Inflow Design Flood Control System Plan

B.C. COBB GENERATING FACILITY

PONDS 0-8
INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

Muskegon, Michigan

Pursuant to 40 CFR 257.82

Submitted To: Consumers Energy Company
1945 W. Parnall Road
Jackson, Michigan 49201

Submitted By: Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, Michigan 48906

October 2016 **1652598**

Golder Associates

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.82(c)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.82 (40 CFR Part 257.82), I attest that this Inflow Design Flood Control System Plan is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.82.

Golder Associates Inc.

Signature

October 14, 2016
Date of Report Certification

John D. Puls, PE
Name

6201055787
Professional Engineer Certification Number

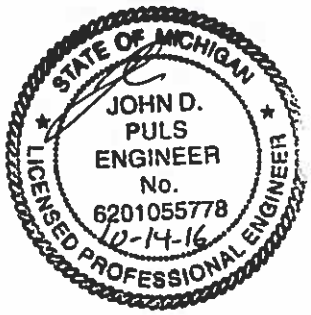


Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

1.1 Background

B.C. Cobb Generating Facility (BC Cobb) is a coal-fired power generation facility located in Muskegon, Michigan as presented on Figure 1 – Site Location Map. BC Cobb formerly operated two coal-burning baseload units but ceased electrical generation on April 15, 2016. Prior to stopping electrical generation, Ponds 0-8 at BC Cobb served two primary functions:

- Receive outflow from the Bottom Ash Pond for secondary detention and settlement of bottom ash
- Receive intermittent sluiced fly ash and low-volume process water from the generating facility for detention and settlement

Ponds 0-8 are interconnected by a subsurface pipe network that discharge from Pond 4 via one primary reinforced concrete pipe (RCP) outflow pipe to the site's permitted National Pollutant Discharge Elimination System (NPDES) outfall as shown on Figure 2 – General Site Plan. Pond 4 also includes dual high density polyethylene (HDPE) emergency outflow pipes. Each discharge pipe was reported to be in good to fair condition in the Barr Engineering Company (Barr) Triennial Ash Dike Risk Assessment Report in Spring 2014 (Barr 2014); and positive flow was observed from the primary RCP outflow pipe in October 2015, as reported in Golder Associates Inc. (Golder) Annual Resource Conservation and Recovery Act (RCRA) coal combustion residual (CCR) Surface Impoundment Inspection Report in January 2016 (Golder 2016). The ponds can be isolated by a series of valves and drained and cleaned out to maintain capacity.

Currently, BC Cobb is being decommissioned. These ponds are no longer receiving CCR from an active power generating plant. Ponds 0-8 are anticipated to accept negligible amounts of CCR contact wash water and other low-volume miscellaneous wastewaters until the expiration of the BC Cobb NPDES permit (October 1, 2018) or a date earlier when the BC Cobb NPDES permit is administratively discharged by the Michigan Department of Environmental Quality (MDEQ) after satisfaction that all permitted potential polluting streams have been addressed. It is anticipated that final receipt of waste into Ponds 0-8 will occur on or before October 1, 2018; and resulting subsequent closure activities will commence within regulated timeframes.

1.2 Purpose

The purpose of the Inflow Design Flood Control System Plan (Plan) is to provide a basis for the certification required by 40 CFR 257.82 (Hydrologic and Hydraulic Capacity Requirements for CCR Surface Impoundments). Ponds 0-8 have been rated a significant hazard potential as determined under 40 CFR 257.73(a)(2). 40 CFR 257.82(a) requires the owner or operator of the significant hazard potential CCR surface impoundment to design, construct, operate, and maintain an inflow flood control system as follows:

- Adequately manage the flow into the CCR unit during and following the peak discharge of the inflow of the 1000-year flood event
- Adequately manage the flow from the CCR unit to collect and control the peak discharge resulting from the 1000-year flood event
- Handle discharge from the CCR unit in accordance with the surface water requirements under 40 CFR 257.3-3

2.0 FLOOD CONTROL SYSTEM

To meet the requirements of 40 CFR 257.82(a), the flood control system must provide flood protection to the CCR unit during the inflow design flood (1000-year event) for two cases: 1) floodwater from outside the unit from Muskegon Lake, and 2) controlling internal water levels within the unit.

2.1 External Floodwater Protection

Ponds 0-8 is surrounded by a perimeter dike that provides external floodwater protection. One potential inflow source to Ponds 0-8 was identified and evaluated; Muskegon Lake.

A publicly available 1000-year flood elevation for Muskegon Lake has not been determined by Federal Emergency Management Agency (FEMA). As a result, Golder Associates Inc. (Golder) has estimated the 1000-year flood elevation by extrapolation of the FEMA data and verification with a hydraulic model. The FEMA Flood Insurance Study (FIS) (FEMA 2015) reported Muskegon Lake levels for the 10-, 50-, 100- and 500-year recurrence intervals. The 100- and 500-year levels are 584.4 and 585.3 feet (NAVD88), respectively. Based on a logarithmic best fit curve extrapolation, the 1000-year Muskegon Lake level is approximately 585.7 feet (NAVD88). The lowest elevation along the perimeter berm is 588.0 feet (NAVD88), which allows for 2.0 feet of freeboard during the 1000-year flood event. Therefore, Muskegon Lake was determined to not be an inflow source to Ponds 0-8.

2.2 Internal Flood Control

The only inflow will be precipitation directly falling on Ponds 0-8 from a 1000-year 24-hour storm event of 11.6 inches, as provided in Appendix B - Rainfall Data. There are three discharge structures in the perimeter berm in Pond 4: one 24-inch reinforced concrete pipe (RCP) that functions as an NPDES outfall pipe and two 18-inch high density polyethylene (HDPE) pipes that are intended to function as emergency overflow pipes. These three pipes were reported to be in good to fair condition in the Barr Triennial Ash Dike Risk Assessment Report in Spring 2014 (Barr 2014). All three of these pipes will be grouted or removed during the closure of Ponds 0-8.

Table 2.2.1 - Discharge Structure Summary

Discharge Structure	Type	Size (Inches)	Length (Feet)	Upstream Invert (NAVD88)	Downstream Invert (NAVD88)	Slope (%)
Primary Pipe	RCP	24	67.0	584.33	580.66	5.48
Emergency Pipe No. 1	HDPE	18	59.0	587.98	580.89	12.02
Emergency Pipe No. 2	HDPE	18	59.0	587.97	581.05	11.73

Given the negligible amount of CCR contact wash water draining to Ponds 0-8, it is expected that the static water elevation in Ponds 0-8 will equalize with Muskegon Lake's (Lake Michigan) normal water elevation of 579.40 feet (NAVD88), as reported by the National Oceanic and Atmospheric Administration (NOAA) and provided in Appendix A - FEMA Flood Elevation and Lake Michigan Normal Elevation. As a result of the reported normal water elevation, Golder input a normal water elevation of 580.00 feet (NAVD88) into the hydrologic and hydraulic model for Ponds 0-8. Table 2.2.2 below provides a storm flow summary that indicates that Ponds 0-8 are contained with zero discharge to Muskegon Lake during the design storm event (1000-year 24-hour). The modeled results indicate that:

- The inflow design flood control system adequately manages flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood (1000-year 24-hour storm event)

The hydrologic and hydraulic model output is provided in Appendix C - Hydrologic and Hydraulic Model Output. It should be noted that the pond elevations presented in Table 2.2.2 were used to assess the maximum storage pool loading condition pursuant to 40 CFR 257.73(e)(1)(i).

Table 2.2.2 – Storm Flow Data

Area	Perimeter Berm Elevation (NAVD88)	Pond Elevation 1000-year 24-hour (NAVD88)	Peak Outflow (cfs)[1]	Volume of Outflow (acre-feet)
Pond 0	589.00	581.64	0.00	0.00
Pond 1	588.00	581.91	0.00	0.00
Pond 2	588.00	581.77	0.00	0.00
Pond 3	588.00	581.60	0.00	0.00
Pond 4	588.00	581.73	0.00	0.00
Pond 5	590.00	582.58	0.00	0.00
Pond 6	592.00	588.75	0.00	0.00
Pond 7	593.00	587.35	0.00	0.00
Pond 8	594.00	587.93	0.00	0.00

Note: [1]cfs = cubic feet per second

3.0 PLAN REVISION AND RECORDKEEPING

Per 40 CFR 257.82(c)(2); “The owner or operator of the CCR unit may amend the written inflow design flood control system plan at any time provided the revised plan is placed in the facility's operating record as required by §257.105(g)(4). The owner or operator must amend the written inflow design flood control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.”

Per 40 CFR 257.82(c)(4); “The owner or operator must prepare periodic inflow design flood control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first periodic plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed an inflow design flood control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(4).”

4.0 REFERENCES

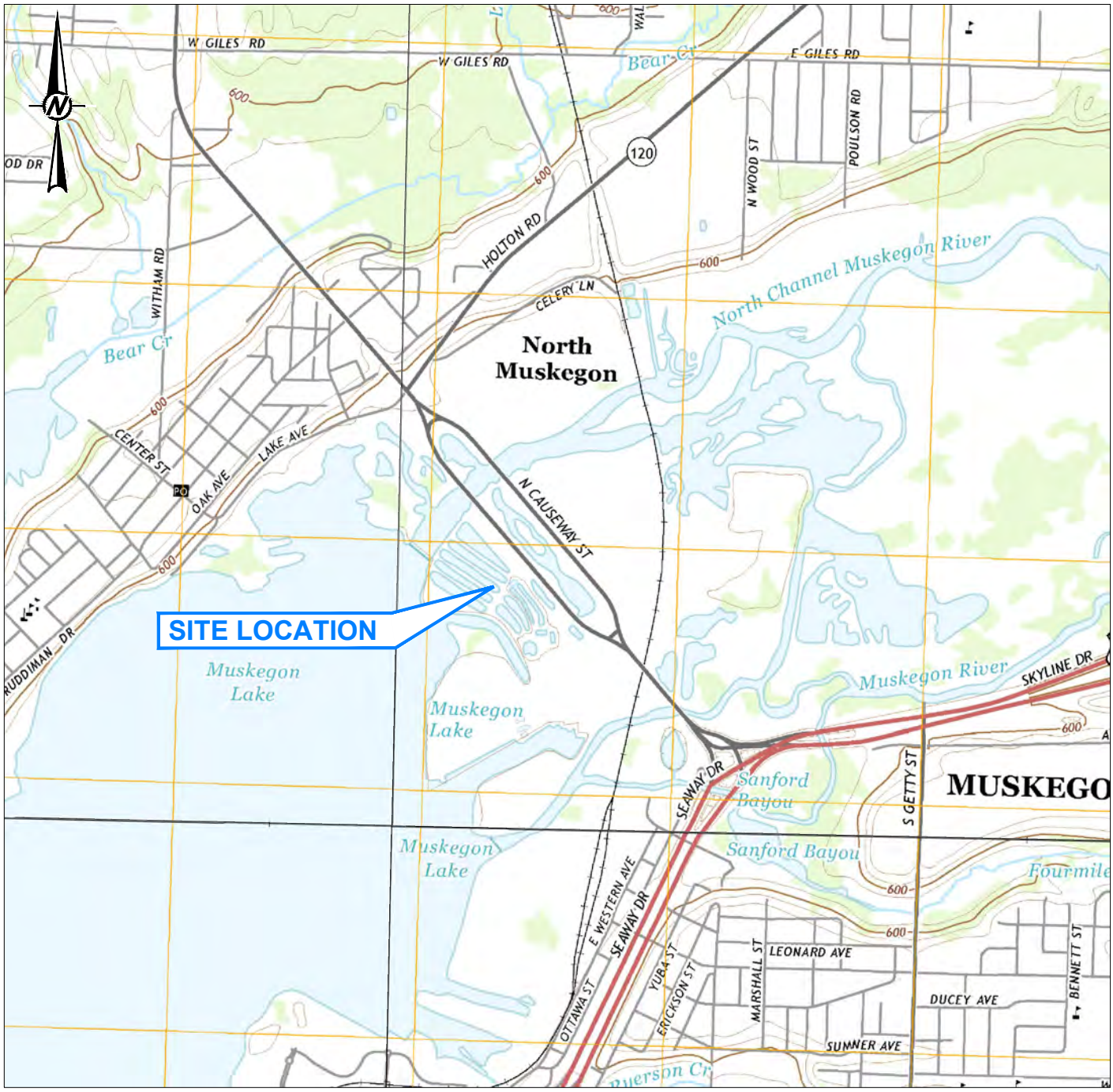
Barr Engineering Company, 2014. B.C. Cobb Ash Disposal Area: Triennial Ash Dike Risk Assessment Report – Spring 2014.

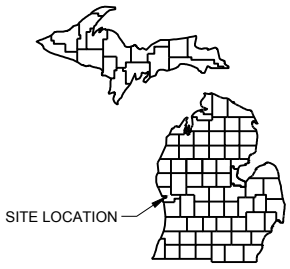
EPA (Environmental Protection Agency). 2015. Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. 40 CFR Part 257. Effective Date October 19, 2015.

FEMA (Federal Emergency Management Agency). 2015. Flood Insurance Study, Muskegon County, Michigan. Effective July 6, 2015. Flood Insurance Study Number 26121CV000A.

Golder Associates Inc., B.C. Cobb Ponds 0-8 Annual RCRA CCR Surface Impoundment Inspection Report – January 2016.

FIGURES





MICHIGAN COUNTIES
NOT TO SCALE

REFERENCE(S)

1. BASE MAP TAKEN FROM 7.5 MINUTE U.S.G.S. □UADRANGLES OF DALTON, TWIN LAKE, MUSKEGON EAST, AND MUSKEGON WEST, MICHIGAN, DATED 2014.

0 1000 2000
1" = 2000' FEET

CLIENT
CONSUMERS ENERGY COMPANY
151 N. CAUSEWAY
MUSKEGON, MI 49445

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-14
DESIGNED	JRP
PREPARED	AM
REVIEWED	JRP
APPROVED	MAB

PROJECT
B.C. COBB PLANT
PONDS 0-8 FLOOD CONTROL PLAN
MUSKEGON, MI 49445

TITLE
SITE LOCATION MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1652598	B001	0	1

Path: \\mtlaurel\cadd\Projects\2016\16525988 Consumers - BC Cobb\PRODUCTION\B - Ponds 0-8 Closure Plan\ | File Name: 16525988B001 - SITE LOCATION MAP.dwg

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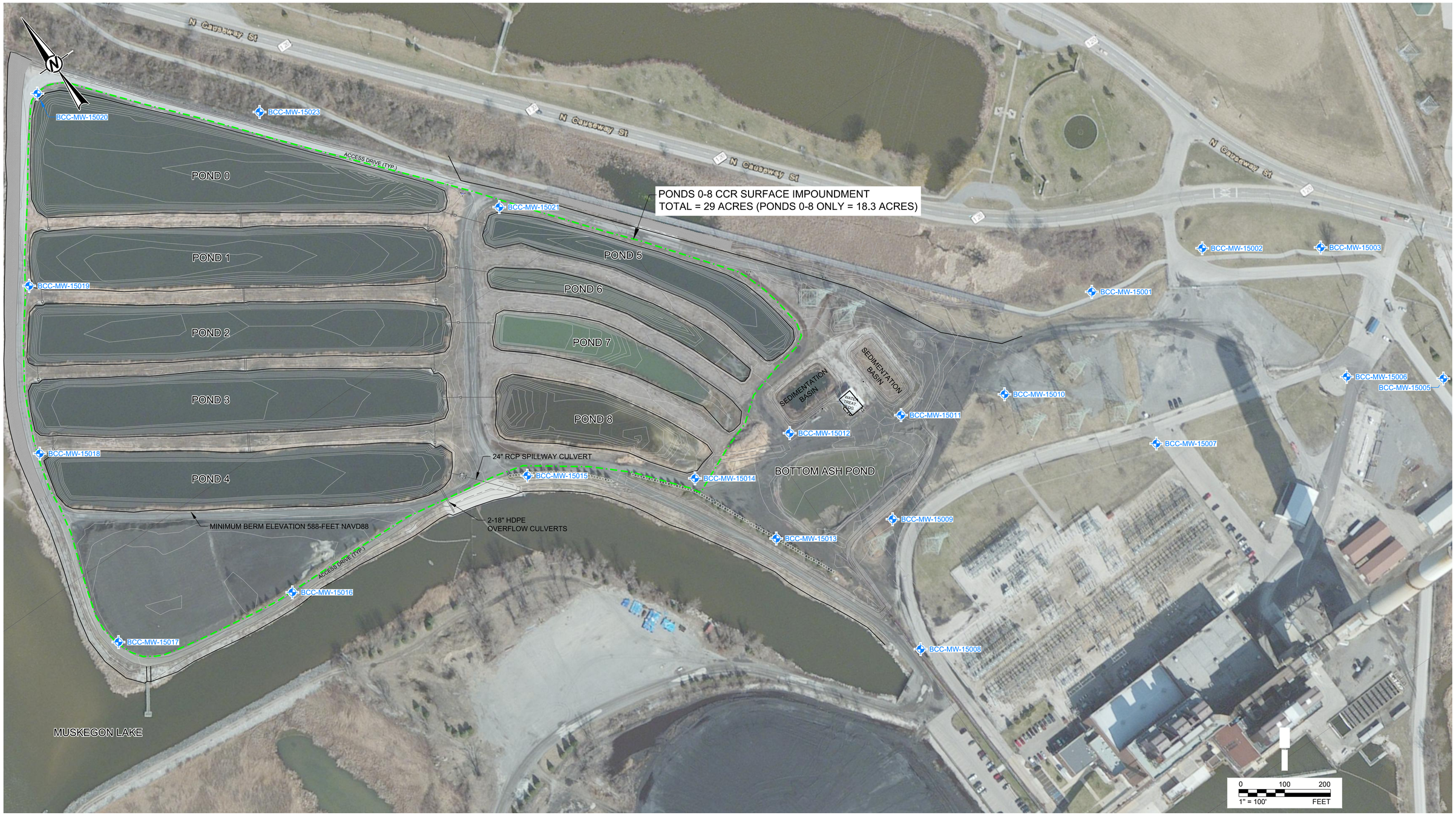
0 1 in



LEGEND

GROUNDWATER MONITORING WELL

REFERENCE(S)

1. TOPOGRAPHIC SURVEY PROVIDED BY SUMMIT SURVEYING, INC.; DATED JANUARY 28, 2015.

CLIENT
CONSUMERS ENERGY COMPANY
151 N. CAUSEWAY
MUSKEGON, MI 49445

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-09-28
DESIGNED	JRP
PREPARED	AM
REVIEWED	JRP
APPROVED	JDP

PROJECT
B.C. COBB PLANT
PONDS 0-8 FLOOD CONTROL PLAN
MUSKEGON, MI 49445

TITLE
GENERAL SITE PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
1652598	B002	0	2

Path: \\nttaurel\cadd\Projects\2016\16529888 Consumers - BC Cobb\PRODUCTION\B - Ponds 0-8 Closure Plan\ | File Name: 16529888B002 - GENERAL SITE PLAN.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

0 1 in

APPENDIX A
FEMA FLOOD ELEVATION AND LAKE MICHIGAN NORMAL ELEVATION

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 16. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey **at (301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base Map information shown on this FIRM was provided in digital format by Farm Services Administration. This information was photogrammetrically compiled at a scale of 1:12,000 from aerial photography dated 2005.

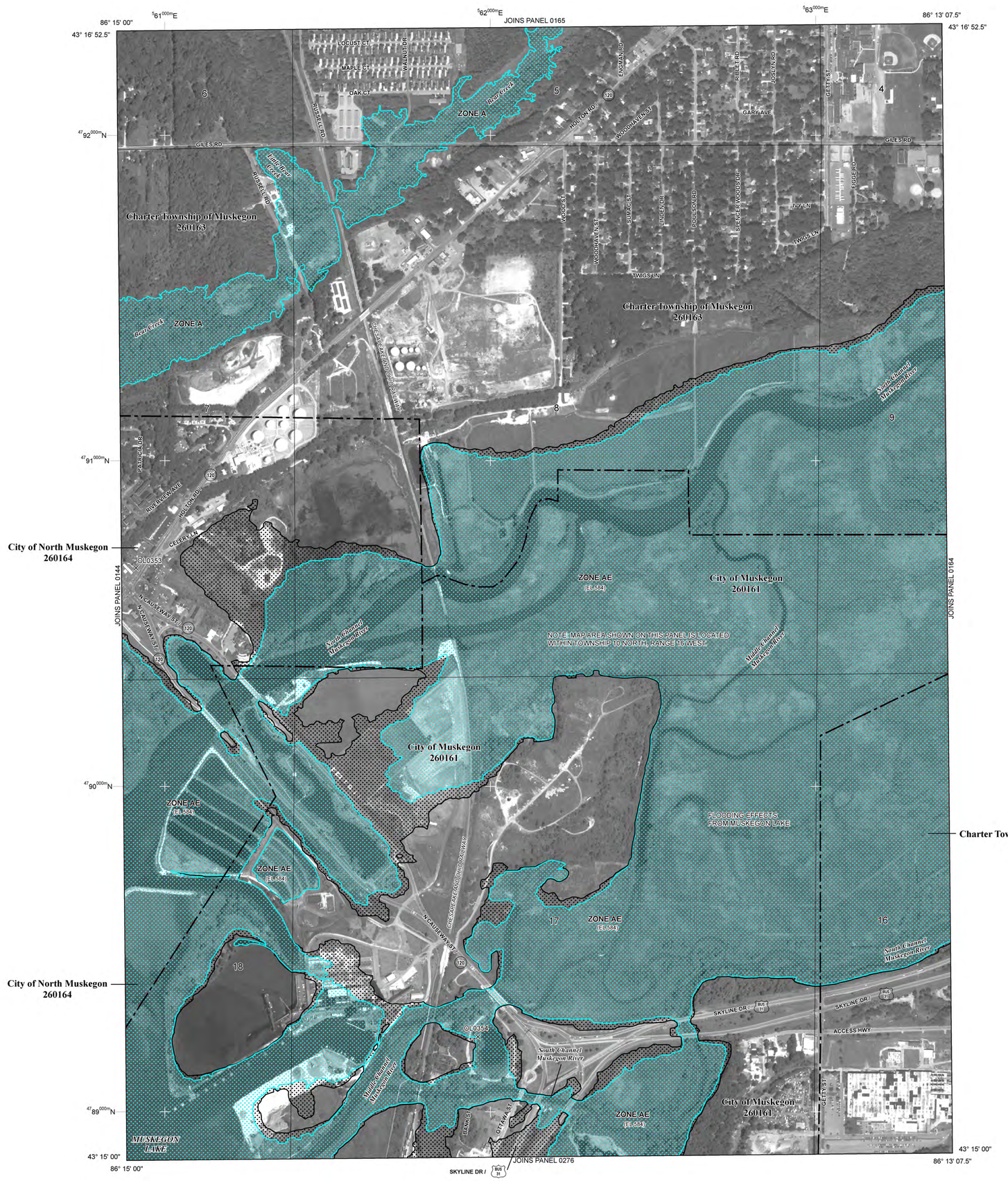
The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map,** how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% Annual Chance Floodplain Boundary
- 0.2% Annual Chance Floodplain Boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

- A — A — Cross section line
- 23 — 23 — Transect line
- 45° 02' 08", 93° 02' 12" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
- 4989 000m N — 1000-meter Universal Transverse Mercator grid values, zone 16
- DX5510 × — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 • — River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
July 6, 2015

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'
250 0 500 1000 FEET
150 0 150 300 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0163D

FIRM

FLOOD INSURANCE RATE MAP

MUSKEGON COUNTY, MICHIGAN
(ALL JURISDICTIONS)

PANEL 163 OF 475
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

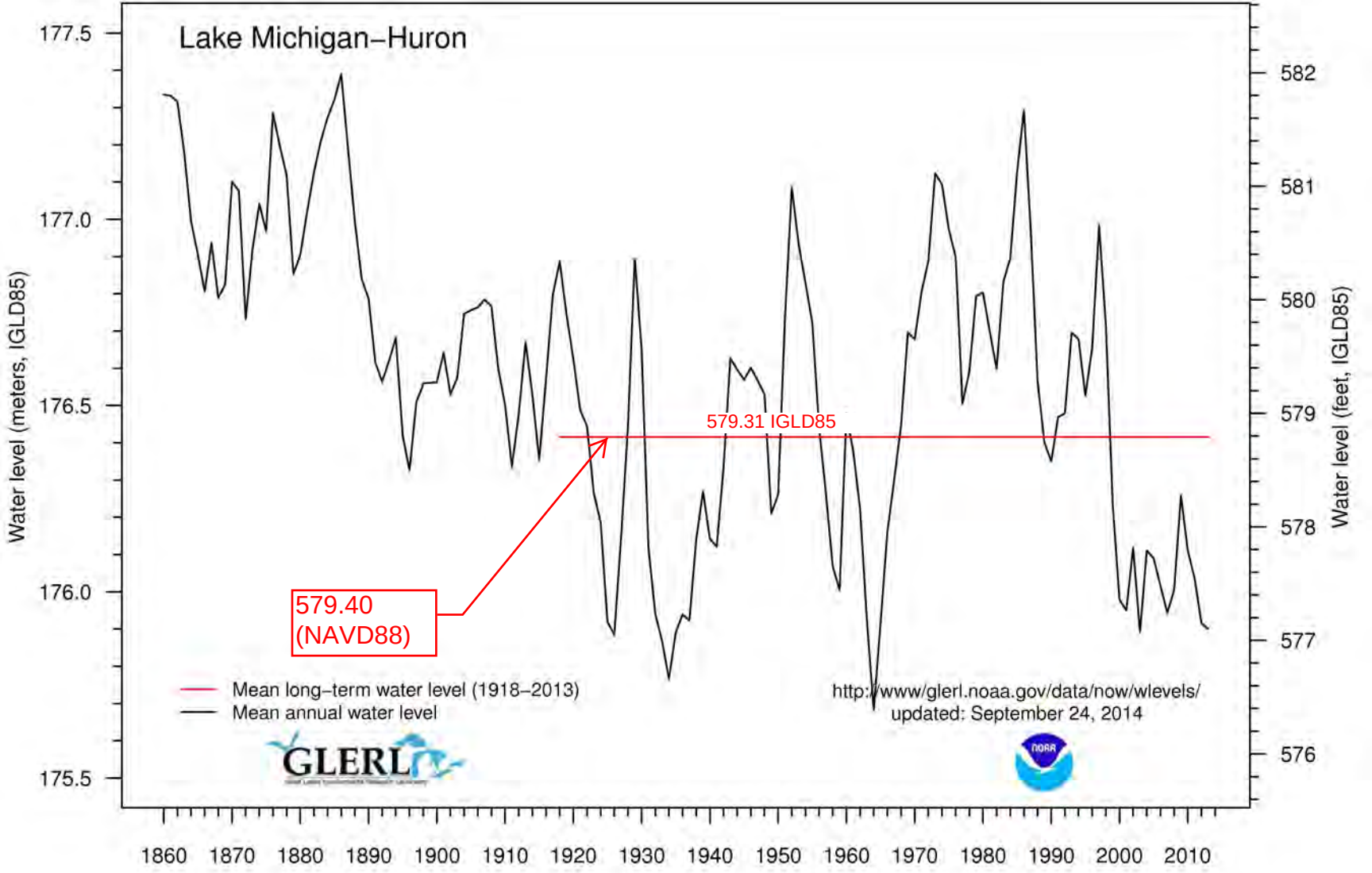
CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MUSKEGON, CHARTER TOWNSHIP OF	260163	0163	D
MUSKEGON, CITY OF	260161	0163	D
NORTH MUSKEGON, CITY OF	260164	0163	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
26121C0163D
EFFECTIVE DATE
JULY 6, 2015

Federal Emergency Management Agency


Lake Michigan–Huron
Water level (meters, IGLD85)
Water level (feet, IGLD85)
177.5
177.0
176.5
176.0
175.5
582
581
580
579
578
577
576
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
579.31 IGLD85
579.40
(NAVD88)
Mean long–term water level (1918–2013)
Mean annual water level
http://www/glerl.noaa.gov/data/now/wlevels/
updated: September 24, 2014
GLERL
NOAA

APPENDIX B
RAINFALL DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: Muskegon, Michigan, US*
Latitude: 43.2588°, Longitude: -86.2463°
Elevation: 587 ft*
* source: Google Maps

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	0.308 (0.262–0.371)	0.365 (0.309–0.439)	0.463 (0.391–0.559)	0.550 (0.462–0.668)	0.680 (0.550–0.868)	0.787 (0.617–1.02)	0.899 (0.676–1.20)	1.02 (0.728–1.41)	1.19 (0.810–1.69)	1.33 (0.871–1.91)
10-min	0.452 (0.384–0.543)	0.534 (0.453–0.643)	0.678 (0.573–0.818)	0.806 (0.676–0.978)	0.995 (0.806–1.27)	1.15 (0.904–1.49)	1.32 (0.990–1.76)	1.49 (1.07–2.06)	1.74 (1.19–2.48)	1.94 (1.28–2.80)
15-min	0.551 (0.468–0.662)	0.651 (0.552–0.784)	0.827 (0.698–0.998)	0.983 (0.825–1.19)	1.21 (0.983–1.55)	1.41 (1.10–1.82)	1.61 (1.21–2.14)	1.82 (1.30–2.51)	2.12 (1.45–3.02)	2.37 (1.56–3.41)
30-min	0.749 (0.637–0.901)	0.890 (0.755–1.07)	1.14 (0.960–1.37)	1.36 (1.14–1.65)	1.68 (1.36–2.15)	1.95 (1.53–2.53)	2.23 (1.68–2.98)	2.54 (1.81–3.50)	2.97 (2.02–4.22)	3.31 (2.18–4.77)
60-min	0.964 (0.819–1.16)	1.14 (0.967–1.37)	1.46 (1.23–1.76)	1.75 (1.46–2.12)	2.18 (1.77–2.80)	2.56 (2.01–3.32)	2.95 (2.22–3.95)	3.39 (2.42–4.68)	4.00 (2.73–5.71)	4.50 (2.96–6.48)
2-hr	1.18 (1.01–1.41)	1.39 (1.19–1.66)	1.78 (1.51–2.13)	2.14 (1.80–2.57)	2.69 (2.20–3.44)	3.16 (2.50–4.09)	3.67 (2.78–4.89)	4.23 (3.05–5.82)	5.03 (3.46–7.14)	5.69 (3.77–8.14)
3-hr	1.33 (1.14–1.58)	1.55 (1.33–1.85)	1.98 (1.69–2.37)	2.39 (2.02–2.87)	3.03 (2.49–3.87)	3.58 (2.85–4.63)	4.19 (3.19–5.57)	4.86 (3.52–6.67)	5.83 (4.02–8.25)	6.62 (4.40–9.44)
6-hr	1.61 (1.39–1.90)	1.87 (1.61–2.21)	2.37 (2.03–2.81)	2.86 (2.44–3.41)	3.65 (3.04–4.66)	4.35 (3.49–5.61)	5.13 (3.94–6.80)	5.99 (4.38–8.20)	7.26 (5.05–10.2)	8.31 (5.56–11.8)
12-hr	1.93 (1.67–2.26)	2.22 (1.92–2.60)	2.80 (2.41–3.29)	3.38 (2.89–4.00)	4.32 (3.62–5.50)	5.17 (4.18–6.63)	6.11 (4.73–8.06)	7.17 (5.27–9.75)	8.73 (6.12–12.2)	10.0 (6.76–14.1)
24-hr	2.26 (1.97–2.63)	2.58 (2.25–3.01)	3.24 (2.80–3.78)	3.90 (3.35–4.58)	4.98 (4.20–6.30)	5.96 (4.85–7.60)	7.05 (5.50–9.25)	8.29 (6.14–11.2)	10.1 (7.14–14.1)	11.6 (7.90–16.3)
2-day	2.58 (2.26–2.98)	2.93 (2.57–3.39)	3.65 (3.18–4.24)	4.38 (3.79–5.11)	5.58 (4.74–7.00)	6.66 (5.45–8.43)	7.87 (6.18–10.3)	9.24 (6.89–12.4)	11.3 (8.01–15.6)	12.9 (8.85–18.0)
3-day	2.77 (2.43–3.18)	3.15 (2.76–3.63)	3.91 (3.42–4.52)	4.67 (4.06–5.43)	5.91 (5.03–7.37)	7.02 (5.77–8.84)	8.27 (6.50–10.7)	9.66 (7.23–12.9)	11.7 (8.36–16.1)	13.4 (9.22–18.6)
4-day	2.95 (2.60–3.38)	3.33 (2.93–3.82)	4.10 (3.59–4.72)	4.86 (4.23–5.63)	6.11 (5.21–7.59)	7.23 (5.95–9.07)	8.48 (6.69–10.9)	9.89 (7.42–13.2)	12.0 (8.56–16.4)	13.7 (9.43–18.9)
7-day	3.53 (3.13–4.02)	3.85 (3.41–4.40)	4.54 (3.99–5.20)	5.26 (4.59–6.05)	6.46 (5.55–7.98)	7.57 (6.27–9.45)	8.82 (7.01–11.3)	10.3 (7.75–13.6)	12.4 (8.92–16.9)	14.2 (9.81–19.4)
10-day	4.06 (3.60–4.61)	4.38 (3.88–4.97)	5.05 (4.46–5.76)	5.76 (5.05–6.60)	6.95 (5.98–8.52)	8.03 (6.68–9.97)	9.27 (7.39–11.8)	10.7 (8.09–14.1)	12.8 (9.24–17.4)	14.5 (10.1–19.9)
20-day	5.48 (4.89–6.17)	6.00 (5.35–6.77)	6.94 (6.16–7.85)	7.79 (6.86–8.86)	9.06 (7.75–10.8)	10.1 (8.41–12.3)	11.3 (8.99–14.1)	12.5 (9.50–16.2)	14.3 (10.4–19.1)	15.7 (11.0–21.3)
30-day	6.65 (5.96–7.46)	7.36 (6.59–8.27)	8.55 (7.61–9.63)	9.55 (8.45–10.8)	10.9 (9.32–12.9)	12.0 (9.99–14.4)	13.2 (10.5–16.3)	14.3 (10.9–18.3)	15.9 (11.5–21.0)	17.0 (12.0–23.1)
45-day	8.16 (7.33–9.11)	9.06 (8.12–10.1)	10.5 (9.37–11.8)	11.6 (10.3–13.1)	13.2 (11.2–15.4)	14.4 (11.9–17.1)	15.5 (12.4–19.0)	16.6 (12.6–21.1)	18.1 (13.1–23.8)	19.1 (13.5–25.8)
60-day	9.48 (8.53–10.5)	10.5 (9.41–11.7)	12.0 (10.8–13.5)	13.3 (11.8–15.0)	15.0 (12.8–17.4)	16.2 (13.5–19.2)	17.4 (14.0–21.3)	18.6 (14.2–23.6)	20.1 (14.7–26.4)	21.2 (15.0–28.5)

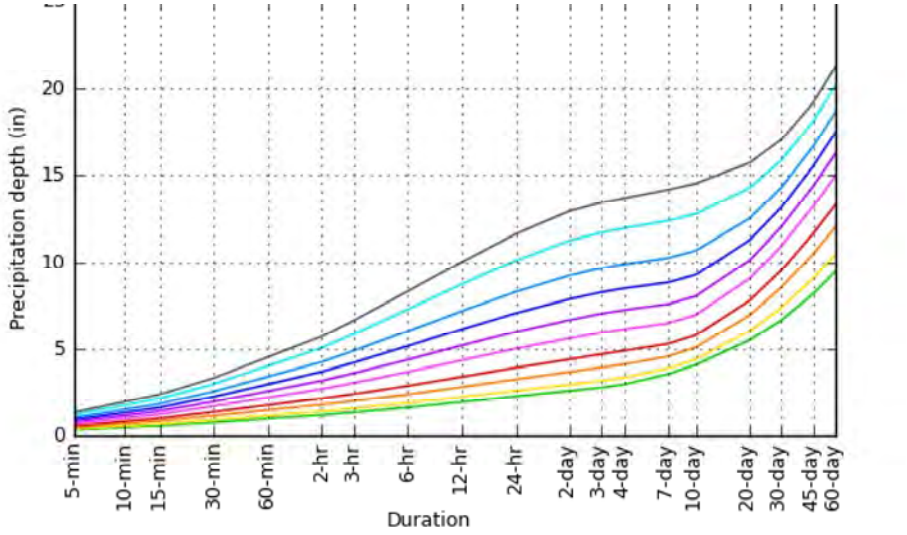
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

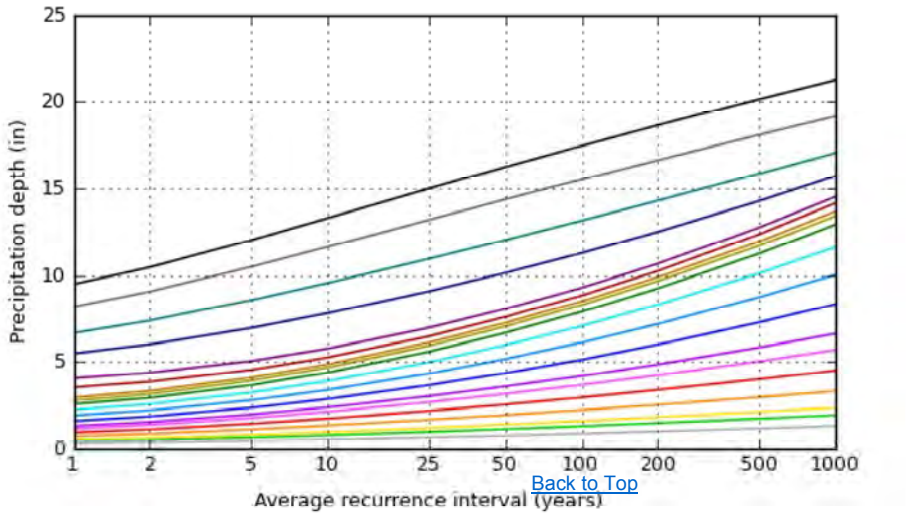
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper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

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical





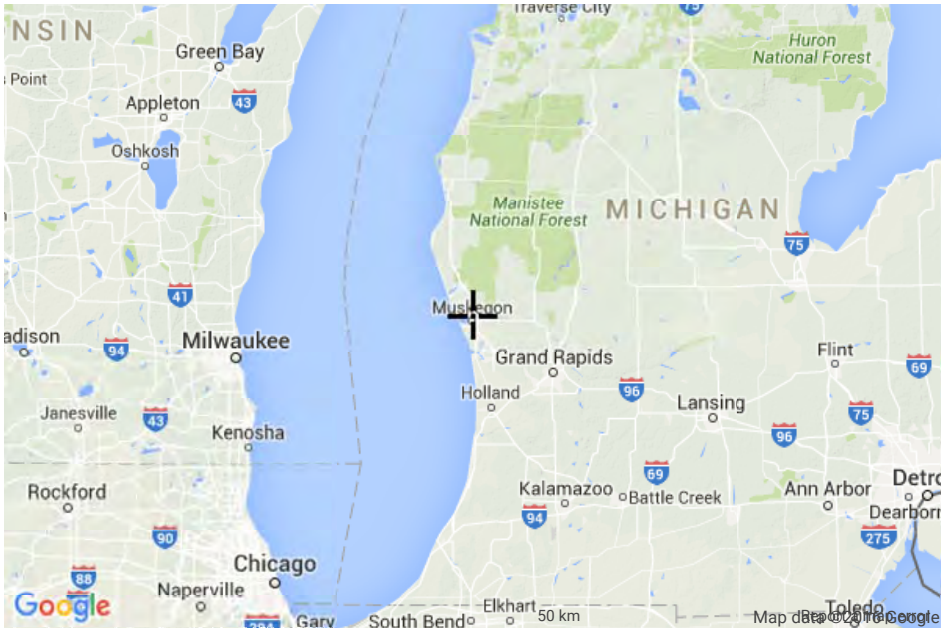
Back to Top

Maps & aerials

NOAA Atlas 14, Volume 8, Version 2

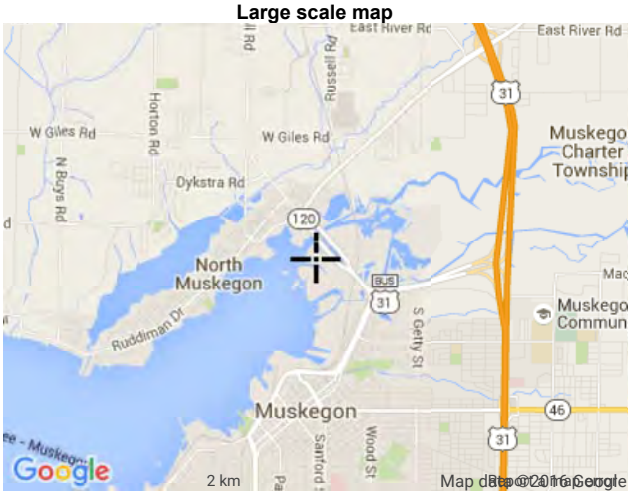
Created (GMT): Mon May 9 13:58:58 2016

Small scale terrain



Large scale terrain

Large scale map

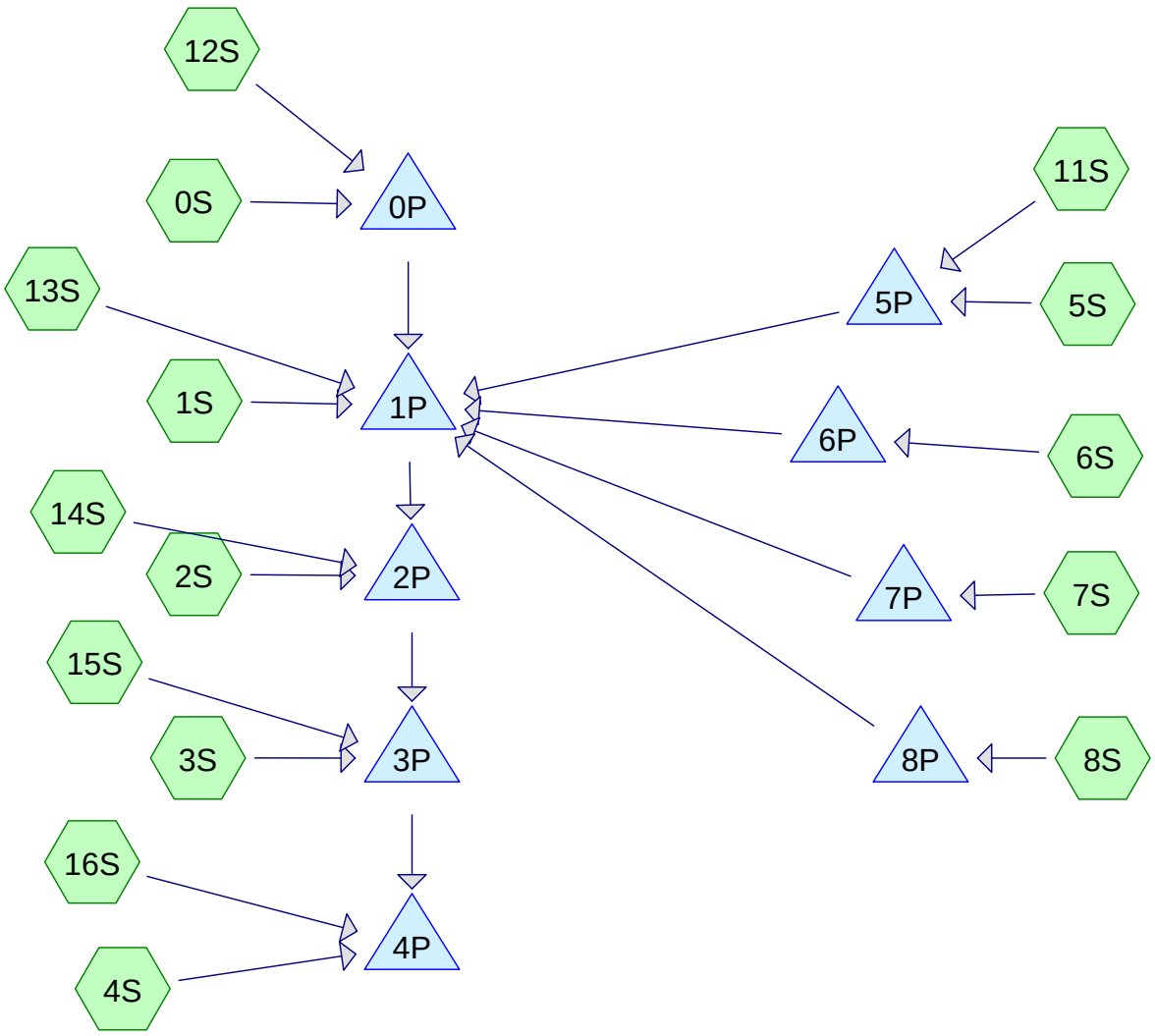


Large scale aerial

Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910

APPENDIX C
HYDROLOGIC AND HYDRAULIC MODEL OUTPUT



Subcat Reach Pond Link

Drainage Diagram for BCC Ponds 0-8_JH
Prepared by Golder Associates Inc. , Printed 7/29/2016

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
17.765	86	Newly graded area, HSG B (0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S)
9.635	98	Water Surface, HSG B (11S, 12S, 13S, 14S, 15S, 16S)

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 0S: Runoff Area=108,303 sf 0.00% Impervious Runoff Depth>9.85"
Flow Length=100' Slope=0.1692 '/' Tc=1.9 min CN=86 Runoff=41.80 cfs 2.041 af

Subcatchment 1S: Runoff Area=96,274 sf 0.00% Impervious Runoff Depth>9.85"
Flow Length=90' Slope=0.2400 '/' Tc=1.5 min CN=86 Runoff=37.85 cfs 1.814 af

Subcatchment 2S: Runoff Area=83,448 sf 0.00% Impervious Runoff Depth>9.85"
Flow Length=70' Slope=0.3125 '/' Tc=1.1 min CN=86 Runoff=33.44 cfs 1.573 af

Subcatchment 3S: Runoff Area=72,052 sf 0.00% Impervious Runoff Depth>9.85"
Flow Length=87' Slope=0.4074 '/' Tc=1.2 min CN=86 Runoff=28.74 cfs 1.358 af

Subcatchment 4S: Runoff Area=84,119 sf 0.00% Impervious Runoff Depth>9.85"
Flow Length=60' Slope=0.4000 '/' Tc=0.9 min CN=86 Runoff=33.98 cfs 1.585 af

Subcatchment 5S: Runoff Area=72,042 sf 0.00% Impervious Runoff Depth>9.85"
Flow Length=50' Slope=0.3000 '/' Tc=0.9 min CN=86 Runoff=29.10 cfs 1.358 af

Subcatchment 6S: Runoff Area=1.457 ac 0.00% Impervious Runoff Depth>9.85"
Flow Length=50' Slope=0.5000 '/' Tc=0.7 min CN=86 Runoff=25.81 cfs 1.196 af

Subcatchment 7S: Runoff Area=2.127 ac 0.00% Impervious Runoff Depth>9.85"
Flow Length=63' Slope=0.5454 '/' Tc=0.8 min CN=86 Runoff=37.56 cfs 1.746 af

Subcatchment 8S: Runoff Area=2.330 ac 0.00% Impervious Runoff Depth>9.85"
Flow Length=100' Slope=0.2000 '/' Tc=1.8 min CN=86 Runoff=39.35 cfs 1.913 af

Subcatchment 11S: Runoff Area=28,451 sf 100.00% Impervious Runoff Depth>11.36"
Flow Length=680' Tc=1.4 min CN=98 Runoff=11.78 cfs 0.618 af

Subcatchment 12S: Runoff Area=101,656 sf 100.00% Impervious Runoff Depth>11.36"
Flow Length=860' Tc=1.3 min CN=98 Runoff=42.29 cfs 2.209 af

Subcatchment 13S: Runoff Area=61,457 sf 100.00% Impervious Runoff Depth>11.36"
Flow Length=860' Tc=2.5 min CN=98 Runoff=24.35 cfs 1.335 af

Subcatchment 14S: Runoff Area=70,406 sf 100.00% Impervious Runoff Depth>11.36"
Flow Length=875' Tc=2.6 min CN=98 Runoff=28.56 cfs 1.530 af

Subcatchment 15S: Runoff Area=79,798 sf 100.00% Impervious Runoff Depth>11.36"
Flow Length=880' Tc=2.6 min CN=98 Runoff=32.37 cfs 1.734 af

Subcatchment 16S: Runoff Area=77,924 sf 100.00% Impervious Runoff Depth>11.36"
Flow Length=830' Tc=2.0 min CN=98 Runoff=31.40 cfs 1.693 af

Pond 0P: Peak Elev=581.64' Storage=7.836 af Inflow=83.93 cfs 4.250 af
18.0" Round Culvert n=0.013 L=39.0' S=0.0003 '/' Outflow=0.00 cfs 0.000 af

Pond 1P: Peak Elev=581.91' Storage=4.958 af Inflow=61.93 cfs 3.150 af
18.0" Round Culvert n=0.025 L=40.0' S=0.0012 '/' Outflow=0.00 cfs 0.000 af

Pond 2P: Peak Elev=581.77' Storage=4.992 af Inflow=60.68 cfs 3.102 af
18.0" Round Culvert n=0.025 L=37.0' S=0.0095 '/' Outflow=0.00 cfs 0.000 af

Pond 3P: Peak Elev=581.60' Storage=5.910 af Inflow=59.74 cfs 3.092 af
18.0" Round Culvert n=0.013 L=42.0' S=0.0255 '/' Outflow=0.00 cfs 0.000 af

Pond 4P: Peak Elev=581.73' Storage=7.878 af Inflow=65.14 cfs 3.279 af
Outflow=0.00 cfs 0.000 af

Pond 5P: Peak Elev=582.58' Storage=2.818 af Inflow=40.87 cfs 1.976 af
24.0" Round Culvert n=0.025 L=106.0' S=0.0242 '/' Outflow=0.00 cfs 0.000 af

Pond 6P: Peak Elev=588.75' Storage=2.386 af Inflow=27.84 cfs 2.379 af
24.0" Round Culvert n=0.025 L=93.0' S=0.0292 '/' Outflow=0.00 cfs 0.000 af

Pond 7P: Peak Elev=587.35' Storage=1.746 af Inflow=37.56 cfs 1.746 af
24.0" Round Culvert n=0.025 L=102.0' S=0.0591 '/' Outflow=0.00 cfs 0.000 af

Pond 8P: Peak Elev=587.93' Storage=1.912 af Inflow=39.35 cfs 1.913 af
24.0" Round Culvert n=0.025 L=117.0' S=0.0597 '/' Outflow=0.00 cfs 0.000 af

Summary for Subcatchment 0S:

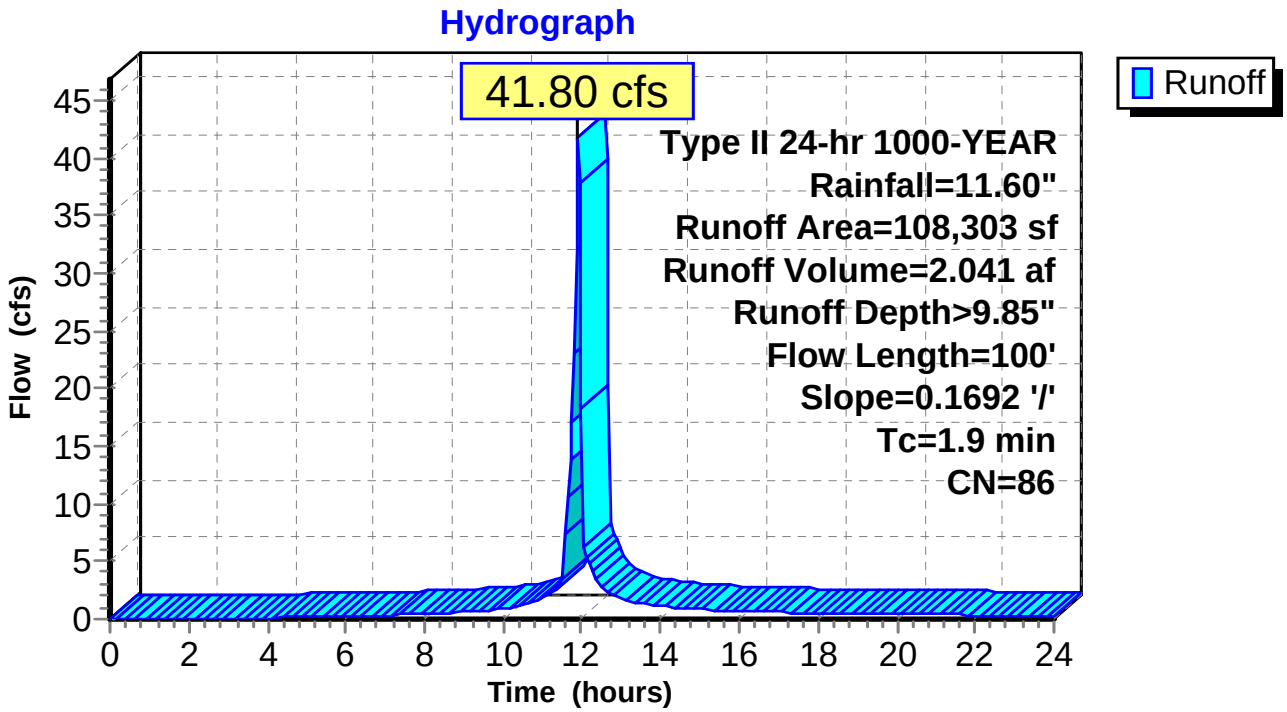
Runoff = 41.80 cfs @ 11.91 hrs, Volume= 2.041 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
108,303	86	Newly graded area, HSG B
108,303		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	100	0.1692	0.86		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 0S:



Summary for Subcatchment 1S:

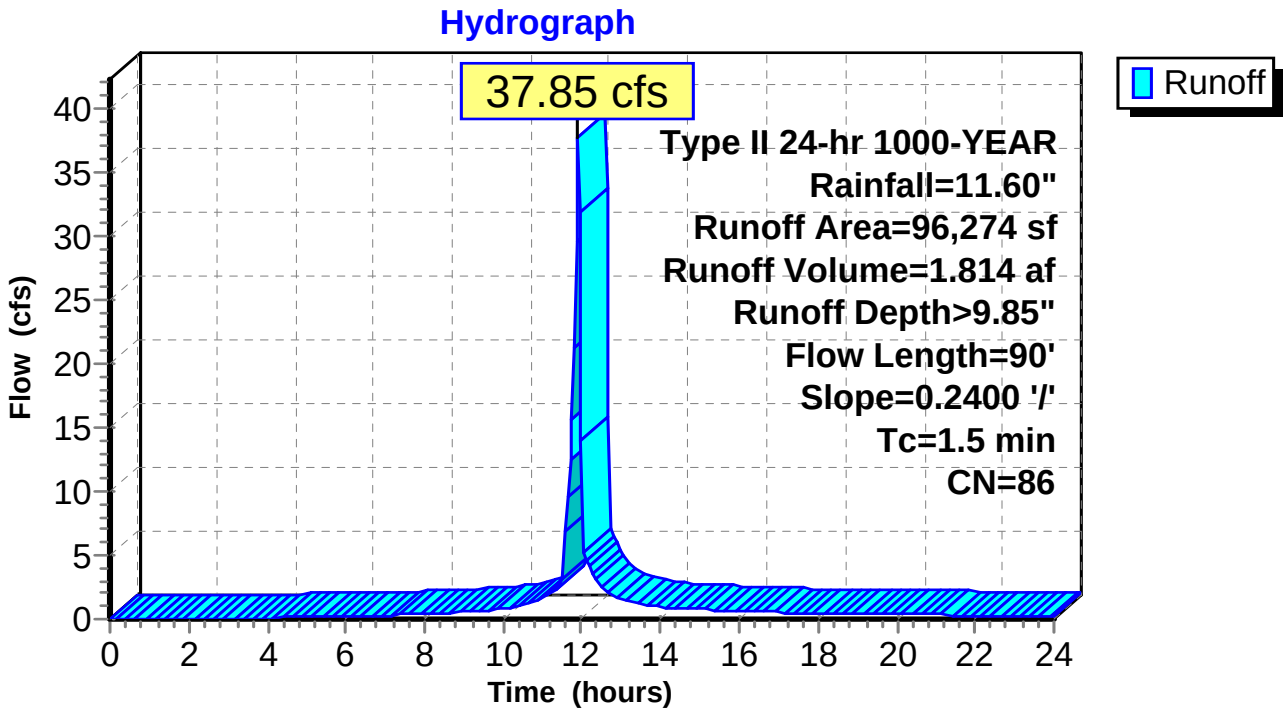
Runoff = 37.85 cfs @ 11.90 hrs, Volume= 1.814 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
96,274	86	Newly graded area, HSG B
96,274		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.5	90	0.2400	0.97		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 1S:



Summary for Subcatchment 2S:

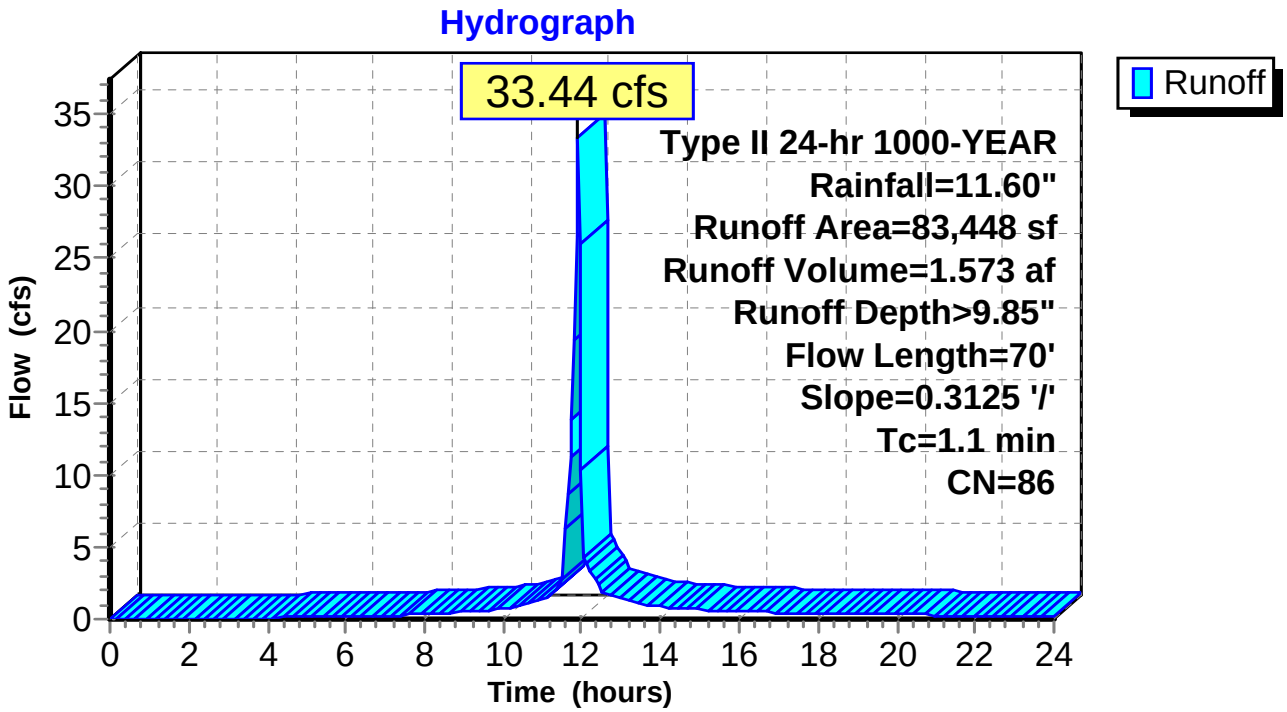
Runoff = 33.44 cfs @ 11.90 hrs, Volume= 1.573 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
83,448	86	Newly graded area, HSG B
83,448		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	70	0.3125	1.03		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 2S:



Summary for Subcatchment 3S:

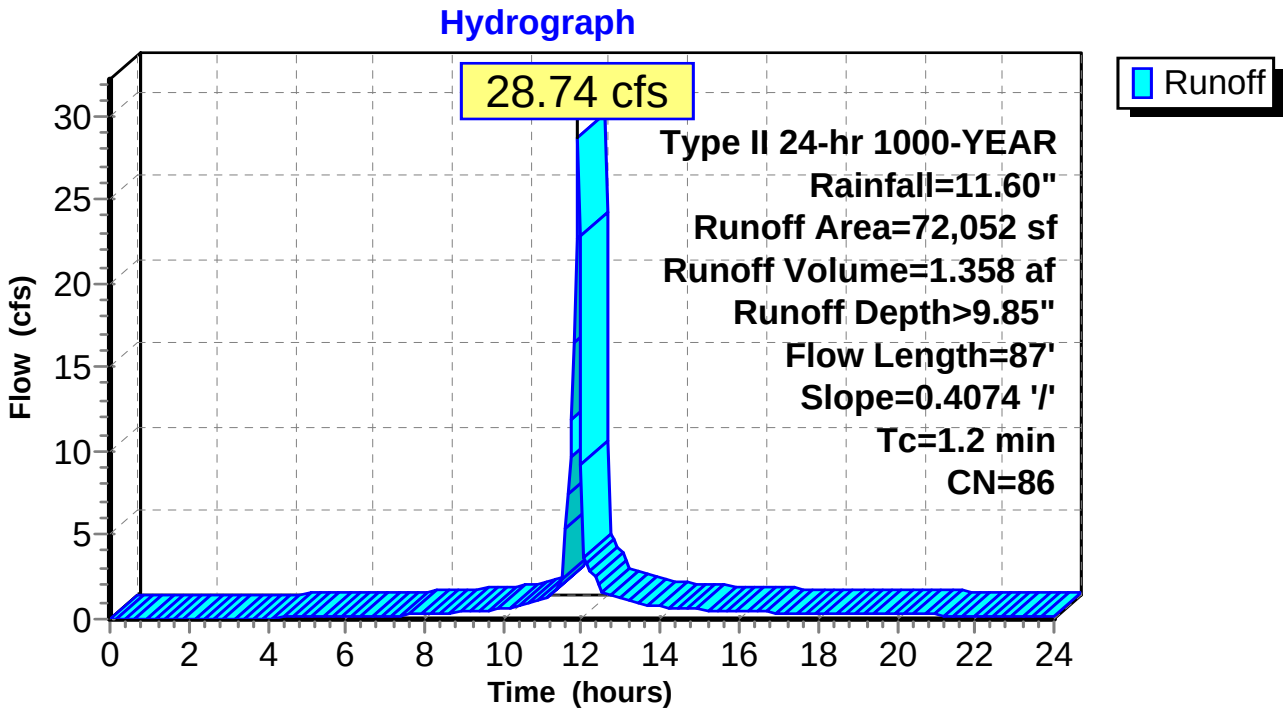
Runoff = 28.74 cfs @ 11.90 hrs, Volume= 1.358 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
72,052	86	Newly graded area, HSG B
72,052		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.2	87	0.4074	1.19		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 3S:



Summary for Subcatchment 4S:

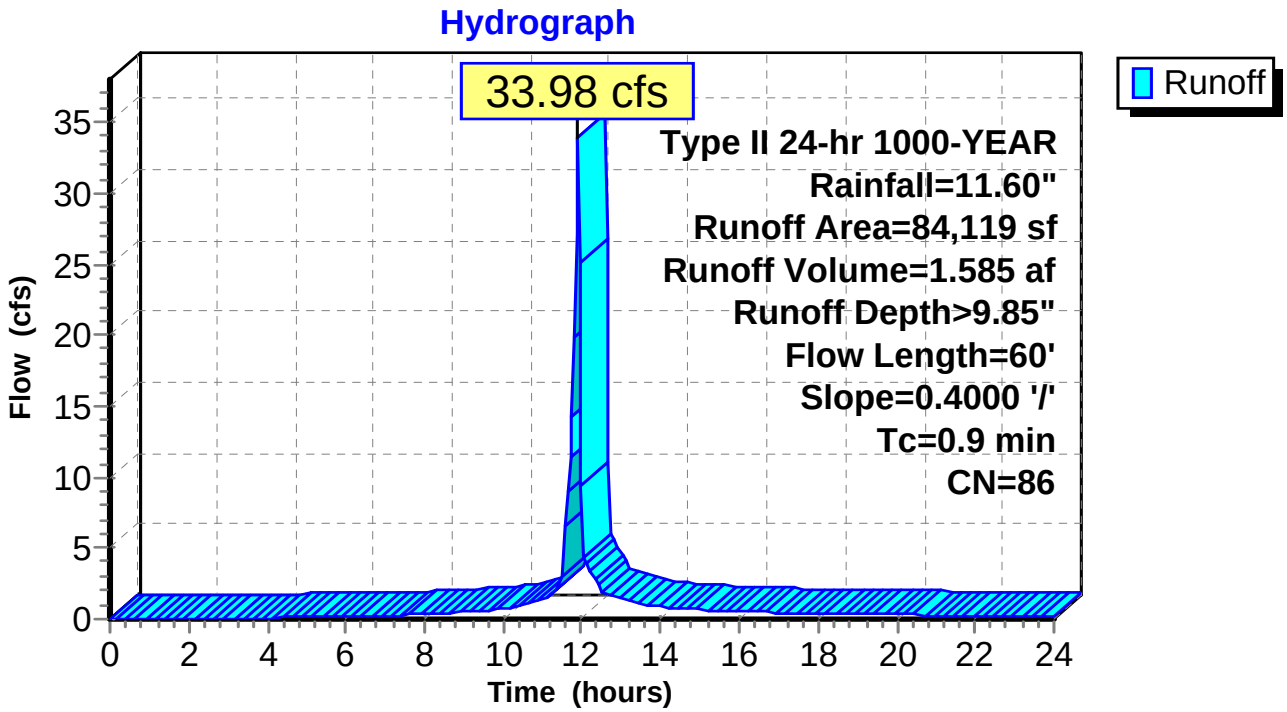
Runoff = 33.98 cfs @ 11.90 hrs, Volume= 1.585 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
84,119	86	Newly graded area, HSG B
84,119		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	60	0.4000	1.10		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 4S:



Summary for Subcatchment 5S:

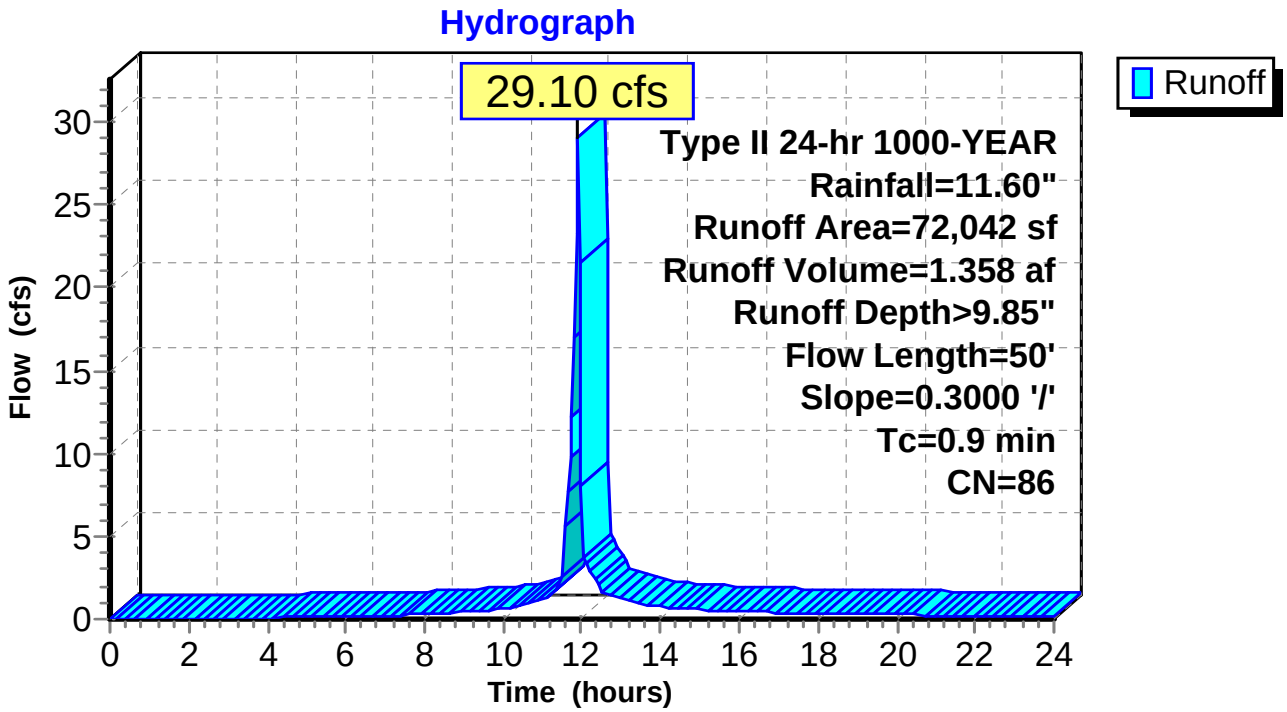
Runoff = 29.10 cfs @ 11.90 hrs, Volume= 1.358 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
72,042	86	Newly graded area, HSG B
72,042		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.3000	0.95		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 5S:



Summary for Subcatchment 6S:

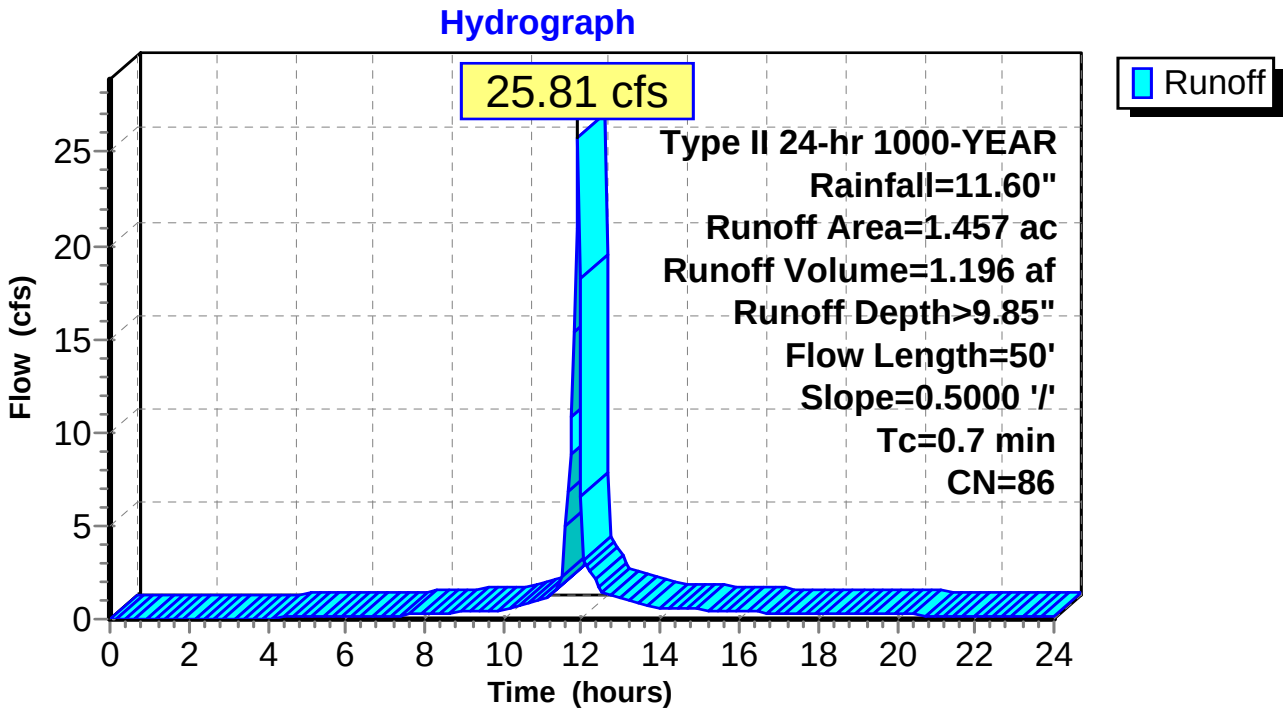
Runoff = 25.81 cfs @ 11.89 hrs, Volume= 1.196 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (ac)	CN	Description
1.457	86	Newly graded area, HSG B
1.457		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.5000	1.16		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 6S:



Summary for Subcatchment 7S:

Runoff = 37.56 cfs @ 11.90 hrs, Volume= 1.746 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (ac)	CN	Description
2.127	86	Newly graded area, HSG B
2.127		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
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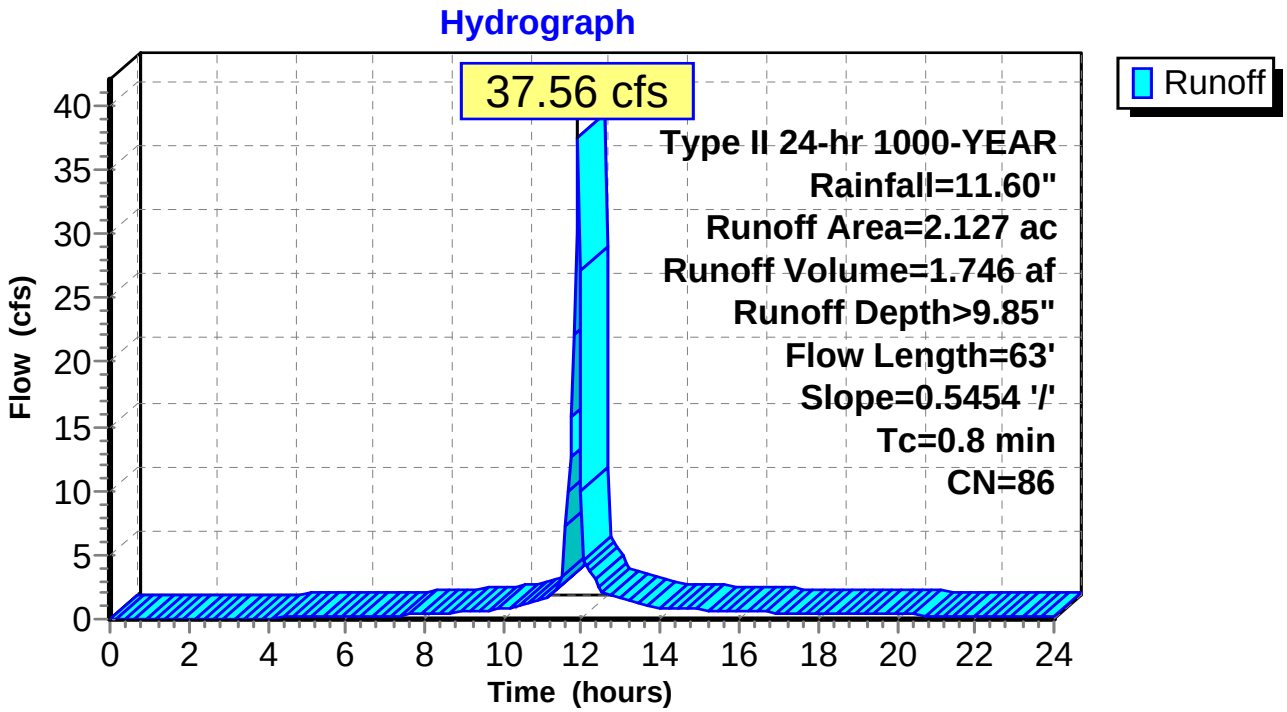
Subcatchment 7S:



Summary for Subcatchment 8S:

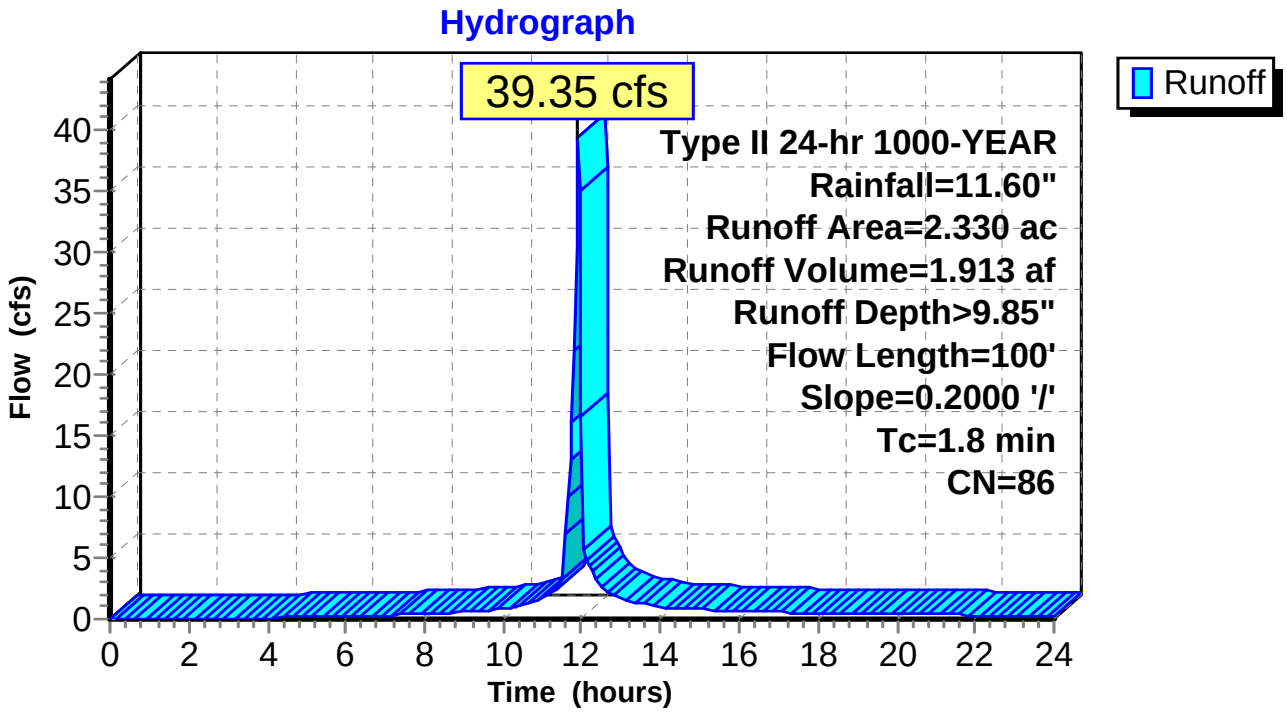
Runoff = 39.35 cfs @ 11.91 hrs, Volume= 1.913 af, Depth> 9.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (ac)	CN	Description
2.330	86	Newly graded area, HSG B
2.330		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.8	100	0.2000	0.92		**Sheet Flow,** Fallow n= 0.050 P2= 2.58"

Subcatchment 8S:



Summary for Subcatchment 11S:

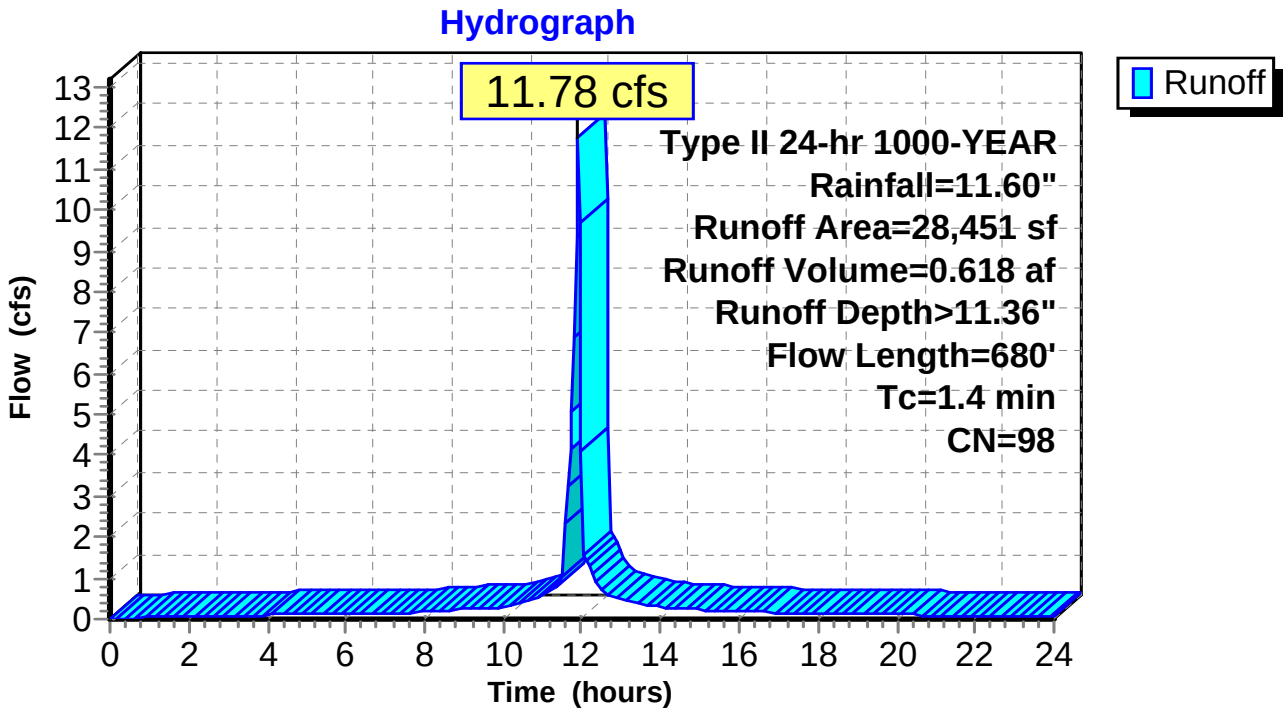
Runoff = 11.78 cfs @ 11.90 hrs, Volume= 0.618 af, Depth>11.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
28,451	98	Water Surface, HSG B
28,451		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	680		8.02		**Lake or Reservoir,** Mean Depth= 2.00'

Subcatchment 11S:



Summary for Subcatchment 12S:

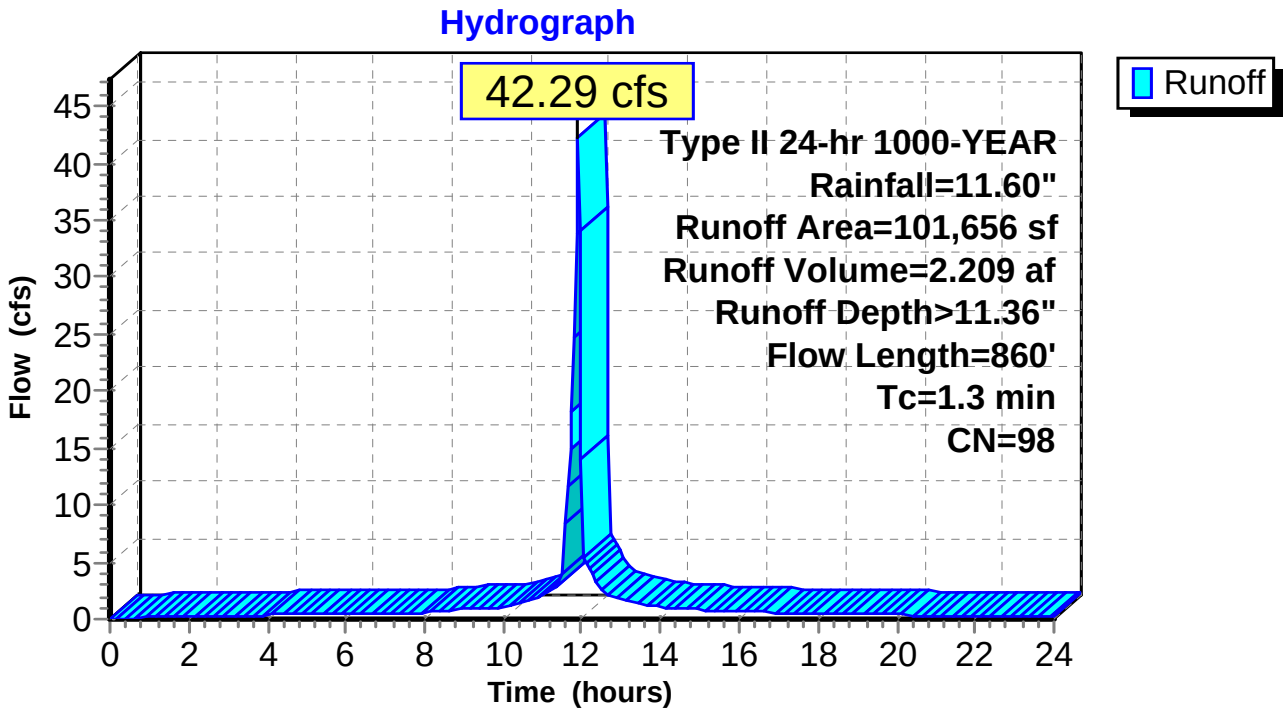
Runoff = 42.29 cfs @ 11.90 hrs, Volume= 2.209 af, Depth>11.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
101,656	98	Water Surface, HSG B
101,656		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.3	860		11.35		**Lake or Reservoir,** Mean Depth= 4.00'

Subcatchment 12S:



Summary for Subcatchment 13S:

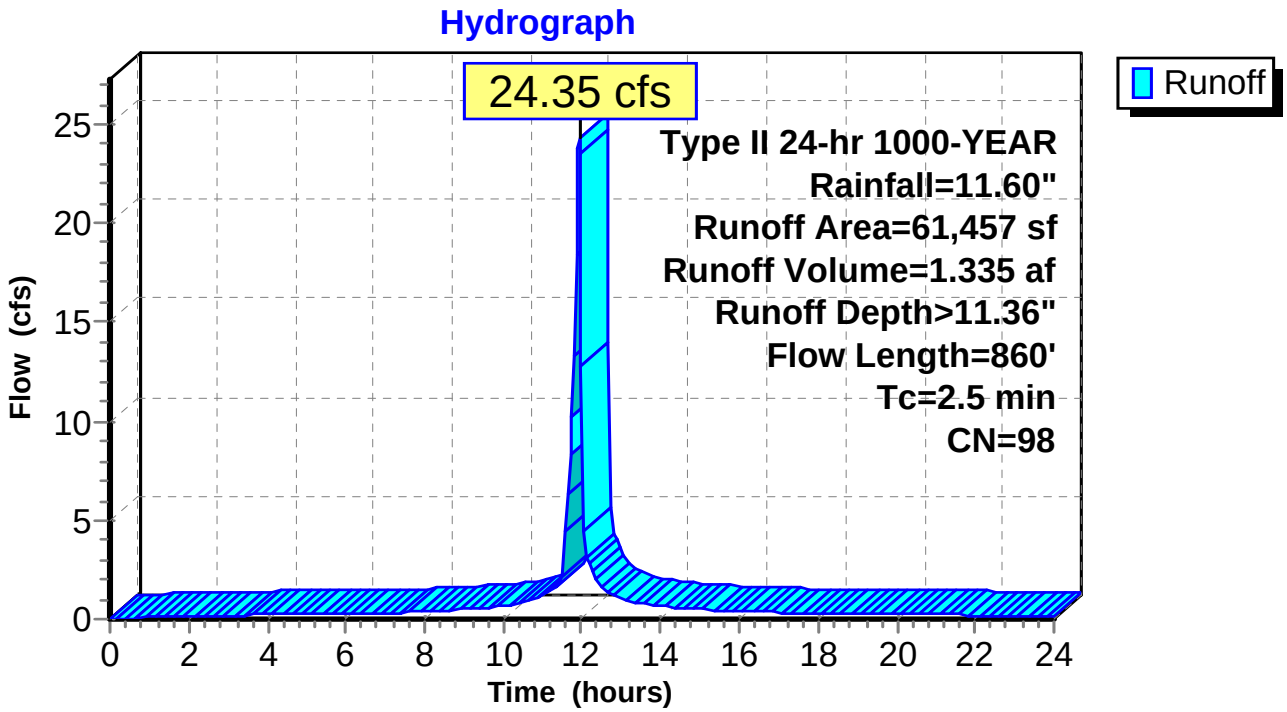
Runoff = 24.35 cfs @ 11.92 hrs, Volume= 1.335 af, Depth>11.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
61,457	98	Water Surface, HSG B
61,457		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	860		5.67		**Lake or Reservoir,** Mean Depth= 1.00'

Subcatchment 13S:



Summary for Subcatchment 14S:

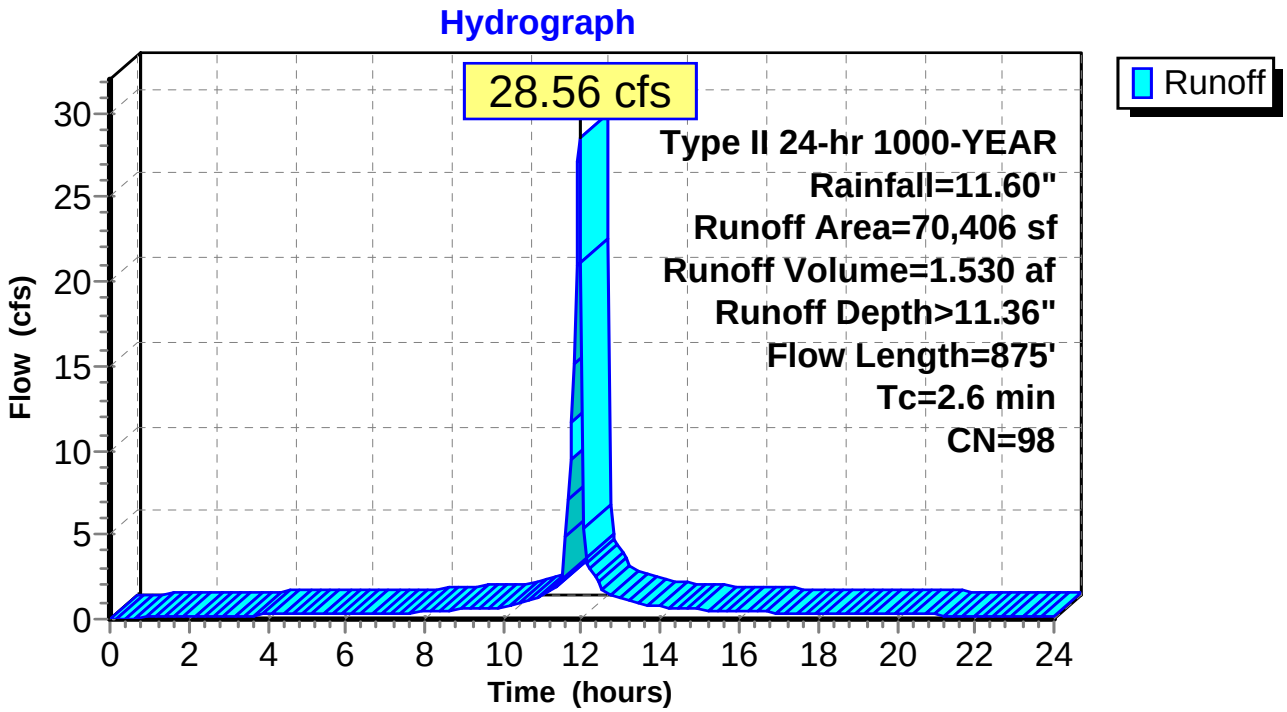
Runoff = 28.56 cfs @ 11.93 hrs, Volume= 1.530 af, Depth>11.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
70,406	98	Water Surface, HSG B
70,406		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.6	875		5.67		**Lake or Reservoir,** Mean Depth= 1.00'

Subcatchment 14S:



Summary for Subcatchment 15S:

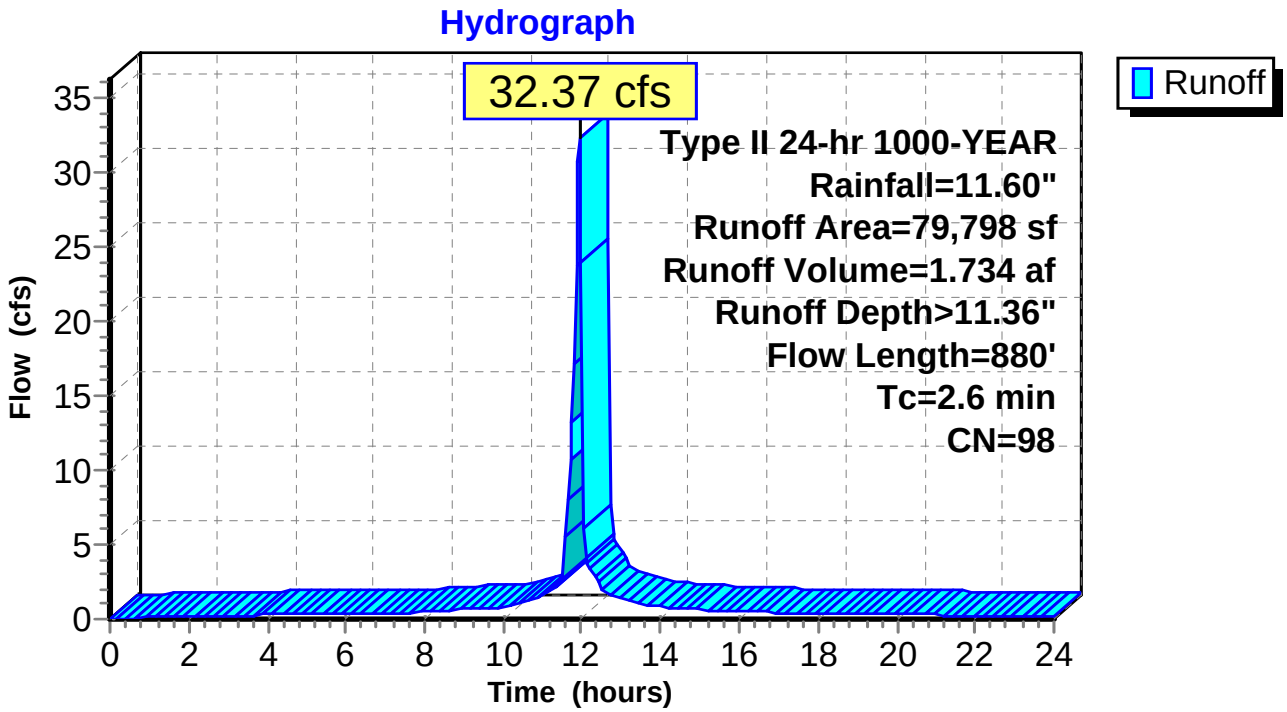
Runoff = 32.37 cfs @ 11.93 hrs, Volume= 1.734 af, Depth>11.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
79,798	98	Water Surface, HSG B
79,798		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.6	880		5.67		**Lake or Reservoir,** Mean Depth= 1.00'

Subcatchment 15S:



Summary for Subcatchment 16S:

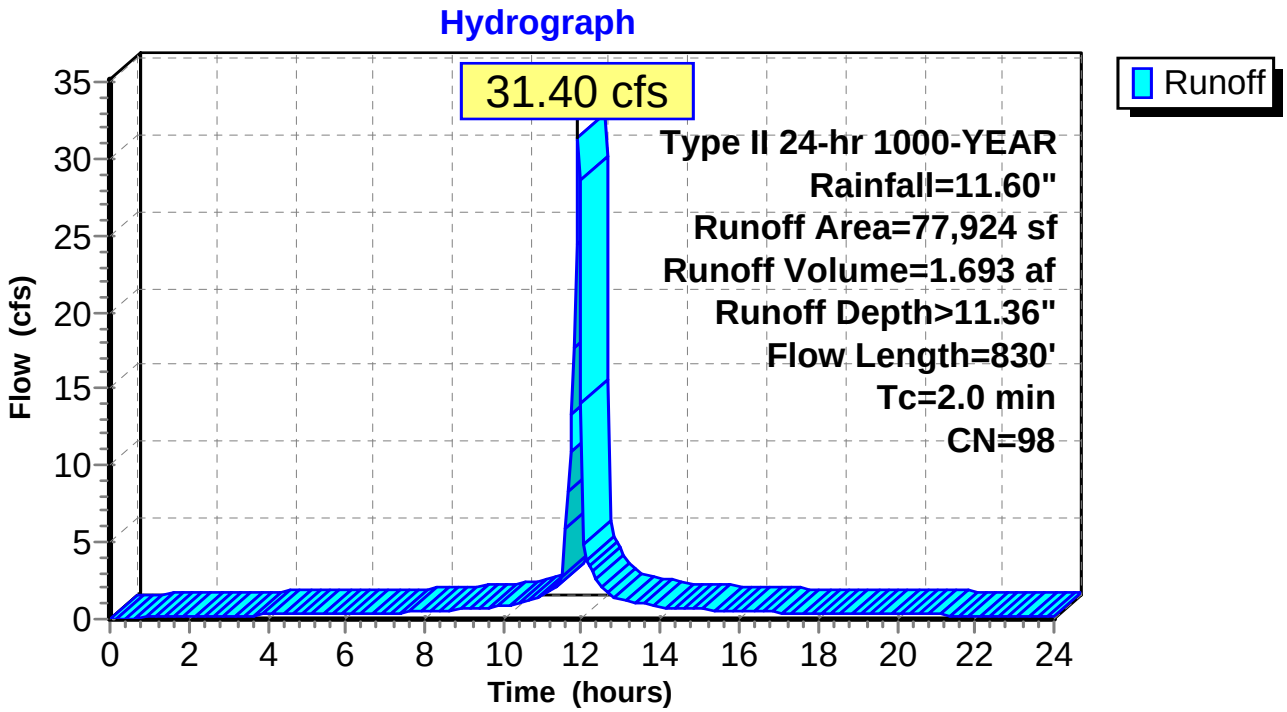
Runoff = 31.40 cfs @ 11.91 hrs, Volume= 1.693 af, Depth>11.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-YEAR Rainfall=11.60"

Area (sf)	CN	Description
77,924	98	Water Surface, HSG B
77,924		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0	830		6.95		**Lake or Reservoir,** Mean Depth= 1.50'

Subcatchment 16S:



Summary for Pond 0P:

Inflow Area = 4.820 ac, 48.42% Impervious, Inflow Depth > 10.58" for 1000-YEAR event
Inflow = 83.93 cfs @ 11.90 hrs, Volume= 4.250 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Starting Elev= 580.00' Surf.Area= 2.334 ac Storage= 3.588 af
Peak Elev= 581.64' @ 24.00 hrs Surf.Area= 2.772 ac Storage= 7.836 af (4.248 af above start)

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

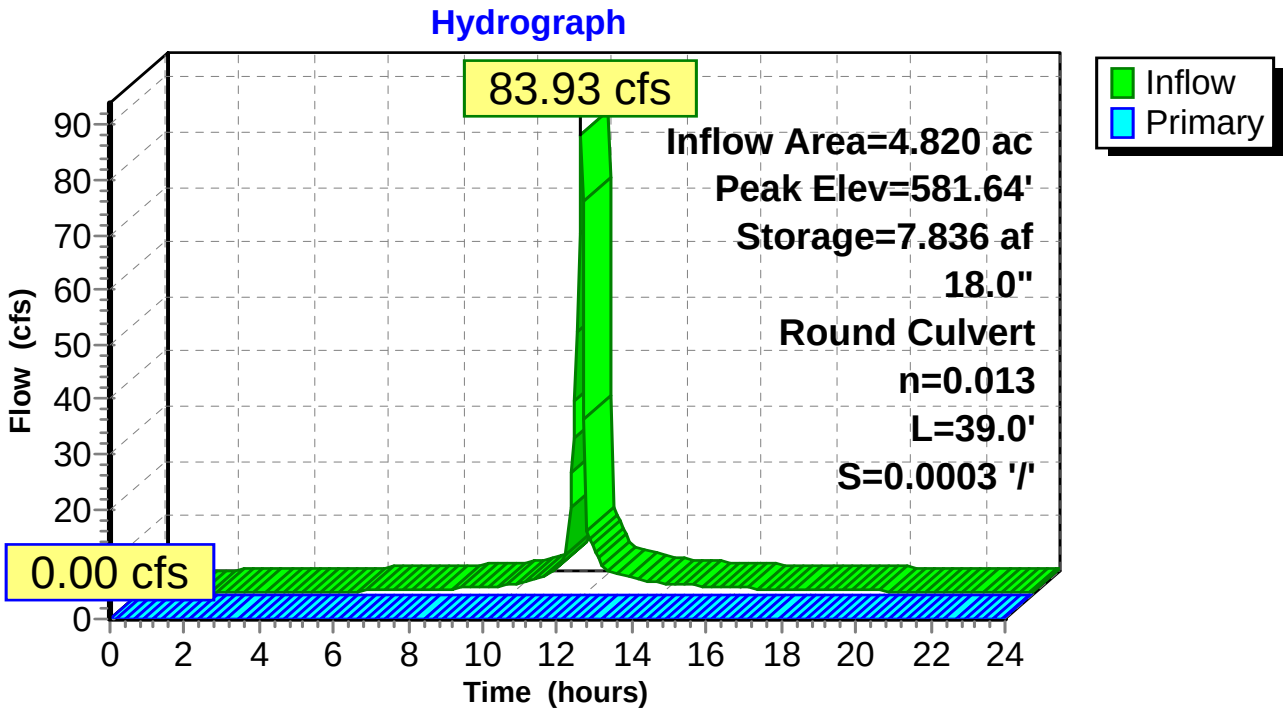
Volume	Invert	Avail.Storage	Storage Description
#1	572.00'	32.047 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
572.00	0.000	0.000	0.000
573.00	0.004	0.002	0.002
574.00	0.013	0.008	0.010
575.00	0.025	0.019	0.029
576.00	0.043	0.034	0.064
577.00	0.168	0.105	0.169
578.00	0.546	0.357	0.526
579.00	1.621	1.084	1.610
580.00	2.334	1.978	3.588
581.00	2.679	2.506	6.094
582.00	2.824	2.751	8.845
583.00	2.962	2.893	11.738
584.00	3.102	3.032	14.770
585.00	3.243	3.172	17.943
586.00	3.386	3.315	21.257
587.00	3.530	3.458	24.715
588.00	3.662	3.596	28.311
589.00	3.808	3.735	32.047

Device	Routing	Invert	Outlet Devices
#1	Primary	586.74'	**18.0" Round Culvert** L= 39.0' RCP, sq.cut end projecting, Ke= 0.500 Outlet Invert= 586.73' S= 0.0003 '/' Cc= 0.900 n= 0.013 Concrete pipe, straight & clean

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Pond 0P:


Hydrograph
83.93 cfs
0.00 cfs
Inflow Area=4.820 ac
Peak Elev=581.64'
Storage=7.836 af
18.0"
Round Culvert
n=0.013
L=39.0'
S=0.0003 '/'
Inflow
Primary
Flow (cfs)
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)

Summary for Pond 1P:

Inflow Area = 18.362 ac, 26.46% Impervious, Inflow Depth > 2.06" for 1000-YEAR event
Inflow = 61.93 cfs @ 11.91 hrs, Volume= 3.150 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Starting Elev= 580.00' Surf.Area= 1.411 ac Storage= 1.810 af
Peak Elev= 581.91' @ 24.00 hrs Surf.Area= 1.856 ac Storage= 4.958 af (3.149 af above start)

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

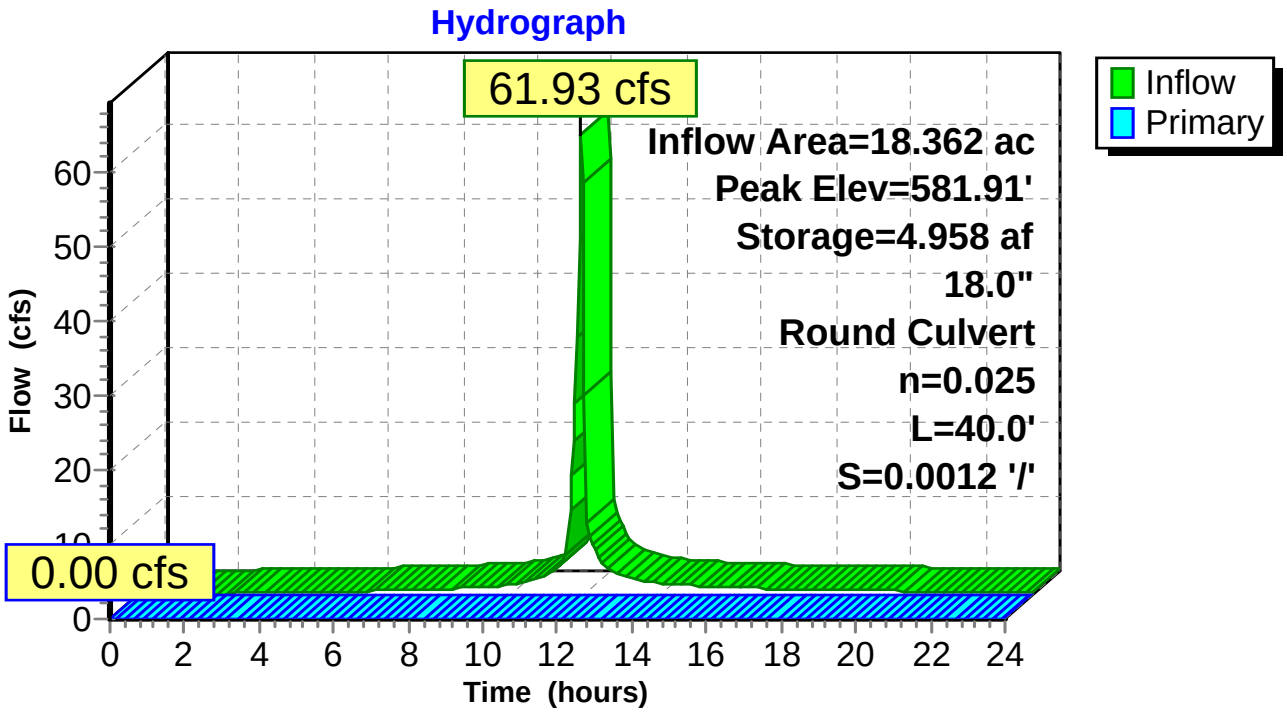
Volume	Invert	Avail.Storage	Storage Description
#1	578.00'	19.402 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
578.00	0.414	0.000	0.000
579.00	0.897	0.656	0.656
580.00	1.411	1.154	1.810
581.00	1.681	1.546	3.356
582.00	1.874	1.777	5.133
583.00	2.087	1.980	7.113
584.00	2.236	2.162	9.275
585.00	2.378	2.307	11.582
586.00	2.530	2.454	14.036
587.00	2.690	2.610	16.646
588.00	2.822	2.756	19.402

Device	Routing	Invert	Outlet Devices
#1	Primary	586.80'	**18.0" Round Culvert** L= 40.0' CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 586.75' S= 0.0012 '/' Cc= 0.900 n= 0.025 Corrugated metal

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Pond 1P:


Hydrograph
61.93 cfs
0.00 cfs
Inflow Area=18.362 ac
Peak Elev=581.91'
Storage=4.958 af
18.0"
Round Culvert
n=0.025
L=40.0'
S=0.0012 '/'
Inflow
Primary
Flow (cfs)
0
20
30
40
50
60
0 2 4 6 8 10 12 14 16 18 20 22 24
Time (hours)

Summary for Pond 2P:

Inflow Area = 21.894 ac, 29.57% Impervious, Inflow Depth > 1.70" for 1000-YEAR event
Inflow = 60.68 cfs @ 11.91 hrs, Volume= 3.102 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Starting Elev= 580.00' Surf.Area= 1.616 ac Storage= 1.891 af
Peak Elev= 581.77' @ 24.00 hrs Surf.Area= 1.878 ac Storage= 4.992 af (3.101 af above start)

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

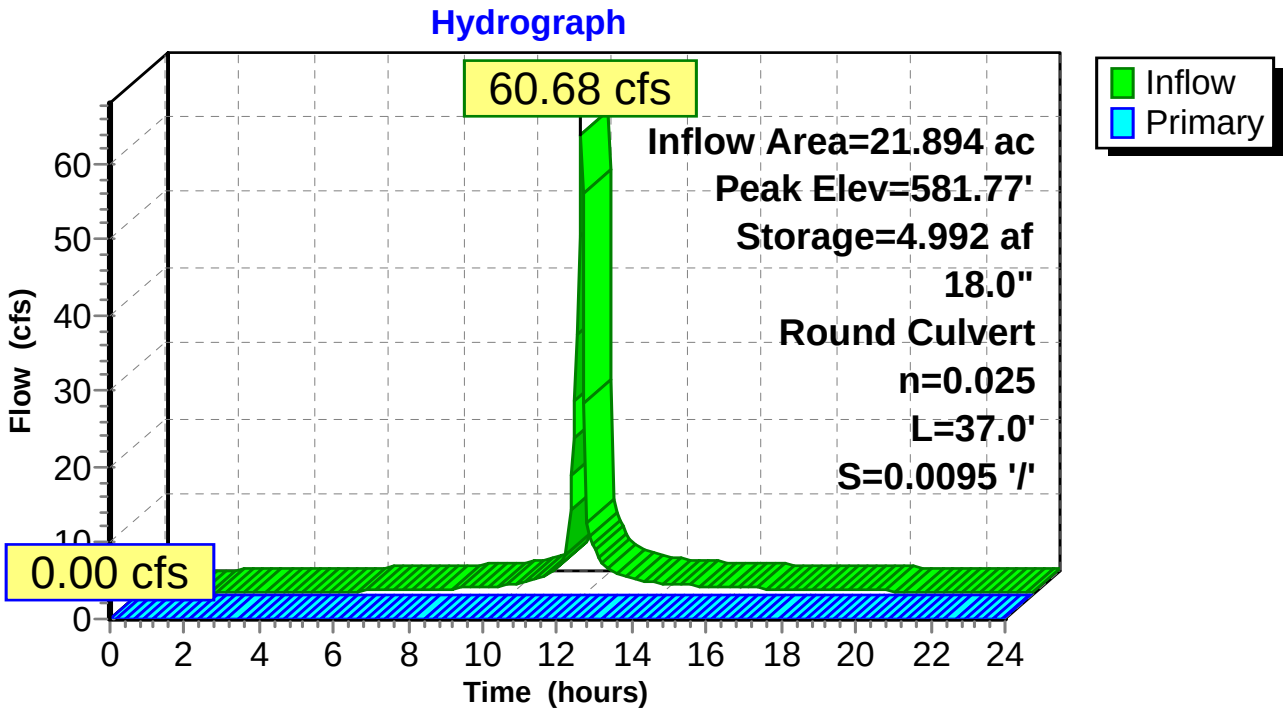
Volume	Invert	Avail.Storage	Storage Description
#1	578.00'	19.256 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
578.00	0.196	0.000	0.000
579.00	0.985	0.590	0.590
580.00	1.616	1.300	1.891
581.00	1.766	1.691	3.582
582.00	1.911	1.838	5.420
583.00	2.051	1.981	7.401
584.00	2.174	2.112	9.514
585.00	2.302	2.238	11.752
586.00	2.432	2.367	14.119
587.00	2.567	2.499	16.618
588.00	2.708	2.638	19.256

Device	Routing	Invert	Outlet Devices
#1	Primary	587.05'	**18.0" Round Culvert** L= 37.0' CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 586.70' S= 0.0095 '/' Cc= 0.900 n= 0.025 Corrugated metal

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Pond 2P:


Hydrograph
60.68 cfs
0.00 cfs
Inflow Area=21.894 ac
Peak Elev=581.77'
Storage=4.992 af
18.0"
Round Culvert
n=0.025
L=37.0'
S=0.0095 '/'
Inflow
Primary
Flow (cfs)
0
10
20
30
40
50
60
0 2 4 6 8 10 12 14 16 18 20 22 24
Time (hours)

Summary for Pond 3P:

Inflow Area = 25.380 ac, 32.73% Impervious, Inflow Depth > 1.46" for 1000-YEAR event
Inflow = 59.74 cfs @ 11.91 hrs, Volume= 3.092 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Starting Elev= 580.00' Surf.Area= 1.832 ac Storage= 2.820 af
Peak Elev= 581.60' @ 24.00 hrs Surf.Area= 2.032 ac Storage= 5.910 af (3.091 af above start)

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

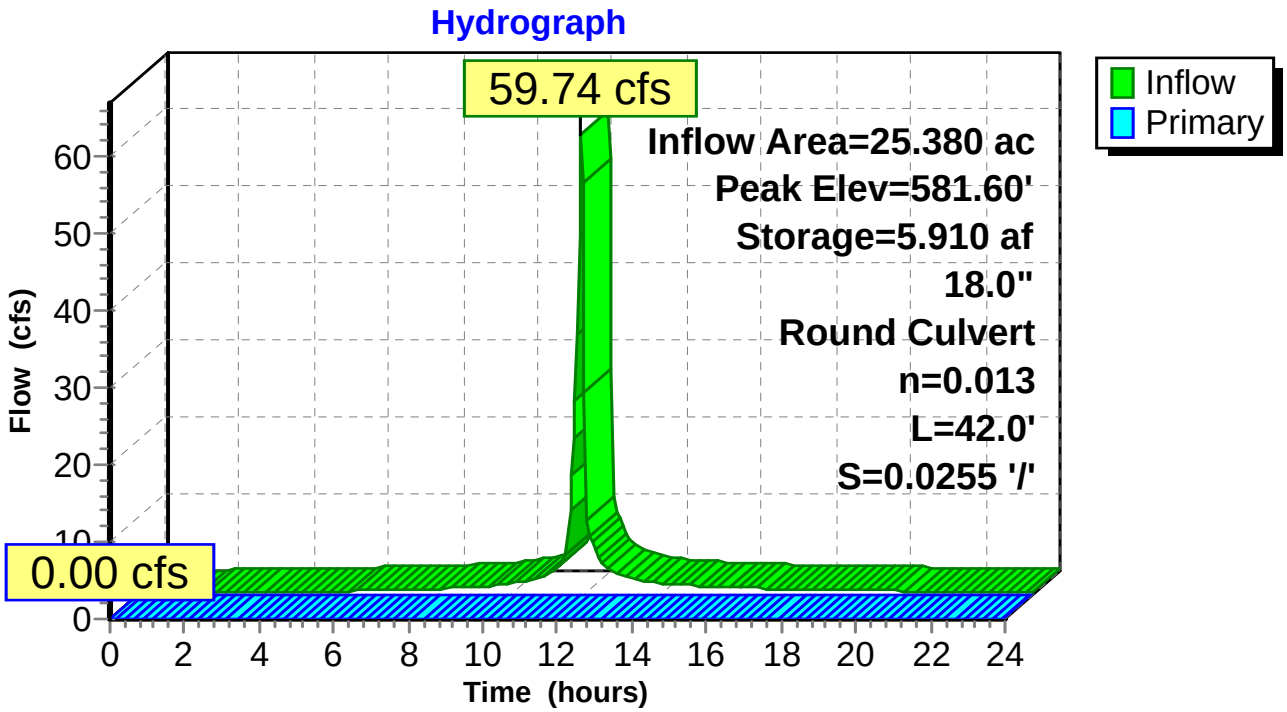
Volume	Invert	Avail.Storage	Storage Description
#1	578.00'	21.519 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
578.00	0.928	0.000	0.000
579.00	1.439	1.184	1.184
580.00	1.832	1.636	2.820
581.00	1.956	1.894	4.714
582.00	2.082	2.019	6.733
583.00	2.210	2.146	8.879
584.00	2.340	2.275	11.154
585.00	2.472	2.406	13.560
586.00	2.605	2.539	16.098
587.00	2.723	2.664	18.762
588.00	2.791	2.757	21.519

Device	Routing	Invert	Outlet Devices
#1	Primary	586.85'	**18.0" Round Culvert** L= 42.0' CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 585.78' S= 0.0255 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Pond 3P:


Hydrograph
59.74 cfs
0.00 cfs
Inflow Area=25.380 ac
Peak Elev=581.60'
Storage=5.910 af
18.0"
Round Culvert
n=0.013
L=42.0'
S=0.0255 '/'
Inflow
Primary
Flow (cfs)
0
10
20
30
40
50
60
0 2 4 6 8 10 12 14 16 18 20 22 24
Time (hours)

Summary for Pond 4P:

Inflow Area = 29.100 ac, 34.69% Impervious, Inflow Depth > 1.35" for 1000-YEAR event
Inflow = 65.14 cfs @ 11.90 hrs, Volume= 3.279 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Starting Elev= 580.00' Surf.Area= 1.789 ac Storage= 4.600 af
Peak Elev= 581.73' @ 24.00 hrs Surf.Area= 1.994 ac Storage= 7.878 af (3.278 af above start)

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

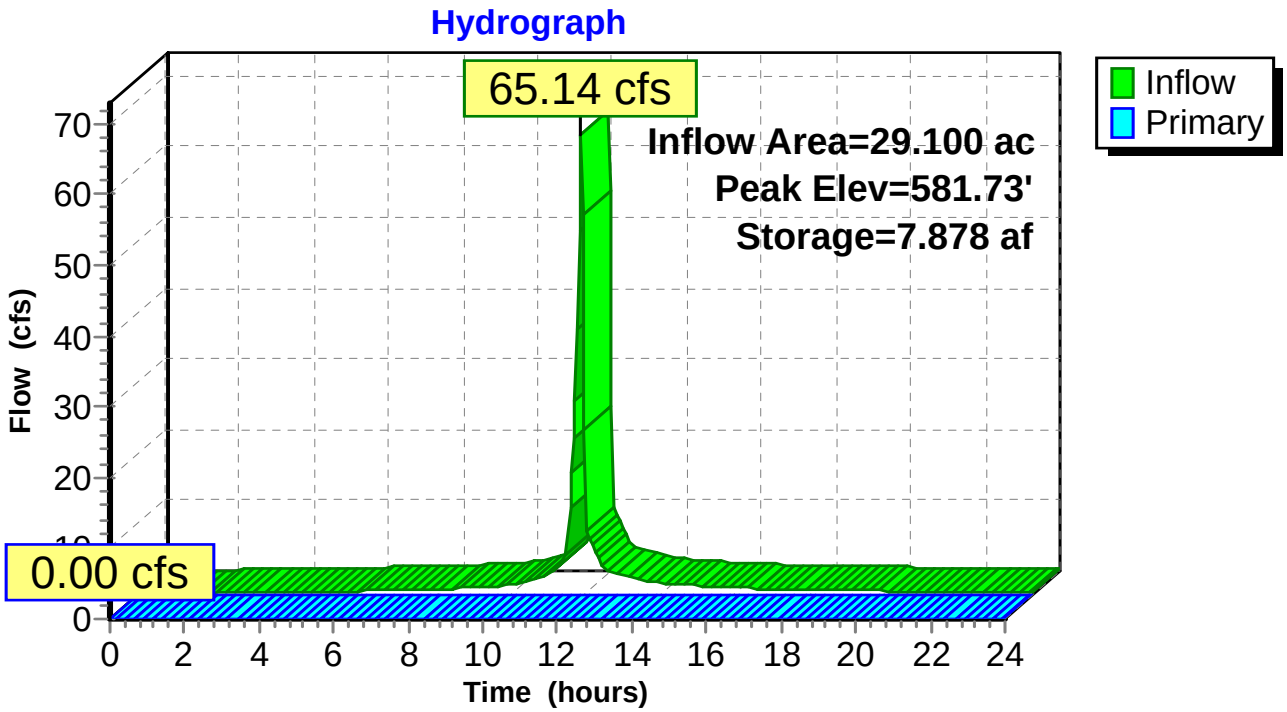
Volume	Invert	Avail.Storage	Storage Description
#1	577.00'	22.714 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
577.00	1.060	0.000	0.000
578.00	1.517	1.289	1.289
579.00	1.658	1.588	2.876
580.00	1.789	1.724	4.600
581.00	1.906	1.848	6.448
582.00	2.026	1.966	8.414
583.00	2.148	2.087	10.501
584.00	2.272	2.210	12.711
585.00	2.397	2.334	15.045
586.00	2.515	2.456	17.501
587.00	2.607	2.561	20.062
588.00	2.696	2.652	22.714

Device	Routing	Invert	Outlet Devices
#1	Primary	584.33'	**24.0" Round Culvert** L= 67.0' CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 580.66' S= 0.0548 '/' Cc= 0.900 n= 0.013 Concrete pipe, straight & clean
#2	Primary	587.98'	**18.0" Round Culvert** L= 59.0' CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 580.89' S= 0.1202 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior
#3	Primary	587.97'	**18.0" Round Culvert** L= 59.0' CPP, projecting, no headwall, Ke= 0.900 Outlet Invert= 581.05' S= 0.1173 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
- **1=Culvert** (Controls 0.00 cfs)
- **2=Culvert** (Controls 0.00 cfs)
- **3=Culvert** (Controls 0.00 cfs)

Pond 4P:


Hydrograph
65.14 cfs
0.00 cfs
Inflow Area=29.100 ac
Peak Elev=581.73'
Storage=7.878 af
Inflow
Primary
Flow (cfs)
0
20
30
40
50
60
70
0 2 4 6 8 10 12 14 16 18 20 22 24
Time (hours)

Summary for Pond 5P:

Inflow Area = 2.307 ac, 28.31% Impervious, Inflow Depth > 10.28" for 1000-YEAR event
Inflow = 40.87 cfs @ 11.90 hrs, Volume= 1.976 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Starting Elev= 580.00' Surf.Area= 0.653 ac Storage= 0.843 af
Peak Elev= 582.58' @ 24.00 hrs Surf.Area= 0.865 ac Storage= 2.818 af (1.975 af above start)

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

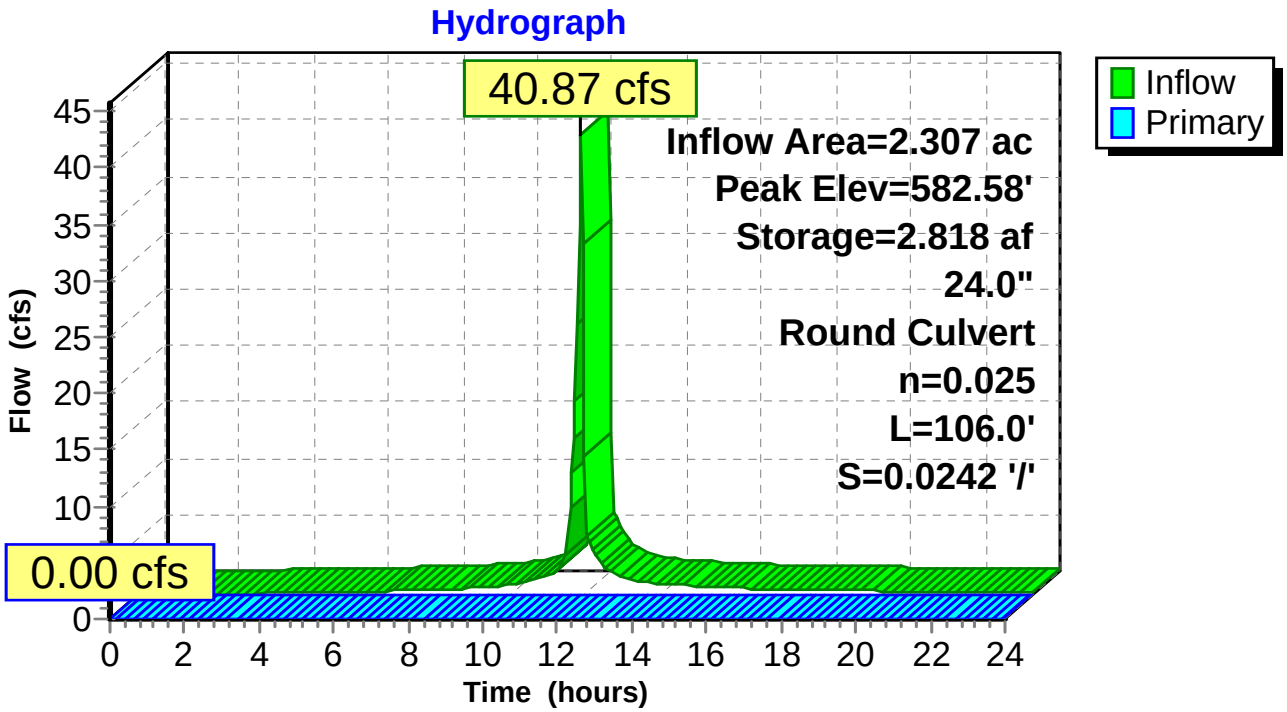
Volume	Invert	Avail.Storage	Storage Description
#1	578.00'	11.184 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
578.00	0.022	0.000	0.000
579.00	0.505	0.264	0.264
580.00	0.653	0.579	0.843
581.00	0.752	0.702	1.545
582.00	0.824	0.788	2.333
583.00	0.895	0.859	3.192
584.00	0.966	0.930	4.123
585.00	1.037	1.002	5.124
586.00	1.110	1.074	6.198
587.00	1.184	1.147	7.345
588.00	1.259	1.221	8.566
589.00	1.310	1.284	9.850
590.00	1.359	1.334	11.184

Device	Routing	Invert	Outlet Devices
#1	Primary	588.64'	**24.0" Round Culvert** L= 106.0' CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 586.08' S= 0.0242 '/' Cc= 0.900 n= 0.025 Corrugated metal

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Pond 5P:


Hydrograph
40.87 cfs
0.00 cfs
Inflow Area=2.307 ac
Peak Elev=582.58'
Storage=2.818 af
24.0"
Round Culvert
n=0.025
L=106.0'
S=0.0242 '/'
Inflow
Primary
Flow (cfs)
0
5
10
15
20
25
30
35
40
45
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)

Summary for Pond 6P:

Inflow Area = 3.157 ac, 14.57% Impervious, Inflow Depth > 9.04" for 1000-YEAR event
Inflow = 27.84 cfs @ 11.90 hrs, Volume= 2.379 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Starting Elev= 580.00' Surf.Area= 0.013 ac Storage= 0.007 af
Peak Elev= 588.75' @ 24.00 hrs Surf.Area= 0.640 ac Storage= 2.386 af (2.378 af above start)

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

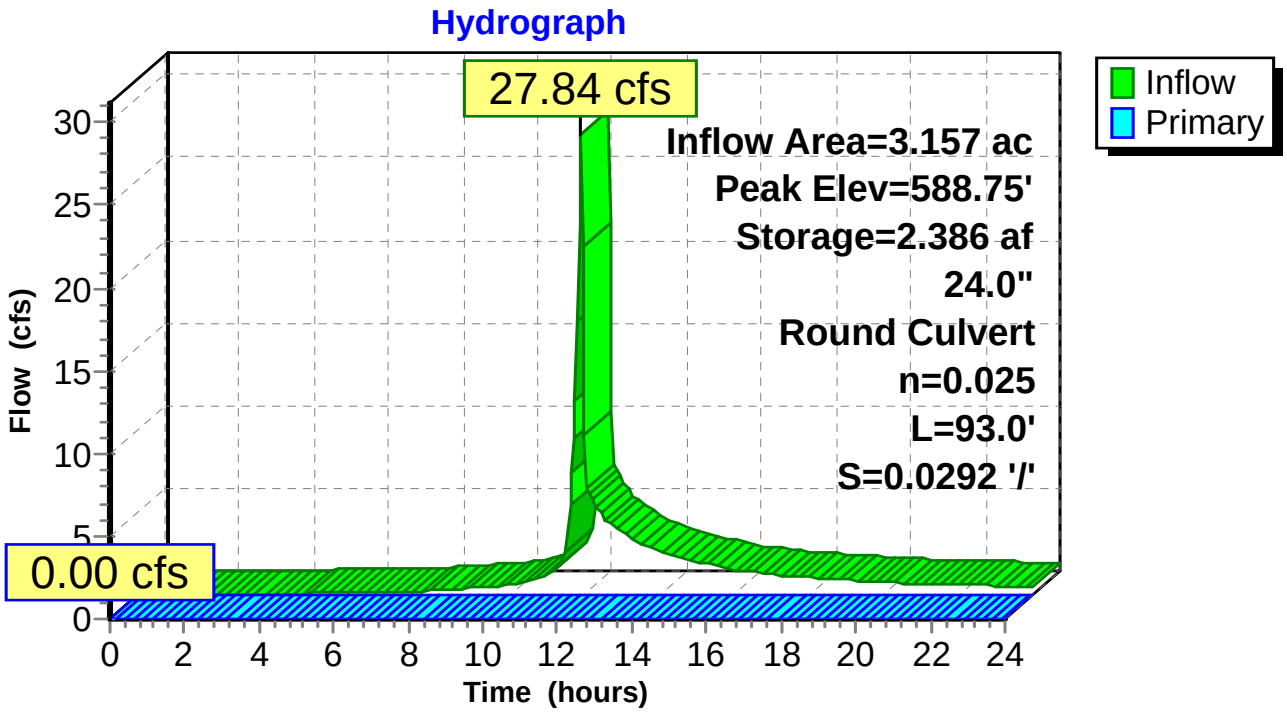
Volume	Invert	Avail.Storage	Storage Description
#1	579.00'	4.686 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
579.00	0.001	0.000	0.000
580.00	0.013	0.007	0.007
581.00	0.047	0.030	0.037
582.00	0.103	0.075	0.112
583.00	0.163	0.133	0.245
584.00	0.228	0.196	0.441
585.00	0.296	0.262	0.704
586.00	0.368	0.332	1.036
587.00	0.442	0.405	1.441
589.00	0.668	1.110	2.551
590.00	0.697	0.683	3.234
591.00	0.726	0.712	3.945
592.00	0.755	0.740	4.686

Device	Routing	Invert	Outlet Devices
#1	Primary	589.06'	**24.0" Round Culvert** L= 93.0' CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 586.34' S= 0.0292 '/' Cc= 0.900 n= 0.025 Rubble masonry, cemented

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Pond 6P:


Hydrograph
27.84 cfs
0.00 cfs
Inflow Area=3.157 ac
Peak Elev=588.75'
Storage=2.386 af
24.0"
Round Culvert
n=0.025
L=93.0'
S=0.0292 '/'
Inflow
Primary
Flow (cfs)
Time (hours)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14 16 18 20 22 24

Summary for Pond 7P:

Inflow Area = 2.127 ac, 0.00% Impervious, Inflow Depth > 9.85" for 1000-YEAR event
Inflow = 37.56 cfs @ 11.90 hrs, Volume= 1.746 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 587.35' @ 24.00 hrs Surf.Area= 0.437 ac Storage= 1.746 af

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

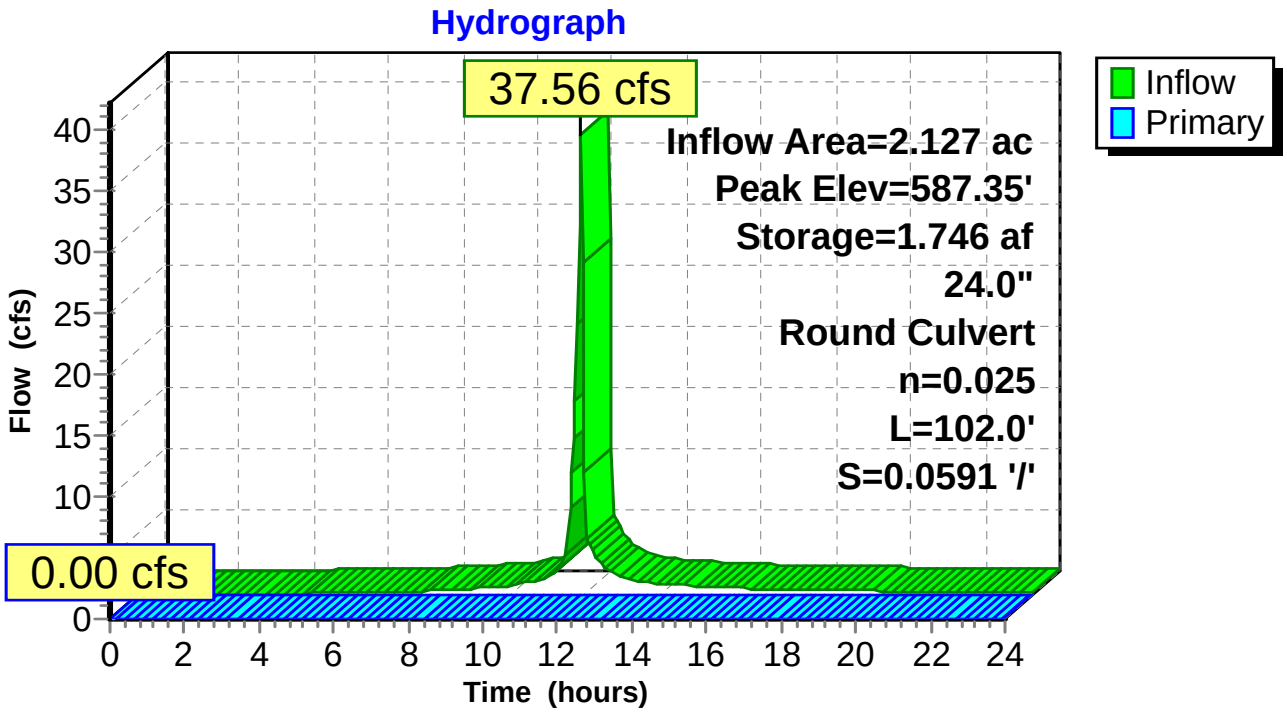
Volume	Invert	Avail.Storage	Storage Description
#1	582.00'	5.332 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
582.00	0.191	0.000	0.000
583.00	0.254	0.223	0.223
584.00	0.306	0.280	0.503
585.00	0.345	0.325	0.828
586.00	0.384	0.365	1.193
587.00	0.423	0.404	1.596
588.00	0.462	0.443	2.039
589.00	0.503	0.483	2.522
590.00	0.546	0.525	3.047
591.00	0.602	0.574	3.621
592.00	0.877	0.739	4.360
593.00	1.067	0.972	5.332

Device	Routing	Invert	Outlet Devices
#1	Primary	592.48'	**24.0" Round Culvert** L= 102.0' CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 586.45' S= 0.0591 '/' Cc= 0.900 n= 0.025 Corrugated metal

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=582.00' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Pond 7P:


Hydrograph
37.56 cfs
0.00 cfs
Inflow Area=2.127 ac
Peak Elev=587.35'
Storage=1.746 af
24.0"
Round Culvert
n=0.025
L=102.0'
S=0.0591 '/'
Inflow
Primary
Flow (cfs)
0
5
10
15
20
25
30
35
40
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)

Summary for Pond 8P:

Inflow Area = 2.330 ac, 0.00% Impervious, Inflow Depth > 9.85" for 1000-YEAR event
Inflow = 39.35 cfs @ 11.91 hrs, Volume= 1.913 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 Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 587.93' @ 24.00 hrs Surf.Area= 0.763 ac Storage= 1.912 af

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

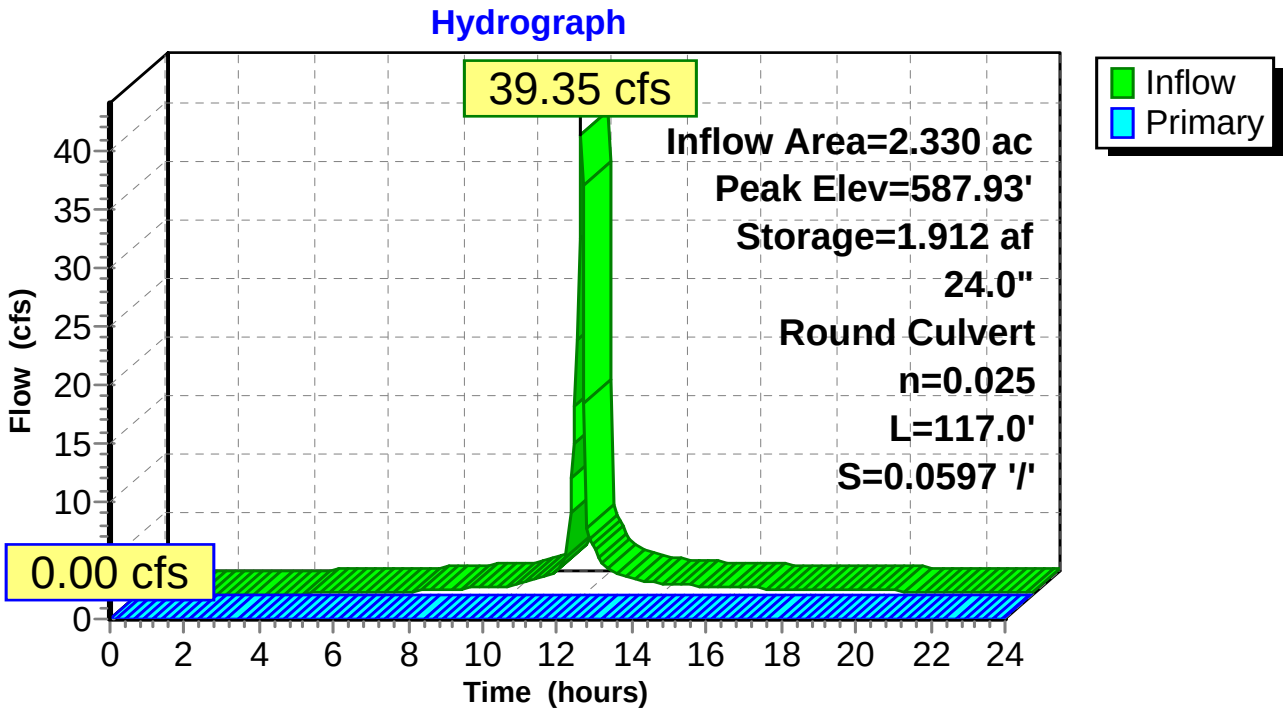
Volume	Invert	Avail.Storage	Storage Description
#1	580.00'	8.422 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
580.00	0.001	0.000	0.000
581.00	0.015	0.008	0.008
582.00	0.041	0.028	0.036
583.00	0.075	0.058	0.094
584.00	0.147	0.111	0.205
585.00	0.247	0.197	0.402
586.00	0.386	0.316	0.719
587.00	0.668	0.527	1.246
588.00	0.770	0.719	1.965
589.00	0.864	0.817	2.782
590.00	0.962	0.913	3.696
591.00	1.066	1.014	4.709
592.00	1.208	1.137	5.846
593.00	1.295	1.251	7.098
594.00	1.354	1.324	8.422

Device	Routing	Invert	Outlet Devices
#1	Primary	592.91'	**24.0" Round Culvert** L= 117.0' CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 585.92' S= 0.0597 '/' Cc= 0.900 n= 0.025 Corrugated metal

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=580.00' (Free Discharge)
↑—**1=Culvert** (Controls 0.00 cfs)

Pond 8P:


Hydrograph
39.35 cfs
0.00 cfs
Inflow Area=2.330 ac
Peak Elev=587.93'
Storage=1.912 af
24.0"
Round Culvert
n=0.025
L=117.0'
S=0.0597 '/'
Inflow
Primary
Flow (cfs)
0
10
15
20
25
30
35
40
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)

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