Stantec

Stantec Consulting Services Inc.
1409 North Forbes Road, Lexington KY 40511-2024

October 5, 2016
File: rpt_001_let_175665013
Revision 0

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

RE: Initial Run-on and Run-off Control System Plan
Peninsula Disposal Area
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Kingston Fossil Plant
Harriman, Tennessee

1.0 PURPOSE

This letter documents Stantec's certification of the run-on and run-off control system plan for the TVA Kingston Fossil Plant's (KIF) Peninsula Disposal Area. Based on this assessment, the Peninsula Disposal Area is in compliance with the run-on and run-off control system requirements in the EPA Final CCR Rule at 40 CFR 257.81.

2.0 RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

As described in 40 CFR 257.81(c), a run-on and run-off control system plan must be prepared to document how the run-on and run-off control system has been designed and constructed to manage the 25-year, 24-hour storm.

3.0 SUMMARY OF FINDINGS

The attached plan presents the analysis of the run-on and run-off control system for the Peninsula Disposal Area. The results show that the landfill meets the requirements set forth in 40 CFR 257.81(a) and (b).

4.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Don W. Fuller II, being a Professional Engineer in good standing in the State of Tennessee, 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 run-on and run-off control system plan for the TVA Kingston Fossil Plant's Peninsula Disposal Area meets the requirements specified in 40 CFR 257.81(a), (b), and (c)(1).

Re: **Initial Run-on and Run-off Control System Plan**
Peninsula Disposal Area
EPA Final Coal Combustion Residuals (CCR) Rule
TVA Kingston Fossil Plant
Harriman, Tennessee

SIGNATURE Don W. Fuller II DATE 10/5/2016

ADDRESS: Stantec Consulting Services Inc.
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TELEPHONE: (859) 422-3000

ATTACHMENTS: Initial Run-on and Run-off Control System Plan

DON W FULLER II
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113120
STATE OF TENNESSEE

Initial Run-On and Run-Off Control System Plan

Kingston Fossil Plant – Peninsula Disposal Area
Harriman, Tennessee

Stantec

Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:
Stantec Consulting Services Inc.

October 5, 2016
Revision 0

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1.0 BACKGROUND

1.1 INTRODUCTION

On April 17, 2015, the Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities [RIN-2050-AE81; FRL-9149-4] (EPA Final CCR Rule) was published in the Federal Register. Stantec Consulting Services Inc. (Stantec) was contracted by the Tennessee Valley Authority (TVA) to perform a run-on and run-off analysis on the Kingston Fossil Plant's (KIF) CCR Peninsula Disposal Area and evaluate compliance with Section §257.81 of the EPA Final CCR Rule.

KIF is a coal-fired, electric generating plant located in Roane County, Tennessee, approximately 30 miles southwest of Knoxville. The plant is located on Swan Pond Road, near the confluence of the Emory and Clinch Rivers. The KIF Peninsula Disposal Area (referred to herein as the PDA) is an Existing CCR Landfill as defined by the EPA Final CCR Rule. The PDA is subject to the EPA Final CCR Rule and consists of the approximate boundary area denoted in Figure 1.

Figure 1 Kingston Fossil Plant

1.2 OBJECTIVE

This Run-on and Run-off Control System Plan documents the design and structures used to meet the requirements of §257.81 of the EPA Final CCR Rule. It addresses run-on and run-off controls for the PDA. The objective of the analysis described herein is to evaluate compliance related to §257.81, specifically the following:

1. Run-off: The PDA run-off control system must collect and control the water volume resulting from a 25-year, 24-hour storm event.

2. Run-off (permitted discharge): Run-off point sources that discharge into waters of the United States must discharge through a permitted outfall, in this case the National Pollutant Discharge Elimination System (NPDES).

3. Run-on: The run-on control system must prevent flow onto the PDA during the peak discharge from a 25-year, 24-hour storm event.

1.3 PLAN ELEMENTS

Specific Run-on and Run-off Control System Plan elements include:

- A description of stormwater control design and structures.
- Appropriate hydrological engineering calculations related to run-on and run-off flows.
- Amendments to the plan whenever there is a change in conditions that would substantially affect the plan.
- A professional engineer's certification stating that the Run-on and Run-off Control System Plan meets the requirements of §257.81 of the EPA Final CCR Rule.

The plan shall be revised every five years, and is considered complete when placed in the facility's operating record.

2.0 EXISTING CONDITIONS

The PDA is located to the southeast of the electrical generating facility and receives fly ash, bottom ash and gypsum. The PDA is broken up into two phases, Phase I (subdivided into Phase 1A and Phase 1B) and Phase II. The current footprint of the PDA covers an area of approximately 51.8 acres, mostly within Phase I. The existing conditions including the stormwater system are temporary and not final. Stormwater run-off from the PDA is conveyed to the Stormwater Pond through a combination of ditches, culverts, a leachate collection system, and pumping system as detailed below. During storm events that result in elevated stormwater conditions such as that from the 25-year, 24-hour storm event, the leachate system conveys a relatively low amount of stormwater run-off. Existing stormwater flow conditions are defined by the LiDAR data dated November, 2014 and supplemented with survey points collected in January, April and May 2016 (TVA topographic data), provided by TVA. A figure displaying the stormwater drainage patterns (leachate system is not shown) is included in Appendix A.

Stormwater falling on the PDA currently sheet flows to three depressions (Depression A, Depression B and Depression C). The west half (19.8 acres) of the PDA CCR limit flows to Depression B before flowing to the Stormwater Pond through a drop inlet structure (Culvert 1). The storage capacity of Depression B is 2.7 acre-feet at the elevation of 769 feet. Depression A also within the west half of the PDA, attenuates flows before flowing to Depression B and has a storage capacity of 0.12 acre feet at an elevation of 776 feet. The east half (32.0 acres) of the PDA CCR limit flows to Depression C before it's pumped to the Stormwater Pond. The storage capacity of Depression C is 137 acre-feet at an elevation of 777 feet.

Culvert 1 consists of three 48-inch reinforced concrete pipes (RCP), each with a drop inlet structure. The RCPs have a 2% slope, are 59 feet in length, have invert elevations of 759.4 (inlet) and 758.2 feet (outlet). The weir elevation of the drop inlet was assumed to be 766-feet based on the TVA topographic data.

The Stormwater Pond has a storage capacity of 51.5 acre-feet at an elevation of 768 feet. The outlet devices of the Stormwater Pond are two pumps for operational flows and an earthen spillway for emergency overflow. The first pump turns on when the water surface elevation in the pond reaches 759.5 feet and the second pump turns on at a water surface elevation of 763.0 feet. The emergency earthen spillway has an invert elevation of 765.9 feet. The Stormwater Pond pumps discharge to the Clinch River through Outfall 01A near the plant. Flow through Outfall 01A is subject to an active NPDES permit (permit number: TN0080870).

Note that all elevations included in this document are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

3.0 METHODS AND DESIGN CRITERIA

Criteria listed in the EPA Final CCR Rule were used to evaluate the performance of the PDA run-on and run-off control system. The following methods were used to evaluate requirements for the existing stormwater conveyance system:

1. Run-off: Collect and control the run-off water volume of a 25-year, 24-hour design storm event.

    - **West Half:** Calculations were completed to demonstrate that the conveyance system (Depression A, Depression B, and the Stormwater Pond) is sufficiently sized to contain the runoff. A hydrologic analysis was conducted to estimate the 25-year, 24-hour water surface elevation for Depression A, B and the Stormwater Pond.

    - **East Half:** Calculations were completed to demonstrate that the conveyance system (Depression C) is sufficiently sized to contain the flows that are intended to reach the Stormwater Pond. A hydrologic analysis was conducted to estimate the 25-year, 24-hour water surface elevation for Depression C.

2. Run-off (permitted discharge): Run-off discharging into waters of the United States must flow through a permitted outfall.

    - Run-off from the site either flows or is pumped to the Stormwater Pond and ultimately Outfall 01A, which flows through active NPDES permit (permit number: TN0080870).

3. Run-on: A run-on control system must be in place to prevent the peak discharge from the 25-year, 24-hour storm event onto the CCR Landfill.

    - No run-on discharges onto the PDA area as it is at an elevation above adjacent ground.

Details of the run-off hydrology and hydraulics are provided in the following sections.

3.1 MODELING ASSUMPTIONS

1. The leachate collection system was not modeled. Interim pumping during stacking was also not modeled. Elevated stormwater conditions were modeled to flow into depression areas and the Stormwater Pond.

2. Tailwater elevation for Culvert 1 was set at an elevation of 763.0 feet, which is when the second of two pumps located at the Stormwater Pond is turned on as stated in the "Operations Manual, Coal Combustion Residuals Disposal Facility Permit Modification Peninsula Site, Kingston Fossil Plant" Report (PDA Operations Manual) by Geosyntec and dated June 2014.
3. The drop inlet structure weir/rim elevation is 766 feet per TVA topographic data and aerial provided by TVA and dated November 2014 (TVA Aerial).
4. A baseflow of 1 cfs (442.3 gpm) was assumed for the Stormwater Pond to represent inflow into the pond from the leachate system. This flowrate represents the full capacity of the leachate system and is based on the PDA Operations Manual.
5. There is no water in Depression A, Depression B, or Depression C prior to the 25-year, 24-hour storm event.
6. KIF process water inflows are negligible and not included in the analysis of the Stormwater Pond.
7. Pipes are assumed to be flowing freely and not clogged or leaking.

3.2 HYDROLOGY INPUTS

The Soil Conservation Services (SCS) Technical Release 55 (TR-55) method was used within U.S. Army Corps of Engineers' Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) Version 4.0 software to estimate the peak flows for the 25-year, 24-hour storm event.

3.2.1 Rainfall Runoff and Distribution

The precipitation depth for the 25-year, 24-hour storm event is 5.52 inches and was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. Appendix B displays the NOAA precipitation data. The SCS Type II storm distribution was applied to develop a rainfall hyetograph.

3.2.2 Curve Number (CN)

The land use cover on the PDA and contributing watersheds includes bare CCR (gypsum, fly ash, and bottom ash), grass (grass covered CCR), gravel, pavement and water.

The cover type for CCR was judged to be represented by "Fallow: Bare soil" per NRCS TR-55, Table 2-2b. The CCR was classified as HSG C and a CN of 91.

The cover type for grass areas was judged to be represented by "Open Space (lawns, parks, etc.)" per NRCS TR-55, Table 2-2a. Vegetated CCR areas were judged to have vegetation cover less than 50 percent and assumed "Poor" cover type per NRCS TR-55, Table 2-2a. The grass was classified as HSG C and a CN of 86.

Gravel surface areas were assumed to be compacted and a CN of 89 was used per NRCS Table 2-2a. Pavement and water surfaces were assigned a CN of 98 and 99, respectively.

Table 1 below summarizes the CN values used for specific soil and land use combinations. Also, Figure 2 in Appendix C depicts the CN boundaries.

Table 1 CN Summary

Soil and Land Use	NRCS TR-55 Tables 2-2a and 2-2b Cover Type	HSG	CN
Grass	Open Space (lawns, parks, etc.), assume "poor" grass cover	C	86
CCR	Fallow, "Bare Soil"	C	91
Gravel	Street and Roads, "Gravel"	C	89
Pavement	Street and Roads, "Paved"	C	98
Water	n/a	n/a	99

3.2.3 Subwatershed Delineation

Subwatersheds were delineated in ArcMap 10.2.2. The watershed delineations were based on the TVA topographic data. Appendix D depicts the watersheds. This topographic data represents an interim condition as CCR material is still being stacked.

3.2.4 Lag Time

The time of concentration for each subwatershed was calculated using the NRCS segmental approach described in TR-55. The longest hydraulic flow path in each subwatershed was delineated using TVA Topographic data. The flowpaths were subdivided into sheet, shallow-concentrated and open-channel flow components. The following methods were used to calculate flow velocities (time of concentration was then found by dividing flow length by velocity) for each flow component:

- Sheet Flow: Sheet flow velocity was computed based on methodology presented in TR-55. This equation calculates time of concentration based on Manning's roughness coefficient for sheet flow, flow length (up to a maximum distance of 100 feet) slope, and the 2-year, 24-hour rainfall depth.

- Shallow Concentrated Flow: Shallow concentrated flow velocity was calculated based on methodology presented in TR-55. This equation calculates average velocity based on the slope and surface of the watercourse.
- Open Channel Flow: Open channel flow velocities were calculated based on an assumed depth and channel geometry.

The time of concentration was multiplied by 0.6 to calculate lag time based on the SCS Lag Time equation.

3.2.5 Reach Routing

Reach routings of subwatersheds through the ditches were analyzed using the Muskingum-Cunge reach routing method.

3.3 HYDRAULIC ANALYSIS

Hydraulic calculations were performed to evaluate whether Depression B (including Culvert 1) is able to convey run-off from the 25-year, 24-hour storm to the Stormwater Pond 1 without overtopping the crest. Hydraulic calculations were also performed to evaluate whether Depression C is able to provide storage for run-off from the 25-year, 24-hour storm event. Existing stormwater structure information was retrieved from construction drawings and hydrologic reports located in the PDA Operations Manual. Excerpts from this document are included in Appendix E.

3.3.1 Depression and Pond Storage

Storage volume and attenuation for Depressions A, B, and C were computed in HEC-HMS. As described in Section 2, Stormwater from the west half of the PDA flows to Depression B, with Depression A attenuating a portion of the stormwater before flowing into Depression B. Stormwater from the east half of the PDA flows to Depression C. Depression A, B, and C elevations and surface areas were obtained from TVA topographic data. The Stormwater Pond elevations and surface areas were taken from the PDA Operations Manual. HEC-HMS Depressions and the Stormwater Pond input data is displayed in Appendix F, Stage Storage Tables.

Stormwater from Depression B discharges to the Stormwater Pond through Culvert 1. The Stormwater Pond has two pumps and an earthen emergency spillway. One of the pumps turns on when the water surface elevation in the pond reaches 759.5 feet and the other at a water surface elevation of 763.0 feet. The emergency earthen spillway has an invert elevation of 765.9 feet. Both pumps were assumed to be off during the 25-year 24-hour storm event. Stage storage volume for the Stormwater Pond was obtained from the PDA Operations Manual and is included in Appendix F.

3.3.2 Culvert Capacity

Flow from the Depression B is conveyed to the Stormwater Pond through Culvert 1. As described in Section 2, Culvert 1 has 3, 48-inch RCPs, each with a drop inlet structure.

Dimensions and elevations for Culvert 1 and the three drop inlet structures were obtained from the PDA Operations Manual and TVA topographic data. Excerpts from this document are included in Appendix E.

Culvert 1 and inlet structures are summarized below in Table 2.

Table 2 Depression B Drop Inlet Structure/Culvert 1 Data

Culvert/Riser Structure	Riser Diameter (inches)	Rim Elevation (feet)	Outlet Pipe Diameter (inches)	Pipe Inlet Invert Elevation (feet)	Pipe Outlet Invert Elevation (feet)	Outlet Pipe Length (feet)
Overflow 1	84	766	48	759.4	758.2	59
Overflow 2	84	766	48	759.4	758.2	59
Overflow 3	84	766	48	759.4	758.2	59

Depending on the headwater elevation, these structures are controlled by weir or orifice flow through the riser, or by orifice, open-channel flow, or pipe flow through the outlet pipe. In developing a hydraulic rating curve for these structures, these four flow conditions are computed for a range of headwater elevations and the limiting flow is used. The methods used to estimate the discharge for each of these components are described below:

<u>Riser – Weir flow</u>

Flow just above the riser crest behaves as weir flow and was computed using:

$$Q = C_w L H^{\frac{3}{2}} \qquad \textbf{Eqn. 1}$$

Where: Q = discharge (cubic feet per second); C_w = weir coefficient; L = weir length (feet); and H = head above the riser crest (feet). The weir was assumed to behave as a sharp-crested weir with a weir coefficient of 3.27 (Chow 1959).

Riser – Orifice flow

As head develops above the riser crest, orifice flow in the riser may limit flow through the spillway system. Orifice flow in the riser was computed as:

$$Q = C_0 A(2gH)^{0.5} \qquad \textbf{Eqn. 2}$$

Where C_0 = orifice discharge coefficient, A = cross sectional area of the riser, g = gravitational constant, and H = head above the riser crest. The orifice discharge coefficient is 0.6 (Brater and King 1976).

Outlet Pipe – Orifice flow

Orifice flow in the outlet pipe was computed for the range of hydraulic conditions using:

$$Q = C_0 A[2g(H_C)]^{0.5} \qquad \textbf{Eqn. 3}$$

Where H_c = head above the outlet pipe springline (at upstream end), A = cross sectional area of the outlet pipe.

Outlet Pipe – Open-channel/submerged inlet flow

Open-channel and submerged inlet flow in the outlet pipe was computed using the HY-8 Culvert Hydraulic Analysis Program developed by the US Department of Transportation Federal Highway Administration (FHWA).

Computed rating curves for the structures are included in Appendix F.

4.0 CALCULATION RESULTS

The calculation results were reviewed to evaluate performance relative to the EPA Final CCR Rule criteria.

4.1 RUN-OFF

Table 3 displays the peak surface water elevation and crest elevation for Depressions B and C and the Stormwater Pond.

Table 3 Depressions and Pond Capacity

ID	Surface Water Elevation (25-year, 24-hour) (feet)	Crest Elevation (feet)
Depression B	766.6	769
Depression C	763.0	777
Stormwater Pond	765.1	768

Table 3 illustrates that the Depressions and the Stormwater Pond are able to convey discharge from the 25-year, 24-hour storm event. Hydrologic results are included in Appendix G.

4.2 CONCLUSION

Based on the calculations included in this report, the PDA meets the requirements of §257.81 of the EPA Final CCR Rule for Run-on and Run-off Controls. The following summarizes compliance with EPA Final CCR Rule criteria:

1. Run-off: Depression B and C are capable of conveying run-off for the 25-year, 24-hour storm event before discharging into the Stormwater Pond. Depressions B and C can convey the 25-year, 24-hour storm event with 2.4 feet and 14 feet of freeboard, respectively. The Stormwater Pond can store the 25-year, 24-hour run-off with 2.9 feet of freeboard. Therefore, the run-off control system collects and controls the water volume resulting from 25-year, 24-hour storm.

2. Run-off (permitted discharge): Run-off from the Stormwater Pond discharges through an active NPDES permitted outfall (permit number: TN0080870), and is therefore handed in accordance with the surface water requirements under §257.3-3.

3. Run-on: The PDA does not have run-on discharge since it is at an elevation above adjacent ground. Therefore the run-on control system prevents flow onto the active portion of the CCR Unit during the peak discharge from a 25-year, 24-hour storm.

5.0 REFERENCES

1. Geosyntec (2014). "Operations Manual Coal Combustion Residuals Deposal Facility Permit Modifications, Peninsula Site, Kingston Fossil Plant" Prepared for Tennessee Valley Authority. June.

2. 2014. "Site aerial imagery." Prepared for Tennessee Valley Authority.

3. November, 2014 and January, April, and May 2016. "Topography." Prepared for Tennessee Valley Authority.

4. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities [RIN-2050-AE81; FRL-9149-4] (EPA Final CCR Rule), April 2015.

5. United States Department of Agriculture (1986). "Urban Hydrology for Small Watersheds, TR-55."June.

6. NOAA Atlas 14, Precipitation Frequency Atlas of the United States, Volume 2, Version 3, 2006.

7. Federal Highway Administration, HY-8 Culvert Hydraulic Analysis Program, Version 7.3, August 18, 2014.

8. United States Army Corps of Engineers, Hydrologic Modeling System (HEC-HMS), Version 4.0, December 31, 2013.

9. Chow, V.T. (1959), Open-Channel Hydraulics, McGraw-Hill, 680 p.

10. Brater, E.F. and H.W. King (1976), Handbook of Hydraulics, McGraw-Hill, New York.

APPENDIX A
GENERAL DRAINAGE MAP

Figure No.
1

Title
General Drainage Map
KIF - Peninsula Disposal Area

Client/Project

Tennessee Valley Authority
Run-on and Run-off Control System Plan

Project Location:
Roane County, Tennessee

Prepared by jjr on 2016-06-20
Technical Review by mam on 2016-06-23
Independent Review by mmm on 2016-06-28

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0 300 600 Feet

1:3,600 (At Original document size of 11x17)

Legend

- Approximate CCR Limit
- Flow Path
- Depression A
- Depression B
- Depression C
- Stormwater Pond
- Topographic Mapping

Notes

1. Contours are based on LiDAR data dated November, 2014 for Kingston supplemented with survey points collected in January, April, and May 2016.
2. Aerial imagery dated November, 2014.

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TVA

U:\175665013\gis\mxd\report\figure1.mxd Revised: 2016-07-13 By: jureyes

APPENDIX B
NOAA RAINFALL DEPTHS

NOAA Atlas 14, Volume 2, Version 3
Location name: Kingston, Tennessee, US*
Latitude: 35.8939°, Longitude: -84.5074°
Elevation: 766 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.346 (0.318-0.379)	0.408 (0.374-0.447)	0.480 (0.441-0.526)	0.547 (0.499-0.597)	0.634 (0.576-0.692)	0.707 (0.637-0.769)	0.782 (0.700-0.850)	0.860 (0.761-0.936)	0.968 (0.844-1.05)	1.06 (0.914-1.16)
10-min	0.552 (0.508-0.606)	0.652 (0.599-0.715)	0.769 (0.707-0.842)	0.874 (0.799-0.955)	1.01 (0.917-1.10)	1.13 (1.01-1.23)	1.24 (1.11-1.35)	1.36 (1.21-1.48)	1.53 (1.33-1.67)	1.67 (1.44-1.82)
15-min	0.690 (0.635-0.758)	0.819 (0.752-0.898)	0.973 (0.894-1.06)	1.11 (1.01-1.21)	1.28 (1.16-1.40)	1.43 (1.28-1.55)	1.57 (1.41-1.71)	1.72 (1.52-1.87)	1.93 (1.68-2.10)	2.09 (1.81-2.28)
30-min	0.946 (0.870-1.04)	1.13 (1.04-1.24)	1.38 (1.27-1.51)	1.60 (1.46-1.75)	1.90 (1.72-2.07)	2.15 (1.94-2.34)	2.41 (2.15-2.62)	2.68 (2.37-2.91)	3.06 (2.67-3.34)	3.39 (2.92-3.70)
60-min	1.18 (1.08-1.29)	1.42 (1.30-1.56)	1.77 (1.63-1.94)	2.09 (1.91-2.28)	2.53 (2.29-2.75)	2.91 (2.62-3.17)	3.31 (2.96-3.60)	3.76 (3.33-4.09)	4.40 (3.83-4.79)	4.95 (4.27-5.40)
2-hr	1.39 (1.28-1.52)	1.67 (1.53-1.82)	2.07 (1.90-2.26)	2.44 (2.23-2.66)	2.95 (2.68-3.21)	3.40 (3.07-3.69)	3.88 (3.46-4.21)	4.40 (3.89-4.77)	5.15 (4.49-5.59)	5.80 (4.98-6.32)
3-hr	1.51 (1.40-1.65)	1.81 (1.66-1.97)	2.23 (2.05-2.43)	2.61 (2.40-2.84)	3.15 (2.87-3.41)	3.62 (3.27-3.91)	4.11 (3.68-4.44)	4.64 (4.12-5.03)	5.41 (4.72-5.87)	6.07 (5.23-6.61)
6-hr	1.88 (1.75-2.04)	2.23 (2.07-2.42)	2.72 (2.52-2.94)	3.15 (2.91-3.41)	3.77 (3.46-4.06)	4.29 (3.92-4.63)	4.85 (4.39-5.23)	5.44 (4.88-5.87)	6.29 (5.56-6.79)	7.01 (6.11-7.59)
12-hr	2.34 (2.17-2.52)	2.77 (2.58-3.00)	3.36 (3.12-3.62)	3.88 (3.59-4.18)	4.59 (4.23-4.94)	5.20 (4.76-5.59)	5.82 (5.30-6.26)	6.48 (5.86-6.98)	7.41 (6.62-7.99)	8.18 (7.22-8.85)
24-hr	2.83 (2.68-3.02)	3.39 (3.20-3.61)	4.13 (3.89-4.39)	4.71 (4.44-5.02)	5.52 (5.18-5.86)	6.15 (5.76-6.53)	6.81 (6.35-7.23)	7.47 (6.95-7.94)	8.37 (7.73-8.90)	9.07 (8.34-9.66)
2-day	3.47 (3.25-3.70)	4.15 (3.88-4.43)	5.05 (4.73-5.40)	5.77 (5.39-6.15)	6.74 (6.28-7.18)	7.51 (6.98-8.01)	8.30 (7.69-8.85)	9.10 (8.39-9.71)	10.2 (9.33-10.9)	11.0 (10.0-11.8)
3-day	3.72 (3.49-3.97)	4.45 (4.17-4.74)	5.40 (5.06-5.76)	6.13 (5.75-6.54)	7.12 (6.65-7.59)	7.89 (7.36-8.41)	8.67 (8.05-9.24)	9.45 (8.75-10.1)	10.5 (9.65-11.2)	11.3 (10.3-12.1)
4-day	3.97 (3.73-4.23)	4.74 (4.46-5.06)	5.75 (5.40-6.12)	6.50 (6.10-6.92)	7.51 (7.02-7.99)	8.28 (7.73-8.81)	9.05 (8.43-9.64)	9.81 (9.10-10.5)	10.8 (9.97-11.5)	11.6 (10.6-12.4)
7-day	4.84 (4.56-5.14)	5.77 (5.44-6.13)	6.92 (6.52-7.35)	7.78 (7.32-8.26)	8.89 (8.36-9.44)	9.73 (9.13-10.3)	10.6 (9.88-11.2)	11.4 (10.6-12.1)	12.4 (11.5-13.2)	13.2 (12.2-14.0)
10-day	5.52 (5.22-5.85)	6.55 (6.20-6.94)	7.79 (7.37-8.25)	8.73 (8.26-9.25)	9.97 (9.40-10.6)	10.9 (10.3-11.6)	11.8 (11.1-12.5)	12.7 (11.9-13.5)	13.9 (12.9-14.8)	14.8 (13.7-15.7)
20-day	7.63 (7.25-8.02)	9.01 (8.57-9.48)	10.5 (9.95-11.0)	11.5 (10.9-12.1)	12.8 (12.2-13.5)	13.8 (13.1-14.5)	14.7 (13.9-15.5)	15.5 (14.7-16.4)	16.5 (15.6-17.4)	17.2 (16.2-18.2)
30-day	9.38 (8.96-9.81)	11.0 (10.5-11.5)	12.6 (12.0-13.2)	13.7 (13.1-14.4)	15.1 (14.4-15.8)	16.1 (15.4-16.9)	17.0 (16.2-17.8)	17.8 (17.0-18.7)	18.8 (17.9-19.7)	19.5 (18.4-20.4)
45-day	11.8 (11.3-12.3)	13.8 (13.2-14.4)	15.6 (15.0-16.3)	17.0 (16.2-17.7)	18.6 (17.8-19.4)	19.7 (18.8-20.6)	20.7 (19.8-21.7)	21.7 (20.6-22.7)	22.7 (21.6-23.8)	23.5 (22.3-24.6)
60-day	14.2 (13.6-14.8)	16.5 (15.9-17.3)	18.7 (17.9-19.5)	20.2 (19.4-21.1)	22.1 (21.1-23.0)	23.3 (22.3-24.4)	24.5 (23.4-25.6)	25.5 (24.3-26.7)	26.7 (25.4-28.0)	27.5 (26.2-28.8)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

APPENDIX C
CURVE NUMBER MAP

Figure No.
2

Title
Curve Number Map
KIF - Peninsula Disposal Area

Client/Project

Tennessee Valley Authority
Run-on and Run-off Control System Plan

Project Location:
Roane County, Tennessee

Prepared by jjr on 2016-06-20
Technical Review by mam on 2016-06-23
Independent Review by mmm on 2016-06-28

175665013

0 300 600 Feet

1:4,000 (At Original document size of 11x17)

Legend

- Approximate CCR Limit
- Flow Path
- Topographic Mapping

Curve Number

- Grass (CN=86)
- Gravel (CN=89)
- CCR (CN=91)
- Pavement (CN=98)
- Water (CN=99)

Notes

1. Contours are based on LiDAR data dated November, 2014 for Kingston supplemented with survey points collected in January, April, and May 2016.
2. Aerial imagery dated November, 2014.

Stantec

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APPENDIX D
WATERSHED MAP

Figure No.
3

Title

Watershed Map
KIF - Peninsula Disposal Area

Client/Project

Tennessee Valley Authority
Run-on and Run-off Control System Plan

Project Location:
Roane County, Tennessee

Prepared by jjr on 2016-06-20
Technical Review by mam on 2016-06-23
Independent Review by mmm on 2016-06-28

175665013

0 300 600 Feet

1:3,600 (At Original document size of 11x17)

Legend

- Approximate CCR Limit
- 1 Watershed
- Flow Path
- Depression
- Topographic Mapping

Notes

1. Contours are based on LiDAR data dated November, 2014 for Kingston supplemented with survey points collected in January, April, and May 2016.
2. Aerial imagery dated November, 2014.

U:\175665013\gis\mxd\report\figure3.mxd Revised: 2016-07-13 By: jureyes

APPENDIX E
EXCERPTS FROM OPERATIONS MANUAL

Prepared for

Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37401-2801

OPERATIONS MANUAL
COAL COMBUSTION RESIDUALS
DISPOSAL FACILITY
PERMIT MODIFICATION
PENINSULA SITE
KINGSTON FOSSIL PLANT
ROANE COUNTY, TENNESSEE

Prepared by

Geosyntec consultants

engineers | scientists | innovators

One Central Plaza
835 Georgia Avenue, Suite 500
Chattanooga, Tennessee 37402

Project Number TN5077

June 2014

NOTES:

1. THE TOPOGRAPHIC MAP SHOWN ON THIS DRAWING WAS PROVIDED BY TVA AND IS BASED ON THE INTEGRATION OF LIDAR SURVEYS CONDUCTED ON AUGUST 2010, MARCH 2011, AND FEBRUARY 2012. TOPOGRAPHIC MAP OF THE PHASE IA AREA WAS PROVIDED BY TVA AND IS BASED ON A SURVEY CONDUCTED ON 2 OCTOBER 2012. EXISTING SITE FEATURES SHOWN ON THIS DRAWING WERE GENERALLY PROVIDED BY TVA AND BASED ON MARCH 2011 AERIAL PHOTOGRAPHY. SELECT FEATURES REVISED BASED ON DECEMBER 2011 AERIAL PHOTOGRAPHY AND SITE VISITS. GRID COORDINATES CORRESPOND TO TENNESSEE STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM (NAD) 1927. ELEVATIONS ARE IN FEET ABOVE SEA LEVEL, NATIONAL GEODETIC VERTICAL DATUM (NGVD) 1929.
2. PERMANENT BENCHMARK "MON–G" PROVIDES PROJECT X, Y, Z CONTROL, LOCATED AT N = 550445.44, E = 2438887.90, ELEV = 764.069.
3. GROUNDWATER MONITORING WELL CONSTRUCTION DATA CAN BE FOUND IN TABLE 1. TYPICAL WELL DETAILS FOR BOTH RESIDUUM AND BEDROCK MONITORING WELLS CAN BE FOUND IN THEIR RESPECTIVE WELL SCHEMATICS.
4. STORMWATER POND WAS LINED WITH A 60–MIL TEXTURED HDPE LINER IN 2010. AS PART OF THE LINER INSTALLATION, BATTENS WERE INSTALLED AT THE PAD AT THE 3–CONCRETE INLET PIPES AS WELL AS THE CONCRETE BRIDGE STRUCTURES HOUSING THE OUTLET PUMPS AND THEIR INFRASTRUCTURE. IN ADDITION, LIQUID BOOT WAS USED TO LINE THE BRIDGE STRUCTURES AS WELL AS INLET PIPES AND THEIR PAD.
5. STORMWATER POND OUTLET STRUCTURE (PRIMARY AND EMERGENCY) DETAILS ARE PROVIDED IN APPENDIX B.1 – DESIGN AND ANALYSIS FOR SURFACE WATER MANAGEMENT SYSTEM OF THIS PERMIT MODIFICATION PACKAGE.

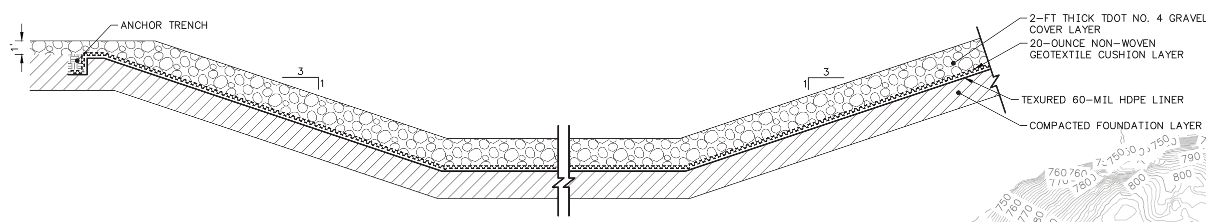
TABLE 1. MONITORING WELL CONSTRUCTION DATA

Monitoring Well	Northing	Easting	Top of Casing (TOC) Elevation (ft)	Ground / Concrete Pad Elevation (ft)	Depth to Well Bottom from TOC (ft)
MW-1B	550851.53	2441832.84	858.30	857.30	128.57
MW-G2A	551374.04	2442500.32	857.30	854.15	49.28
MW-G2B	551363.34	2442507.03	857.84	854.42	92.52
MW-3A	549356.19	2441014.76	749.63	746.09	31.95
MW-3B	549350.72	2441002.52	750.35	746.79	62.96
MW-4B	549210.27	2441685.63	766.90	764.66	82.09
MW-5A	549252.05	2442286.02	759.07	756.40	28.12
MW-5B	549251.59	2442272.64	758.64	756.32	60.24
MW-6B	549410.25	2442853.29	773.69	770.78	59.68
MW-G7A	549533.68	2443378.85	766.75	762.98	46.78
MW-G7B	549532.98	2443367.83	766.45	762.94	51.54
MW-G8A	549707.81	2443649.58	771.47	768.19	53.15
MW-G8B	549715.25	2443656.09	770.74	767.34	80.08
MW-G9A	550258.07	2444408.45	752.13	748.76	55.38
MW-G9B	550263.34	2444417.91	751.99	748.80	73.59
MW-G10A	550644.83	2444612.97	768.76	765.42	67.45
MW-G10B	550635.3	2444607.13	768.53	765.22	102.10

NOTES:

1) MONITORING WELLS MW–G1A, G4A, AND G6A COULD NOT BE INSTALLED DUE TO AN APPARENT LACK OF SATURATED OVERBURDEN THICKNESS AT THE TIME OF DRILLING.

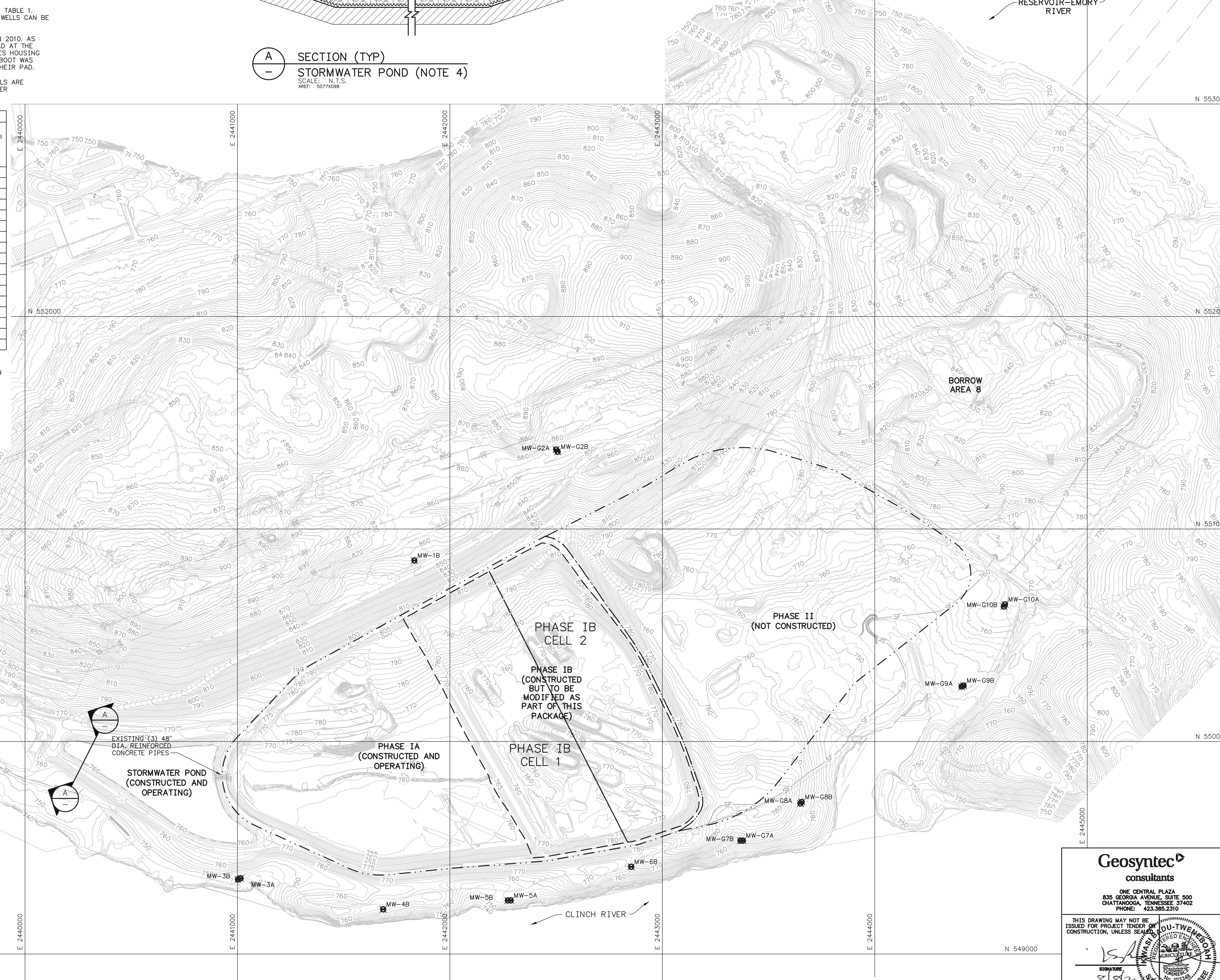
2) SURVEY REFERENCE:
PROJECTION: TENNESSEE LAMBERT
HORIZONTAL DATUM: NAD 27
VERTICAL DATUM: NGVD 29
UNITS: US SURVEY FEET

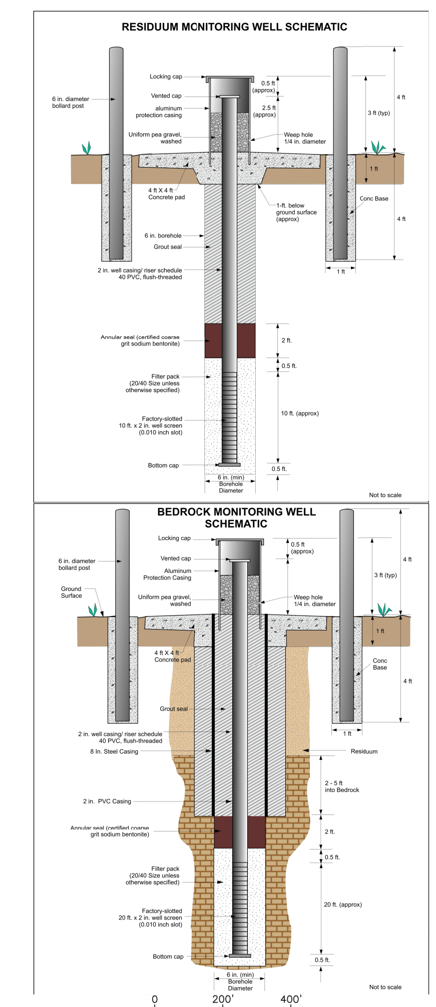


SECTION (TYP)
STORMWATER POND (NOTE 4)
SCALE: N.T.S.

LEGEND

- EXISTING GRADES
- EXISTING ROAD
- EXISTING TREELINE
- EXISTING OVERHEAD ELECTRICAL TOWER AND TRANSMISSION LINES
- EXISTING OVERHEAD POWER LINES
- PHASE BOUNDARY
- CELL BOUNDARY
- MON–G VERTICAL ELEV=764.069 — PERMANENT BENCHMARK (NOTE 2)
- MW–3B — EXISTING GW MONITORING WELL (NOTE 3)





0 200' 400'
SCALE IN FEET

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 3	JULY 2014	MI	RO	CG	RBC	KBT	MST				
TDEC COMMENTS ROUND 3											
R 2	FEB 2014	MI	RO	CG	RBC	KBT	MST				
TDEC COMMENTS ROUND 2											
R 1	JUNE 2013	MI	RO	CG	RBC	KBT	MST				
TDEC COMMENTS ROUND 1											
R 0	DEC 2012	MI/SBF	CET	CG	RBC	KBT	MST				
INITIAL ISSUE											

DISCIPLINE INTERFACE
1
2
3
4

SCALE: AS SHOWN EXCEPT AS NOTED

COAL–COMBUSTION RESIDUALS DISPOSAL FACILITY
PERMIT MODIFICATION, PERMIT DRAWINGS

EXISTING CONDITIONS AND SITE PLAN

Geosyntec consultants
ONE CENTRAL PLAZA
835 GEORGIA AVENUE, SUITE 500
CHATTANOOGA, TENNESSEE 37402
PHONE: 423.385.2310

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE
8/8/2014
DATE

KWASI BADU-TWENEBOAH REGISTERED ENGINEER AGRICULTURE COMMERCE No. 103348 STATE OF TENNESSEE

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
M. ISCIMEN/ S.B. FICK	RON ORTIZ	C. GOKMEN	R.B. COMBS	K.B. TWENEBOAH	M.S. TURNBOW	

KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

CIVIL 3D 2014 | DATE JULY 2014 | 36 | C | 10W438–02 | R 3

GEOSYNTEC CONSULTANTS | 3
TASK COMPLETED BY: | REV NO.

PLOT FACTOR:1:1
W_TVA

C.A.D. DRAWING DO NOT ALTER MANUALLY

Written by:	**J. Antonio Sanchez, P.E.**	Date:	**5/30/2014**	Reviewed by:	**Kwasi Badu-Tweneboah, Ph.D., P.E.**	Date:	**6/6/2014**

Client:	**TVA**	Project:	**Kingston Peninsula Permit Modification**	Project/ Proposal No.:	**TN5398**	Task No.:	**03**		

DESIGN & ANALYSIS OF THE PROPOSED RUN-OFF MANAGEMENT SYSTEM

PURPOSE

The purpose of this calculation package is to present the design and analysis of the proposed run-off management system for the Kingston Fossil Plant Peninsula Disposal Facility (hereafter referenced as KIF disposal facility). The specific goals of this package are to present:

- an overview of the proposed run-off management system for the KIF disposal facility;
- the regulatory requirements and the design criteria;
- the design of the various components of the run-off management system including the sediment basin, diversion berms, drainage benches, downdrain pipes, perimeter drainage channels, and culverts; and
- the results of the calculations for peak discharges from the site.

PROPOSED RUN-OFF MANAGEMENT SYSTEM - OVERVIEW

The proposed run-off management system plan is provided in **Attachment 1**. The final cover system will have a 3 percent slope from the crest to an elevation of 845 ft and 890 ft for Phase I and Phase II, respectively, and then a 33 percent (i.e., 3 horizontal: 1 vertical) slope downwards. Diversion berms and drainage benches in the final cover system areas with 3 percent and 3H:1V (3 horizontal: 1 vertical) slopes, respectively, will intercept stormwater run-off and convey the run-off to downdrain pipes, which will convey the run-off to the perimeter drainage channels located at the toe of the final cover system. The perimeter drainage channels are sloped towards the western tip of the disposal facility. Flows from the perimeter drainage channels are conveyed through a drop-inlet to a culvert system (three 48-inch diameter pipes). The flows from the culvert system are conveyed under the perimeter access road to the existing stormwater pond located west of the disposal facility.

The outlet devices of the existing stormwater pond are pumps for operational flows and an earthen spillway for emergency overflows. The water levels in the existing stormwater pond are controlled by pumping. Run-off collected in the pond is pumped using a lift station and conveyed via a force main to the National Pollutant Discharge Elimination System (NPDES) discharge point Outfall 01A near the plant (i.e., discharges to plant discharge channel).

The lift station is comprised of two pumps. The first pump turns on when the water surface elevation in the pond reaches 759.5 feet (ft) Mean Sea Level (MSL). The second pump turns on when the water surface elevation in the pond reaches 763.0 ft-MSL. Both pumps turn off when the water surface elevation in the pond returns to 758.5 ft-MSL. These elevations are generally referred to as the on- and off-elevations of each pump. For the purposes of the design and analysis presented herein, pumping operations are described as either Lift Station Pumps On or Lift Station Pumps Off. Lift Station Pumps On indicates that both pumps are operating according to their specified on- and off-elevations. Lift Station Pumps Off indicates that both pumps are inactive and do not discharge when the water surface elevation within the existing stormwater pond exceeds the on-elevation. Neither pump operating condition includes sluicing operation flows into the pond.

The earthen spillway is built into the roadway located along the top of the existing stormwater pond embankment. The invert elevation of the spillway is located at 765.9 ft-MSL. Emergency overflows from the spillway are conveyed into an overflow channel, which acts as an energy dissipation structure. The non-erosive flows from the overflow channel are then conveyed to the Clinch River.

REGULATORY REQUIREMENTS & DESIGN CRITERIA

The proposed run-off management system is designed to generally satisfy the regulatory requirements of the "Rules of the Tennessee Department of Environment and Conservation (TDEC), Division of Solid Waste Management" [TDEC, 2012a]; the "Tennessee Erosion and Sediment Control Handbook (TESC)" [TDEC, 2012b]; the "Master Programmatic Document" [TVA, 2011]; and the "Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams" [FEMA, 2004]. These requirements were also considered in assessing the functionality of the existing stormwater pond. Specifically, the requirements utilized as design criteria for the proposed run-off management system are listed below. Criteria that are either not met or not included in this calculation package are addressed in italic below the requirement.

1 SEDIMENT BASIN

1.1 Design Flow and Volume

1.1.1 The operator must design, construct, operate, and maintain a run-on collection system capable of preventing peak flow onto the active portion of the facility for

Summary for Pond SP1: Stormwater Pond

Inflow Area = 103.460 ac, 14.18% Impervious, Inflow Depth = 3.79" for 25-year 24-hour event
Inflow = 300.20 cfs @ 12.19 hrs, Volume= 32.661 af
Outflow = 7.57 cfs @ 13.75 hrs, Volume= 28.172 af, Atten= 97%, Lag= 93.5 min
Primary = 7.57 cfs @ 13.75 hrs, Volume= 28.172 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 763.54' @ 19.97 hrs Surf.Area= 5.446 ac Storage= 25.411 af

Plug-Flow detention time= 1,552.8 min calculated for 28.153 af (86% of inflow)
Center-of-Mass det. time= 1,487.7 min (2,304.7 - 817.0)

Volume	Invert	Avail.Storage	Storage Description
#1	758.50'	51.528 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
758.50	4.650	0.000	0.000
759.00	4.729	2.345	2.345
760.00	4.885	4.807	7.152
761.00	5.043	4.964	12.116
762.00	5.201	5.122	17.238
763.00	5.359	5.280	22.518
764.00	5.522	5.440	27.958
765.00	5.692	5.607	33.565
766.00	5.880	5.786	39.351
768.00	6.297	12.177	51.528

Device	Routing	Invert	Outlet Devices
#1	Secondary	765.89'	**24.0' long x 40.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#2	Primary	759.50'	**Pump Discharges@741.00'** Flow (gpm)= 2,440.0 Head (feet)= 100.00
#3	Primary	763.00'	**Pump Discharges@741.00'** Flow (gpm)= 960.0 Head (feet)= 100.00

Primary OutFlow Max=7.57 cfs @ 13.75 hrs HW=763.00' (Free Discharge)
├─**2=Pump** (Pump Controls 5.44 cfs)
└─**3=Pump** (Pump Controls 2.14 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=741.00' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Subcatchment Road9:

Runoff = 3.69 cfs @ 11.90 hrs, Volume= 0.187 af, Depth= 5.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-year 24-hour Rainfall=5.70"

Area (ac)	CN	Description
0.410	98	Paved parking & roofs
0.410		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					**Direct Entry,**

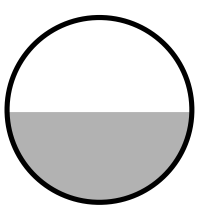
Summary for Reach C1: culvert

Inflow Area = 96.590 ac, 8.08% Impervious, Inflow Depth = 3.67" for 25-year 24-hour event
Inflow = 293.89 cfs @ 12.19 hrs, Volume= 29.534 af
Outflow = 293.73 cfs @ 12.19 hrs, Volume= 29.534 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 16.09 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.71 fps, Avg. Travel Time= 0.2 min

Peak Storage= 1,074 cf @ 12.19 hrs
Average Depth at Peak Storage= 1.95'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 613.04 cfs

A factor of 3.00 has been applied to the storage and discharge capacity
48.0" Round Pipe
n= 0.013 Concrete pipe, straight & clean
Length= 58.8' Slope= 0.0202 '/'
Inlet Invert= 759.39', Outlet Invert= 758.20'



Summary for Reach R1:

Inflow Area = 32.290 ac, 7.12% Impervious, Inflow Depth = 3.65" for 25-year 24-hour event
Inflow = 97.52 cfs @ 12.14 hrs, Volume= 9.823 af
Outflow = 96.99 cfs @ 12.15 hrs, Volume= 9.823 af, Atten= 1%, Lag= 0.9 min

Written by:	Ali Ebrahimi	Date:	12/7/2012	Reviewed by:	Cuneyt Gokmen	Date:	12/7/2012

Client:	TVA	Project:	Phase I&II Permit Modification	Project/ Proposal No.:	TN5077	Task No.:	01

LCS CORRIDOR PIPE DESIGN
TVA Kingston Peninsula: Critical Cell

Pipe Type:

Name: 8-in nominal diameter SDR 9 pipe

Norminal Outer Diameter	$D =$	**8.625**	in
Minimum wall thickness	$t =$	**0.958**	in
Average inner diameter	$D_i =$	**6.594**	in
Standard Dimension Ratio of pipe	$SDR =$	**9**	

Pipe Flow Capacity:

Hydraulic Radius
$R_h = D_i / 4$
= 6.594 / 4
= 1.65 in

Hydraulic Gradient $i_p =$ **0.013** Most Critical Slope in Phase IB and II

Manning's roughness coefficient $n =$ **0.011** $s/ft^{0.33}$

Cross-sectional area of pipe
$A_p = PI*D_i\text{^}2 / 4$
= 3.14 * 6.594^2 / 4
= 34.15 in^2

Pipe flow capacity

$$Q = \frac{1.486 R_h^{0.66} i_p^{0.5} A_p}{n}$$

= 1.486 * (1.65 / 12)^0.66 * 0.013^0.5 *(34.15 / 144) / 0.011
= 0.985 cfs
= 442.31 gpm **<== Flow Capacity of one 8-in nominal diameter SDR 9 pipe**

Design Flow Capacity $Q_{pr} =$ **178.37** gpm **<== (17,343 * 14.3) /24/60**
17,343 <== Flow in gpad for Case IA (gpad)
14.81 <== Drainage area of Largest Phase IB and II Cell (acres)

Factor of safety for flow capacity
$FS_Q = Q_p / Q_{pr}$
= 442.31 / 178.37
= **2.48** OK **<== Assuming one 8-in nominal diameter SDR 9 pipes in LCS corridor (FS > 1.5)**

Pipe Perforation Sizing:

$d_{85} =$ **32** mm
Factor varying from 1.2 ~ 2.0 $F =$ **1.2**
$d_{hmax} = d_{85} / F$
= 32 / 1.2
= 26.7 mm
= 1.05 inch Use **1.00** inch

APPENDIX F
HYDRAULIC RESULTS

HEC-HMS Input - Peninsula Disposal Area
CCR Rule Run-on and Run-off
Peninsula Disposal Area, Kingston Fossil Plant
Project Number: 175565013
Calculation Performed by: JJR   Calculation Date: 6/16/16
Checked by: MAM   Checked By Date: 6/23/16

Elevation (ft)	Discharge (cfs)	Storage (acre-ft)
766.00	0.00	0.55
766.50	76.27	0.80
767.00	215.73	1.05
767.50	396.33	1.37
768.00	466.33	1.68
768.50	483.68	2.20
769.00	500.42	2.71
769.50	516.62	3.46
770.00	532.32	4.21

Notes:

1. Storage information computed based on LiDAR data dated November, 2014 supplemented with survey points collected in January, April and May 2016 (TVA Topographic Data).

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Rating Curves - Peninsula Disposal Area
CCR Rule Run-on and Run-off
Peninsula Disposal Area, Kingston Fossil Plant
Project Number: 175565013
Calculation Performed by: JJR   Calculation Date: 6/16/16
Checked by: MAM   Checked By Date: 6/23/16

Overflow 1

Elevation	Weir Flow		Orifice Flow		Pipe Orifice Flow		Outlet Pipe Flow (from HY-8)		Rating Curve for HEC-HMS	
	H (ft)	$Q=CLH^{1.5}$ (cfs)	H (ft)	$Q=C_0A(2gH)^{0.5}$ (cfs)	H_c (ft)	$Q=C_0A(2gH_c)^{0.5}$ (cfs)	Assumed TW (ft)	Q (cfs)	HW Elevation (ft)	Q (cfs)
766.00	0.0	0.00	0.0	0.00	4.60	129.77	763	139.04	766.00	0.00
766.50	0.5	25.42	0.5	131.03	5.10	136.64	763	147.83	766.50	25.42
767.00	1.0	71.91	1.0	185.30	5.60	143.19	763	155.50	767.00	71.91
767.50	1.5	132.11	1.5	226.95	6.10	149.44	763	162.92	767.50	132.11
768.00	2.0	203.40	2.0	262.06	6.60	155.44	763	170.35	768.00	155.44
768.50	2.5	284.25	2.5	292.99	7.10	161.23	763	177.77	768.50	161.23
769.00	3.0	373.66	3.0	320.95	7.60	166.81	763	184.64	769.00	166.81
769.50	3.5	470.87	3.5	346.67	8.10	172.21	763	191.26	769.50	172.21
770.00	4.0	575.29	4.0	370.60	8.60	177.44	763	197.88	770.00	177.44

Overflow 2

Elevation	Weir Flow		Orifice Flow		Pipe Orifice Flow		Outlet Pipe Flow (from HY-8)		Rating Curve for HEC-HMS	
	H (ft)	$Q=CLH^{1.5}$ (cfs)	H (ft)	$Q=C_0A(2gH)^{0.5}$ (cfs)	H_c (ft)	$Q=C_0A(2gH_c)^{0.5}$ (cfs)	Assumed TW (ft)	Q (cfs)	HW Elevation (ft)	Q (cfs)
766.00	0.0	0.00	0.0	0.00	4.60	129.77	763	139.04	766.00	0.00
766.50	0.5	25.42	0.5	131.03	5.10	136.64	763	147.83	766.50	25.42
767.00	1.0	71.91	1.0	185.30	5.60	143.19	763	155.50	767.00	71.91
767.50	1.5	132.11	1.5	226.95	6.10	149.44	763	162.92	767.50	132.11
768.00	2.0	203.40	2.0	262.06	6.60	155.44	763	170.35	768.00	155.44
768.50	2.5	284.25	2.5	292.99	7.10	161.23	763	177.77	768.50	161.23
769.00	3.0	373.66	3.0	320.95	7.60	166.81	763	184.64	769.00	166.81
769.50	3.5	470.87	3.5	346.67	8.10	172.21	763	191.26	769.50	172.21
770.00	4.0	575.29	4.0	370.60	8.60	177.44	763	197.88	770.00	177.44

Overflow 3

Elevation	Weir Flow		Orifice Flow		Pipe Orifice Flow		Outlet Pipe Flow (from HY-8)		Rating Curve for HEC-HMS	
	H (ft)	$Q=CLH^{1.5}$ (cfs)	H (ft)	$Q=C_0A(2gH)^{0.5}$ (cfs)	H_c (ft)	$Q=C_0A(2gH_c)^{0.5}$ (cfs)	Assumed TW (ft)	Q (cfs)	HW Elevation (ft)	Q (cfs)
766.00	0.0	0.00	0.0	0.00	4.60	129.77	763	139.04	766.00	0.00
766.50	0.5	25.42	0.5	131.03	5.10	136.64	763	147.83	766.50	25.42
767.00	1.0	71.91	1.0	185.30	5.60	143.19	763	155.50	767.00	71.91
767.50	1.5	132.11	1.5	226.95	6.10	149.44	763	162.92	767.50	132.11
768.00	2.0	203.40	2.0	262.06	6.60	155.44	763	170.35	768.00	155.44
768.50	2.5	284.25	2.5	292.99	7.10	161.23	763	177.77	768.50	161.23
769.00	3.0	373.66	3.0	320.95	7.60	166.81	763	184.64	769.00	166.81
769.50	3.5	470.87	3.5	346.67	8.10	172.21	763	191.26	769.50	172.21
770.00	4.0	575.29	4.0	370.60	8.60	177.44	763	197.88	770.00	177.44

Notes:

1. Cells highlighted in yellow indicate selected flow condition.

HY-8 Output - Peninsula Disposal Area
CCR Rule Run-on and Run-off
Peninsula Disposal Area, Kingston Fossil Plant
Project Number: 175565013
Calculation Performed by: JJR Calculation Date: 6/16/16
Checked by: MAM Checked By Date: 6/23/16

Overflow 1		Overflow 2		Overflow 3	
Q (cfs)	Headwater (ft)	Q (cfs)	Headwater (ft)	Q (cfs)	Headwater (ft)
0	763	0	763	0	763
18	763.05	18	763.05	18	763.05
54	763.42	54	763.42	54	763.42
72	763.74	72	763.74	72	763.74
108	764.66	108	764.66	108	764.66
126	765.29	126	765.29	126	765.29
144	766.27	144	766.27	144	766.27
150	766.63	150	766.63	150	766.63
180	768.65	180	768.65	180	768.65
191	769.5	191	769.5	191	769.5

Notes:

1. Tailwater elevation was set at the lift station pump on elevation of 763-feet per the "Operations Manual Coal Combustion Residuals Deposal Facility Permit Modifications, Peninsula Site, Kingston Fossil Plant", by Geosyntec dated June 2014.

Inputs - Peninsula Disposal Area
CCR Rule Run-on and Run-off
Peninsula Disposal Area, Kingston Fossil Plant
Project Number: 175565013
Calculation Performed by: JJR   Calculation Date: 6/16/16
Checked by: MAM   Checked By Date: 6/23/16

References:

1 Elevation and area information retrieved from topographic data dated November, 2014 supplemented with survey data dated January, April and May, 2016.
2 Aerial provided by TVA and dated November 2014.
3 "Operations Manual Coal Combustion Residuals Deposal Facility Permit Modifications, Peninsula Site, Kingston Fossil Plant", by Geosyntec dated June 2014.

Depression B

Overflow 1 - Concrete Riser Structure			Overflow 2 - Concrete Riser Structure			Overflow 3 - Concrete Riser Structure			Data Source/Reference
Weir Elev=	766	feet	Weir Elev=	766	feet	Weir Elev=	766	feet	1
Riser D =	84	in	Riser D =	84	in	Riser D =	84	in	2
Pipe Inlet=	759.4	feet	Pipe Inlet=	759.4	feet	Pipe Inlet=	759.4	feet	3
Pipe Outlet=	758.2	feet	Pipe Outlet=	758.2	feet	Pipe Outlet=	758.2	feet	3
Pipe D=	48	in	Pipe D=	48	in	Pipe D=	48	in	3
Length=	59	feet	Length=	59	feet	Length=	59	feet	3
C=	3.27		C=	3.27		C=	3.27		(Assumed to behave as sharp crested weir)
C_0=	0.6		C_0=	0.6		C_0=	0.6		(Based on Brater and King 1976)
Computed Values			Computed Values			Computed Values			Equation
L_{weir}=	22.0	ft	L_{weir}=	22.0	ft	L_{weir}=	22.0	ft	Circumference=PI()*D
A_{riser}=	38.5	sq. ft.	A_{riser}=	38.5	sq. ft.	A_{riser}=	38.5	sq. ft.	Area = $PI*D^2/4$
A_{pipe}=	12.6	sq. ft.	A_{pipe}=	12.6	sq. ft.	A_{pipe}=	12.6	sq. ft.	Area = $PI*D^2/4$
Elev C=	761.4	feet	Elev C=	761.4	feet	Elev C=	761.4	feet	

Notes:

1 "Elev C" under Computed Values is referring to the elevation of centerline of the outlet pipe inlet.

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Stage Storage Tables - Peninsula Disposal Area
CCR Rule Run-on and Run-off
Peninsula Disposal Area, Kingston Fossil Plant
Project Number: 175565013
Calculation Performed by: JJR   Calculation Date: 6/16/16
Checked by: MAM   Checked By Date: 6/23/16

Depression A

Elevation (ft)	Area (sf)	Area (ac)
774	901	0.02
775	2,672	0.06
776	3,842	0.09
777	5,011	0.12
778	6,181	0.14

Depression B

Elevation (ft)	Area (sf)	Area (ac)
763	2,581	0.06
764	4,874	0.11
765	8,421	0.19
766	18,893	0.43
767	24,642	0.57
768	30,478	0.70
769	59,008	1.35
770	71,767	1.65
771	91,281	2.10

Depression C

Elevation (ft)	Area (sf)	Area (ac)
757	885	0.02
758	9,501	0.22
759	45,316	1.04
760	82,463	1.89
761	108,410	2.49
762	167,825	3.85
763	221,303	5.08
764	268,649	6.17
765	295,864	6.79
766	317,410	7.29
767	336,647	7.73
768	355,084	8.15
769	372,613	8.55
770	390,409	8.96
771	407,264	9.35
772	424,711	9.75
773	446,984	10.26
774	469,887	10.79
775	493,548	11.33
776	517,252	11.87
777	540,742	12.41

Existing Stormwater Pond

Elevation (ft)	Surface Area (acres)	Cumulative Storage (acre-feet)
759	4.650	0.000
759	4.729	2.345
760	4.885	7.152
761	5.043	12.116
762	5.201	17.238
763	5.359	22.518
764	5.522	27.958
765	5.692	33.565
766	5.880	39.351
768	6.297	51.528

Notes:

1. Elevation and area information retrieved from topographic data dated November, 2014 supplemented with survey data dated January, April and May, 2016.
2. Overtopping elevations for Depressions A, B, and C are 777 feet, 770 feet, and 777 feet, respectively.
3. Elevation-Area information for Existing Stormwater Pond taken from "Operations Manual - Coal Combustion Residuals Disposal Facility Permit Modification - Peninsula Site Kingston Fossil Plant Roane County, Tennessee" prepared by Geosyntec consultants.

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 0 cfs
Design Flow: 150 cfs
Maximum Flow: 180 cfs

Table 1 - Summary of Culvert Flows at Crossing: PAD

Headwater Elevatio	Total Discharge (c	Culvert 1 Discharg (cfs)	Roadway Discharg (cfs)	Iterations
763.00	0.00	0.00	0.00	1
763.05	18.00	18.00	0.00	1
763.19	36.00	36.00	0.00	1
763.42	54.00	54.00	0.00	1
763.74	72.00	72.00	0.00	1
764.16	90.00	90.00	0.00	1
764.66	108.00	108.00	0.00	1
765.29	126.00	126.00	0.00	1
766.27	144.00	144.00	0.00	1
766.63	150.00	150.00	0.00	1
768.65	180.00	180.00	0.00	1
769.50	191.26	191.26	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	763.00	0.000	3.600	0-NF	0.000	0.000	4.000	4.800	0.000	0.000
18.00	18.00	763.05	1.671	3.647	1-S1	0.763	1.241	4.000	4.800	1.500	0.000
36.00	36.00	763.19	2.487	3.786	1-S1	1.088	1.786	4.000	4.800	3.001	0.000
54.00	54.00	763.42	3.147	4.018	1-S1	1.334	2.206	4.000	4.800	4.501	0.000
72.00	72.00	763.74	3.738	4.343	1-S1	1.561	2.561	4.000	4.800	6.001	0.000
90.00	90.00	764.16	4.354	4.758	1-S1	1.769	2.873	4.000	4.800	7.501	0.000
108.00	108.00	764.66	5.060	5.264	1-S1	1.964	3.140	4.000	4.800	9.002	0.000
126.00	126.00	765.29	5.893	5.862	5-S1	2.155	3.366	4.000	4.800	10.502	0.000
144.00	144.00	766.27	6.868	6.549	5-JS1	2.345	3.546	4.000	4.800	12.002	0.000
150.00	150.00	766.63	7.226	6.800	5-JS1	2.407	3.595	4.000	4.800	12.502	0.000
180.00	180.00	768.65	9.247	8.208	5-JS1	2.735	3.772	4.000	4.800	15.003	0.000

****

Straight Culvert

Inlet Elevation (invert): 759.40 ft,   Outlet Elevation (invert): 758.20 ft

Culvert Length: 59.01 ft,   Culvert Slope: 0.0203

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 759.40 ft
Outlet Station: 59.00 ft
Outlet Elevation: 758.20 ft
Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0120
Culvert Type: Straight
Inlet Configuration: Grooved End Projecting
Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: PAD)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	763.00	4.80
18.00	763.00	4.80
36.00	763.00	4.80
54.00	763.00	4.80
72.00	763.00	4.80
90.00	763.00	4.80
108.00	763.00	4.80
126.00	763.00	4.80
144.00	763.00	4.80
150.00	763.00	4.80
180.00	763.00	4.80

Tailwater Channel Data - PAD

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 763.00 ft

Roadway Data for Crossing: PAD

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 30.00 ft
Crest Elevation: 769.50 ft
Roadway Surface: Gravel
Roadway Top Width: 22.00 ft

APPENDIX G
HYDROLOGY RESULTS

HEC-HMS Results
CCR Rule Run-on and Run-off
Peninsula Disposal Area, Kingston Fossil Plant
Project Number: 175565013
Calculation Performed by: JJR   Calculation Date: 6/16/16
Checked by: MAM   Checked By Date: 6/23/16

Summary Results for Reservoir "B"

Project: KIF Simulation Run: 25-year_24-hour
Reservoir: B

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 00:01	Meteorologic Model:	25-year 24-hour
Compute Time:	30Jun2016, 10:26:48	Control Specifications:	24hr

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Inflow:	118.1 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 11:59
Peak Discharge:	116.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 12:00
Inflow Volume:	7.0 (AC-FT)	Peak Storage:	0.9 (AC-FT)
Discharge Volume:	6.5 (AC-FT)	Peak Elevation:	766.6 (FT)

Summary Results for Reservoir "C"

Project: KIF Simulation Run: 25-year_24-hour
Reservoir: C

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 00:01	Meteorologic Model:	25-year 24-hour
Compute Time:	30Jun2016, 10:26:48	Control Specifications:	24hr

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Inflow:	207.4 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 11:58
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	11.9 (AC-FT)	Peak Storage:	12.0 (AC-FT)
Discharge Volume:	0.0 (AC-FT)	Peak Elevation:	763.0 (FT)

Summary Results for Reservoir "Stormwater Pond"

Project: KIF Simulation Run: 25-year_24-hour
Reservoir: Stormwater Pond

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 00:01	Meteorologic Model:	25-year 24-hour
Compute Time:	30Jun2016, 10:26:48	Control Specifications:	24hr

Volume Units: ○ IN ◉ AC-FT

Computed Results

Peak Inflow:	169.8 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 11:59
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	11.9 (AC-FT)	Peak Storage:	34.4 (AC-FT)
Discharge Volume:	0.0 (AC-FT)	Peak Elevation:	765.1 (FT)

Lag Time Summary
Run-on and Run-off Control System Plan
Peninsula, Kingston Fossil Plant
Project Number: 175665013
Calculation Performed by: JJR   Calculation Date: 6/16/16
Checked by: MAM   Checked By Date: 6/23/16

Watershed ID	T_L(hr)	T_L(hr) Used[1]	T_L(min)
1	0.03	0.06	3.5
2	0.05	0.06	3.5
3	0.12	0.12	6.9
4	0.08	0.08	4.8
Stormwater Pond[2]			3.5

Notes:
1. HEC-HMS model uses minimum lag time of 3.5 minutes. Therefore, any time less than 3.5 minutes will be modified to 3.5 minutes.
2. Assumed a lag time of 3.5minutes for Stormwater Pond.

Time of Concentration
KIF CCR Rule Run-on and Run-off
Peninsula, Kingston Fossil Plant
Project Number: 175665013
Calculation Performed by: JJR Calculation Date: 6/16/16
Checked by: MAM Checked By Date: 6/23/16

Project: PDA
Watershed ID: 1

Sheet Flow	Segment ID				
1. Surface description		Smooth surfaces (concrete, asphalt, gravel, bare soil)			
2. Manning's roughness coef., n		0.011			
3. Flow length, L (Total L less than 300/100	ft	100			
4. Two-year, 24-hour Rainfall, P2	in	3.39			
5a. Upstream elevation	ft	811.5			
5b. Downstream elevation	ft	799			
5. Land slope, S	ft / ft	0.125			
6. Tt = $[0.007(nL)^{0.8}]/[\text{sqrt}(P2)\ S^{0.4}]$	hr	0.01		=	0.01 hr
Shallow Concentrated Flow	Segment ID				
7. Surface description (paved or unpaved)		Unpaved			
8. Flow length, L	ft	52			
9a. Upstream elevation	ft	774.9			
9b. Downstream elevation	ft	773.5			
9. Watercourse slope, S	ft / ft	0.026923077			
10. Average velocity, V	ft / s	2.6			
11. Tt = L / 3600V	hr	0.01		=	0.01 hr
Open Channel Flow	Segment ID				
12. Pipe or Open Channel		Open-channel			
13. Diam (pipe) or depth (open)	ft	0.5			
14. Base width (open)	ft	0			
15. Channel side slope	XH:1V	8			
16. Cross sectional flow area	ft2	2.00			
17. Wetted perimeter, Pw	ft	8.06			
18. Hydraulic radius, r = a/Pw	ft	0.25			
19a. Upstream elevation	ft	799			
19b. Downstream elevation	ft	775			
19. Channel slope, S	ft / ft	0.033			
20. Runoff surface / pipe material		bare soil			
21. Manning's roughness coef., n		0.02			
22. V= (1.49 r2/3 S1/2 / n)	ft / s	5.31			
23. Flow length, L	ft	739			
24. Tt = L / 3600V	hr	0.04		=	0.04 hr
25. Watershed Tc (sum Tt from 6, 11, 24)					0.05 hr
26. Watershed lag time, TL (=0.6 x Tc)					0.032 hr

Time of Concentration
KIF CCR Rule Run-on and Run-off
Peninsula, Kingston Fossil Plant
Project Number: 175665013
Calculation Performed by: JJR Calculation Date: 6/16/16
Checked by: MAM Checked By Date: 6/23/16

Project: PDA
Watershed ID: 2

<u>Sheet Flow</u>	Segment ID					
1. Surface description		Smooth surfaces (concrete, asphalt, gravel, bare soil)				
2. Manning's roughness coef., n		0.011				
3. Flow length, L (Total L less than 300/100	ft	100				
4. Two-year, 24-hour Rainfall, P2	in	3.39				
5a. Upstream elevation	ft	798				
5b. Downstream elevation	ft	796.3				
5. Land slope, S	ft / ft	0.017				
6. Tt = $[0.007(nL)^{0.8}]/[\text{sqrt}(P2)\ S^{0.4}]$	hr	0.02		=	0.02	hr
<u>Shallow Concentrated Flow</u>	Segment ID					
7. Surface description (paved or unpaved)		Unpaved				
8. Flow length, L	ft	774				
9a. Upstream elevation	ft	796.3				
9b. Downstream elevation	ft	768				
9. Watercourse slope, S	ft / ft	0.036563307				
10. Average velocity, V	ft / s	3.1				
11. Tt = L / 3600V	hr	0.07		=	0.07	hr
<u>Open Channel Flow</u>	Segment ID					
12. Pipe or Open Channel						
13. Diam (pipe) or depth (open)	ft					
14. Base width (open)	ft					
15. Channel side slope	XH:1V					
16. Cross sectional flow area	ft2					
17. Wetted perimeter, Pw	ft					
18. Hydraulic radius, r = a/Pw	ft					
19a. Upstream elevation	ft					
19b. Downstream elevation	ft					
19. Channel slope, S	ft / ft					
20. Runoff surface / pipe material						
21. Manning's roughness coef., n						
22. V= (1.49 r2/3 S1/2 / n)	ft / s					
23. Flow length, L	ft					
24. Tt = L / 3600V	hr			=	0.00	hr
25. Watershed Tc (sum Tt from 6, 11, 24)					0.09	hr
26. Watershed lag time, TL (=0.6 x Tc)					0.0544	hr

Project: PDA
Watershed ID: 3

Sheet Flow	Segment ID					
1. Surface description		Smooth surfaces (concrete, asphalt, gravel, bare soil)				
2. Manning's roughness coef., n		0.011				
3. Flow length, L (Total L less than 300/100	ft	100				
4. Two-year, 24-hour Rainfall, P2	in	3.39				
5a. Upstream elevation	ft	784				
5b. Downstream elevation	ft	779				
5. Land slope, S	ft / ft	0.050				
6. Tt = $[0.007(nL)^{0.8}]/[\text{sqrt}(P2)\ S^{0.4}]$	hr	0.01		=	0.01	hr
Shallow Concentrated Flow	Segment ID					
7. Surface description (paved or unpaved)		Unpaved				
8. Flow length, L	ft	507				
9a. Upstream elevation	ft	770				
9b. Downstream elevation	ft	764				
9. Watercourse slope, S	ft / ft	0.01183432				
10. Average velocity, V	ft / s	1.8				
11. Tt = L / 3600V	hr	0.08		=	0.08	hr
Open Channel Flow	Segment ID					
12. Pipe or Open Channel		Open-channel				
13. Diam (pipe) or depth (open)	ft	0.3				
14. Base width (open)	ft	0				
15. Channel side slope	XH:1V	10				
16. Cross sectional flow area	ft2	0.90				
17. Wetted perimeter, Pw	ft	6.03				
18. Hydraulic radius, r = a/Pw	ft	0.15				
19a. Upstream elevation	ft	779				
19b. Downstream elevation	ft	770				
19. Channel slope, S	ft / ft	0.011				
20. Runoff surface / pipe material		bare soil				
21. Manning's roughness coef., n		0.02				
22. V= (1.49 r2/3 S1/2 / n)	ft / s	2.24				
23. Flow length, L	ft	791				
24. Tt = L / 3600V	hr	0.10		=	0.10	hr
25. Watershed Tc (sum Tt from 6, 11, 24)					0.19	hr
26. Watershed lag time, TL (=0.6 x Tc)					0.115	hr

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Time of Concentration
KIF CCR Rule Run-on and Run-off
Peninsula, Kingston Fossil Plant
Project Number: 175665013
Calculation Performed by: JJR Calculation Date: 6/16/16
Checked by: MAM Checked By Date: 6/23/16

Project: PDA
Watershed ID: 4

Sheet Flow	Unit	Segment ID			
1. Surface description		Smooth surfaces (concrete, asphalt, gravel, bare soil)			
2. Manning's roughness coef., n		0.011			
3. Flow length, L (Total L less than 300/100	ft	100			
4. Two-year, 24-hour Rainfall, P2	in	3.39			
5a. Upstream elevation	ft	793.5			
5b. Downstream elevation	ft	774			
5. Land slope, S	ft / ft	0.195			
6. $Tt = [0.007(nL)^{0.8}]/[sqrt(P2)\ S^{0.4}]$	hr	0.01		= 0.01	hr

Shallow Concentrated Flow	Unit	Segment ID			
7. Surface description (paved or unpaved)		Unpaved			
8. Flow length, L	ft	961			
9a. Upstream elevation	ft	774			
9b. Downstream elevation	ft	757			
9. Watercourse slope, S	ft / ft	0.017689906			
10. Average velocity, V	ft / s	2.1			
11. Tt = L / 3600V	hr	0.12		= 0.12	hr

Open Channel Flow	Unit	Segment ID			
12. Pipe or Open Channel					
13. Diam (pipe) or depth (open)	ft				
14. Base width (open)	ft				
15. Channel side slope	XH:1V				
16. Cross sectional flow area	ft2				
17. Wetted perimeter, Pw	ft				
18. Hydraulic radius, r = a/Pw	ft				
19a. Upstream elevation	ft				
19b. Downstream elevation	ft				
19. Channel slope, S	ft / ft				
20. Runoff surface / pipe material					
21. Manning's roughness coef., n					
22. V= (1.49 r2/3 S1/2 / n)	ft / s				
23. Flow length, L	ft				
24. Tt = L / 3600V	hr			= 0.00	hr

5

25. Watershed Tc (sum Tt from 6, 11, 24) 0.13 hr

26. Watershed lag time, TL (=0.6 x Tc) 0.0794 hr

Stantec

Curve Number Calculation
Run-on and Run-off Control System Plan
Peninsula, Kingston Fossil Plant
Project Number: 175665013
Calculation Performed by: JJR   Calculation Date: 6/16/16
Checked by: MAM   Checked By Date: 6/23/16

Watershed	Subbasin	Subbasin Curve Number	Subbasin Area, Acre	Area Weighted Curve Number	Composite Curve Number
1	3	91	1.9204	174.76	
	5	89	0.2776	24.71	
		sum	2.1980	199.4663	91
2	2	91	1.9401	176.55	
	9	86	0.8664	74.51	
		sum	2.8065	251.0632	89
3	0	91	9.8228	893.87	
	6	89	0.0615	5.48	
	7	91	1.6456	149.75	
	8	86	3.3332	286.66	
		sum	14.8632	1335.7609	90
4	1	91	30.3477	2761.64	
	4	89	0.6802	60.54	
	10	86	0.9410	80.93	
		sum	31.9689	2903.1062	91
Stormwater Pond	11	98	0.1869	18.31	
	12	99	4.5602	451.46	
	13	89	3.6628	325.99	
		sum	8.4098	795.7579	95

Cover Type	CN
Gravel	89
Grass	86
CCR	91
Pavement	98
Water	99