# Inflow Design Flood Control System Plan

For Compliance with the Coal Combustion Residuals Rule
(40 CFR Part 257)

Cherokee Station - CCR Surface Impoundments
*Public Service Company of Colorado*
*Denver, Colorado*

October 17, 2016

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# Table of Abbreviations and Acronyms

| Abbreviation | Definition |
|---|---|
| CCR | Coal Combustion Residuals |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| CN | Curve Number |
| EPA | Environmental Protection Agency |
| HSG | Hydrologic Soil Group |
| NOAA | National Oceanic and Atmospheric Administration |
| PSCo | Public Service Company of Colorado |
| RCRA | Resource Conservation and Recovery Act |
| SCS | Soil Conservation Service |
| TR-20 | Technical Release 20 |
| TR-55 | Technical Release 55 |

# 1.0 Introduction

On April 17, 2015, the U.S. Environmental Protection Agency published regulations under Subtitle D of the Resource Conservation and Recovery Act meant to control the safe disposal of coal combustion residuals (CCR) generated by coal-fired electric utilities. The rule defines a set of requirements for the disposal and handling of CCR within CCR units (defined as either landfills or surface impoundments). The requirements include preparation of an Inflow Design Flood Control System Plan to evaluate the inflow design flood control system for active surface impoundments.

This Inflow Design Flood Control System Plan was prepared for the active CCR surface impoundments at the Cherokee Station, owned and operated by Public Service Company of Colorado (PSCo), an Xcel Energy Company, and in accordance with the requirements of Title 40 of the Code of Federal Regulations (CFR) §257.82. The regulation requires an initial Inflow Design Flood Control System Plan be prepared no later than October 17, 2016.

## 1.1 Facility Description

Cherokee Station is a natural gas and coal-fired, steam-electric generating station located at 6198 Franklin Street in Denver Colorado. Cherokee Station currently operates three (3) CCR surface impoundments. Two of the ponds (East Ash Pond and Central Ash Pond) are used for temporary storage and dewatering of wet sluiced bottom ash. The third pond (West Ash Pond) was converted to a storm water pond in 2013 and is no longer used to store ash. However, because the pond is actively used as a storm water pond and still contains some CCR waste below a clean soil layer, this pond is included in this Plan. The three CCR impoundments are located northeast of the main plant.

**Figure 1** displays a Site Location Map**.**

Two CCR surface impoundments are currently in use to temporarily store bottom ash for dewatering prior to removal for final disposal. Fly ash is handled dry and collected in on-site silos. Both bottom and fly ash are hauled off-site to facilities permitted for either beneficial use or disposal. Cherokee Station has a Colorado Discharge Permit System (CDPS) permit (CO-0001104) to discharge treated wastewater to the South Platte River.

Per 40 CFR §257.53, the surface impoundments are defined as incised CCR surface impoundments because they were constructed by excavation and hold their accumulation of CCR entirely below the natural ground surface.

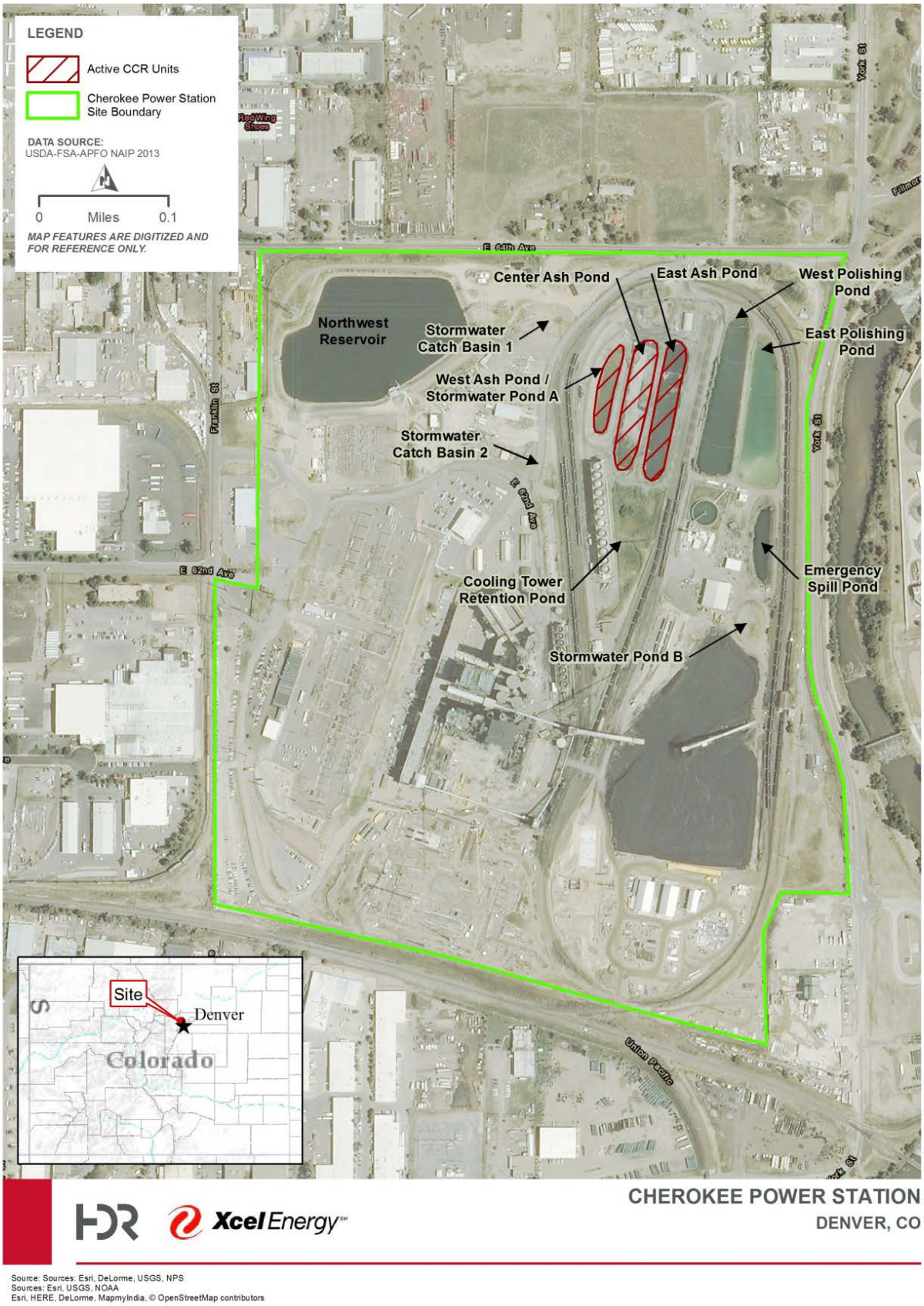



**Figure 1. Cherokee Station Location Map**

## 1.2 Regulatory Requirements

Title 40 CFR §257.82 requires that an owner or operator of an existing or new CCR surface impoundment or any lateral expansion of a CCR surface impoundment to design, construct, operate, and maintain an inflow design flood control system per the requirements below:

1. The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood specified in item 3) below;
2. The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood specified in item 3) below;
3. The inflow design flood is the 25-year flood for incised CCR surface impoundments; and

Discharge from the CCR surface impoundment must not cause a discharge of pollutants to waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System under Section 402 of the Clean Water Act.

# 2.0 Hydrologic and Hydraulic Analysis for CCR Impoundments

A hydrologic and hydraulic analysis was completed for the three CCR surface impoundments at Cherokee Station. The evaluation was completed in accordance with 40 CFR §257.82 and identified the drainage basin for each impoundment and evaluated the capacity of the outfalls to ensure safe passage of the 25-year, 24-hour storm event.

The evaluation included preparation of a surface water run-off model using HydroCAD® 10.00-11 to determine whether existing flood control systems meet the required criteria for controlling inflow from the 25-year flood and to evaluate whether the existing outfalls were sufficiently designed to accommodate the 25-year, 24-hour storm event.

The evaluation was completed based on the best available information provided by PSCo at the time of this report. The most recent survey of the CCR surface impoundments was completed in September 2015. Information on the existing subsurface drainage structures for the converted West Ash Pond/Storm Water Pond and up-gradient drainage facilities are based on construction drawings entitled *"CACJ – Clean Air/Clean Jobs Project Site Development Plot Plan"* dated August 2013. The location of the existing underground drainage pipe leading from the East and Central Ash Ponds is based on the drawing set entitled *"Micro/Nano Filtration System General Arrangement Piping Plan"* dated September 2003.

## 2.1 Description of CCR Impoundments and Drainage Area

The three CCR impoundments are located northeast of the main plant between two railroad beds. The surrounding area of the ponds includes vegetated areas and paved areas. A description of the CCR impoundments and the surrounding drainage areas is presented in detail below.

### 2.1.1 West Ash/Storm Water Pond

The West Ash/Storm Water Pond is approximately 455 feet long by 90 feet wide and 7 feet deep, with a current storage capacity of approximately 4.3 acre-feet based on the survey completed in September 2015. Historically this pond received influent water from multiple sources with the primary source being sluiced bottom ash. In 2013, the West Ash Pond was converted for use as a storm water pond. During its conversion, the side slopes were re-graded, approximately 10 feet of CCR was excavated and disposed of off-site, and clean fill was placed on the bottom to bring the bottom elevation up to the conversion design elevation. However, approximately 10 feet of legacy CCR remains in the bottom of the West Ash/Storm Water Pond below the clean fill.

Storm water drains via overland flow from the immediately surrounding vegetated and paved areas. This drainage area encompasses approximately 3.5 acres. Storm water also drains to the West Ash/Storm Water Pond from two drainage areas identified as Storm Water Catch Basins #1 and #2. These drainage areas were constructed in 2013 and collect storm water from the northwest portion of the site. Storm Water Catch Basin #1 is located northwest of the ash ponds, and Storm Water Catch Basin #2 is located southwest of the ash ponds. The drainage area associated with Storm Water Catch Basins #1 and #2 is approximately 11.5 acres and 3.0 acres, respectively. Both drainage areas discharge to the West Ash/Storm Water Pond via reinforced concrete pipes, with a combined flow of 7.24 cfs during a 25-year, 24-hour storm event.

In addition to storm water, the West Ash/Storm Water Pond also collects emergency overflow from the Northwest Reservoir. The Northwest Reservoir was constructed in 2002 and encompasses approximately 9.2 acres. The pond is used to store water used in the plant's processes (primarily cooling). The influent sources include the South Platte River, Copeland Reservoir, and the Denver Metro Waste Water Recycle Water.

The overall delineated drainage areas for the West Ash/Storm Water Pond are shown on **Figure 2**.

### 2.1.2 Central Ash Pond

The Central Ash Pond is approximately 520 feet long by 80 feet wide and 20 feet deep, with a current available storage capacity of approximately 2.3 acre-feet based on the survey completed in September 2015. At the time of this plan, the Central Ash Pond was actively storing bottom ash and was approximately 90 percent full.

The drainage area to the pond encompasses approximately 2.0 acres and includes the area immediately surrounding the pond and a small portion of area north of the pond. The delineated drainage area for the Central Ash Pond is shown on **Figure 2.**

### 2.1.3 East Ash Pond

The East Ash Pond is approximately 580 feet long by 90 feet wide and 20 feet deep, with a current available storage capacity of approximately 11.99 acre-feet based on the survey completed in September 2015. At the time of this plan, there was no bottom ash being stored in the East Ash Pond.

The drainage area to the pond encompasses approximately 1.95 acres and includes the area immediately surrounding the pond and a small portion of area north of the pond. The delineated drainage area for the East Ash Pond is shown on **Figure 2.**

## 2.2 Existing Inflow Design Flood Controls

### 2.2.1 East and Central Ash Ponds

The areas surrounding the East and Central Ash Ponds are paved and/or gravel, which prevents any surface water erosion from occurring in the immediate vicinity of the impoundments. The drainage areas contributing to these ponds are also very small and in general encompass only the immediate surrounding area, which reduces the amount of surface water run-off entering the pond and alleviates any need for additional erosion control measures around the pond. As a result, no inflow flood controls are necessary.

### 2.2.2 West Ash/Storm Water Pond

Catch Basin Drainage Areas #1 and #2 drain into the West Ash/Storm Water Pond via reinforced concrete pipes. The outlet of these pipes is armored with rip rap, which prevents erosion from occurring along the pond side slopes. The West Ash/Storm Water Pond also receives emergency overflow from the Northwest Reservoir via a 24-inch high-density polyethylene (HDPE) pipe. The inlet end of this pipe is also armored with rip rap to protect the side slope from erosion. No other inflow design controls are required.

## 2.3 Existing Outflow Design Controls

### 2.3.1 East and Central Ash Ponds

The outlet structures for the East and Central Ash Ponds are skimmers, each consisting of a wire mesh filter mounted to a concrete vertical pipe that is surrounded by a metal shield. This structure discharges to a 36-inch reinforced concrete pipe (RCP), which connects to an underground drainage system that gravity feeds to a lift pump station. The pump station then pumps influent water to the on-site wastewater treatment system before it is discharged to the South Platte River through a CDPS permitted outfall.

### 2.3.2 West Ash/Storm Water Pond

The outlet structure for the West Ash/Storm Water Pond consists of a series of orifices, an overflow grate, and a 22-inch HDPE outlet pipe. The outlet pipe drains to the existing underground drainage system, which gravity feeds to a lift pump station. The pump station then pumps influent water to the on-site wastewater treatment system before it is discharged to the South Platte River through a CDPS permitted outfall. A detail of the existing outlet structure is provided as **Figure 3**.

## 2.4 Hydrologic and Hydraulic Model

A surface water run-off model was prepared using HydroCAD, which utilizes procedures outlined in the Soil Conservation Service (SCS) Technical Release 55 (TR-55) for computing curve numbers and times of concentration and SCS TR-20 for calculating and generating run-off hydrographs and modeling the existing outfall structures. The model is included as **Appendix A**. A detailed discussion of the information inputted into the model is provided below.

### 2.4.1 Rainfall Data

Rainfall data were taken from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server. Rainfall data inputted into the model included the 2-year and 25-year, 24-hour storm events. The precipitation amounts are summarized below in **Table 1**

and the information from the NOAA Precipitation Frequency Data Server is included as **Appendix B**.

| Table 1. Rainfall Data | |
|---|---|
| **24-Hour Rainfall Event** | **Precipitation (inches)** |
| 2-year | 1.89 |
| 25-year | 3.60 |

### 2.4.2 Weighted Curve Number

The weighted curve number (CN) is determined according to a hydrologic soil group (HSG) and ground cover for a delineated drainage basin. The drainage areas were identified as an industrial use with an impervious coverage of 72 percent. The Soil Conservation District Web Soil Survey was consulted to identify the hydrologic soil groups for the native soils. According to the web soil map, the native soils consist of Terrace escarpments, Vona sandy loam 0 to 3 percent slopes, and Vona sandy loam 1 to 3 percent slopes). All these soils are in HSG A. A soil report for the native soils is included in **Appendix C**.

### 2.4.3 Time of Concentration

The time of concentration is defined as the time required for run-off to travel from the most hydrologically distant point of a sub-catchment to the point of collection. It is determined by summing the travel time for consecutive flow segments along the sub-catchment's hydraulic path. The time of concentration was calculated based on the distance from the edge of the drainage basin area to the estimated edge of the surface impoundment and the slope of the path. The paths for the time of concentration for each drainage area are shown on **Figure 2**.

### 2.4.4 Pond Model Inputs

As previously stated, the evaluation was completed based on the best available information provided by PSCo at the time of this report. Existing pond elevations and inlet and outlet structure information from the September 2015 survey were used as the most current and up-to-date information. Secondary sources of information used were as-built and construction drawings, which were used when survey data was unavailable. In some instances, there was no information on pipe slopes and inverts. At these locations, pipe inverts were estimated based on an assumed pipe slope. Locations of underground piping were estimated based on available as-built or construction drawings. Assumptions used in the model are noted on **Figure 4**, which provides an enlarged view of the three active CCR surface impoundments. A more detailed discussion is also provided below.

#### Central and East Ash Ponds

The pond volumes were determined based on contours from the September 2015 survey. At the time of the survey, the Central Pond was filled to an elevation of approximately 5,136.74 feet, which leaves just over 2 foot of freeboard (the top elevation is 5,139 feet). For the model, it was assumed that the pond was constructed using 2H:1V side slopes with a bottom elevation of 5,119 feet. The start elevation in the model was input as 5,136.74 feet to reflect the reduced storage capacity of the pond in its current condition.

At the time of the September 2015 survey, the East Ash Pond was not storing any bottom ash. The water surface elevation at the time of the survey was at approximately 5,122.37 feet and the top elevation was 5,138 feet.

The 2015 survey provided elevations for the top of the structure and concrete outlet pipe for the exposed outlet structure of the East Ash Pond. According to the survey, the invert of the 36-inch reinforced concrete pipe is 5,133.17 feet, and the top of the 6-foot-diameter wire mesh inlet structure is 5,139.66 feet. An estimate of the invert for the vertical stand pipe was made based on photographs and historic as-built drawings of the previous skimmer. Based on this information, the total height of the wire mesh inlet was estimated to be 3 feet.

It was assumed that the outlet structure for the Central Ash Pond was constructed similarly to the outlet structure of the East Ash Pond. The September 2015 survey provided only the top elevation of the wire mesh structure because the outlet pipe was submerged. The invert for the outlet pipe was estimated based on the difference in elevation between the top of the structure and outlet pipe for the East Ash Pond. A summary of the outlet structure information inputted into the model is provided in **Table 2** below.

**Table 2. East and Central Ash Ponds Outfall Structure Information**

| **Outfall Structure & Type** | | **Elevation (feet)** | **Dimensions & Description** |
|---|---|---|---|
| East Ash Pond | Top of Wire Mesh Inlet | 5,139.66 | 6 ft diameter |
| | Vertical Pipe Opening | 5,136.66 | 6 ft diameter |
| | Outlet Pipe | 5,133.17 | 36” RCP, protruding |
| Central Ash Pond | Top of Wire Mesh Inlet | 5,140.07 | 6 ft diameter |
| | Vertical Pipe Opening | 5,137.07 | 6 ft diameter |
| | Outlet Pipe | 5,133.58 | 36” RCP, protruding |

### West Ash/Storm Water Pond

The pond volumes were determined based on contours from the September 2015 survey. At the time of the survey, no water was observed in the West Ash/Storm Water Pond. The pond volume survey notes a bottom elevation of 5,131 feet and a top elevation of 5,138 feet.

Inflows from Catch Basin Areas #1 and #2 to the West Ash/Storm Water Pond were determined based on the drainage area, curve numbers, and times of concentration calculated for each of the areas.

There was no information available on the inflows to the West Ash/Storm Water Pond from the Northwest Reservoir. According to PSCo personnel, there has never been a known discharge from the Northwest Reservoir to the West Ash/Storm Water Pond. Because no data were available, it was assumed that the Northwest Reservoir was approximately half-full. According to survey data from 2012 the water surface elevation for the Northwest Reservoir is 5,165 feet and the top of the Northwest Reservoir berm is 5,171 feet. Using a surface water elevation of 5,168 feet (mid point between the surveyed water surface elevation and top of berm), the model was run for the 25-year, 24-hour storm event. Using these assumptions, the peak flow from the Northwest Reservoir to the West Ash/Storm Water pond was 30.25 cfs; Storm Water Catchbasins #1 and #2 contribute an additional 7.24 cfs. The total peak flow into the West Ash/Storm Water Pond is 37.49 cfs. This flow was controlled by the West Ash/Storm Water Pond. The water level rises to approximately 5,137 feet, which allows for 1-foot of freeboard.

The 2015 survey provided elevations for the top of grate and the inlet elevation of the outlet structure for the West Ash/Storm Water Pond. Information for the remaining inverts was based on the record drawing for the outlet structure, which is included as **Figure 3**. **Table 3** below summarizes the data input into the model for the West Ash/Storm Water Pond outfall structure.

| Table 3. West Ash/Storm Water Pond Outfall Structure Information | | |
|---|---|---|
| **Outfall Structure Type** | **Elevation (feet)** | **Dimensions & Description** |
| Orifice #1 | 5,131.56 | 2 – 2” dia. orifice, 3” apart |
| Orifice #2 | 5,131.89 | 2 – 2” dia. orifice, 3” apart |
| Orifice #3 | 5,132.22 | 2 – 2” dia. orifice, 3” apart |
| Orifice #4 | 5,132.55 | 2 – 2” dia. orifice, 3” apart |
| Orifice #5 | 5,133.05 | 1 – 4.25”x4.25” orifice |
| Grate | 5,135.61 | 5’-3”x5’3” grate with 4”x4” openings |
| Outlet Pipe | 5,131.61 | 22” HDPE pipe |

## 2.5 Evaluation of Existing Inflow/Outflow Design Controls

To comply with 40 CFR §257.82, the inflow and outflow design flood control systems must adequately manage flow into and out of the CCR unit during the 25-year, 24-hour storm event.

### 2.5.1 Central and East Ash Ponds

The Central and East Ash Ponds are located in an area that generally prevents any surface water from large up-gradient catchment areas draining into the impoundments. The areas surrounding both impoundments are paved, which prevents surface water from directly adjacent areas eroding the sides of the impoundment. The inflow design system for both the Central and East Ash Ponds meets the requirements of 40 CFR §257.82(a)(1).

The HydroCAD model was used to evaluate the inflow, outflow, and peak elevations observed for the 25-year, 24-hour storm event for the impoundments in their current conditions. The model results are summarized below in **Table 4**.

| Table 4. Central and East Ash Pond Model Results | | | | |
|---|---|---|---|---|
| **24-Hour Storm Event** | **CCR Surface Impoundment** | **Inflow (cfs)** | **Outflow (cfs)** | **Peak Elevation (feet)** |
| 25-year | Central Ash Pond | 11.66 | 6.36 | 5,137.34 |
| | East Ash Pond | 10.99 | 0.00 | 5,124.11 |

Based on the model results, the outflow design control systems for both impoundments are capable of managing flows from the 25-year, 24-hour storm event and meet the requirements of 40 CFR §257.82(a)(2).

### 2.5.2 West Ash/Storm Water Pond

The West Ash/Storm Water Pond was redesigned in 2013 to accommodate surface water run-off from the immediate area and western portion of the Cherokee Station. The inflow design system

consists of rip-rapped inlet pipes constructed to prevent surface erosion along the embankments of the pond. The side slopes are also vegetated, which assists in mitigating any surface erosion from storm water run-off from the immediate surrounding area of the pond. The inflow design system for the West Ash/Storm Water Pond meets the requirements of 40 CFR §257.82(a)(1).

The HydroCAD® model was used to evaluate the inflow, outflow, and peak elevations observed for the 25-year, 24-hour storm event. The model results for the West Ash/Storm Water Pond are summarized below in **Table 5** and are based on a maximum inflow from the Northwest Reservoir of 30.25 cfs.

**Table 5. West Ash/Storm Water Pond Model Results**

| 24-Hour Storm Event | Inflow (cfs) | Outflow (cfs) | Peak Elevation (feet) |
|---|---|---|---|
| 25-year | 37.49 | 29.76 | 5,137.05 |

Based on the model, the limiting factor appears to be the underground drainage pipe leading from the West Ash/Storm Water Pond to the lift station, which reduces the overall capacity of flow from the West Ash/Storm Water Pond. Based on the model results, the pond is capable of managing flows from the 25-year, 24-hour storm event and meet the requirements of 40 CFR §257.82(a)(2), assuming that the Northwest Reservoir is half full during the 25-year, 24-hour storm event.

## 2.6 Improvements to Existing Inflow/Outflow Design Controls

Based on the available information and the model results, the existing inflow design flood control systems in place for the West Ash/Storm Water Pond, Central Ash Pond, and East Ash Pond meet the requirements of 40 CFR §257.82. At this time, there are no improvements proposed for the existing inflow design flood control systems.

# 3.0 Professional Engineer Certification

**Cherokee Station CCR Unit 2016 Initial Hydrologic and Hydraulic Capacity Requirements for CCR Surface Impoundments Compliance with the Federal Coal Combustion Residuals Rule**

The undersigned Registered Professional Engineer is familiar with the requirements of Part 257 of Title 40 of the Code of Federal Regulations (40 CFR §257) and has supervised examination of the facility by appropriately qualified personnel. The undersigned Registered Professional Engineer attests that this Run-on and Run-off Controls System Plan has been prepared in accordance with good engineering practice, including consideration of applicable industry standards and the requirements of 40 CFR §257.

This Plan is valid only to the extent that the facility owner or operator maintains existing inflow design flood control systems described in this Plan.

SIGNATURE:


Christopher M. Koehler, PE — Colorado PE 0051359

DATE: October 14, 2016

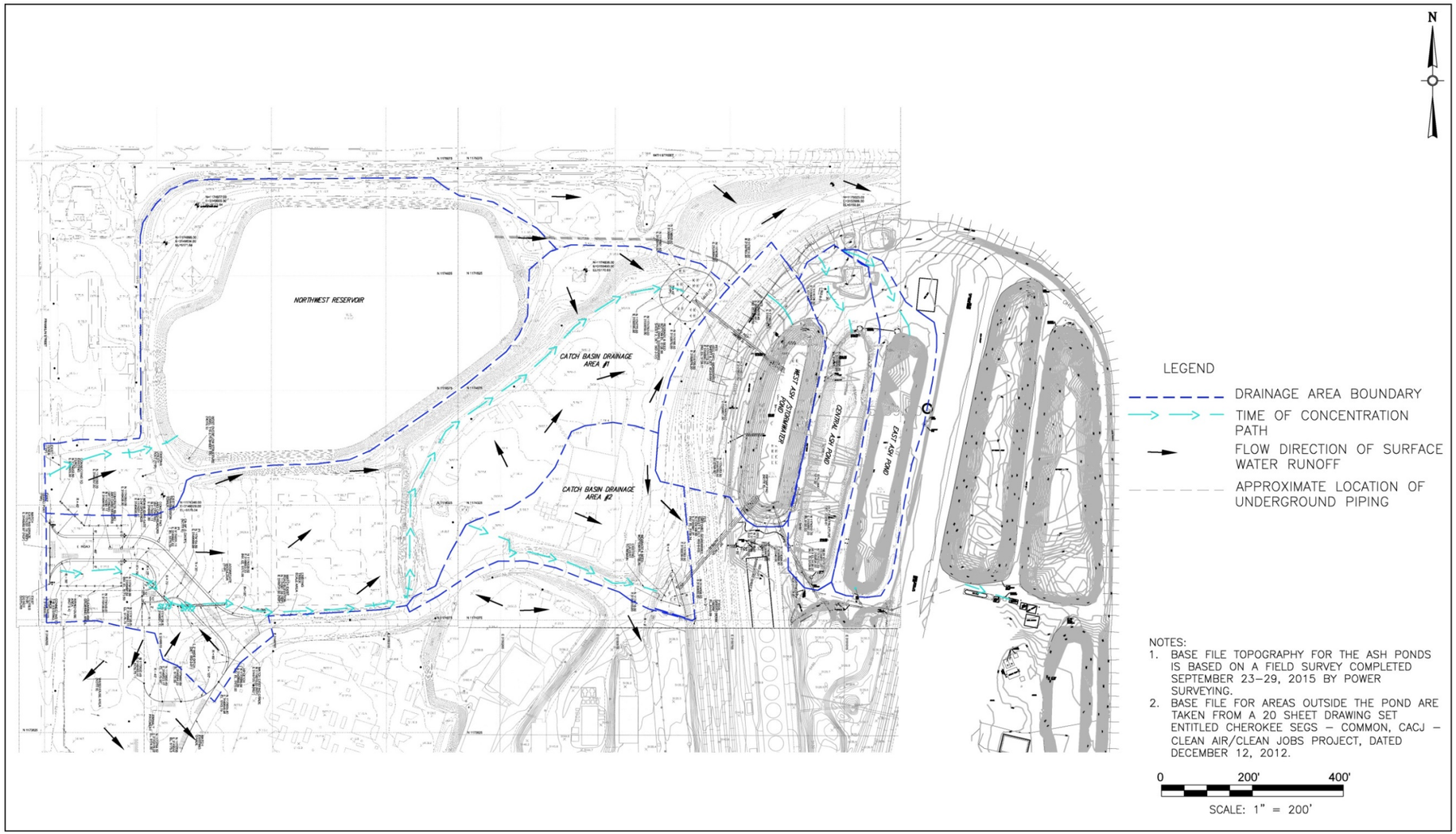
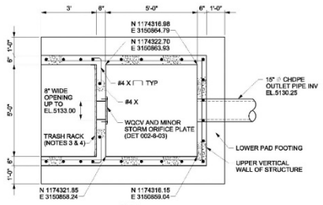
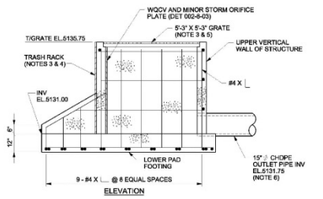
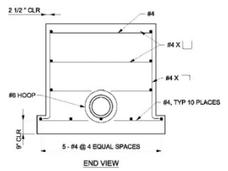


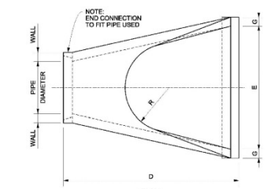

**Figure 2. Storm Water Drainage Map**

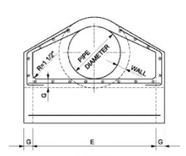


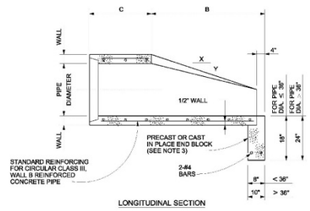




WATER QUALITY SEDIMENTATION BASIN OUTLET STRUCTURE
DETAIL 002-6-01
N.T.S.



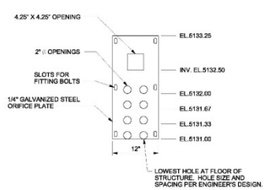




NOTES:
(1) PRECAST CONCRETE FLARED END SECTIONS SHALL CONFORM TO THE APPLICABLE REQUIREMENTS OF AASHTO M-170 CLASS III, WALL B REINFORCED CONCRETE PIPE.
(2) PRECAST CONCRETE FLARED END SECTION FOR PIPE DIAMETER REQUIRED SHALL BE AS INDICATED ON DETAIL PLAN FOR EACH INDIVIDUAL INSTALLATION.
(3) THE END BLOCK SHALL BE PLACED PRIOR TO THE INSTALLATION OF THE FLARED END SECTION.

| PIPE DIA. | APPROX. WT.(lbs) | WALL | A | B | C | D | E | G | R | SLOPE |
|---|---|---|---|---|---|---|---|---|---|---|
| 30" | 2490 | 3 1/2" | 1'-0" | 4'-6" | 1'-7 1/8" | 6'-1 1/8" | 5'-0" | 3 1/2" | 15° | 3:1 |
| 36" | 4100 | 4" | 1'-3" | 5'-3" | 2'-10 3/4" | 6'-1 3/4" | 6'-0" | 4" | 20° | 3:1 |

CONCRETE FLARED-END SECTION
DETAIL 002-6-02
N.T.S




WQCV AND MINOR STORM ORIFICE PLATE
DETAIL 002-6-03
N.T.S.

NOTES

1. ALL WORK SHOWN ON THIS DRAWING SHALL BE FURNISHED AND INSTALLED IN ACCORDANCE WITH PROJECT SPECIFICATIONS, UNLESS NOTED OTHERWISE.
2. FOR GENERAL NOTES, ABBREVIATIONS, AND LEGEND SEE DRAWING D11000-SGRS0000001 SHEET 2.
3. TRASH RACKS AND GRATES SHALL BE MOUNTED USING STAINLESS STEEL HARDWARE. MOUNTING DEVICES SHALL BE ALUMINUM OR GALVANIZED STEEL.
4. TRASH RACK SHALL BE STAINLESS STEEL, ALUMINUM, OR GALVANIZED STEEL AND SHALL BE DESIGNED IN ACCORDANCE WITH THE USP CO DOM. VS. TRASH RACK SHALL BE INSTALLED TO THE SAME HEIGHT AS THE WQCV PLATE.
5. GRATE SHALL BE CONSTRUCTED OF ALUMINUM OR GALVANIZED STEEL AND SHALL BE WATERTIGHT EXCEPT FOR OPENINGS. GRATE SHALL BE MOUNTED SO THAT THE TOP SURFACE OF THE GRATE IS FLUSH WITH THE TOP SURFACE OF THE CONCRETE STRUCTURE, AND SHALL BE SECURELY BOLTED TO THE TOP OF THE STRUCTURE.
6. ALL INLET AND OUTLET PIPES SHALL BE CONNECTED TO THE MANHOLE WITH A GASKETED FLEXIBLE WATER TIGHT CONNECTING PER ASTM C-923.

NOTES:
1. DRAWING TAKEN FROM CHEROKEE SEGS – COMMON, CACJ – CLEAN AIR/CLEAN JOBS PROJECT SITE GRADING AND DRAINAGE DETAILS, LAST DATED AUGUST 15, 2013.
2. SURVEYED ELEVATIONS WERE USED OVER ELEVATIONS SHOWN IN DETAILS.
3. SURVEYED PIPE SIZES WERE USED OVER PIPE SIZES SHOWN IN DETAILS.

Xcel Energy®

CHEROKEE POWER STATION
DENVER, CO

CCR INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

**Figure 3. West Ash/Storm Water Pond Outlet Detail**

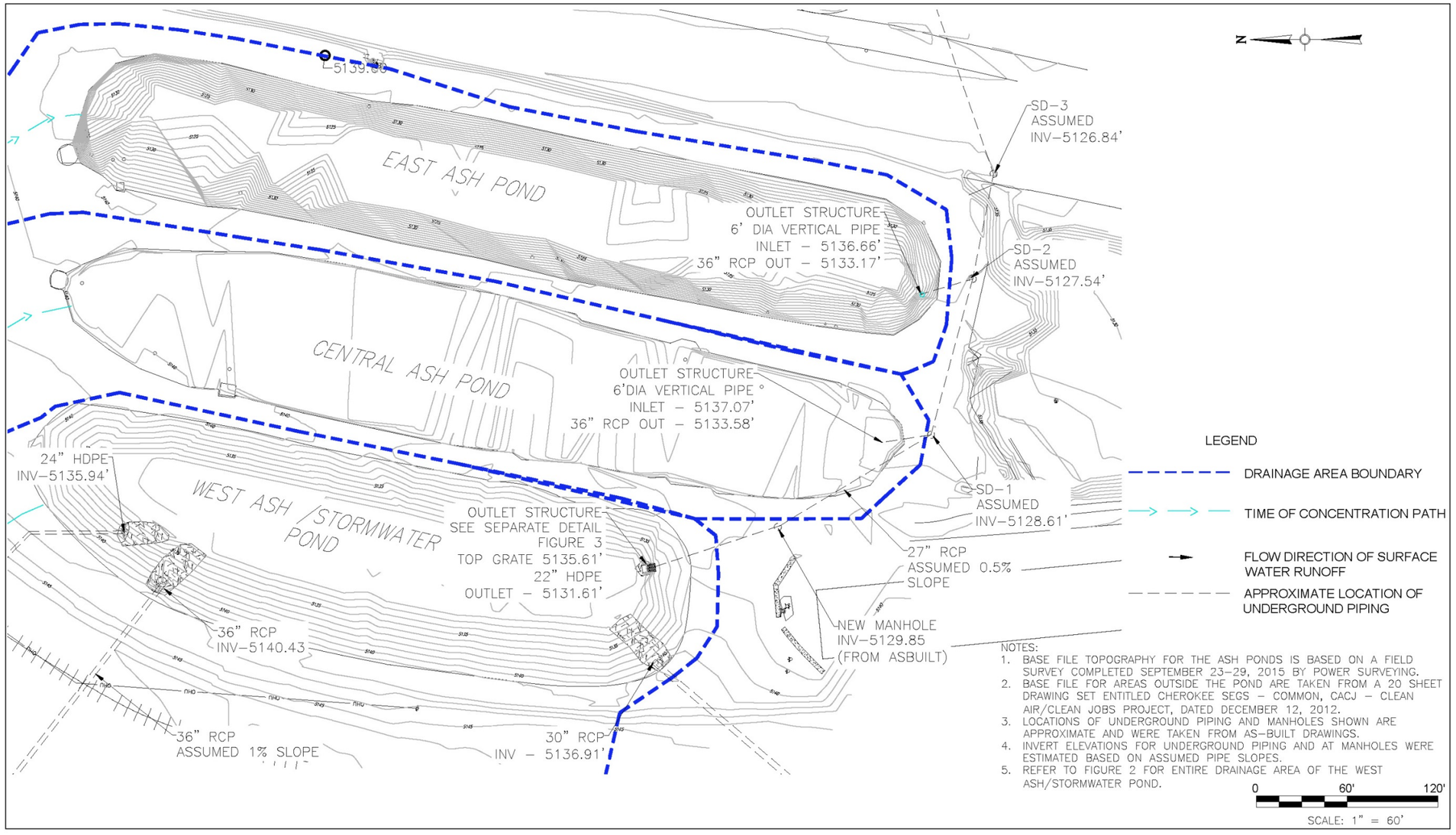
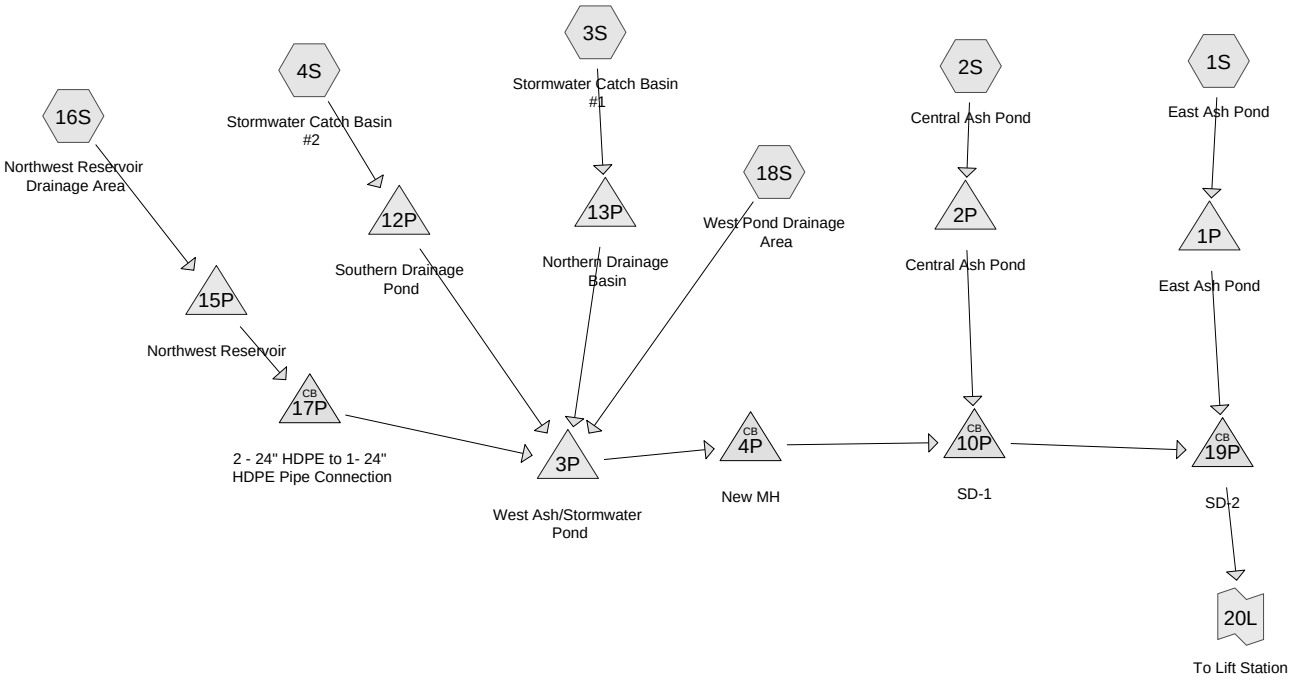



**Figure 4. CCR Impoundments Plan View**

# APPENDIX A - HYDROCAD® MODEL RESULTS




Subcat Reach Pond Link

**Routing Diagram for Cherokee Station-Impoundments4**
Prepared by HDR Inc, Printed 10/17/2016
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## Area Listing (selected nodes)

| Area (acres) | CN | Description (subcatchment-numbers) |
|---|---|---|
| 33.860 | 81 | Urban industrial, 72% imp, HSG A (1S, 2S, 3S, 4S, 16S, 18S) |
| **33.860** | **81** | **TOTAL AREA** |

## Soil Listing (selected nodes)

| Area (acres) | Soil Group | Subcatchment Numbers |
|---|---|---|
| 33.860 | HSG A | 1S, 2S, 3S, 4S, 16S, 18S |
| 0.000 | HSG B | |
| 0.000 | HSG C | |
| 0.000 | HSG D | |
| 0.000 | Other | |
| **33.860** | | **TOTAL AREA** |

## Ground Covers (selected nodes)

| HSG-A (acres) | HSG-B (acres) | HSG-C (acres) | HSG-D (acres) | Other (acres) | Total (acres) | Ground Cover | Subcatchment Numbers |
|---|---|---|---|---|---|---|---|
| 33.860 | 0.000 | 0.000 | 0.000 | 0.000 | 33.860 | Urban industrial, 72% imp | 1S, 2S, 3S, 4S, 16S, 18S |
| **33.860** | **0.000** | **0.000** | **0.000** | **0.000** | **33.860** | **TOTAL AREA** | |

## Pipe Listing (selected nodes)

| Line# | Node Number | In-Invert (feet) | Out-Invert (feet) | Length (feet) | Slope (ft/ft) | n | Diam/Width (inches) | Height (inches) | Inside-Fill (inches) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3S | 0.00 | 0.00 | 64.0 | 0.0070 | 0.013 | 18.0 | 0.0 | 0.0 |
| 2 | 3S | 0.00 | 0.00 | 98.0 | 0.0100 | 0.011 | 48.0 | 48.0 | 0.0 |
| 3 | 4S | 0.00 | 0.00 | 61.0 | 0.0400 | 0.025 | 18.0 | 0.0 | 0.0 |
| 4 | 1P | 5,133.17 | 5,128.74 | 35.0 | 0.1266 | 0.011 | 36.0 | 0.0 | 0.0 |
| 5 | 2P | 5,133.58 | 5,129.27 | 30.0 | 0.1437 | 0.011 | 36.0 | 0.0 | 0.0 |
| 6 | 3P | 5,131.75 | 5,129.85 | 87.0 | 0.0218 | 0.010 | 22.0 | 0.0 | 0.0 |
| 7 | 4P | 5,129.85 | 5,128.61 | 87.0 | 0.0143 | 0.013 | 22.0 | 0.0 | 0.0 |
| 8 | 10P | 5,128.61 | 5,127.54 | 107.0 | 0.0100 | 0.011 | 27.0 | 0.0 | 0.0 |
| 9 | 12P | 5,139.34 | 5,137.10 | 241.0 | 0.0093 | 0.011 | 30.0 | 0.0 | 0.0 |
| 10 | 13P | 5,139.11 | 5,136.88 | 208.0 | 0.0107 | 0.011 | 36.0 | 0.0 | 0.0 |
| 11 | 15P | 5,166.00 | 5,160.00 | 350.0 | 0.0171 | 0.013 | 24.0 | 0.0 | 0.0 |
| 12 | 15P | 5,166.00 | 5,160.00 | 350.0 | 0.0171 | 0.013 | 24.0 | 0.0 | 0.0 |
| 13 | 17P | 5,160.00 | 5,135.94 | 150.0 | 0.1604 | 0.013 | 24.0 | 0.0 | 0.0 |
| 14 | 19P | 5,127.54 | 5,126.84 | 70.0 | 0.0100 | 0.011 | 27.0 | 0.0 | 0.0 |

Time span=0.00-100.00 hrs, dt=0.22 hrs, 456 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment 1S: East Ash Pond** Runoff Area=1.950 ac 72.00% Impervious Runoff Depth=1.79"
Flow Length=249' Slope=0.0290 '/' Tc=2.8 min CN=81 Runoff=4.84 cfs 0.291 af

**Subcatchment 2S: Central Ash Pond** Runoff Area=2.020 ac 72.00% Impervious Runoff Depth=1.79"
Flow Length=186' Slope=0.0380 '/' Tc=2.0 min CN=81 Runoff=5.17 cfs 0.301 af

**Subcatchment 3S: Stormwater Catch** Runoff Area=11.580 ac 72.00% Impervious Runoff Depth=1.79"
Flow Length=1,808' Tc=13.7 min CN=81 Runoff=23.41 cfs 1.727 af

**Subcatchment 4S: Stormwater Catch Basin** Runoff Area=3.020 ac 72.00% Impervious Runoff Depth=1.79"
Flow Length=460' Tc=3.4 min CN=81 Runoff=7.28 cfs 0.450 af

**Subcatchment 16S: Northwest Reservoir** Runoff Area=11.800 ac 72.00% Impervious Runoff Depth=1.79"
Flow Length=297' Tc=3.4 min CN=81 Runoff=28.43 cfs 1.760 af

**Subcatchment 18S: West Pond Drainage** Runoff Area=3.490 ac 72.00% Impervious Runoff Depth=1.79"
Flow Length=85' Slope=0.0460 '/' Tc=7.2 min CN=81 Runoff=6.65 cfs 0.521 af

**Pond 1P: East Ash Pond** Peak Elev=5,123.49' Storage=0.291 af Inflow=4.84 cfs 0.291 af
Outflow=0.00 cfs 0.000 af

**Pond 2P: Central Ash Pond** Peak Elev=5,137.04' Storage=10.075 af Inflow=5.17 cfs 0.301 af
Outflow=0.00 cfs 0.000 af

**Pond 3P: West Ash/Stormwater Pond** Peak Elev=5,137.05' Storage=3.489 af Inflow=37.49 cfs 19.464 af
Outflow=29.76 cfs 19.230 af

**Pond 4P: New MH** Peak Elev=5,137.81' Inflow=26.66 cfs 20.132 af
22.0" Round Culvert n=0.013 L=87.0' S=0.0143 '/' Outflow=26.66 cfs 20.132 af

**Pond 10P: SD-1** Peak Elev=5,131.35' Inflow=26.66 cfs 20.132 af
27.0" Round Culvert n=0.011 L=107.0' S=0.0100 '/' Outflow=26.66 cfs 20.132 af

**Pond 12P: Southern Drainage Pond** Peak Elev=5,140.24' Storage=3,160 cf Inflow=7.28 cfs 0.450 af
30.0" Round Culvert n=0.011 L=241.0' S=0.0093 '/' Outflow=6.12 cfs 0.411 af

**Pond 13P: Northern Drainage Basin** Peak Elev=5,140.74' Storage=0.067 af Inflow=23.41 cfs 1.727 af
36.0" Round Culvert n=0.011 L=208.0' S=0.0107 '/' Outflow=22.69 cfs 1.708 af

**Pond 15P: Northwest Reservoir** Peak Elev=5,168.00' Storage=22.814 af Inflow=28.43 cfs 1.760 af
Outflow=30.25 cfs 16.824 af

**Pond 17P: 2 - 24" HDPE to 1- 24" HDPE Pipe Connection** Peak Elev=5,165.00' Inflow=30.25 cfs 16.824 af
24.0" Round Culvert n=0.013 L=150.0' S=0.1604 '/' Outflow=30.25 cfs 16.824 af

**Pond 19P: SD-2** Peak Elev=5,130.12' Inflow=26.66 cfs 20.132 af
27.0" Round Culvert n=0.011 L=70.0' S=0.0100 '/' Outflow=26.66 cfs 20.132 af

**Link 20L: To Lift Station**

Inflow=26.66 cfs 20.132 af
Primary=26.66 cfs 20.132 af

**Total Runoff Area = 33.860 ac Runoff Volume = 5.050 af Average Runoff Depth = 1.79"**
**28.00% Pervious = 9.481 ac 72.00% Impervious = 24.379 ac**

## Summary for Subcatchment 1S: East Ash Pond

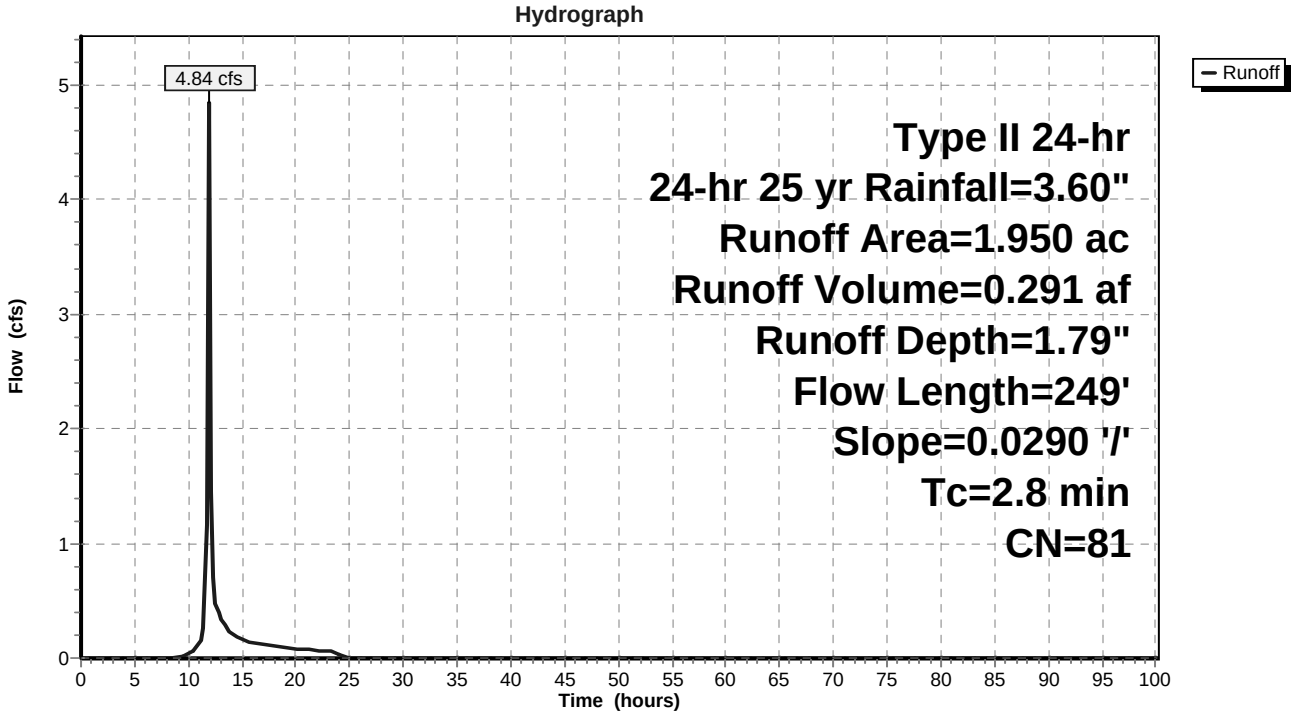
Runoff = 4.84 cfs @ 11.88 hrs, Volume= 0.291 af, Depth= 1.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs
Type II 24-hr 24-hr 25 yr Rainfall=3.60"

| Area (ac) | CN | Description |
|---|---|---|
| 1.950 | 81 | Urban industrial, 72% imp, HSG A |
| 0.546 | | 28.00% Pervious Area |
| 1.404 | | 72.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.8 | 249 | 0.0290 | 1.47 | | **Sheet Flow, overland flow**<br>Smooth surfaces n= 0.011 P2= 1.89" |

## Subcatchment 1S: East Ash Pond



## Summary for Subcatchment 2S: Central Ash Pond

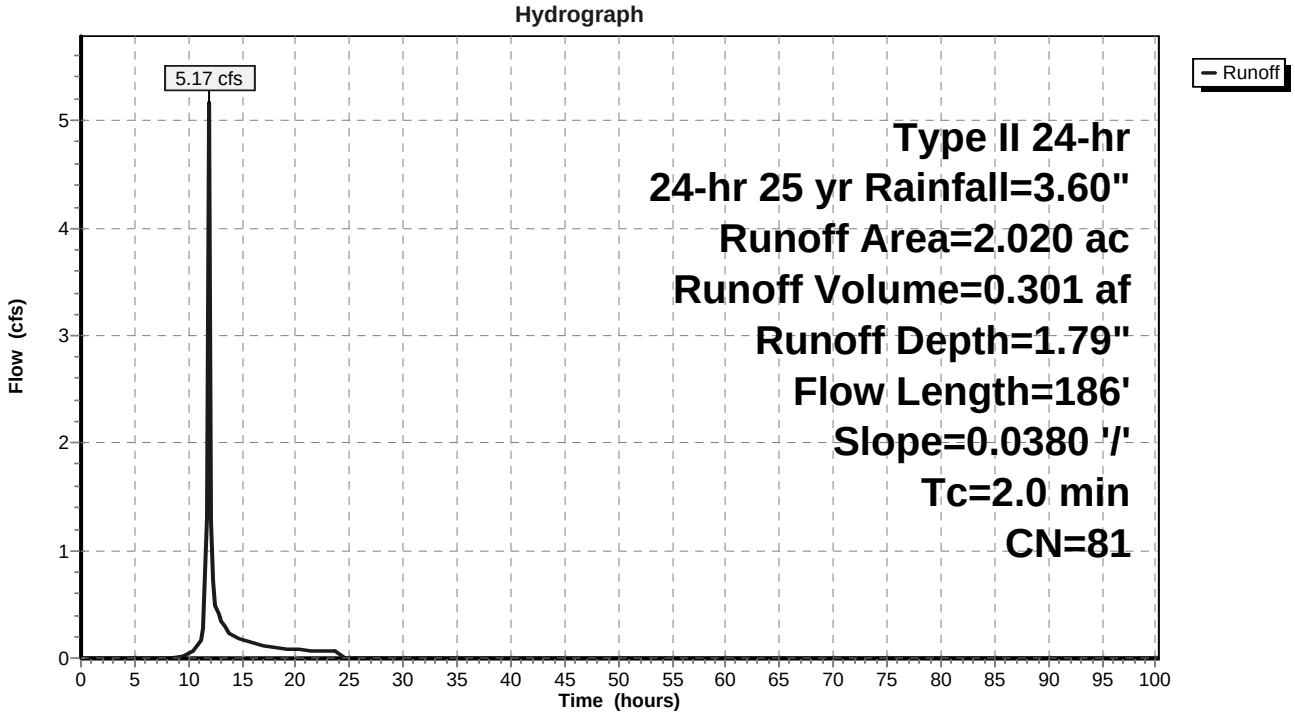
Runoff = 5.17 cfs @ 11.88 hrs, Volume= 0.301 af, Depth= 1.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs
Type II 24-hr 24-hr 25 yr Rainfall=3.60"

| Area (ac) | CN | Description |
|---|---|---|
| 2.020 | 81 | Urban industrial, 72% imp, HSG A |
| 0.566 | | 28.00% Pervious Area |
| 1.454 | | 72.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.0 | 186 | 0.0380 | 1.55 | | **Sheet Flow, sheet flow** Smooth surfaces n= 0.011 P2= 1.89" |

## Subcatchment 2S: Central Ash Pond



## Summary for Subcatchment 3S: Stormwater Catch Basin #1

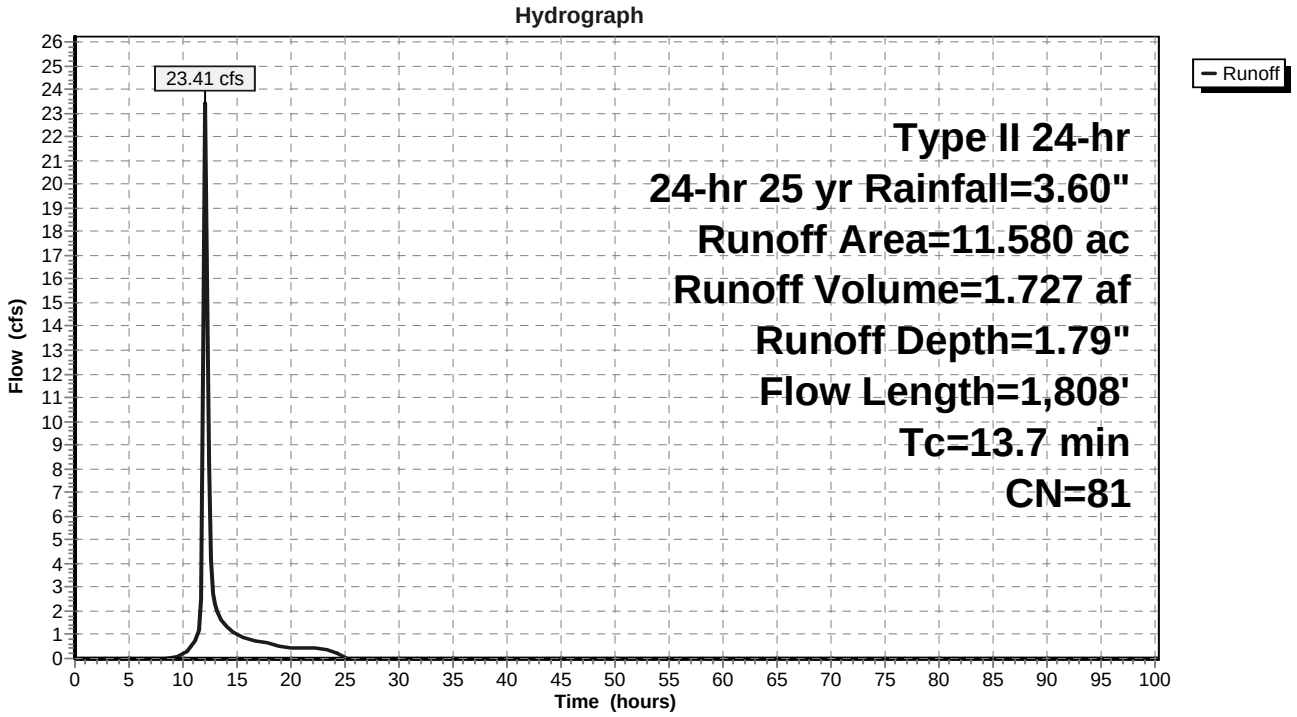
Runoff = 23.41 cfs @ 12.08 hrs, Volume= 1.727 af, Depth= 1.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs
Type II 24-hr 24-hr 25 yr Rainfall=3.60"

| Area (ac) | CN | Description |
|---|---|---|
| 11.580 | 81 | Urban industrial, 72% imp, HSG A |
| 3.242 | | 28.00% Pervious Area |
| 8.338 | | 72.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.5 | 204 | 0.0270 | 1.37 | | **Sheet Flow, sheet flow**<br>Smooth surfaces n= 0.011 P2= 1.89" |
| 0.2 | 64 | 0.0070 | 4.97 | 8.79 | **Pipe Channel, 18" HDPE**<br>18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'<br>n= 0.013 Corrugated PE, smooth interior |
| 0.1 | 24 | 0.0400 | 3.22 | | **Shallow Concentrated Flow, leg 1**<br>Unpaved Kv= 16.1 fps |
| 0.1 | 98 | 0.0100 | 13.51 | 216.15 | **Pipe Channel, 48" Concrete Pipe**<br>48.0" x 48.0" Box Area= 16.0 sf Perim= 16.0' r= 1.00'<br>n= 0.011 Concrete pipe, straight & clean |
| 3.1 | 328 | 0.0120 | 1.76 | | **Shallow Concentrated Flow, leg 2**<br>Unpaved Kv= 16.1 fps |
| 0.4 | 73 | 0.0400 | 3.22 | | **Shallow Concentrated Flow, leg 3**<br>Unpaved Kv= 16.1 fps |
| 0.0 | 20 | 0.2500 | 8.05 | | **Shallow Concentrated Flow, leg 4**<br>Unpaved Kv= 16.1 fps |
| 7.3 | 997 | 0.0200 | 2.28 | | **Shallow Concentrated Flow, leg 5**<br>Unpaved Kv= 16.1 fps |
| 13.7 | 1,808 | Total | | | |

## Subcatchment 3S: Stormwater Catch Basin #1



## Summary for Subcatchment 4S: Stormwater Catch Basin #2

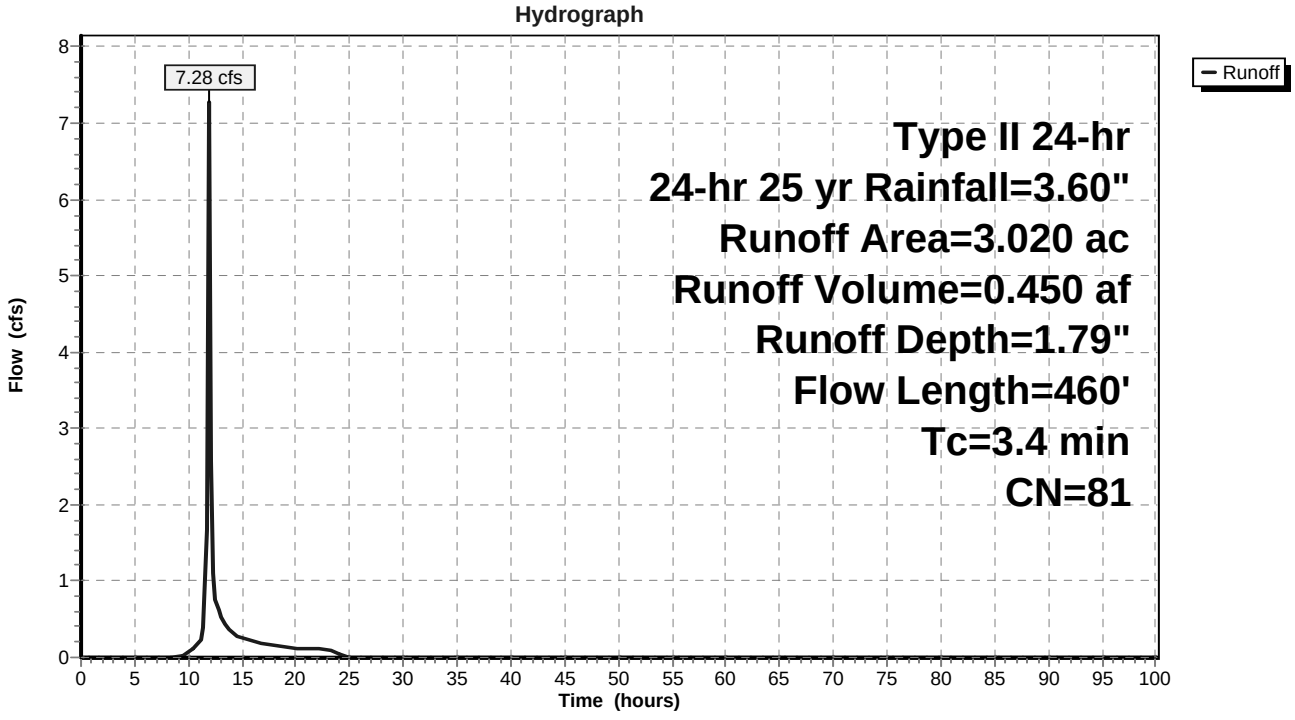
Runoff = 7.28 cfs @ 11.89 hrs, Volume= 0.450 af, Depth= 1.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs
Type II 24-hr 24-hr 25 yr Rainfall=3.60"

| Area (ac) | CN | Description |
|---|---|---|
| 3.020 | 81 | Urban industrial, 72% imp, HSG A |
| 0.846 | | 28.00% Pervious Area |
| 2.174 | | 72.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.7 | 90 | 0.0130 | 0.87 | | **Sheet Flow, sheet flow**<br>Smooth surfaces n= 0.011 P2= 1.89" |
| 1.5 | 309 | 0.0430 | 3.34 | | **Shallow Concentrated Flow, leg 1**<br>Unpaved Kv= 16.1 fps |
| 0.2 | 61 | 0.0400 | 6.18 | 10.92 | **Pipe Channel, 18" CMP**<br>18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'<br>n= 0.025 Corrugated metal |
| 3.4 | 460 | Total | | | |

## Subcatchment 4S: Stormwater Catch Basin #2



## Summary for Subcatchment 16S: Northwest Reservoir Drainage Area

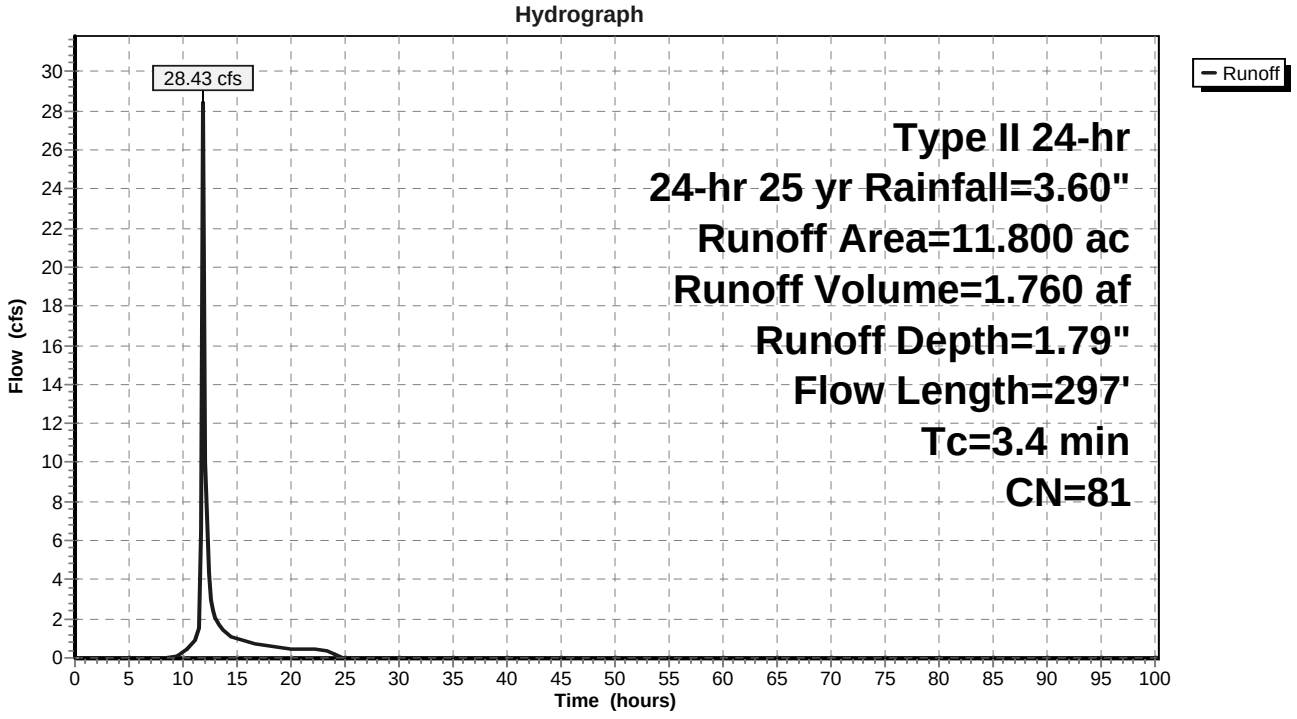
Runoff = 28.43 cfs @ 11.89 hrs, Volume= 1.760 af, Depth= 1.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs
Type II 24-hr 24-hr 25 yr Rainfall=3.60"

| Area (ac) | CN | Description |
|---|---|---|
| 11.800 | 81 | Urban industrial, 72% imp, HSG A |
| 3.304 | | 28.00% Pervious Area |
| 8.496 | | 72.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 2.9 | 183 | 0.0140 | 1.03 | | **Sheet Flow, sheet flow** Smooth surfaces n= 0.011 P2= 1.89" |
| 0.4 | 86 | 0.0470 | 3.49 | | **Shallow Concentrated Flow, leg 1** Unpaved Kv= 16.1 fps |
| 0.1 | 28 | 0.2500 | 8.05 | | **Shallow Concentrated Flow, leg 2** Unpaved Kv= 16.1 fps |
| 3.4 | 297 | Total | | | |

## Subcatchment 16S: Northwest Reservoir Drainage Area



## Summary for Subcatchment 18S: West Pond Drainage Area

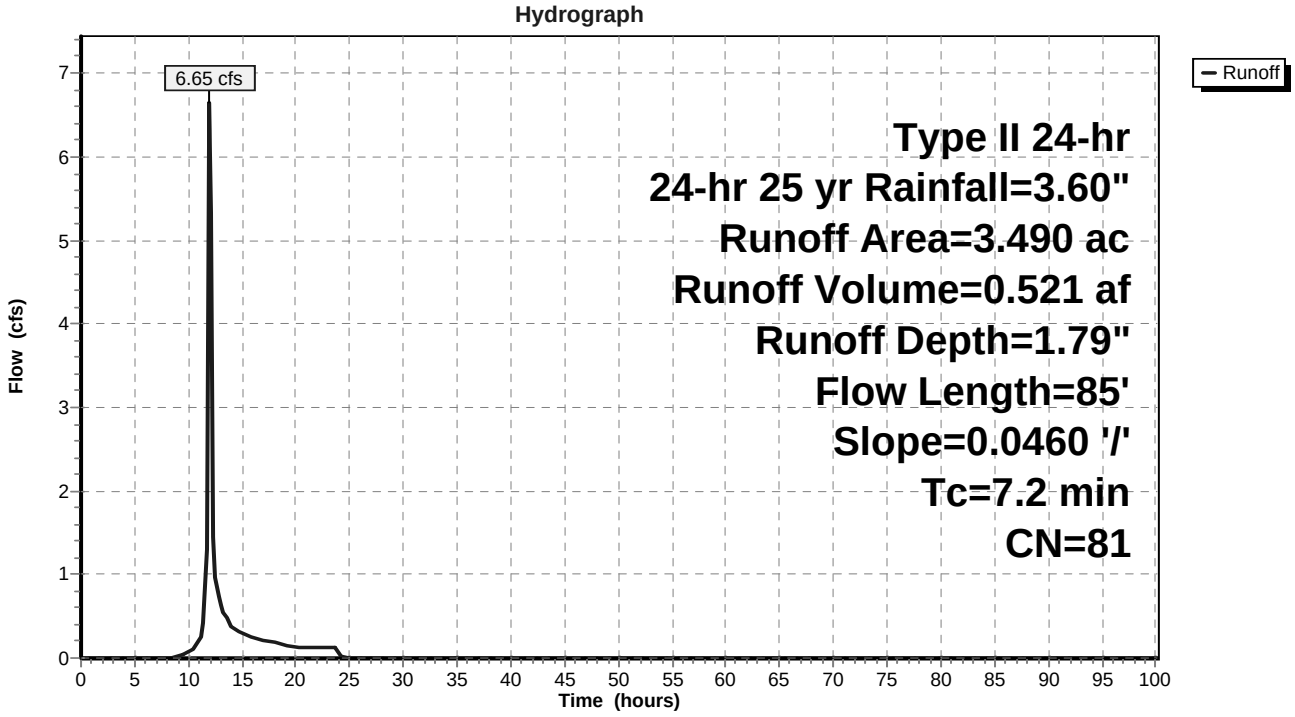
Runoff = 6.65 cfs @ 11.95 hrs, Volume= 0.521 af, Depth= 1.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs
Type II 24-hr 24-hr 25 yr Rainfall=3.60"

| Area (ac) | CN | Description |
|---|---|---|
| 3.490 | 81 | Urban industrial, 72% imp, HSG A |
| 0.977 | | 28.00% Pervious Area |
| 2.513 | | 72.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 7.2 | 85 | 0.0460 | 0.20 | | **Sheet Flow, 85** Range n= 0.130 P2= 1.89" |

## Subcatchment 18S: West Pond Drainage Area



## Summary for Pond 1P: East Ash Pond

Inflow Area = 1.950 ac, 72.00% Impervious, Inflow Depth = 1.79" for 24-hr 25 yr event
Inflow = 4.84 cfs @ 11.88 hrs, Volume= 0.291 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,123.49' @ 24.42 hrs Surf.Area= 0.376 ac Storage= 0.291 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

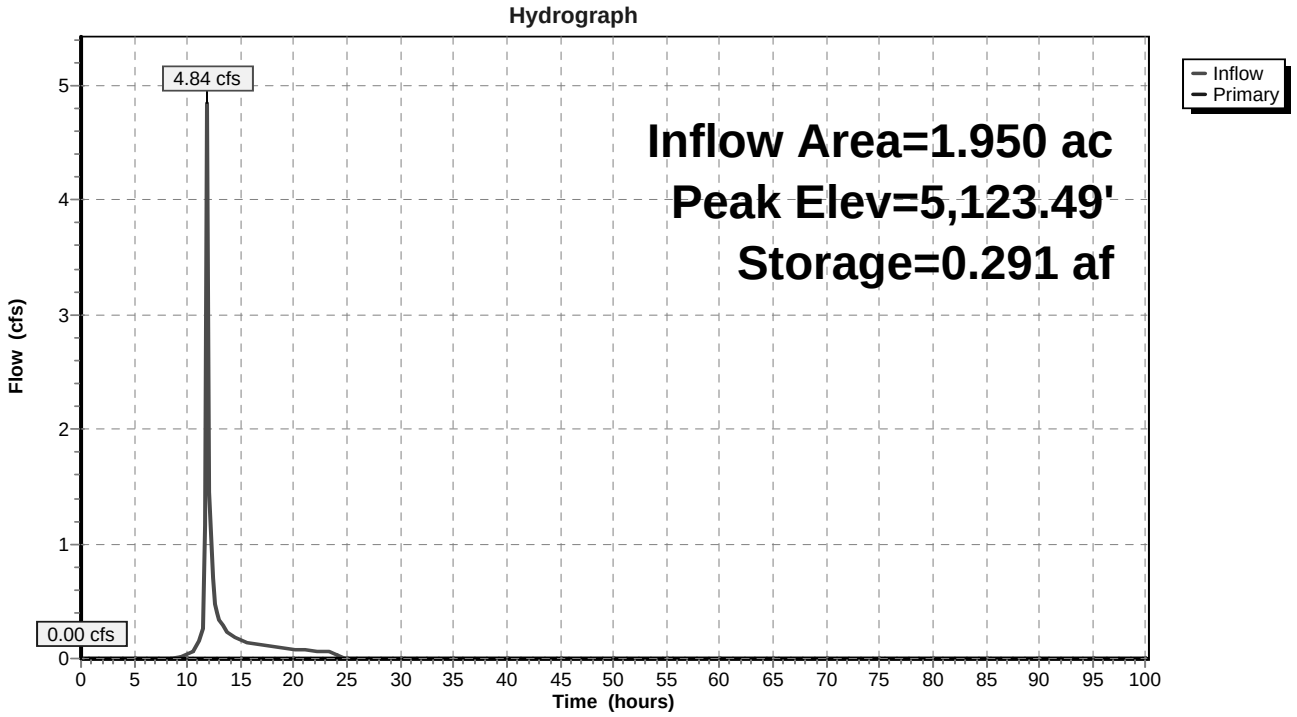
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5,122.00' | 12.113 af | **Custom Stage Data (Irregular)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Perim. (feet) | Inc.Store (acre-feet) | Cum.Store (acre-feet) | Wet.Area (acres) |
|---|---|---|---|---|---|
| 5,122.00 | 0.006 | 94.7 | 0.000 | 0.000 | 0.006 |
| 5,123.00 | 0.315 | 1,329.7 | 0.121 | 0.121 | 3.220 |
| 5,124.00 | 0.444 | 1,338.0 | 0.378 | 0.499 | 3.270 |
| 5,125.00 | 0.529 | 1,278.8 | 0.486 | 0.985 | 3.555 |
| 5,126.00 | 0.595 | 1,236.9 | 0.562 | 1.547 | 3.750 |
| 5,127.00 | 0.649 | 1,231.3 | 0.622 | 2.169 | 3.788 |
| 5,128.00 | 0.700 | 1,232.7 | 0.674 | 2.843 | 3.817 |
| 5,129.00 | 0.748 | 1,234.2 | 0.724 | 3.567 | 3.846 |
| 5,130.00 | 0.796 | 1,237.0 | 0.772 | 4.339 | 3.877 |
| 5,131.00 | 0.842 | 1,240.2 | 0.819 | 5.157 | 3.909 |
| 5,132.00 | 0.887 | 1,242.6 | 0.864 | 6.022 | 3.939 |
| 5,133.00 | 0.932 | 1,246.9 | 0.909 | 6.931 | 3.974 |
| 5,134.00 | 0.975 | 1,251.0 | 0.953 | 7.885 | 4.008 |
| 5,135.00 | 1.016 | 1,254.7 | 0.995 | 8.880 | 4.042 |
| 5,136.00 | 1.057 | 1,258.1 | 1.036 | 9.917 | 4.074 |
| 5,137.00 | 1.098 | 1,261.4 | 1.077 | 10.994 | 4.107 |
| 5,138.00 | 1.140 | 1,269.0 | 1.119 | 12.113 | 4.153 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,133.17' | **36.0" Round Culvert**<br>L= 35.0' RCP, groove end projecting, Ke= 0.200<br>Inlet / Outlet Invert= 5,133.17' / 5,128.74' S= 0.1266 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 7.07 sf |
| #2 | Device 1 | 5,136.66' | **72.0" Horiz. Orifice/Grate X 0.75** C= 0.600<br>Limited to weir flow at low heads |

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=5,122.00' TW=5,127.72' (Dynamic Tailwater)
↑**1=Culvert** ( Controls 0.00 cfs)
↑**2=Orifice/Grate** ( Controls 0.00 cfs)

## Pond 1P: East Ash Pond



## Summary for Pond 2P: Central Ash Pond

Inflow Area = 2.020 ac, 72.00% Impervious, Inflow Depth = 1.79" for 24-hr 25 yr event
Inflow = 5.17 cfs @ 11.88 hrs, Volume= 0.301 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Starting Elev= 5,136.74' Surf.Area= 0.995 ac Storage= 9.774 af
Peak Elev= 5,137.04' @ 24.42 hrs Surf.Area= 1.012 ac Storage= 10.075 af (0.301 af above start)
Flood Elev= 5,138.85' Surf.Area= 1.112 ac Storage= 11.996 af (2.222 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

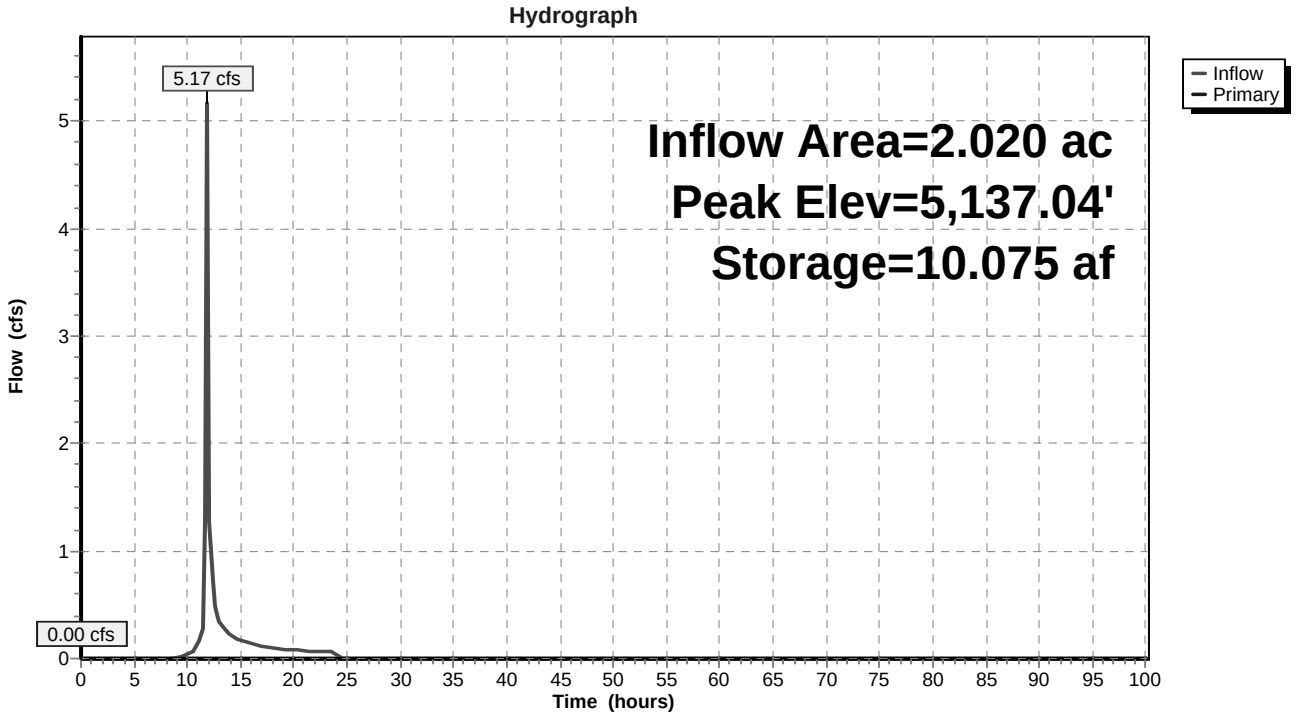
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5,119.00' | 12.164 af | **Custom Stage Data (Irregular)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Perim. (feet) | Inc.Store (acre-feet) | Cum.Store (acre-feet) | Wet.Area (acres) |
|---|---|---|---|---|---|
| 5,119.00 | 0.140 | 865.0 | 0.000 | 0.000 | 0.140 |
| 5,121.00 | 0.230 | 936.0 | 0.366 | 0.366 | 0.377 |
| 5,123.00 | 0.310 | 975.0 | 0.538 | 0.904 | 0.520 |
| 5,125.00 | 0.410 | 1,010.0 | 0.718 | 1.622 | 0.655 |
| 5,127.00 | 0.500 | 1,042.0 | 0.909 | 2.530 | 0.784 |
| 5,129.00 | 0.600 | 1,071.0 | 1.098 | 3.629 | 0.906 |
| 5,131.00 | 0.700 | 1,098.0 | 1.299 | 4.928 | 1.024 |
| 5,133.00 | 0.800 | 1,124.0 | 1.499 | 6.427 | 1.141 |
| 5,135.00 | 0.900 | 1,150.0 | 1.699 | 8.126 | 1.261 |
| 5,137.00 | 1.010 | 1,176.0 | 1.909 | 10.035 | 1.384 |
| 5,139.00 | 1.120 | 1,202.0 | 2.129 | 12.164 | 1.509 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,133.58' | **36.0" Round Culvert**<br>L= 30.0' RCP, groove end projecting, Ke= 0.200<br>Inlet / Outlet Invert= 5,133.58' / 5,129.27' S= 0.1437 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 7.07 sf |
| #2 | Device 1 | 5,137.07' | **72.0" Horiz. Orifice/Grate X 0.75** C= 0.600<br>Limited to weir flow at low heads |

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=5,136.74' TW=5,128.79' (Dynamic Tailwater)
↑**1=Culvert** (Passes 0.00 cfs of 54.81 cfs potential flow)
↑**2=Orifice/Grate** ( Controls 0.00 cfs)

## Pond 2P: Central Ash Pond



## Summary for Pond 3P: West Ash/Stormwater Pond

Inflow Area = 29.890 ac, 72.00% Impervious, Inflow Depth > 7.81" for 24-hr 25 yr event
Inflow = 37.49 cfs @ 12.07 hrs, Volume= 19.464 af
Outflow = 29.76 cfs @ 2.09 hrs, Volume= 19.230 af, Atten= 21%, Lag= 0.0 min
Primary = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,137.05' @ 1.99 hrs Surf.Area= 0.840 ac Storage= 3.489 af

Plug-Flow detention time= 383.1 min calculated for 18.916 af (97% of inflow)
Center-of-Mass det. time= 275.6 min ( 981.5 - 706.0 )

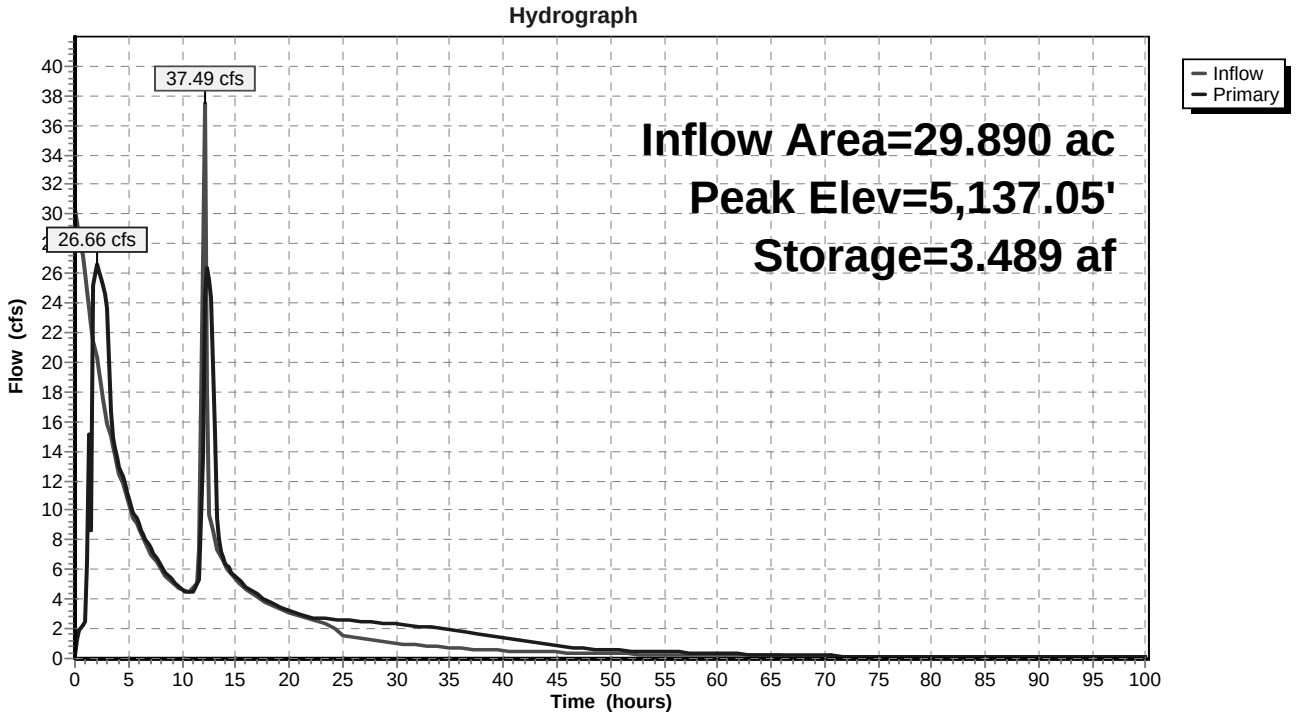
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5,131.00' | 4.332 af | **Custom Stage Data (Irregular)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Perim. (feet) | Inc.Store (acre-feet) | Cum.Store (acre-feet) | Wet.Area (acres) |
|---|---|---|---|---|---|
| 5,131.00 | 0.174 | 531.0 | 0.000 | 0.000 | 0.174 |
| 5,132.00 | 0.419 | 758.2 | 0.288 | 0.288 | 0.709 |
| 5,133.00 | 0.520 | 829.5 | 0.469 | 0.756 | 0.917 |
| 5,134.00 | 0.595 | 856.4 | 0.557 | 1.313 | 1.002 |
| 5,135.00 | 0.672 | 874.5 | 0.633 | 1.946 | 1.063 |
| 5,136.00 | 0.752 | 897.2 | 0.712 | 2.658 | 1.139 |
| 5,137.00 | 0.836 | 954.8 | 0.794 | 3.452 | 1.335 |
| 5,138.00 | 0.925 | 976.2 | 0.880 | 4.332 | 1.414 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,131.75' | **22.0" Round Culvert**<br>L= 87.0' CPP, square edge headwall, Ke= 0.500<br>Inlet / Outlet Invert= 5,131.75' / 5,129.85' S= 0.0218 '/' Cc= 0.900<br>n= 0.010 PVC, smooth interior, Flow Area= 2.64 sf |
| #2 | Device 1 | 5,131.00' | **2.0" Vert. Orifice/Grate** X 2 rows with 3.0" cc spacing C= 0.600 |
| #3 | Device 1 | 5,131.33' | **2.0" Vert. Orifice/Grate** X 2 rows with 3.0" cc spacing C= 0.600 |
| #4 | Device 1 | 5,131.67' | **2.0" Vert. Orifice/Grate** X 2 rows with 3.0" cc spacing C= 0.600 |
| #5 | Device 1 | 5,132.00' | **2.0" Vert. Orifice/Grate** X 2 rows with 3.0" cc spacing C= 0.600 |
| #6 | Device 1 | 5,132.50' | **4.2" W x 4.2" H Vert. Orifice/Grate** C= 0.600 |
| #7 | Device 1 | 5,135.75' | **4.0" x 4.0" Horiz. Orifice/Grate X 10.00 columns**<br>X 10 rows C= 0.600 in 60.0" x 60.0" Grate<br>Limited to weir flow at low heads |

**Primary OutFlow** Max=0.00 cfs @ 2.04 hrs HW=5,137.01' TW=5,137.73' (Dynamic Tailwater)
- **1=Culvert** ( Controls 0.00 cfs)
  - **2=Orifice/Grate** ( Controls 0.00 cfs)
  - **3=Orifice/Grate** ( Controls 0.00 cfs)
  - **4=Orifice/Grate** ( Controls 0.00 cfs)
  - **5=Orifice/Grate** ( Controls 0.00 cfs)
  - **6=Orifice/Grate** ( Controls 0.00 cfs)
  - **7=Orifice/Grate** ( Controls 0.00 cfs)

## Pond 3P: West Ash/Stormwater Pond



## Summary for Pond 4P: New MH

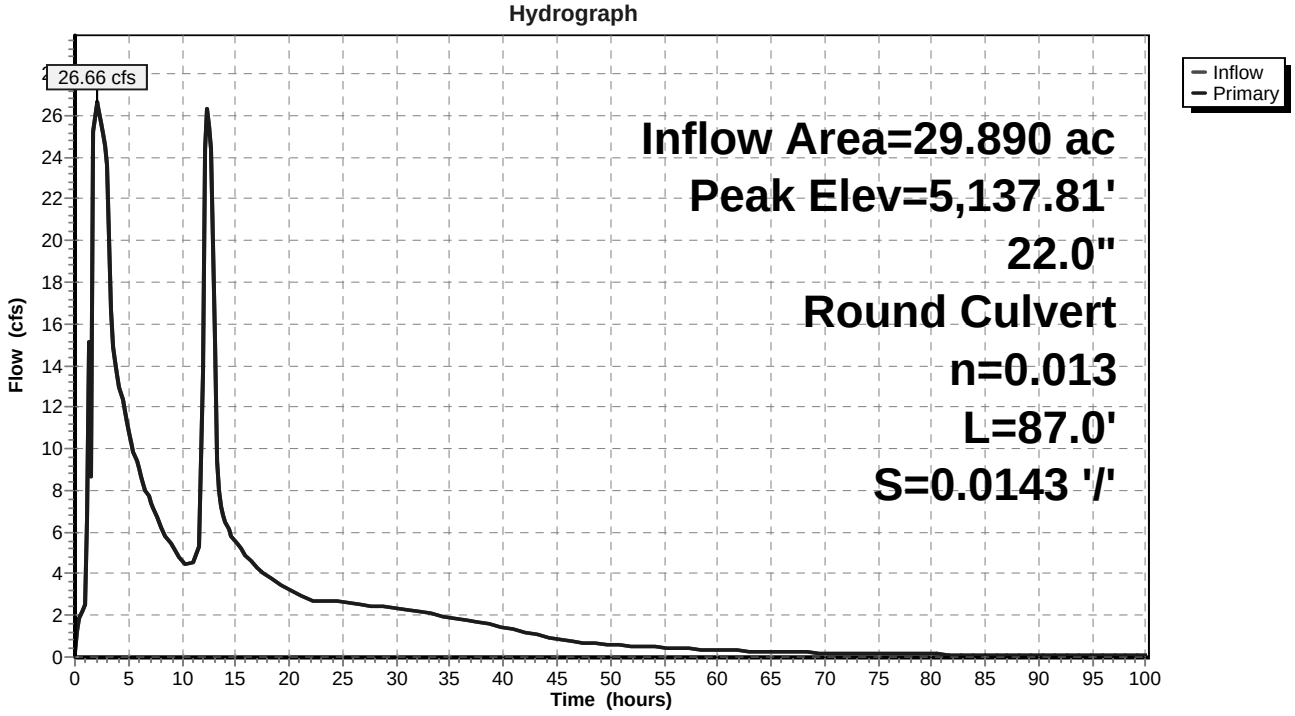
Inflow Area = 29.890 ac, 72.00% Impervious, Inflow Depth > 8.08" for 24-hr 25 yr event
Inflow = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af
Outflow = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af, Atten= 0%, Lag= 0.0 min
Primary = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,137.81' @ 2.03 hrs
Flood Elev= 5,139.00'

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,129.85' | **22.0" Round Culvert**<br>L= 87.0' CPP, projecting, no headwall, Ke= 0.900<br>Inlet / Outlet Invert= 5,129.85' / 5,128.61' S= 0.0143 '/' Cc= 0.900<br>n= 0.013 Corrugated PE, smooth interior, Flow Area= 2.64 sf |

**Primary OutFlow** Max=25.96 cfs @ 2.04 hrs HW=5,137.73' TW=5,131.04' (Dynamic Tailwater)
↑**1=Culvert** (Inlet Controls 25.96 cfs @ 9.84 fps)

### Pond 4P: New MH



## Summary for Pond 10P: SD-1

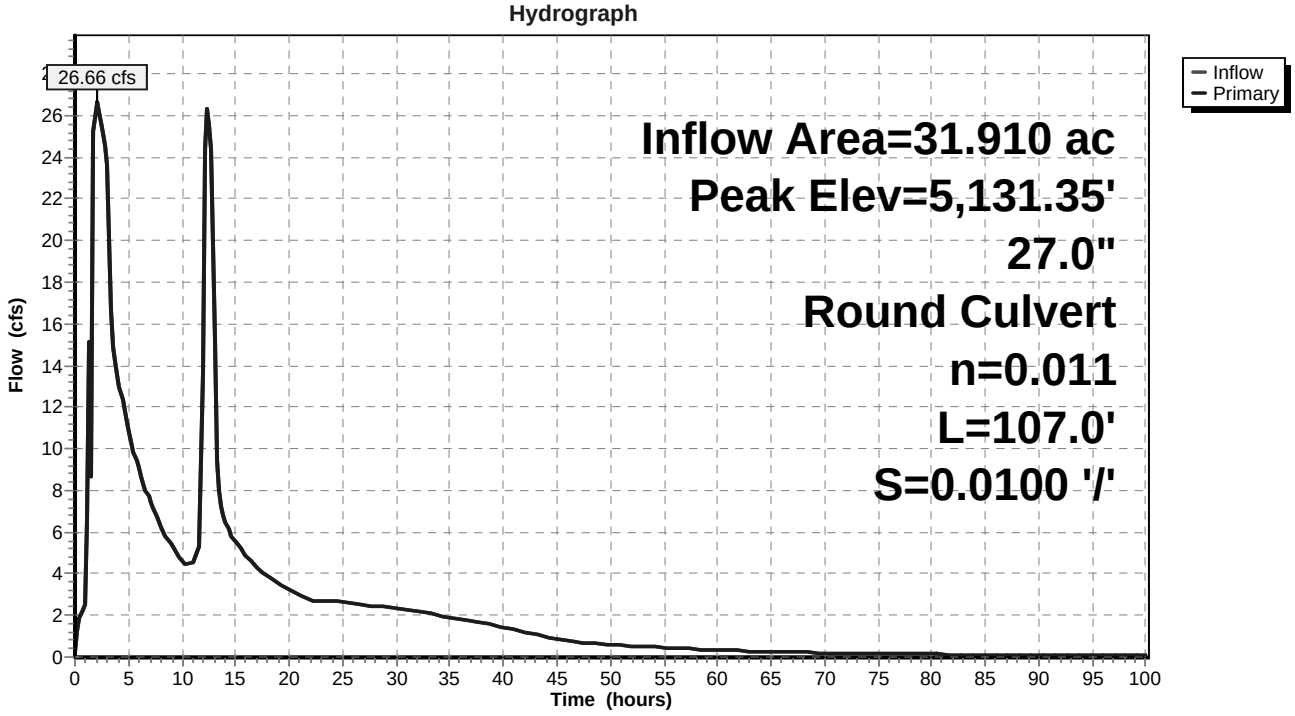
Inflow Area = 31.910 ac, 72.00% Impervious, Inflow Depth > 7.57" for 24-hr 25 yr event
Inflow = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af
Outflow = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af, Atten= 0%, Lag= 0.0 min
Primary = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,131.35' @ 1.83 hrs
Flood Elev= 5,138.10'

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,128.61' | **27.0" Round Culvert**<br>L= 107.0' RCP, groove end projecting, Ke= 0.200<br>Inlet / Outlet Invert= 5,128.61' / 5,127.54' S= 0.0100 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 3.98 sf |

**Primary OutFlow** Max=19.75 cfs @ 2.04 hrs HW=5,131.04' TW=5,130.10' (Dynamic Tailwater)
↑**1=Culvert** (Outlet Controls 19.75 cfs @ 5.73 fps)

## Pond 10P: SD-1



## Summary for Pond 12P: Southern Drainage Pond

Inflow Area = 3.020 ac, 72.00% Impervious, Inflow Depth = 1.79" for 24-hr 25 yr event
Inflow = 7.28 cfs @ 11.89 hrs, Volume= 0.450 af
Outflow = 6.12 cfs @ 11.95 hrs, Volume= 0.411 af, Atten= 16%, Lag= 3.7 min
Primary = 6.12 cfs @ 11.95 hrs, Volume= 0.411 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,140.24' @ 11.96 hrs Surf.Area= 1,773 sf Storage= 3,160 cf

Plug-Flow detention time= 72.2 min calculated for 0.410 af (91% of inflow)
Center-of-Mass det. time= 28.2 min ( 856.1 - 828.0 )

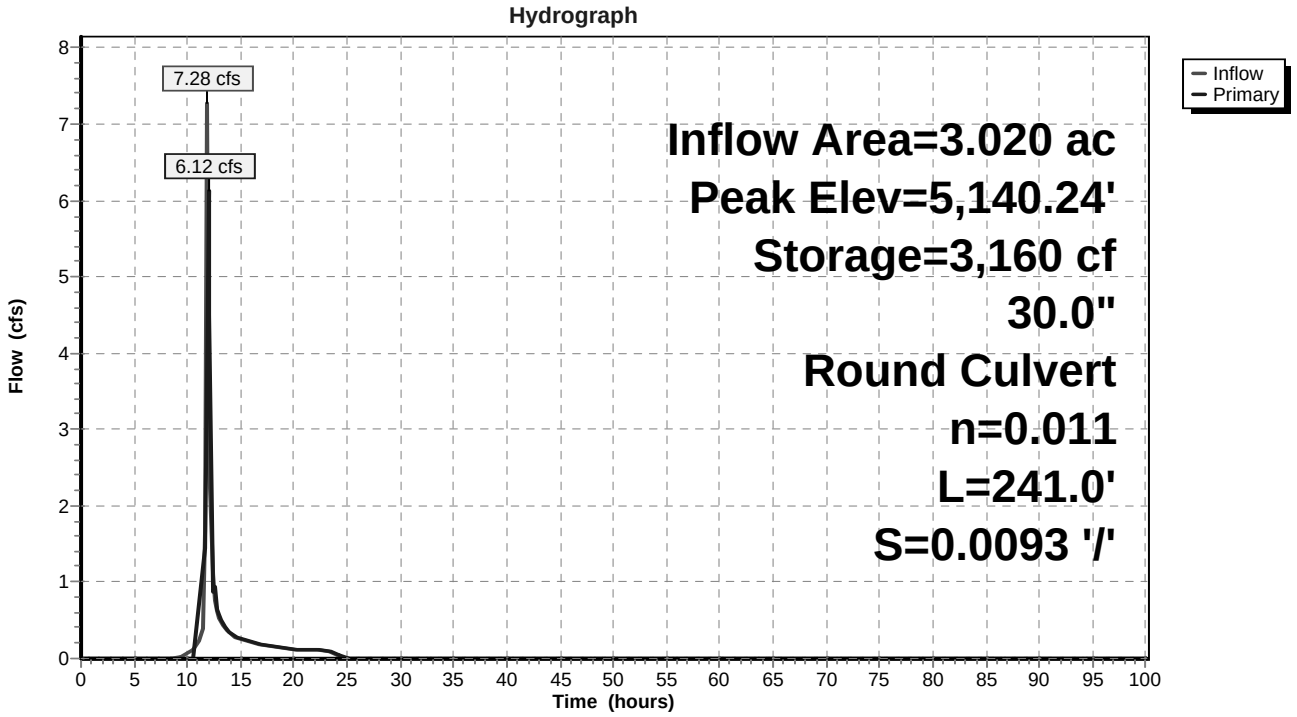
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5,138.00' | 16,164 cf | **Custom Stage Data (Irregular)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Perim. (feet) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) | Wet.Area (sq-ft) |
|---|---|---|---|---|---|
| 5,138.00 | 1,088 | 155.2 | 0 | 0 | 1,088 |
| 5,139.00 | 1,366 | 173.9 | 1,224 | 1,224 | 1,605 |
| 5,140.00 | 1,691 | 193.5 | 1,526 | 2,750 | 2,206 |
| 5,141.00 | 2,050 | 213.1 | 1,868 | 4,618 | 2,872 |
| 5,142.00 | 2,443 | 230.3 | 2,244 | 6,861 | 3,518 |
| 5,143.00 | 2,866 | 246.5 | 2,652 | 9,513 | 4,178 |
| 5,144.00 | 3,320 | 262.7 | 3,090 | 12,603 | 4,882 |
| 5,145.00 | 3,808 | 269.5 | 3,561 | 16,164 | 5,274 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,139.34' | **30.0" Round Culvert**<br>L= 241.0' RCP, rounded edge headwall, Ke= 0.100<br>Inlet / Outlet Invert= 5,139.34' / 5,137.10' S= 0.0093 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 4.91 sf |

**Primary OutFlow** Max=5.35 cfs @ 11.95 hrs HW=5,140.14' TW=5,136.24' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 5.35 cfs @ 5.90 fps)

## Pond 12P: Southern Drainage Pond



## Summary for Pond 13P: Northern Drainage Basin

Inflow Area = 11.580 ac, 72.00% Impervious, Inflow Depth = 1.79" for 24-hr 25 yr event
Inflow = 23.41 cfs @ 12.08 hrs, Volume= 1.727 af
Outflow = 22.69 cfs @ 12.10 hrs, Volume= 1.708 af, Atten= 3%, Lag= 1.1 min
Primary = 22.69 cfs @ 12.10 hrs, Volume= 1.708 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,140.74' @ 12.10 hrs Surf.Area= 0.038 ac Storage= 0.067 af

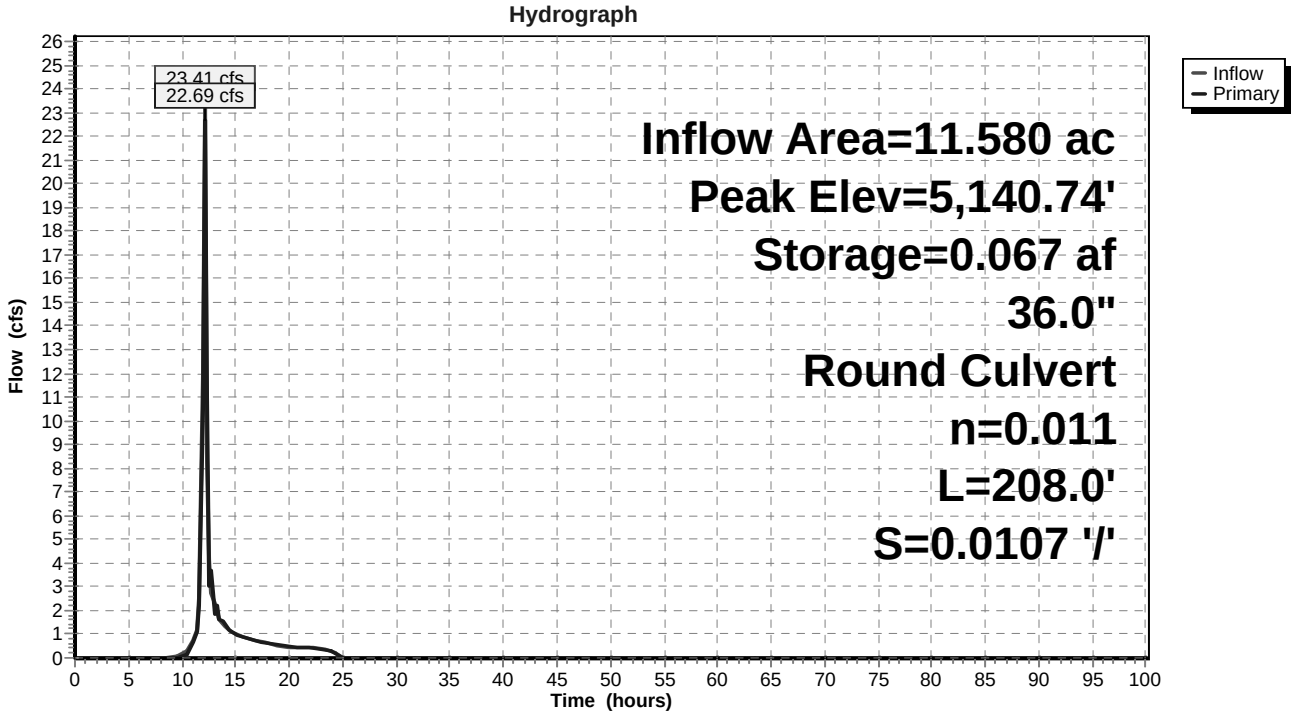
Plug-Flow detention time= 18.0 min calculated for 1.708 af (99% of inflow)
Center-of-Mass det. time= 6.6 min ( 844.3 - 837.8 )

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5,138.00' | 1.111 af | **24.00'W x 24.00'L x 12.00'H Prismatoid Z=3.0** |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,139.11' | **36.0" Round Culvert**<br>L= 208.0' RCP, rounded edge headwall, Ke= 0.100<br>Inlet / Outlet Invert= 5,139.11' / 5,136.88' S= 0.0107 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 7.07 sf |

**Primary OutFlow** Max=22.54 cfs @ 12.10 hrs HW=5,140.73' TW=5,136.64' (Dynamic Tailwater)
↑**1=Culvert** (Barrel Controls 22.54 cfs @ 8.39 fps)

## Pond 13P: Northern Drainage Basin



## Summary for Pond 15P: Northwest Reservoir

Inflow Area = 11.800 ac, 72.00% Impervious, Inflow Depth = 1.79" for 24-hr 25 yr event
Inflow = 28.43 cfs @ 11.89 hrs, Volume= 1.760 af
Outflow = 30.25 cfs @ 0.00 hrs, Volume= 16.824 af, Atten= 0%, Lag= 0.0 min
Primary = 30.25 cfs @ 0.00 hrs, Volume= 16.824 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Starting Elev= 5,168.00' Surf.Area= 7.835 ac Storage= 22.814 af
Peak Elev= 5,168.00' @ 0.00 hrs Surf.Area= 7.835 ac Storage= 22.814 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

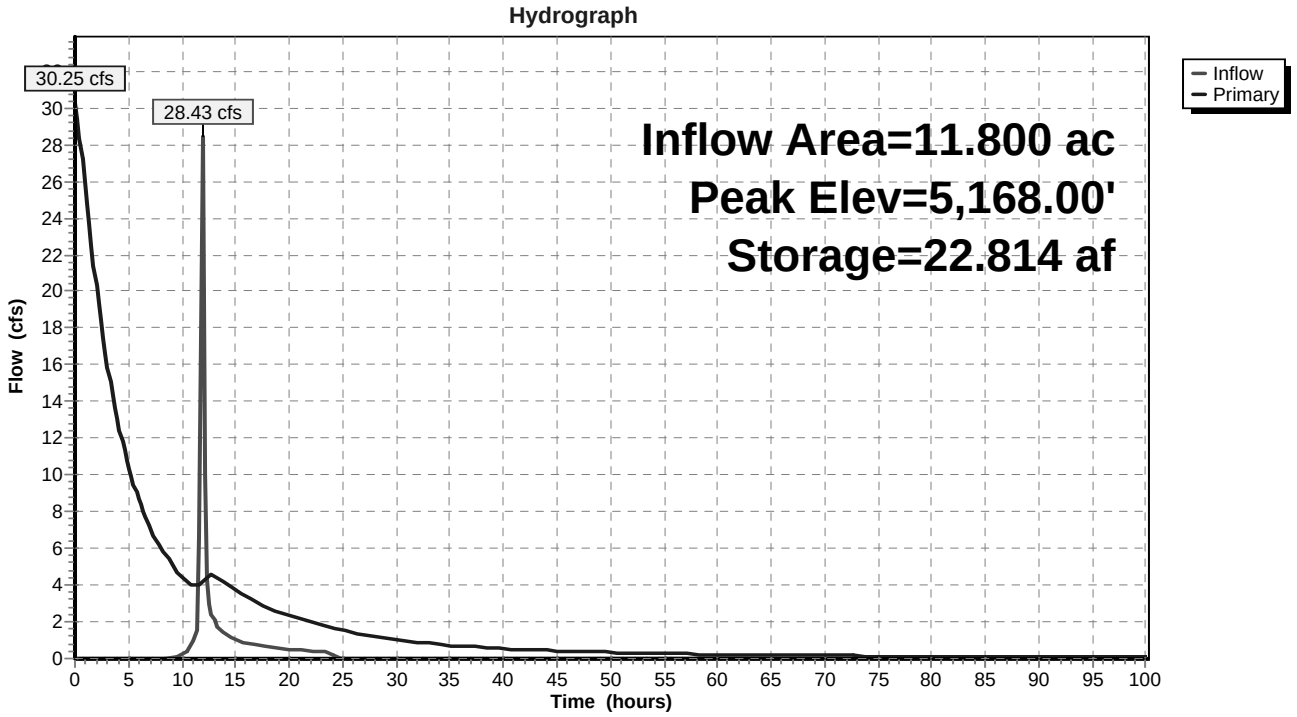
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5,165.00' | 47.023 af | **Custom Stage Data (Irregular)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Perim. (feet) | Inc.Store (acre-feet) | Cum.Store (acre-feet) | Wet.Area (acres) |
|---|---|---|---|---|---|
| 5,165.00 | 7.376 | 2,195.8 | 0.000 | 0.000 | 7.376 |
| 5,166.00 | 7.528 | 2,214.1 | 7.452 | 7.452 | 7.532 |
| 5,167.00 | 7.681 | 2,232.3 | 7.604 | 15.056 | 7.688 |
| 5,168.00 | 7.835 | 2,250.8 | 7.758 | 22.814 | 7.848 |
| 5,169.00 | 7.991 | 2,269.6 | 7.913 | 30.727 | 8.012 |
| 5,170.00 | 8.148 | 2,288.4 | 8.069 | 38.796 | 8.177 |
| 5,171.00 | 8.306 | 2,307.3 | 8.227 | 47.023 | 8.344 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,166.00' | **24.0" Round Culvert**<br>L= 350.0' CPP, square edge headwall, Ke= 0.500<br>Inlet / Outlet Invert= 5,166.00' / 5,160.00' S= 0.0171 '/' Cc= 0.900<br>n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf |
| #2 | Primary | 5,166.00' | **24.0" Round Culvert**<br>L= 350.0' CPP, square edge headwall, Ke= 0.500<br>Inlet / Outlet Invert= 5,166.00' / 5,160.00' S= 0.0171 '/' Cc= 0.900<br>n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf |

**Primary OutFlow** Max=30.25 cfs @ 0.00 hrs HW=5,168.00' TW=5,165.00' (Dynamic Tailwater)
**1=Culvert** (Inlet Controls 15.13 cfs @ 4.81 fps)
**2=Culvert** (Inlet Controls 15.13 cfs @ 4.81 fps)

## Pond 15P: Northwest Reservoir



## Summary for Pond 17P: 2 - 24" HDPE to 1- 24" HDPE Pipe Connection

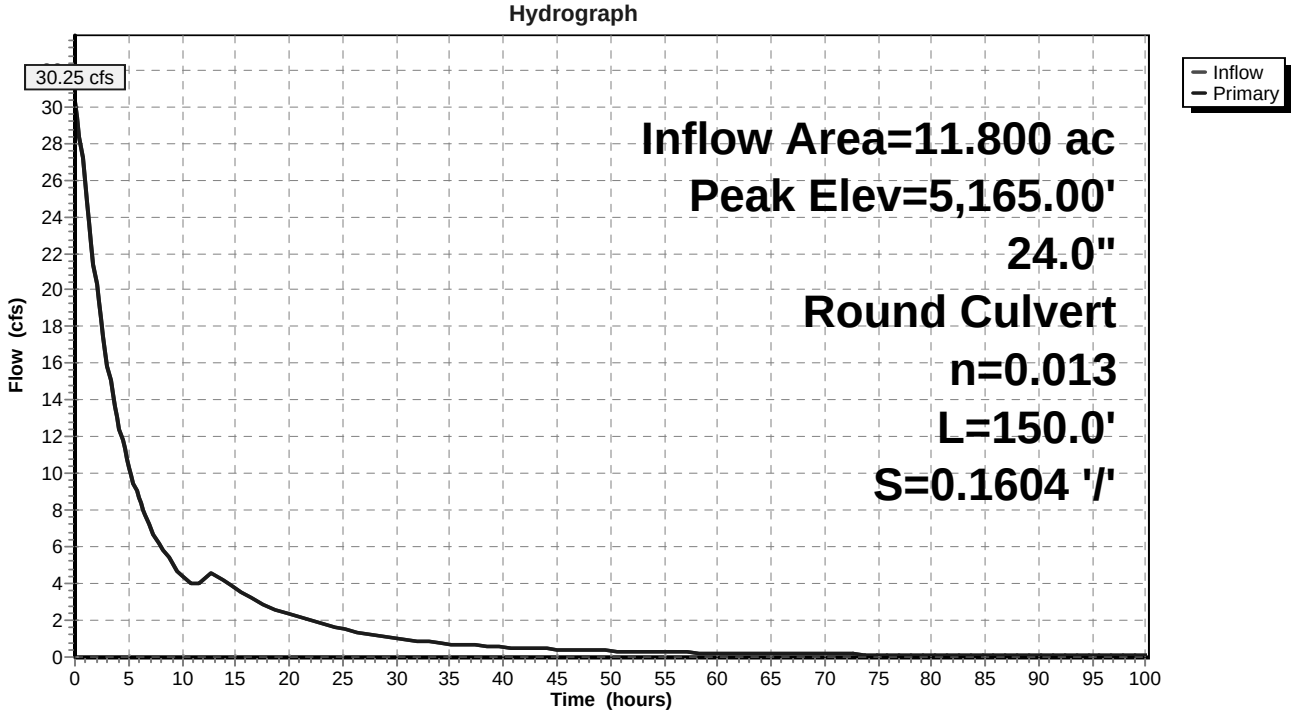
Inflow Area = 11.800 ac, 72.00% Impervious, Inflow Depth > 17.11" for 24-hr 25 yr event
Inflow = 30.25 cfs @ 0.00 hrs, Volume= 16.824 af
Outflow = 30.25 cfs @ 0.00 hrs, Volume= 16.824 af, Atten= 0%, Lag= 0.0 min
Primary = 30.25 cfs @ 0.00 hrs, Volume= 16.824 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,165.00' @ 0.00 hrs
Flood Elev= 5,168.00'

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,160.00' | **24.0" Round Culvert**<br>L= 150.0' CPP, square edge headwall, Ke= 0.500<br>Inlet / Outlet Invert= 5,160.00' / 5,135.94' S= 0.1604 '/' Cc= 0.900<br>n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf |

**Primary OutFlow** Max=30.25 cfs @ 0.00 hrs HW=5,165.00' TW=5,131.96' (Dynamic Tailwater)
**1=Culvert** (Inlet Controls 30.25 cfs @ 9.63 fps)

## Pond 17P: 2 - 24" HDPE to 1- 24" HDPE Pipe Connection



## Summary for Pond 19P: SD-2

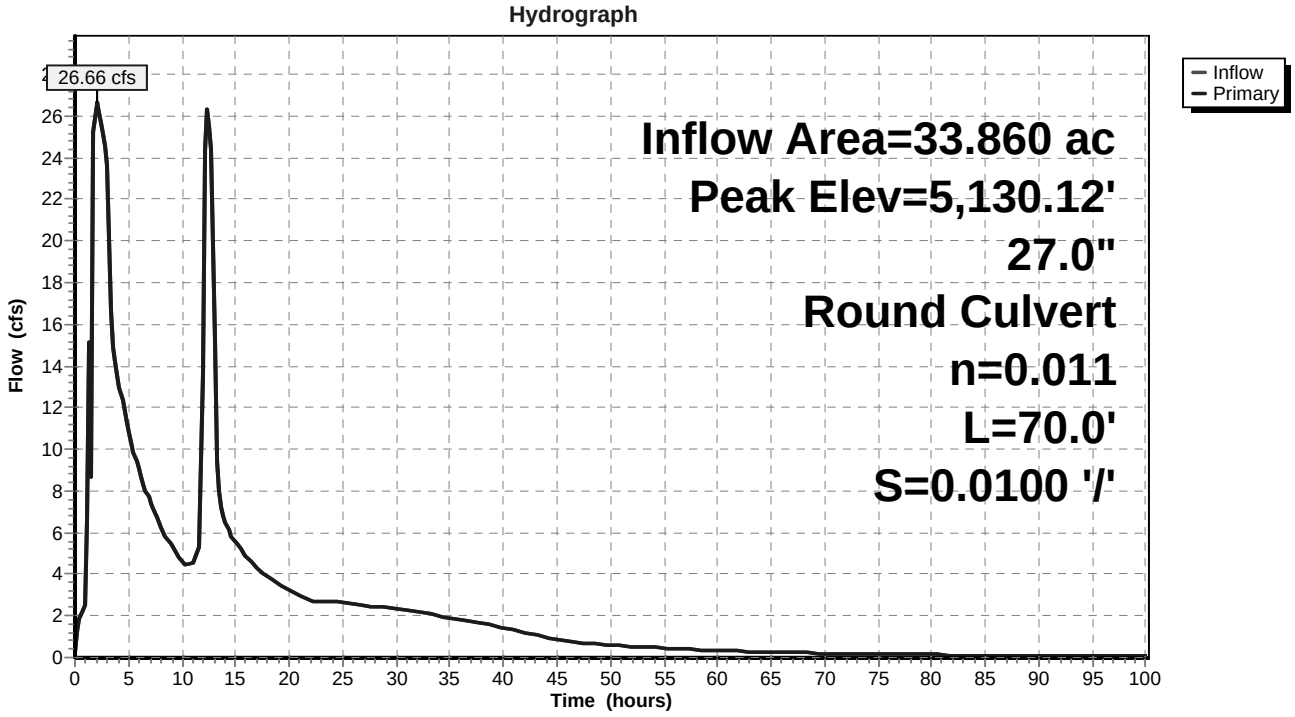
Inflow Area = 33.860 ac, 72.00% Impervious, Inflow Depth > 7.13" for 24-hr 25 yr event
Inflow = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af
Outflow = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af, Atten= 0%, Lag= 0.0 min
Primary = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs / 2
Peak Elev= 5,130.12' @ 2.04 hrs

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5,127.54' | **27.0" Round Culvert**<br>L= 70.0' RCP, groove end projecting, Ke= 0.200<br>Inlet / Outlet Invert= 5,127.54' / 5,126.84' S= 0.0100 '/' Cc= 0.900<br>n= 0.011 Concrete pipe, straight & clean, Flow Area= 3.98 sf |

**Primary OutFlow** Max=26.48 cfs @ 2.04 hrs HW=5,130.10' TW=0.00' (Dynamic Tailwater)
**1=Culvert** (Barrel Controls 26.48 cfs @ 7.32 fps)

## Pond 19P: SD-2

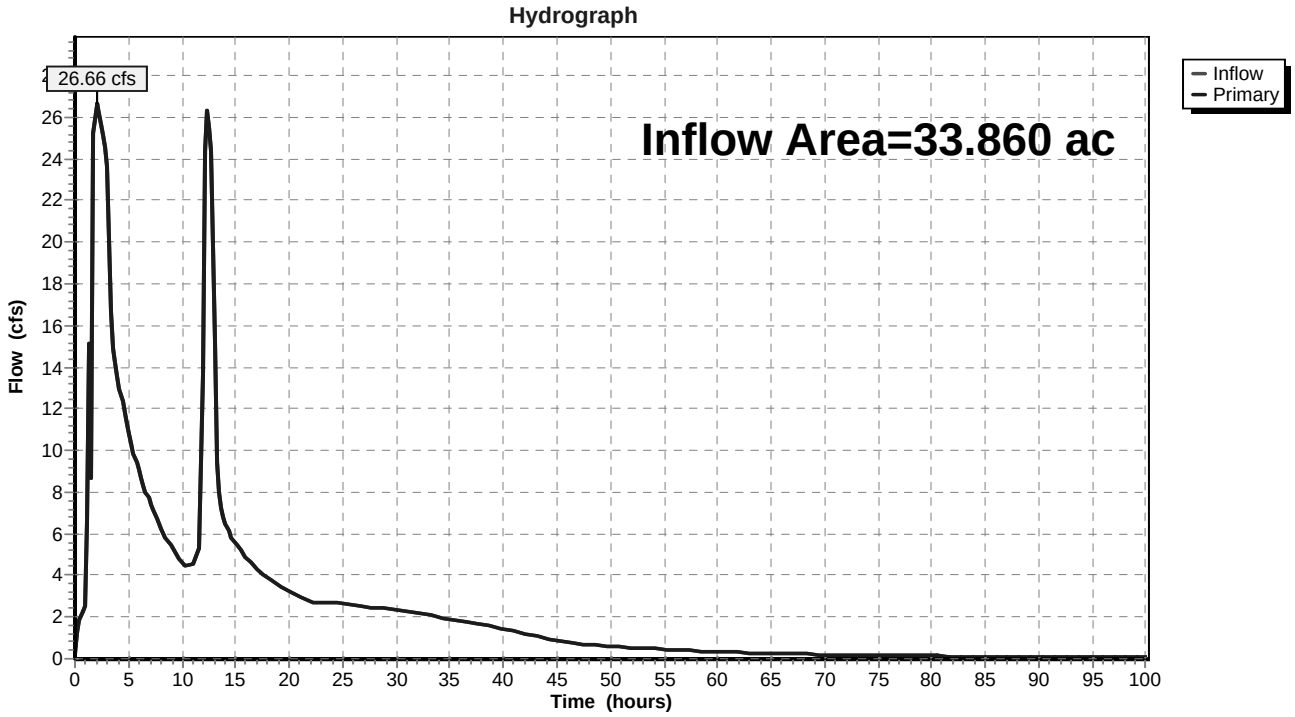


## Summary for Link 20L: To Lift Station

Inflow Area = 33.860 ac, 72.00% Impervious, Inflow Depth > 7.13" for 24-hr 25 yr event
Inflow = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af
Primary = 26.66 cfs @ 2.04 hrs, Volume= 20.132 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-100.10 hrs, dt= 0.22 hrs

## Link 20L: To Lift Station



# APPENDIX B - NOAA RAINFALL DATA

**NOAA Atlas 14, Volume 8, Version 2**
**Location name: Denver, Colorado, USA***
**Latitude: 39.8077°, Longitude: -104.9673°**
**Elevation: 5172.9 ft****
* source: ESRI Maps
** source: USGS

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

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 | 0.216 (0.169–0.276) | 0.266 (0.208–0.340) | 0.357 (0.278–0.457) | 0.440 (0.341–0.566) | 0.566 (0.429–0.765) | 0.672 (0.496–0.915) | 0.787 (0.561–1.09) | 0.912 (0.624–1.30) | 1.09 (0.717–1.58) | 1.23 (0.787–1.80) |
| 10-min | 0.316 (0.247–0.404) | 0.390 (0.305–0.498) | 0.522 (0.407–0.670) | 0.644 (0.499–0.829) | 0.828 (0.629–1.12) | 0.985 (0.727–1.34) | 1.15 (0.822–1.60) | 1.34 (0.913–1.90) | 1.60 (1.05–2.32) | 1.81 (1.15–2.64) |
| 15-min | 0.385 (0.302–0.493) | 0.475 (0.372–0.608) | 0.637 (0.496–0.817) | 0.785 (0.609–1.01) | 1.01 (0.767–1.37) | 1.20 (0.886–1.63) | 1.41 (1.00–1.95) | 1.63 (1.11–2.31) | 1.95 (1.28–2.83) | 2.20 (1.41–3.22) |
| 30-min | 0.544 (0.426–0.696) | 0.669 (0.523–0.856) | 0.893 (0.696–1.15) | 1.10 (0.851–1.41) | 1.41 (1.07–1.90) | 1.67 (1.23–2.27) | 1.95 (1.39–2.70) | 2.25 (1.54–3.20) | 2.68 (1.76–3.89) | 3.03 (1.93–4.42) |
| 60-min | 0.677 (0.530–0.865) | 0.830 (0.649–1.06) | 1.10 (0.861–1.42) | 1.36 (1.05–1.75) | 1.73 (1.32–2.34) | 2.05 (1.51–2.79) | 2.40 (1.71–3.33) | 2.77 (1.89–3.93) | 3.29 (2.17–4.79) | 3.72 (2.37–5.44) |
| 2-hr | 0.809 (0.640–1.02) | 0.991 (0.783–1.25) | 1.32 (1.04–1.67) | 1.61 (1.26–2.05) | 2.06 (1.58–2.75) | 2.44 (1.82–3.28) | 2.84 (2.05–3.90) | 3.28 (2.27–4.61) | 3.91 (2.60–5.61) | 4.41 (2.85–6.37) |
| 3-hr | 0.880 (0.701–1.11) | 1.07 (0.854–1.35) | 1.42 (1.13–1.79) | 1.74 (1.37–2.20) | 2.22 (1.71–2.94) | 2.62 (1.97–3.50) | 3.06 (2.21–4.17) | 3.53 (2.45–4.92) | 4.19 (2.80–5.98) | 4.73 (3.07–6.79) |
| 6-hr | 1.05 (0.842–1.30) | 1.27 (1.02–1.58) | 1.66 (1.33–2.07) | 2.02 (1.61–2.53) | 2.56 (1.99–3.35) | 3.01 (2.28–3.98) | 3.50 (2.56–4.71) | 4.02 (2.82–5.54) | 4.76 (3.22–6.71) | 5.36 (3.51–7.60) |
| 12-hr | 1.29 (1.05–1.59) | 1.55 (1.26–1.91) | 2.01 (1.63–2.49) | 2.43 (1.95–3.01) | 3.04 (2.39–3.93) | 3.55 (2.71–4.62) | 4.09 (3.02–5.44) | 4.67 (3.31–6.35) | 5.49 (3.74–7.63) | 6.14 (4.07–8.60) |
| 24-hr | 1.57 (1.29–1.91) | 1.89 (1.55–2.30) | 2.43 (1.99–2.97) | 2.91 (2.36–3.56) | 3.60 (2.84–4.57) | 4.16 (3.21–5.34) | 4.75 (3.54–6.22) | 5.37 (3.84–7.19) | 6.23 (4.29–8.54) | 6.91 (4.63–9.57) |
| 2-day | 1.84 (1.53–2.21) | 2.21 (1.83–2.66) | 2.83 (2.34–3.42) | 3.37 (2.77–4.08) | 4.12 (3.28–5.15) | 4.72 (3.67–5.97) | 5.34 (4.02–6.89) | 5.98 (4.32–7.89) | 6.85 (4.76–9.26) | 7.53 (5.10–10.3) |
| 3-day | 1.99 (1.66–2.38) | 2.37 (1.98–2.84) | 3.02 (2.51–3.62) | 3.57 (2.96–4.30) | 4.36 (3.49–5.41) | 4.98 (3.90–6.24) | 5.61 (4.25–7.19) | 6.27 (4.56–8.22) | 7.17 (5.02–9.63) | 7.87 (5.37–10.7) |
| 4-day | 2.11 (1.77–2.51) | 2.50 (2.09–2.97) | 3.15 (2.64–3.76) | 3.72 (3.09–4.45) | 4.51 (3.64–5.58) | 5.15 (4.05–6.43) | 5.80 (4.41–7.39) | 6.48 (4.73–8.45) | 7.40 (5.21–9.88) | 8.12 (5.56–11.0) |
| 7-day | 2.41 (2.04–2.84) | 2.81 (2.38–3.31) | 3.49 (2.94–4.13) | 4.07 (3.41–4.83) | 4.90 (3.98–5.99) | 5.55 (4.41–6.86) | 6.22 (4.78–7.86) | 6.92 (5.11–8.94) | 7.88 (5.59–10.4) | 8.62 (5.96–11.5) |
| 10-day | 2.68 (2.28–3.14) | 3.10 (2.64–3.63) | 3.80 (3.22–4.46) | 4.39 (3.71–5.18) | 5.24 (4.28–6.36) | 5.91 (4.72–7.25) | 6.59 (5.09–8.26) | 7.30 (5.41–9.36) | 8.26 (5.90–10.8) | 9.00 (6.26–12.0) |
| 20-day | 3.48 (2.99–4.03) | 3.95 (3.40–4.58) | 4.74 (4.06–5.50) | 5.39 (4.60–6.29) | 6.30 (5.20–7.54) | 7.01 (5.66–8.49) | 7.73 (6.03–9.55) | 8.46 (6.34–10.7) | 9.44 (6.81–12.2) | 10.2 (7.17–13.4) |
| 30-day | 4.11 (3.57–4.73) | 4.67 (4.04–5.38) | 5.57 (4.81–6.43) | 6.31 (5.42–7.31) | 7.33 (6.08–8.68) | 8.10 (6.58–9.72) | 8.87 (6.96–10.9) | 9.64 (7.27–12.1) | 10.7 (7.74–13.7) | 11.4 (8.09–14.9) |
| 45-day | 4.89 (4.26–5.58) | 5.58 (4.86–6.38) | 6.68 (5.81–7.66) | 7.58 (6.55–8.71) | 8.77 (7.31–10.3) | 9.66 (7.88–11.5) | 10.5 (8.31–12.8) | 11.4 (8.62–14.1) | 12.5 (9.10–15.8) | 13.3 (9.46–17.1) |
| 60-day | 5.52 (4.84–6.27) | 6.35 (5.56–7.22) | 7.67 (6.69–8.74) | 8.72 (7.57–9.97) | 10.1 (8.44–11.8) | 11.1 (9.10–13.1) | 12.1 (9.57–14.6) | 13.0 (9.91–16.1) | 14.2 (10.4–17.9) | 15.0 (10.8–19.3) |

[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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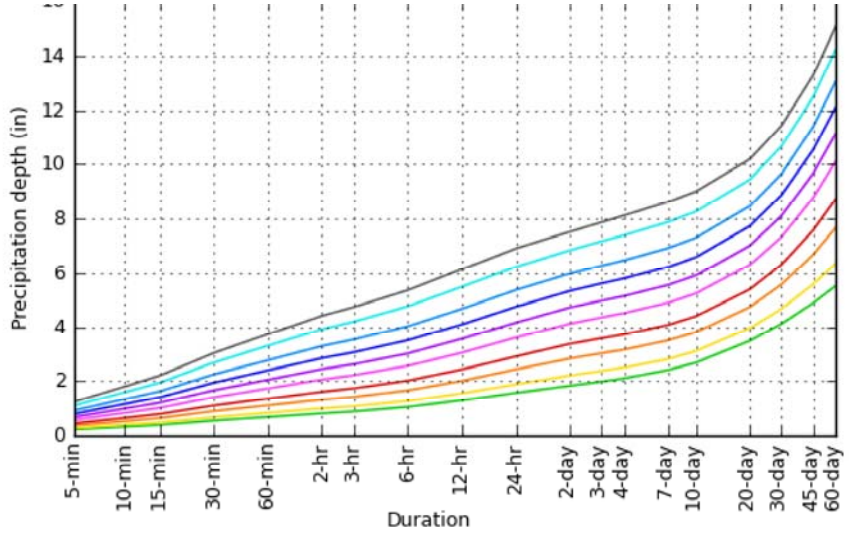
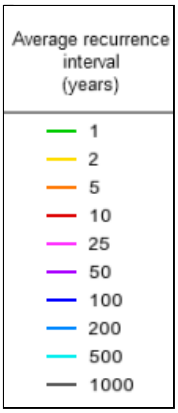
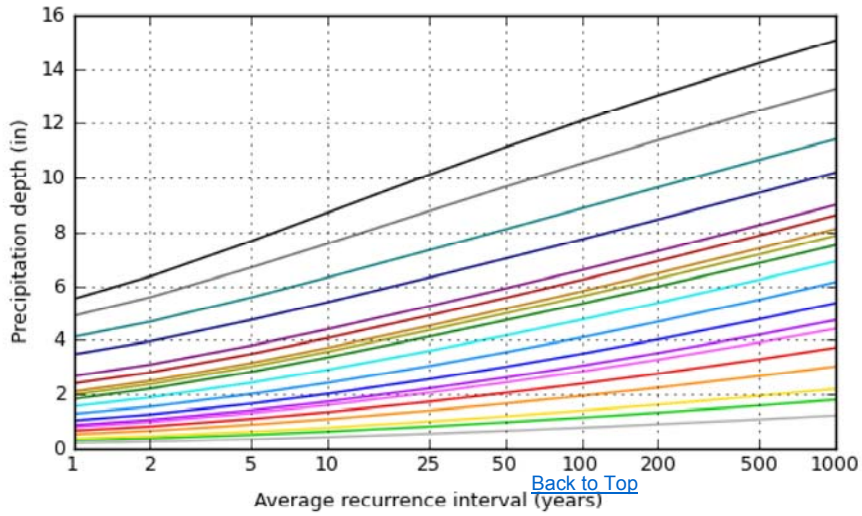
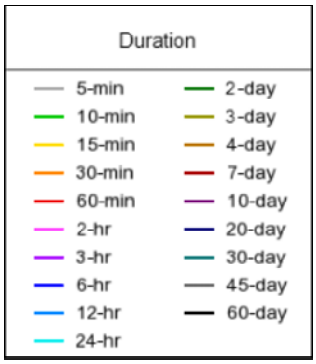
## PF graphical

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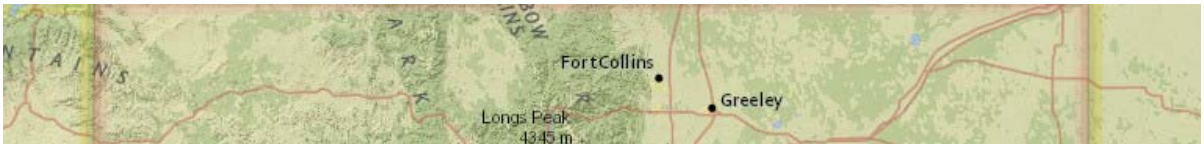
## Maps & aerials

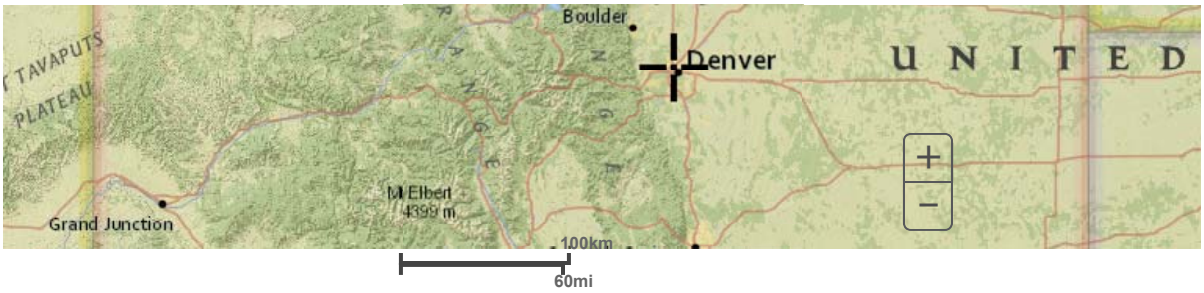
NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Fri Sep 23 19:41:08 2016

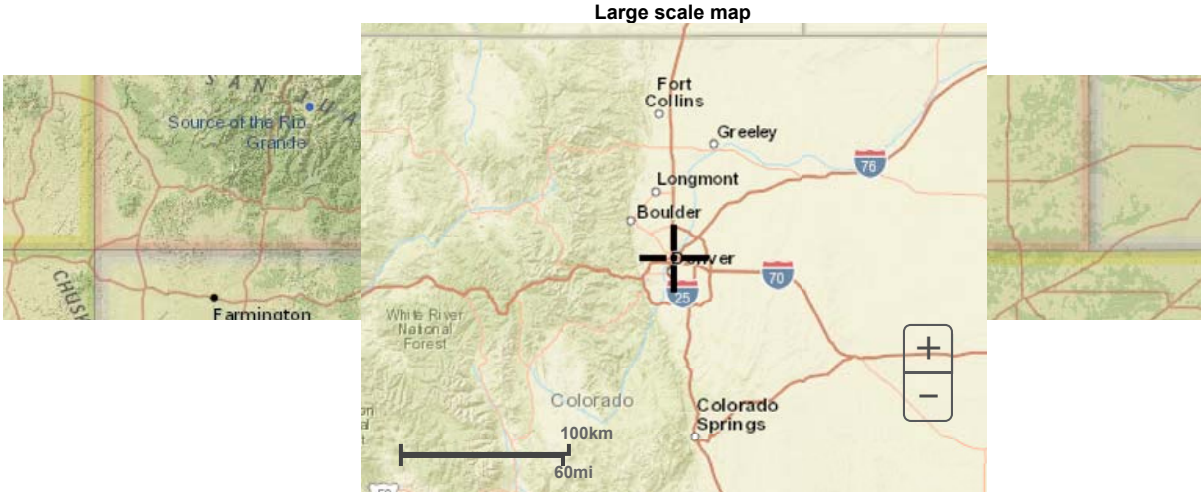
**Small scale terrain**


**Large scale terrain**

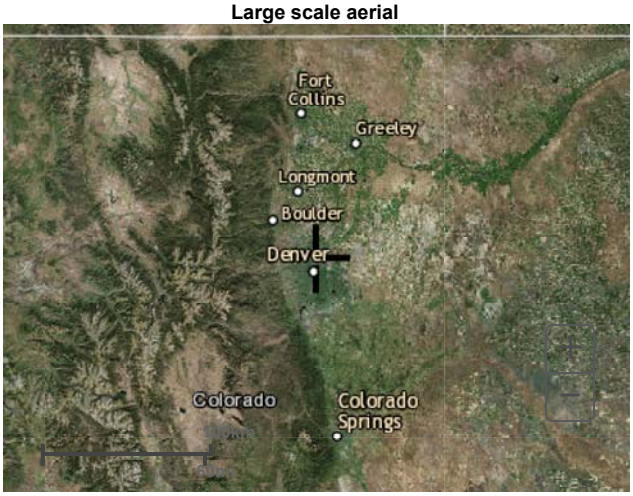





**Large scale map**




**Large scale aerial**

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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 C - SOILS REPORT

United States Department of Agriculture

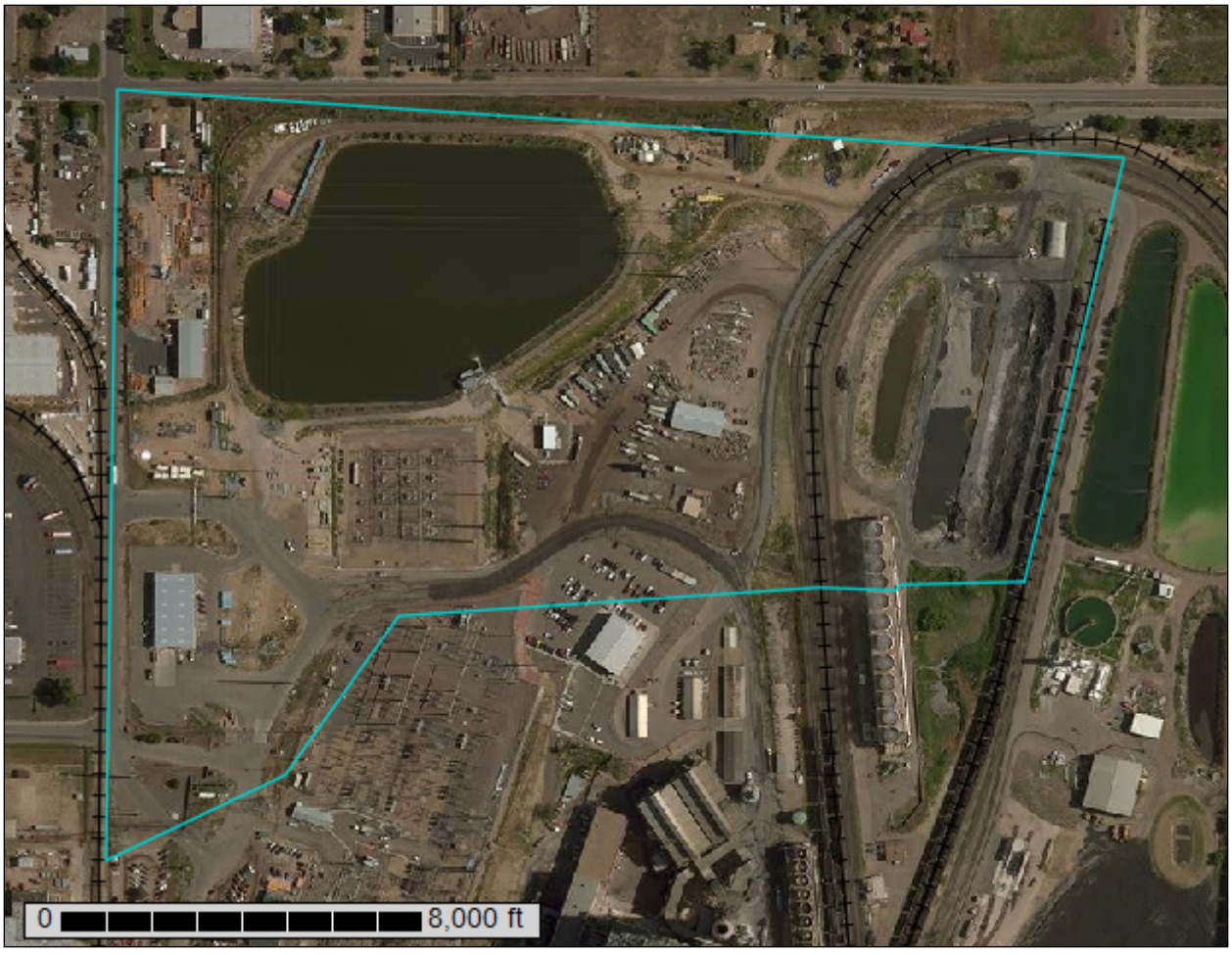
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

# Custom Soil Resource Report for Adams County Area, Parts of Adams and Denver Counties, Colorado

## Cherokee Impoundments




September 26, 2016

# Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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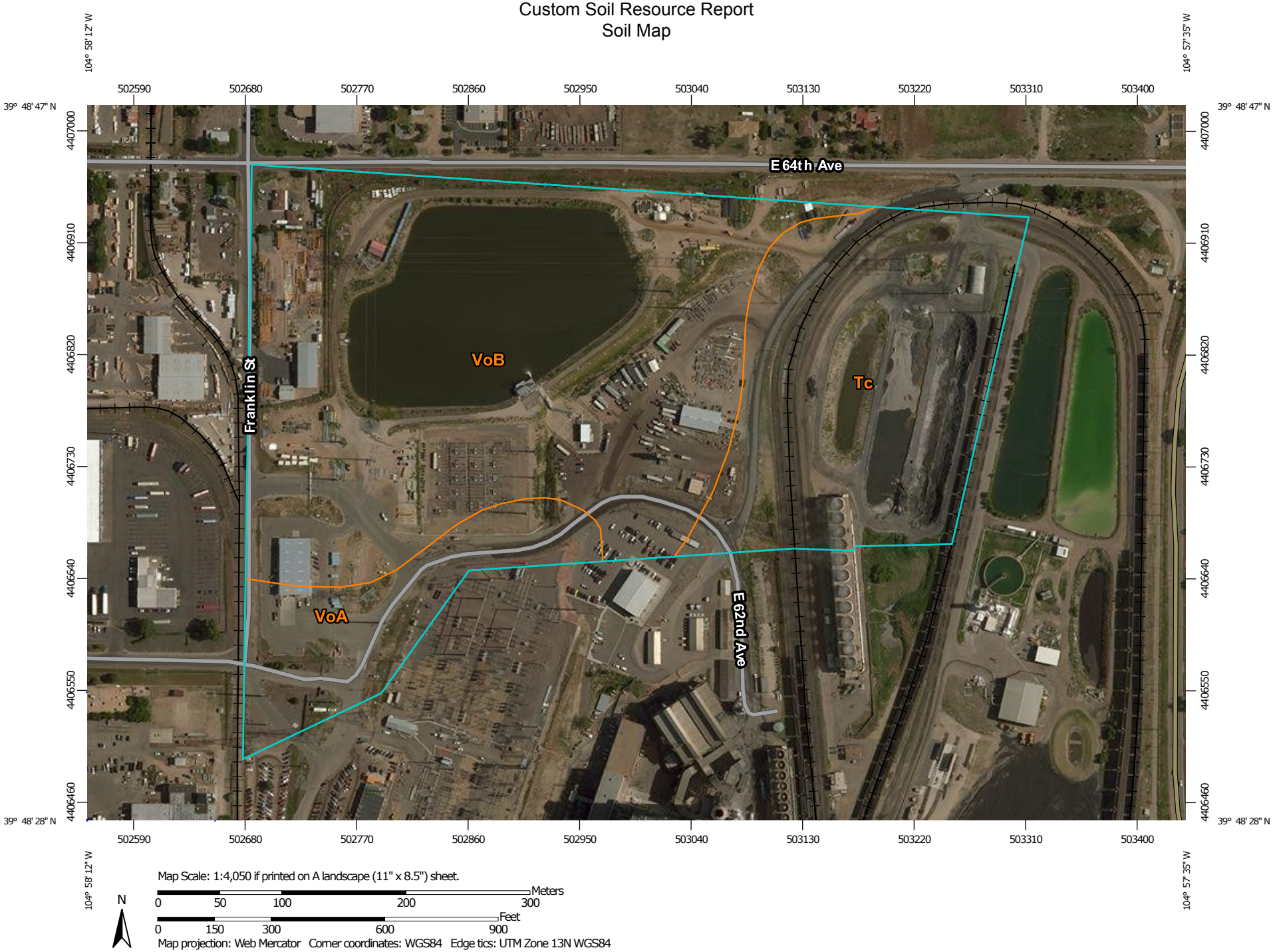
# Contents

# Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

# Custom Soil Resource Report
## Soil Map



## MAP LEGEND

**Area of Interest (AOI)**
- Area of Interest (AOI)

**Soils**
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

**Special Point Features**
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

**Water Features**
- Streams and Canals

**Transportation**
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

**Background**
- Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Adams County Area, Parts of Adams and Denver Counties, Colorado
Survey Area Data: Version 12, Sep 22, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 10, 2014—Aug 21, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

# Map Unit Legend

| Adams County Area, Parts of Adams and Denver Counties, Colorado (CO001) | | | |
|---|---|---|---|
| **Map Unit Symbol** | **Map Unit Name** | **Acres in AOI** | **Percent of AOI** |
| Tc | Terrace escarpments | 13.6 | 28.1% |
| VoA | Vona sandy loam, 0 to 1 percent slopes | 5.6 | 11.5% |
| VoB | Vona sandy loam, 1 to 3 percent slopes | 29.3 | 60.3% |
| **Totals for Area of Interest** | | **48.5** | **100.0%** |

# Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If

intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

# Adams County Area, Parts of Adams and Denver Counties, Colorado

## Tc—Terrace escarpments

### Map Unit Setting

*National map unit symbol:* 34ws
*Elevation:* 4,400 to 5,500 feet
*Mean annual precipitation:* 12 to 14 inches
*Mean annual air temperature:* 46 to 54 degrees F
*Frost-free period:* 120 to 160 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Terrace escarpments:* 90 percent
*Minor components:* 10 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Terrace Escarpments

#### Setting

*Landform:* Terraces
*Landform position (three-dimensional):* Riser
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Alluvium derived from mixed

#### Typical profile

*H1 - 0 to 3 inches:* gravelly sand
*H2 - 3 to 60 inches:* gravelly sand

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* A
*Ecological site:* Gravel Breaks (R067BY063CO)
*Hydric soil rating:* No

### Minor Components

#### Vona

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

#### Dacono

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

## VoA—Vona sandy loam, 0 to 1 percent slopes

### Map Unit Setting

*National map unit symbol:* 34x9

*Elevation:* 4,000 to 5,600 feet
*Mean annual precipitation:* 13 to 15 inches
*Mean annual air temperature:* 48 to 52 degrees F
*Frost-free period:* 125 to 155 days
*Farmland classification:* Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

**Map Unit Composition**

*Vona and similar soils:* 90 percent
*Minor components:* 10 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Vona**

**Setting**

*Landform:* Plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Eolian sands

**Typical profile**

*H1 - 0 to 9 inches:* sandy loam
*H2 - 9 to 22 inches:* sandy loam
*H3 - 22 to 60 inches:* loamy sand

**Properties and qualities**

*Slope:* 0 to 1 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High (1.98 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Gypsum, maximum in profile:* 2 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Available water storage in profile:* Moderate (about 6.3 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 2s
*Land capability classification (nonirrigated):* 4c
*Hydrologic Soil Group:* A
*Ecological site:* Sandy Plains (R067BY024CO)
*Hydric soil rating:* No

**Minor Components**

**Dacono**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Truckton**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

## VoB—Vona sandy loam, 1 to 3 percent slopes

### Map Unit Setting

*National map unit symbol:* 34xb
*Elevation:* 4,000 to 5,600 feet
*Mean annual precipitation:* 13 to 15 inches
*Mean annual air temperature:* 48 to 52 degrees F
*Frost-free period:* 125 to 155 days
*Farmland classification:* Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

### Map Unit Composition

*Vona and similar soils:* 90 percent
*Minor components:* 10 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Vona

#### Setting

*Landform:* Plains
*Landform position (three-dimensional):* Talf
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Eolian sands

#### Typical profile

*H1 - 0 to 9 inches:* sandy loam
*H2 - 9 to 22 inches:* sandy loam
*H3 - 22 to 60 inches:* loamy sand

#### Properties and qualities

*Slope:* 1 to 3 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Runoff class:* Very low
*Capacity of the most limiting layer to transmit water (Ksat):* High (1.98 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum in profile:* 10 percent
*Gypsum, maximum in profile:* 2 percent
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
*Available water storage in profile:* Moderate (about 6.3 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3e
*Land capability classification (nonirrigated):* 4c
*Hydrologic Soil Group:* A
*Ecological site:* Sandy Plains (R067BY024CO)
*Hydric soil rating:* No

**Minor Components**

**Dacono**

*Percent of map unit:* 8 percent
*Hydric soil rating:* No

**Tryon**

*Percent of map unit:* 2 percent
*Landform:* Swales
*Hydric soil rating:* Yes

# References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf