a)(3) as the inflow design storm flood event based upon the hazard potential classification.

3.0 SUMMARY OF FINDINGS

The attached plan presents the analysis of the inflow design flood control system for the Slag Ponds 2A and 2B, and Slag Stilling Pond 2C. The resulting water surface elevations are shown in the following table. The plan and results show that the impoundments meet the requirements set forth in 40 CFR 257.82(a) and (b).

Plant	Facility	Inflow Design Storm	Water Surface Elevation (feet)	Minimum Embankment Elevation (feet)
PAF	Slag Pond 2A	1,000-year storm	413.4	415.0
	Slag Pond 2B	1,000-year storm	412.6	414.0
	Slag Stilling Pond 2C	1,000-year storm	407.7	410.0

4.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Nicholas S. Golden PE, being a Professional Engineer in good standing in the State of Kentucky do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this certification is prepared in accordance with the accepted practice of engineering;
2. that the information contained herein is accurate as of the date of my signature below; and
3. that the inflow design flood control system plan for the TVA Paradise Fossil Plant's Slag Ponds 2A and 2B, and Slag Stilling Pond 2C meet the requirements specified in 40 CFR 257.82(a), (b), and (c)(1).

SIGNATURE ______________________ DATE 9/30/16

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ATTACHMENTS: Initial Inflow Design Flood Control System Plan

STATE OF KENTUCKY
NICHOLAS
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30816
LICENSED
PROFESSIONAL ENGINEER

COAL COMBUSTION PRODUCT DISPOSAL PROGRAM

TENNESSEE VALLEY AUTHORITY – SLAG PONDS 2A AND 2B;
SLAG STILLING POND 2C
TVA PARADISE FOSSIL PLANT
DRAKESBORO, KENTUCKY

INITIAL INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN (40 CFR §257.82) FOR COAL COMBUSTION RESIDUALS (CCR)

EXISTING SURFACE IMPOUNDMENT

Prepared for

TVA

Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402-2801

September 30, 2016 - Rev0

STATE OF KENTUCKY
NICHOLAS GOLDEN
30816
LICENSED PROFESSIONAL ENGINEER

9/30/16

Prepared by

AECOM

TABLE OF CONTENTS

1.0 BACKGROUND 3

1.1 Site Location 4
1.2 Site History 4

2.0 EXISTING CONDITIONS - § 257.82(a)(1) 4

3.0 METHODS/ DESIGN CRITERIA 5

3.1 Watershed Delineation and Runoff Variables 6
3.2 Hydraulics and Routing 7

4.0 CALCULATION RESULTS - §257.82(a)(2) 7

5.0 CONCLUSIONS 8

6.0 REFERENCES 8

TABLES

Table 1: Rainfall Depth for Analyzed Storm

Table 2: Slag Pond 2A Estimated Peak Inflow and Estimated Peak Pool Elevation

Table 3: Slag Pond 2B Estimated Peak Inflow and Estimated Peak Pool Elevation

Table 4: Slag Stilling Pond 2C Estimated Peak Inflow and Estimated Peak Pool Elevation

FIGURES

Figure 1: Site Overview

Figure 2: HEC-HMS Model Schematic

APPENDICES

Appendix A HEC-HMS Output Sheets

1.0 BACKGROUND

This plan outlines compliance to **Rule § 257.82** of the EPA Final CCR Rule.

The owner or operator of an existing CCR surface impoundment must design, construct, operate, and maintain an inflow design flood control system as specified in **Rule §257.82 (a),** which is directly stated below for clarity.

Rule §257.82(a)(1): The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood.

Rule §257.82(a)(2): The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood.

Rule §257.82(a)(3): The inflow design flood is:

- **(i):** For a high hazard potential CCR surface impoundment, the probable maximum flood;
- **(ii):** For a significant hazard potential CCR surface impoundment, the 1,000-year flood;
- **(iii):** For a low hazard potential CCR surface impoundment, the 100-year flood; or
- **(iv):** For an incised CCR surface impoundment, the 25-year flood.

According to **Rule §257.82(b)**, discharge from the CCR unit must be handled in accordance with the surface water requirements under **§257.3-3.**

Section **§257.82(c)(1)** states that the owner or operator must prepare initial and periodic inflow design flood control system plans for the CCR unit according to the timeframes specified in paragraphs **(c)(3)** and **(4)**. The plans must document how the inflow design flood control system has been designed and constructed to meet the requirements of the section. Each plan must be supported by appropriate engineering calculations. The owner or operator of the CCR unit has completed the inflow design flood control system plan when the plan has been placed in the facility's operating record.

Section **§257.82(c)(2)** allows amendments to the written inflow design flood control system plan at any time and requires amendments to the written inflow design flood control system plan whenever there is a change in conditions that would substantially affect the written plan in effect. The revised plan must be placed in the facility's operating record.

Section **§257.82(c)(3)** requires that the initial inflow design flood control system plan be completed no later than October 17, 2016.

Section **§257.82(c)(4)** states that the owner or operator must prepare periodic inflow design flood control system plans every five years.

Section **§257.82(c)(5)** requires a certification from a qualified professional engineer stating that the initial and periodic inflow design flood control system plans meet the requirements of **Rule §257.82**.

According to **Rule §257.82(d)**, the owner or operator must comply with recordkeeping, notification, and internet requirements specified elsewhere in the Rule.

1.1 SITE LOCATION

Tennessee Valley Authority (TVA) owns and operates the Paradise Fossil Plant (PAF) in Drakesboro, Kentucky. The plant is located along the southwestern side of the Green River along State Route 176. Slag Ponds 2A and 2B and Slag Stilling Pond 2C make up one of the Coal Combustion Residual (CCR) impoundments that manage process water flows and CCR waste during power generation. The Slag Ponds are north of the plant. The impoundments are bordered by the Green River on the east and the Coal Storage Yard to the west. Red Water Pond #2 lies just north of the impoundments, and Red Water Pond #1 is located just southeast of the Slag Ponds. The ponds currently serve as bottom ash settling ponds and manage process water flows from the plant.

Figure 1: Site Overview

1.2 SITE HISTORY

Slag Ponds 2A and 2B, and Slag Stilling Pond 2C are three hydraulically connected ponds consisting of a combination of incised and diked impoundments with a total surface area of approximately 25 acres. The Slag Ponds area was originally put into use as fly ash sluice ponds in 1967.

More information on the construction history of the Slag Ponds can be found in the History of Construction document prepared for CCR Certification.

2.0 EXISTING CONDITIONS - § 257.82(a)(1)

Under existing conditions, the drainage area for Slag Ponds 2A and 2B, and Slag Stilling Pond 2C is approximately 60 acres. The drainage area is west and south of the ponds. The following areas are included in the Slag Ponds drainage area:

- Coal Storage Yard
- Coal Wash Plant
- Coal Yard Basins # 1, 2, and 3
- Red Water Ponds # 1, 2, 3, 4, and 5
- Truck and Rail Coal Unloading Areas
- Facilities Maintenance Base

Boiler slag is sluiced into the south end of Slag Pond 2A, which serves as the primary solids collection pond. The pond is primarily an incised impoundment below surrounding grades. Accumulated slag is continually excavated, and stockpiled for dewatering and removal for beneficial reuse. Slag Ponds 2A and 2B are divided by an internal divider dike, with Slag Pond 2A on the western side and Slag Pond 2B on the eastern side of the divider dike. Flow from Slag Pond 2A travels to Slag Pond 2B through two 48-inch culverts and one 60-inch culvert, all three of which penetrate through the internal divider dike. Flow is then directed through a series of baffles and exits into Slag Stilling Pond 2C to the east through a concrete flume spillway.

At the south end of Slag Stilling Pond 2C, decanted sluice water flows into three spillway devices which discharge through a permitted KPDES outfall into the Green River. The spillways consist of 36" slip-lined culvert pipes with 48" concrete vertical risers topped by skimmer devices made from 5 foot sections of 120-inch diameter galvanized corrugated metal pipe with interior bracing. According to construction documents, the lengths of the 36" spillway concrete pipes, north to south, are 201 feet, 182 feet and 192 feet.

An emergency spillway, consisting of a grouted rip-rap overflow on a depressed section of the dike with an elevation of 410, is located on the east side of Slag Stilling Pond 2C.

3.0 Methods/ Design Criteria

AECOM performed a hydrologic and hydraulic modeling analysis of the Slag Ponds for compliance with the new Federal Register Coal Combustion Residual regulations (40 CFR Part 257.82). A Hazard Potential Classification Assessment was previously completed for the Slag Ponds. This area was determined to be a "significant" hazard. Based on this classification, the regulations require that the ponds safely store and convey the 1000-yr storm event in addition to normal process flow conditions (40 CFR Part 257.82(a)(3)(ii)).

To assess the capacity of the ponds to store and convey the storm flows, a hydraulic model was created in HEC-HMS. HEC-HMS is a deterministic model and as such, assumes boundary conditions, initial conditions, and parameters of the model elements are well established. The model incorporates model element characteristics and meteorological data to calculate infiltration losses, runoff, and reservoir storage and flow conditions. The model was developed based upon Aerial LiDAR data and plans provided by TVA.

The following table shows the storms that were analyzed. The 6-hour, 1000-year precipitation depth was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 2, Version 3.

Table 1: Rainfall Depth for Analyzed Storm

Reoccurrence Interval	Storm Duration	Rainfall Depth	Storm Distribution
1,000 year	6 hour	7.14 inches	SCS Type II

The Soil Conservation Service (SCS) Type II distribution for average conditions was selected for Paradise Fossil Plant in Drakesboro, Kentucky. SCS Curve Number method was used for estimating infiltration losses. SCS Unit hydrograph was used to transform precipitation into runoff for each subbasin. The pond routing method used was an outflow curve.

A base flow of 44.38 MGD or 68.69 cfs is considered for current normal operating conditions, according to TVA Paradise Fossil Plant Wastewater Flow Schematic Rev 9-11. This base flow was applied to Slag Pond 2A.

Slag Pond 2A collects stormwater drainage from the coal pile area and plant area to the west and southwest and discharges to Slag Pond 2B through three culverts. Slag Pond 2B discharges through a 16-foot long concrete flume, modeled as a broad-crested weir outletting to Slag Stilling Pond 2C, which then outlets to the Green River through three riser structures. Additional subbasins were added to the model to incorporate surface runoff from the areas outside the Slag Ponds area. Also, the surface areas of the normal pond elevation were added to capture precipitation falling directly on the pond surfaces. The general site configuration as set up in HEC-HMS is presented below.

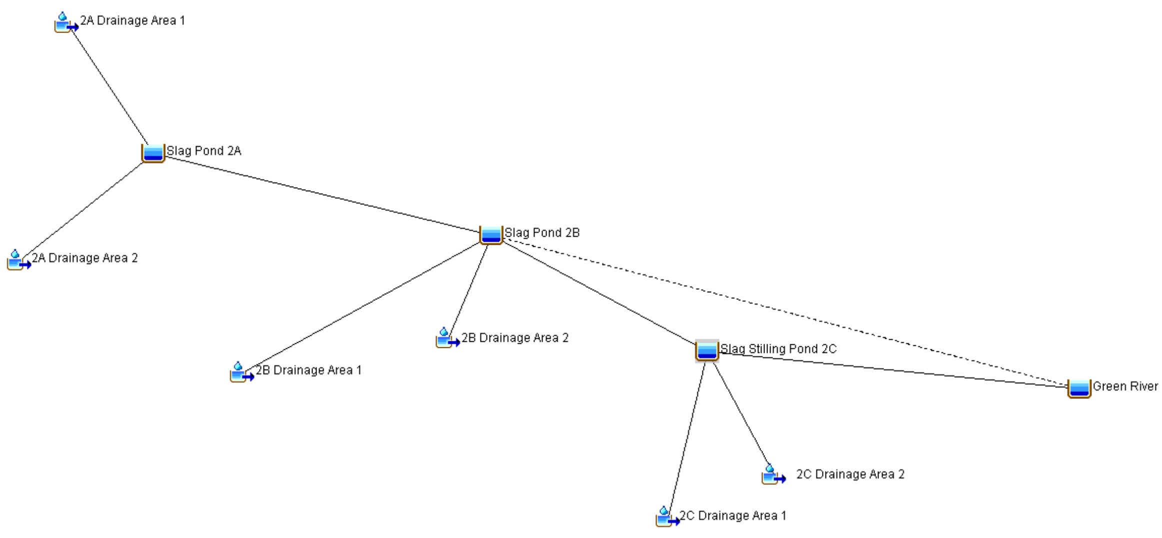


Figure 2: HEC-HMS Model Schematic

3.1 Watershed Delineation and Runoff Variables

The drainage area of the slag ponds was delineated into subcatchments based on LiDAR contour data. Data inputs such as area, runoff curve number, percent impervious area, and lag time were entered into the model for each subbasin. Curve numbers were assigned to each subcatchment based on the type of land cover present. For the portion of subcatchments located on grassy areas a curve number for "Open space, grass cover > 75%" or "Open space, grass cover 50% to 75%" was given based on observations of aerial imagery. Type C Hydraulic Soil Group characteristics were used for all of the subcatchments in the model.

Runoff from subbasins was routed directly to a pond. Six subbasins were identified to drain to the Slag Ponds. Each subbasin was defined by the contouring presented in the most recent available LiDAR data for the site. Area of each subbasin was calculated in AutoCAD Civil 3D, a runoff curve number was applied to each, and the lag time was specified for each subcatchment.

3.2 HYDRAULICS AND ROUTING

Ponds were input into HEC-HMS as reservoirs and defined with stage storage information. For this model, an Elevation - Area relationship was used. This was done by noting the area of each contour line within the ponded area in AutoCAD Civil 3D and entering these values into the model. Outlet structures were entered for each reservoir and included culvert sizes, weir lengths, and designation of primary versus auxiliary overflow structures. Slag Pond 2A is equipped with three culverts ranging in size from 4 ft. to 5 ft. in diameter and invert elevations between 409.4' to 410.3'. Slag Pond 2B is equipped with a primary outlet structure that flows to Slag Stilling Pond 2C. The structure is a 16-foot long concrete flume, modeled as a broad-crested weir with an invert elevation of 410.25'. Slag Stilling Pond 2C is equipped with three 48" riser outlet structures with opening elevations of 406.5'. The three riser structures drain to the Green River at elevation 396'. Slag Stilling Pond 2C is also equipped with a secondary outlet structure at elevation 410' with a grouted riprap overflow structure. If Slag Stilling Pond 2C were to fill to an elevation of 410', the emergency spillway would be utilized as a broad-crested weir and water would flow directly to the Green River.

Starting water surface elevation of Slag Pond 2A is 412.09', 411.62' for Pond 2B, and 407.17' for Pond 2C based on running the baseflow through the model without any rainfall. All structure dimensions, and invert elevations are modeled using the best available information for current operating conditions of the PAF Plant. Existing topographic and survey information for the PAF Slag Pond Area was provided by TVA. Drainage areas, volumes, and other site geometry were determined using the AutoCAD Civil 3D 2013 software package in conjunction with survey data provided by TVA.

A detailed H&H modeling summary of the Slag Ponds is provided in **Appendix A**. Computer model outputs are provided for the existing drainage conditions and drainage structures including culverts, weirs, and riser structures for the three Slag Ponds.

4.0 CALCULATION RESULTS - §257.82(a)(2)

The followings results represent the 1000-yr 6-hr storm being run through the existing Slag Ponds with existing outlet structures in use. Inflow and outflow hydrographs for Slag Ponds 2A and 2B, and Slag Stilling Pond 2C can be found **Appendix A**.

The Slag Ponds estimated peak pool elevations for the storm analyzed are shown in **Tables 2** through **4**. The tables also show the remaining freeboard in each pond.

Table 2: Slag Pond 2A Estimated Peak Inflow and Peak Pool Elevation

Reoccurrence Interval (year)	Storm Duration	Peak Inflow (cfs)	Peak Pool Elevation (ft)	Notes
1,000	6 hour	471.9	413.4	1.6 ft. of freeboard remaining

Table 3: Slag Pond 2B Estimated Peak Inflow and Peak Pool Elevation

Reoccurrence Interval (year)	Storm Duration	Peak Inflow (cfs)	Peak Pool Elevation (ft)	Notes
1,000	6 hour	288.5	412.6	1.4 ft. of freeboard remaining

Table 4: Slag Stilling Pond 2C Estimated Peak Inflow and Peak Pool Elevation

Reoccurrence Interval (year)	Storm Duration	Peak Inflow (cfs)	Peak Pool Elevation (ft)	Notes
1,000	6 hour	172.5	407.7	2.3 ft. of freeboard remaining

5.0 CONCLUSIONS

The modeling results indicate the ponds would not overtop during a 1000-year, 6-hour design storm. The inflow design flood control system adequately manages flow into the CCR unit during and following the peak discharge of the inflow design flood. Discharge is handled in accordance with the surface water requirements under Final CCR Rule 40 CFR 257.82.

6.0 REFERENCES

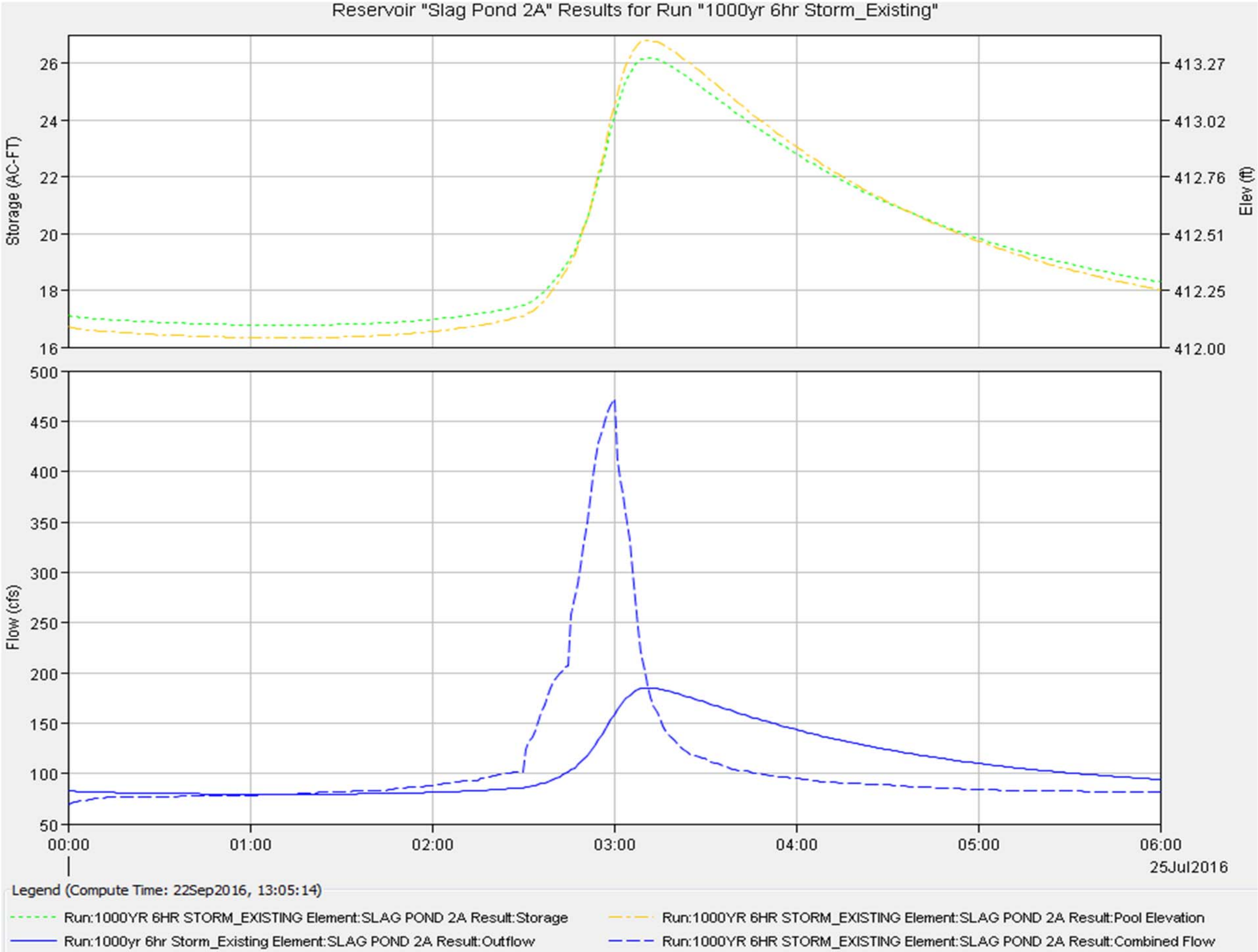
1. Environmental Protection Agency, "Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities", Federal Register, April 17, 2015.
2. AECOM, Slag Ponds 2A and 2B, Slag Stilling Pond 2C, History of Construction 257.73(c)(1) prepared for CCR Certification, 2016
3. Stantec Consulting Services Inc., Hazard Potential Classification Assessment, Slag Stilling Pond 2C, 2016
4. National Oceanic and Atmospheric Administration, Atlas 14, Volume 2, Version 3; 2016
5. TVA, Paradise Fossil Plant Permit No. KY0004201 Wastewater Flow Schematic Rev 9-2011.
6. United States Army Corps of Engineers, Hydrologic Modeling System (HEC-HMS), Version 4.0, 2016.

APPENDIX A
HEC-HMS OUTPUT

Project: Proposed Slag Pond		Simulation Run:	1000yr 6hr Storm_Existing
Start of Run:	25JUL2016, 00:00	Basin ModeL:	TVA Paradise Slag Pond-Exist
End of Run:	25JUL2016, 06:00	Meteorologic Model:	1000yr 6hr
Compute Time:	25AUG2016, 15:21:26	Control Specifications:	6hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
2A Drainage Area 2	0.0486	304.7	25Jul2016, 03:01	5.94
2A Drainage Area 1	0.0141	169.9	25Jul2016, 02:49	52.43
Slag Pond 2A	0.0627	184.6	25Jul2016, 03:11	16.04
2B Drainage Area 1	0.0151	108.4	25Jul2016, 02:49	7.14
2B Drainage Area 2	0.005	24.1	25Jul2016, 03:04	4.65
Slag Pond 2B	0.0828	153	25Jul2016, 03:59	12.39
2C Drainage Area 2	0.009	36.5	25Jul2016, 03:11	5.44
2C Drainage Area 1	0.002	14.4	25Jul2016, 02:49	7.14
Slag Stilling Pond 2C	0.0938	170	25Jul2016, 03:20	11.53
Green River	0.0938	0.4	25Jul2016, 06:00	0.01

Slag Pond 2A
1000yr 6hr



Slag Pond 2A
1000yr 6hr

Project: Proposed Slag Pond
Simulation Run: 1000yr 6hr Storm_Existing   Reservoir: Slag Pond 2A

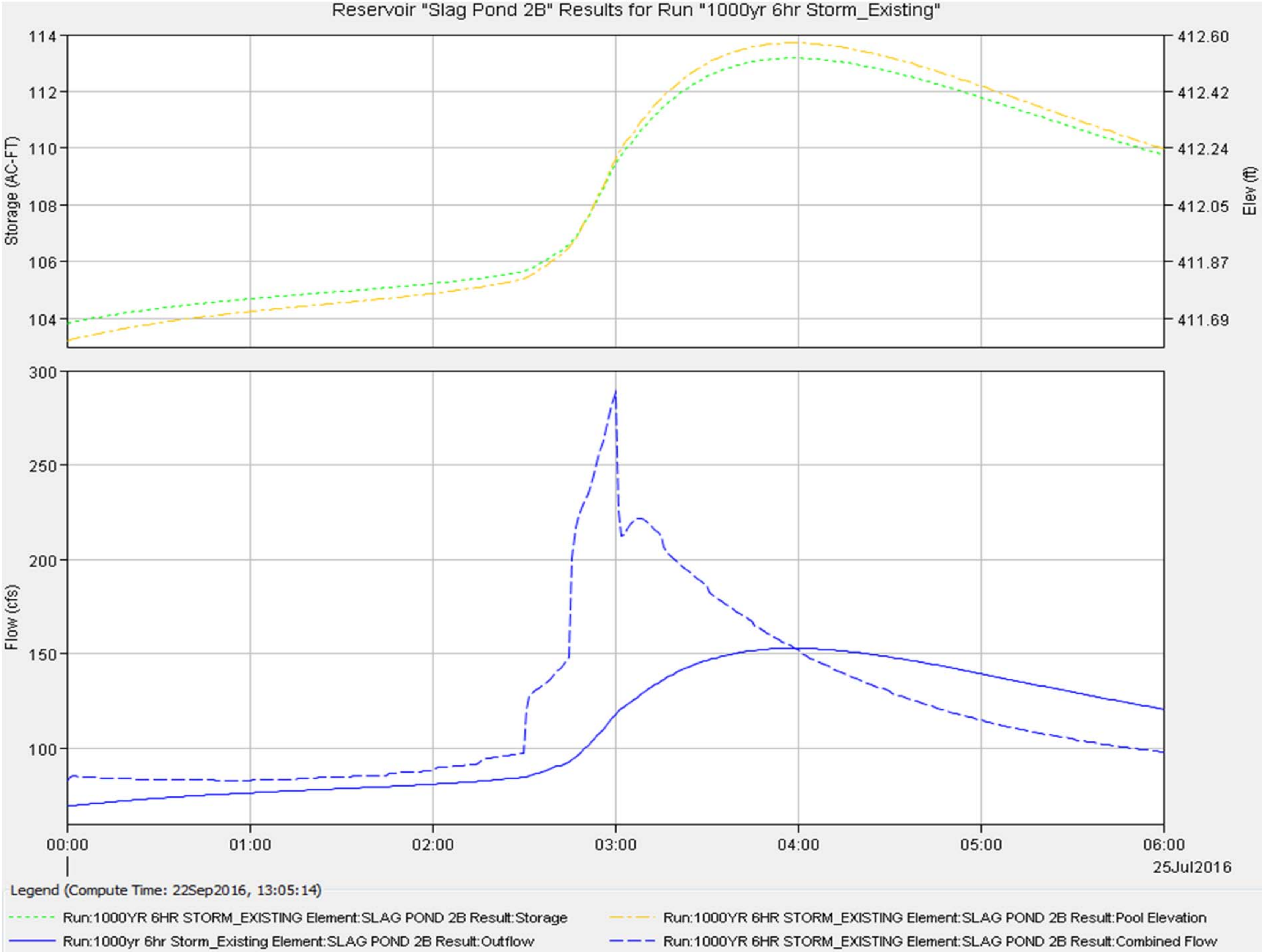
Start of Run:	25Jul2016, 00:00	Basin Model:	TVA Paradise Slag Pond-Exist
End of Run:	25Jul2016, 06:00	Meteorologic Model:	1000yr 6hr
Compute Time:	22Sep2016, 13:05:14	Control Specifications:	6hr

Volume Units: (●) IN ( ) AC-FT

Computed Results

Peak Inflow :	471.9 (CFS)	Date/Time of Peak Inflow :	25Jul2016, 03:00
Peak Outflow :	184.6 (CFS)	Date/Time of Peak Outflow :	25Jul2016, 03:11
Total Inflow :	16.40 (IN)	Peak Storage :	26.2 (AC-FT)
Total Outflow :	16.04 (IN)	Peak Elevation :	413.4 (FT)

Slag Pond 2B
1000yr 6hr



Slag Pond 2B
1000yr 6hr

Project: Proposed Slag Pond
Simulation Run: 1000yr 6hr Storm_Existing   Reservoir: Slag Pond 2B

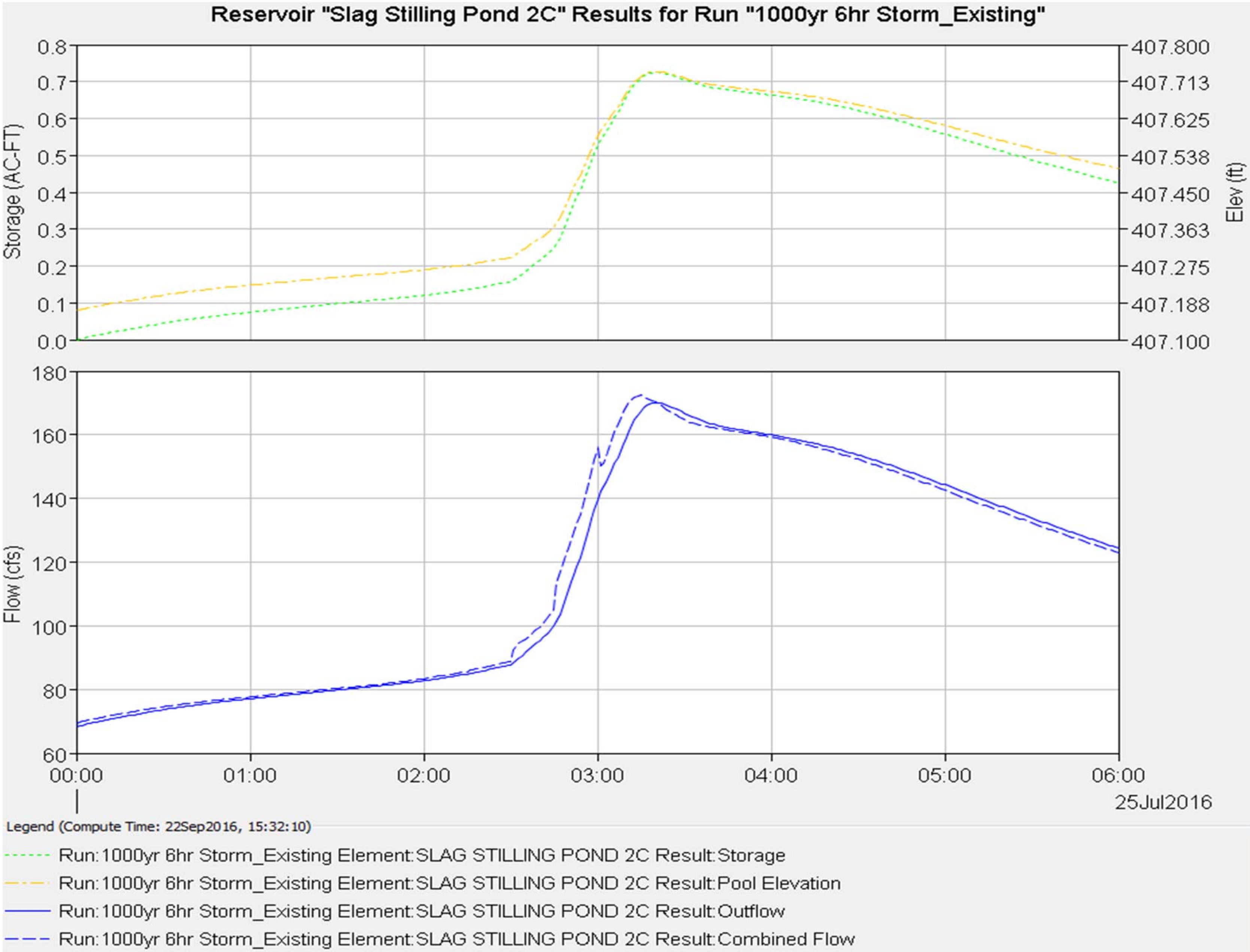
Start of Run:	25Jul2016, 00:00	Basin Model:	TVA Paradise Slag Pond-Exist
End of Run:	25Jul2016, 06:00	Meteorologic Model:	1000yr 6hr
Compute Time:	22Sep2016, 13:05:14	Control Specifications:	6hr

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow :	288.5 (CFS)	Date/Time of Peak Inflow :	25Jul2016, 03:00
Peak Outflow :	153.0 (CFS)	Date/Time of Peak Outflow :	25Jul2016, 03:59
Total Inflow :	13.73 (IN)	Peak Storage :	113.2 (AC-FT)
Total Outflow :	12.39 (IN)	Peak Elevation :	412.6 (FT)

Slag Stilling Pond 2C
1000yr 6hr



Slag Stilling Pond 2C
1000yr 6hr

Project: Proposed Slag Pond
Simulation Run: 1000yr 6hr Storm_Existing Reservoir: Slag Stilling Pond 2C

Start of Run:	25Jul2016, 00:00	Basin Model:	TVA Paradise Slag Pond-Exist
End of Run:	25Jul2016, 06:00	Meteorologic Model:	1000yr 6hr
Compute Time:	22Sep2016, 15:32:10	Control Specifications:	6hr

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow :	172.5 (CFS)	Date/Time of Peak Inflow :	25Jul2016, 03:15
Peak Outflow :	170.0 (CFS)	Date/Time of Peak Outflow :	25Jul2016, 03:20
Total Inflow :	11.61 (IN)	Peak Storage :	0.7 (AC-FT)
Total Outflow :	11.53 (IN)	Peak Elevation :	407.7 (FT)