Stantec Consulting Services Inc.
3052 Beaumont Centre Circle, Lexington KY 40513

March 26, 2021
File: rpt_002_let_175666001
Revision 0

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

RE: Initial Run-On and Run-Off Control System Plan
New CCR Landfill
TVA Shawnee Fossil Plant
Paducah, McCracken County, Kentucky

1.0 PURPOSE

As described in 40 CFR § 257.81, an owner or operator of a new CCR landfill is required to demonstrate that run-on and run-off control systems have been designed and constructed to meet the EPA Final CCR Rule. This letter documents Stantec's certification that the Initial Run-On and Run-Off Plan for the TVA Shawnee Fossil Plant's (SHF) New CCR Landfill complies with requirements in the EPA Final CCR Rule 40 CFR § 257.81.

2.0 SUMMARY OF FINDINGS

The attached plan documents that the run-on and run-off control system requirements for the New CCR Landfill meet the requirements set forth in 40 CFR § 257.81.

3.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Michael J. Steele, being a Professional Engineer in good standing in the Commonwealth 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 Initial Run-On and Run-Off Control System Plan for the TVA SHF New CCR Landfill meets the requirements specified in 40 CFR § 257.81.

Stantec

RE: Initial Run-On and Run-Off Control System Plan
New CCR Landfill
TVA Shawnee Fossil Plant
Paducah, McCracken County, Kentucky

SIGNATURE ______________________ DATE 3/26/2021

ADDRESS: Stantec Consulting Services Inc.
3052 Beaumont Centre Circle
Lexington, Kentucky 40513

TELEPHONE: (859) 422-3000

ATTACHMENTS: Initial Run-On and Run-Off Control System Plan

STATE OF KENTUCKY
MICHAEL J.
STEELE
23731
LICENSED
PROFESSIONAL ENGINEER

Initial Run-On and Run-Off Control System Plan TVA Shawnee New CCR Landfill

New CCR Landfill
TVA Shawnee Fossil Plant
Paducah, McCracken County, Kentucky

Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:
Stantec Consulting Services Inc.
Lexington, Kentucky

March 26, 2021
Revision 0

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LIST OF APPENDICES

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) published the "Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" final rule (EPA Final CCR Rule) in the Federal Register. The Tennessee Valley Authority (TVA) contracted with Stantec Consulting Services Inc. (Stantec) to provide an initial run-on and run-off control system plan for the Shawnee Fossil Plant's (SHF) New CCR Landfill that meets requirements of the EPA Final CCR Rule § 257.81.

1.1 OBJECTIVE

As required by § 257.81 of the EPA Final CCR Rule, an owner or operator of a new CCR landfill is required to demonstrate that run-on and run-off control systems have been designed and constructed to meet the CCR Rule. The objective of this plan is to document that these systems comply with the requirements.

1.2 UNIT DESCRIPTION

SHF is a coal-fired, electric-generating plant. The plant is located in McCracken County, Kentucky, along the south shore of the Ohio River near river mile 946, just east of the confluence of Little Bayou Creek with the Ohio River.

The New CCR Landfill will be located on the Shawnee East Site, which consists of about 205 acres that TVA acquired in 2016 next to the eastern boundary of the SHF reservation. The landfill will be constructed in three stages over a total footprint of 88 acres. The embankment will be about 115 feet tall with maximum 4H:1V slopes and will accommodate about 8 million cubic yards of CCR material (fly ash, bottom ash, and gypsum) across an estimated 25-year operational life.

2.0 CRITERIA

The EPA Final CCR Rule § 257.81 requirements for the run-on and run-off control system are:

> ***40 CFR § 257.81(a).*** *The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate and maintain:*
>
> *(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and*
>
> *(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.*

> ***40 CFR § 257.81(b).*** *Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under* § 257.3-3.
>
> ***40 CFR § 257.81(c)(1).*** *The owner or operator must prepare initial and periodic run-on and run-off control system plans for the CCR unit according to the timeframes specified in paragraphs (c) (3) and (4) of this section. These plans must document how the run-on and run-off control systems have been designed and constructed to meet the applicable requirements of this section. Each plan must be supported by appropriate engineering calculations.*
>
> ***40 CFR § 257.81(c)(3)(ii).*** *The owner or operator must prepare the initial run-on and run-off control system plan no later than the date of initial receipt of CCR in the CCR unit.*

3.0 INITIAL RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

This plan describes how the New CCR Landfill will meet requirements of § 257.81 of the EPA Final CCR Rule. It is noted that the landfill will not have run-on flow as it will be constructed to elevations above adjacent ground.

The designed run-off controls for the New CCR Landfill will consist of ditches/flumes, piping, and ponds. A series of flumes and bench ditches will convey surface water from the landfill to a perimeter ditch that follows the base of the embankment. Within the perimeter ditch, drop inlet structures will collect and convey flow to an underground pipe system that will generally follow the alignment of the perimeter ditch. The pipe system will flow by gravity to one of two stormwater ponds, which will serve as sediment control structures and ultimately discharge into an unnamed tributary of Little Bayou Creek. The pond discharge will be monitored through a Kentucky Pollutant Discharge Elimination System (KPDES) compliance point.

Criteria listed in Section 2.0 was used to design the system described above. PC-SWMM modeling software (version 5.1) was used to model the hydrology and hydraulics. The model consists of subwatersheds to simulate run-off over a specified area, inlets collecting the run-off, pipes conveying the run-off downstream, and hydraulic outlet structures which store and release the run-off.

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

3.1 HYDROLOGIC ANALYSIS

The hydrology of the site was modeled using Natural Resources Conservation Service (NRCS) methodologies within PC-SWMM. Standard values were selected from tables provided with the *User's Guide to SWMM 5 (13th Edition)* for parameters not discussed below.

3.1.1 Rainfall Run-off and Distribution

The precipitation depth for the 24-hour, 25-year storm is 6.1 inches and was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. The NOAA precipitation data is provided in Appendix A. The SCS Type II storm distribution was applied to develop a rainfall hyetograph.

3.1.2 Curve Number

The Curve Number method was used to model stormwater infiltration. For the closed/capped condition, the cover type was assumed to be "open space (lawns, parks, etc.)". The design final cover system will consist of (from bottom to top) a minimum 6-inch soil base, 40-mil thick textured Linear Low Density Polyethylene (LLDPE) flexible geomembrane, a geocomposite drainage layer, 18 inches of protective cover soil, and 6 inches of vegetative cover soil. A soil group D classification was assumed for the cover. This yields a curve number of 80/84/89 for Good/Fair/Poor (respectively) grass cover conditions. A "good condition (grass cover > 75%)" has been assumed. Therefore, the curve number used in modeling capped landfill areas was 80.

3.1.3 Subwatershed Delineation

Subwatersheds were delineated based on the landfill surface.

3.1.4 Lag Time

Each subwatershed was assigned an average slope percentage, determined from the landfill surface. Flow lengths were also calculated for each subwatershed as the sum of the sheet flow, shallow concentrated flow, and channel flow.

3.1.5 Reach Routing

The dynamic wave method was the selected routing method. The dynamic wave method in PC-SWMM allows for channel storage, backwater, entrance/exit losses, flow reversal, and pressurized flow. This routing represents pressurized flow when a closed conduit is full and allows flooding to occur when the water depth exceeds the maximum available depth at an inlet.

3.2 HYDRAULIC ANALYSIS

Hydraulic calculations were performed to design the bench ditches, flumes, perimeter ditch, pipe network, and stormwater ponds as described below.

3.2.1 Bench Ditches and Flumes

The bench ditches will be v-shaped with a right side-slope of 10H:1V, a left side-slope of 4H:1V, a depth of 2.5 feet, and a channel slope of 1-2%. A Manning's roughness (n) of 0.033 was assumed based on a vegetated condition. PC-SWMM was used to estimate the peak run-off for the 24-hour, 25-year storm for the drainage area associated with each bench ditch. The peak run-off associated with the largest subwatershed area was used to check the capacity of the bench ditches using Manning's equation for open channel flow.

The flumes will be trapezoidal in shape with a 6-foot bottom width, 3H:1V side slopes, a depth of 2 feet, and a channel slope of 25%. A Manning's roughness (n) of 0.04 was assumed for the armored flumes. PC-SWMM was used to estimate the peak run-off for the 24-hour, 25-year storm for the drainage area associated with each flume. The peak run-off associated with the largest subwatershed was used to check the capacity of the flumes.

3.2.2 Pipes and Perimeter Ditch

The perimeter ditch and pipe network were designed using PC-SWMM.

The perimeter ditch will serve as storage above the rim of the drop inlet structures. Each inlet was modeled as a storage node within PC-SWMM to account for this storage. Stage-area curves were computed using the landfill surface and were computed from the rim of the drop inlet structure to the crest of the perimeter road (which represents the top of the ditch). The tabular stage-area curves are included in the PC-SWMM input in Appendix B.

3.2.3 Stormwater Ponds

Two stormwater ponds were designed to collect and control the stormwater from the landfill prior to discharging it to an unnamed tributary of Little Bayou Creek. Each pond will include a perforated primary spillway, and an emergency spillway. The low flow outlets will be located on the riser to reduce exit velocities during smaller storm events, thus reducing the amount of sediment transported from the site. The first set of perforations will consist of six, 1.5-inch diameter orifices set at elevation 354 feet. After that, there will be additional rows consisting of six, 1-inch diameter perforations placed at 1-foot intervals from elevation 355 feet to elevation 358 feet. These perforations are used to set the normal pool elevation. The first row of six, 1.5-inch diameter orifices are modeled in PC-SWMM to allow the ponds to accurately portray the normal pool elevation. The primary spillway will consist of a 24-inch diameter high-density polyethylene (HDPE) riser structure with a top elevation of 359 feet. The risers will be connected to horizontal 24-inch diameter HDPE pipes. This vertical riser was modeled in PC-SWMM as a bottom orifice connected to a pipe.

The emergency spillway will be trapezoidal in shape with a 10-foot bottom width, 2-foot height, 5H:1V side-slopes, and placed at an invert elevation of 362 feet. The emergency spillway was modeled as a trapezoidal weir.

3.3 RESULTS

Results are shown in Appendix C for the bench ditches and flumes, and Appendix D for the pipe network.

The peak run-off associated with the bench ditches was 5.9 cubic feet per second (cfs). The maximum depth was determined to be 0.6 feet for the 24-hour, 25-year storm. This results in a minimum of 1.9 feet of freeboard.

The peak run-off associated with the flumes was 27.5 cfs. The maximum depth was determined to be 0.5 feet for the 24-hour, 25-year storm. This results in a minimum of 1.5 feet of freeboard.

The pipe network profiles from PC-SWMM were used to check the elevations within the perimeter ditch for the 24-hour, 25-year storm. The profiles show that the water surface elevation is below the top of the road elevation, with a minimum of 2.9 feet of freeboard.

The peak 24-hour, 25-year water surface elevation within the ponds is 359.6 and 359.7 for the north and south stormwater ponds, respectively. This results in a freeboard of 4.4 feet for the north stormwater pond and 4.3 feet for the south stormwater pond.

3.4 CONSTRUCTION

The Stage 1 stormwater pipes and perimeter ditch and facility stormwater pond have been constructed in accordance with the design. Temporary benches and flumes will be constructed as embankment placement reaches design bench elevations and temporary cover is placed on the outslopes. During closure of the landfill cell (Stage 1), permanent flumes will be constructed on top of the final cover system.

3.5 SUMMARY

The following summarizes compliance with EPA Final CCR Rule criteria:

1. Run-on: The landfill will not have run-on flow as it will be constructed to elevations above adjacent ground.

2. Run-off: The bench ditches, flumes, pipe network, perimeter ditch, and stormwater ponds are capable of collecting and controlling the run-off water volume of a 24-hour, 25-year storm. The closed condition of the landfill was evaluated for design purposes. The landfill will be constructed in stages, with run-off increasing as each subsequent stage is constructed. The results presented above show that the landfill will be capable of conveying the run-off associated with the closed condition, and therefore will also be capable of conveying the run-off for interim conditions.

3. Run-off (permitted discharge): Run-off from the landfill flows to the stormwater ponds. The pond discharge will be monitored through a KPDES compliance point. Therefore, the run-off is handled in accordance with the surface water requirements.

3.6 INITIAL RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

This document constitutes the Initial Run-On and Run-Off Control System Plan as required by § 257.81(c).

3.7 AMENDMENTS TO PLAN

If there is a change in conditions that would substantially affect the current version of the Initial Run-on and Run-off Control System Plan, then the plan will be amended as required by § 257.81(c)(2) and placed in the operating record as required by § 257.105(g)(3).

4.0 CONCLUSION

The Initial Run-on and Run-off Control System Plan for the TVA SHF New CCR Landfill meets the requirements of § 257.81 of the EPA Final CCR Rule.

5.0 REFERENCES

James, et. al., User's Guide to SWMM5, 13th Edition, November, 2010.

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

APPENDIX A
NOAA RAINFALL DEPTHS

NOAA Atlas 14, Volume 2, Version 3
Location name: West Paducah, Kentucky, USA*
Latitude: 37.1399°, Longitude: -88.7742°
Elevation: 362 ft**
* source: ESRI Maps
** source: USGS

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	0.421 (0.388-0.458)	0.496 (0.458-0.540)	0.577 (0.531-0.627)	0.641 (0.590-0.696)	0.721 (0.660-0.782)	0.779 (0.712-0.844)	0.837 (0.761-0.905)	0.897 (0.812-0.970)	0.973 (0.875-1.05)	1.03 (0.921-1.12)
10-min	0.657 (0.605-0.715)	0.779 (0.718-0.847)	0.902 (0.830-0.980)	0.996 (0.916-1.08)	1.11 (1.02-1.20)	1.19 (1.09-1.29)	1.27 (1.16-1.38)	1.35 (1.22-1.46)	1.45 (1.30-1.57)	1.52 (1.36-1.65)
15-min	0.807 (0.744-0.879)	0.956 (0.882-1.04)	1.11 (1.03-1.21)	1.23 (1.13-1.34)	1.38 (1.26-1.49)	1.48 (1.35-1.60)	1.59 (1.44-1.72)	1.69 (1.52-1.82)	1.81 (1.63-1.96)	1.90 (1.70-2.06)
30-min	1.08 (0.991-1.17)	1.29 (1.19-1.40)	1.54 (1.42-1.67)	1.73 (1.59-1.87)	1.96 (1.80-2.13)	2.14 (1.96-2.32)	2.31 (2.10-2.50)	2.49 (2.25-2.69)	2.72 (2.45-2.94)	2.89 (2.58-3.13)
60-min	1.32 (1.22-1.44)	1.59 (1.46-1.73)	1.94 (1.78-2.10)	2.20 (2.03-2.39)	2.56 (2.34-2.77)	2.83 (2.59-3.07)	3.11 (2.83-3.37)	3.40 (3.08-3.67)	3.79 (3.41-4.10)	4.09 (3.65-4.43)
2-hr	1.58 (1.45-1.72)	1.90 (1.74-2.07)	2.33 (2.13-2.54)	2.67 (2.44-2.90)	3.12 (2.84-3.39)	3.48 (3.15-3.78)	3.85 (3.47-4.19)	4.23 (3.80-4.60)	4.76 (4.24-5.18)	5.18 (4.58-5.64)
3-hr	1.72 (1.57-1.88)	2.06 (1.89-2.27)	2.53 (2.32-2.78)	2.91 (2.65-3.19)	3.42 (3.11-3.74)	3.83 (3.47-4.18)	4.26 (3.84-4.64)	4.70 (4.21-5.13)	5.33 (4.73-5.81)	5.83 (5.13-6.35)
6-hr	2.12 (1.94-2.34)	2.55 (2.33-2.81)	3.13 (2.86-3.44)	3.59 (3.27-3.94)	4.23 (3.83-4.63)	4.74 (4.28-5.19)	5.29 (4.74-5.78)	5.86 (5.22-6.40)	6.66 (5.88-7.28)	7.30 (6.40-7.99)
12-hr	2.56 (2.34-2.81)	3.08 (2.81-3.38)	3.78 (3.45-4.14)	4.34 (3.95-4.76)	5.11 (4.63-5.59)	5.74 (5.18-6.27)	6.39 (5.72-6.98)	7.07 (6.30-7.73)	8.03 (7.08-8.80)	8.80 (7.70-9.66)
24-hr	3.09 (2.88-3.32)	3.72 (3.47-3.99)	4.57 (4.25-4.90)	5.21 (4.85-5.59)	6.07 (5.64-6.51)	6.75 (6.24-7.23)	7.43 (6.86-7.96)	8.13 (7.47-8.71)	9.08 (8.30-9.73)	9.81 (8.93-10.5)
2-day	3.66 (3.41-3.93)	4.40 (4.10-4.73)	5.39 (5.02-5.78)	6.14 (5.71-6.58)	7.13 (6.61-7.63)	7.89 (7.31-8.45)	8.66 (8.00-9.28)	9.44 (8.69-10.1)	10.5 (9.61-11.2)	11.3 (10.3-12.1)
3-day	3.88 (3.61-4.16)	4.66 (4.34-5.00)	5.69 (5.30-6.10)	6.47 (6.01-6.93)	7.49 (6.95-8.03)	8.29 (7.67-8.88)	9.08 (8.38-9.73)	9.88 (9.10-10.6)	10.9 (10.0-11.8)	11.8 (10.7-12.7)
4-day	4.09 (3.81-4.39)	4.91 (4.57-5.27)	5.99 (5.58-6.42)	6.79 (6.32-7.29)	7.86 (7.29-8.43)	8.68 (8.04-9.30)	9.50 (8.77-10.2)	10.3 (9.50-11.1)	11.4 (10.5-12.3)	12.3 (11.2-13.2)
7-day	4.75 (4.42-5.11)	5.70 (5.30-6.13)	6.96 (6.47-7.48)	7.93 (7.35-8.52)	9.22 (8.53-9.91)	10.2 (9.44-11.0)	11.2 (10.3-12.1)	12.3 (11.2-13.2)	13.6 (12.4-14.7)	14.7 (13.4-15.9)
10-day	5.30 (4.94-5.69)	6.34 (5.91-6.81)	7.69 (7.17-8.26)	8.71 (8.12-9.35)	10.1 (9.35-10.8)	11.1 (10.3-11.9)	12.1 (11.2-13.1)	13.2 (12.2-14.2)	14.6 (13.4-15.7)	15.6 (14.3-16.8)
20-day	7.21 (6.76-7.67)	8.57 (8.05-9.14)	10.2 (9.57-10.9)	11.4 (10.7-12.2)	13.0 (12.1-13.8)	14.2 (13.2-15.1)	15.3 (14.3-16.3)	16.4 (15.3-17.5)	17.9 (16.6-19.1)	19.0 (17.6-20.3)
30-day	8.80 (8.29-9.35)	10.4 (9.84-11.1)	12.3 (11.6-13.1)	13.7 (12.9-14.5)	15.4 (14.5-16.4)	16.7 (15.7-17.8)	18.0 (16.9-19.2)	19.3 (18.0-20.5)	20.9 (19.5-22.3)	22.1 (20.6-23.6)
45-day	11.0 (10.4-11.7)	13.1 (12.3-13.9)	15.3 (14.4-16.2)	16.9 (15.8-17.9)	18.9 (17.7-20.0)	20.4 (19.1-21.6)	21.9 (20.4-23.2)	23.3 (21.7-24.7)	25.1 (23.3-26.6)	26.4 (24.4-28.1)
60-day	13.1 (12.3-13.8)	15.4 (14.6-16.3)	17.9 (17.0-18.9)	19.8 (18.7-20.8)	22.0 (20.8-23.2)	23.7 (22.3-25.0)	25.3 (23.8-26.7)	26.8 (25.2-28.3)	28.8 (27.0-30.5)	30.2 (28.2-32.0)

[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.

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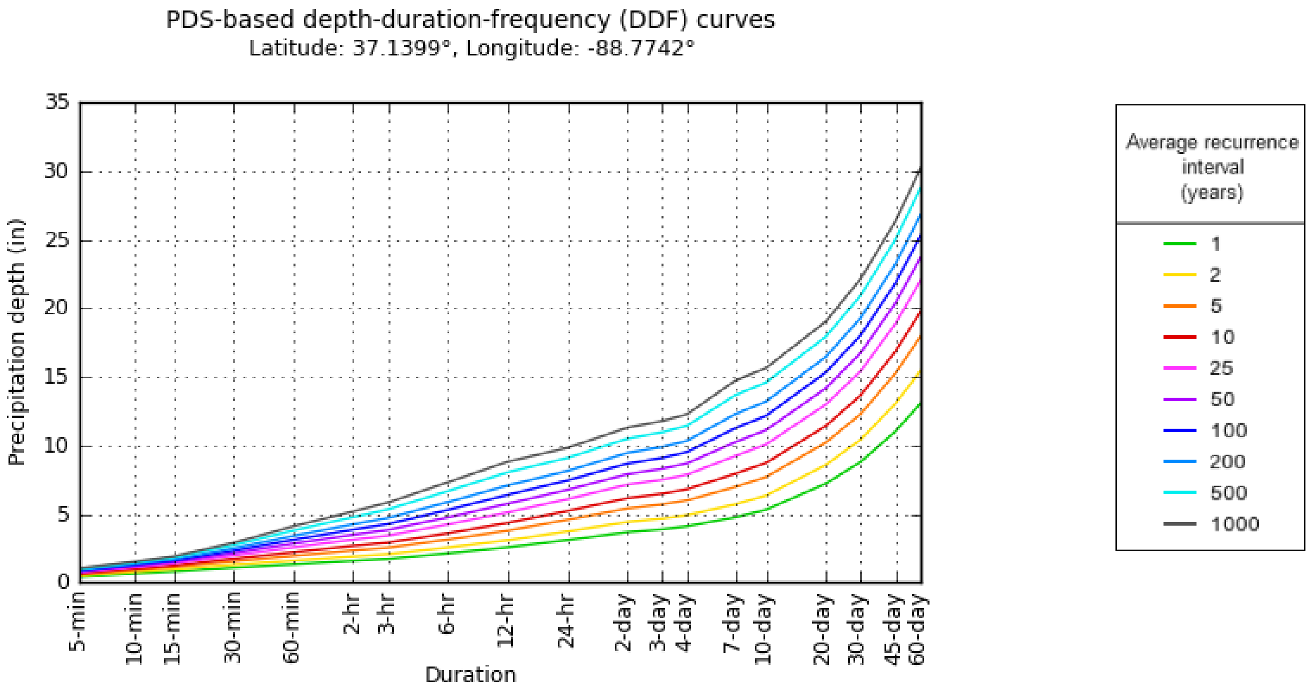
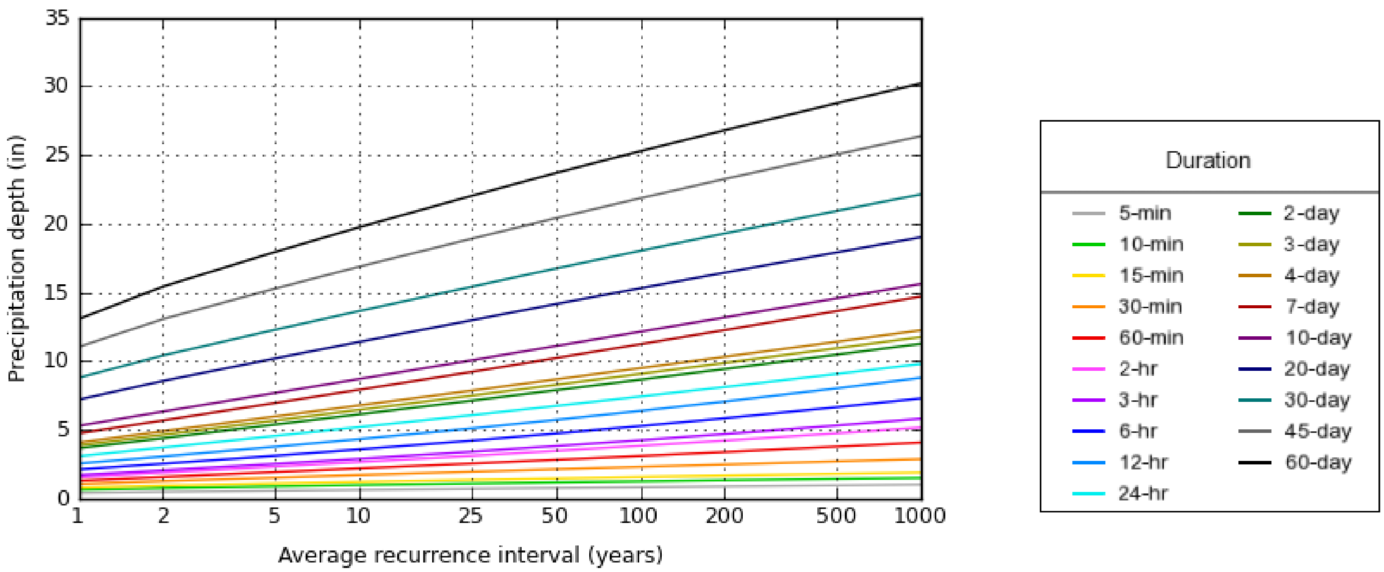
PF graphical





NOAA Atlas 14, Volume 2, Version 3

Created (GMT): Fri Dec 9 14:41:10 2016

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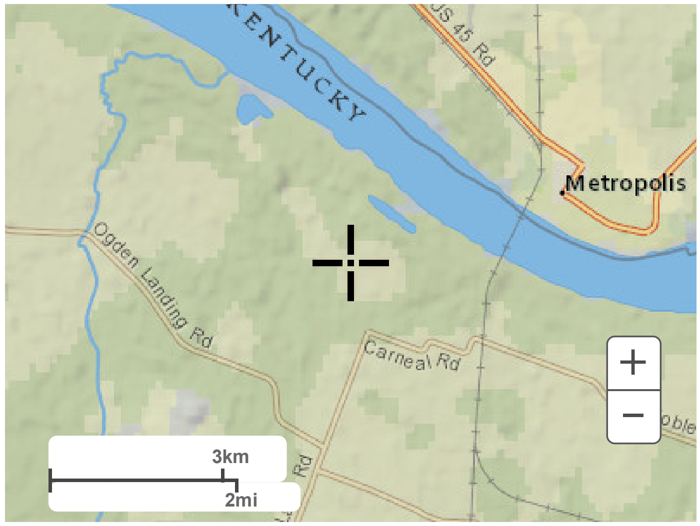
Maps & aerials

Small scale terrain



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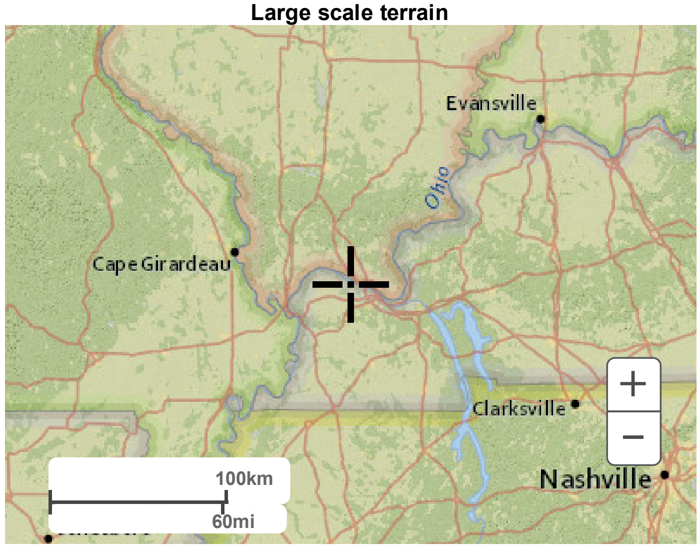
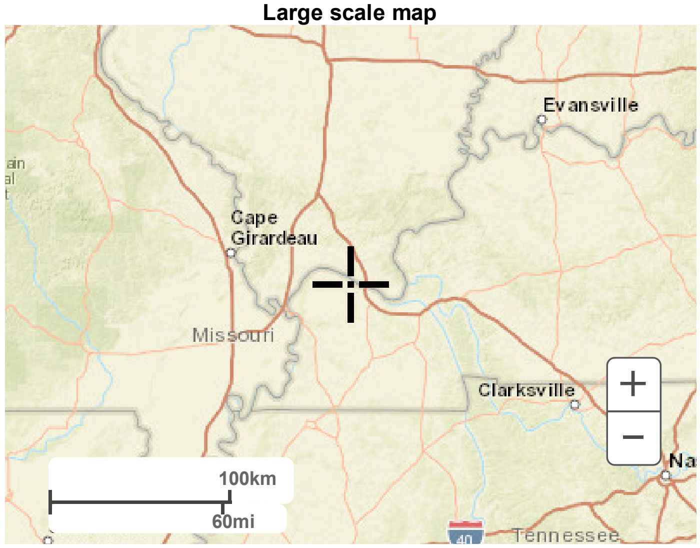


Large scale map



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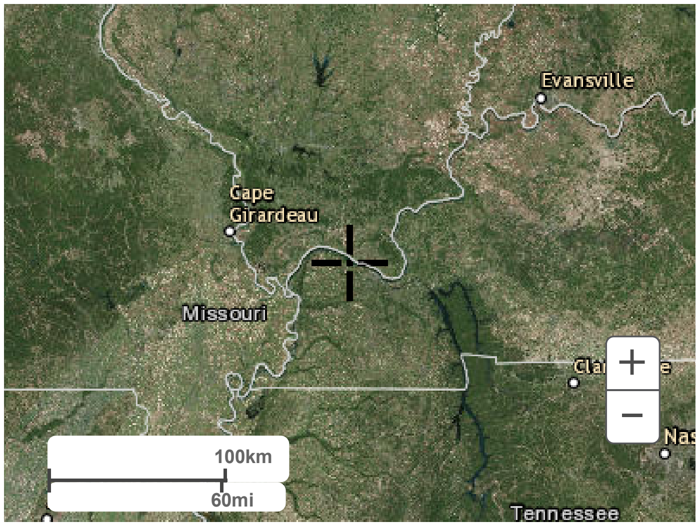

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

APPENDIX B
PC-SWMM INPUT FILE

SHAWNEE FOSSIL PLANT PC-SWMM

```
[OPTIONS]
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;;------------------- ------------
FLOW_UNITS            CFS
INFILTRATION          CURVE_NUMBER
FLOW_ROUTING          DYNWAVE
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START_TIME            00:00:00
REPORT_START_DATE     11/18/2016
REPORT_START_TIME     00:00:00
END_DATE              11/20/2016
END_TIME              00:00:00
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SWEEP_END             12/31
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WET_STEP              00:05:00
DRY_STEP              00:05:00
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INERTIAL_DAMPING      PARTIAL
VARIABLE_STEP         0.75
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NORMAL_FLOW_LIMITED   BOTH
SKIP_STEADY_STATE     NO
FORCE_MAIN_EQUATION   H-W
LINK_OFFSETS          DEPTH
MIN_SLOPE             0
MAX_TRIALS            8
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SYS_FLOW_TOL          5
LAT_FLOW_TOL          5
MINIMUM_STEP          0.5
THREADS               4

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;;Type          Parameters
;;------------- ----------
CONSTANT      0.0
DRY_ONLY      NO

[RAINGAGES]
;;                     Rain      Time   Snow   Data
;;Name                 Type      Intrvl Catch  Source
;;-------------------- --------- ------ ------ ----------
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SCS_24h_Type_II_5.21in CUMULATIVE 0:05   1.0    TIMESERIES SCS_24h_Type_II_5.21in
;25-Year Storm Event
SCS_24h_Type_II_6.08in CUMULATIVE 0:05   1.0    TIMESERIES SCS_24h_Type_II_6.08in
SCS_24h_Type_II_7.43in CUMULATIVE 0:05   1.0    TIMESERIES SCS_24h_Type_II_7.43in
SCS_24h_Type_II_9.08in CUMULATIVE 0:05   1.0    TIMESERIES SCS_24h_Type_II_9.08in

[SUBCATCHMENTS]
;;                                                   Total    Pcnt.             Pcnt.
Curb     Snow
;;Name  Raingage         Outlet           Area     Imperv   Width    Slope    Length
Pack
;;-------------- ---------------- ---------------- -------- -------- -------- --------
-------- --------
```

```
S1    SCS_24h_Type_II_6.08in DI-14      9.1642   0        328.283  15.77    0
S10   SCS_24h_Type_II_6.08in DI-40      9.3767   0        333.973  16.24    0
S11   SCS_24h_Type_II_6.08in DI-51      3.6687   0        221.342  18.52    0
S12   SCS_24h_Type_II_6.08in DI-36      3.7858   0        221.951  20.17    0
S13   SCS_24h_Type_II_6.08in DI-48      8.4764   0        313.174  16.16    0
S14   SCS_24h_Type_II_6.08in DI-34      8.1437   0        291.967  16.21    0
S15   SCS_24h_Type_II_6.08in DI-46      3.6164   0        185.112  20.1     0
S16   SCS_24h_Type_II_6.08in DI-30      3.8669   0        260.746  15.78    0
S17   SCS_24h_Type_II_6.08in DI-42      3.4645   0        221.281  21.14    0
S18   SCS_24h_Type_II_6.08in DI-28      8.8979   0        313.586  16.1     0
S19   SCS_24h_Type_II_6.08in North      3.6043   0        1570.033 10       0
S2    SCS_24h_Type_II_6.08in DI-27      5.3815   0        263.391  18.56    0
S20   SCS_24h_Type_II_6.08in South      3.523    0        1534.619 10       0
S3    SCS_24h_Type_II_6.08in DI-12      2.508    0        220.704  18.96    0
S4    SCS_24h_Type_II_6.08in DI-23      5.5567   0        352.842  18.43    0
S5    SCS_24h_Type_II_6.08in DI-8       8.6482   0        314.454  16.17    0
S6    SCS_24h_Type_II_6.08in DI-21      7.9114   0        288.627  15.83    0
S7    SCS_24h_Type_II_6.08in DI-6       3.6253   0        250.266  19.71    0
S8    SCS_24h_Type_II_6.08in DI-17      3.1802   0        191.869  19.5     0
S9    SCS_24h_Type_II_6.08in DI-2       9.0393   0        319.604  16.19    0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo
PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ----------
----------
S1               0.012      0.24       0.05       0.2        0          OUTLET
S10              0.012      0.24       0.05       0.2        0          OUTLET
S11              0.012      0.24       0.05       0.2        0          OUTLET
S12              0.012      0.24       0.05       0.2        0          OUTLET
S13              0.012      0.24       0.05       0.2        0          OUTLET
S14              0.012      0.24       0.05       0.2        0          OUTLET
S15              0.012      0.24       0.05       0.2        0          OUTLET
S16              0.012      0.24       0.05       0.2        0          OUTLET
S17              0.012      0.24       0.05       0.2        0          OUTLET
S18              0.012      0.24       0.05       0.2        0          OUTLET
S19              0.012      0.24       0.05       0.2        0          OUTLET
S2               0.012      0.24       0.05       0.2        0          OUTLET
S20              0.012      0.24       0.05       0.2        0          OUTLET
S3               0.012      0.24       0.05       0.2        0          OUTLET
S4               0.012      0.24       0.05       0.2        0          OUTLET
S5               0.012      0.24       0.05       0.2        0          OUTLET
S6               0.012      0.24       0.05       0.2        0          OUTLET
S7               0.012      0.24       0.05       0.2        0          OUTLET
S8               0.012      0.24       0.05       0.2        0          OUTLET
S9               0.012      0.24       0.05       0.2        0          OUTLET

[INFILTRATION]
;;Subcatchment   CurveNum   HydCon     DryTime
;;-------------- ---------- ---------- ----------
S1               80         0          14
S10              80         0          14
S11              80         0          14
S12              80         0          14
S13              80         0          14
S14              80         0          14
S15              80         0          14
S16              80         0          14
S17              80         0.5        14
S18              80         0.5        14
S19              98         0.5        14
S2               80         0          14
S20              98         0.5        14
```

```
S3               80         0.5        14
S4               80         0          14
S5               80         0          14
S6               80         0          14
S7               80         0.5        14
S8               80         0.5        14
S9               80         0.5        14

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
J1               362        0          0          0          0
J2               362        0          0          0          0
J30              353        0          0          0          0
J31              353.5      8          0          0          0
J32              353.5      8          0          0          0
MH-1             354.04     10.27      0          0          0
MH-10            355.05     16.42      0          0          0
MH-11            355.1      16.48      0          0          0
MH-13            355.32     10.58      0          0          0
MH-15            354.05     12.89      0          0          0
MH-16            354.16     11.64      0          0          0
MH-18            354.37     16.06      0          0          0
MH-19            354.4      16.01      0          0          0
MH-20            354.49     12.91      0          0          0
MH-22            354.79     14.21      0          0          0
MH-24            355.05     16.43      0          0          0
MH-25            355.1      16.47      0          0          0
MH-26            355.17     10.63      0          0          0
MH-29            354.18     10.91      0          0          0
MH-3             354.28     13.32      0          0          0
MH-31            354.37     11.89      0          0          0
MH-32            354.41     12.71      0          0          0
MH-33            354.6      11.5       0          0          0
MH-35            354.87     11.33      0          0          0
MH-37            355.12     13.6       0          0          0
MH-38            355.16     12.16      0          0          0
MH-39            355.19     11.14      0          0          0
MH-4             354.37     16.06      0          0          0
MH-41            354.05     12.1       0          0          0
MH-43            354.35     11.51      0          0          0
MH-44            354.37     12.03      0          0          0
MH-45            354.42     12.89      0          0          0
MH-47            354.69     11.31      0          0          0
MH-49            355.04     11.76      0          0          0
MH-5             354.4      16.01      0          0          0
MH-50            355.12     13.6       0          0          0
MH-51            355.16     12.24      0          0          0
MH-7             354.61     13.39      0          0          0
MH-9             354.95     13.75      0          0          0

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
O1               352        FREE                          NO

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve    Ponded   Evap.
;;Name           Elev.    Depth    Depth    Curve      Params
;;-------------- -------- -------- -------- ---------- -------- -------- --------
DI-12            355.17   10.63    0        TABULAR    SU3      0        0
```

```
DI-14            355.44   10.96    0        TABULAR    SU1        0         0
DI-17            354.27   13.33    0        TABULAR    SU8        0         0
DI-2             354.16   11.64    0        TABULAR    SU9        0         0
DI-21            354.6    13.4     0        TABULAR    SU6        0         0
DI-23            354.94   13.76    0        TABULAR    SU4        0         0
DI-27            355.31   10.59    0        TABULAR    SU2        0         0
DI-28            354.05   12.1     0        TABULAR    SU18       0         0
DI-30            354.35   11.45    0        TABULAR    SU16       0         0
DI-34            354.69   11.31    0        TABULAR    SU14       0         0
DI-36            355.04   11.76    0        TABULAR    SU12       0         0
DI-40            355.38   10.82    0        TABULAR    SU10       0         0
DI-42            354.18   10.91    0        TABULAR    SU17       0         0
DI-46            354.6    11.5     0        TABULAR    SU15       0         0
DI-48            354.87   11.33    0        TABULAR    SU13       0         0
DI-51            355.2    11       0        TABULAR    SU11       0         0
DI-6             354.49   12.91    0        TABULAR    SU7        0         0
DI-8             354.79   14.21    0        TABULAR    SU5        0         0
North            349      15       5        TABULAR    North      0         0
South            349      15       5        TABULAR    South      0         0

[CONDUITS]
;;     Inlet    Outlet           Manning    Inlet      Outlet     Init.      Max.
;;Name  Node      Node   Length     N       Offset     Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ----------
C1      J1      J30       170         0.013        0          0          0          0
C2      J2      J30       54          0.013        0          0          0          0
Ditch   J30     O1        475.71      0.011        0          0          0          0
Pipe1   MH-1    South     121         0.011        0          5          0          0
Pipe10  MH-10   MH-9      257         0.011        0          0          0          0
Pipe11  MH-11   MH-10     145         0.011        0          0          0          0
Pipe12  DI-12   MH-11     172         0.011        0          0          0          0
Pipe13  MH-13   DI-12     403         0.011        0          0          0          0
Pipe14  DI-14   MH-13     320         0.011        0          0          0          0
Pipe15  MH-15   South     111         0.011        0          5          0          0
Pipe16  MH-16   MH-15     302         0.011        0          0          0          0
Pipe17  DI-17   MH-16     300         0.011        0          0          0          0
Pipe18  MH-18   DI-17     260         0.011        0          0          0          0
Pipe19  MH-19   MH-18     85          0.011        0          0          0          0
Pipe2   DI-2    MH-1      312         0.011        0          0          0          0
Pipe20  MH-20   MH-19     243         0.011        0          0          0          0
Pipe21  DI-21   MH-20     300         0.011        0          0          0          0
Pipe22  MH-22   DI-21     501         0.011        0          0          0          0
Pipe23  DI-23   MH-22     425         0.011        0          0          0          0
Pipe24  MH-24   DI-23     280         0.011        0          0          0          0
Pipe25  MH-25   MH-24     153         0.011        0          0          0          0
Pipe26  MH-26   MH-25     178         0.011        0          0          0          0
Pipe27  DI-27   MH-26     383         0.011        0          0          0          0
Pipe28  DI-28   North     128         0.011        0          5          0          0
Pipe29  MH-29   DI-28     378         0.011        0          0          0          0
Pipe3   MH-3    DI-2      320         0.011        0          0          0          0
Pipe30  DI-30   MH-29     441         0.011        0          0          0          0
Pipe31  MH-31   DI-30     61          0.011        0          0          0          0
Pipe32  MH-32   MH-31     98          0.011        0          0          0          0
Pipe33  MH-33   MH-32     484         0.011        0          0          0          0
Pipe34  DI-34   MH-33     251         0.011        0          0          0          0
Pipe35  MH-35   DI-34     485         0.011        0          0          0          0
Pipe36  DI-36   MH-35     473         0.011        0          0          0          0
Pipe37  MH-37   DI-36     219         0.011        0          0          0          0
Pipe38  MH-38   MH-37     89          0.011        0          0          0          0
Pipe39  MH-39   MH-38     72          0.011        0          0          0          0
Pipe4   MH-4    MH-3      237         0.011        0          0          0          0
Pipe40  DI-40   MH-39     527         0.011        0          0          0          0
Pipe41  MH-41   North     119         0.011        0          5          0          0
```

```
Pipe42 DI-42  MH-41     348        0.011      0          0          0          0
Pipe43 MH-43  DI-42     457        0.011      0          0          0          0
Pipe44 MH-44  MH-43     68         0.011      0          0          0          0
Pipe45 MH-45  MH-44     111        0.011      0          0          0          0
Pipe46 DI-46  MH-45     503        0.011      0          0          0          0
Pipe47 MH-47  DI-46     231        0.011      0          0          0          0
Pipe48 DI-48  MH-47     506        0.011      0          0          0          0
Pipe49 MH-49  DI-48     455        0.011      0          0          0          0
Pipe5  MH-5   MH-4      78         0.011      0          0          0          0
Pipe50 MH-50  MH-49     220        0.011      0          0          0          0
Pipe51 MH-51  MH-50     96         0.011      0          0          0          0
Pipe52 DI-51  MH-51     96         0.011      0          0          0          0
Pipe53 J32    J30       184.84     0.011      0          0          0          0
Pipe54 J31    J30       192.81     0.011      0          0          0          0
Pipe6  DI-6   MH-5      239        0.011      0          0          0          0
Pipe7  MH-7   DI-6      320        0.011      0          0          0          0
Pipe8  DI-8   MH-7      481        0.011      0          0          0          0
Pipe9  MH-9   DI-8      446        0.011      0          0          0          0

[ORIFICES]
;;               Inlet            Outlet   Orifice      Crest      Disch.   Flap
Open/Close
;;Name           Node             Node     Type         Height     Coeff.   Gate Time
;;-------------- ---------------- ---------------- ------------ ---------- ----------
---- ----------
N-spillway       North            J31      BOTTOM       10         0.65       NO    0
OR1              South            J32      SIDE         5          0.65       NO    0
OR10             North            J31      SIDE         5          0.65       NO    0
OR11             North            J31      SIDE         5          0.65       NO    0
OR12             North            J31      SIDE         5          0.65       NO    0
OR2              South            J32      SIDE         5          0.65       NO    0
OR3              South            J32      SIDE         5          0.65       NO    0
OR4              South            J32      SIDE         5          0.65       NO    0
OR5              South            J32      SIDE         5          0.65       NO    0
OR6              South            J32      SIDE         5          0.65       NO    0
OR7              North            J31      SIDE         5          0.65       NO    0
OR8              North            J31      SIDE         5          0.65       NO    0
OR9              North            J31      SIDE         5          0.65       NO    0
S-spillway       South            J32      BOTTOM       10         0.65       NO    0

[WEIRS]
;;            Inlet    Outlet   Weir     Crest  Disch.     Flap End       End
;;Name       Node     Node     Type     Height Coeff.     Gate Con.      Coeff.
Surcharge  RoadWidth  RoadSurf
;;-------------- ---------------- ---------------- ------------ ---------- ----------
---- --------- ---------- ---------- ---------- ----------
N-emergency   North   J1    TRAPEZOIDAL  13   3.33       NO   0         0          YES
S-emergency   South   J2    TRAPEZOIDAL  13   3.33       NO   0         0          YES

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4
Barrels
;;-------------- ------------ ---------------- ---------- ---------- ----------
----------
C1               TRAPEZOIDAL  2                10         3          3          1
C2               TRAPEZOIDAL  2                10         3          3          1
Ditch            TRAPEZOIDAL  5                5          3          3          1
Pipe1            CIRCULAR     3.739            0          0          0          1
Pipe10           CIRCULAR     3.272            0          0          0          1
Pipe11           CIRCULAR     3.272            0          0          0          1
Pipe12           CIRCULAR     3.272            0          0          0          1
Pipe13           CIRCULAR     3.272            0          0          0          1
Pipe14           CIRCULAR     3.272            0          0          0          1
```

Pipe15	CIRCULAR	3.272	0	0	0	1
Pipe16	CIRCULAR	3.272	0	0	0	1
Pipe17	CIRCULAR	3.272	0	0	0	1
Pipe18	CIRCULAR	3.272	0	0	0	1
Pipe19	CIRCULAR	3.272	0	0	0	1
Pipe2	CIRCULAR	3.739	0	0	0	1
Pipe20	CIRCULAR	3.272	0	0	0	1
Pipe21	CIRCULAR	3.272	0	0	0	1
Pipe22	CIRCULAR	3.272	0	0	0	1
Pipe23	CIRCULAR	3.272	0	0	0	1
Pipe24	CIRCULAR	3.272	0	0	0	1
Pipe25	CIRCULAR	3.272	0	0	0	1
Pipe26	CIRCULAR	3.272	0	0	0	1
Pipe27	CIRCULAR	3.272	0	0	0	1
Pipe28	CIRCULAR	3.739	0	0	0	1
Pipe29	CIRCULAR	3.739	0	0	0	1
Pipe3	CIRCULAR	3.739	0	0	0	1
Pipe30	CIRCULAR	3.272	0	0	0	1
Pipe31	CIRCULAR	3.272	0	0	0	1
Pipe32	CIRCULAR	3.272	0	0	0	1
Pipe33	CIRCULAR	3.272	0	0	0	1
Pipe34	CIRCULAR	3.272	0	0	0	1
Pipe35	CIRCULAR	3.272	0	0	0	1
Pipe36	CIRCULAR	3.272	0	0	0	1
Pipe37	CIRCULAR	3.272	0	0	0	1
Pipe38	CIRCULAR	3.272	0	0	0	1
Pipe39	CIRCULAR	3.272	0	0	0	1
Pipe4	CIRCULAR	3.739	0	0	0	1
Pipe40	CIRCULAR	3.272	0	0	0	1
Pipe41	CIRCULAR	3.272	0	0	0	1
Pipe42	CIRCULAR	3.272	0	0	0	1
Pipe43	CIRCULAR	3.272	0	0	0	1
Pipe44	CIRCULAR	3.272	0	0	0	1
Pipe45	CIRCULAR	3.272	0	0	0	1
Pipe46	CIRCULAR	3.272	0	0	0	1
Pipe47	CIRCULAR	3.272	0	0	0	1
Pipe48	CIRCULAR	3.272	0	0	0	1
Pipe49	CIRCULAR	3.272	0	0	0	1
Pipe5	CIRCULAR	3.739	0	0	0	1
Pipe50	CIRCULAR	3.272	0	0	0	1
Pipe51	CIRCULAR	3.272	0	0	0	1
Pipe52	CIRCULAR	3.272	0	0	0	1
Pipe53	CIRCULAR	2	0	0	0	1
Pipe54	CIRCULAR	2	0	0	0	1
Pipe6	CIRCULAR	3.739	0	0	0	1
Pipe7	CIRCULAR	3.739	0	0	0	1
Pipe8	CIRCULAR	3.739	0	0	0	1
Pipe9	CIRCULAR	3.739	0	0	0	1
N-spillway	CIRCULAR	2	0	0	0	
OR1	CIRCULAR	0.125	0	0	0	
OR10	CIRCULAR	0.125	0	0	0	
OR11	CIRCULAR	0.125	0	0	0	
OR12	CIRCULAR	0.125	0	0	0	
OR2	CIRCULAR	0.125	0	0	0	
OR3	CIRCULAR	0.125	0	0	0	
OR4	CIRCULAR	0.125	0	0	0	
OR5	CIRCULAR	0.125	0	0	0	
OR6	CIRCULAR	0.125	0	0	0	
OR7	CIRCULAR	0.125	0	0	0	
OR8	CIRCULAR	0.125	0	0	0	
OR9	CIRCULAR	0.125	0	0	0	
S-spillway	CIRCULAR	2	0	0	0	
N-emergency	TRAPEZOIDAL	2	10	5	5	

```
S-emergency      TRAPEZOIDAL  2                10         5          5

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate  SeepageRate
;;-------------- ---------- ---------- ---------- ---------- ----------
Pipe1            0          1          0          NO         0
Pipe15           0          1          0          NO         0
Pipe28           0          1          0          NO         0
Pipe41           0          1          0          NO         0
Pipe53           0.5        1          0          NO         0
Pipe54           0.5        1          0          NO         0

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
;Northern stormwater basin
North            Storage    0          57290.52
North                       1          61519.44
North                       2          65836.58
North                       3          70232.92
North                       4          74704.11
North                       5          79248.77
North                       6          83883.62
North                       7          88520.13
North                       8          93223.80
North                       9          97994.66
North                       10         102832.68
North                       11         107737.86
North                       12         112710.21
North                       13         117749.76
North                       14         122858.56
North                       15         128032.65

;Southern stormwater basin
South            Storage    0          54915.65
South                       1          58999.93
South                       2          63166.16
South                       3          67409.57
South                       4          71728.89
South                       5          76123.83
South                       6          80607.03
South                       7          85092.94
South                       8          89645.91
South                       9          94265.98
South                       10         98953.10
South                       11         103707.28
South                       12         108528.55
South                       13         113416.90
South                       14.00      118371.51
South                       15         123394.7

SU1              Storage    0          38.5
SU1                         6.03       38.5
SU1                         6.56       1249.18
SU1                         7.56       4507.77
SU1                         8.56       8163.12
SU1                         9.56       11779.46
SU1                         10.56      15221.95
SU1                         10.96      16588.84

SU10             Storage    0          38.5
SU10                        5.85       38.5
SU10                        6.62       1764.19
```

SU10		7.62	5027.48
SU10		8.62	9538.41
SU10		9.62	13779.39
SU10		10.62	17849.18
SU10		10.82	18671.25
SU11	Storage	0	38.5
SU11		6.02	38.5
SU11		6.8	1551.96
SU11		7.8	4552.06
SU11		8.8	8582.74
SU11		9.8	12048.12
SU11		10.8	15579.32
SU11		11	16277.03
SU12	Storage	0	38.5
SU12		6.76	38.5
SU12		6.96	355.59
SU12		7.96	3089.71
SU12		8.96	7281.46
SU12		9.96	10876.5
SU12		10.96	14385.72
SU12		11.76	17265.86
SU13	Storage	0	38.5
SU13		6.37	38.5
SU13		7.13	1476.29
SU13		8.13	4589.11
SU13		9.13	8889.86
SU13		10.13	12651.27
SU13		11.13	16401.38
SU13		11.33	17092.52
SU14	Storage	0	38.5
SU14		6.33	38.5
SU14		7.31	2424.7
SU14		8.31	5402.92
SU14		9.31	8668.28
SU14		10.31	11629.54
SU14		11.31	14595.13
SU15	Storage	0	38.5
SU15		6.33	38.5
SU15		6.4	134.76
SU15		7.4	2583.63
SU15		8.4	5527.2
SU15		9.4	9011.89
SU15		10.4	12361.01
SU15		11.4	15733.36
SU15		11.5	16461.34
SU16	Storage	0	38.5
SU16		6.52	38.5
SU16		6.65	344.78
SU16		7.65	2891.95
SU16		8.65	6863.96
SU16		9.65	11256.31
SU16		10.65	15386.52
SU16		11.45	18683.21
SU17	Storage	0	38.5
SU17		5.96	38.5
SU17		6.82	1561.06

SU17		7.82	4512.1
SU17		8.82	8548.05
SU17		9.82	12043.83
SU17		10.82	15536.9
SU17		10.96	15849.29
SU18	Storage	0	38.5
SU18		7.11	38.5
SU18		7.95	1965.46
SU18		8.95	5740.29
SU18		9.95	9430.91
SU18		10.95	12814.43
SU18		11.95	16188.36
SU18		12.15	16886.33
SU2	Storage	0	38.5
SU2		5.56	38.5
SU2		5.69	263.16
SU2		6.69	2906.41
SU2		7.69	6442.56
SU2		8.69	9296.94
SU2		9.69	12168.04
SU2		10.59	14759.17
SU3	Storage	0	38.5
SU3		5.62	38.5
SU3		5.83	251.33
SU3		6.83	2075.3
SU3		7.83	4715
SU3		8.83	7249.66
SU3		9.83	10025.45
SU3		10.63	12279.74
SU4	Storage	0	38.5
SU4		8.79	38.5
SU4		9.06	409.15
SU4		10.06	2762.28
SU4		11.06	6462
SU4		12.06	11146.58
SU4		13.06	16286.26
SU4		13.76	19401.77
SU5	Storage	0	38.5
SU5		9.23	38.5
SU5		10.21	2376.15
SU5		11.21	6372.16
SU5		12.21	10875.9
SU5		13.21	14826.39
SU5		14.22	18814.42
SU6	Storage	0	38.5
SU6		8.4	38.5
SU6		9.4	2112.13
SU6		10.4	4613.06
SU6		11.4	7604.39
SU6		12.4	10785.09
SU6		13.38	13677.33
SU7	Storage	0	38.5
SU7		7.91	38.5
SU7		8.51	1192.78
SU7		9.51	4301.47
SU7		10.51	7893.57

SU7		11.51	11887.75
SU7		12.51	15600.63
SU7		12.91	17120.95
SU8	Storage	0	38.5
SU8		8.31	38.5
SU8		8.73	799.25
SU8		9.73	3785.41
SU8		10.73	7512.08
SU8		11.73	11613.82
SU8		12.73	15403.11
SU8		13.33	17663.26
SU9	Storage	0	38.5
SU9		6.67	38.5
SU9		6.84	308.12
SU9		7.84	2230.74
SU9		8.84	5253.25
SU9		9.84	8803.95
SU9		10.84	12090.59
SU9		11.64	14662.58

APPENDIX C
BENCH DITCH AND FLUME CALCULATIONS

Bench Ditch Hydraulic Capacity

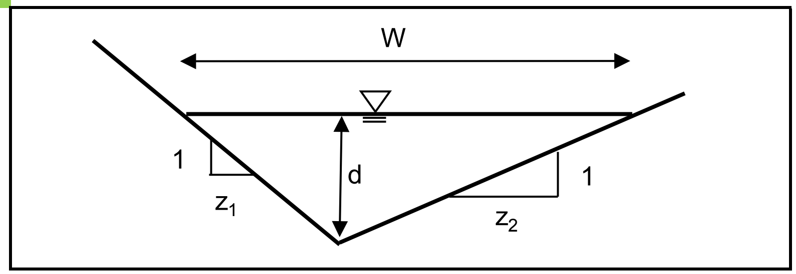
Client	Tennessee Valley Authority		
Project Name	SHF Proposed CCR Landfill		
	Bench ditch sizing calculation	**Prepared By:**	Caitlin Johnson, EIT
Location	Paducah, McCracken County, KY		
Date	3/7/2017	**Reviewed By:**	Joshua Kopp, PE
Stantec Project Number	175666001		

Drainage Ditch - Channel Capacity & Depth Calculations

Channel Section 4

4. Non-Symmetrical Triangular Section

Channel Sketch



Input Data:

Manning's "n" value	0.033	
Longitudinal Slope - S_o	0.020	ft/ft
Design Discharge - Q	5.9	ft^3/s - cfs

Channel Geometry Data:

Side Slope(s)

z_1 or z	10.0	z H:1V
z_2	4.0	z H:1V

Governing Geometry Equations

$$W = d(z_1 + z_2)$$

$$A = \frac{d^2}{2}(z_1 + z_2)$$

$$W_P = d\left(\sqrt{z_1^2 + 1} + \sqrt{z_2^2 + 1}\right)$$

Output Data:

Calculated Depth - d	**0.56**	feet
Calculated Top Width - W	**7.82**	feet
Calculated Area - A	2.18	ft^2
Calc. Wetted Perimeter - Wp	7.92	feet
Calc. Hydr. Radius - R	0.28	feet
Calculated Discharge - Q'	5.91	ft^3/s - cfs
Convergence	0.0400	ft^3/s - cfs
Calculated Velocity	**2.71**	ft / s
Calculated Shear Stress - τ_d	**0.70**	lb / ft^2

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S_o^{\frac{1}{2}} \qquad R = \frac{A}{W_p}$$

$$\tau_d = \gamma d S \qquad V = \frac{Q}{A}$$

Riprap Ditch Hydraulic Capacity

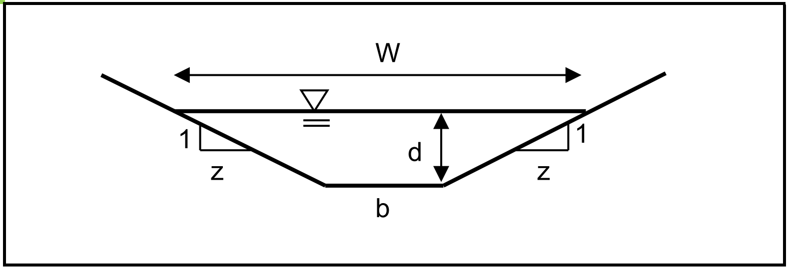
Client	Tennessee Valley Authority		
Project Name	SHF Proposed CCR Landfill		
	Flume sizing calculation	**Prepared By:**	Caitlin Johnson, EIT
Location	Paducah, McCracken County, KY		
Date	3/6/2017	**Reviewed By:**	Joshua Kopp, PE
Stantec Project Number	175666001		

Drainage Ditch - Channel Capacity & Depth Calculations

Channel Section 1

1. Uniform (Symmetrical) Trapezoidal Section

Channel Sketch



Input Data:

Manning's "n" value	0.04	
Longitudinal Slope - S_o	0.150	ft/ft
Design Discharge - Q	27.5	ft^3/s - cfs

Channel Geometry Data:

Bottom Width(s)

b_1 or b	6	feet

Side Slope(s)

z_1 or z	3.0	z H:1V

Governing Geometry Equations

$$W = b + 2dz$$

$$A = bd + zd^2$$

$$W_P = b + 2d\sqrt{z^2 + 1}$$

Output Data:

Calculated Depth - d	**0.48**	feet
Calculated Top Width - W	**8.88**	feet
Calculated Area - A	3.56	ft^2
Calc. Wetted Perimeter - Wp	9.03	feet
Calc. Hydr. Radius - R	0.39	feet
Calculated Discharge - Q'	27.67	ft^3/s - cfs
Convergence	0.1682	ft^3/s - cfs
Calculated Velocity	**7.76**	ft / s
Calculated Shear Stress - τ_d	**4.49**	lb / ft^2

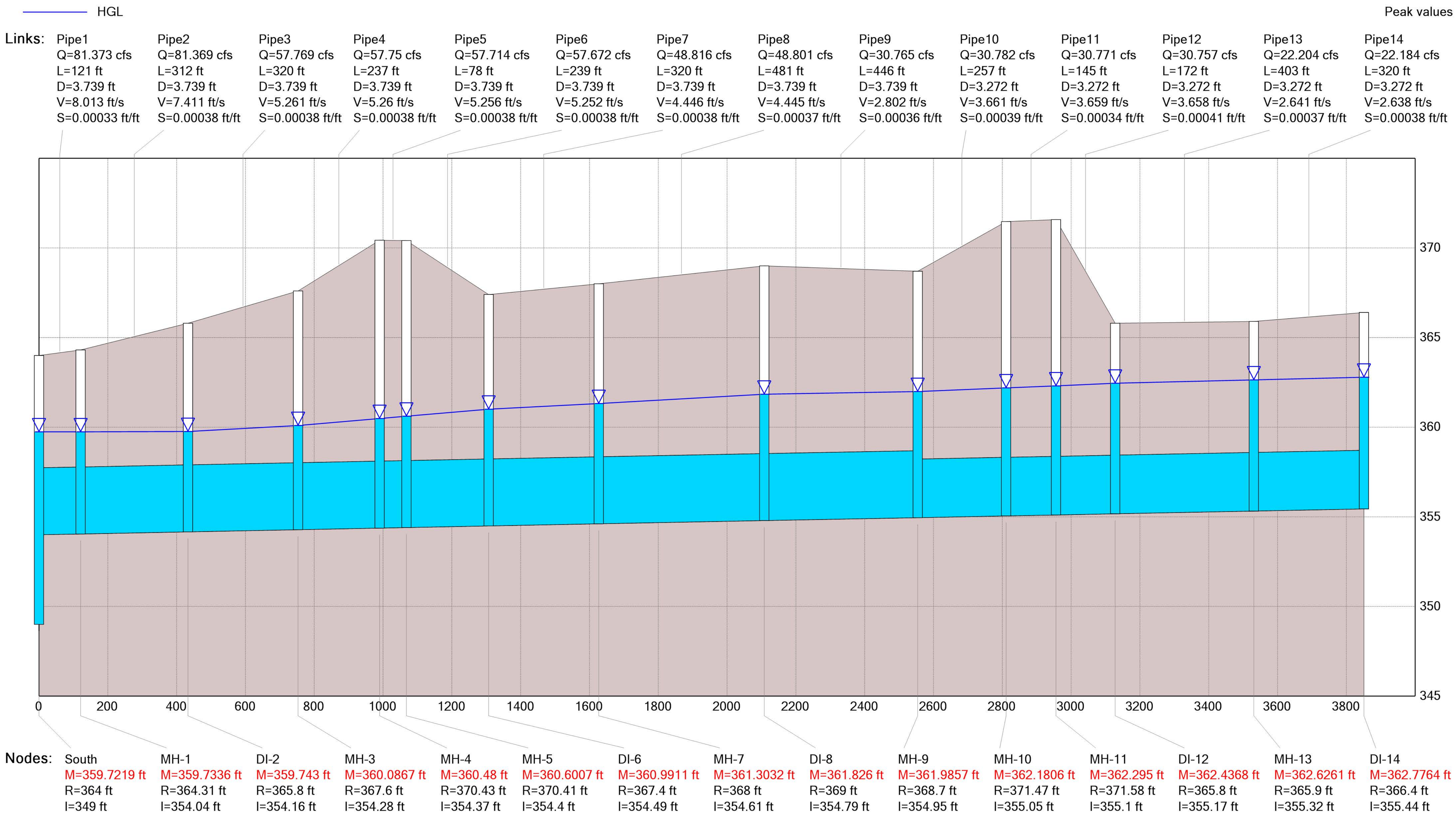
$$Q = \frac{1.49}{n} AR^{\frac{2}{3}} S_o^{\frac{1}{2}} \qquad R = \frac{A}{W_p}$$

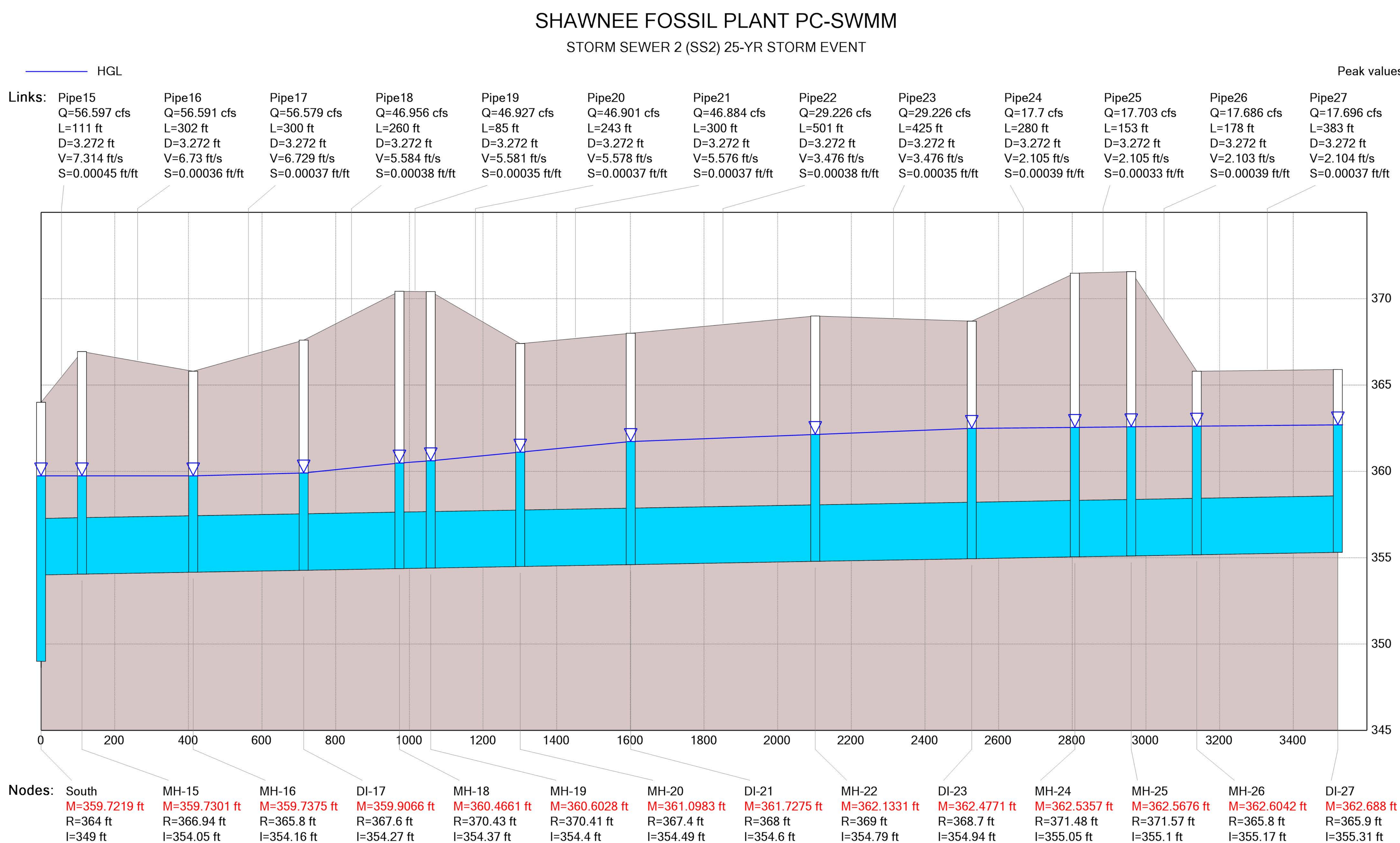
$$\tau_d = \gamma dS \qquad V = \frac{Q}{A}$$

APPENDIX D
25-YEAR, 24-HOUR STORM EVENT PROFILES

SHAWNEE FOSSIL PLANT PC-SWMM

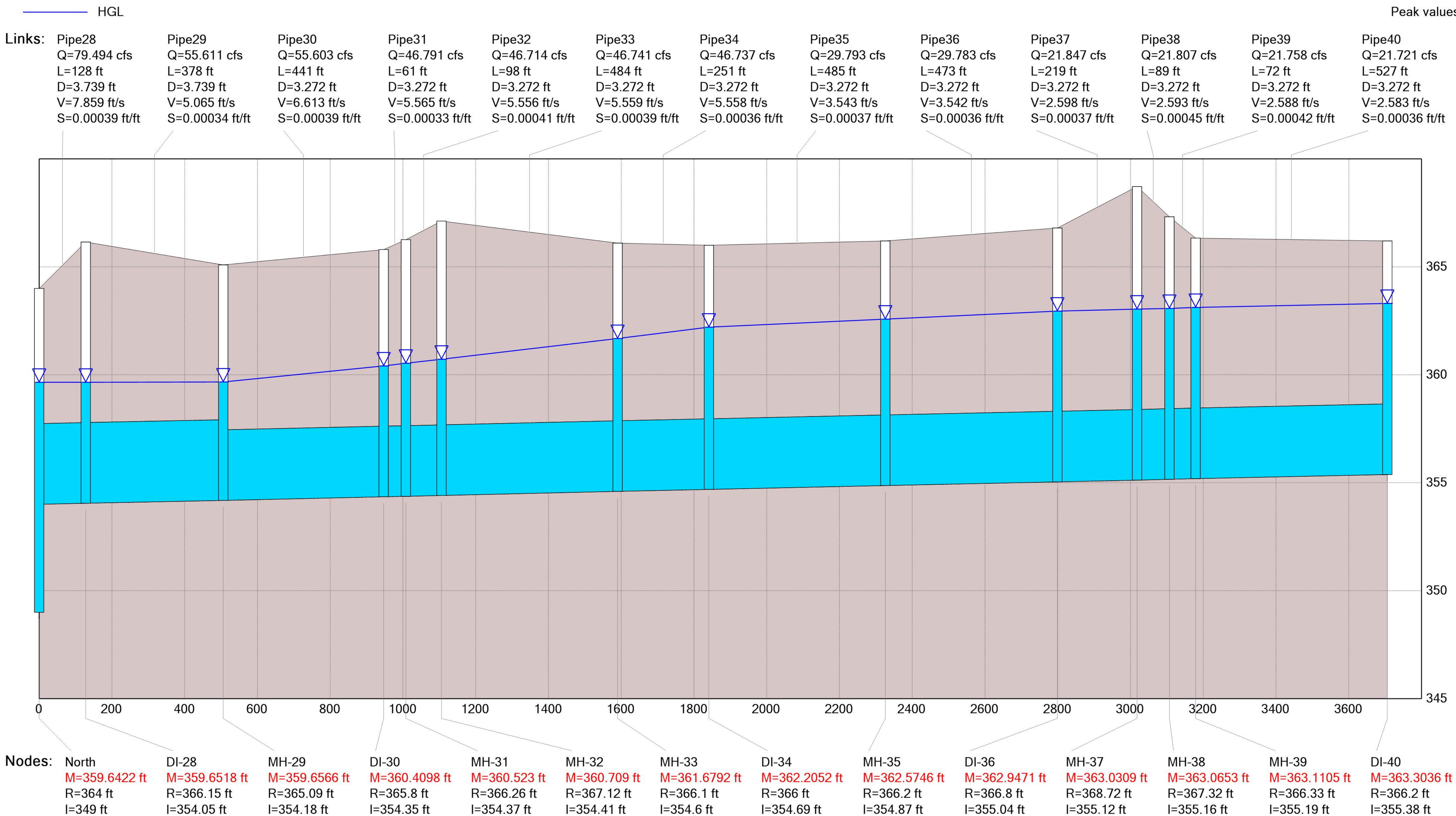
STORM SEWER 1 (SS1) 25-YR STORM EVENT




SHAWNEE FOSSIL PLANT PC-SWMM
STORM SEWER 2 (SS2) 25-YR STORM EVENT
HGL
Peak values
Links:
Pipe15 Q=56.597 cfs L=111 ft D=3.272 ft V=7.314 ft/s S=0.00045 ft/ft
Pipe16 Q=56.591 cfs L=302 ft D=3.272 ft V=6.73 ft/s S=0.00036 ft/ft
Pipe17 Q=56.579 cfs L=300 ft D=3.272 ft V=6.729 ft/s S=0.00037 ft/ft
Pipe18 Q=46.956 cfs L=260 ft D=3.272 ft V=5.584 ft/s S=0.00038 ft/ft
Pipe19 Q=46.927 cfs L=85 ft D=3.272 ft V=5.581 ft/s S=0.00035 ft/ft
Pipe20 Q=46.901 cfs L=243 ft D=3.272 ft V=5.578 ft/s S=0.00037 ft/ft
Pipe21 Q=46.884 cfs L=300 ft D=3.272 ft V=5.576 ft/s S=0.00037 ft/ft
Pipe22 Q=29.226 cfs L=501 ft D=3.272 ft V=3.476 ft/s S=0.00038 ft/ft
Pipe23 Q=29.226 cfs L=425 ft D=3.272 ft V=3.476 ft/s S=0.00035 ft/ft
Pipe24 Q=17.7 cfs L=280 ft D=3.272 ft V=2.105 ft/s S=0.00039 ft/ft
Pipe25 Q=17.703 cfs L=153 ft D=3.272 ft V=2.105 ft/s S=0.00033 ft/ft
Pipe26 Q=17.686 cfs L=178 ft D=3.272 ft V=2.103 ft/s S=0.00039 ft/ft
Pipe27 Q=17.696 cfs L=383 ft D=3.272 ft V=2.104 ft/s S=0.00037 ft/ft
370
365
360
355
350
345
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
Nodes:
South M=359.7219 ft R=364 ft I=349 ft
MH-15 M=359.7301 ft R=366.94 ft I=354.05 ft
MH-16 M=359.7375 ft R=365.8 ft I=354.16 ft
DI-17 M=359.9066 ft R=367.6 ft I=354.27 ft
MH-18 M=360.4661 ft R=370.43 ft I=354.37 ft
MH-19 M=360.6028 ft R=370.41 ft I=354.4 ft
MH-20 M=361.0983 ft R=367.4 ft I=354.49 ft
DI-21 M=361.7275 ft R=368 ft I=354.6 ft
MH-22 M=362.1331 ft R=369 ft I=354.79 ft
DI-23 M=362.4771 ft R=368.7 ft I=354.94 ft
MH-24 M=362.5357 ft R=371.48 ft I=355.05 ft
MH-25 M=362.5676 ft R=371.57 ft I=355.1 ft
MH-26 M=362.6042 ft R=365.8 ft I=355.17 ft
DI-27 M=362.688 ft R=365.9 ft I=355.31 ft

SHAWNEE FOSSIL PLANT PC-SWMM

STORM SEWER 3 (SS3) 25-YR STORM EVENT



SHAWNEE FOSSIL PLANT PC-SWMM

STORM SEWER 4 (SS4) 25-YR STORM EVENT