Inflow Design Flood Control System Plan

J.H. CAMPBELL GENERATING FACILITY

BOTTOM ASH POND 3 INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

West Olive, 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 **1654923**

Golder Associates

CERTIFICATION

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

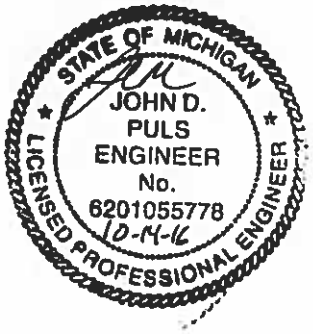
I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.82 (40 CFR Part 257.82), I attest that this Inflow Design Flood Control System Plan is accurate and has been prepared in accordance with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

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1.0 INTRODUCTION

1.1 Background

J.H. Campbell Generating Facility (JH Campbell) is a coal-fired power generation facility located near West Olive, Michigan as presented on Figure 1 – Site Location Map. Bottom ash is sluiced from JH Campbell Unit 3 electrical generating unit to a pair of ponds, classified as Bottom Ash Pond 3. An elevated trestle and pipe system hydraulically conveys bottom ash to the pond system. Stored bottom ash is removed via mechanical equipment from the ponds as required to maintain storage capacity. Water is discharged from the ponds via corrugated high-density polyethylene (HDPE) outflow pipes into an internal ditch that conveys the flow to an internal pond system and ultimately to the site's permitted National Pollutant Discharge Elimination System (NPDES) outfall. Additionally, a perimeter ditch (West Ditch) and associated culverts are located toward the northern and western toe of Bottom Ash Pond 3. This ditch is covered under the site's NPDES permit and flows into the internal pond system and is ultimately discharged through the site's NPDES outfall.

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 Coal Combustion Residuals (CCR) Surface Impoundments]. Bottom Ash Pond 3 has been rated a low hazard potential as determined under 40 CFR 257.73(a)(2). 40 CFR 257.82(a) requires the owner or operator of the low 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 100-year flood event
- Adequately manage the flow from the CCR unit to collect and control the peak discharge resulting from the 100-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 (100-year event) for two cases: 1) floodwater from outside the unit from the West Ditch and the Pigeon River, and 2) controlling internal water levels within the unit.

2.1 External Floodwater Protection

Bottom Ash Pond 3 is surrounded by a perimeter berm that provides external flood water protection. Based on borings completed in 2015, the berm is generally constructed of sand. Berms were constructed in 12-inch loose lifts and were compacted to a minimum 90 percent maximum compaction as documented in Sheet 2 of Drawing number 690-G-3930 (Commonwealth 1978). An access road travels the length of the perimeter berm.

Two potential inflow sources to Bottom Ash Pond 3 were identified and evaluated; the West Ditch and the Pigeon River. The West Ditch parallels Bottom Ash Pond 3 to the north and to the west. Given that the outer bank elevation of the West Ditch is approximately 605.00 feet (NGVD29) and the lowest perimeter berm elevation is 631.75 feet (NGVD29), overbank flow from the West Ditch during a 100-year event would inundate areas to the north and west, away from Bottom Ash Pond 3. Therefore, the West Ditch should not be an inflow source to Bottom Ash Pond 3.

A publicly available 100-year flood elevation for the Pigeon River has been determined by Federal Emergency Management Agency (FEMA). Based on FEMA Firm Map Numbers 26139C0195E and 26139C0190E, both Pigeon Lake and Pigeon River have 100-year flood elevations of 584.8 feet (NGVD29). FEMA elevations were converted from NAVD88 to NGVD29. The lowest elevation along the perimeter berm is 631.75 feet (NGVD29), which allows for 46.95 feet of freeboard during the 100-year flood event. Therefore, the Pigeon River should not be an inflow source to Bottom Ash Pond 3.

2.2 Internal Flood Control

The only inflow other than ash sluice water and low-volume miscellaneous wastewater will be precipitation directly falling on the pond from a 100-year 24-hour storm event of 6.95 inches, as provided in Appendix B - Rainfall Data. There are two discharge structures in the perimeter berm: one 18-inch HDPE pipe from Bottom Ash Pond 3 North and one 18-inch HDPE pipe from Bottom Ash Pond 3 South. Table 2.2.1 below provides a summary of the outflow structures as surveyed in May 2016.

Table 2.2.1 - Discharge Structure Summary

Discharge Structure	Type	Size (Inches)	Length (Feet)	Upstream Invert (NGVD29)	Downstream Invert (NGVD29)	Slope (%)
18-inch	HDPE	18	109.2	625.34	623.56	1.63
18-inch	HDPE	18	119.5	624.66	622.08	2.16

Bottom Ash Pond 3 was modeled as a two-pond network with water levels in each pond equal to that of the outfall pipe upstream invert elevation. Table 2.2.2 below provides a storm flow summary that indicates that Bottom Ash Pond 3 is contained with a minimum 5.32 feet of freeboard (Bottom Ash Pond 3 South), a peak discharge rate of 9.0 cubic feet per second (cfs) during the design storm event (100-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 (100-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 (NGVD29)	Pond Elevation 100-year,24-hour (NGVD29)	Peak Outflow (cfs)
Bottom Ash Pond 3 North	631.75	626.23	3.0
Bottom Ash Pond 3 South	631.75	626.43	6.0

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).”

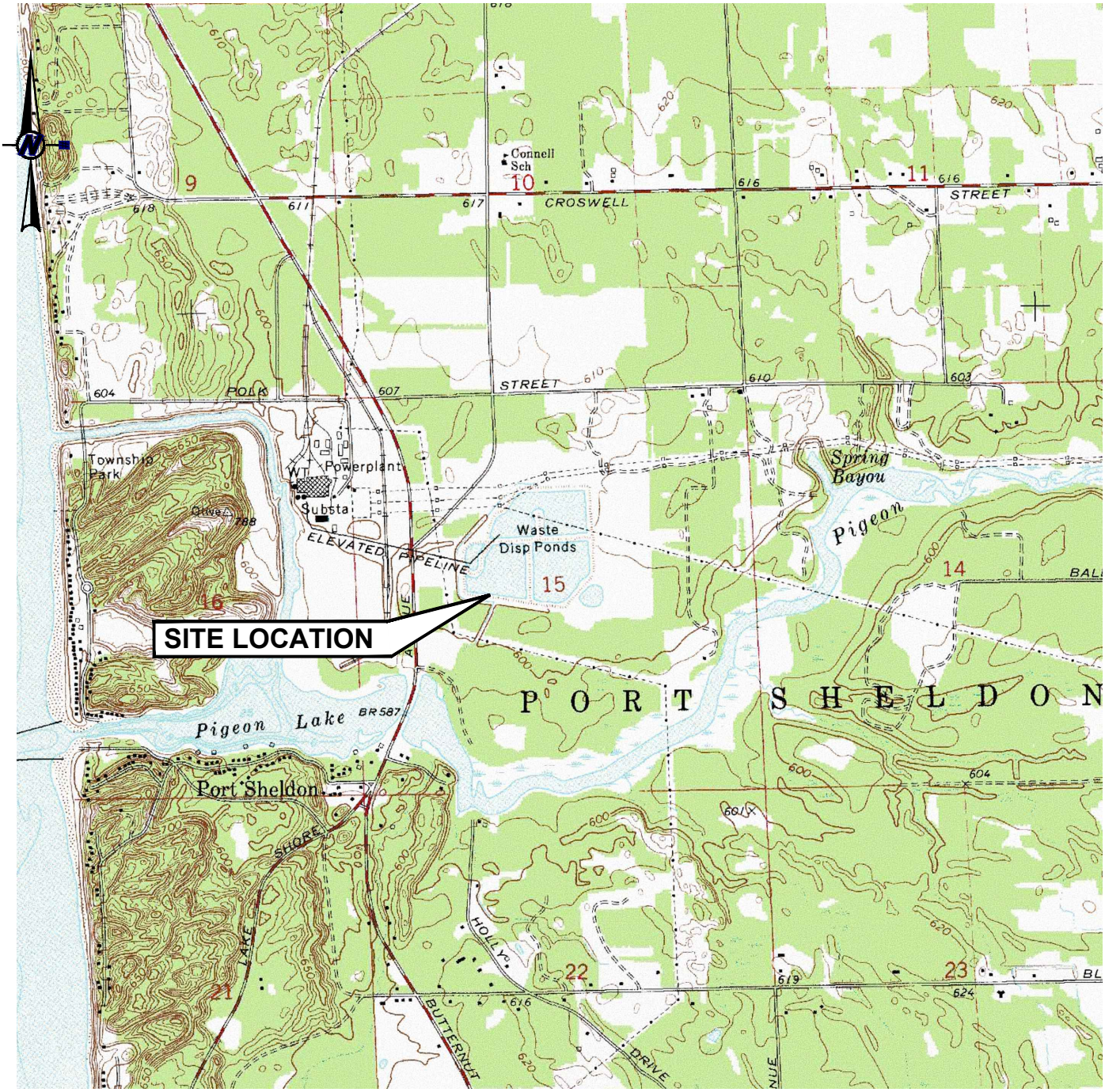
4.0 REFERENCES

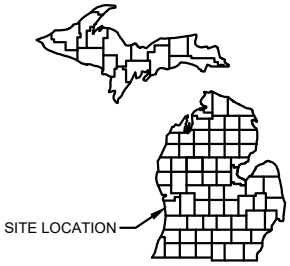
Commonwealth Associates Inc., Ash Pond Plan. Drawing number 690-G-3930. Sheet 2. September 6, 1978.

FEMA (Federal Emergency Management Agency). 2013. Flood Insurance Study, Ottawa County, Michigan. Effective May 16, 2013. Flood Insurance Study Number 26139CV001B.

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

FIGURES





MICHIGAN COUNTIES
NOT TO SCALE

REFERENCE(S)

1. BASE MAP TAKEN FROM 7.5 MINUTE U.S.G.S. QUADRANGLES OF PORT SHELDON MICHIGAN, DOWNLOADED FROM MICHIGAN DNR WEBSITE JUNE 2016.

0 1000 2000
1" = 2000' FEET

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

CLIENT
CONSUMERS ENERGY COMPANY
17000 CROSWELL ST.
WEST OLIVE, MI 49460

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-06
DESIGNED	BAL
PREPARED	ARM
REVIEWED	DJS
APPROVED	MAB

PROJECT
J.H. CAMPBELL GENERATING FACILITY
BOTTOM ASH POND 3 FLOOD CONTROL PLAN

TITLE
SITE LOCATION MAP

PROJECT NO. 1654923
REV. #
FIGURE 1

0 200 400
SCALE: 1"=200'

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	BY	CHK	APP

REV	DATE	DESCRIPTION	BY	CHK	APP
	10/6/2016	FILED IN OWNER'S OPERATING RECORD	AM	DS	JP

Consumers Energy

J.H. CAMPBELL ASH STORAGE FACILITY

EXISTING CONDITIONS
SITE MAP

SCALE	1" = 200'	DRAWING NO.	FIGURE	REV.
JOB	1654923		2	A

UNIT#

S:\Projects\094 - Golder Associates\2016 Projects\094-16-004 - JH Campbell RCRA Ash Pond Closure\CAD\094-16-004-EXIST-HYDRO.dwg 10/7/2016 9:17 AM

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.

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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 Michigan State Plane South zone 6401 (FIPSZONE 2113). The **horizontal datum** was NAD83. Differences in datum, spheroid, projection or state plane 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/.

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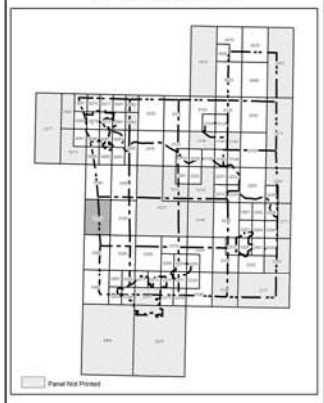
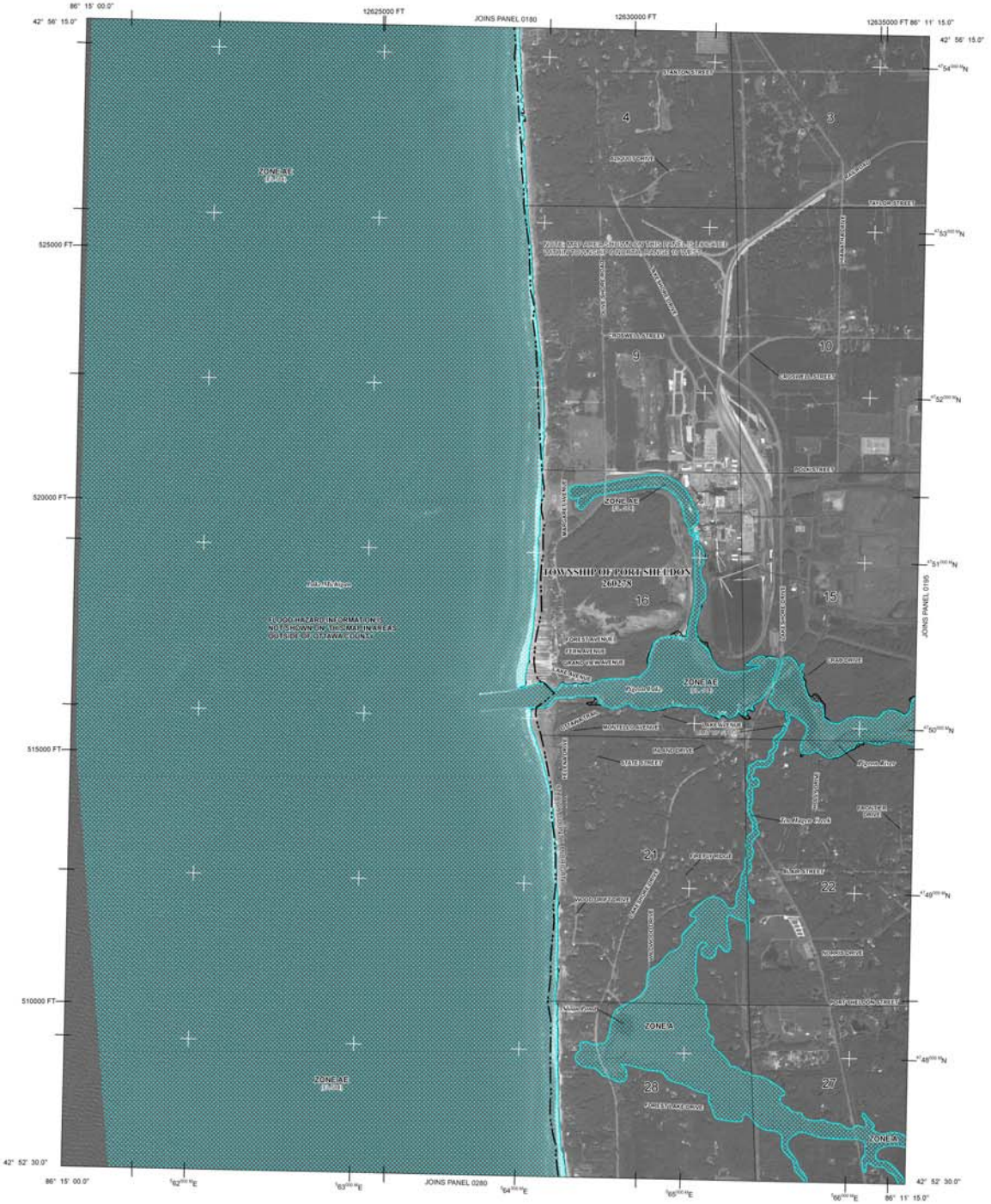
PANEL INDEX





LEGEND

SPECIAL FLOOD HAZARD AREAS 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 may 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** — Area of special flood hazard formerly protected from the 1% annual chance flood event 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 event 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 of 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 Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 10) — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

- Cross section line
- Transect line
- Bridge
- Culvert
- 85° 03' 45.0", 41° 24' 22.5" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
- 4637000 m — 1000-meter Universal Transverse Mercator grid values, zone 16
- 2250000 FT — 5000-foot grid ticks; Michigan State Plane South Coordinate System, 6401 zone (FIPSZONE 2113), Lambert Conformal Conic projection
- KA0015 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
December 16, 2011

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" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

PANEL 0190E

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP
OTTAWA COUNTY, MICHIGAN
(ALL JURISDICTIONS)

PANEL 190 OF 425
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PORT SHELDON, TOWNSHIP OF	260278	0190	E

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
26139C0190E

EFFECTIVE DATE
DECEMBER 16, 2011

Federal Emergency Management Agency

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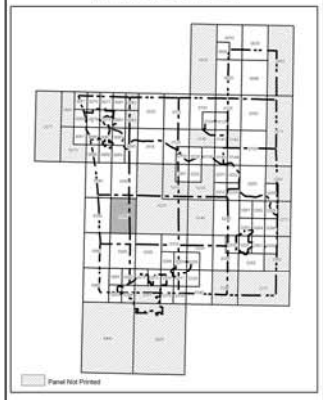

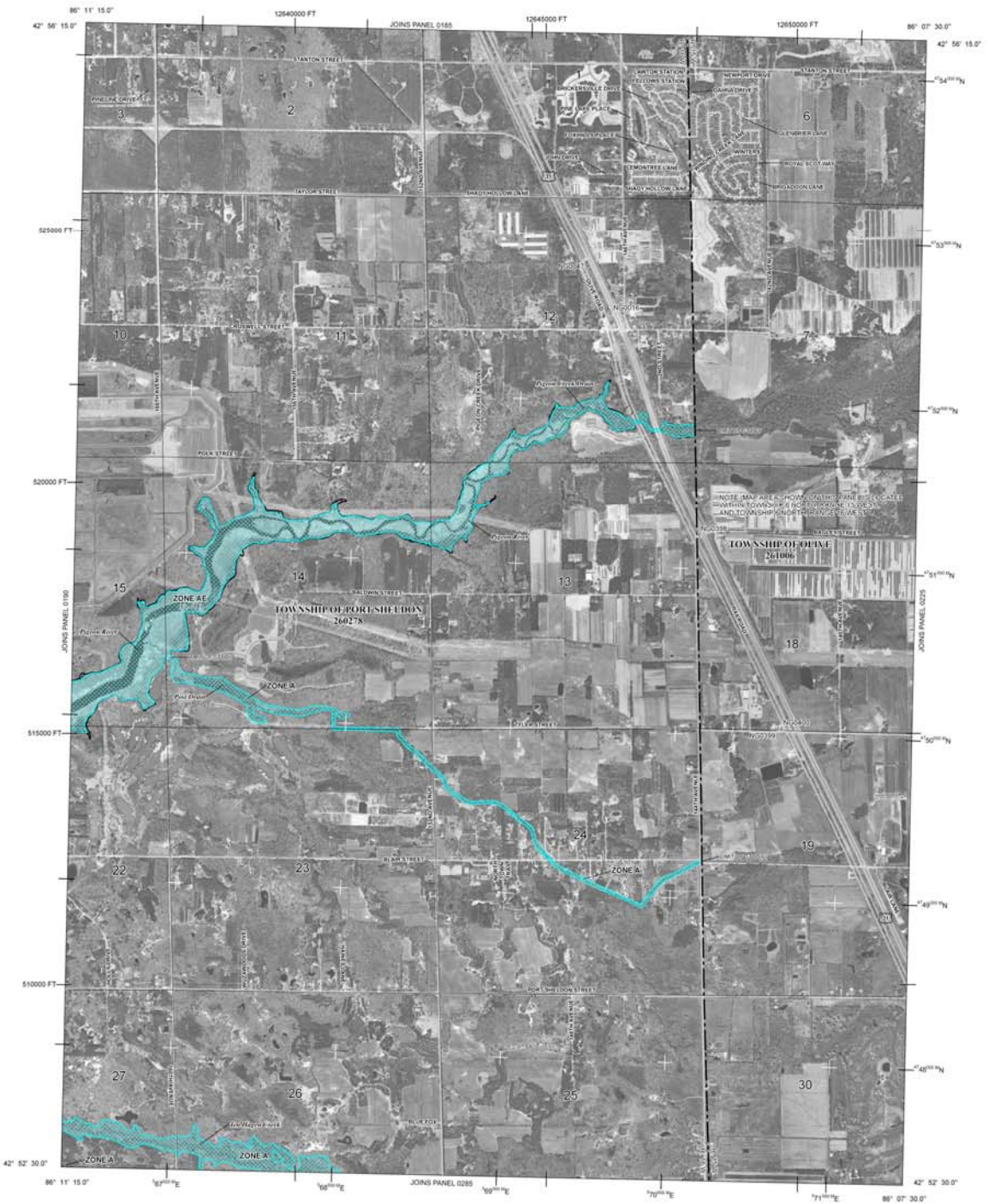

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ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

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(EL 10) Base Flood Elevation value where uniform within zone; elevation in feet*

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Transect line

Bridge

Culvert

85° 03' 45.0", 41° 24' 22.5" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere

4637000 m 1000-meter Universal Transverse Mercator grid values, zone 16

2250000 FT 5000-foot grid ticks; Michigan State Plane South Coordinate System, 6401 zone (FIPSZONE 2113), Lambert Conformal Conic projection

KA0015 Bench mark (see explanation in Notes to Users section of this FIRM panel)

M1.5 River Mile

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
December 16, 2011

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" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0195E

FIRM
FLOOD INSURANCE RATE MAP
OTTAWA COUNTY, MICHIGAN
(ALL JURISDICTIONS)

PANEL 195 OF 425
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
OLIVE, TOWNSHIP OF	260006	0195	E
PORT SHELDON, TOWNSHIP OF	260278	0195	E

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
26139C0195E

EFFECTIVE DATE
DECEMBER 16, 2011

Federal Emergency Management Agency

APPENDIX B
RAINFALL DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: West Olive, Michigan, US*
Latitude: 42.9081°, Longitude: -86.1972°
Elevation: 606 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	**0.307** (0.251–0.382)	**0.362** (0.296–0.451)	**0.459** (0.373–0.572)	**0.544** (0.440–0.682)	**0.671** (0.526–0.877)	**0.776** (0.591–1.03)	**0.886** (0.650–1.20)	**1.01** (0.704–1.39)	**1.17** (0.786–1.66)	**1.30** (0.848–1.87)
10-min	**0.450** (0.368–0.560)	**0.531** (0.433–0.661)	**0.671** (0.546–0.838)	**0.797** (0.644–0.999)	**0.982** (0.771–1.28)	**1.14** (0.866–1.50)	**1.30** (0.952–1.75)	**1.47** (1.03–2.04)	**1.71** (1.15–2.44)	**1.91** (1.24–2.74)
15-min	**0.549** (0.449–0.683)	**0.647** (0.528–0.806)	**0.819** (0.666–1.02)	**0.972** (0.786–1.22)	**1.20** (0.940–1.57)	**1.39** (1.06–1.83)	**1.58** (1.16–2.14)	**1.79** (1.26–2.49)	**2.09** (1.40–2.97)	**2.33** (1.51–3.34)
30-min	**0.768** (0.628–0.955)	**0.907** (0.741–1.13)	**1.15** (0.937–1.44)	**1.37** (1.11–1.72)	**1.69** (1.33–2.21)	**1.96** (1.49–2.59)	**2.24** (1.64–3.03)	**2.54** (1.78–3.52)	**2.96** (1.99–4.22)	**3.30** (2.15–4.74)
60-min	**0.999** (0.817–1.24)	**1.18** (0.962–1.47)	**1.50** (1.22–1.87)	**1.79** (1.44–2.24)	**2.22** (1.75–2.92)	**2.59** (1.98–3.43)	**2.98** (2.19–4.03)	**3.40** (2.39–4.72)	**4.00** (2.69–5.69)	**4.48** (2.91–6.43)
2-hr	**1.23** (1.01–1.52)	**1.45** (1.19–1.79)	**1.84** (1.51–2.28)	**2.20** (1.80–2.74)	**2.75** (2.18–3.58)	**3.21** (2.48–4.23)	**3.71** (2.75–4.99)	**4.26** (3.01–5.87)	**5.03** (3.41–7.11)	**5.66** (3.71–8.05)
3-hr	**1.38** (1.14–1.69)	**1.62** (1.34–1.99)	**2.06** (1.70–2.53)	**2.47** (2.02–3.05)	**3.10** (2.48–4.03)	**3.64** (2.82–4.77)	**4.23** (3.15–5.67)	**4.87** (3.46–6.69)	**5.79** (3.94–8.16)	**6.54** (4.31–9.27)
6-hr	**1.66** (1.38–2.01)	**1.93** (1.61–2.34)	**2.45** (2.03–2.98)	**2.94** (2.43–3.60)	**3.72** (3.01–4.81)	**4.40** (3.44–5.73)	**5.14** (3.87–6.86)	**5.97** (4.29–8.16)	**7.17** (4.93–10.0)	**8.15** (5.41–11.5)
12-hr	**1.95** (1.64–2.34)	**2.26** (1.90–2.71)	**2.85** (2.39–3.44)	**3.44** (2.86–4.16)	**4.36** (3.56–5.61)	**5.18** (4.09–6.70)	**6.08** (4.62–8.05)	**7.09** (5.14–9.63)	**8.56** (5.94–11.9)	**9.78** (6.54–13.6)
24-hr	**2.26** (1.91–2.68)	**2.60** (2.20–3.09)	**3.26** (2.75–3.89)	**3.92** (3.28–4.70)	**4.97** (4.09–6.34)	**5.91** (4.71–7.58)	**6.95** (5.32–9.12)	**8.11** (5.93–10.9)	**9.82** (6.87–13.6)	**11.2** (7.58–15.5)
2-day	**2.60** (2.23–3.07)	**2.96** (2.53–3.49)	**3.67** (3.13–4.34)	**4.38** (3.70–5.20)	**5.51** (4.58–6.96)	**6.53** (5.24–8.29)	**7.65** (5.91–9.96)	**8.91** (6.57–11.9)	**10.8** (7.60–14.7)	**12.3** (8.37–16.9)
3-day	**2.86** (2.45–3.34)	**3.23** (2.77–3.78)	**3.96** (3.38–4.65)	**4.68** (3.97–5.52)	**5.83** (4.86–7.31)	**6.86** (5.54–8.66)	**8.01** (6.21–10.4)	**9.29** (6.88–12.3)	**11.2** (7.91–15.2)	**12.7** (8.69–17.4)
4-day	**3.06** (2.64–3.57)	**3.45** (2.97–4.02)	**4.20** (3.60–4.91)	**4.93** (4.20–5.79)	**6.09** (5.09–7.59)	**7.13** (5.77–8.95)	**8.27** (6.43–10.6)	**9.54** (7.09–12.6)	**11.4** (8.11–15.5)	**13.0** (8.88–17.6)
7-day	**3.58** (3.10–4.13)	**4.01** (3.48–4.64)	**4.82** (4.16–5.59)	**5.59** (4.79–6.51)	**6.78** (5.68–8.31)	**7.80** (6.34–9.68)	**8.93** (6.98–11.3)	**10.2** (7.58–13.3)	**11.9** (8.54–16.0)	**13.4** (9.25–18.1)
10-day	**4.05** (3.53–4.65)	**4.53** (3.94–5.21)	**5.40** (4.68–6.23)	**6.20** (5.34–7.18)	**7.41** (6.21–9.00)	**8.44** (6.87–10.4)	**9.54** (7.48–12.0)	**10.7** (8.04–13.9)	**12.4** (8.92–16.6)	**13.8** (9.59–18.6)
20-day	**5.50** (4.83–6.25)	**6.11** (5.36–6.95)	**7.15** (6.25–8.16)	**8.05** (6.99–9.23)	**9.34** (7.85–11.1)	**10.4** (8.50–12.5)	**11.5** (9.04–14.2)	**12.6** (9.49–16.1)	**14.2** (10.2–18.6)	**15.4** (10.8–20.6)
30-day	**6.76** (5.97–7.64)	**7.49** (6.61–8.47)	**8.69** (7.64–9.86)	**9.69** (8.47–11.1)	**11.1** (9.34–13.0)	**12.2** (10.0–14.6)	**13.3** (10.5–16.3)	**14.4** (10.9–18.2)	**15.9** (11.5–20.7)	**17.0** (12.0–22.6)
45-day	**8.39** (7.45–9.43)	**9.29** (8.23–10.4)	**10.7** (9.47–12.1)	**11.9** (10.4–13.5)	**13.4** (11.3–15.6)	**14.6** (12.0–17.3)	**15.7** (12.5–19.1)	**16.8** (12.7–21.1)	**18.3** (13.2–23.6)	**19.3** (13.6–25.5)
60-day	**9.80** (8.73–11.0)	**10.9** (9.66–12.2)	**12.5** (11.1–14.0)	**13.8** (12.2–15.6)	**15.5** (13.1–17.9)	**16.8** (13.8–19.7)	**17.9** (14.3–21.7)	**19.1** (14.5–23.8)	**20.4** (14.9–26.3)	**21.4** (15.2–28.2)

[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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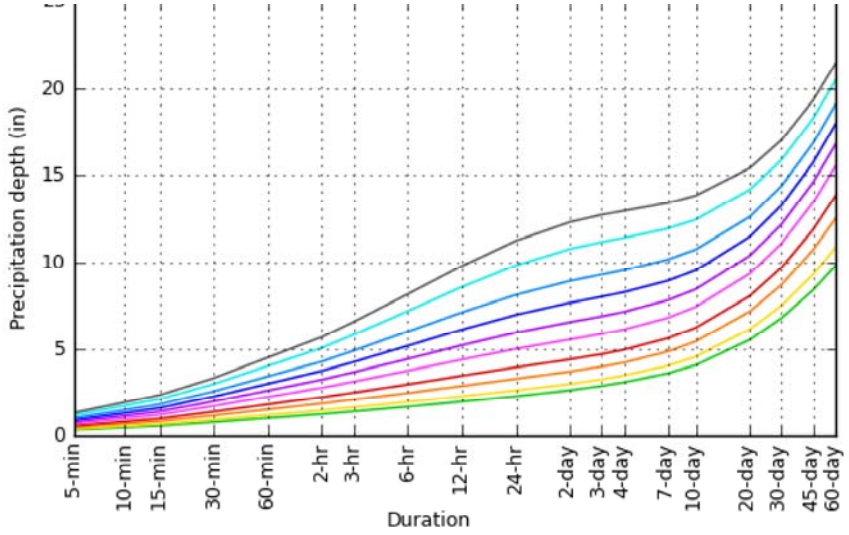
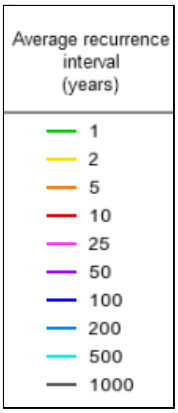
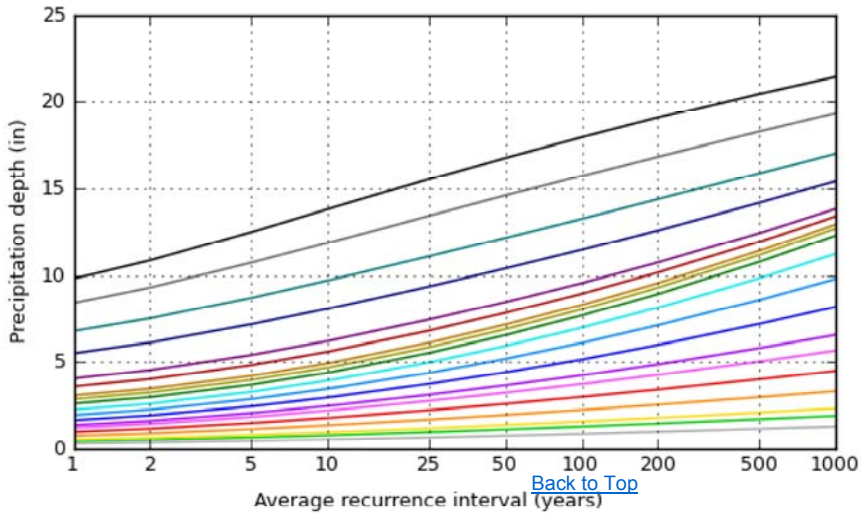
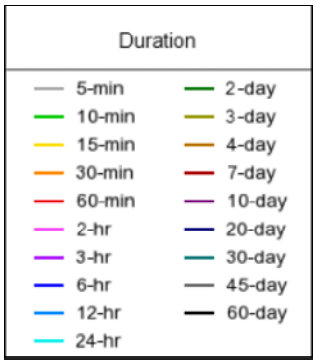
PF graphical









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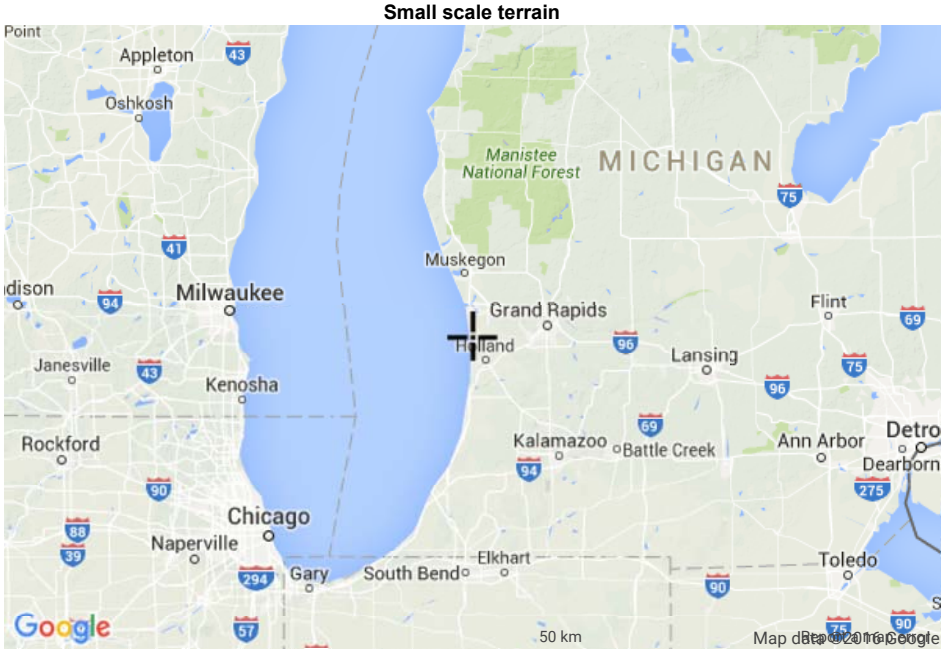
Maps & aerials

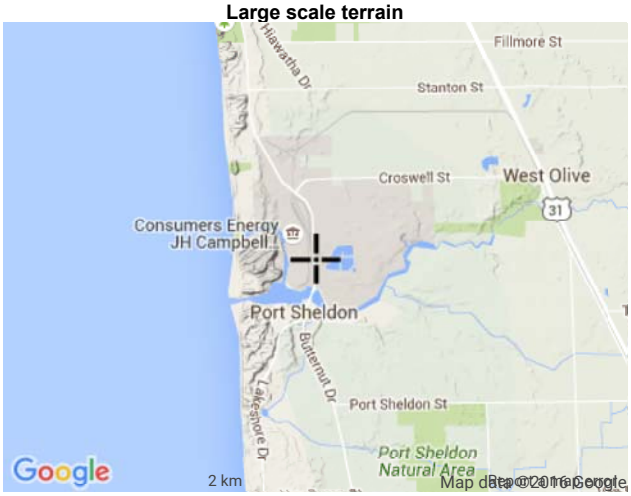
NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Mon Jul 18 19:24:26 2016

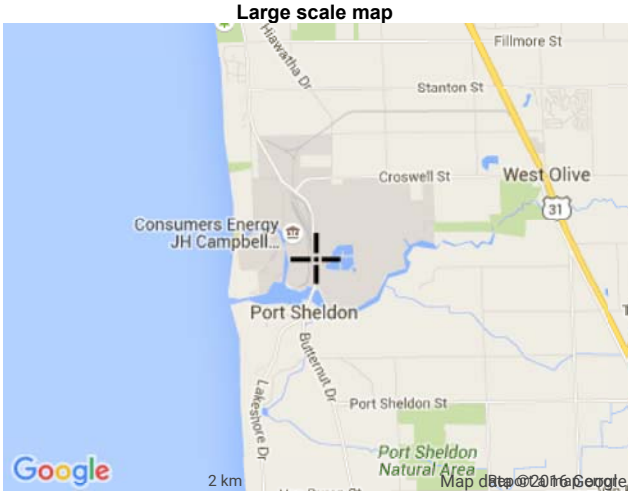
Small scale terrain



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

Disclaimer

APPENDIX C
HYDROLOGIC AND HYDRAULIC MODEL OUTPUT

Project Description

File Name	Campbell Units 1-3.SPF

Project Options

Flow Units	CFS
Elevation Type	Depth
Hydrology Method	EPA SWMM
EPA SWMM Infiltration Method	Horton
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Jun 01, 2016	00:00:00
End Analysis On	Jun 04, 2016	00:00:00
Start Reporting On	Jun 01, 2016	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	9
Nodes	21
Junctions	12
Outfalls	3
Flow Diversions	0
Inlets	0
Storage Nodes	6
Links	20
Channels	4
Pipes	14
Pumps	0
Orifices	1
Weirs	1
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	Rain Gage-01	Time Series	TS-100	Cumulative	inches				6.95	

Subbasin Summary

SN	Subbasin ID	Area	Impervious Area	Average Slope	Equivalent Width	Impervious Area Manning's Roughness	Pervious Area Manning's Roughness	Total Rainfall	Total Infiltration	Total Runoff	Total Runoff Volume	Peak Runoff	Time of Concentration
		(ac)	(%)	(%)	(ft)			(in)	(in)	(in)	(ac-in)	(cfs)	(days hh:mm:ss)
1	Sub-100	8.85	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.5620	3.38	29.94	37.34	0 01:26:19
2	Sub-101	3.60	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.4250	3.52	12.68	20.85	0 00:50:19
3	Sub-102	1.70	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.3660	3.59	6.10	12.47	0 00:32:04
4	Sub-103	14.00	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.6670	3.28	45.85	49.78	0 01:53:39
5	Sub-Pond1-2N	2.78	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.4000	3.55	9.86	17.61	0 00:43:04
6	Sub-Pond1-2S	2.09	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.3780	3.57	7.46	14.47	0 00:36:16
7	Sub-Pond3N	5.02	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.4660	3.48	17.47	25.78	0 01:01:25
8	Sub-Pond3S	4.52	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.4520	3.50	15.79	24.06	0 00:57:39
9	Sub-PondA	11.13	25.00	0.5000	500.00	0.0150	0.1000	6.95	3.6110	3.33	37.09	43.11	0 01:39:03

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft²)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Jun-10	Junction	619.90	631.46	0.00	0.00	0.00	7.80	623.50	0.00	7.96	0 00:00	0.00	0.00
2	Jun-101	Junction	616.82	625.00	0.00	0.00	0.00	36.29	618.36	0.00	6.64	0 00:00	0.00	0.00
3	Jun-103	Junction	618.16	632.32	0.00	0.00	0.00	48.85	623.10	0.00	9.22	0 00:00	0.00	0.00
4	Jun-104	Junction	623.00	631.60	0.00	0.00	0.00	49.60	624.93	0.00	6.67	0 00:00	0.00	0.00
5	Jun-105	Junction	628.00	633.20	0.00	0.00	0.00	49.78	630.24	0.00	2.96	0 00:00	0.00	0.00
6	Jun-11	Junction	619.06	632.11	0.00	0.00	0.00	7.80	621.62	0.00	10.49	0 00:00	0.00	0.00
7	Jun-12	Junction	608.50	610.50	0.00	0.00	0.00	13.64	609.27	0.00	1.23	0 00:00	0.00	0.00
8	Jun-12N-Out	Junction	618.36	631.07	0.00	6.00	0.00	28.16	619.94	0.00	11.13	0 00:00	0.00	0.00
9	Jun-12S-Out	Junction	617.72	624.87	0.00	0.00	0.00	12.64	618.68	0.00	6.19	0 00:00	0.00	0.00
10	Jun-13	Junction	613.50	619.50	0.00	0.00	0.00	13.92	616.27	0.00	3.23	0 00:00	0.00	0.00
11	Jun-3N-Out	Junction	623.46	631.99	0.00	6.00	0.00	3.02	626.16	0.00	5.83	0 00:00	0.00	0.00
12	Jun-3S-Out	Junction	622.10	633.70	0.00	6.00	0.00	7.80	625.84	0.00	7.86	0 00:00	0.00	0.00
13	Out-01	Outfall	589.75					25.18	590.68					
14	Out-02	Outfall	602.00					0.00	602.00					
15	Out-04	Outfall	596.80					13.64	597.51					
16	Stor-100	Storage Node	625.00	632.00	625.93		0.00	37.34	626.60				0.00	0.00
17	Stor-Pond1-2N	Storage Node	604.00	626.00	619.08		0.00	26.43	619.86				0.00	0.00
18	Stor-Pond1-2S	Storage Node	600.00	626.00	618.78		0.00	14.47	619.10				0.00	0.00
19	Stor-Pond3N	Storage Node	604.00	632.00	625.34		0.00	31.68	626.23				0.00	0.00
20	Stor-Pond3S	Storage Node	604.00	632.00	624.66		0.00	30.08	626.43				0.00	0.00
21	Stor-PondA	Storage Node	600.00	626.00	615.50		0.00	96.32	617.04				0.00	0.00

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Outlet Invert Elevation	Average Slope	Diameter or Height	Manning's Roughness	Peak Flow	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio
					(ft)	(ft)	(ft)	(%)	(ft)		(cfs)	(cfs)		(ft/sec)	(ft)	
1	Link-17	Pipe	Jun-10	Jun-11	285.40	619.90	619.16	0.2600	1.500	0.0130	7.80	5.35	1.46	4.41	1.50	1.00
2	Link-18	Pipe	Jun-11	Jun-12N-Out	192.01	619.06	619.03	0.0200	1.500	0.0130	7.80	1.31	5.94	4.82	1.29	0.86
3	Pipe-001	Pipe	Jun-3N-Out	Jun-3S-Out	658.20	623.46	622.08	0.2100	1.500	0.0130	3.02	4.77	0.63	1.76	1.50	1.00
4	Pipe-002	Pipe	Jun-3S-Out	Jun-10	341.45	622.10	620.00	0.6200	1.500	0.0130	7.80	8.24	0.95	4.41	1.50	1.00
5	Pipe-Outfall01	Pipe	Jun-101	Out-01	173.41	617.37	589.75	15.9300	2.500	0.0250	25.18	85.12	0.30	14.48	0.95	0.38
6	Pipe-Pond12N-Outlet	Pipe	Stor-Pond1-2N	Jun-12N-Out	78.49	619.08	618.36	0.9200	2.000	0.0250	3.43	11.27	0.30	2.40	1.13	0.57
7	Pipe-Pond12S-Outlet	Pipe	Stor-Pond1-2S	Jun-12S-Out	59.89	618.78	617.72	1.7700	2.000	0.0250	0.86	15.65	0.05	2.88	0.58	0.29
8	Pipe-Pond3N-Outlet	Pipe	Stor-Pond3N	Jun-3N-Out	109.20	625.34	623.56	1.6300	1.500	0.0130	3.02	13.41	0.23	3.81	1.20	0.80
9	Pipe-Pond3S-Outlet	Pipe	Stor-Pond3S	Jun-3S-Out	119.51	624.66	622.08	2.1600	1.500	0.0130	5.98	15.37	0.39	4.84	1.50	1.00
10	Pipe-PondA-In1	Pipe	Stor-100	Stor-PondA	99.23	625.93	614.05	11.9700	2.500	0.0250	11.58	73.80	0.16	3.53	1.58	0.63
11	Pipe-PondA-In2	Pipe	Jun-103	Stor-PondA	100.72	618.16	615.82	2.3200	2.000	0.0130	35.11	34.48	1.02	11.49	1.96	1.00
12	Pipe-PondA-In3	Pipe	Jun-101	Stor-PondA	640.00	616.82	615.14	0.2600	2.000	0.0130	9.27	11.59	0.80	4.01	1.43	0.72
13	Pipe-Pond-A-Oulet1	Pipe	Jun-13	Jun-12	345.00	613.50	608.50	1.4500	2.000	0.0250	13.64	14.16	0.96	6.35	1.38	0.69
14	Pipe-Pond-A-Outlet2	Pipe	Jun-12	Out-04	65.00	608.50	596.80	18.0000	2.000	0.0250	13.64	49.91	0.27	12.85	0.74	0.37
15	Ditch-001	Channel	Jun-12N-Out	Jun-101	1154.00	618.36	616.82	0.1300	7.000	0.0350	24.97	462.65	0.05	1.73	1.53	0.22
16	Ditch-002	Channel	Jun-12S-Out	Jun-101	558.30	617.72	616.82	0.1600	7.000	0.0350	11.60	508.49	0.02	1.11	1.22	0.18
17	Ditch-003	Channel	Jun-105	Jun-104	753.20	628.00	623.00	0.6600	5.000	0.0350	49.60	378.54	0.13	3.97	2.06	0.41
18	Ditch-004	Channel	Jun-104	Jun-103	504.30	623.00	618.16	0.9600	5.000	0.0350	48.85	455.15	0.11	3.45	3.28	0.66
19	Orifice-01	Orifice	Stor-PondA	Jun-13		600.00	613.50		2.000		13.92					
20	Weir-Pond1-2S	Weir	Out-02	Stor-Pond1-2N		602.00	604.00				0.00					

Subbasin Hydrology

Subbasin : Sub-100

Input Data

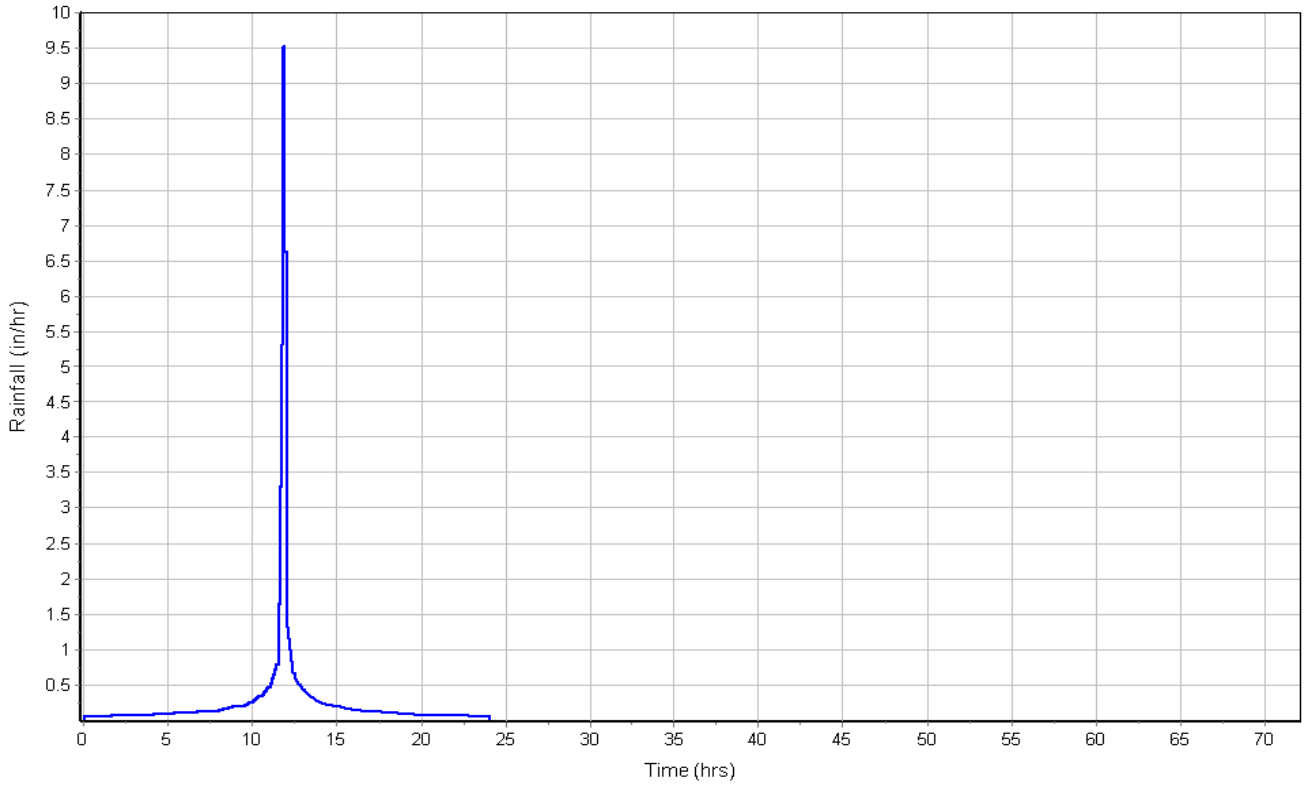
Area (ac)	8.85
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

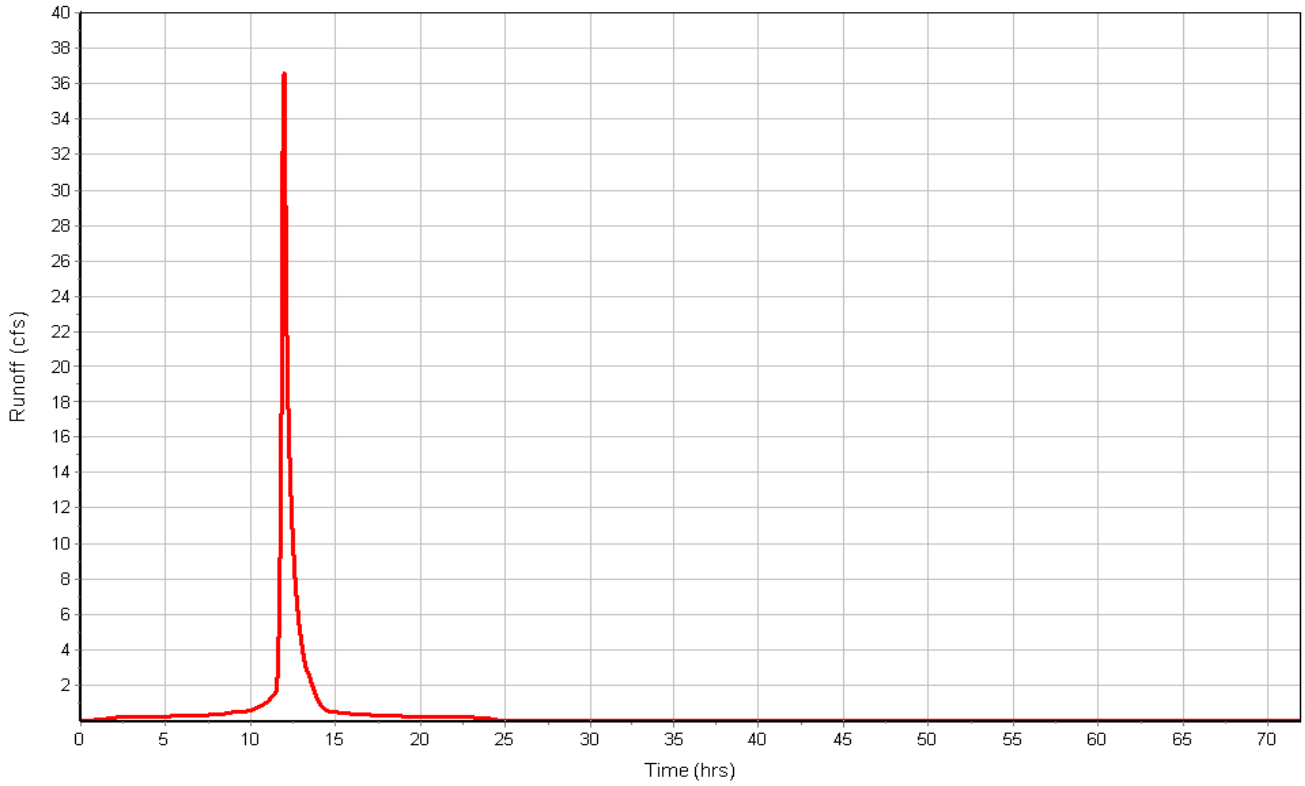
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.5620
Total Runoff (in)	3.38
Peak Runoff (cfs)	37.34
Time of Concentration (days hh:mm:ss)	0 01:26:19

Subbasin : Sub-100

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-101

Input Data

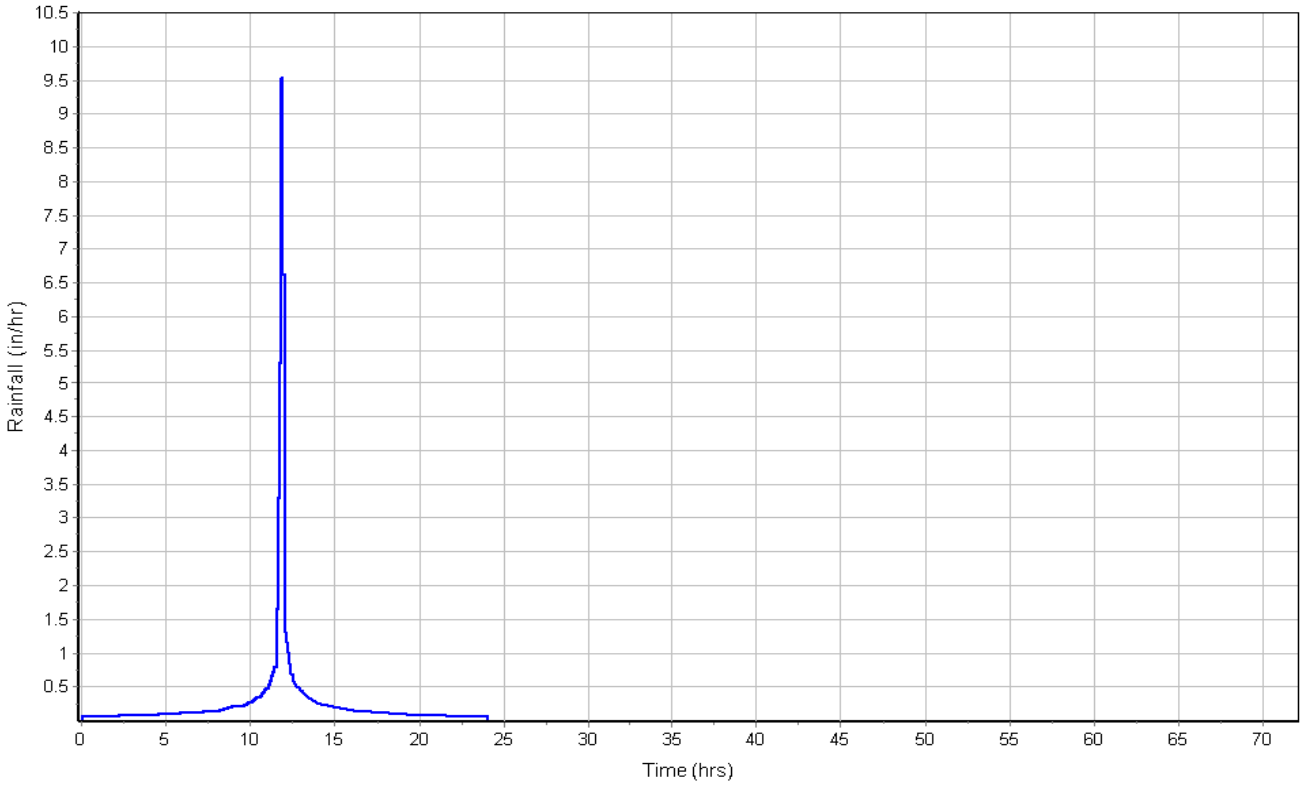
Area (ac)	3.60
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

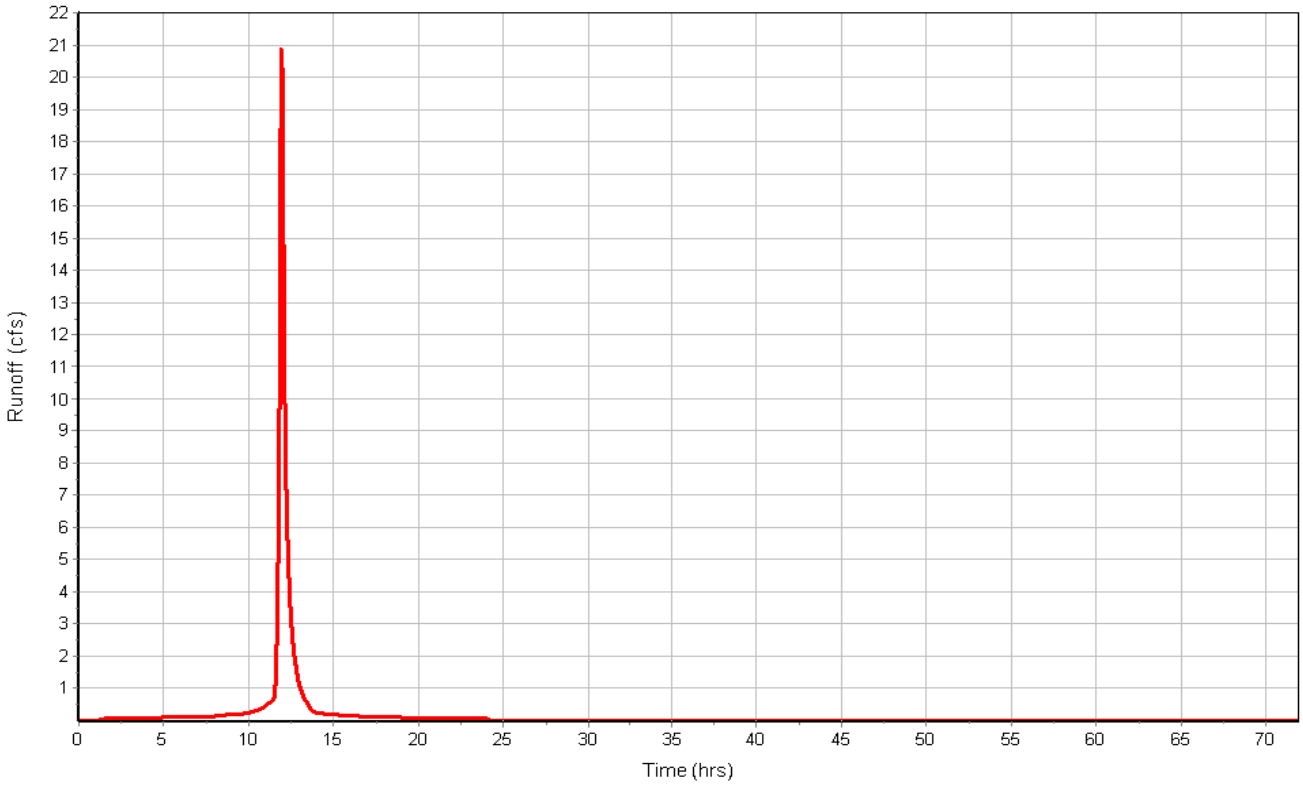
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.4250
Total Runoff (in)	3.52
Peak Runoff (cfs)	20.85
Time of Concentration (days hh:mm:ss)	0 00:50:19

Subbasin : Sub-101

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-102

Input Data

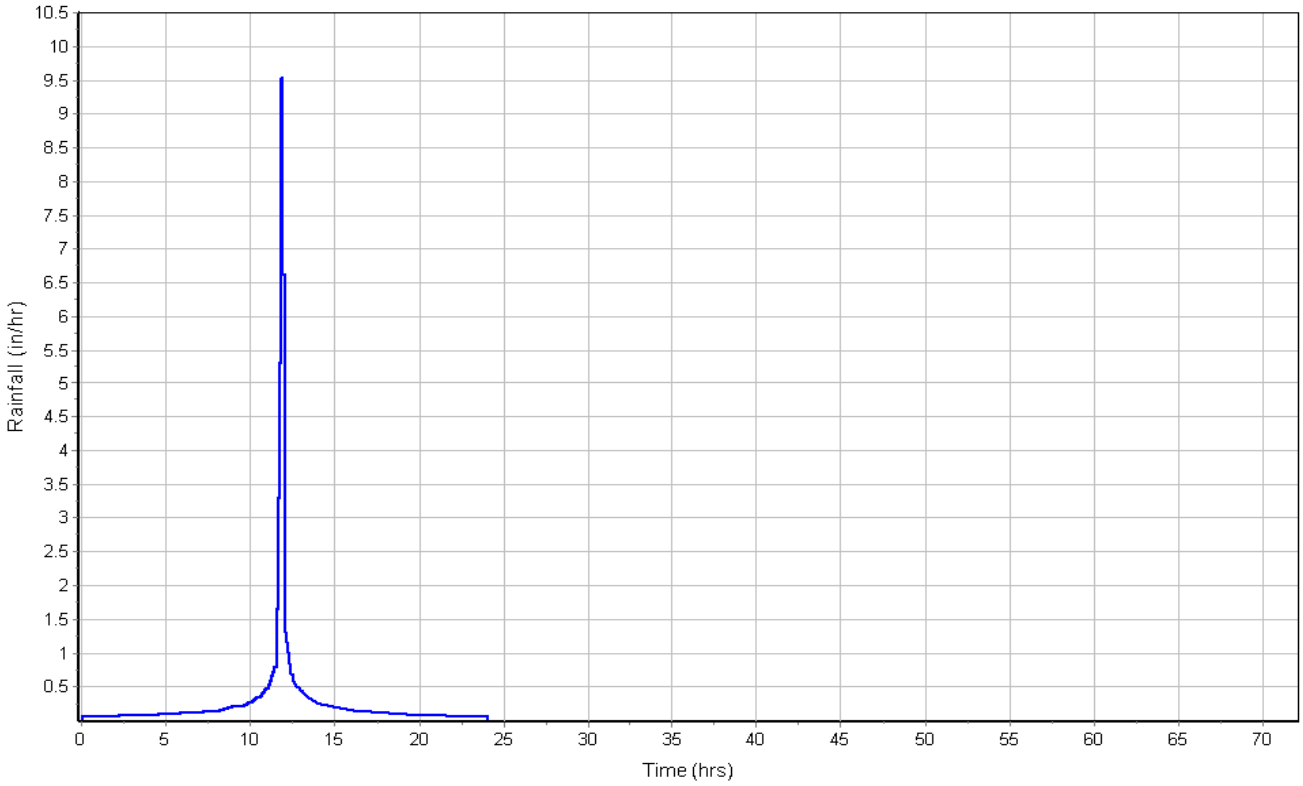
Area (ac)	1.70
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

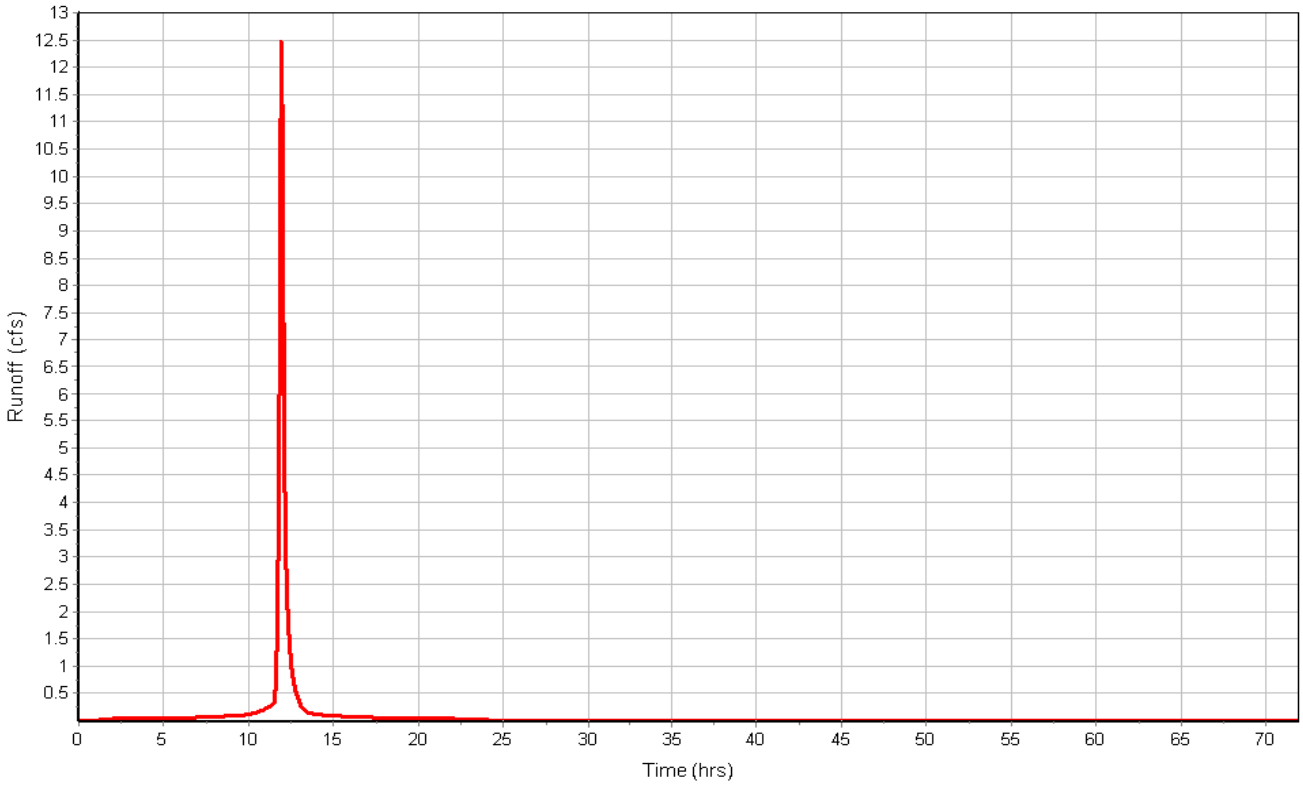
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.3660
Total Runoff (in)	3.59
Peak Runoff (cfs)	12.47
Time of Concentration (days hh:mm:ss)	0 00:32:04

Subbasin : Sub-102

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-103

Input Data

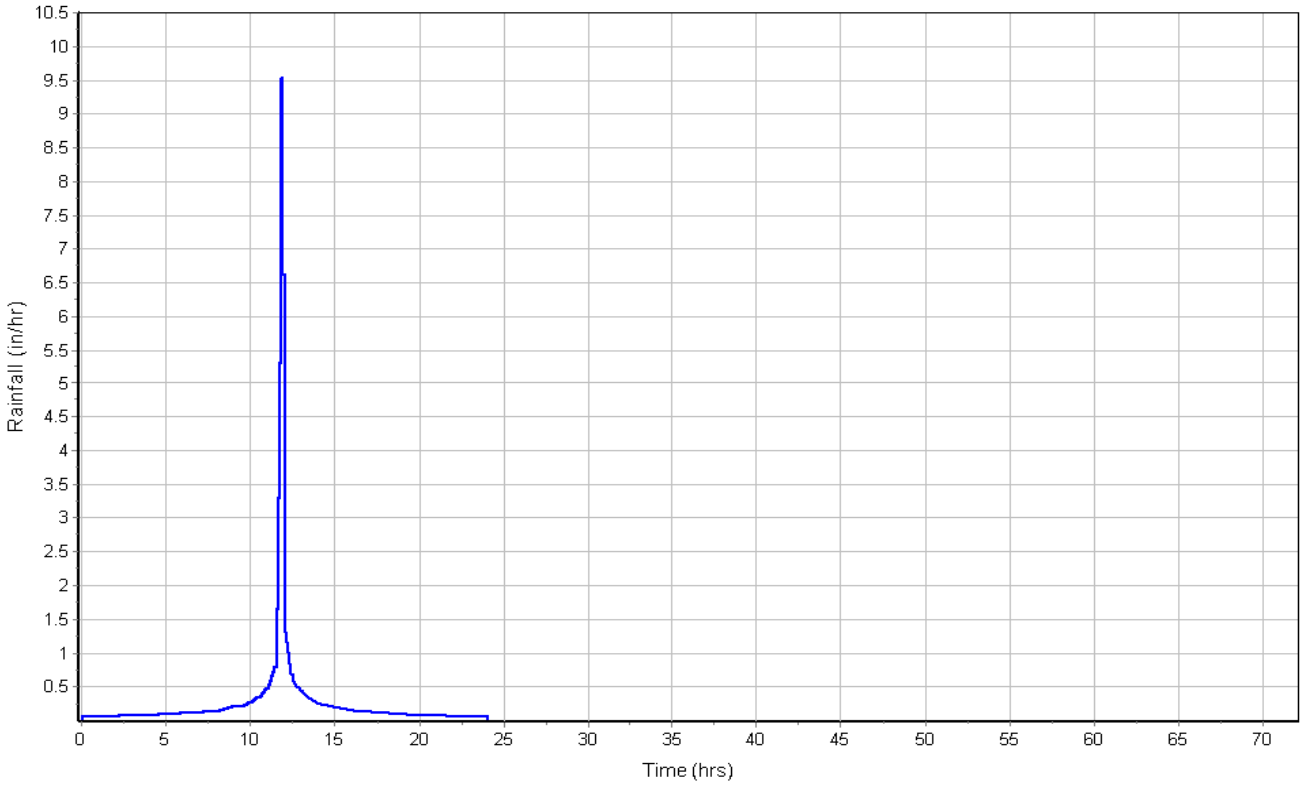
Area (ac)	14.00
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

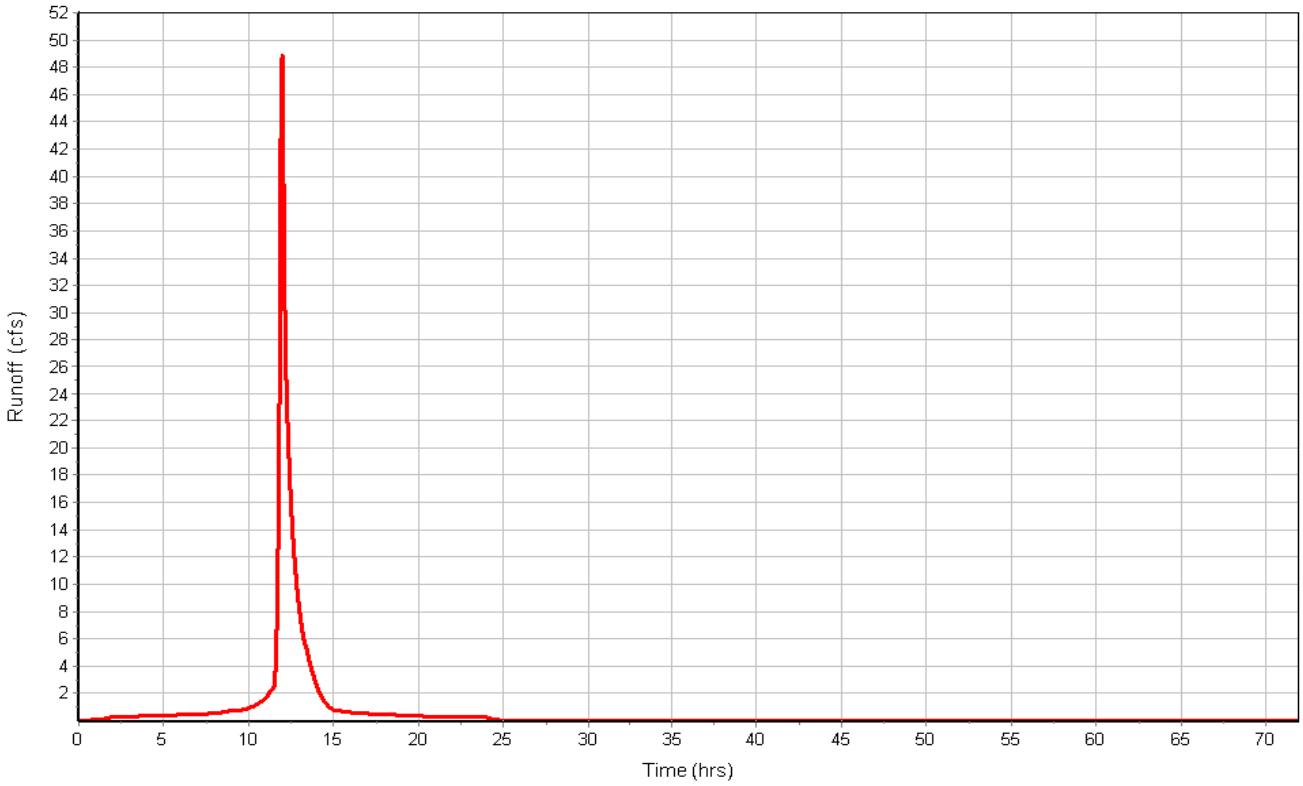
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.6670
Total Runoff (in)	3.28
Peak Runoff (cfs)	49.78
Time of Concentration (days hh:mm:ss)	0 01:53:39

Subbasin : Sub-103

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-Pond1-2N

Input Data

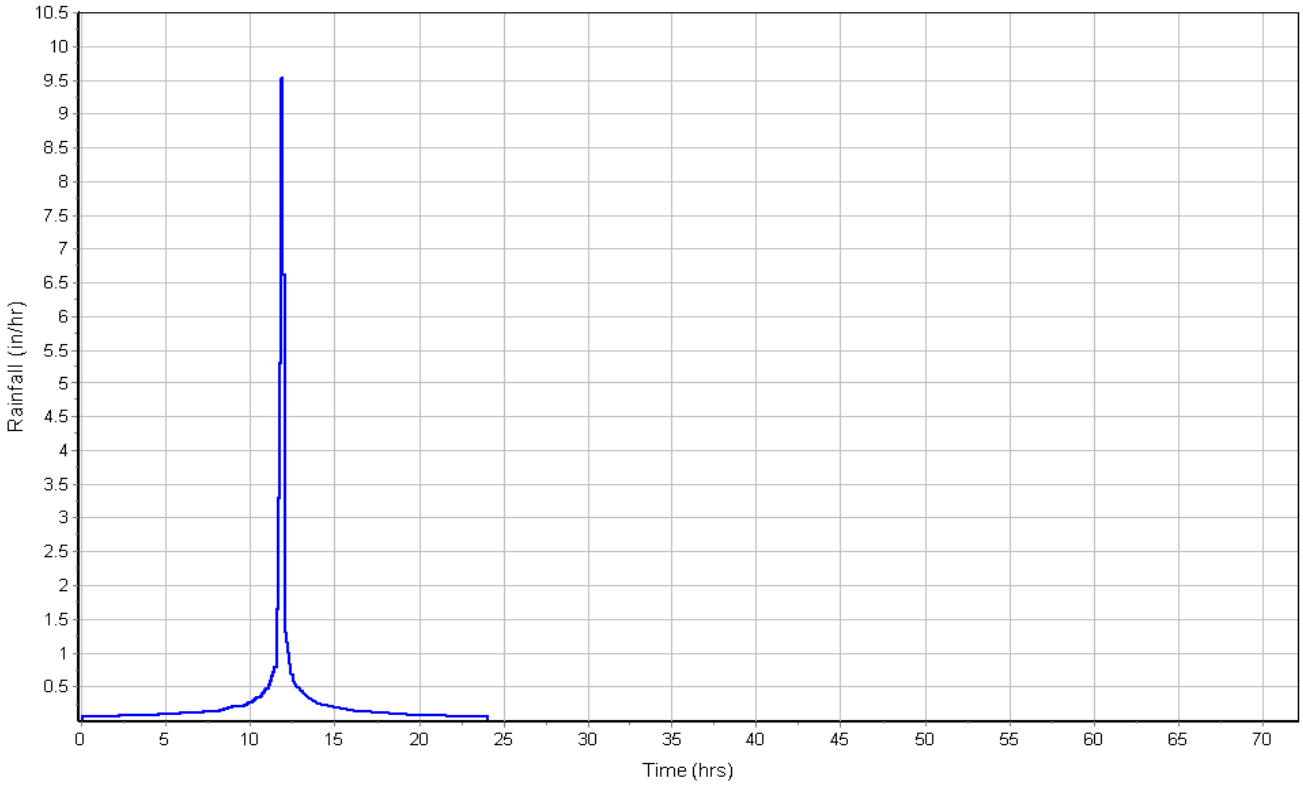
Area (ac)	2.78
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

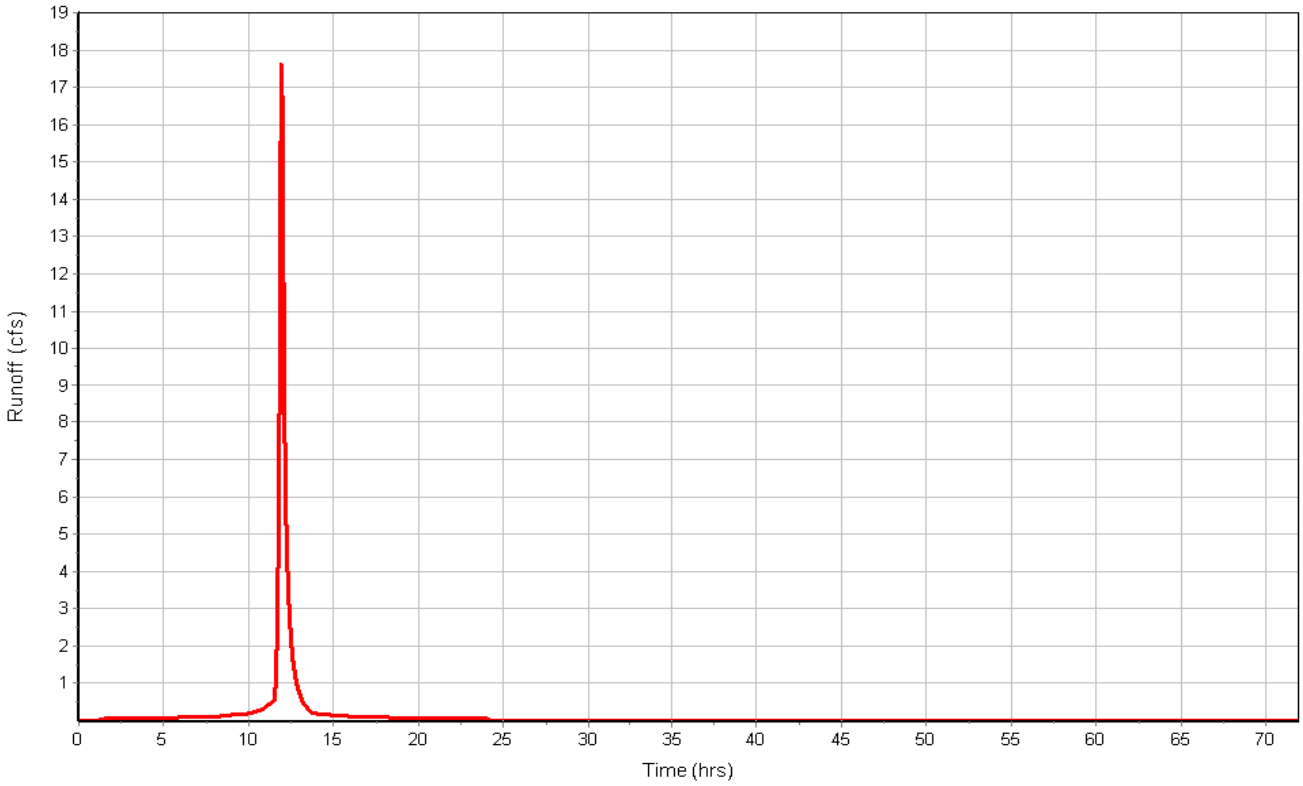
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.4000
Total Runoff (in)	3.55
Peak Runoff (cfs)	17.61
Time of Concentration (days hh:mm:ss)	0 00:43:04

Subbasin : Sub-Pond1-2N

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-Pond1-2S

Input Data

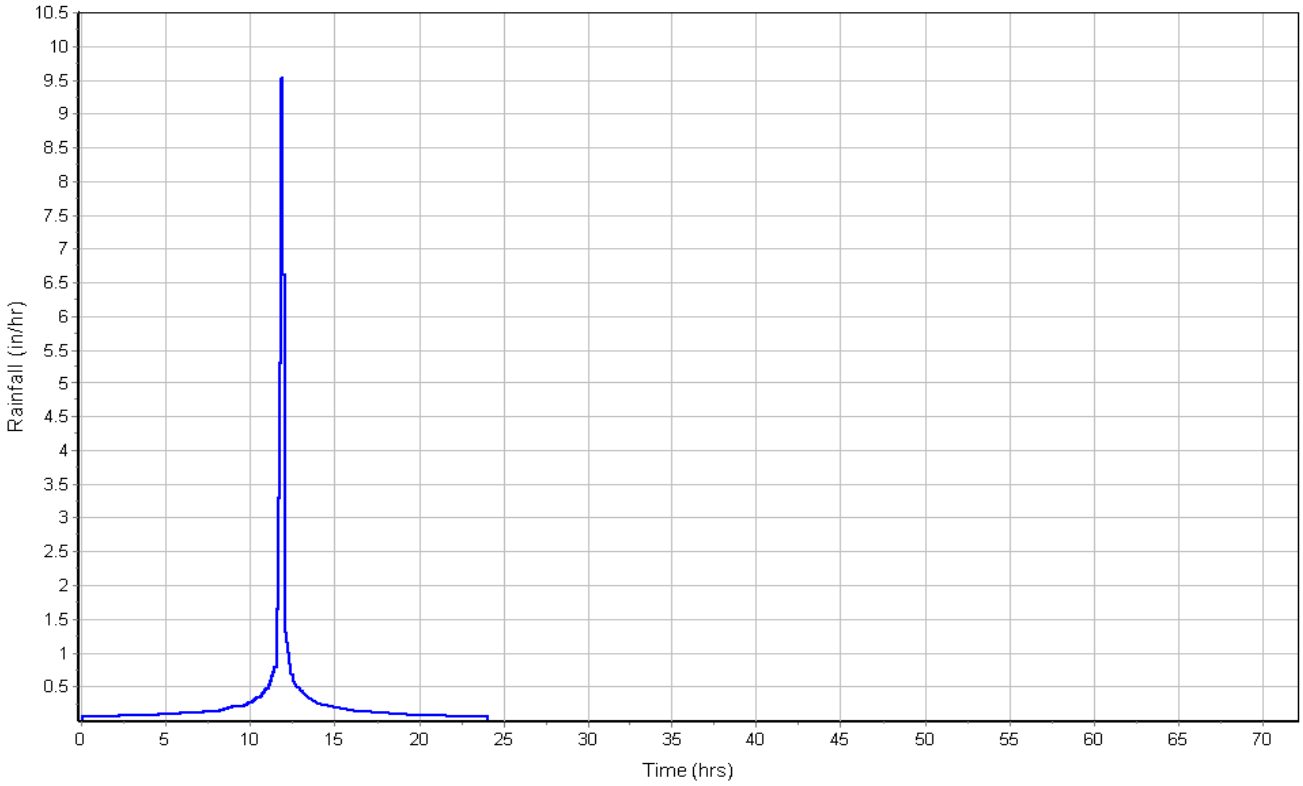
Area (ac)	2.09
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

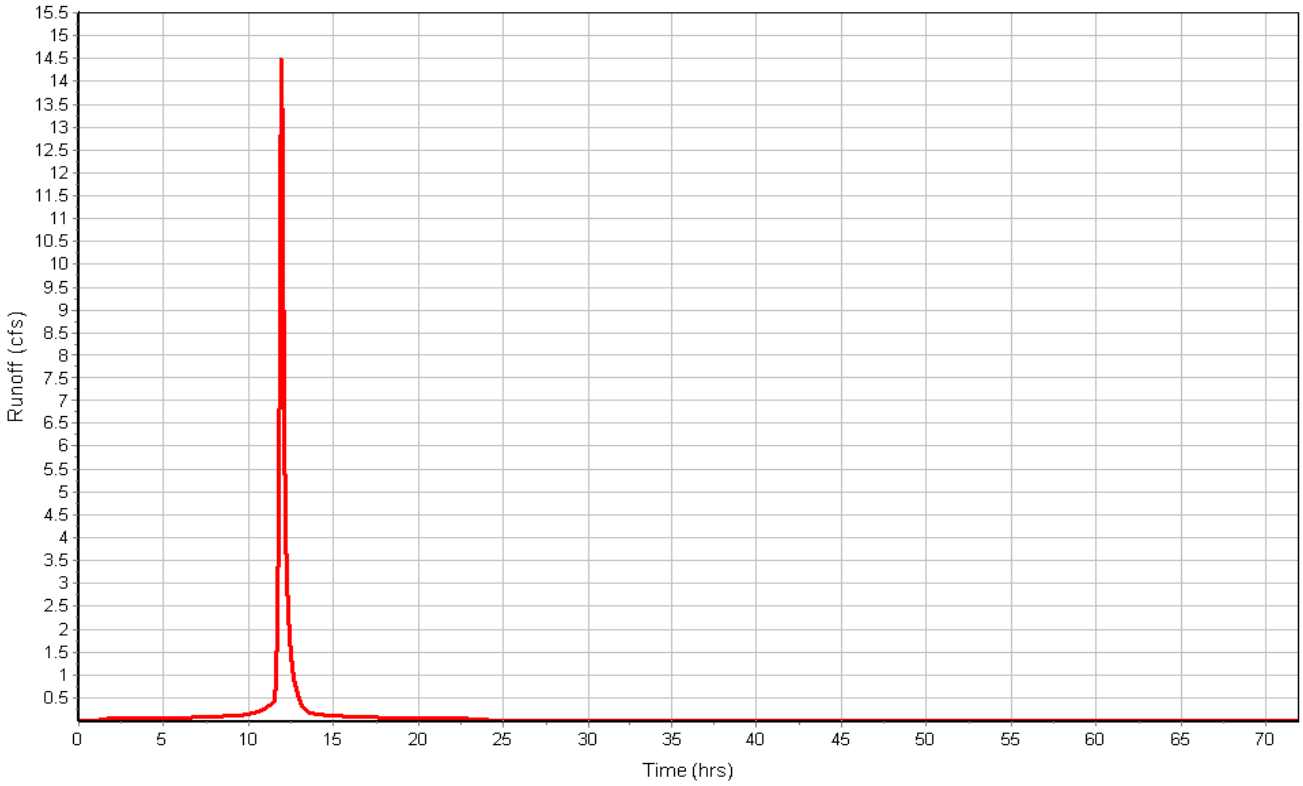
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.3780
Total Runoff (in)	3.57
Peak Runoff (cfs)	14.47
Time of Concentration (days hh:mm:ss)	0 00:36:16

Subbasin : Sub-Pond1-2S

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-Pond3N

Input Data

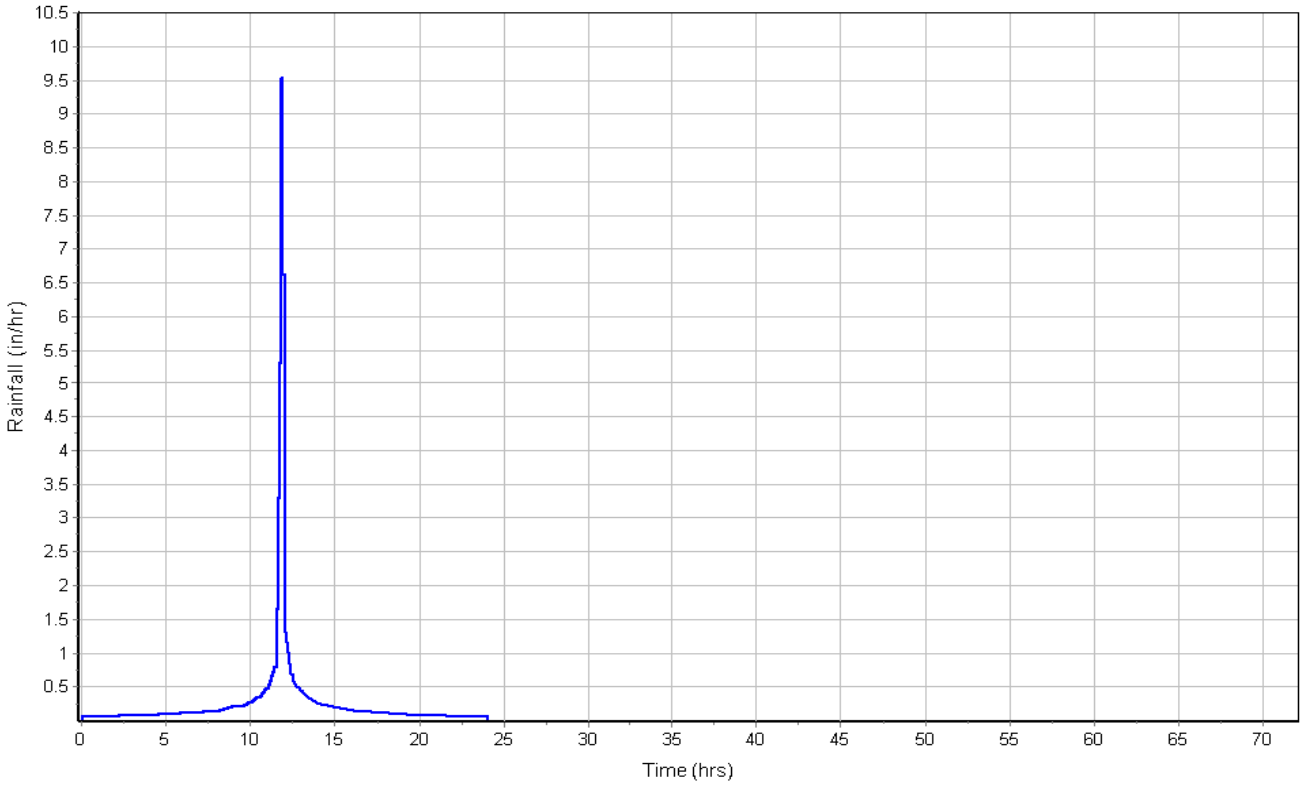
Area (ac)	5.02
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

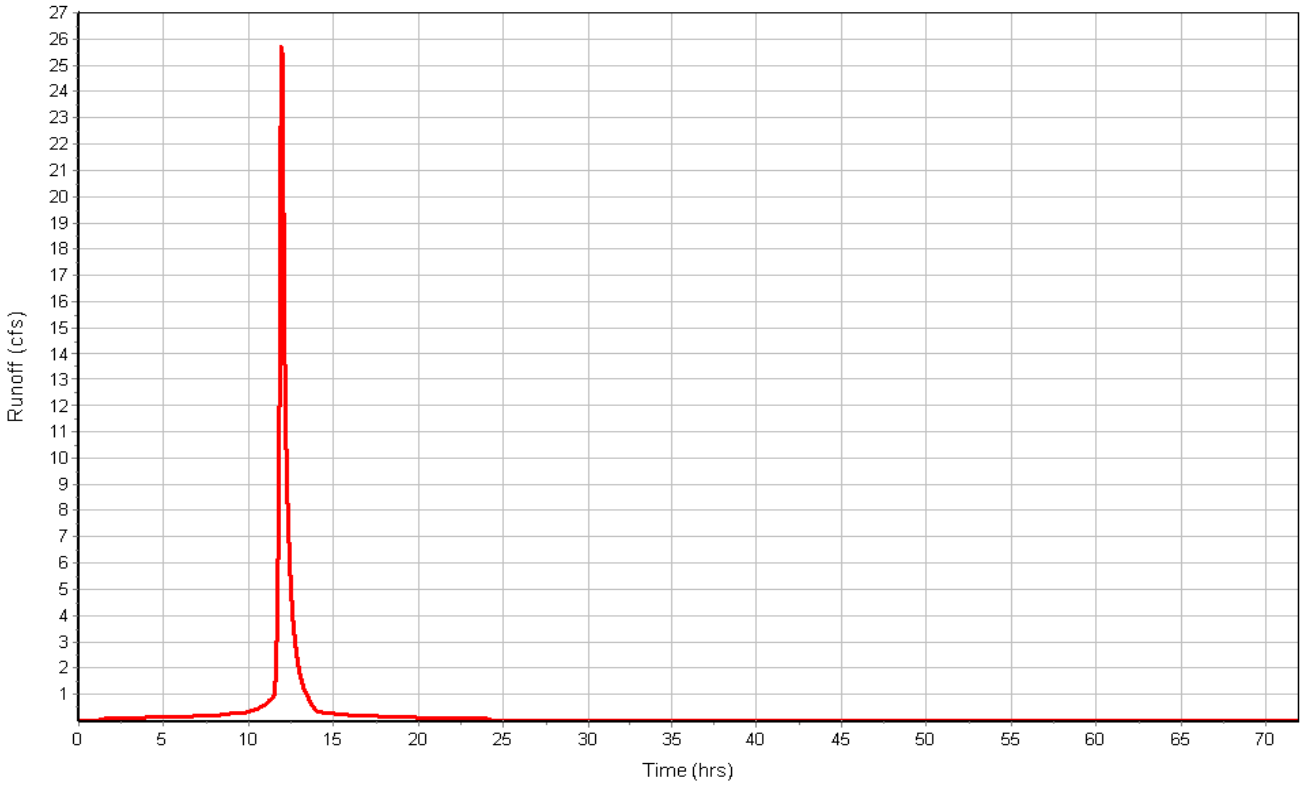
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.4660
Total Runoff (in)	3.48
Peak Runoff (cfs)	25.78
Time of Concentration (days hh:mm:ss)	0 01:01:25

Subbasin : Sub-Pond3N

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-Pond3S

Input Data

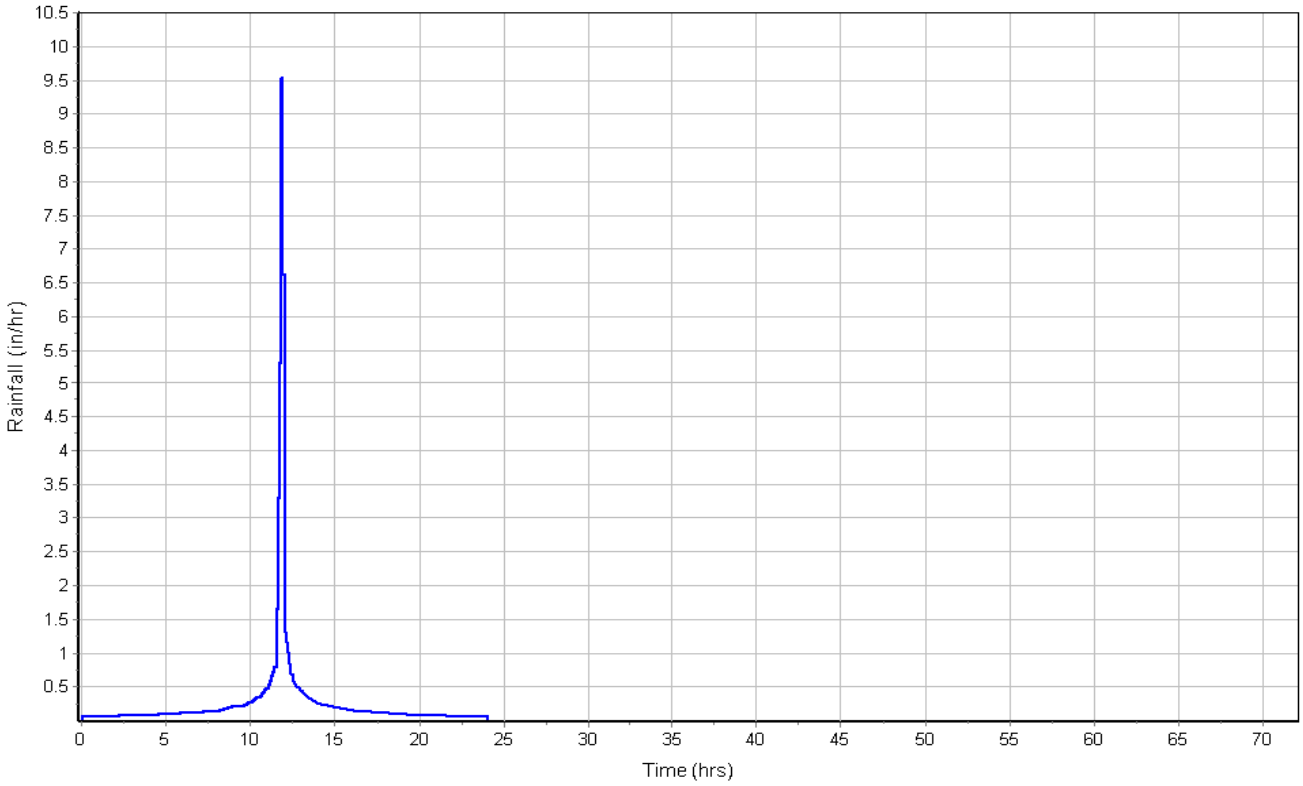
Area (ac)	4.52
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

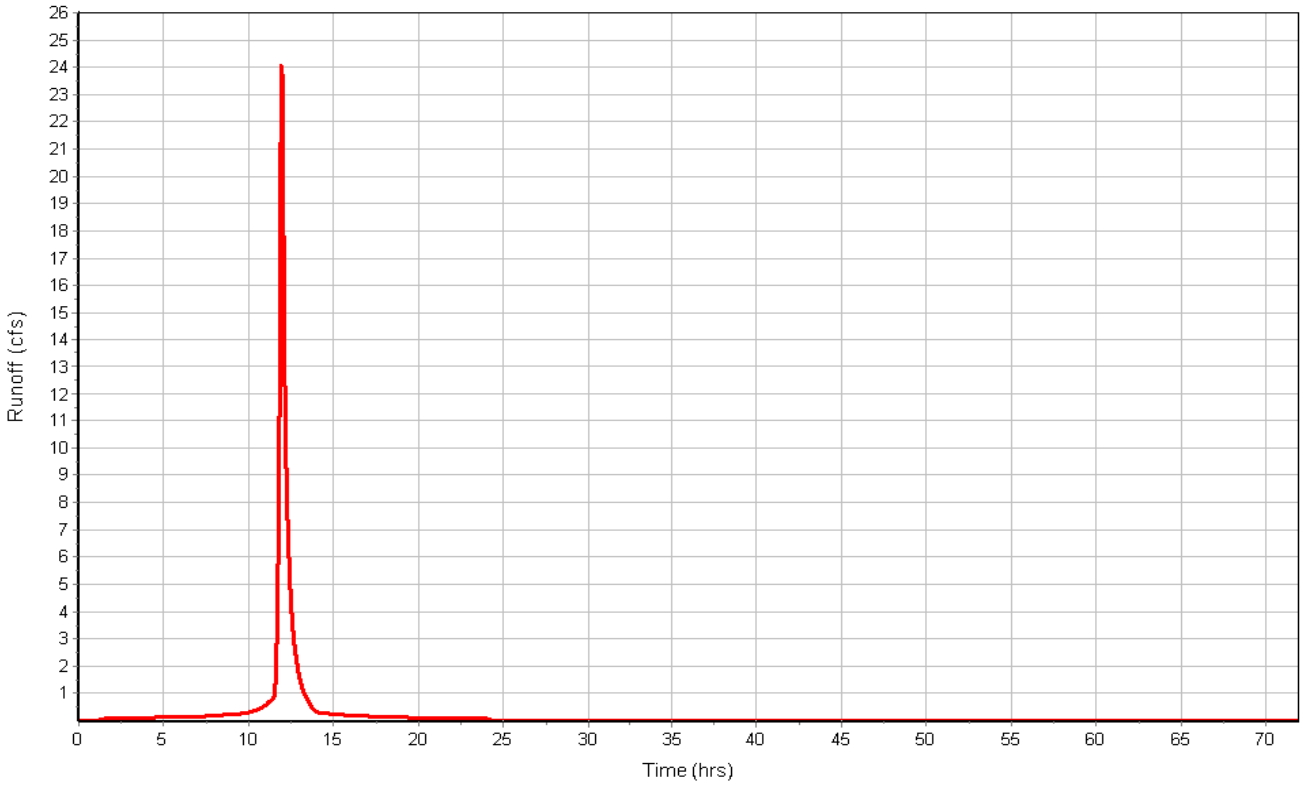
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.4520
Total Runoff (in)	3.50
Peak Runoff (cfs)	24.06
Time of Concentration (days hh:mm:ss)	0 00:57:39

Subbasin : Sub-Pond3S

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : Sub-PondA

Input Data

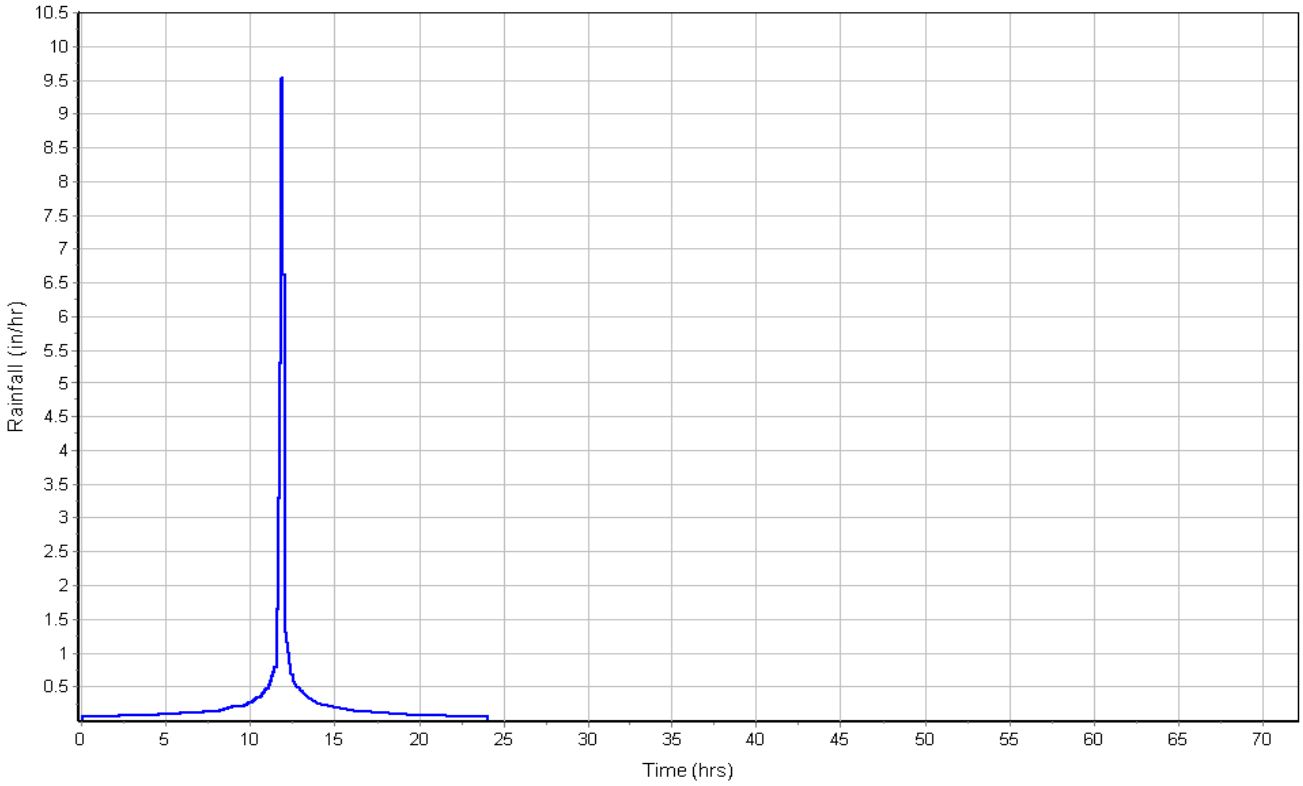
Area (ac)	11.13
Impervious Area (%)	25.00
Max Infiltration Rate (in/hr)	3.0000
Min Infiltration Rate (in/hr)	0.5000
Drying Time (days)	7.00
Decay Constant (1/hrs)	4.0000
Max Volume (in)	0.00
Average Slope (%)	0.5000
Equivalent Width (ft)	500.00
Impervious Area	
Manning's Roughness	0.0150
Pervious Area	
Manning's Roughness	0.1000
Curb & Gutter Length (ft)	0.00
Rain Gage ID	Rain Gage-01

Subbasin Runoff Results

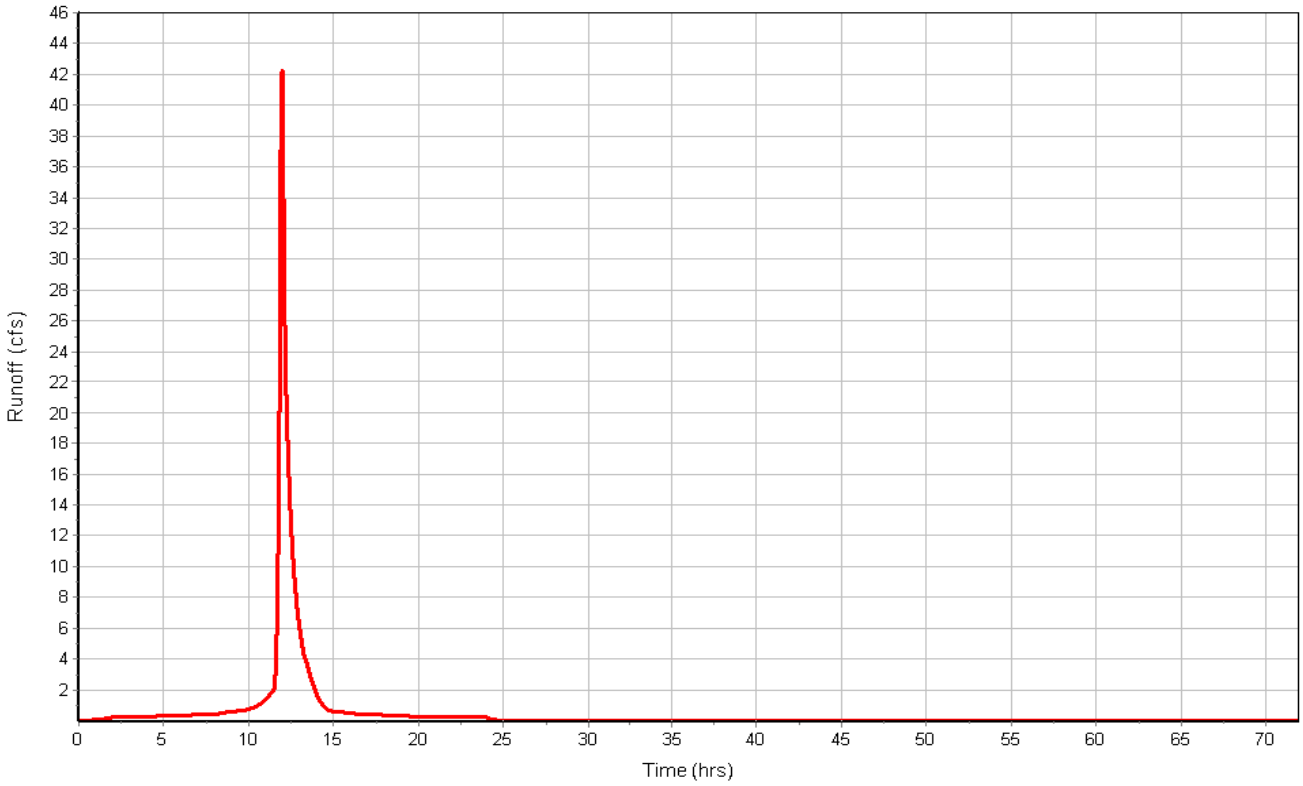
Total Rainfall (in)	6.95
Total Runon (in)	0.00
Total Evaporation (in)	0.0000
Total Infiltration (in)	3.6110
Total Runoff (in)	3.33
Peak Runoff (cfs)	43.11
Time of Concentration (days hh:mm:ss)	0 01:39:03

Subbasin : Sub-PondA

Rainfall Intensity Graph



Runoff Hydrograph



Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft^2)	Minimum Pipe Cover (ft)
1	Jun-10	619.90	631.46	11.56	0.00	-619.90	0.00	-631.46	0.00	0.00
2	Jun-101	616.82	625.00	8.18	0.00	-616.82	0.00	-625.00	0.00	0.00
3	Jun-103	618.16	632.32	14.16	0.00	-618.16	0.00	-632.32	0.00	0.00
4	Jun-104	623.00	631.60	8.60	0.00	-623.00	0.00	-631.60	0.00	0.00
5	Jun-105	628.00	633.20	5.20	0.00	-628.00	0.00	-633.20	0.00	0.00
6	Jun-11	619.06	632.11	13.05	0.00	-619.06	0.00	-632.11	0.00	0.00
7	Jun-12	608.50	610.50	2.00	0.00	-608.50	0.00	-610.50	0.00	0.00
8	Jun-12N-Out	618.36	631.07	12.71	0.00	-618.36	6.00	-625.07	0.00	0.00
9	Jun-12S-Out	617.72	624.87	7.15	0.00	-617.72	0.00	-624.87	0.00	0.00
10	Jun-13	613.50	619.50	6.00	0.00	-613.50	0.00	-619.50	0.00	0.00
11	Jun-3N-Out	623.46	631.99	8.53	0.00	-623.46	6.00	-625.99	0.00	0.00
12	Jun-3S-Out	622.10	633.70	11.60	0.00	-622.10	6.00	-627.70	0.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Jun-10	7.80	0.00	623.50	3.60	0.00	7.96	623.24	3.34	2 21:00	0 00:00	0.00	0.00
2	Jun-101	36.29	0.00	618.36	1.54	0.00	6.64	617.73	0.91	0 12:08	0 00:00	0.00	0.00
3	Jun-103	48.85	0.00	623.10	4.94	0.00	9.22	618.27	0.11	0 12:14	0 00:00	0.00	0.00
4	Jun-104	49.60	0.00	624.93	1.93	0.00	6.67	623.09	0.09	0 12:07	0 00:00	0.00	0.00
5	Jun-105	49.78	49.78	630.24	2.24	0.00	2.96	628.10	0.10	0 12:02	0 00:00	0.00	0.00
6	Jun-11	7.80	0.00	621.62	2.56	0.00	10.49	621.51	2.45	2 21:00	0 00:00	0.00	0.00
7	Jun-12	13.64	0.00	609.27	0.77	0.00	1.23	609.21	0.71	0 16:00	0 00:00	0.00	0.00
8	Jun-12N-Out	28.16	20.85	619.94	1.58	0.00	11.13	619.21	0.85	0 12:06	0 00:00	0.00	0.00
9	Jun-12S-Out	12.64	12.47	618.68	0.96	0.00	6.19	617.78	0.06	0 12:03	0 00:00	0.00	0.00
10	Jun-13	13.92	0.00	616.27	2.77	0.00	3.23	615.57	2.07	0 16:00	0 00:00	0.00	0.00
11	Jun-3N-Out	3.02	0.00	626.16	2.70	0.00	5.83	625.77	2.31	2 21:00	0 00:00	0.00	0.00
12	Jun-3S-Out	7.80	0.00	625.84	3.74	0.00	7.86	625.43	3.33	2 21:00	0 00:00	0.00	0.00

Channel Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Shape	Height (ft)	Width (ft)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	Flap Gate
1	Ditch-001	1154.00	618.36	0.00	616.82	0.00	1.54	0.1300	Trapezoidal	7.000	28.000	0.0350	0.0000	0.0000	0.0000	0.00	No
2	Ditch-002	558.30	617.72	0.00	616.82	0.00	0.90	0.1600	Trapezoidal	7.000	28.000	0.0350	0.0000	0.0000	0.0000	0.00	No
3	Ditch-003	753.20	628.00	0.00	623.00	0.00	5.00	0.6600	Trapezoidal	5.000	22.000	0.0350	0.0000	0.0000	0.0000	0.00	No
4	Ditch-004	504.30	623.00	0.00	618.16	0.00	4.84	0.9600	Trapezoidal	5.000	22.000	0.0350	0.0000	0.0000	0.0000	0.00	No

Channel Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number	Reported Condition
1	Ditch-001	24.97	0 12:06	462.65	0.05	1.73	11.12	1.53	0.22	0.00	0.23	
2	Ditch-002	11.60	0 12:03	508.49	0.02	1.11	8.38	1.22	0.18	0.00	0.01	
3	Ditch-003	49.60	0 12:06	378.54	0.13	3.97	3.16	2.06	0.41	0.00	0.26	
4	Ditch-004	48.85	0 12:07	455.15	0.11	3.45	2.44	3.28	0.66	0.00	0.31	

Pipe Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (ft)	Pipe Width (ft)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	Flap Gate
1	Link-17	285.40	619.90	0.00	619.16	0.10	0.74	0.2600	CIRCULAR	1.500	1.500	0.0130	0.5000	0.5000	0.0000	0.00	No
2	Link-18	192.01	619.06	0.00	619.03	0.67	0.03	0.0200	CIRCULAR	1.500	1.500	0.0130	0.5000	0.5000	0.0000	0.00	No
3	Pipe-001	658.20	623.46	0.00	622.08	-0.02	1.38	0.2100	CIRCULAR	1.500	1.500	0.0130	0.5000	1.0000	0.0000	0.00	No
4	Pipe-002	341.45	622.10	0.00	620.00	0.10	2.10	0.6200	CIRCULAR	1.500	1.500	0.0130	0.5000	1.0000	0.0000	0.00	No
5	Pipe-Outfall01	173.41	617.37	0.55	589.75	0.00	27.62	15.9300	CIRCULAR	2.500	2.500	0.0250	0.5000	1.0000	0.0000	0.00	No
6	Pipe-Pond12N-Outlet	78.49	619.08	15.08	618.36	0.00	0.72	0.9200	CIRCULAR	2.000	2.000	0.0250	0.5000	1.0000	0.0000	0.00	No
7	Pipe-Pond12S-Outlet	59.89	618.78	18.78	617.72	0.00	1.06	1.7700	CIRCULAR	2.000	2.000	0.0250	0.5000	1.0000	0.0000	0.00	No
8	Pipe-Pond3N-Outlet	109.20	625.34	21.34	623.56	0.10	1.78	1.6300	CIRCULAR	1.500	1.500	0.0130	0.5000	1.0000	0.0000	0.00	No
9	Pipe-Pond3S-Outlet	119.51	624.66	20.66	622.08	-0.02	2.58	2.1600	CIRCULAR	1.500	1.500	0.0130	0.5000	1.0000	0.0000	0.00	No
10	Pipe-PondA-In1	99.23	625.93	0.93	614.05	14.05	11.88	11.9700	CIRCULAR	2.500	2.500	0.0250	0.5000	1.0000	0.0000	0.00	No
11	Pipe-PondA-In2	100.72	618.16	0.00	615.82	15.82	2.34	2.3200	CIRCULAR	2.000	2.000	0.0130	0.5000	1.0000	0.0000	0.00	No
12	Pipe-PondA-In3	640.00	616.82	0.00	615.14	15.14	1.68	0.2600	CIRCULAR	2.000	2.000	0.0130	0.5000	1.0000	0.0000	0.00	No
13	Pipe-Pond-A-Oulet1	345.00	613.50	0.00	608.50	0.00	5.00	1.4500	CIRCULAR	2.000	2.000	0.0250	0.5000	0.5000	0.0000	0.00	No
14	Pipe-Pond-A-Outlet2	65.00	608.50	0.00	596.80	0.00	11.70	18.0000	CIRCULAR	2.000	2.000	0.0250	0.5000	0.5000	0.0000	0.00	No

No. of Barrels
1
1
1
1
1
1
1
1
1
1
1
1
1
1

Pipe Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)	Froude Number
1	Link-17	7.80	2 21:00	5.35	1.46	4.41	1.08	1.50	1.00	4028.00	0.01
2	Link-18	7.80	2 21:00	1.31	5.94	4.82	0.66	1.29	0.86	0.00	0.67
3	Pipe-001	3.02	0 13:00	4.77	0.63	1.76	6.23	1.50	1.00	3645.00	0.02
4	Pipe-002	7.80	2 21:00	8.24	0.95	4.41	1.29	1.50	1.00	3915.00	0.03
5	Pipe-Outfall01	25.18	0 12:08	85.12	0.30	14.48	0.20	0.95	0.38	0.00	3.01
6	Pipe-Pond12N-Outlet	3.43	0 12:39	11.27	0.30	2.40	0.55	1.13	0.57	0.00	0.29
7	Pipe-Pond12S-Outlet	0.86	0 12:34	15.65	0.05	2.88	0.35	0.58	0.29	0.00	1.15
8	Pipe-Pond3N-Outlet	3.02	0 12:59	13.41	0.23	3.81	0.48	1.20	0.80	0.00	0.33
9	Pipe-Pond3S-Outlet	5.98	2 18:00	15.37	0.39	4.84	0.41	1.50	1.00	2165.00	0.21
10	Pipe-PondA-In1	11.58	0 12:31	73.80	0.16	3.53	0.47	1.58	0.63	0.00	0.03
11	Pipe-PondA-In2	35.11	0 12:13	34.48	1.02	11.49	0.15	1.96	1.00	2.00	0.26
12	Pipe-PondA-In3	9.27	0 12:09	11.59	0.80	4.01	2.66	1.43	0.72	0.00	0.52
13	Pipe-Pond-A-Oulet1	13.64	0 16:00	14.16	0.96	6.35	0.91	1.38	0.69	0.00	1.00
14	Pipe-Pond-A-Outlet2	13.64	0 16:00	49.91	0.27	12.85	0.08	0.74	0.37	0.00	3.07

Storage Nodes

Storage Node : Stor-100

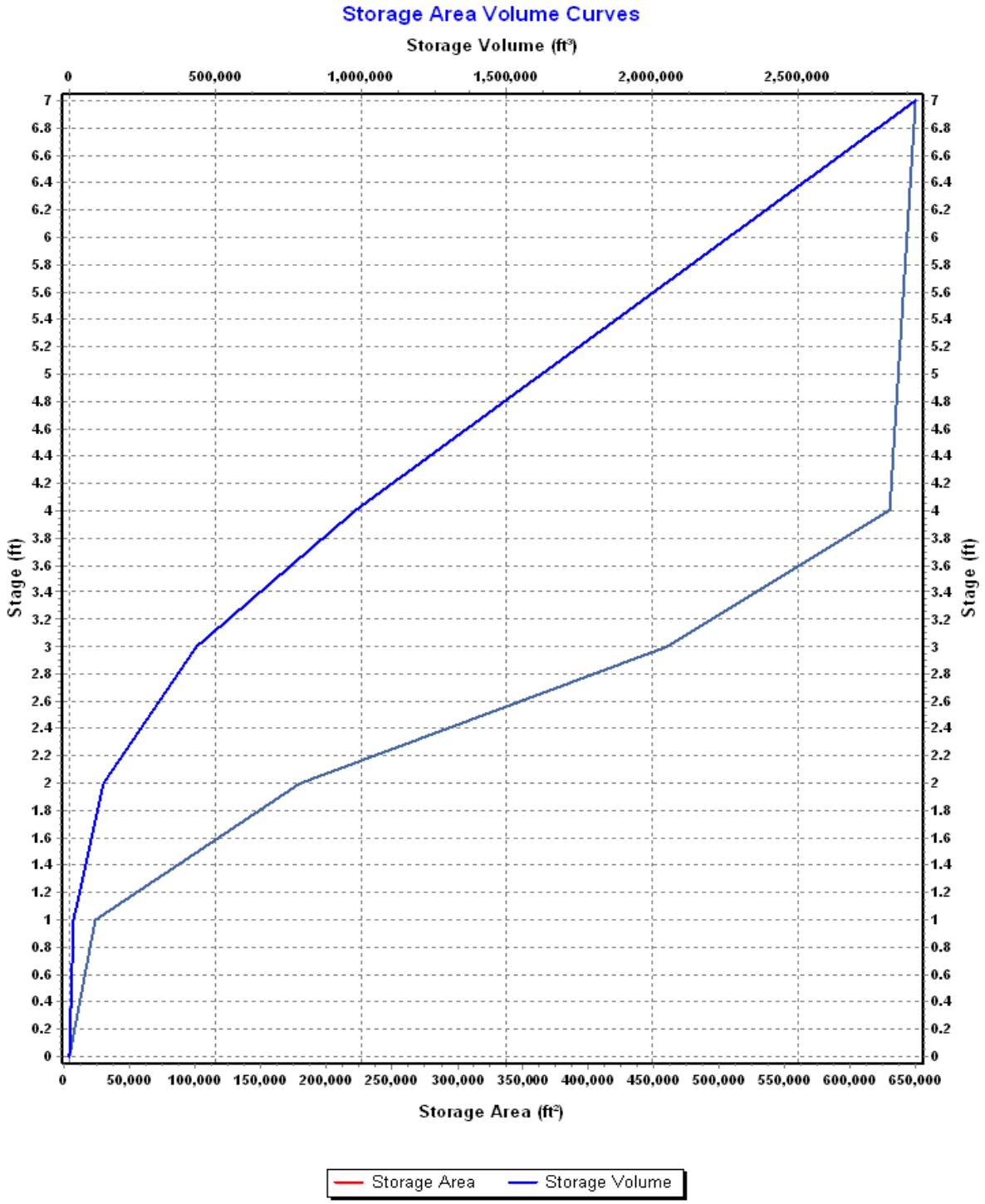
Input Data

Invert Elevation (ft)	625.00
Max (Rim) Elevation (ft)	632.00
Max (Rim) Offset (ft)	7.00
Initial Water Elevation (ft)	625.93
Initial Water Depth (ft)	0.93
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Storage-100

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	4000	0.000
1	24000	14000.00
2	180000	116000.00
3	460000	436000.00
4	630000	981000.00
7	650000	2901000.00


Storage Area Volume Curves
Storage Volume (ft³)
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
Stage (ft)
Stage (ft)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
6.4
6.6
6.8
7
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
500,000
550,000
600,000
650,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Stor-100 (continued)

Output Summary Results

Peak Inflow (cfs)	37.34
Peak Lateral Inflow (cfs)	37.34
Peak Outflow (cfs)	11.58
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	626.6
Max HGL Depth Attained (ft)	1.60
Average HGL Elevation Attained (ft)	626
Average HGL Depth Attained (ft)	1.00
Time of Max HGL Occurrence (days hh:mm)	0 12:31
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Stor-Pond1-2N

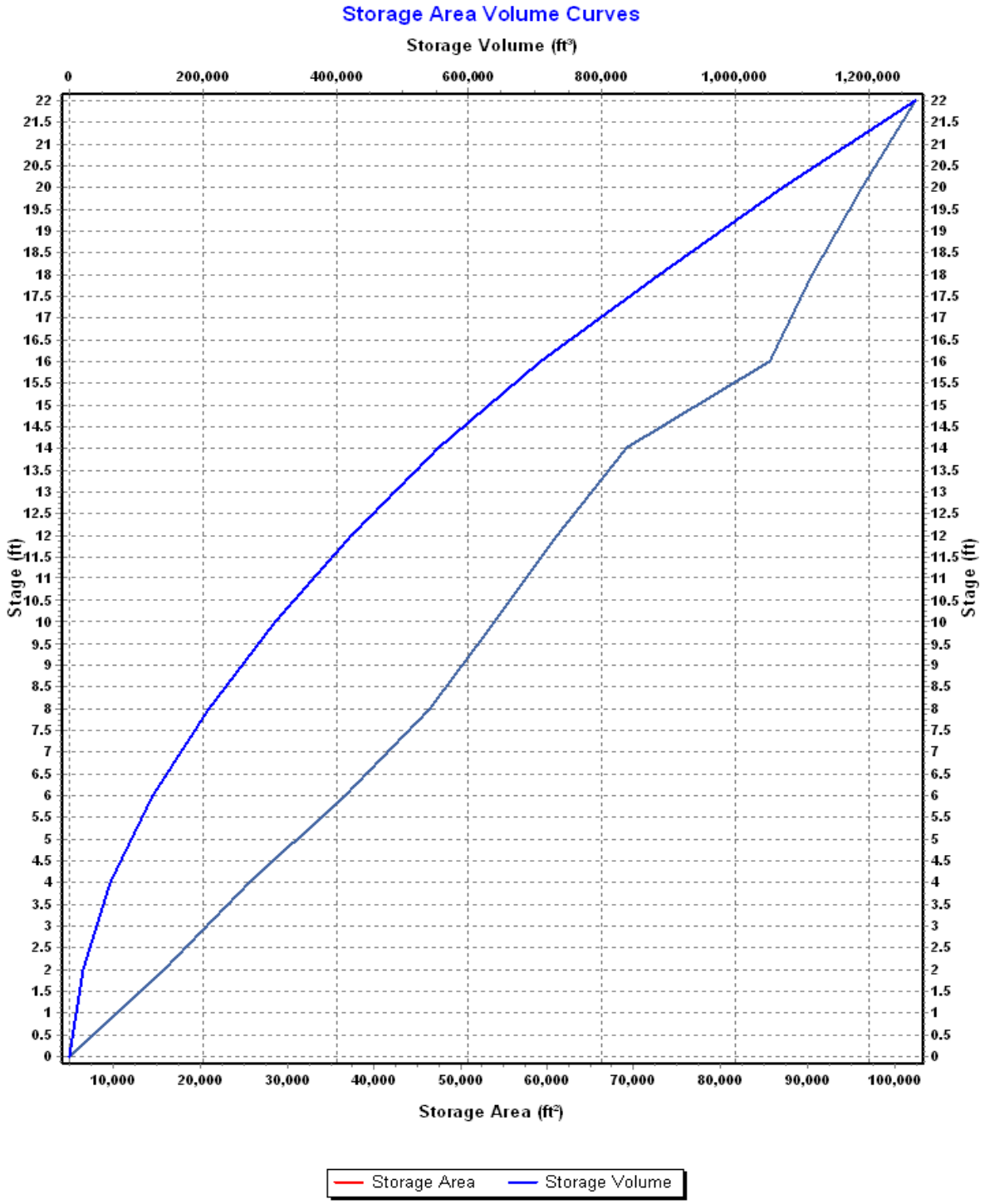
Input Data

Invert Elevation (ft)	604.00
Max (Rim) Elevation (ft)	626.00
Max (Rim) Offset (ft)	22.00
Initial Water Elevation (ft)	619.08
Initial Water Depth (ft)	15.08
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Storage-Pond12N

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	4955.10	0.000
2	15820.19	20775.29
4	25676.42	62271.90
6	36648.10	124596.42
8	46410.19	207654.71
10	53887.47	307952.37
12	61209.12	423048.96
14	69122.69	553380.77
16	85688.98	708192.44
18	90544.27	884425.69
20	96239.46	1071209.42
22	102428.12	1269877.00


Storage Area Volume Curves
Storage Volume (ft³)
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
Stage (ft)
Stage (ft)
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Stor-Pond1-2N (continued)

Output Summary Results

Peak Inflow (cfs)	26.43
Peak Lateral Inflow (cfs)	24.69
Peak Outflow (cfs)	3.43
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	619.86
Max HGL Depth Attained (ft)	15.86
Average HGL Elevation Attained (ft)	619.47
Average HGL Depth Attained (ft)	15.47
Time of Max HGL Occurrence (days hh:mm)	0 12:27
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Stor-Pond1-2S

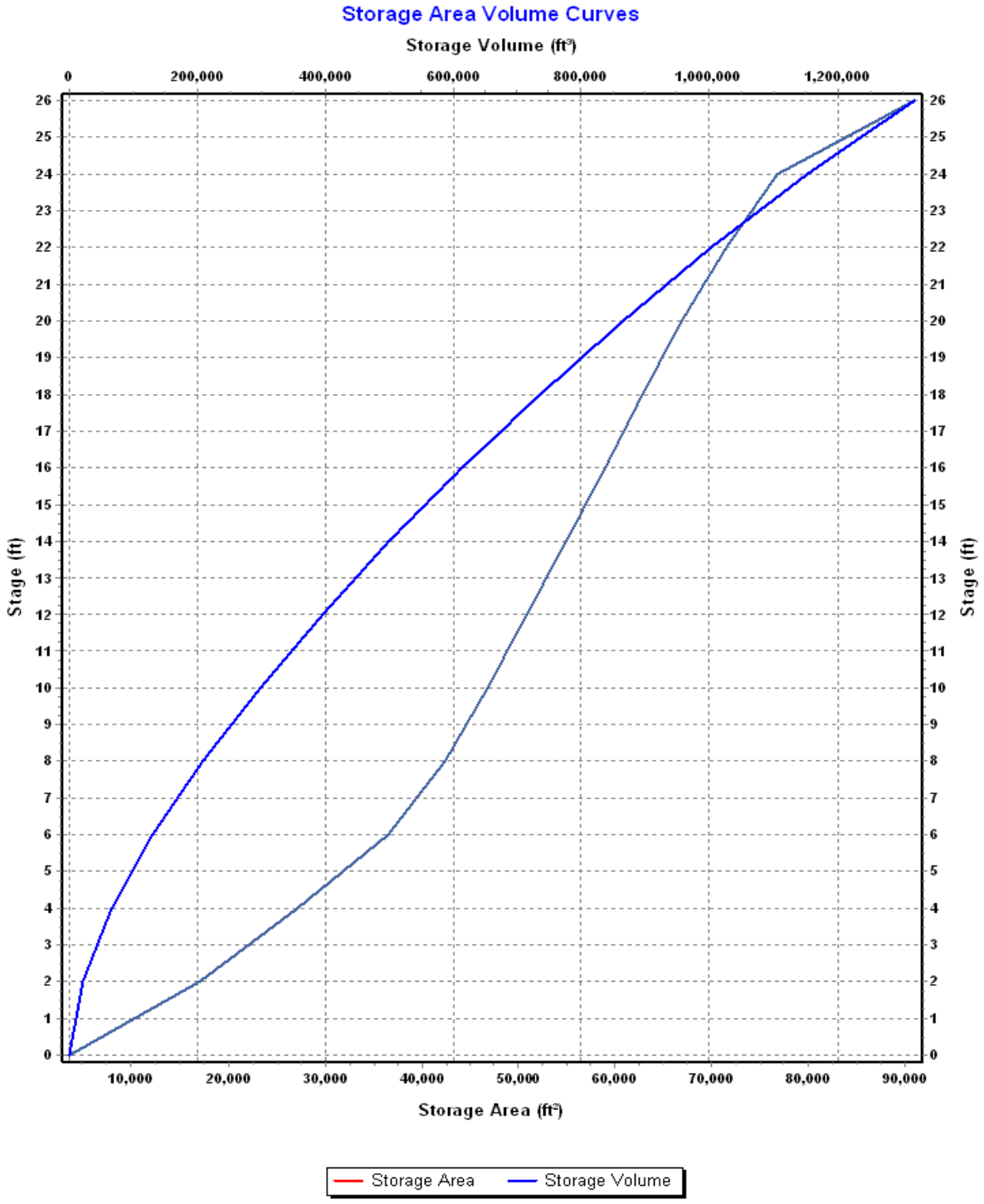
Input Data

Invert Elevation (ft)	600.00
Max (Rim) Elevation (ft)	626.00
Max (Rim) Offset (ft)	26.00
Initial Water Elevation (ft)	618.78
Initial Water Depth (ft)	18.78
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Storage-Pond12S

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	3604.98	0.000
2	17159.40	20764.38
4	27121.01	65044.79
6	36533.37	128699.17
8	42427.01	207659.55
10	46794.54	296881.10
12	50912.71	394588.35
14	54856.85	500357.91
16	58996.35	614211.11
18	62792.91	736000.37
20	66866.07	865659.35
22	71514.01	1004039.43
24	76770.32	1152323.76
26	90921.00	1320015.08


Storage Area Volume Curves
Storage Volume (ft³)
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
Stage (ft)
Stage (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Stor-Pond1-2S (continued)

Output Summary Results

Peak Inflow (cfs)	14.47
Peak Lateral Inflow (cfs)	14.47
Peak Outflow (cfs)	0.86
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	619.1
Max HGL Depth Attained (ft)	19.10
Average HGL Elevation Attained (ft)	618.88
Average HGL Depth Attained (ft)	18.88
Time of Max HGL Occurrence (days hh:mm)	0 12:51
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Stor-Pond3N

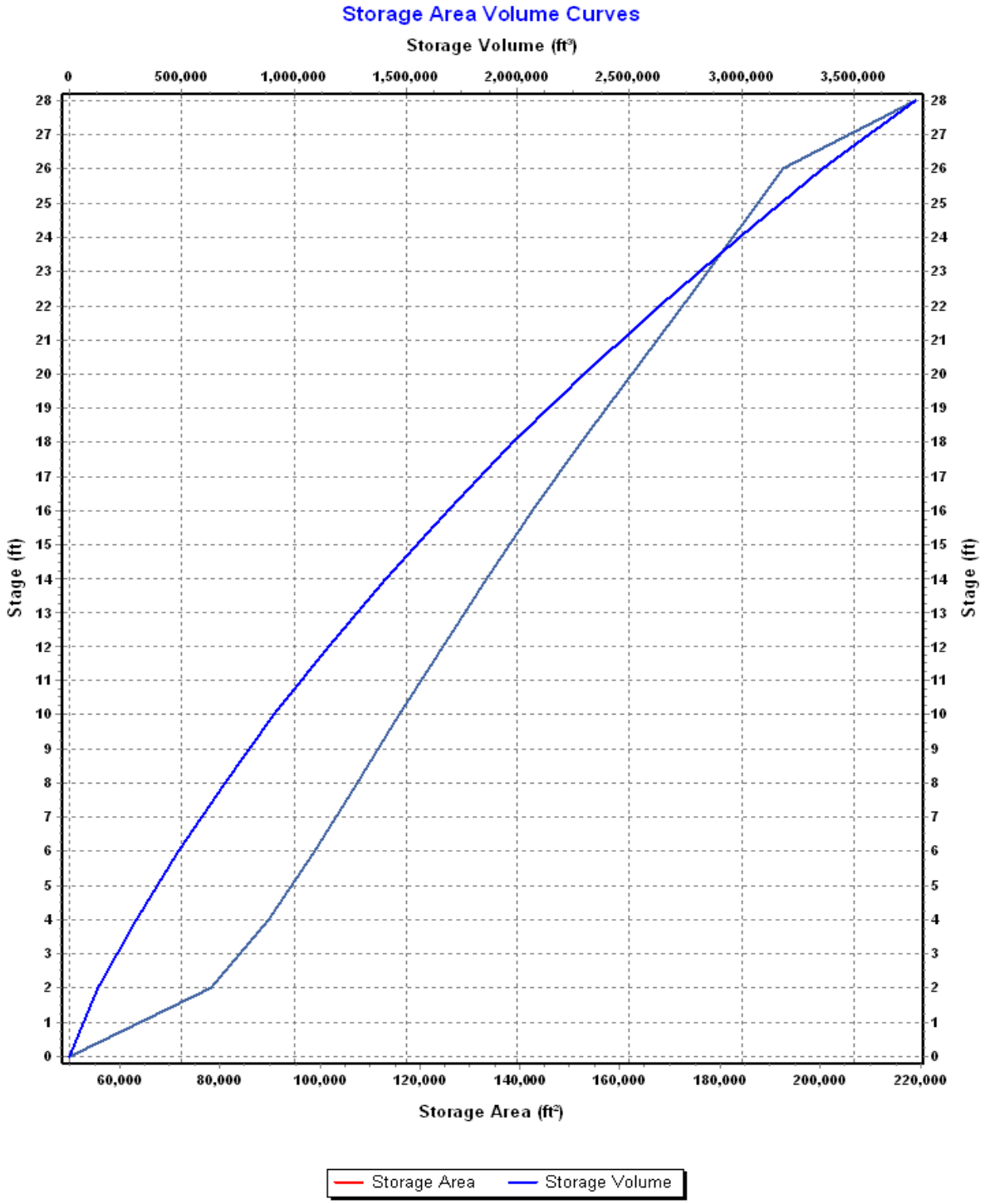
Input Data

Invert Elevation (ft)	604.00
Max (Rim) Elevation (ft)	632.00
Max (Rim) Offset (ft)	28.00
Initial Water Elevation (ft)	625.34
Initial Water Depth (ft)	21.34
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Storage-Pond3N

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	49967.95	0.000
2	78356.09	128324.04
4	89739.44	296419.57
6	98856.66	485015.67
8	107309.16	691181.49
10	115789.97	914280.62
12	124461.94	1154532.53
14	133313.10	1412307.57
16	142403.76	1688024.43
18	152229.55	1982657.74
20	162328.39	2297215.68
22	172534.85	2632078.92
24	182457.24	2987071.01
26	192696.07	3362224.32
28	218974.00	3773894.39


Storage Area Volume Curves
Storage Volume (ft³)
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
3,500,000
Stage (ft)
Stage (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
220,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Stor-Pond3N (continued)

Output Summary Results

Peak Inflow (cfs)	31.68
Peak Lateral Inflow (cfs)	31.68
Peak Outflow (cfs)	3.02
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	626.23
Max HGL Depth Attained (ft)	22.23
Average HGL Elevation Attained (ft)	625.98
Average HGL Depth Attained (ft)	21.98
Time of Max HGL Occurrence (days hh:mm)	2 21:00
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Stor-Pond3S

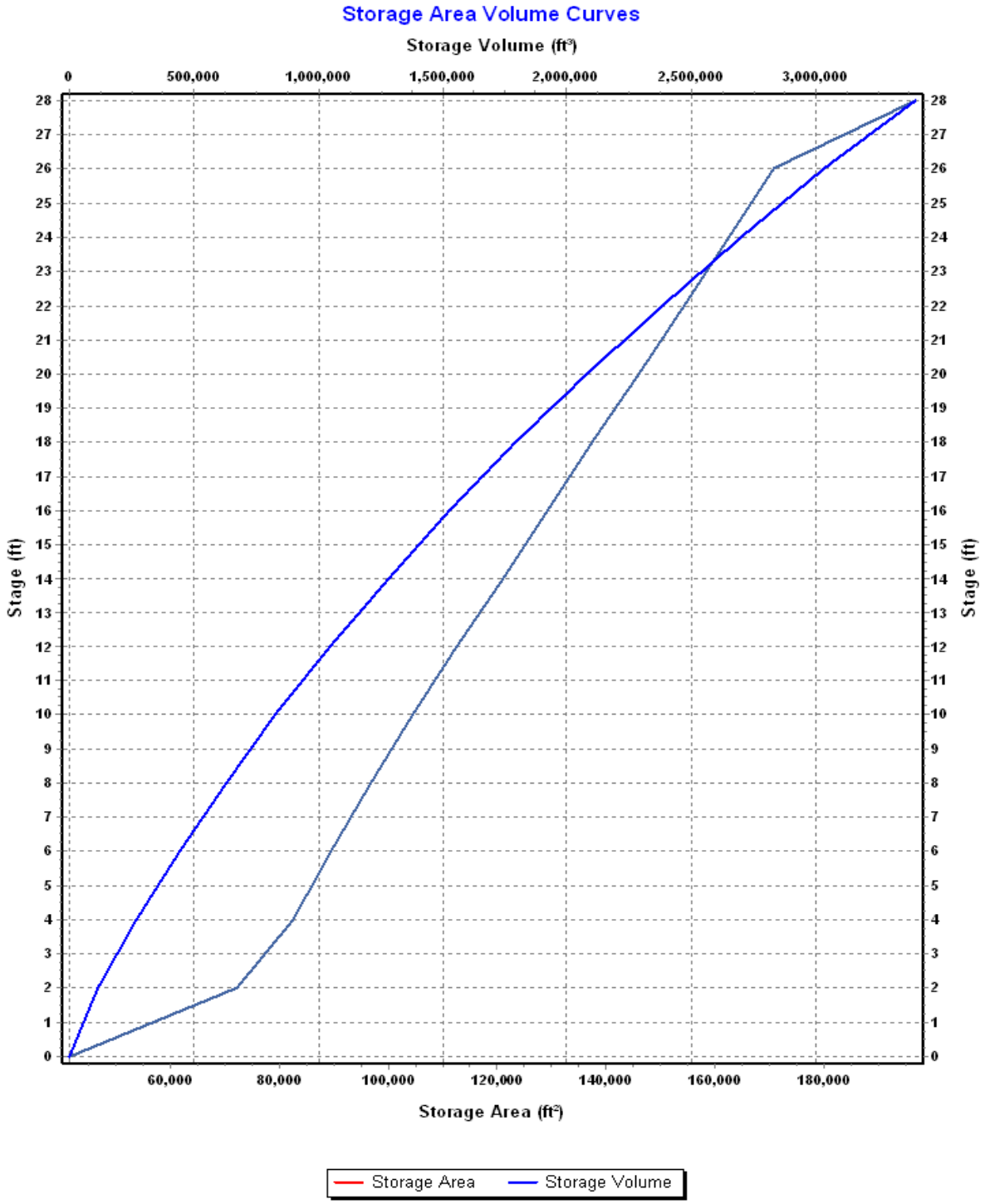
Input Data

Invert Elevation (ft)	604.00
Max (Rim) Elevation (ft)	632.00
Max (Rim) Offset (ft)	28.00
Initial Water Elevation (ft)	624.66
Initial Water Depth (ft)	20.66
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Storage-Pond3S

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	41626.09	0.000
2	72438.46	114064.55
4	82587.06	269090.07
6	89505.89	441183.02
8	96741.54	627430.45
10	104521.74	828693.73
12	112486.68	1045702.15
14	120990.09	1279178.92
16	129285.30	1529454.31
18	137679.45	1796419.06
20	146088.97	2080187.48
22	154269.17	2380545.62
24	162544.34	2697359.13
26	170930.02	3030833.49
28	196791.00	3398554.51


Storage Area Volume Curves
Storage Volume (ft³)
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
Stage (ft)
Stage (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
60,000
80,000
100,000
120,000
140,000
160,000
180,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Stor-Pond3S (continued)

Output Summary Results

Peak Inflow (cfs)	30.08
Peak Lateral Inflow (cfs)	30.08
Peak Outflow (cfs)	5.98
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	626.43
Max HGL Depth Attained (ft)	22.43
Average HGL Elevation Attained (ft)	626.07
Average HGL Depth Attained (ft)	22.07
Time of Max HGL Occurrence (days hh:mm)	3 00:00
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Stor-PondA

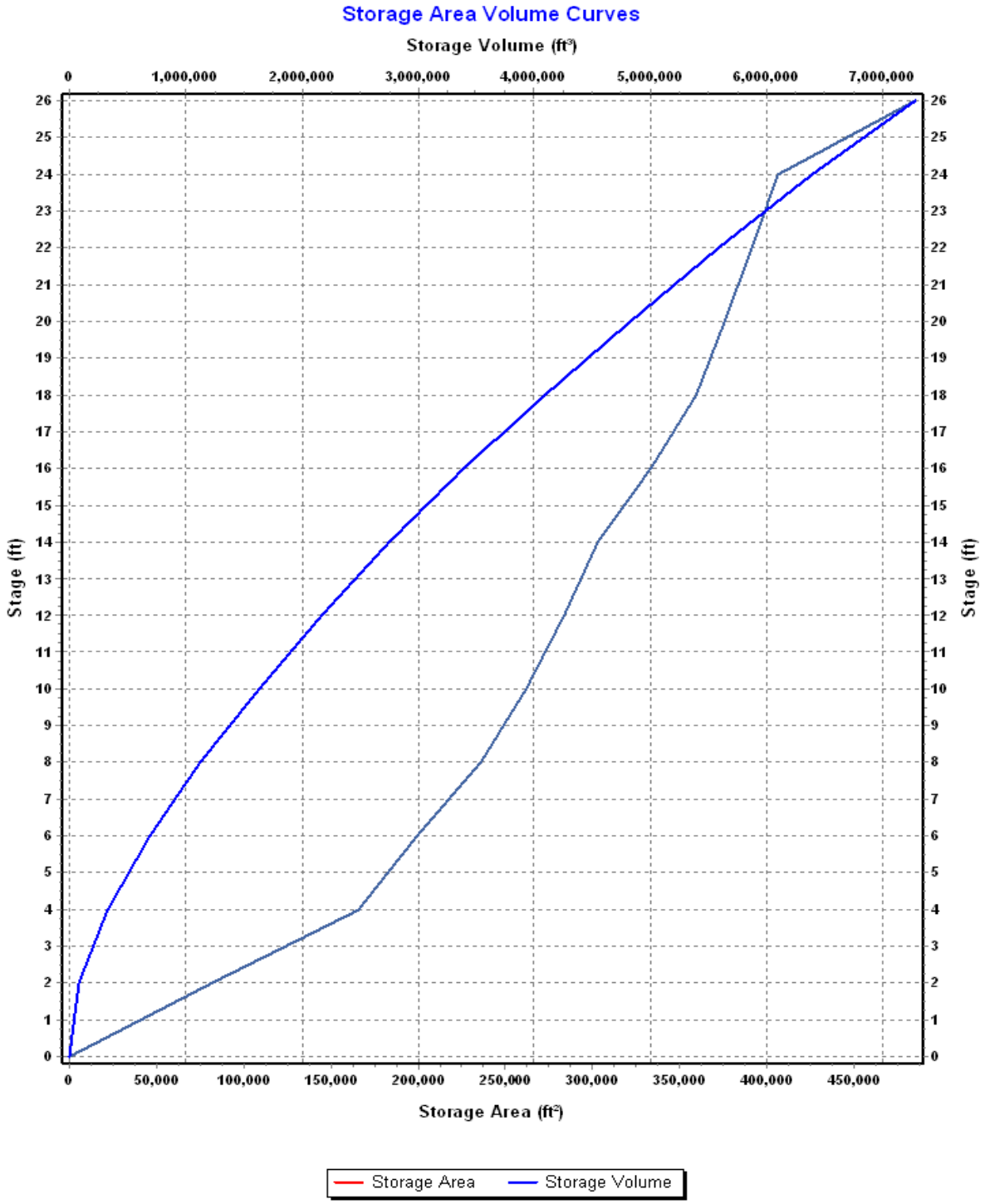
Input Data

Invert Elevation (ft)	600.00
Max (Rim) Elevation (ft)	626.00
Max (Rim) Offset (ft)	26.00
Initial Water Elevation (ft)	615.50
Initial Water Depth (ft)	15.50
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Storage-PondA

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	169	0.000
2	82304	82473.00
4	165720	330497.00
6	199134	695351.00
8	235912	1130397.00
10	262021	1628330.00
12	283586	2173937.00
14	302913	2760436.00
16	333408	3396757.00
18	359569	4089734.00
20	375557	4824860.00
22	391075	5591492.00
24	406267	6388834.00
26	484900	7280001.00


Storage Area Volume Curves
Storage Volume (ft³)
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
7,000,000
Stage (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
Storage Area (ft²)
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
Storage Area
Storage Volume

Storage Node : Stor-PondA (continued)

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (ft)	Rectangular Orifice Height (ft)	Rectangular Orifice Width (ft)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	Orifice-01	Bottom	CIRCULAR	No	2.00			615.50	0.61

Output Summary Results

Peak Inflow (cfs)	96.32
Peak Lateral Inflow (cfs)	49.13
Peak Outflow (cfs)	13.92
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	617.04
Max HGL Depth Attained (ft)	17.04
Average HGL Elevation Attained (ft)	616.48
Average HGL Depth Attained (ft)	16.48
Time of Max HGL Occurrence (days hh:mm)	0 16:00
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

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Golder Associates

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