Geosyntec consultants

16644 West Bernardo Drive, Suite 301
San Diego, CA 92127
Phone: 858.674.6559
Fax: 858.674.6586
www.geosyntec.com

INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN
ASH POND 2
JOLIET 29 STATION
OCTOBER 2016

Pursuant to Code of Federal Regulations Title 40, Part 257, Subpart D (40 CFR), herein referred to as the coal combustion residual (CCR) Rule, §257.82(c), Geosyntec Consultants (Geosyntec) prepared this Inflow Design Flood Control System Plan for Ash Pond 2 located at the Joliet 29 Station (Site) in Joliet, Illinois (Figure 1). The Site is owned and operated by Midwest Generation, LLC (Midwest Generation).

Section 257.82(c) of the CCR Rule requires that operators of every existing or new CCR surface impoundment design, construct, operate, and maintain an inflow design flood control system that adequately manages flow into the CCR unit during and following the peak discharge of the inflow design flood. The Preamble to the CCR Rule provides guidance on the documentation that should be provided for the inflow design flood control system plan.

This Inflow Design Flood Control System Plan demonstrates that the existing outlet structures, conveyance piping, and downstream hydraulic structures for Ash Pond 2 adequately manage inflow from the design event.

The work presented in this report was performed under the direction of Ms. Jane Soule, P.E., of Geosyntec in accordance with §257.82(c). Mr. Robert White reviewed this plan in accordance with Geosyntec's senior review policy.

1. Pond Design

Ash Pond 2 is located approximately 70 feet south of U.S. Route 6, east of Pond 1, west of Pond 3 and the east entrance to the Joliet 29 Station, and north of the Des Plaines River and station intake canal. Prior to the conversion of the Joliet 29 Station to natural gas in May 2016, Ash Pond 2 received sluiced CCR and other process water. Ash Pond 2 is currently operated to receive non-CCR process water from plant operations. Pond 1, located just west of Ash Pond 2, is also operated to receive non-CCR process water. Plant flows are generally directed to one pond (the receiving pond) at a time. Inflow to Ash Pond 2 (or Pond 1) is on the order of 1,400 gallons per minute (gpm) intermittently, typically over a period of approximately 90 minutes per day. Inflow is discharged into the pond via an inlet flume and distribution trough on the western side of the pond. Outflow from Ash Pond 2 occurs on the east side of the pond where an outlet weir and trough connect to a 30-inch reinforced concrete pipe. Based on design drawings provided in Appendix A, the design elevation of the top of the outlet weir is 532.85 feet Mean Sea Level (ft MSL).

Water discharged from Pond 1 and Ash Pond 2 gravity flows to Pond 3, located east of both ponds, through a single buried 30-inch diameter pipe (referred to herein as $Culvert_{1-2}$). Water is discharged from Pond 3 through an overflow structure located in the southwest corner of the pond. The overflow structure includes a 30-inch standpipe with an invert elevation of approximately 529.8 ft MSL that connects to a 24-inch corrugated metal pipe that drains south to the intake canal. Pond 3 also includes a pump station which is not relied upon to manage the existing inflows and is therefore not discussed further in this document.

Because Pond 1 and Ash Pond 2 discharge via a common pipe, $Culvert_{1-2}$, to Pond 3, outflow from Pond 1 is evaluated in this plan.

2. Inflow Design Flood Control System Plan Documentation

Because of the operating procedures for Ash Pond 2, some of the references and drawings recommended for inclusion in the Inflow Design Flood Control System Plan by the Preamble to the CCR Rule (page 21392) are not applicable. Table 1 below provides a summary of the recommended documentation.

Table 1: Recommended Documentation

Documentation	Assessment
Identification of the design storm event for the catchment area and CCR unit	Identification of the design storm event is provided in Section 3. A drawing of the Pond 1, Ash Pond 2, and Pond 3 catchment areas is presented in Figure 2.
Characterization of the rainfall abstractions, including but not limited to depression storage and infiltration in the upstream catchment area and selection of the appropriate run-off model	Full capture of the design precipitation event was assumed, so rainfall abstractions were assumed to be zero, i.e., 100% of the volume falling within the catchment area for each pond was routed to the appropriate pond. Typical abstractions include mechanisms such as evaporation and infiltration.
Identification and characterization of and intake or decant structures	Inflow and outflow structures associated with Ash Pond 2 and Ponds 1 and 3 are described in Section 1 and evaluated in Appendix A.
Appropriate characterization and capacity of spillways	Ash Pond 2 does not include a spillway. The capacity of the overflow structure for Pond 3 is evaluated in Appendix A.
Characterization of downstream hydraulic structures	Pond 3 and associated piping is considered a downstream structure and is described in Section 1. Capacity of these structures is presented in Appendix A.

3. Catchment Areas

Ash Pond 2 is surrounded by embankments on the south, east and west. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north toward U.S. Route 6. Based on site topography, inflow from precipitation is limited to run-on from the embankment crests and road north of the pond and precipitation falling directly into the pond. The catchment areas for Ash Pond 2, Pond 1, and Pond 3 are shown in Figure 2.

4. Design Event

As Ash Pond 2 is classified as significant hazard potential surface impoundment (Geosyntec, 2016), the inflow design flood is defined as the 1,000-year flood. Because direct precipitation is collected within the pond and run-on is limited to the embankment crest areas, the inflow design is based on the 1,000-year precipitation event. The 1,000-year, 24-hour and 1,000-year, 6-hour storm depths were used to determine inflows to the pond in this analysis. The 24-hour storm duration was selected to maximize the volume entering the pond during a 1000-year event, while the 6-hour duration was used maximize peak flow entering the pond due to a shorter duration. Table 2 presents the storm depths for each frequency and duration.

Table 2: Design Precipitation Events

Return Interval	Duration	Depth
1,000-year	6-hour	8.89 inches
1,000-year	24-hour	14.2 inches

Source: NOAA, 2016

Total inflow from the design events is calculated as the depth of precipitation multiplied by the catchment area[1].

5. Analysis of Inflow Design Flow and Storage Capacity

Evaluation of the inflow design flood control system included routing of stormwater inflows from the design event to Pond 1, Ash Pond 2, and Pond 3 as well as process water to Ash Pond 2 (or Pond 1)[2]. For this analysis, inflows of process water are assumed to occur concurrently with

[1] Depression storage or infiltration of stormwater into the embankment crest and other rainfall abstractions are negligible and are not included in inflow volume calculations. Similarly, this calculation does not require the use of a run-on model for the precipitation falling on the embankment crest.

[2] Process water is directed to either Pond 1 or Ash Pond 2. The ponds are not operated to receive process water concurrently.

the peak flows of the design storm events. Volume of discharge from the ponds and changes in water levels within the ponds were calculated by considering the maximum capacity of $Culvert_{1-2}$ and the Pond 3 overflow structure. A description of the analysis is presented in Appendix A.

Table 3: Results 1,000-year, 24-hour Precipitation Event

Pond	Minimum Freeboard During Design Event (feet)
Pond 1	1.9
Ash Pond 2	1.8
Pond 3	0.8

Table 4: Results 1,000-year, 6-hour Precipitation Event

Pond	Minimum Freeboard During Design Event (feet)
Pond 1	1.7
Ash Pond 2	1.7
Pond 3	0.6

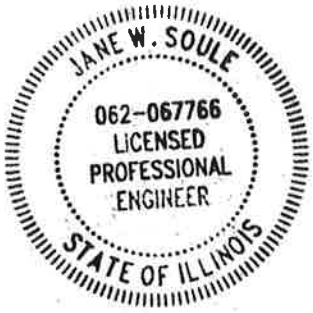
Tables 3 and 4 summarize the analysis results for the design storm events and indicate that a minimum of 1.7 feet and 0.6 feet of freeboard is maintained throughout the design event in Ash Pond 2 and downstream Pond 3, respectively. The inflow design system, as designed and constructed, meets the requirements of 40 CFR §257.82.

6. Plan Amendments and Revisions

In accordance with §257.82(c)(2) and (4), this Inflow Design Flood Control System Plan will be amended or revised whenever there is a change in conditions that would substantially affect the plan or every five years.

7. Limitations and Certification

This inflow design flood control system plan meets the requirements of §257.82(c) of the Code of Federal Regulations Title 40, Part 257, Subpart D and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jane W. Soule, P.E.
Illinois Professional Engineer No. 062-067766
License Expires: 11/30/17

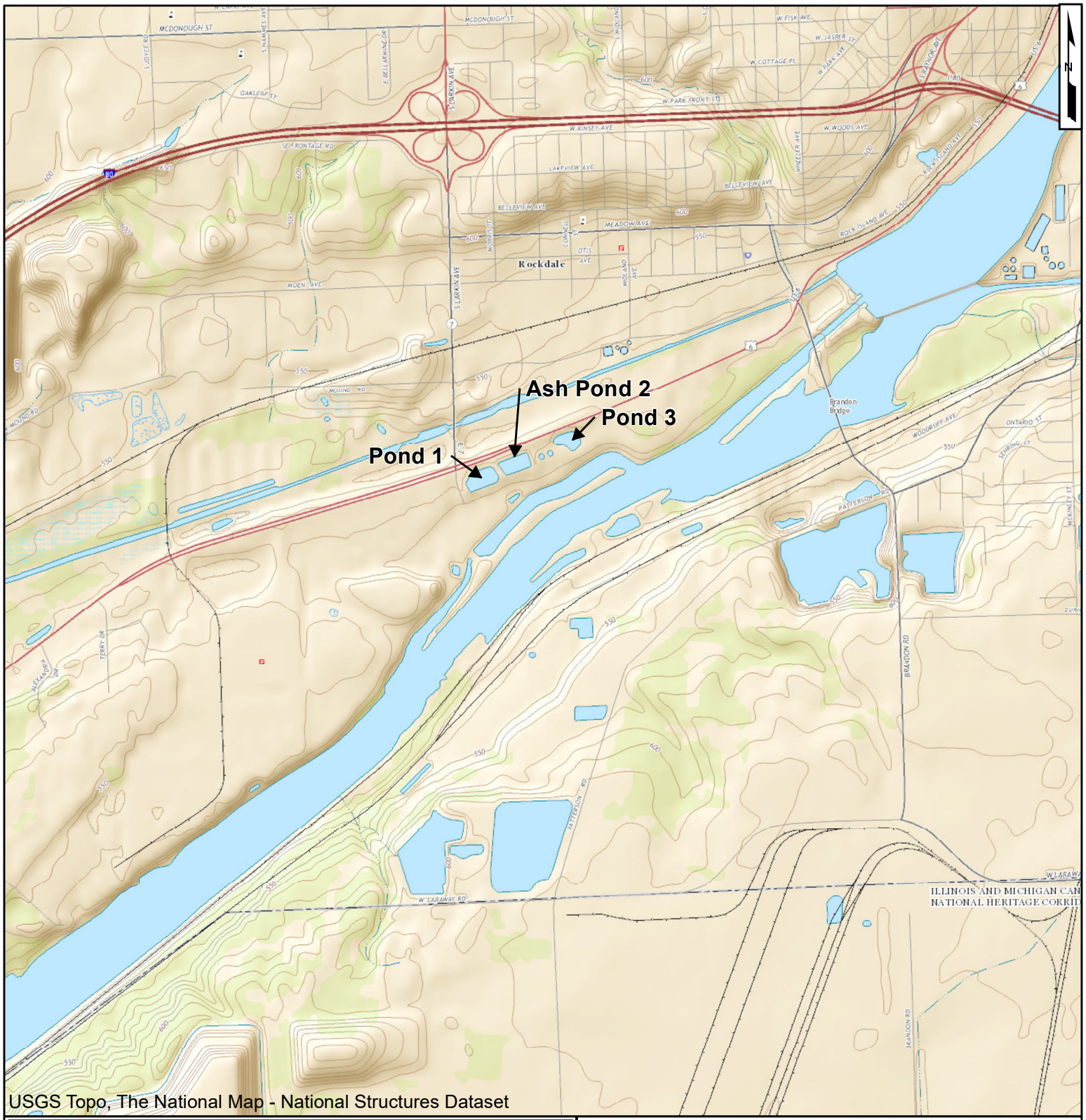
8. References

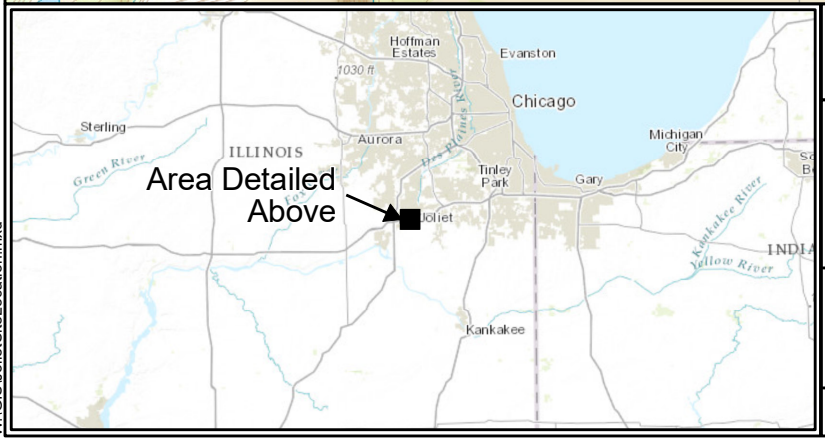
Geosyntec Consultants, 2016, Hazard Potential Classification Assessment, Ash Pond 2, Joliet 29 Station, October 2016.

NOAA, 2016, NOAA Atlas 14 Point Precipitation Frequency Estimates: Illinois, available at: http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

Attachments

Figure 1:	Vicinity Map
Figure 2:	Catchment Area
Appendix A:	Ash Pond 2 Routing Calculations





2,000 1,000 0 2,000 Feet

Site Location

Ash Pond 2
Joliet 29 Station
Joliet, Illinois

Geosyntec consultants

San Diego | October 2016

Figure 1

W:\GIS\JolietSiteLocation.mxd

Catchment Areas
Ash Pond 2 - Joliet 29
Midwest Generation, LLC
Joliet, Illinois

Geosyntec consultants

San Diego | October 2016

Figure 2

Appendix A

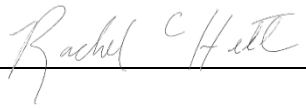
Ash Pond 2 Routing Calculations

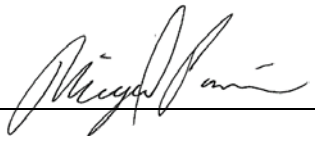
GEOSYNTEC CONSULTANTS

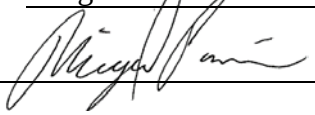
COMPUTATION COVER SHEET

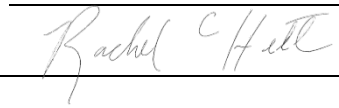
Client: Midwest Generation **Project:** Joliet 29 **Project #:** SW0251 **Task #:** 05/06

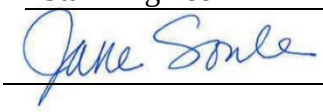
TITLE OF COMPUTATIONS INFLOW ROUTING CALCULATIONS, ASH POND 2

COMPUTATIONS BY:
Signature  7 October 2016 DATE
Printed Name and Title: Rachel Hill, Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY: (Peer Reviewer)
Signature  7 October 2016 DATE
Printed Name and Title: Miguel Parames, Engineer

COMPUTATIONS CHECKED BY:
Signature  7 October 2016 DATE
Printed Name and Title: Miguel Parames, Engineer

COMPUTATIONS BACKCHECKED BY: (Originator)
Signature  7 October 2016 DATE
Printed Name and Title: Rachel Hill, Staff Engineer

APPROVED BY: (PM or Designate)
Signature  7 October 2016 DATE
Printed Name and Title: Jane Soule P.E., Senior Engineer

APPROVAL NOTES:

INFLOW ROUTING CALCULATIONS
ASH POND 2
JOLIET 29, JOLIET, ILLINOIS

1. BACKGROUND AND PURPOSE

Pursuant to Code of Federal Regulations Title 40, Part 257, Subpart D, (40 CFR) Section 257.82(c), Geosyntec Consultants (Geosyntec) prepared this calculation package to support development of the Inflow Design Flood Control System Plan for Ash Pond 2 at the Joliet 29 Station (Site) in Joliet, Illinois. 40 CFR Section 257.82(c) requires that operators of every existing or new CCR (coal combustion residuals) surface impoundment design, construct, operate, and maintain an inflow design flood control system that adequately manages flow into the CCR unit during and following the peak discharge of the inflow design flood. This calculation evaluates the inflow design flood and evaluates the capacity of Ash Pond 2 and downstream outflow systems to handle inflow from this event.

2. POND DESCRIPTION

Ash Pond 2 is located approximately 70 feet south of U.S. Route 6, east of Pond 1, west of Pond 3 and the east entrance to the Joliet 29 Station, and north of the Des Plaines River and station intake canal (see Figure 1). Inflow is discharged into the pond via an inlet flume and distribution trough on the western side of the pond. Outflow from Ash Pond 2 occurs on the east side of the pond where an outlet weir and trough connect to a 30-inch reinforced concrete pipe (RCP). Based on design drawings, the design elevation of the top of the outlet weir is 532.85 feet Mean Sea Level (ft MSL). Copies of relevant design drawings are provided in Attachment A.

Water discharged from Pond 1 and Ash Pond 2 gravity flows to Pond 3, located east of both ponds, through a single buried 30-inch diameter pipe (referred to herein as $Culvert_{1\text{-}2}$). Water discharges from Pond 3 through an overflow structure located in the southwest corner of Pond 3. The overflow structure includes a 30-inch standpipe with an invert elevation of approximately 529.8 ft MSL that connects to a 24 inch corrugated metal pipe that drains south to the intake canal. Pond 3 also includes a pump station which is not relied upon to manage the existing inflows and is therefore not discuss further in this document.

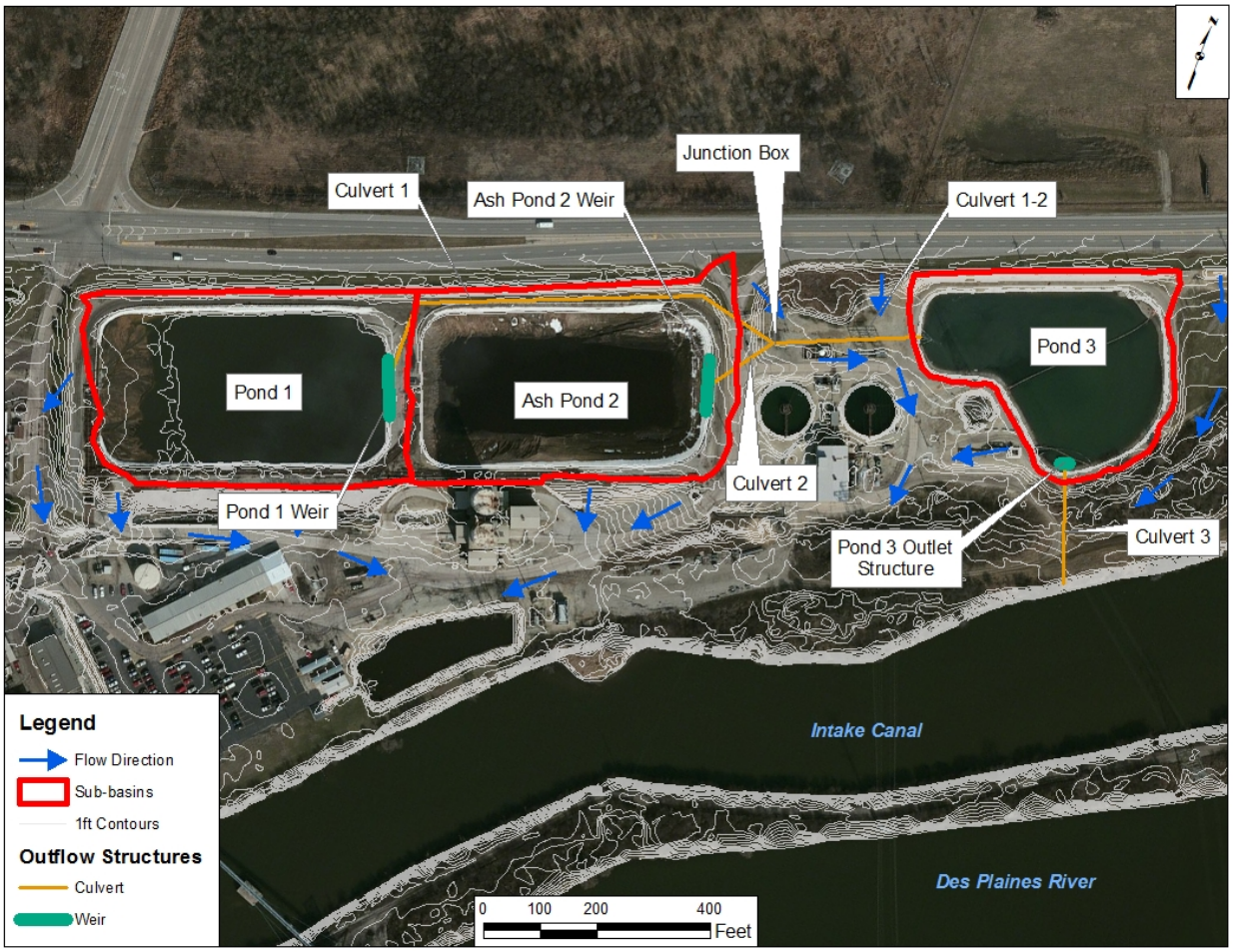


Figure 1. Site Map

3. INFLOW DESIGN ANALYSIS

3.1 Design Event

Flood flows are typically established by performing statistical analysis on historical stream gauge records. In instances where measured stream flow records are not available, deterministic methods such as a design storm method (ASCE, 1996) is used to establish flood flows. In the design storm method, a rainfall to runoff analysis is used to establish the flood flows. The underlying assumptions in the design storm method are: 1) rainfall will occur uniformly across the entire contributing watershed; and 2) a specified return period storm event produces the same return period flood flow. The design storm method was used to estimate the inflows to the ponds for the 1,000-year precipitation event.

3.2 Precipitation

Precipitation data was obtained from National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Point Precipitation Frequency Estimates: IL, see Attachment B (NOAA, 2016). The 1,000-year, 24-hour and 1,000-year, 6-hour storm depths were used to determine inflows to the ponds in this analysis. The 24-hour storm duration was selected to model a high total storm volume entering the ponds during a 1000-year event, while the 6-hour duration was used to model a higher peak flow entering the ponds due to a shorter duration. Table 1 presents the storm depths for each frequency and duration.

Table 1: Precipitation Data

Return Interval (years)	Duration (hours)	Depth (inches)
1,000	6	8.89
1,000	24	14.2

3.2 Hydrology and Sub-basin Characteristics

Pond 1 and Ash Pond 2 are surrounded by embankments on the south, east and west. There are no embankments on the north side of the ponds where existing ground elevations generally increase to the north toward U.S. Route 6. Inflow into these ponds is limited to run-on from the ponds' embankments, existing sloped areas north of the ponds, and direct precipitation into the ponds. Sub-basins for each pond were delineated in ArcGIS and are based on best available topography (Aero-Metric, Inc., 2008). The catchment areas for Pond 1, Ash Pond 2, and Pond 3 are presented in Table 2. Due to the limited size of the catchment areas, no losses associated with infiltration or other abstractions were considered and 100% of rainfall in each catchment area is considered to enter the associated pond.

Table 2: Drainage Areas

Drainage Area	Pond Surface Area (acres)	Total Drainage Area (acres)
Pond 1	3.2	4.4
Pond 2	3.4	4.5
Pond 3	2.5	3.0

3.3 Process Flow

Pond 1 and Ash Pond 2 are currently operated to receive non-CCR process water from plant operations. Plant flows are generally directed to one pond at a time. Inflow to Ash Pond 2 (or Pond 1) is on the order of 1,400 gallons per minute (gpm) intermittently, typically over a period of approximately 90 minutes per day. Inflow is discharged into the pond via an inlet flume and

distribution trough on the western side of the pond. This analysis assumes that the process flows occur at approximately the same time as the peak inflow from 1,000-year events.

3.3 Basin Outlet Structures and Culverts

Pond 1 and Ash Pond 2 both have approximately 100-foot long outlet weirs at an elevation of 532.85 ft located along their eastern boundary. The weirs flow into separate 30-inch RCP culverts ($Culvert_1$ and $Culvert_2$), which gravity flow to a junction box where the two flows are combined approximately 260 feet west of Pond 3. A 30-inch diameter RCP ($Culvert_{1-2}$) exits the junction box and discharges into Pond 3. The outlet structure of Pond 3 is a 36-inch riser pipe with a 24-inch outlet pipe ($Culvert_3$). Tables 3 and 4 present the properties of the outlet structures and culverts for the ponds based on available design drawings, provided in Attachment A.

Table 3: Pond Outlet Structure

Outlet Structure	Length (feet)	Invert Elevation
Pond 1 Weir	100 ft	532.85ft
Ash Pond 2 Weir	100 ft	532.85ft
Pond 3 Drop Inlet	36-inch diameter riser pipe	529.8ft

Table 4: Pond Outflow Structure

Culvert	Estimated Length (feet)	Inlet Invert Elevation (feet)	Outlet Invert Elevation (feet)	Estimated Slope (ft/ft)	Size and Type
$Culvert_1$	750	530.50	527.96	0.003	30-inch RCP
$Culvert_2$	135	530.50	527.96	0.019	30-inch RCP
$Culvert_{1-2}$	261	527.96	526.69	0.005	30-inch RCP
$Culvert_3$	216	521.63	515.42	0.029	24-inch CMP

Elevation-Discharge Curves and Routing Methodology

Discharge from the ponds was evaluated by developing elevation-discharge curves at incremental depths of 0.01 ft for each pond based on the configuration of the outflow structures (Figure 2). These curves, in conjunction with Equations 1 through 11, were used to evaluate routing through the ponds and culverts throughout the duration of the design storm event. The following sections describe the development of the elevation-discharge curves.

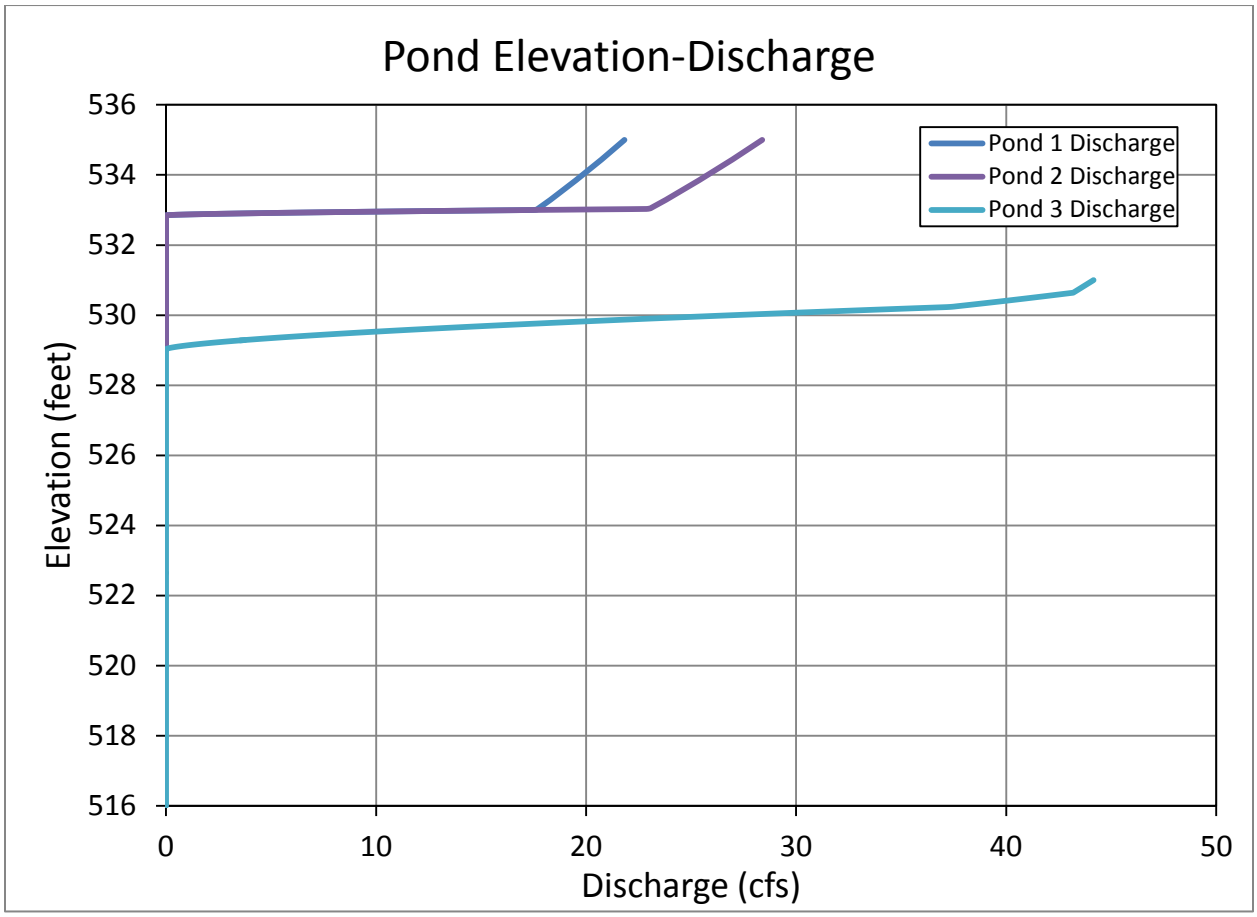


Figure 2. Elevation-Discharge Curves

Pond 1 and Ash Pond 2

Pond 1 and Ash Pond 2 were evaluated for both weir and culvert outflow in order to develop elevation-discharge curves. Weir flow was determined using Equation 1.

$$Q_w = C_w * L * H^{1.5} \quad \text{Eqn. 1}$$

Where: Q_w = flow over the weir (cfs)
C_w = weir coefficient = 3.0 (unitless) (IDOT, 2011)
L = length of weir (ft)
H = head above weir (ft)

Elevation-discharge curves for the culverts from Pond 1 and Ash Pond 2 ($Culvert_1$ and $Culvert_2$) were developed using the HY-8 culvert modeling program (see Attachment C for results). The tail water condition was set at a constant elevation of 529.25 ft to account for the condition in

which the average water surface elevation during the 1,000-year event in Pond 3 would control the system. Equations 2 and 3 were used to determine whether the weir or culvert controlled flow out of Pond 1 and Ash Pond 2.

$$Q_{out1} = \text{Min}(Q_{w1}, Q_{c1}) \quad \text{Eqn. 2}$$

$$Q_{out2} = \text{Min}(Q_{w2}, Q_{c2}) \quad \text{Eqn. 3}$$

Where: Q_{out1} = flow out of Pond 1 (cfs)
Q_{out2} = flow out of Ash Pond 2 (cfs)
Q_{w1} = flow over the weir at Pond 1 (cfs)
Q_{w2} = flow over the weir at Ash Pond 2 (cfs)
Q_{c1} = flow through $Culvert_1$ (cfs)
Q_{c2} = flow through the $Culvert_2$ (cfs)

The outflow from the 30-inch culverts of Pond 1 and Ash Pond 2 combines into one 30-inch RCP culvert ($Culvert_{1\text{-}2}$) that discharges into Pond 3. The outlet of the combined pipe is submerged in Pond 3 and flow through the pipe will be pressure flow. Elevation-discharge curves were developed for $Culvert_{1\text{-}2}$ using the same methods as described for $Culvert_1$ and $Culvert_2$. The outflows of the ponds were controlled by either the outflow from each upstream pond (Pond 1 and Ash Pond 2) or the combined piped discharging to Pond 3 ($Culvert_{1\&2}$). Equations 4, 5 and 6 were used to determine which outlet structure would be the controlling structure for discharges entering Pond 3. The outflow from Pond 1 and Ash Pond 2 is limited by the capacity of $Culvert_{1\&2}$, Equation 4.

$$Q_{c1\&2} = Q_{out1} + Q_{out2} \quad \text{Eqn. 4}$$

Where: $Q_{c1\&2}$ = flow through the $Culvert_{1\&2}$ (cfs)

The combined flow in $Culvert_{1\text{-}2}$ from Pond 1 and Ash Pond 2 was modelled as a ratio (Equation 5 and 6) of the maximum flow in $Culvert_1$ (29.16 cfs) and $Culvert_2$ (41.80 cfs) based on an assumed maximum water surface elevation of 535 feet in Pond 1 and Ash Pond 2 (see Attachment C).

$$f_1 = \frac{\text{Max}(Q_{out1})}{\text{Max}(Q_{out1}) + \text{Max}(Q_{out2})} = 0.41 \quad \text{Eqn. 5}$$

$$f_2 = \frac{\text{Max}(Q_{out2})}{\text{Max}(Q_{out1}) + \text{Max}(Q_{out2})} = 0.59 \quad \text{Eqn. 6}$$

Where: f_1 = ratio of total outflow from Pond 1
f_2 = ratio of total outflow from Ash Pond 2

The outflows from each pond were determined using Equations 7 and 8.

$$Q_{out1} = If(Q_{out1} \leq f_1 * Q_{c1\&2} \quad then \quad Q_{out1}, \quad else \quad f_1 * Q_{c1\&2}) \qquad \text{Eqn. 7}$$

$$Q_{out2} = If(Q_{out2} \leq f_2 * Q_{c1\&2} \quad then \quad Q_{out2}, \quad else \quad f_2 * Q_{c1\&2}) \qquad \text{Eqn. 8}$$

Pond 3

The Pond 3 outflow structure consists of a 36-inch riser pipe connected to a 24-inch corrugated metal pipe (CMP) culvert ($Culvert_3$). Three conditions can control the discharge from the Pond 3 outflow structure: a weir condition of the outflow riser pipe, the capacity of the outflow riser pipe (orifice condition), or the capacity of the downstream discharge pipe (24-inch CMP culvert). Weir flow was determined using Equation 1. Orifice flow was determined using Equation 9.

$$Q_{o3} = C_o * A * \sqrt{2 * g * H} \qquad \text{Eqn. 9}$$

Where: Q_{o3} = flow through the orifice at Pond 3 (cfs)
C_o = orifice coefficient = 0.61 (unitless) (IDOT, 2011)
A = cross-sectional area of the drop inlet (square ft)
g = gravitational constant = 32.2 (square ft / second)
H = head above the orifice (ft)

Outlet pipe flow was determined using the HY-8 computer program and the controlling outflow for the outlet structure was determined using Equation 10 (Attachment C).

$$Q_{out3} = Min(Q_{w3}, Q_{o3}, Q_{c3}) \qquad \text{Eqn. 10}$$

Where: Q_{out3} = flow out of the Pond 3 (cfs)
Q_{w3} = weir flow through the drop inlet (cfs)
Q_{o3} = orifice flow through the drop inlet (cfs)
Q_{c3} = flow through the outlet pipe (cfs)

3.4 Inflow Design Routing

The starting water surface elevation was assumed to be at the invert of the outflow structure at each pond (weir elevation for the Pond 1 and Ash Pond 2, and overflow pipe for Pond 3). Inflow to the ponds from precipitation within the sub-basins was developed using the Type II SCS Rainfall Distribution (shown in Figure 3) and multiplied by the design storm precipitation depth, (Table 1). For Ash Pond 2, an additional 1,400 gpm representing process water inflows (see Section 3.3) was added during the peak 90 minutes of the storm. Routing of the outflow was evaluated based on the methodologies and results described in Section 3.3 and elevation- storage curves for the ponds. Inflow to Pond 3 is the sum of outflow from $Culvert_{1\&2}$ and precipitation inflow for Pond 3.

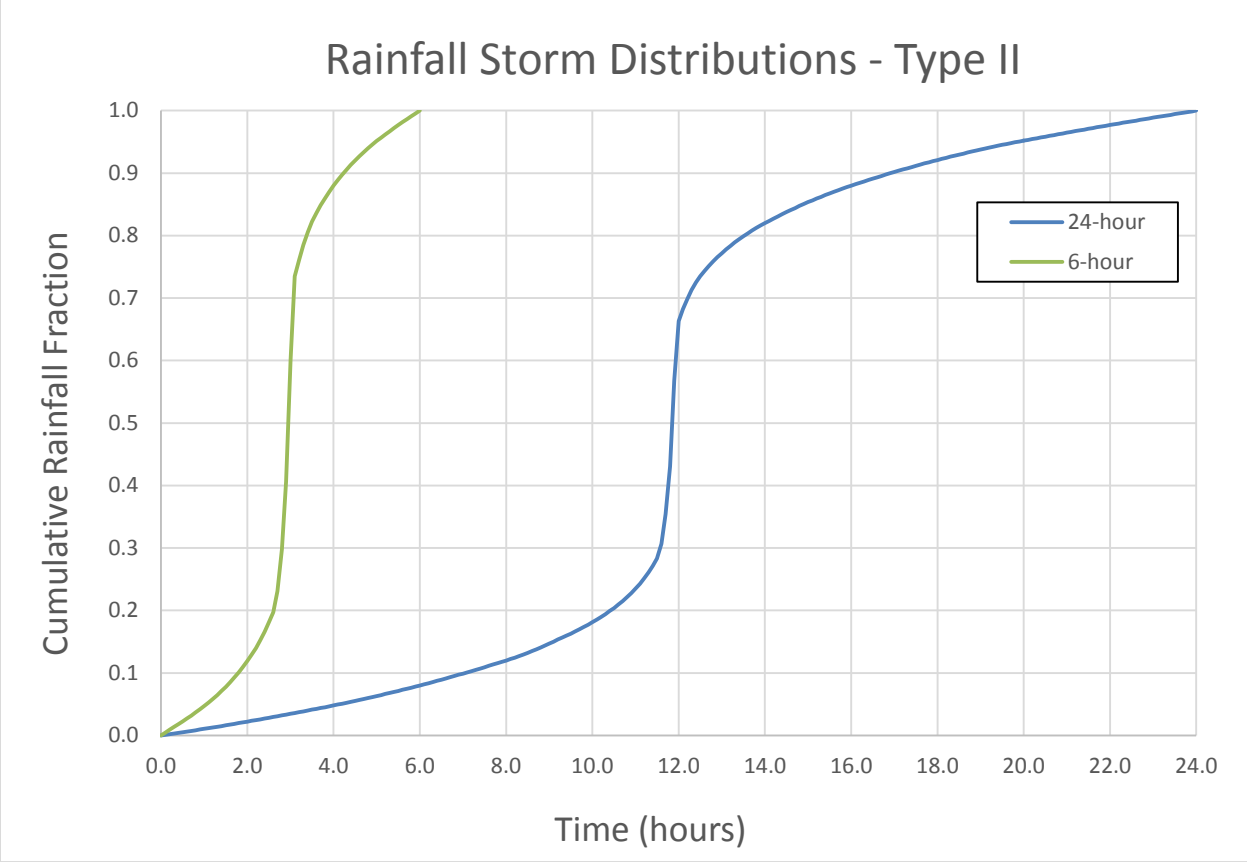


Figure 3. SCS Type II Rainfall Distribution

The inflow was routed through each pond using 1-minute time steps, the elevation-storage curves, elevation-discharge curves, and Equation 11.

$$V_t = V_{t-1} + V_{t(in)} - V_{t(out)} \qquad \text{Eqn. 11}$$

Where t = time step (minutes)
V = volume in pond at time t
V_{in} = volume flowing into the pond
V_{out} = volume flowing out of the pond

4. RESULTS AND CONCLUSIONS

Based on the analysis of both the 1,000-year, 24-hour storm and the 1,000-year, 6-hour storm, Ash Pond 2 and its associated downstream hydraulic structures convey the flow and maintain a minimum of 0.6 to 1.9 ft of freeboard. Tables 5 and 6 summarize the results of the maximum elevation reached in the ponds and the maximum inflows and outflows. Full inflow and outflow hydrographs are provided in Attachment D.

Table 5: Results 1,000-year, 24-hour Storm

Pond	Maximum Elevation (ft)	Freeboard[1] (ft)	Maximum Inflow (cfs)	Maximum Outflow (cfs)
Pond 1	533.1	1.9	53.5	17.9
Ash Pond 2	533.2	1.8	58.6	23.4
Pond 3	530.2	0.8	77.5	35.3

Table 6: Results 1,000-year, 6-hour Storm

Pond	Maximum Elevation (ft)	Freeboard[1] (ft)	Maximum Inflow (cfs)	Maximum Outflow (cfs)
Pond 1	533.3	1.7	75.8	18.3
Ash Pond 2	533.3	1.7	81.7	23.9
Pond 3	530.4	0.6	93.2	39.7

[1] Freeboard estimated based on available as-built and design elevations of pond crests (see Attachment A).

6. REFERENCES

Aero-Metric, Inc., 2008. Aerial topography, flight date: 06-17-2008, Project No. 1080609

ASCE, 1996. American Society of Civil Engineers Task Committee on Hydrology Handbook. Hydrology Handbook. ASCE Publications.

Federal Highway Administration. 2015, HY-8 Computer Program, Version 7.40, February 25, 2015.

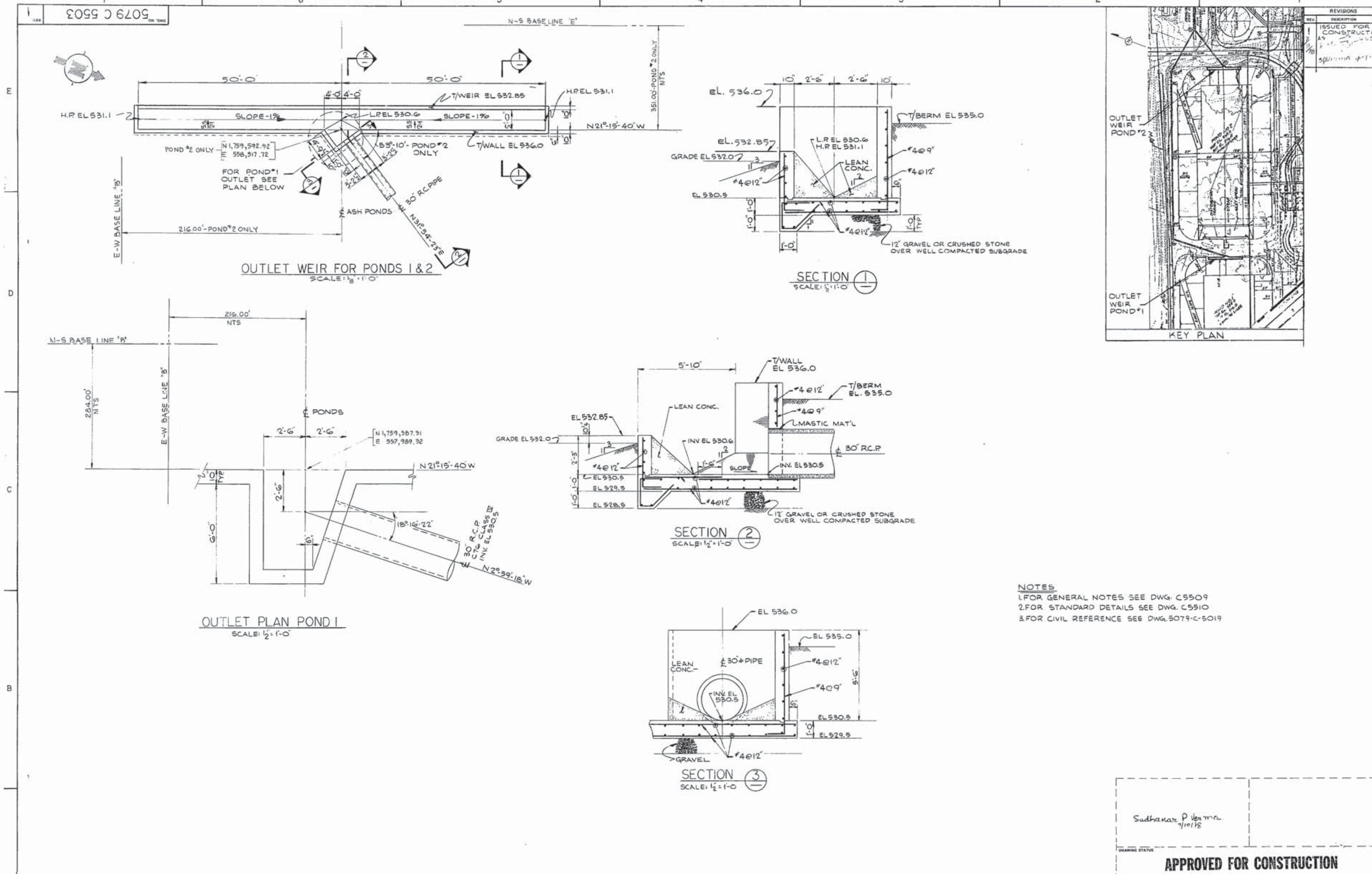
IDOT, 2011. Illinois Department of Transportation. Drainage Manual. July, 2011.

NOAA, 2016, NOAA Atlas 14 Point Precipitation Frequency Estimates: Illinois, available at: http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

United States Department of Agriculture and Natural Resource Conservation Service, 1993 "Chapter 4: Storm Rainfall Depth and Distribution." National Engineering Handbook Part 630 Hydrology. March 1993.

ATTACHMENT A

DESIGN DRAWINGS



NOTES
1. FOR GENERAL NOTES SEE DWG. C5509
2. FOR STANDARD DETAILS SEE DWG. C5510
3. FOR CIVIL REFERENCE SEE DWG. 5079-C-5019

REVISIONS: 1 ISSUED FOR CONSTRUCTION

APPROVED FOR CONSTRUCTION

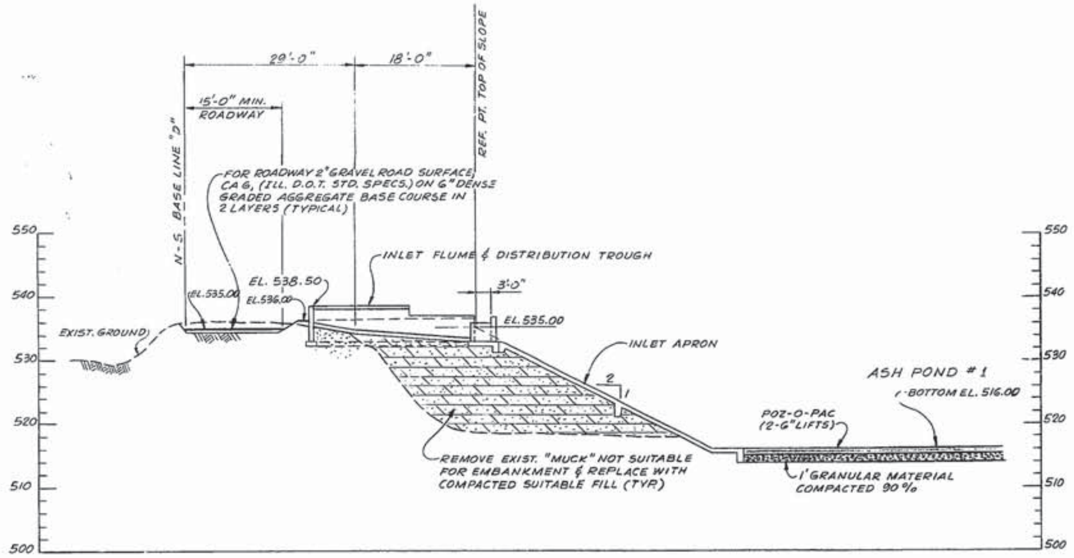
COMMONWEALTH EDISON COMPANY
WASTE WATER TREATMENT FACILITIES
JOLIET 7 - 8
ASH POND 1 & 2
OUTLET WEIRS

NUS CORPORATION, ROCKVILLE, MD.
DWG. NO. 5079 C 5503 REV. 1
SCALE: NOTED SHEET 1 OF 1

5079C5503

5079C5019 SH3

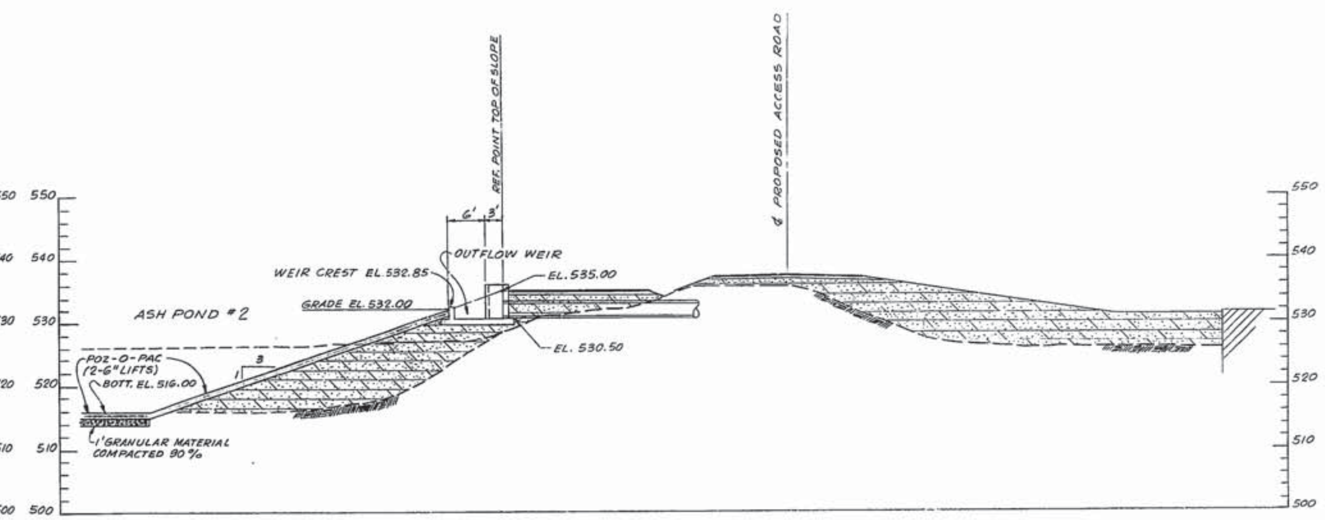
5079 C5019 REV. 2



SECTION AT INLET FLUME & DISTRIBUTION THROUGH ASH POND NO. 1

SCALE: HORIZ. 1"=10' VERT. 1"=10'

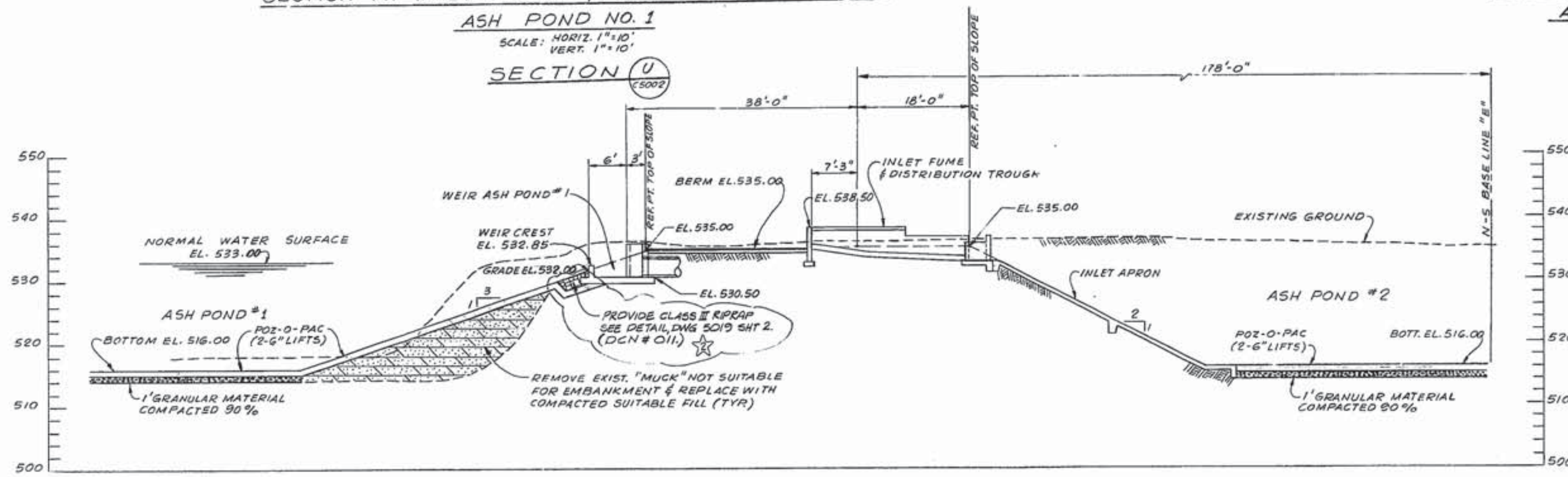
SECTION (U / C5002)



SECTION AT WEIR ASH POND NO. 2 AND ACCESS ROAD

SCALE: HORIZ. 1"=10' VERT. 1"=10'

SECTION (V / C5003)



SECTION AT WEIR ASH POND NO. 1 AND DISTRIBUTION THROUGH ASH POND NO. 2

SCALE: HORIZ. 1"=10' VERT. 1"=10'

SECTION (W / C5003)

FOR POZ-O-PAC NOTES SEE SHEET 2 OF 3

REVISIONS	
REV.	DESCRIPTION
1	APPROVED FOR CONSTRUCTION
2	REVISED SECTION (W) WEIR ASH POND #1 TO SHOW RIPRAP AS PER DCN # 011.

Sudhakar P. Verma 6/17/78

DRAWING STATUS: APPROVED FOR CONSTRUCTION 6/17/78

COMMONWEALTH EDISON COMPANY
WASTE WATER TREATMENT FACILITIES
JOLIET 7 - 8

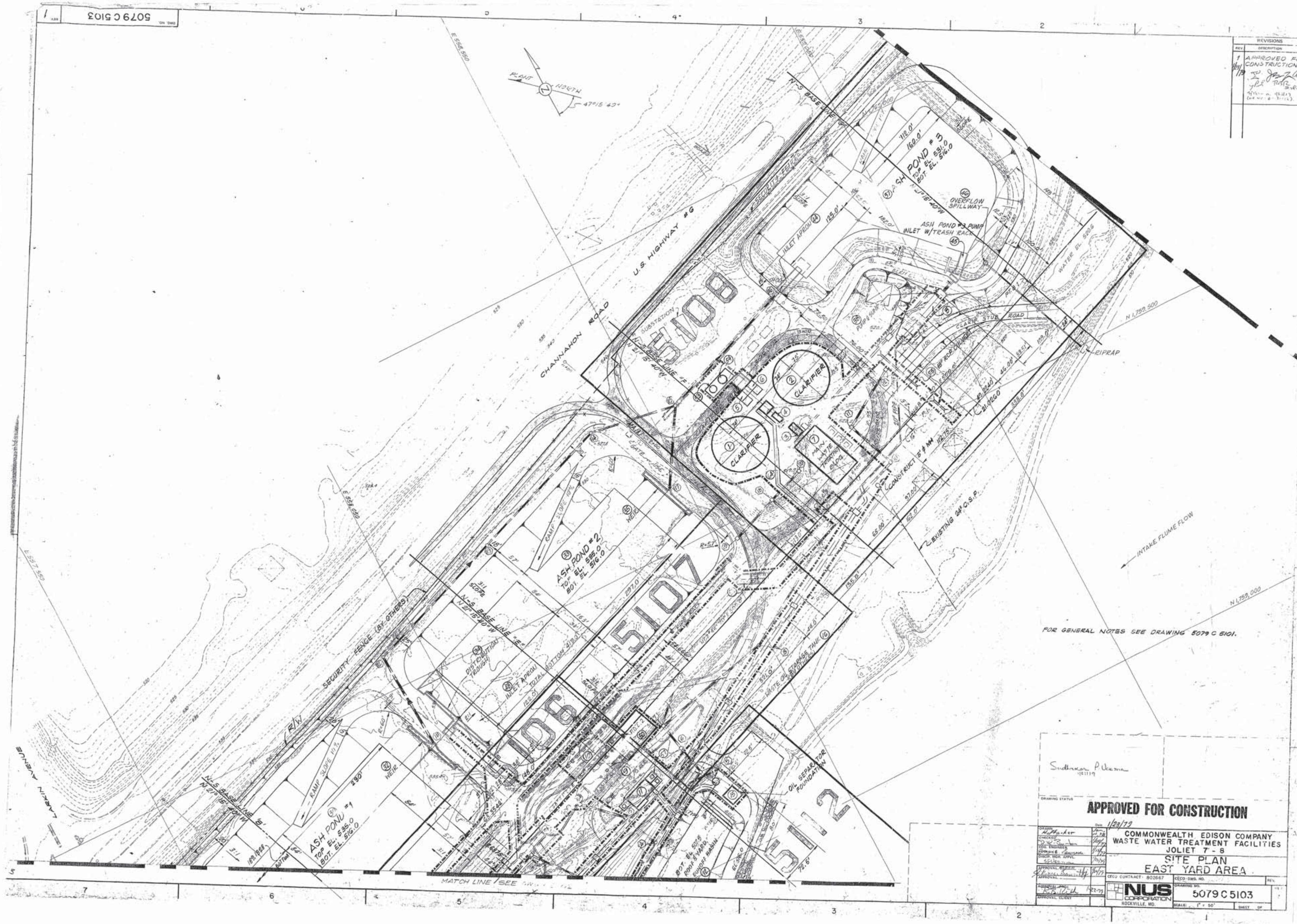
PONDS & BASINS PROFILES
SECTIONS & DETAILS

CECO CONTRACT: 802667

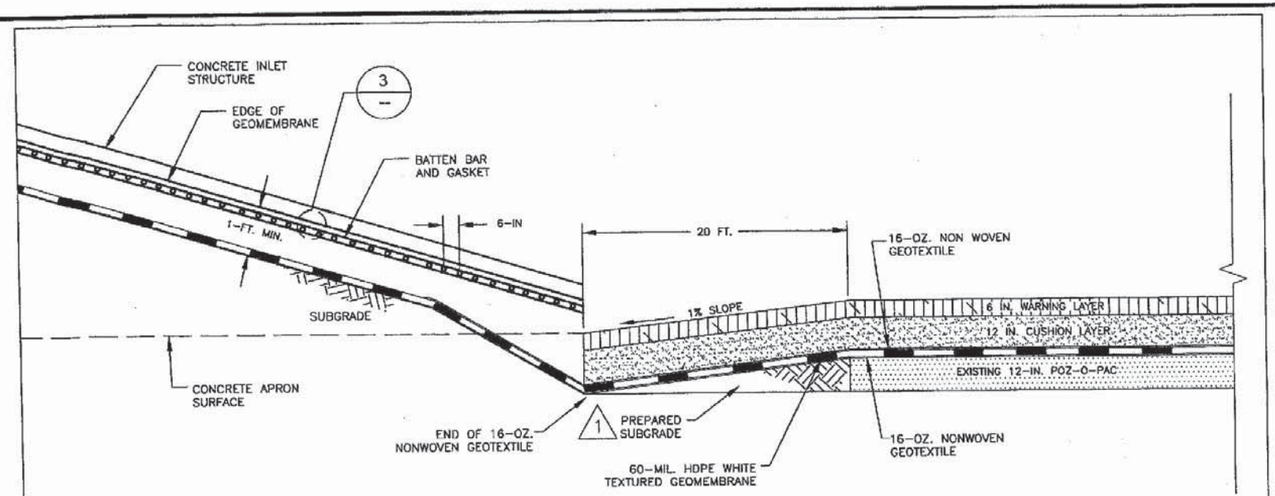
NUS CORPORATION ROCKVILLE, MD.

DRAWING NO. 5079C5019 REV. 2

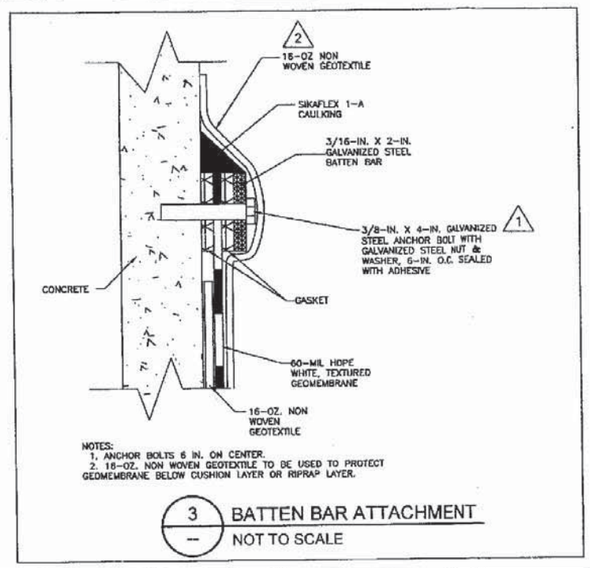
SCALE: AS NOTED SHEET 3 OF 3



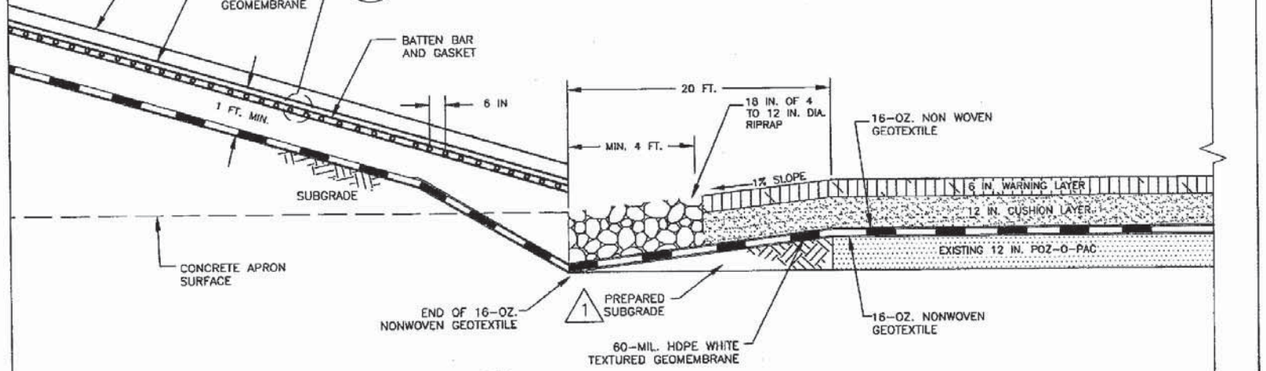
APPROVED FOR CONSTRUCTION
COMMONWEALTH EDISON COMPANY
WASTE WATER TREATMENT FACILITIES
JOLIET 7 - 8
SITE PLAN
EAST YARD AREA
CECO CONTRACT: 802667
NUS CORPORATION
ROCKVILLE, MD.
5079 C 5103
SCALE: 1" = 50'
FOR GENERAL NOTES SEE DRAWING 5079 C 5101.
ASH POND #1
ASH POND #2
ASH POND #3
CLARIFIER
CHANNAHON ROAD
U.S. HIGHWAY #6
SECURITY FENCE (BY OTHERS)
LARKIN AVENUE
INTAKE FLUME FLOW
OVERFLOW SPILLWAY
OIL SEPARATOR FOUNDATION
5106
5107
5108
5112



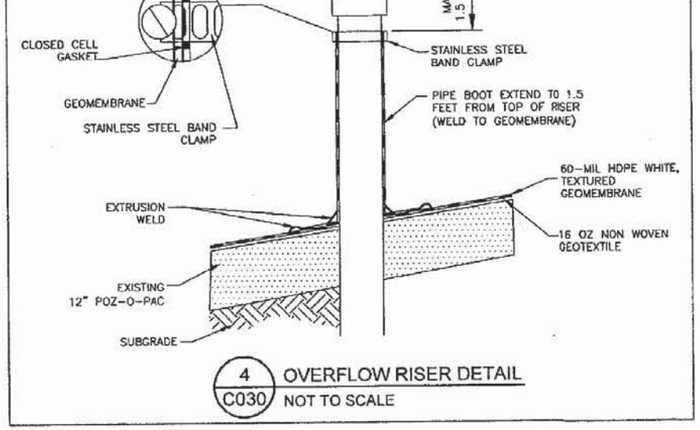
C / C030 CONCRETE RECYCLE SUMP SECTION
NOT TO SCALE



3 / – BATTEN BAR ATTACHMENT
NOT TO SCALE



D / C030 CONCRETE INLET SECTION
NOT TO SCALE



4 / C030 OVERFLOW RISER DETAIL
NOT TO SCALE

CONTRACTOR NOTES:
1. CONTRACTOR SHALL REMOVE 12 INCH POZ-O-PAC LAYER AND ADDITIONAL 6 INCHES OF SUBGRADE MATERIAL AT BASE OF STRUCTURE. GRADE SUBGRADE AT A 1% SLOPE.

6.			
5.			
4.			
3.			
2.			
1.			
0.	ISSUED FOR PERMIT	01/03/13	HMS
REVISION:		DATE:	APP'D BY:

NATURAL RESOURCE TECHNOLOGY

PROJECT NO.	2113.3
DRAWN BY:	RLH 12/13/12
CHECKED BY:	RJG 12/13/12
APPROVED BY:	HMS 01/03/13

DETAILS AND SECTIONS

SOUTH POND #3 LINER REPLACEMENT
JOLIET GENERATING STATION NO. 29
MIDWEST GENERATION
JOLIET, ILLINOIS

DRAWING NO: 2113SC032-00
REFERENCE: .

SHEET NO. C032

ATTACHMENT B

NOAA ATLAS 14

General Info
Homepage
Current Projects
FAQ
Glossary

Precipitation Frequency (PF)
PF Data Server
- PF in GIS Format
- PF Maps
- Temporal Distr.
- Time Series Data
- PFDS Perform.

PF Documents

Probable Maximum Precipitation (PMP)
PMP Documents

Miscellaneous
Publications
AEP Storm Analysis
Record Precipitation

Contact Us
Inquiries
List-server

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: IL

DATA DESCRIPTION

Data type: precipitation depth **Units:** english **Time series type:** partial duration

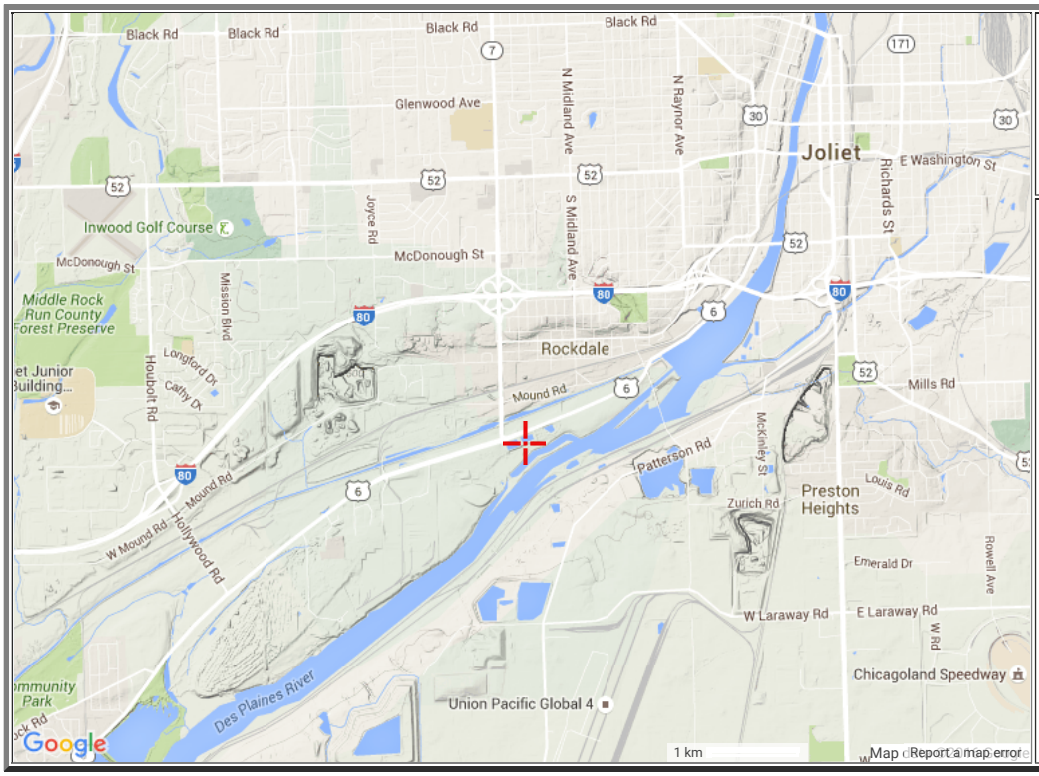
SELECT LOCATION

1. Manually:

a) Enter location (decimal degrees, use "-" for S and W): latitude: longitude: submit

b) Select station (click here for a list of stations used in frequency analysis for IL): select station

2. Use map:



a) Select location
(move crosshair or double click)
b) Click on station icon
(show stations on map)

LOCATION INFORMATION:
Name: Joliet, Illinois, US*
Latitude: 41.4971°
Longitude: -88.1210°
Elevation: 531 ft*

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 2, Version 3

PF tabular | PF graphical | Supplementary information | Print Page

PDS-based 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	0.388 (0.350-0.432)	0.432 (0.393-0.475)	0.472 (0.430-0.519)	0.570 (0.518-0.628)	0.653 (0.589-0.719)	0.753 (0.673-0.833)	0.840 (0.742-0.935)	0.936 (0.815-1.05)	1.05 (0.900-1.20)	1.20 (1.00-1.39)
10-min	0.603 (0.544-0.671)	0.674 (0.614-0.742)	0.733 (0.668-0.807)	0.880 (0.800-0.969)	0.999 (0.901-1.10)	1.14 (1.02-1.26)	1.26 (1.12-1.41)	1.40 (1.22-1.57)	1.55 (1.32-1.76)	1.75 (1.46-2.02)
15-min	0.739 (0.667-0.823)	0.824 (0.750-0.907)	0.900 (0.820-0.991)	1.08 (0.984-1.19)	1.23 (1.11-1.36)	1.41 (1.26-1.56)	1.57 (1.39-1.75)	1.74 (1.51-1.95)	1.93 (1.65-2.19)	2.19 (1.83-2.53)
30-min	0.978 (0.882-1.09)	1.10 (1.00-1.21)	1.23 (1.12-1.36)	1.50 (1.37-1.66)	1.74 (1.57-1.92)	2.02 (1.80-2.23)	2.27 (2.00-2.52)	2.54 (2.21-2.85)	2.86 (2.45-3.25)	3.28 (2.74-3.79)
60-min	1.19 (1.08-1.33)	1.35 (1.23-1.49)	1.55 (1.41-1.70)	1.91 (1.74-2.11)	2.26 (2.04-2.49)	2.66 (2.38-2.94)	3.03 (2.68-3.37)	3.44 (3.00-3.87)	3.96 (3.38-4.49)	4.61 (3.85-5.33)
2-hr	1.39 (1.25-1.54)	1.58 (1.44-1.74)	1.82 (1.65-2.00)	2.27 (2.06-2.50)	2.70 (2.43-2.98)	3.21 (2.86-3.56)	3.68 (3.25-4.11)	4.21 (3.66-4.73)	4.88 (4.16-5.54)	5.72 (4.76-6.61)
3-hr	1.50 (1.34-1.67)	1.70 (1.54-1.89)	1.97 (1.78-2.19)	2.47 (2.23-2.75)	2.95 (2.65-3.29)	3.52 (3.12-3.93)	4.05 (3.55-4.55)	4.65 (4.01-5.26)	5.40 (4.58-6.17)	6.36 (5.26-7.39)
6-hr	1.78 (1.59-2.02)	2.02 (1.82-2.28)	2.36 (2.11-2.66)	3.00 (2.68-3.38)	3.65 (3.24-4.12)	4.46 (3.90-5.04)	5.25 (4.51-5.96)	6.15 (5.19-7.03)	7.34 (6.05-8.47)	8.89 (7.11-10.4)

12-hr	**2.06** (1.83-2.36)	**2.34** (2.09-2.66)	**2.71** (2.42-3.08)	**3.42** (3.04-3.89)	**4.15** (3.65-4.72)	**5.04** (4.38-5.74)	**5.90** (5.06-6.75)	**6.90** (5.81-7.95)	**8.21** (6.75-9.54)	**9.90** (7.90-11.7)
24-hr	**2.39** (2.16-2.66)	**2.88** (2.62-3.23)	**3.68** (3.32-4.11)	**4.38** (3.92-4.92)	**5.51** (4.85-6.20)	**6.56** (5.68-7.46)	**7.82** (6.63-8.97)	**9.33** (7.70-10.8)	**11.8** (9.39-14.0)	**14.2** (10.9-17.2)
2-day	**2.77** (2.52-3.10)	**3.34** (3.03-3.73)	**4.20** (3.80-4.70)	**4.96** (4.45-5.56)	**6.17** (5.43-6.97)	**7.29** (6.30-8.31)	**8.60** (7.29-9.94)	**10.2** (8.39-11.9)	**12.7** (10.1-15.3)	**15.1** (11.7-18.6)
3-day	**2.94** (2.69-3.25)	**3.53** (3.23-3.91)	**4.40** (4.01-4.88)	**5.19** (4.68-5.78)	**6.45** (5.71-7.25)	**7.62** (6.63-8.66)	**9.01** (7.68-10.4)	**10.7** (8.87-12.5)	**13.5** (10.7-16.3)	**16.1** (12.4-19.9)
4-day	**3.10** (2.86-3.41)	**3.71** (3.43-4.08)	**4.60** (4.23-5.06)	**5.41** (4.92-5.99)	**6.72** (6.00-7.52)	**7.95** (6.96-9.02)	**9.43** (8.07-10.8)	**11.2** (9.34-13.1)	**14.2** (11.4-17.2)	**17.1** (13.2-21.3)
7-day	**3.63** (3.38-3.95)	**4.31** (4.02-4.70)	**5.24** (4.87-5.71)	**6.09** (5.60-6.65)	**7.45** (6.74-8.24)	**8.72** (7.74-9.76)	**10.2** (8.88-11.6)	**12.0** (10.2-14.0)	**15.1** (12.2-18.0)	**17.9** (14.1-22.0)
10-day	**4.12** (3.86-4.43)	**4.87** (4.57-5.25)	**5.85** (5.48-6.30)	**6.74** (6.26-7.29)	**8.14** (7.45-8.88)	**9.43** (8.48-10.4)	**10.9** (9.65-12.3)	**12.7** (11.0-14.6)	**15.6** (13.0-18.4)	**18.5** (14.9-22.4)
20-day	**5.61** (5.28-5.99)	**6.62** (6.23-7.07)	**7.82** (7.35-8.35)	**8.87** (8.30-9.50)	**10.5** (9.69-11.3)	**11.9** (10.9-13.0)	**13.6** (12.2-15.0)	**15.5** (13.6-17.4)	**18.5** (15.8-21.4)	**21.2** (17.6-25.0)
30-day	**6.97** (6.59-7.40)	**8.19** (7.75-8.70)	**9.54** (9.00-10.1)	**10.7** (10.0-11.4)	**12.4** (11.5-13.3)	**13.9** (12.8-15.0)	**15.5** (14.1-17.0)	**17.4** (15.5-19.3)	**20.2** (17.6-23.0)	**22.6** (19.3-26.2)
45-day	**8.76** (8.30-9.27)	**10.3** (9.74-10.9)	**11.8** (11.2-12.5)	**13.1** (12.4-13.9)	**15.0** (14.0-16.0)	**16.6** (15.4-17.8)	**18.3** (16.7-19.8)	**20.1** (18.2-22.1)	**22.8** (20.3-25.6)	**25.2** (22.0-28.7)
60-day	**10.6** (10.0-11.2)	**12.4** (11.8-13.1)	**14.2** (13.5-15.0)	**15.7** (14.8-16.5)	**17.7** (16.6-18.8)	**19.4** (18.1-20.8)	**21.3** (19.6-23.0)	**23.2** (21.2-25.3)	**26.0** (23.4-28.9)	**28.4** (25.1-31.9)

[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.

Estimates from the table in csv format: precipitation frequency estimates ▼ Submit

Main Link Categories:
Home | OWP(OHD)

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Water Prediction (OWP)
1325 East West Highway
Silver Spring, MD 20910
Page Author: HDSC webmaster
Page last modified: August 27, 2014

Map Disclaimer
Disclaimer
Credits
Glossary

Privacy F
Abo
Career Opportu

ATTACHMENT C

HY-8 RESULTS

HY-8 Culvert Analysis Report
Culvert 1

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: Culvert 1 (TW=529.25)

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
531.06	1.62	1.62	0.00	1
531.31	3.24	3.24	0.00	1
531.50	4.86	4.86	0.00	1
531.66	6.48	6.48	0.00	1
531.82	8.10	8.10	0.00	1
531.98	9.72	9.72	0.00	1
532.13	11.34	11.34	0.00	1
532.41	12.96	12.96	0.00	1
532.54	14.58	14.58	0.00	1
532.67	16.20	16.20	0.00	1
532.79	17.82	17.82	0.00	1
532.91	19.44	19.44	0.00	1
533.02	21.06	21.06	0.00	1
533.14	22.68	22.68	0.00	1
533.26	24.30	24.30	0.00	1
533.38	25.92	25.92	0.00	1
533.55	27.54	27.54	0.00	1
535.04	35.00	32.22	2.70	18
535.00	32.08	32.08	0.00	Overtopping

Rating Curve Plot for Crossing: Culvert 1 (TW=529.25)

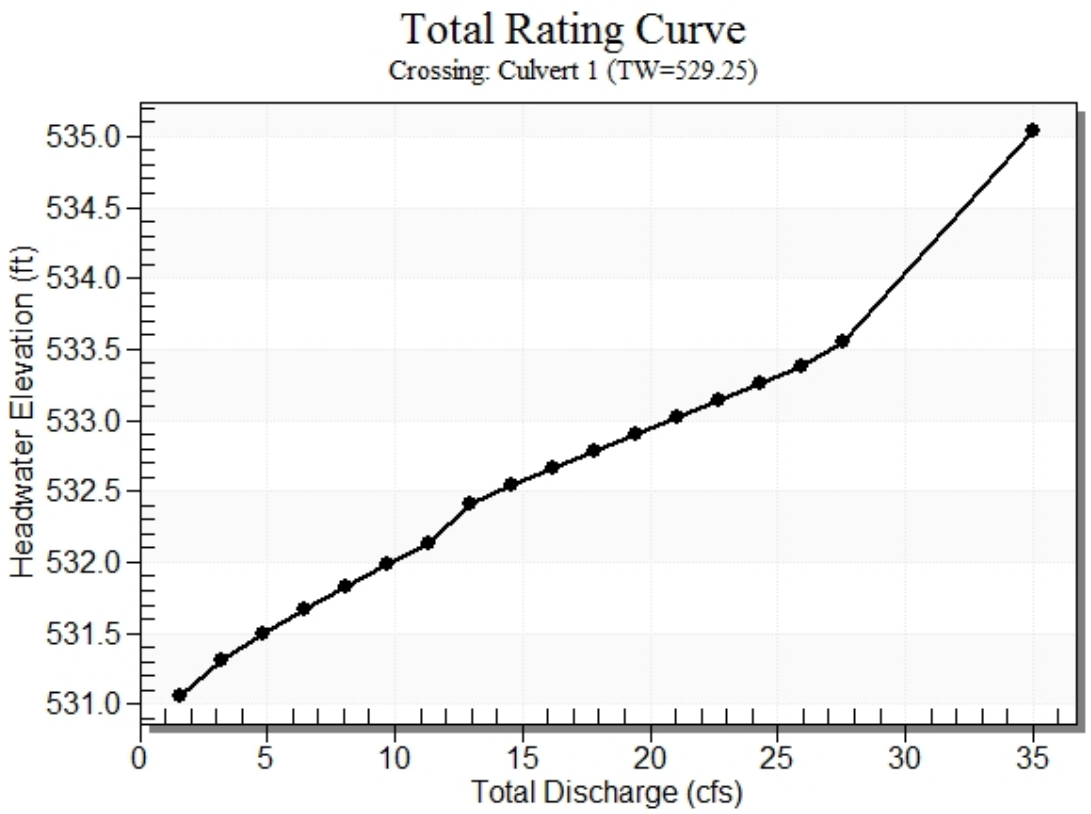


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1.62	1.62	531.06	0.563	0.0*	1-S2n	0.412	0.412	0.412	1.290	2.966	0.000
3.24	3.24	531.31	0.805	0.0*	1-S2n	0.581	0.587	0.581	1.290	3.605	0.000
4.86	4.86	531.50	0.997	0.0*	1-S2n	0.714	0.722	0.714	1.290	4.050	0.000
6.48	6.48	531.66	1.161	0.0*	1-JS1t	0.830	0.841	1.290	1.290	2.455	0.000
8.10	8.10	531.82	1.322	0.0*	1-S2n	0.935	0.944	0.935	1.290	4.672	0.000
9.72	9.72	531.98	1.483	0.0*	1-S2n	1.034	1.038	1.034	1.290	4.902	0.000
11.34	11.34	532.13	1.632	0.0*	1-S2n	1.127	1.128	1.127	1.290	5.105	0.000
12.96	12.96	532.41	1.772	1.912	3-M1t	1.218	1.210	1.290	1.290	5.074	0.000
14.58	14.58	532.54	1.904	2.042	3-M2t	1.307	1.286	1.290	1.290	5.708	0.000
16.20	16.20	532.67	2.031	2.166	2-M2c	1.396	1.356	1.356	1.290	5.958	0.000
17.82	17.82	532.79	2.156	2.287	2-M2c	1.484	1.426	1.426	1.290	6.158	0.000
19.44	19.44	532.91	2.279	2.405	2-M2c	1.574	1.491	1.491	1.290	6.368	0.000
21.06	21.06	533.02	2.403	2.522	7-M2c	1.667	1.557	1.557	1.290	6.554	0.000
22.68	22.68	533.14	2.530	2.639	7-M2c	1.766	1.617	1.617	1.290	6.753	0.000
24.30	24.30	533.26	2.660	2.758	7-M2c	1.873	1.675	1.675	1.290	6.952	0.000
25.92	25.92	533.38	2.795	2.883	7-M2c	1.998	1.730	1.730	1.290	7.151	0.000
27.54	27.54	533.55	2.936	3.051	7-M2c	2.500	1.787	1.787	1.290	7.335	0.000
35.00	32.22	535.04	3.384	4.544	7-M2c	2.500	1.931	1.931	1.290	7.922	0.000

* Full Flow Headwater elevation is below inlet invert.

****

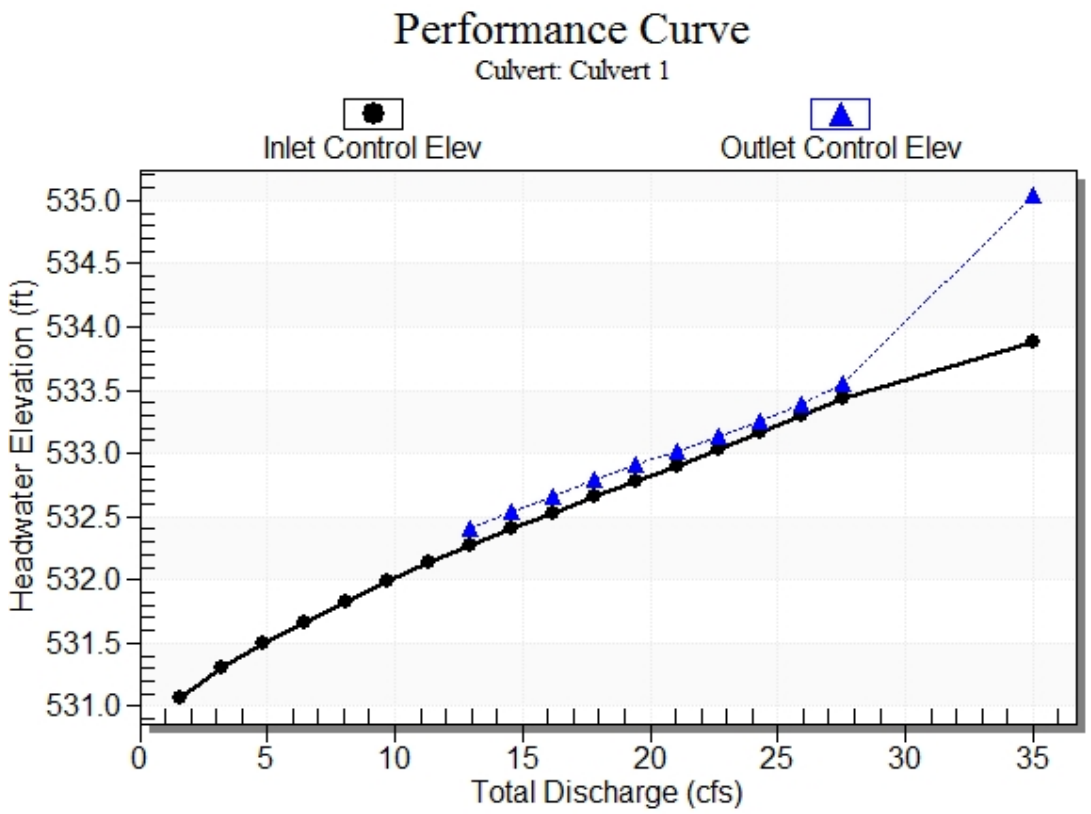
Straight Culvert

Inlet Elevation (invert): 530.50 ft, Outlet Elevation (invert): 527.96 ft

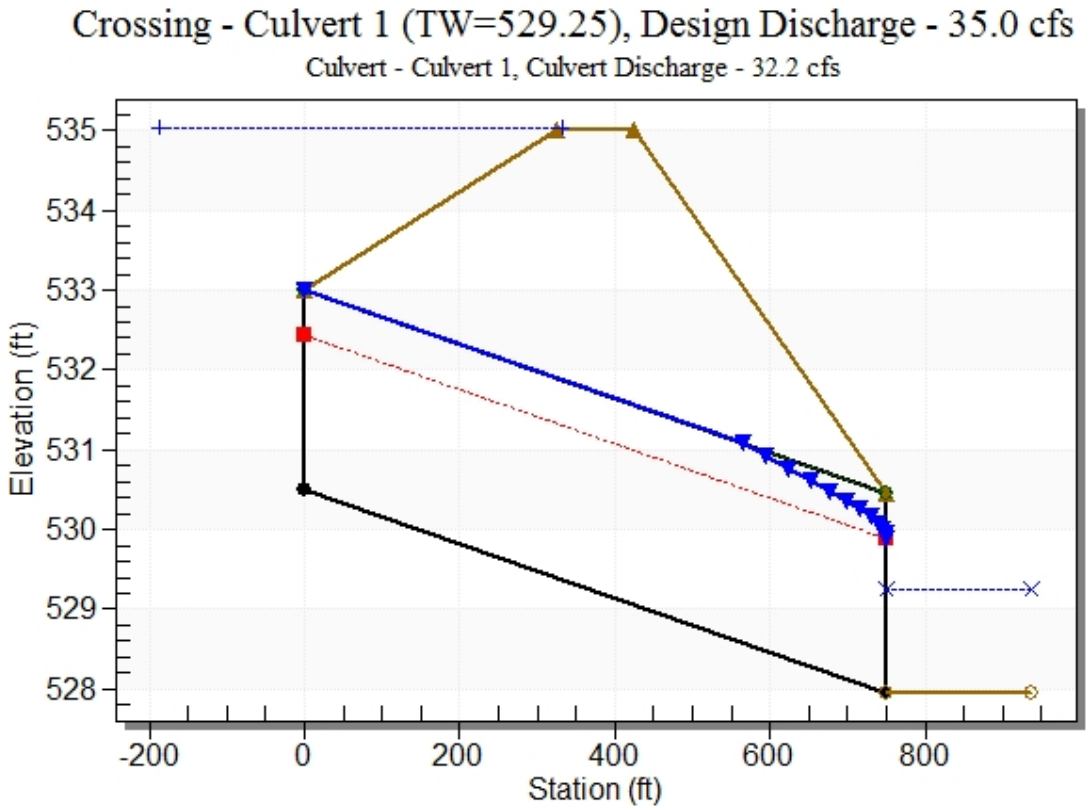
Culvert Length: 750.00 ft, Culvert Slope: 0.0034

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 530.50 ft

Outlet Station: 750.00 ft

Outlet Elevation: 527.96 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Culvert 1 (TW=529.25))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
1.62	529.25	1.29
3.24	529.25	1.29
4.86	529.25	1.29
6.48	529.25	1.29
8.10	529.25	1.29
9.72	529.25	1.29
11.34	529.25	1.29
12.96	529.25	1.29
14.58	529.25	1.29
16.20	529.25	1.29
17.82	529.25	1.29
19.44	529.25	1.29
21.06	529.25	1.29
22.68	529.25	1.29
24.30	529.25	1.29
25.92	529.25	1.29
27.54	529.25	1.29
35.00	529.25	1.29

Tailwater Channel Data - Culvert 1 (TW=529.25)

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 529.25 ft

Roadway Data for Crossing: Culvert 1 (TW=529.25)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 535.00 ft

Roadway Surface: Paved

Roadway Top Width: 100.00 ft

HY-8 Culvert Analysis Report
Culvert 2

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: Culvert 2 (TW=529.25)

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
531.17	2.34	2.34	0.00	1
531.46	4.65	4.65	0.00	1
531.69	6.96	6.96	0.00	1
531.92	9.27	9.27	0.00	1
532.13	11.58	11.58	0.00	1
532.33	13.89	13.89	0.00	1
532.51	16.20	16.20	0.00	1
532.69	18.51	18.51	0.00	1
532.87	20.82	20.82	0.00	1
533.05	23.13	23.13	0.00	1
533.24	25.44	25.44	0.00	1
533.44	27.75	27.75	0.00	1
533.65	30.06	30.06	0.00	1
533.88	32.37	32.37	0.00	1
534.13	34.68	34.68	0.00	1
534.39	36.99	36.99	0.00	1
534.68	39.30	39.30	0.00	1
535.05	45.00	42.05	2.82	14
535.00	41.72	41.72	0.00	Overtopping

Rating Curve Plot for Crossing: Culvert 2 (TW=529.25)

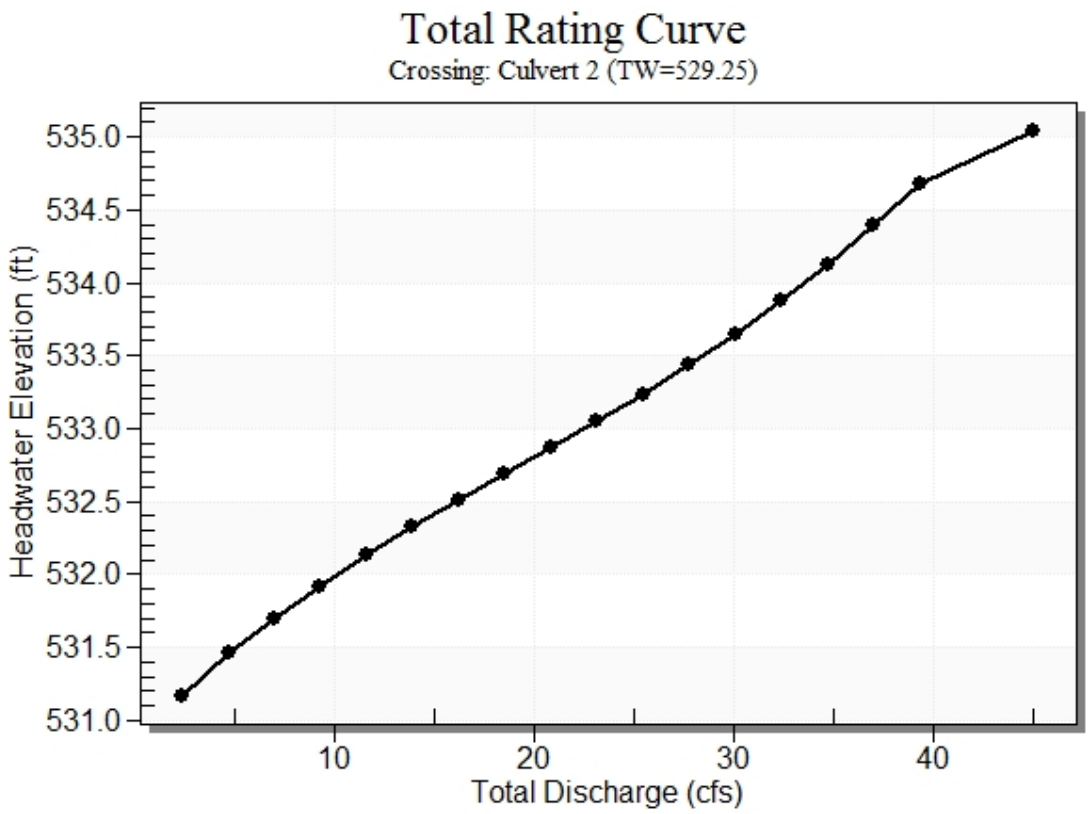


Table 2 - Culvert Summary Table: Culvert 2

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2.34	2.34	531.17	0.673	0.0*	1-JS1t	0.325	0.495	1.290	1.290	0.887	0.000
4.65	4.65	531.46	0.961	0.0*	1-JS1t	0.454	0.706	1.290	1.290	1.762	0.000
6.96	6.96	531.69	1.192	0.0*	1-S2n	0.554	0.870	0.554	1.290	8.314	0.000
9.27	9.27	531.92	1.420	0.0*	1-S2n	0.641	1.011	0.668	1.290	8.488	0.000
11.58	11.58	532.13	1.634	0.0*	1-S2n	0.718	1.141	0.749	1.290	9.051	0.000
13.89	13.89	532.33	1.829	0.0*	1-S2n	0.789	1.254	0.830	1.290	9.405	0.000
16.20	16.20	532.51	2.012	0.0*	1-S2n	0.856	1.356	0.856	1.290	10.525	0.000
18.51	18.51	532.69	2.189	0.0*	1-S2n	0.920	1.454	0.963	1.290	10.256	0.000
20.82	20.82	532.87	2.366	0.0*	1-S2n	0.980	1.548	1.039	1.290	10.433	0.000
23.13	23.13	533.05	2.546	0.0*	5-S2n	1.039	1.633	1.095	1.290	10.806	0.000
25.44	25.44	533.24	2.735	0.240	5-S2n	1.096	1.714	1.161	1.290	11.023	0.000
27.75	27.75	533.44	2.935	0.522	5-S2n	1.152	1.794	1.224	1.290	11.236	0.000
30.06	30.06	533.65	3.150	0.814	5-S2n	1.207	1.867	1.281	1.290	11.494	0.000
32.37	32.37	533.88	3.380	1.403	5-S2n	1.261	1.935	1.336	1.290	11.738	0.000
34.68	34.68	534.13	3.627	1.690	5-S2n	1.314	1.999	1.397	1.290	11.909	0.000
36.99	36.99	534.39	3.893	1.992	5-S2n	1.368	2.058	1.456	1.290	12.082	0.000
39.30	39.30	534.68	4.179	2.309	5-S2n	1.421	2.112	1.512	1.290	12.271	0.000
45.00	42.05	535.05	4.545	2.707	5-S2n	1.485	2.171	1.585	1.290	12.430	0.000

* Full Flow Headwater elevation is below inlet invert.

****

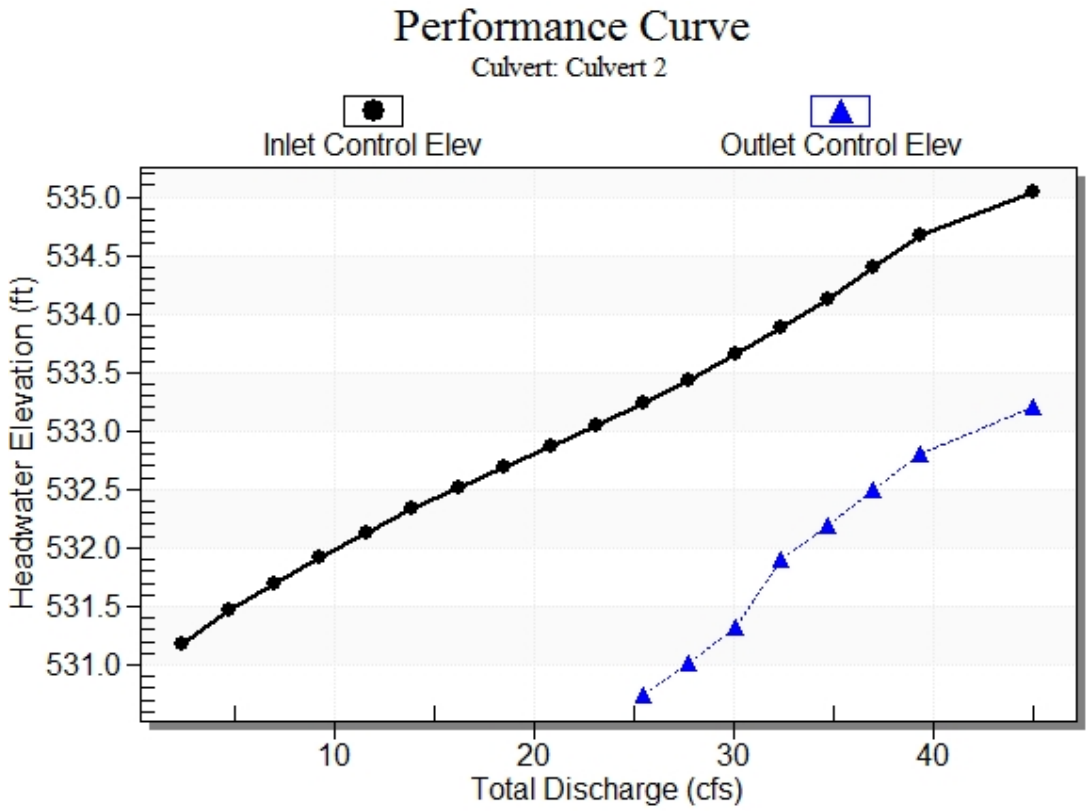
Straight Culvert

Inlet Elevation (invert): 530.50 ft, Outlet Elevation (invert): 527.96 ft

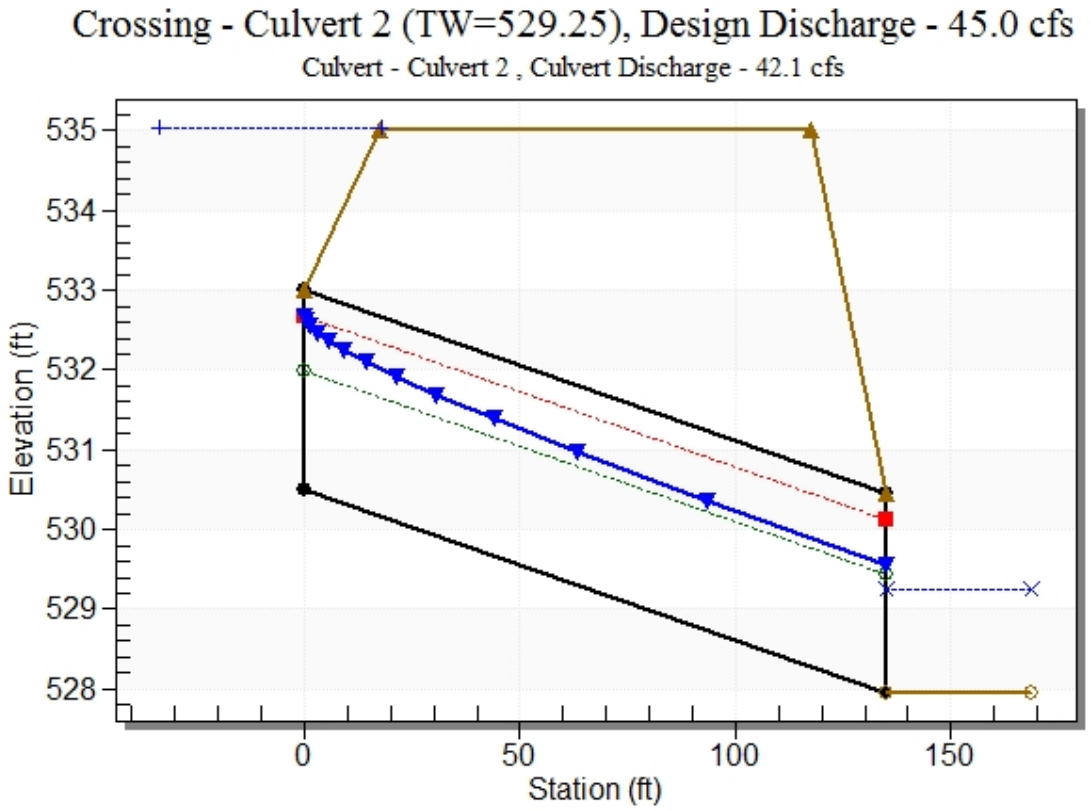
Culvert Length: 135.02 ft, Culvert Slope: 0.0188

****

Culvert Performance Curve Plot: Culvert 2



Water Surface Profile Plot for Culvert: Culvert 2



Site Data - Culvert 2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 530.50 ft

Outlet Station: 135.00 ft

Outlet Elevation: 527.96 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 2

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Culvert 2 (TW=529.25))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
2.34	529.25	1.29
4.65	529.25	1.29
6.96	529.25	1.29
9.27	529.25	1.29
11.58	529.25	1.29
13.89	529.25	1.29
16.20	529.25	1.29
18.51	529.25	1.29
20.82	529.25	1.29
23.13	529.25	1.29
25.44	529.25	1.29
27.75	529.25	1.29
30.06	529.25	1.29
32.37	529.25	1.29
34.68	529.25	1.29
36.99	529.25	1.29
39.30	529.25	1.29
45.00	529.25	1.29

Tailwater Channel Data - Culvert 2 (TW=529.25)

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 529.25 ft

Roadway Data for Crossing: Culvert 2 (TW=529.25)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 535.00 ft

Roadway Surface: Paved

Roadway Top Width: 100.00 ft

HY-8 Culvert Analysis Report
Culvert 1&2

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: Culvert 1&2 (TW=529.25)

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1&2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
529.28	2.90	2.90	0.00	1
529.37	5.70	5.70	0.00	1
529.52	8.50	8.50	0.00	1
529.71	11.30	11.30	0.00	1
529.95	14.10	14.10	0.00	1
530.20	16.90	16.90	0.00	1
530.26	19.70	19.70	0.00	1
530.61	22.50	22.50	0.00	1
530.79	25.30	25.30	0.00	1
531.02	28.10	28.10	0.00	1
531.43	30.90	30.90	0.00	1
531.84	33.70	33.70	0.00	1
532.29	36.50	36.50	0.00	1
532.77	39.30	39.30	0.00	1
533.29	42.10	42.10	0.00	1
533.85	44.90	44.90	0.00	1
534.44	47.70	47.70	0.00	1
535.03	52.00	50.34	1.54	27
535.00	50.21	50.21	0.00	Overtopping

Rating Curve Plot for Crossing: Culvert 1&2 (TW=529.25)

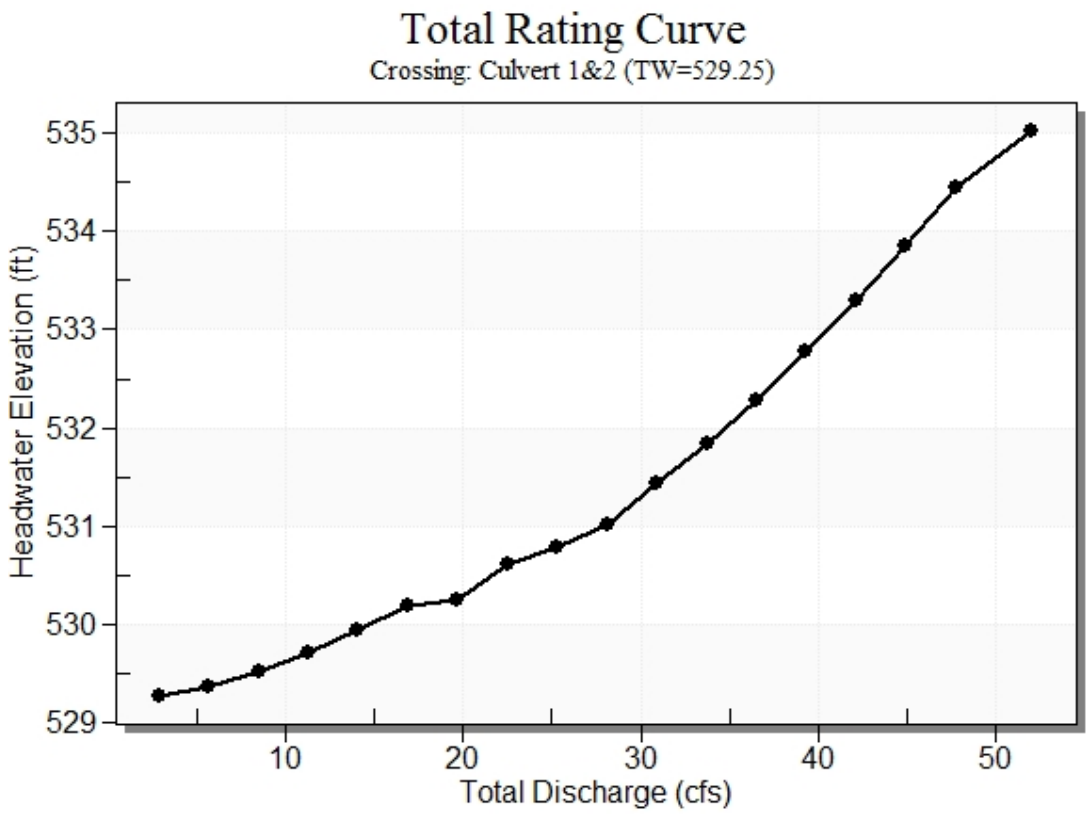


Table 2 - Culvert Summary Table: Culvert 1&2

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2.90	2.90	529.28	0.760	1.322	1-S1f	0.502	0.554	2.500	2.560	0.591	0.000
5.70	5.70	529.37	1.083	1.411	1-S1f	0.707	0.786	2.500	2.560	1.161	0.000
8.50	8.50	529.52	1.361	1.556	1-S1f	0.871	0.968	2.500	2.560	1.732	0.000
11.30	11.30	529.71	1.627	1.750	1-S1f	1.016	1.126	2.500	2.560	2.302	0.000
14.10	14.10	529.95	1.863	1.991	1-S1f	1.151	1.264	2.500	2.560	2.872	0.000
16.90	16.90	530.20	2.083	2.240	1-S1f	1.281	1.385	2.500	2.560	3.443	0.000
19.70	19.70	530.26	2.297	2.175	1-S2n	1.408	1.501	1.408	2.560	6.699	0.000
22.50	22.50	530.61	2.514	2.654	1-S1f	1.537	1.610	2.500	2.560	4.584	0.000
25.30	25.30	530.79	2.741	2.832	1-S1f	1.670	1.709	2.500	2.560	5.154	0.000
28.10	28.10	531.02	2.984	3.063	3-M1f	1.815	1.805	2.500	2.560	5.724	0.000
30.90	30.90	531.43	3.249	3.468	4-FFf	1.985	1.892	2.500	2.560	6.295	0.000
33.70	33.70	531.84	3.537	3.881	4-FFf	2.500	1.972	2.500	2.560	6.865	0.000
36.50	36.50	532.29	3.853	4.329	4-FFf	2.500	2.046	2.500	2.560	7.436	0.000
39.30	39.30	532.77	4.196	4.813	4-FFf	2.500	2.112	2.500	2.560	8.006	0.000
42.10	42.10	533.29	4.569	5.333	4-FFf	2.500	2.172	2.500	2.560	8.577	0.000
44.90	44.90	533.85	4.971	5.889	4-FFf	2.500	2.224	2.500	2.560	9.147	0.000
47.70	47.70	534.44	5.401	6.480	4-FFf	2.500	2.269	2.500	2.560	9.717	0.000
52.00	50.34	535.03	5.832	7.070	4-FFf	2.500	2.303	2.500	2.560	10.255	0.000

****

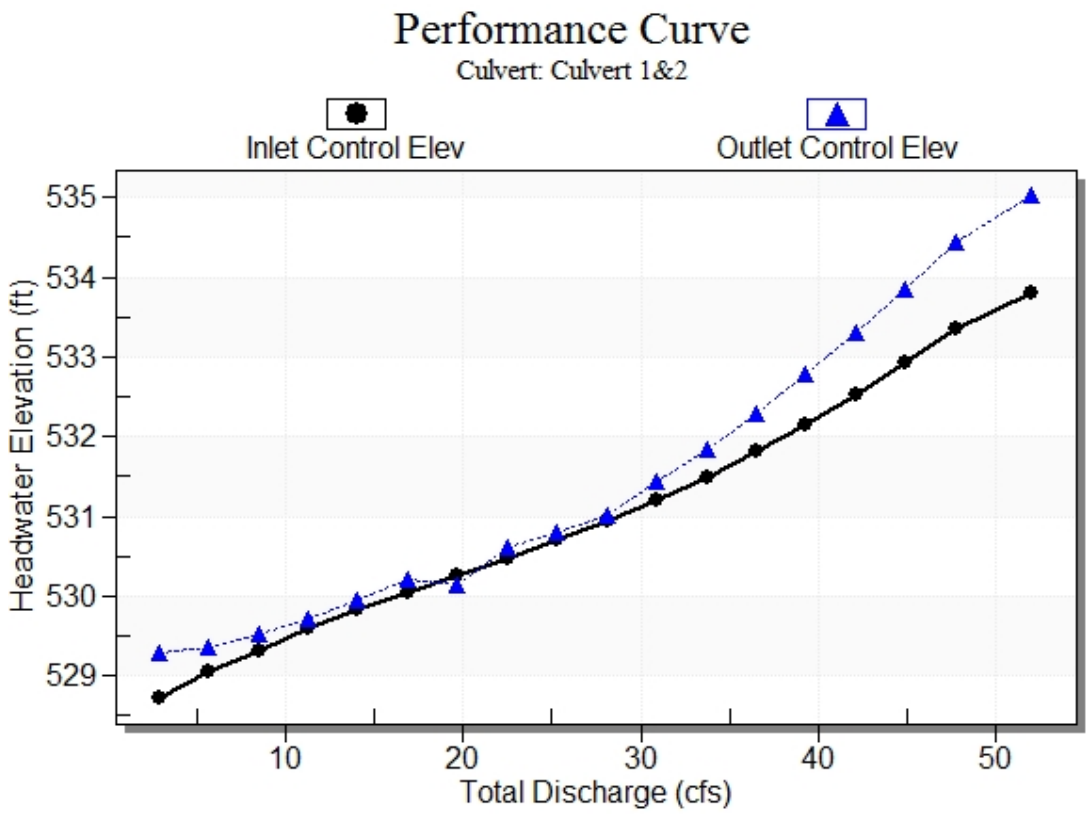
Straight Culvert

Inlet Elevation (invert): 527.96 ft, Outlet Elevation (invert): 526.69 ft

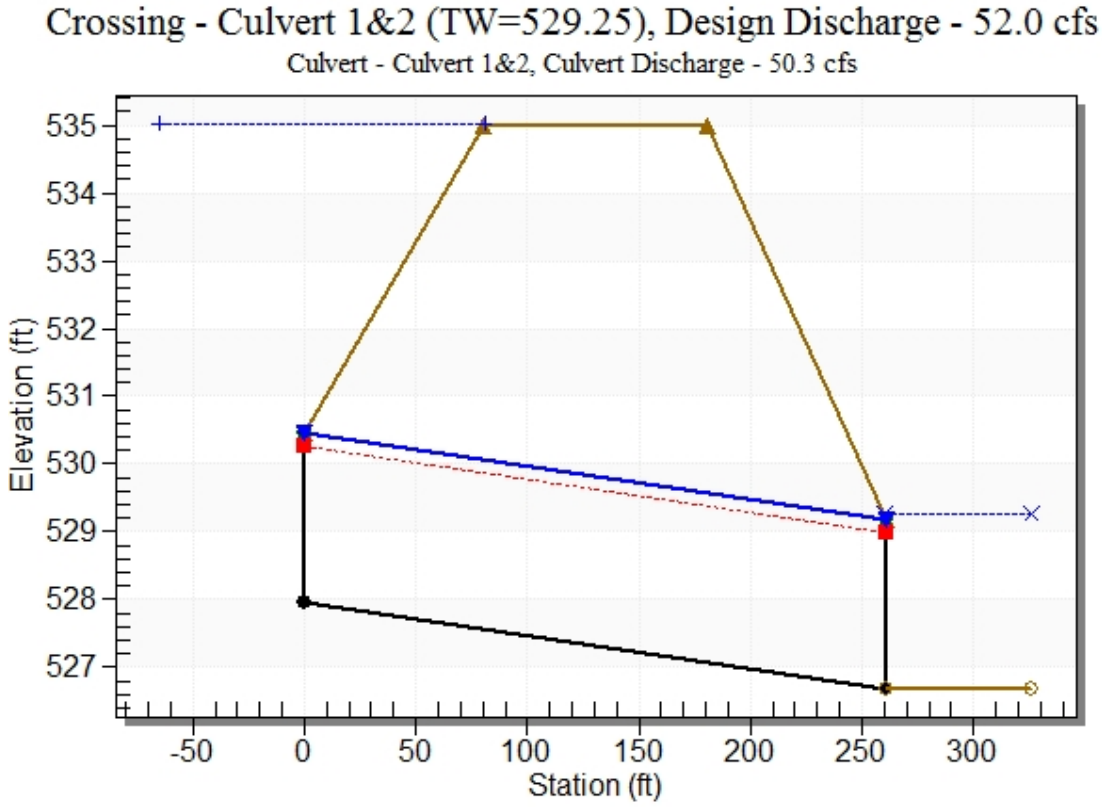
Culvert Length: 261.00 ft, Culvert Slope: 0.0049

****

Culvert Performance Curve Plot: Culvert 1&2



Water Surface Profile Plot for Culvert: Culvert 1&2



Site Data - Culvert 1&2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 527.96 ft

Outlet Station: 261.00 ft

Outlet Elevation: 526.69 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1&2

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Culvert 1&2 (TW=529.25))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
2.90	529.25	2.56
5.70	529.25	2.56
8.50	529.25	2.56
11.30	529.25	2.56
14.10	529.25	2.56
16.90	529.25	2.56
19.70	529.25	2.56
22.50	529.25	2.56
25.30	529.25	2.56
28.10	529.25	2.56
30.90	529.25	2.56
33.70	529.25	2.56
36.50	529.25	2.56
39.30	529.25	2.56
42.10	529.25	2.56
44.90	529.25	2.56
47.70	529.25	2.56
52.00	529.25	2.56

Tailwater Channel Data - Culvert 1&2 (TW=529.25)

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 529.25 ft

Roadway Data for Crossing: Culvert 1&2 (TW=529.25)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 535.00 ft

Roadway Surface: Paved

Roadway Top Width: 100.00 ft

HY-8 Culvert Analysis Report
Culvert 3

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: Culvert 3

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
522.76	0.10	0.10	0.00	1
522.41	2.80	2.80	0.00	1
522.78	5.50	5.50	0.00	1
523.11	8.20	8.20	0.00	1
523.40	10.90	10.90	0.00	1
523.70	13.60	13.60	0.00	1
524.02	16.30	16.30	0.00	1
524.39	19.00	19.00	0.00	1
524.82	21.70	21.70	0.00	1
525.32	24.40	24.40	0.00	1
525.88	27.10	27.10	0.00	1
526.51	29.80	29.80	0.00	1
527.19	32.50	32.50	0.00	1
527.95	35.20	35.20	0.00	1
528.80	37.90	37.90	0.00	1
529.70	40.60	40.60	0.00	1
530.68	43.30	43.30	0.00	1
531.03	46.00	44.24	1.61	22
531.00	44.16	44.16	0.00	Overtopping

Rating Curve Plot for Crossing: Culvert 3

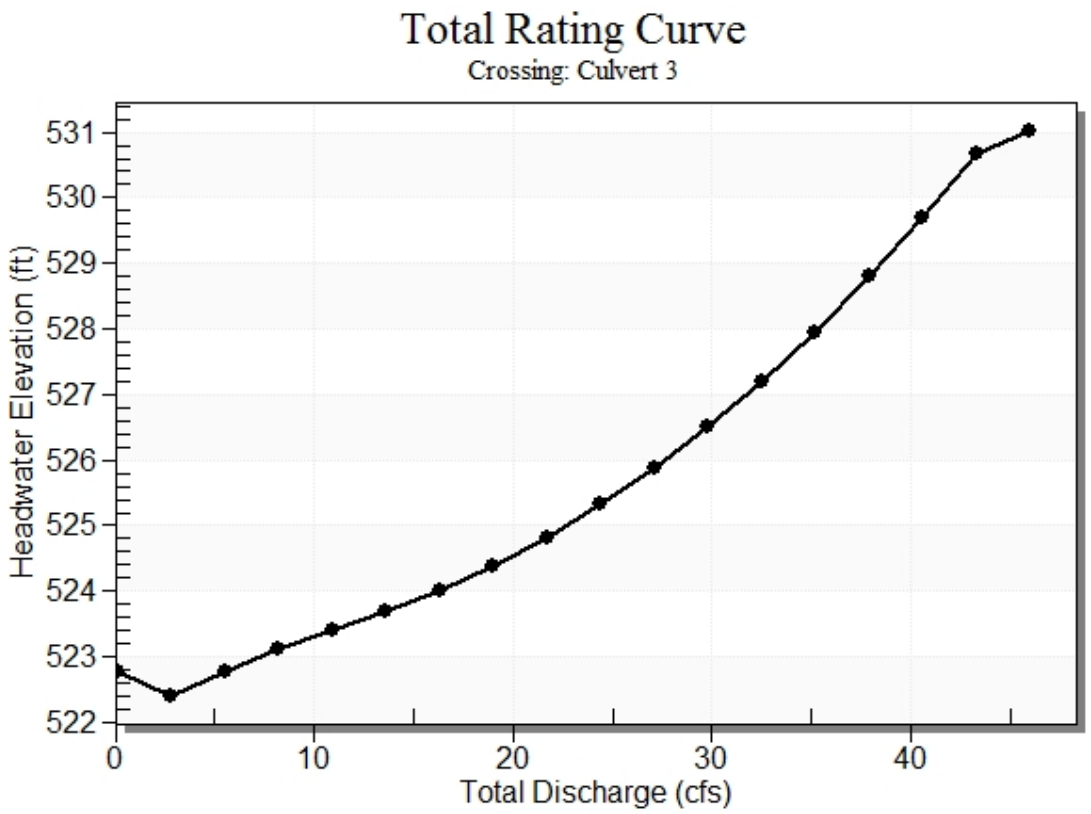


Table 2 - Culvert Summary Table: Culvert 3

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.10	0.10	522.76	0.140	1.133	2-M2c	0.039	0.037	0.037	0.030	7.644	0.336
2.80	2.80	522.41	0.784	0.0*	1-S2n	0.332	0.580	0.332	0.224	7.547	1.253
5.50	5.50	522.78	1.153	0.0*	1-S2n	0.462	0.825	0.462	0.338	9.259	1.627
8.20	8.20	523.11	1.481	0.0*	1-S2n	0.568	1.019	0.568	0.433	10.334	1.896
10.90	10.90	523.40	1.774	0.0*	1-S2n	0.659	1.180	0.716	0.516	10.011	2.111
13.60	13.60	523.70	2.067	0.0*	5-S2n	0.742	1.325	0.793	0.593	10.866	2.294
16.30	16.30	524.02	2.391	0.0*	5-S2n	0.820	1.451	0.892	0.664	11.165	2.454
19.00	19.00	524.39	2.762	0.0*	5-S2n	0.895	1.566	0.895	0.732	12.954	2.597
21.70	21.70	524.82	3.194	0.0*	5-S2n	0.968	1.664	1.044	0.796	12.187	2.726
24.40	24.40	525.32	3.690	0.0*	5-S2n	1.039	1.746	1.116	0.858	12.625	2.845
27.10	27.10	525.88	4.251	0.056	5-S2n	1.110	1.811	1.202	0.917	12.852	2.955
29.80	29.80	526.51	4.877	0.991	5-S2n	1.182	1.857	1.266	0.975	13.306	3.057
32.50	32.50	527.19	5.561	2.007	5-S2n	1.256	1.892	1.256	1.030	14.637	3.154
35.20	35.20	527.95	6.318	3.065	5-S2n	1.332	1.836	1.430	1.085	13.800	3.244
37.90	37.90	528.80	7.165	4.319	5-S2n	1.416	2.000	1.510	1.138	14.085	3.330
40.60	40.60	529.70	8.075	5.577	5-S2n	1.511	2.000	1.511	1.190	15.088	3.412
43.30	43.30	530.68	9.047	6.922	6-FFc	2.000	2.000	2.000	1.241	13.783	3.489
46.00	44.24	531.03	9.401	7.412	6-FFc	2.000	2.000	2.000	1.291	14.083	3.563

* Full Flow Headwater elevation is below inlet invert.

****

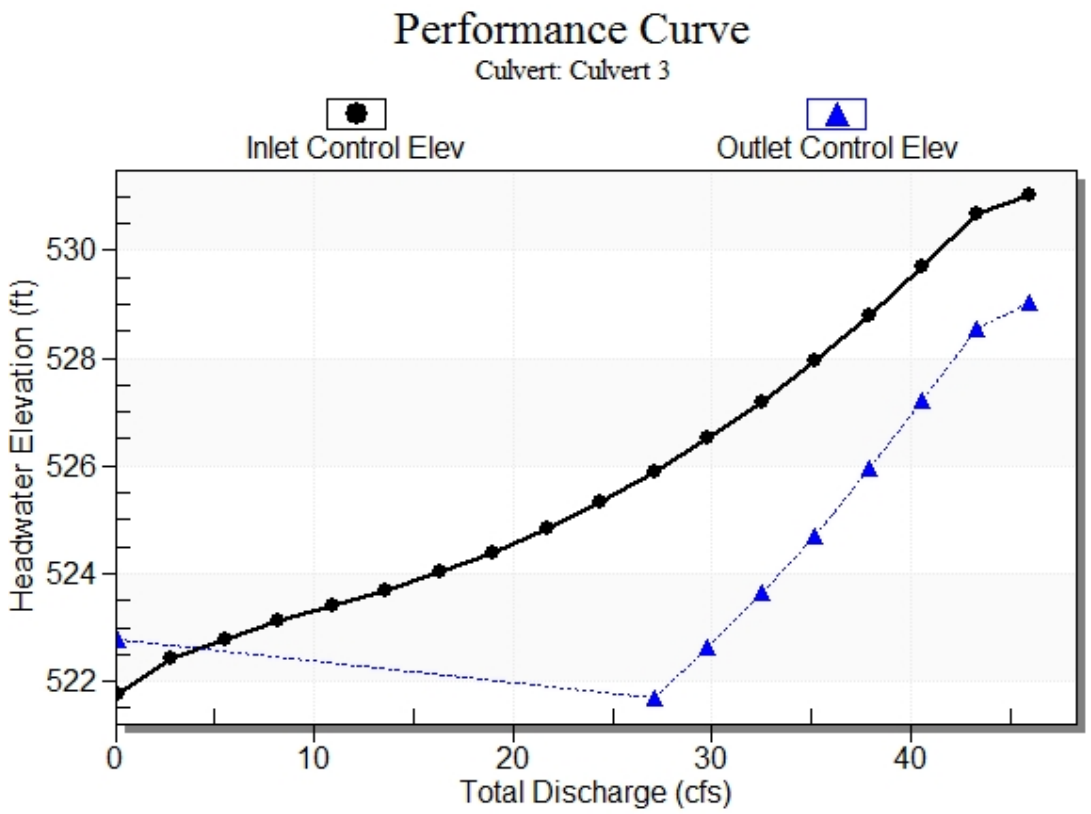
Straight Culvert

Inlet Elevation (invert): 521.63 ft, Outlet Elevation (invert): 515.42 ft

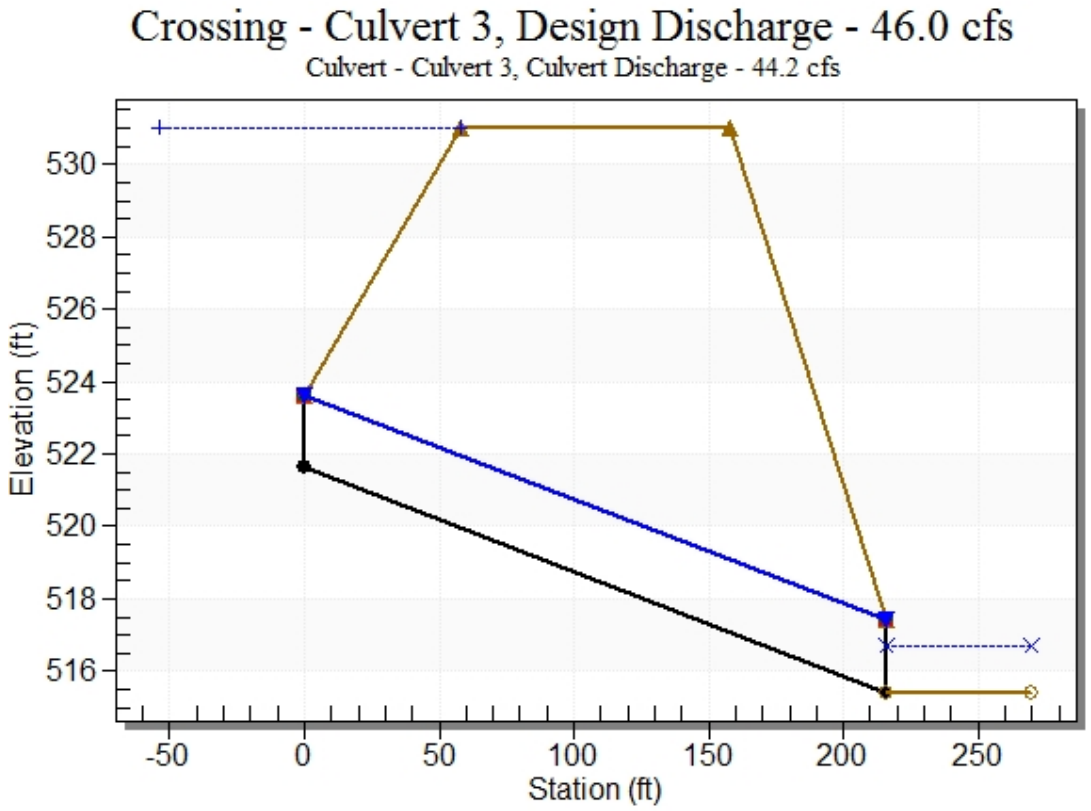
Culvert Length: 216.09 ft, Culvert Slope: 0.0288

****

Culvert Performance Curve Plot: Culvert 3



Water Surface Profile Plot for Culvert: Culvert 3



Site Data - Culvert 3

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 521.63 ft

Outlet Station: 216.00 ft

Outlet Elevation: 515.42 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 3

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

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

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.10	515.45	0.03	0.34	0.01	0.34
2.80	515.64	0.22	1.25	0.07	0.47
5.50	515.76	0.34	1.63	0.11	0.49
8.20	515.85	0.43	1.90	0.13	0.51
10.90	515.94	0.52	2.11	0.16	0.52
13.60	516.01	0.59	2.29	0.18	0.52
16.30	516.08	0.66	2.45	0.21	0.53
19.00	516.15	0.73	2.60	0.23	0.53
21.70	516.22	0.80	2.73	0.25	0.54
24.40	516.28	0.86	2.85	0.27	0.54
27.10	516.34	0.92	2.95	0.29	0.54
29.80	516.39	0.97	3.06	0.30	0.55
32.50	516.45	1.03	3.15	0.32	0.55
35.20	516.50	1.08	3.24	0.34	0.55
37.90	516.56	1.14	3.33	0.36	0.55
40.60	516.61	1.19	3.41	0.37	0.55
43.30	516.66	1.24	3.49	0.39	0.55
46.00	516.71	1.29	3.56	0.40	0.55

Tailwater Channel Data - Culvert 3

Tailwater Channel Option: Rectangular Channel

Bottom Width: 10.00 ft

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 515.42 ft

Roadway Data for Crossing: Culvert 3

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

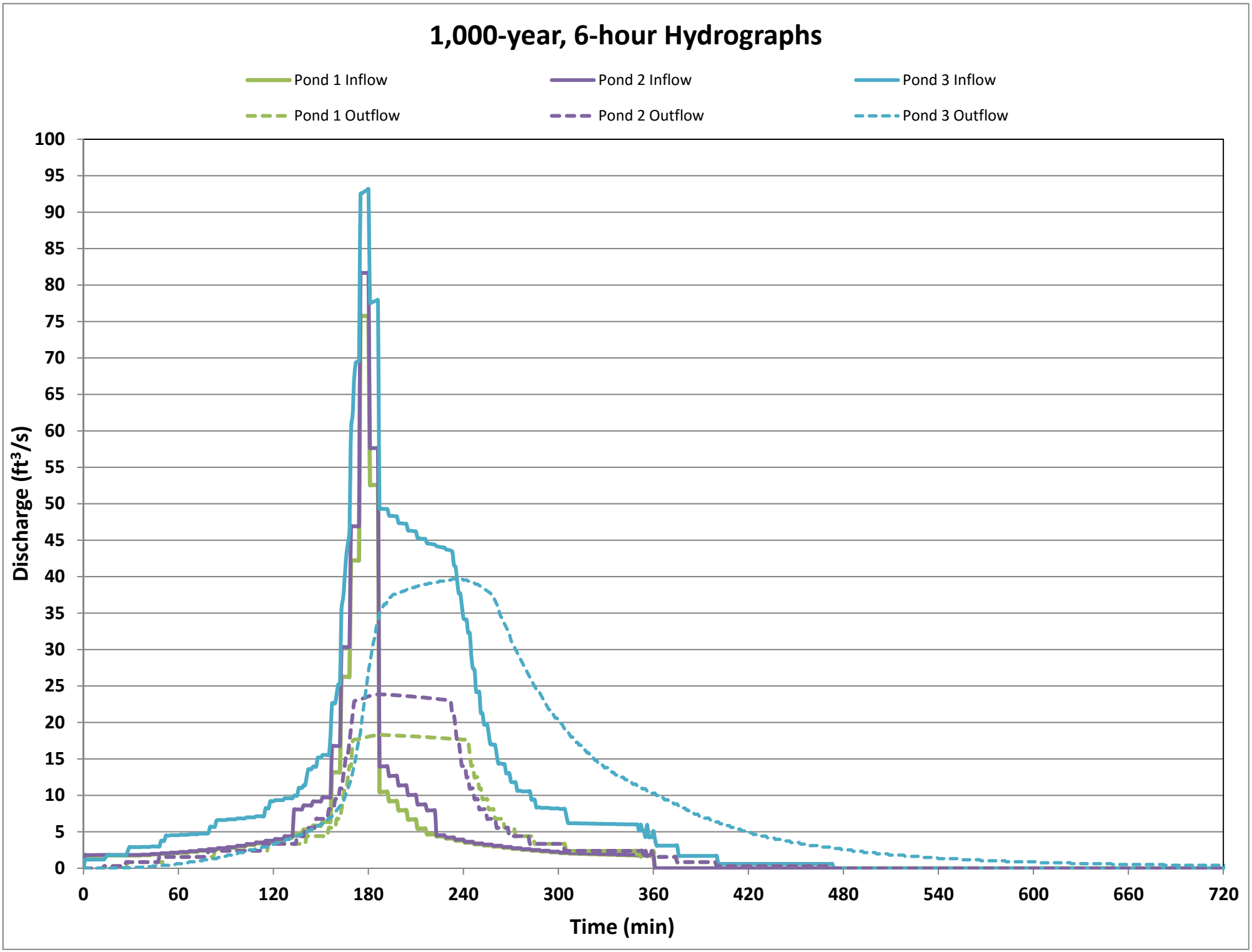
Crest Elevation: 531.00 ft

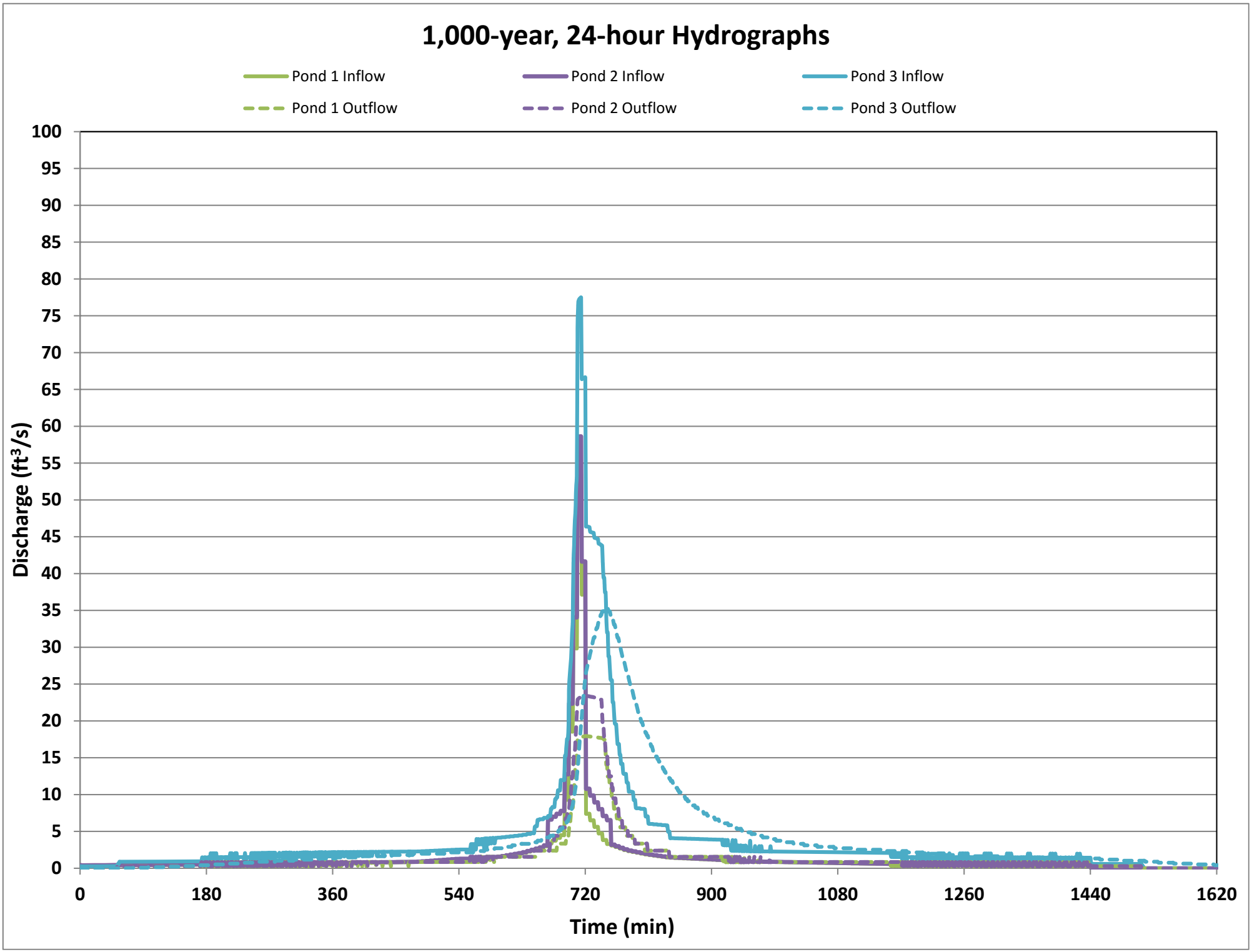
Roadway Surface: Paved

Roadway Top Width: 100.00 ft

ATTACHMENT D

HYDROGRAPHS


1,000-year, 6-hour Hydrographs
Pond 1 Inflow
Pond 2 Inflow
Pond 3 Inflow
Pond 1 Outflow
Pond 2 Outflow
Pond 3 Outflow
Discharge (ft3/s)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0
60
120
180
240
300
360
420
480
540
600
660
720
Time (min)


1,000-year, 24-hour Hydrographs
Pond 1 Inflow
Pond 2 Inflow
Pond 3 Inflow
Pond 1 Outflow
Pond 2 Outflow
Pond 3 Outflow
Discharge (ft³/s)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0
180
360
540
720
900
1080
1260
1440
1620
Time (min)