



J.H. Campbell Generating Facility

Dry Ash Landfill Cell 5 Expansion - Run-On and Run-Off Control System Plan

Pursuant to:

40 CFR 257.81

Submitted to:

Consumers Energy Company

1945 W. Parnall Road
Jackson, Michigan USA 49201

Submitted by:

Golder Associates Inc.

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18101379

December 2018



CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.81(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 257.81 (40 CFR Part 257.81), I attest that this Run-on and Run-off 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 257.81.

Golder Associates Inc.



Signature

December 5, 2018

Date of Report Certification

John D. Puls, PE

Name

6201055778

Professional Engineer Certification Number

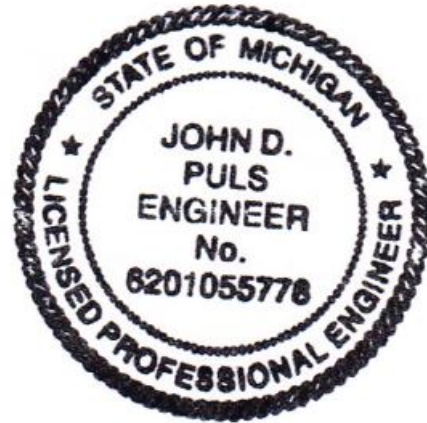


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1.0 INTRODUCTION

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. The JH Campbell Dry Ash Landfill (Dry Ash Landfill) serves as the facility's primary disposal for dry ash and consists of five dual composite lined landfill cells and two leachate storage ponds. The Dry Ash Landfill utilizes a dual composite liner system with primary and secondary leachate collection layers between each composite liner. The total permitted capacity of the Dry Ash Landfill is 9,500,000 cubic yards (cy). As of August 22, 2018, approximately 4,879,950 cy of airspace was consumed per an airspace evaluation completed by Engineering & Environmental Solutions, LLC (EES). It is anticipated that the total permitted volume will be consumed once the nine permitted cells have been constructed and filled in accordance with the Dry Ash Landfill Cell Construction, Filling, and Final Cover Plan (Golder 2018).

1.2 Purpose

Per 40 CFR 257.81, the owner or operator of an existing or new Coal Combustion Residual (CCR) landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain:

- A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour 25-year storm
- A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour 25-year storm

The JH Campbell Dry Ash Landfill Cell 5 expansion is considered a lateral expansion of a CCR landfill and; therefore, is required to comply with 40 CFR 257.81.

2.0 RUN-ON AND RUN-OFF CONTROLS

To meet the requirements of 40 CFR 257.81(a), the run-on and run-off control system must prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour 25-year storm and collect and control at least the water volume resulting from a 24-hour 25-year storm. The 24-hour 25-year storm depth is 4.97 inches as provided in Appendix A – Rainfall Data. Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under 40 CFR 257.3-3.

The Run-on and Run-off Control System Plan was developed by assessing the 2018-2023 Dry Ash Landfill Cell Construction, Filling, and Final Cover Plan (Golder, 2018) for a probable grading scenario that could be modeled with the 24-hour 25-year storm event to document certification pursuant to 40 CFR 257.81. The probable grading scenario is provided in Figure 2 – Probable Fill Progression Condition.

2.1 Run-on Control System

Run-on to the active portions of the Dry Ash Landfill is controlled using two methods. The first method is a perimeter berm around the landfill that creates a barrier that does not allow stormwater to enter the active areas. A drainage channel exists on the outboard slope of the perimeter berm that collects stormwater from the adjacent areas and directs it towards the site's National Pollutant Discharge Elimination System (NPDES) outfall in accordance with Permit No. MI0001422.

The second method is positive grading away from the active areas so that run-off from closed areas (non-contact water) is not diverted into the leachate collection system. The South Drainage Ditch collects stormwater from the South Drainage Watershed that includes closed portions of Cells 1 through 4 (50.18 acres). The South Drainage Ditch directs stormwater from closed portions of the landfill to the site's NPDES outfall.

The perimeter berm elevations and stormwater run-on was modeled using topography acquired as part of the airspace evaluation (EES 2018). The model indicates that the 24-hour 25-year storm event (summarized in Table 2.1.1) will not run-on to active portions of the landfill. Model outputs are provided in Appendix B – Hydraulic and Hydrologic Model Output and approximate drainage patterns are provided on Figure 2.

Table 2.1.1 - 24-hour 25-year Storm Run-on Summary

Channel	24-hr, 25-yr Flow (cfs)	24-hr, 25-yr Flow Elevation (ft)	Perimeter Berm Elevation (ft)	24-hr, 25-yr Freeboard (ft)
South Drainage	186.78	606.1	631.9	25.8
West Drainage	90.68	606.8	615.4	8.6

Note: Elevations provided are in the J.H. Campbell Plant Datum (NGVD29)

2.2 Run-off Control System

Run-off from active portions of the Dry Ash Landfill is controlled within the active landfill cells. Precipitation that comes in contact with CCR infiltrates within the unit and is collected in leachate pipes where it is then pumped from a sump to catch basins which gravity drain to the leachate holding ponds. The run-off control system was developed with two active area watersheds as shown on Figure 2. Active Area 1 is 16.4 acres and has a west perimeter berm that ranges from elevation 619.2 to 624.0 feet NGVD29 and a south perimeter berm that extends

to elevation 616.0 feet NGVD29. Active Area 2 is 11.5 acres and has a west perimeter berm that ranges from elevation 615.4 to 626.4 feet NGVD29, and south perimeter berm that ranges from elevation 631.9 to 632.0 feet NGVD29.

Active Area 1 was modeled with topography that was acquired as part of the airspace evaluation (EES 2018). Active Area 2 was modeled with probable grading conditions that were presented in 2018-2023 Dry Ash Landfill Cell Construction, Filling, and Final Cover Plan (Golder 2018). The volume of runoff from the 24-hour 25-year storm event in Active Area 1 and Active Area 2 is contained by the landfill perimeter berms. The runoff calculations are summarized in Table 2.2.1 and are presented in Appendix B – Hydraulic and Hydrologic Model Output.

Table 2.2.1 - 24-hour 25-year Storm Run-off Summary

Dry Ash Landfill Area	Volume of Run-off (Acre-feet)	Minimum Berm Elevation (NGVD29)	Peak Water Elevation (NGVD29)	Peak Outflow (cfs)
Active Area 1	3.785	616.0	615.7	0.3
Active Area 2	2.615	615.4	613.7	0.3

Note: Elevations provided are in the J.H. Campbell Plant Datum (NGVD29)

3.0 PLAN REVISION AND RECORDKEEPING

Per 40 CFR 257.81(c)(2); “The owner or operator of the CCR unit may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility’s operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.”

Per 40 CFR 257.81(c)(4); “The owner or operator of the CCR unit must prepare periodic run-on and run-off 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 subsequent 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 a run-on and run-off control system plan when the plan has been placed in the facility’s operating record as required by §257.105(g)(3).”

4.0 REFERENCES

Engineering & Environmental Solutions, LLC. October 3, 2017. AutoCAD Civil 3D JHC Survey Data. Collected by ground survey on October 3, 2017.

Engineering & Environmental Solutions, LLC. 2018. J.H. Campbell Dry Landfill Airspace Evaluation

Golder Associates, Inc. May 22, 2018. 2018-2013 Dry Ash Landfill Cell Construction, Filling, and Final Cover Plan.

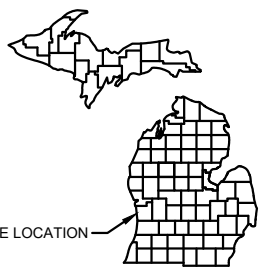
Golder Associates, Inc. September 24, 2018. J.H. Campbell Generating Facility, Dry Ash Landfill, Cell 5 Record Drawings.

NOAA's National Weather Service. August 2014. Hydrometeorological Design Studies. Precipitation Frequency Data Server (PFDS). <http://hdsc.nws.noaa.gov/hdsc/pfds/>. (Appendix A).

STS Consultants Ltd. (September 5, 1996). JH Campbell Ash Storage Facility Expansion Type III Landfill, Cell 1 and Leachate Pond – Construction Drawings -Issued for Record Per DCR 690-96-7 (LNR). Consumers Energy Company. West Olive, Michigan.

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.

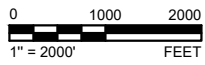
Figures



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.



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

PROJECT
J.H. CAMPBELL GENERATING FACILITY
DRY ASH LANDFILL RUN-ON AND RUN-OFF CONTROL
SYSTEM PLAN

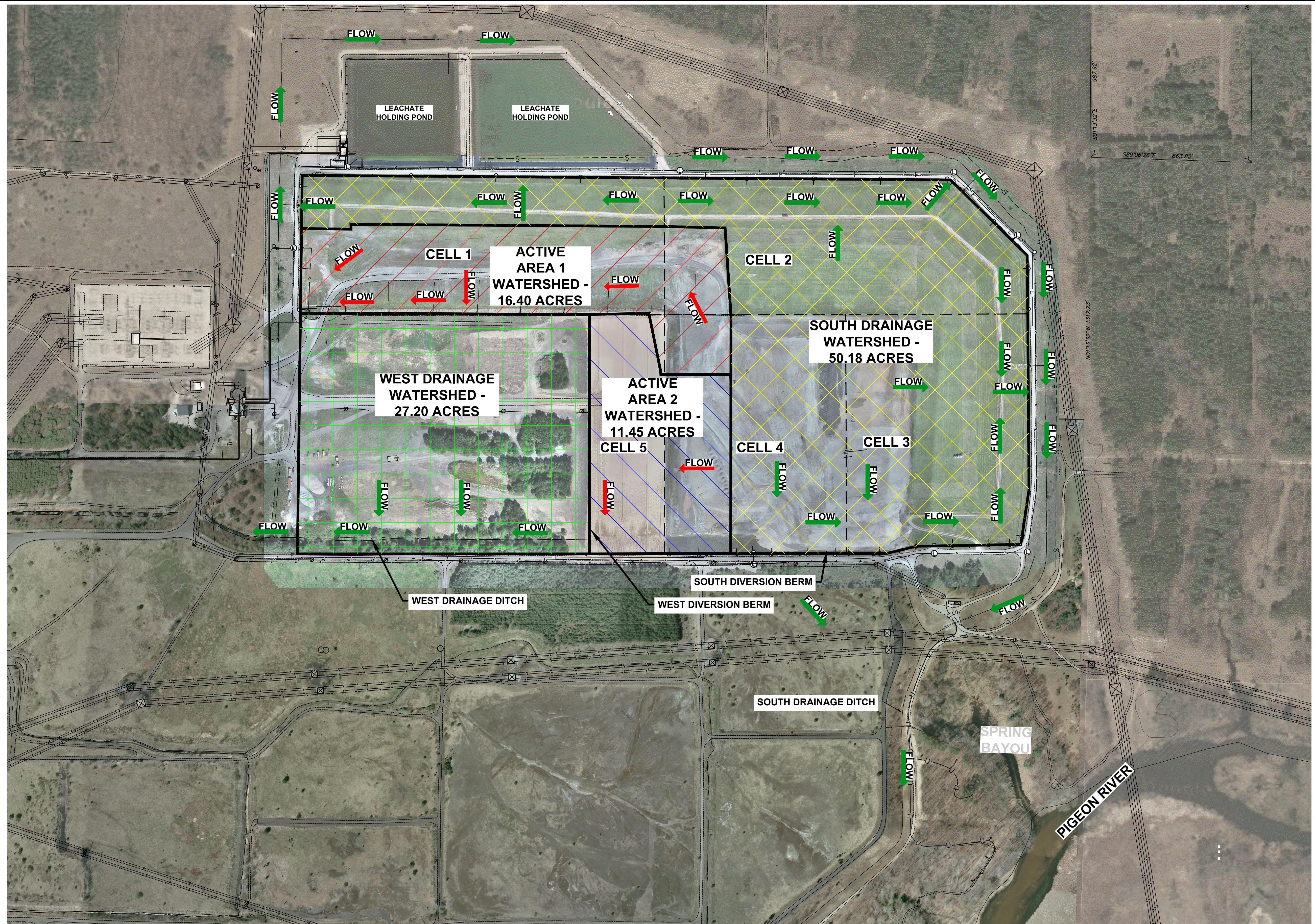
CONSULTANT	YYYY-MM-DD	2018-11-08
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	PREPARED	DS
	REVIEWED	JP
	APPROVED	

TITLE
SITE LOCATION MAP

PROJECT NO. 1810379	REV. ----	FIGURE 1
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LEGEND

- MONITORING WELL
- CONTACT WATER FLOW
- NON-CONTACT WATER FLOW
- SOUTH DRAINAGE WATERSHED
- ACTIVE AREA 1 WATERSHED
- ACTIVE AREA 2 WATERSHED
- WEST DRAINAGE WATERSHED

SCALE: 1" = 200'

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	BY	CHK	APP	REV	DATE	DESCRIPTION	BY	CHK	APP
							B	12/05/2018	2018 UPDATE	DS	HD	JP
							A	10/6/2016	FILED IN OWNER'S OPERATING RECORD	AM	DS	JP



J.H. CAMPBELL ASH STORAGE FACILITY

LANDFILL CLOSURE PLAN
PROBABLE FILL PROGRESSION CONDITIONS

SCALE 1" = 200'	DRAWING NO.	FIGURE	UNIT#
JOB 1810379		2	A

APPENDIX A

Rainfall Data



NOAA Atlas 14, Volume 8, Version 2
Location name: West Olive, Michigan, USA*
Latitude: 42.9147°, Longitude: -86.1836°
Elevation: 609.22 ft**
 * source: ESRI Maps
 ** source: USGS



POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

[PF_tabular](#) | [PF_graphical](#) | [Maps & aeriels](#)

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 (0.251-0.383)	0.362 (0.295-0.451)	0.458 (0.372-0.572)	0.544 (0.439-0.682)	0.670 (0.525-0.877)	0.775 (0.590-1.02)	0.885 (0.648-1.20)	1.00 (0.702-1.39)	1.17 (0.784-1.66)	1.30 (0.845-1.87)
10-min	0.450 (0.367-0.560)	0.530 (0.432-0.661)	0.671 (0.545-0.838)	0.796 (0.642-0.999)	0.981 (0.768-1.28)	1.13 (0.863-1.50)	1.30 (0.949-1.75)	1.47 (1.03-2.04)	1.71 (1.15-2.43)	1.91 (1.24-2.73)
15-min	0.548 (0.447-0.683)	0.646 (0.527-0.806)	0.818 (0.664-1.02)	0.971 (0.783-1.22)	1.20 (0.937-1.57)	1.38 (1.05-1.83)	1.58 (1.16-2.14)	1.79 (1.25-2.48)	2.09 (1.40-2.97)	2.33 (1.51-3.33)
30-min	0.767 (0.626-0.956)	0.907 (0.739-1.13)	1.15 (0.935-1.44)	1.37 (1.10-1.72)	1.69 (1.32-2.21)	1.96 (1.49-2.59)	2.24 (1.64-3.03)	2.54 (1.78-3.52)	2.96 (1.98-4.21)	3.30 (2.14-4.73)
60-min	0.999 (0.815-1.25)	1.18 (0.960-1.47)	1.50 (1.21-1.87)	1.78 (1.44-2.24)	2.22 (1.74-2.91)	2.58 (1.97-3.42)	2.97 (2.18-4.03)	3.39 (2.38-4.71)	3.99 (2.68-5.68)	4.47 (2.90-6.41)
2-hr	1.23 (1.01-1.52)	1.45 (1.19-1.79)	1.84 (1.51-2.28)	2.20 (1.79-2.73)	2.75 (2.17-3.58)	3.21 (2.47-4.22)	3.71 (2.74-4.98)	4.25 (3.00-5.85)	5.02 (3.39-7.09)	5.64 (3.69-8.02)
3-hr	1.38 (1.14-1.70)	1.62 (1.34-1.99)	2.06 (1.69-2.53)	2.47 (2.01-3.05)	3.09 (2.47-4.02)	3.63 (2.81-4.76)	4.22 (3.14-5.65)	4.86 (3.45-6.67)	5.77 (3.93-8.13)	6.52 (4.29-9.24)
6-hr	1.65 (1.38-2.01)	1.93 (1.60-2.34)	2.44 (2.03-2.98)	2.94 (2.42-3.60)	3.72 (3.00-4.81)	4.39 (3.43-5.72)	5.13 (3.86-6.84)	5.96 (4.27-8.14)	7.15 (4.91-10.0)	8.13 (5.39-11.4)
12-hr	1.95 (1.63-2.34)	2.26 (1.89-2.71)	2.85 (2.38-3.44)	3.43 (2.85-4.16)	4.36 (3.55-5.60)	5.17 (4.08-6.70)	6.08 (4.61-8.04)	7.08 (5.13-9.61)	8.55 (5.92-11.9)	9.76 (6.52-13.6)
24-hr	2.26 (1.91-2.68)	2.60 (2.20-3.09)	3.26 (2.75-3.89)	3.91 (3.28-4.69)	4.97 (4.09-6.33)	5.90 (4.70-7.57)	6.94 (5.31-9.11)	8.10 (5.92-10.9)	9.81 (6.86-13.5)	11.2 (7.56-15.5)
2-day	2.60 (2.22-3.06)	2.96 (2.53-3.49)	3.67 (3.12-4.34)	4.37 (3.69-5.19)	5.51 (4.57-6.95)	6.52 (5.23-8.28)	7.64 (5.90-9.94)	8.91 (6.56-11.9)	10.8 (7.58-14.7)	12.3 (8.36-16.9)
3-day	2.85 (2.45-3.34)	3.22 (2.77-3.78)	3.95 (3.38-4.64)	4.67 (3.97-5.51)	5.83 (4.86-7.30)	6.86 (5.53-8.66)	8.00 (6.20-10.3)	9.28 (6.87-12.3)	11.2 (7.90-15.2)	12.7 (8.68-17.4)
4-day	3.06 (2.64-3.57)	3.45 (2.97-4.02)	4.19 (3.60-4.90)	4.92 (4.20-5.78)	6.09 (5.09-7.58)	7.12 (5.76-8.94)	8.27 (6.43-10.6)	9.54 (7.08-12.6)	11.4 (8.10-15.5)	12.9 (8.87-17.6)
7-day	3.57 (3.10-4.13)	4.01 (3.47-4.63)	4.82 (4.16-5.58)	5.58 (4.79-6.50)	6.77 (5.67-8.30)	7.79 (6.33-9.66)	8.92 (6.97-11.3)	10.2 (7.57-13.3)	11.9 (8.52-16.0)	13.4 (9.24-18.1)
10-day	4.05 (3.53-4.65)	4.53 (3.94-5.21)	5.39 (4.68-6.22)	6.19 (5.33-7.17)	7.40 (6.20-8.98)	8.42 (6.86-10.3)	9.53 (7.47-12.0)	10.7 (8.03-13.9)	12.4 (8.91-16.6)	13.8 (9.58-18.6)
20-day	5.50 (4.84-6.25)	6.11 (5.36-6.95)	7.14 (6.25-8.15)	8.04 (6.99-9.22)	9.34 (7.85-11.1)	10.4 (8.50-12.5)	11.5 (9.04-14.2)	12.6 (9.48-16.1)	14.2 (10.2-18.6)	15.4 (10.8-20.6)
30-day	6.76 (5.97-7.63)	7.49 (6.61-8.47)	8.69 (7.64-9.85)	9.69 (8.47-11.0)	11.1 (9.34-13.0)	12.2 (10.0-14.5)	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 (7.45-9.41)	9.28 (8.24-10.4)	10.7 (9.48-12.1)	11.9 (10.4-13.4)	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	9.79 (8.74-10.9)	10.8 (9.66-12.1)	12.5 (11.1-14.0)	13.8 (12.2-15.6)	15.5 (13.1-17.9)	16.7 (13.8-19.7)	17.9 (14.3-21.7)	19.0 (14.5-23.7)	20.4 (14.9-26.3)	21.4 (15.2-28.2)

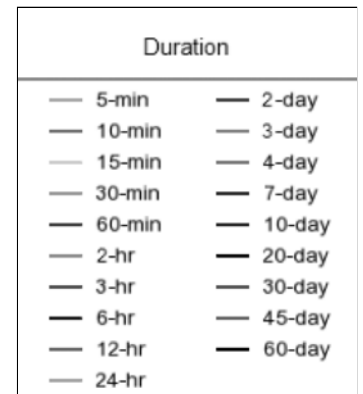
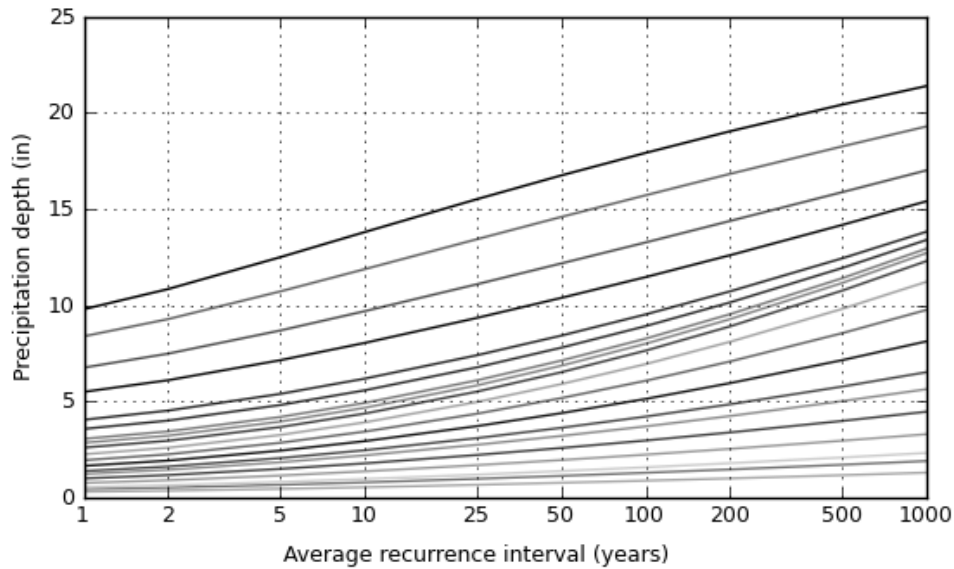
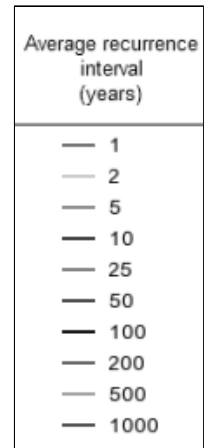
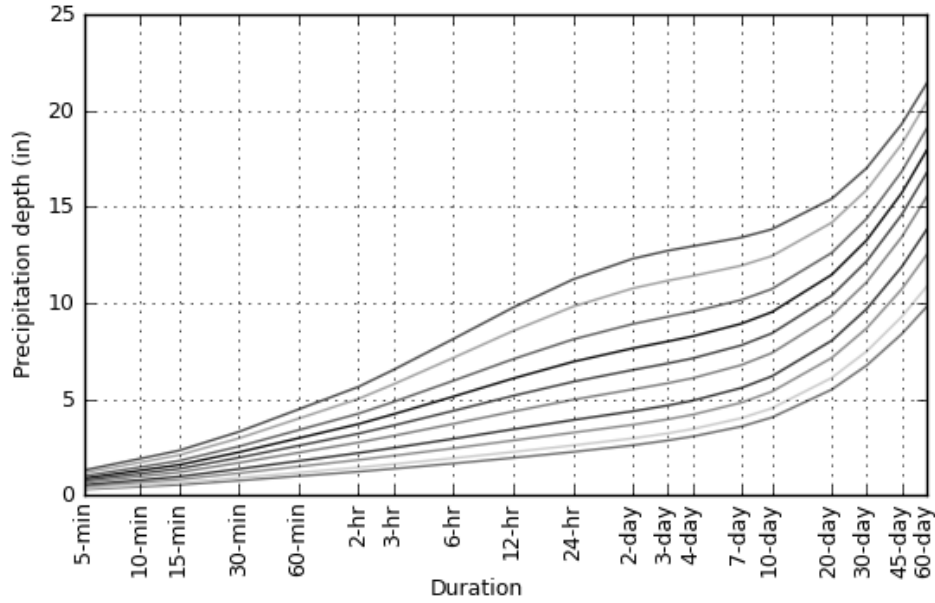
¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average 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

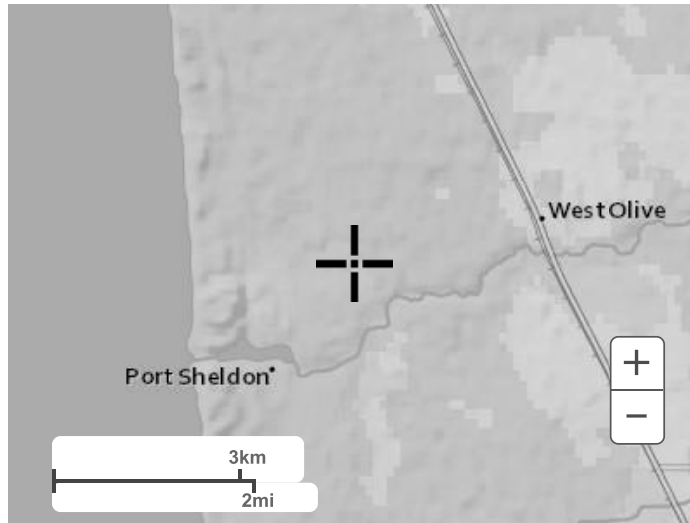
PDS-based depth-duration-frequency (DDF) curves

Latitude: 42.9147°, Longitude: -86.1836°

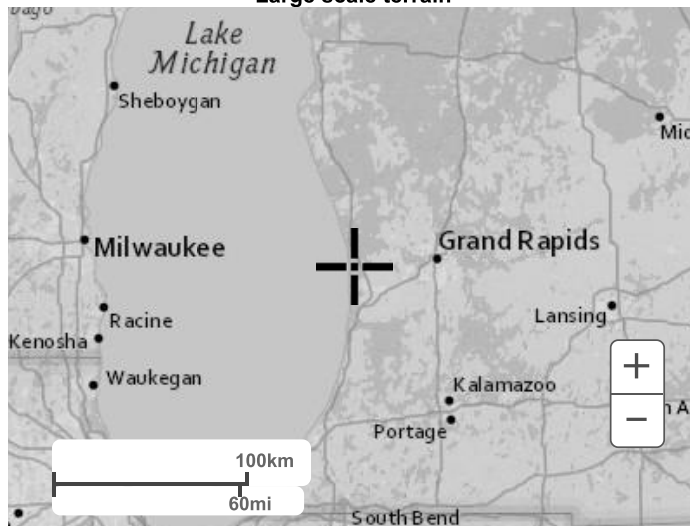


Maps & aerials

Small scale terrain



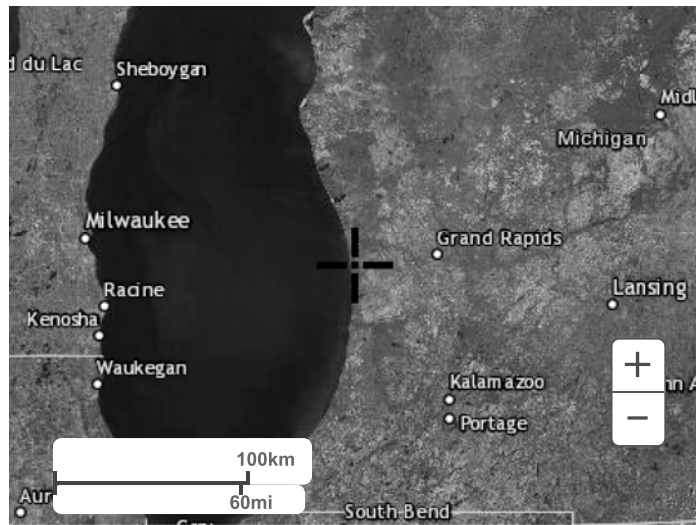
Large scale terrain



Large scale map



Large scale aerial



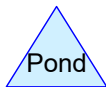
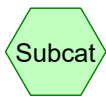
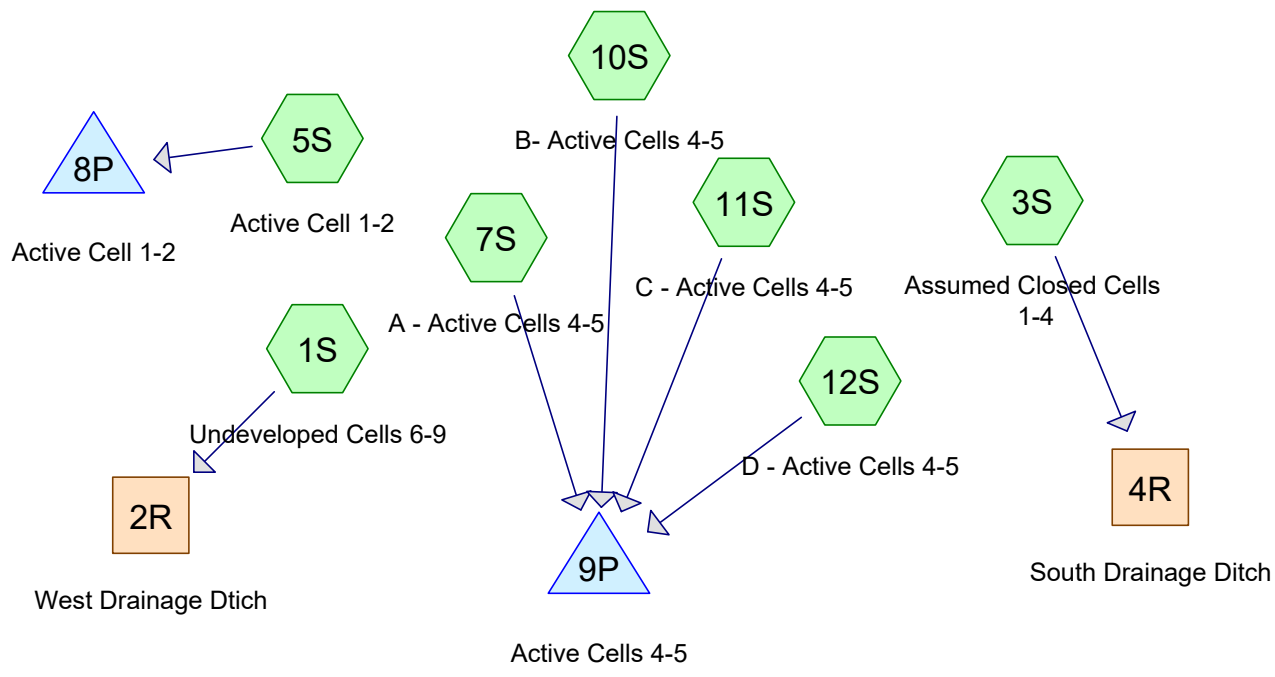
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APPENDIX B

**Hydrologic and Hydraulic Model
Output**



Run-On& Run-Off System

Prepared by Golder Associates

HydroCAD® 10.00-20 s/n 10215 © 2017 HydroCAD Software Solutions LLC

Printed 11/9/2018

Page 2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
77.380	79	50-75% Grass cover, Fair, HSG C (1S, 3S)
23.950	79	fly ash (5S, 10S, 11S)
3.600	78	fly ash and sand (7S)
0.300	77	sand (12S)
105.230	79	TOTAL AREA

Run-On& Run-Off System

Prepared by Golder Associates

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Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
77.380	HSG C	1S, 3S
0.000	HSG D	
27.850	Other	5S, 7S, 10S, 11S, 12S
105.230		TOTAL AREA

Run-On& Run-Off System

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Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	77.380	0.000	0.000	77.380	50-75% Grass cover, Fair	1S, 3S
0.000	0.000	0.000	0.000	23.950	23.950	fly ash	5S, 10S, 11S
0.000	0.000	0.000	0.000	3.600	3.600	fly ash and sand	7S
0.000	0.000	0.000	0.000	0.300	0.300	sand	12S
0.000	0.000	77.380	0.000	27.850	105.230	TOTAL AREA	

Run-On& Run-Off System

Prepared by Golder Associates

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Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	7S	0.00	0.00	850.0	0.0150	0.012	8.0	0.0	0.0
2	7S	0.00	0.00	68.0	0.0150	0.012	8.0	0.0	0.0
3	10S	0.00	0.00	428.0	0.0150	0.022	8.0	0.0	0.0
4	11S	0.00	0.00	426.0	0.0120	0.010	8.0	0.0	0.0

Run-On& Run-Off System

Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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

Subcatchment 1S: Undeveloped Cells 6-9 Runoff Area=27.200 ac 0.00% Impervious Runoff Depth>2.76"
Flow Length=544' Slope=0.0200 '/' Tc=17.2 min CN=79 Runoff=90.68 cfs 6.266 af

Subcatchment 3S: Assumed Closed Cells Runoff Area=50.180 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=948' Tc=13.7 min CN=79 Runoff=186.78 cfs 11.571 af

Subcatchment 5S: Active Cell 1-2 Runoff Area=16.400 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=1,671' Tc=10.3 min CN=79 Runoff=67.98 cfs 3.785 af

Subcatchment 7S: A - Active Cells 4-5 Runoff Area=3.600 ac 0.00% Impervious Runoff Depth>2.68"
Flow Length=1,158' Tc=4.4 min CN=78 Runoff=17.77 cfs 0.805 af

Subcatchment 10S: B - Active Cells 4-5 Runoff Area=3.000 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=672' Tc=5.5 min CN=79 Runoff=14.55 cfs 0.693 af

Subcatchment 11S: C - Active Cells 4-5 Runoff Area=4.550 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=1,120' Tc=6.0 min CN=79 Runoff=21.61 cfs 1.051 af

Subcatchment 12S: D - Active Cells 4-5 Runoff Area=0.300 ac 0.00% Impervious Runoff Depth>2.60"
Flow Length=165' Tc=1.9 min CN=77 Runoff=1.48 cfs 0.065 af

Reach 2R: West Drainage Ditch Avg. Flow Depth=2.78' Max Vel=2.49 fps Inflow=90.68 cfs 6.266 af
n=0.030 L=1,868.0' S=0.0013 '/' Capacity=78.12 cfs Outflow=65.89 cfs 6.173 af

Reach 4R: South Drainage Ditch Avg. Flow Depth=2.12' Max Vel=4.10 fps Inflow=186.78 cfs 11.571 af
n=0.030 L=4,956.0' S=0.0040 '/' Capacity=2,681.96 cfs Outflow=105.57 cfs 11.266 af

Pond 8P: Active Cell 1-2 Peak Elev=615.74' Storage=3.397 af Inflow=67.98 cfs 3.785 af
Outflow=0.30 cfs 0.387 af

Pond 9P: Active Cells 4-5 Peak Elev=613.69' Storage=2.221 af Inflow=54.98 cfs 2.615 af
Outflow=0.32 cfs 0.393 af

Total Runoff Area = 105.230 ac Runoff Volume = 24.237 af Average Runoff Depth = 2.76"
100.00% Pervious = 105.230 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Undeveloped Cells 6-9

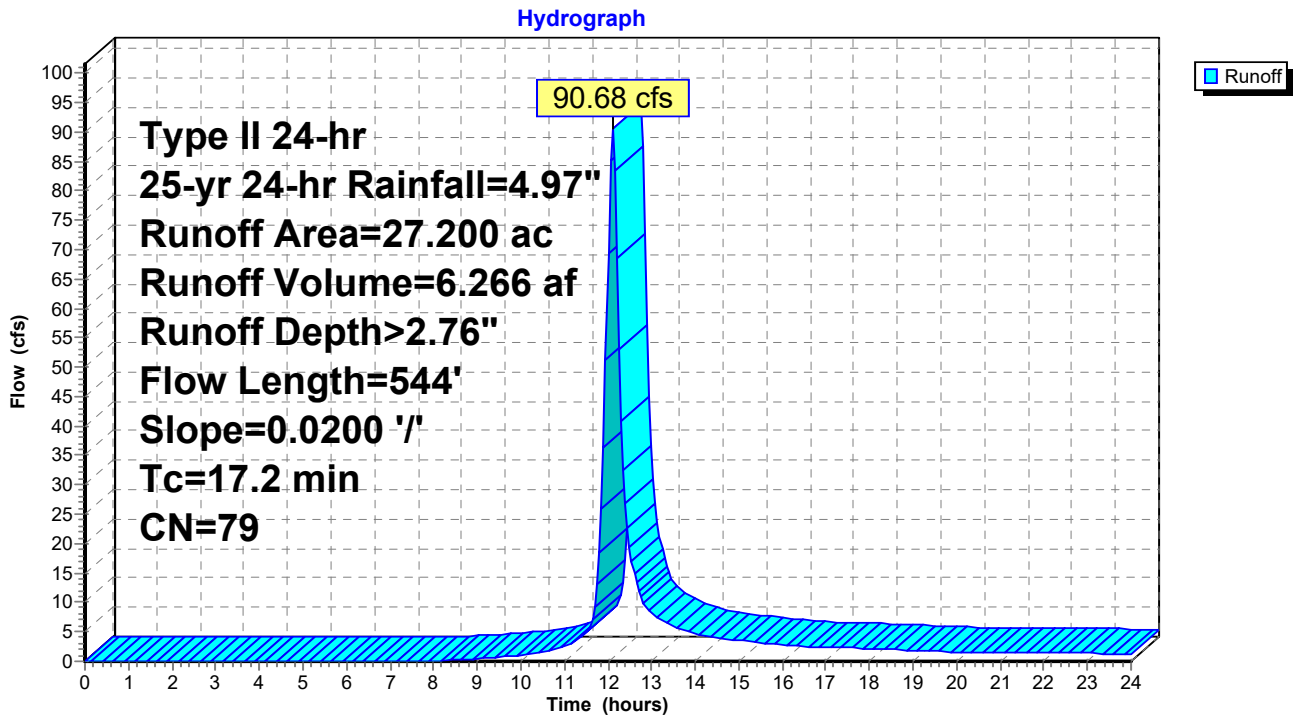
Runoff = 90.68 cfs @ 12.10 hrs, Volume= 6.266 af, Depth> 2.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
27.200	79	50-75% Grass cover, Fair, HSG C
27.200		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.7	100	0.0200	0.17		Sheet Flow, Range n= 0.130 P2= 2.60"
7.5	444	0.0200	0.99		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
17.2	544	Total			

Subcatchment 1S: Undeveloped Cells 6-9



Summary for Subcatchment 3S: Assumed Closed Cells 1-4

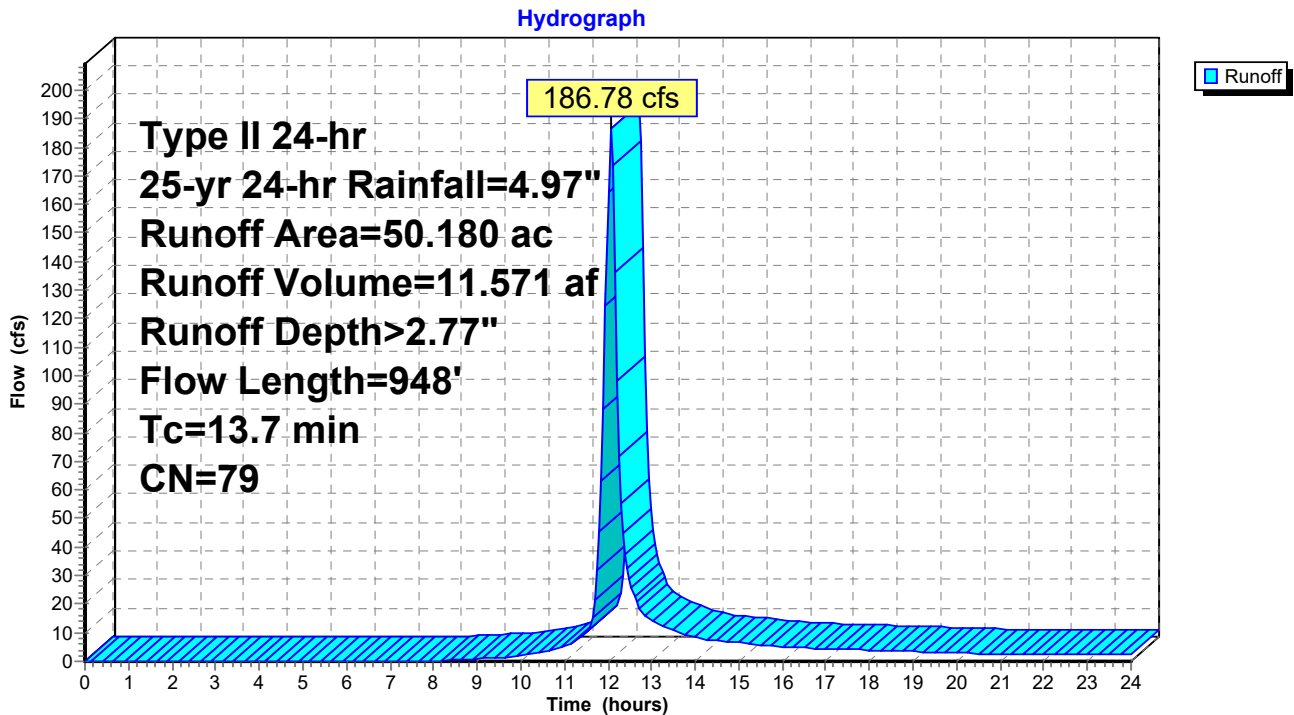
Runoff = 186.78 cfs @ 12.06 hrs, Volume= 11.571 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
50.180	79	50-75% Grass cover, Fair, HSG C
50.180		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.7	100	0.0200	0.17		Sheet Flow, Range n= 0.130 P2= 2.60"
4.0	848	0.2500	3.50		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
13.7	948	Total			

Subcatchment 3S: Assumed Closed Cells 1-4



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Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Subcatchment 5S: Active Cell 1-2

Runoff = 67.98 cfs @ 12.02 hrs, Volume= 3.785 af, Depth> 2.77"

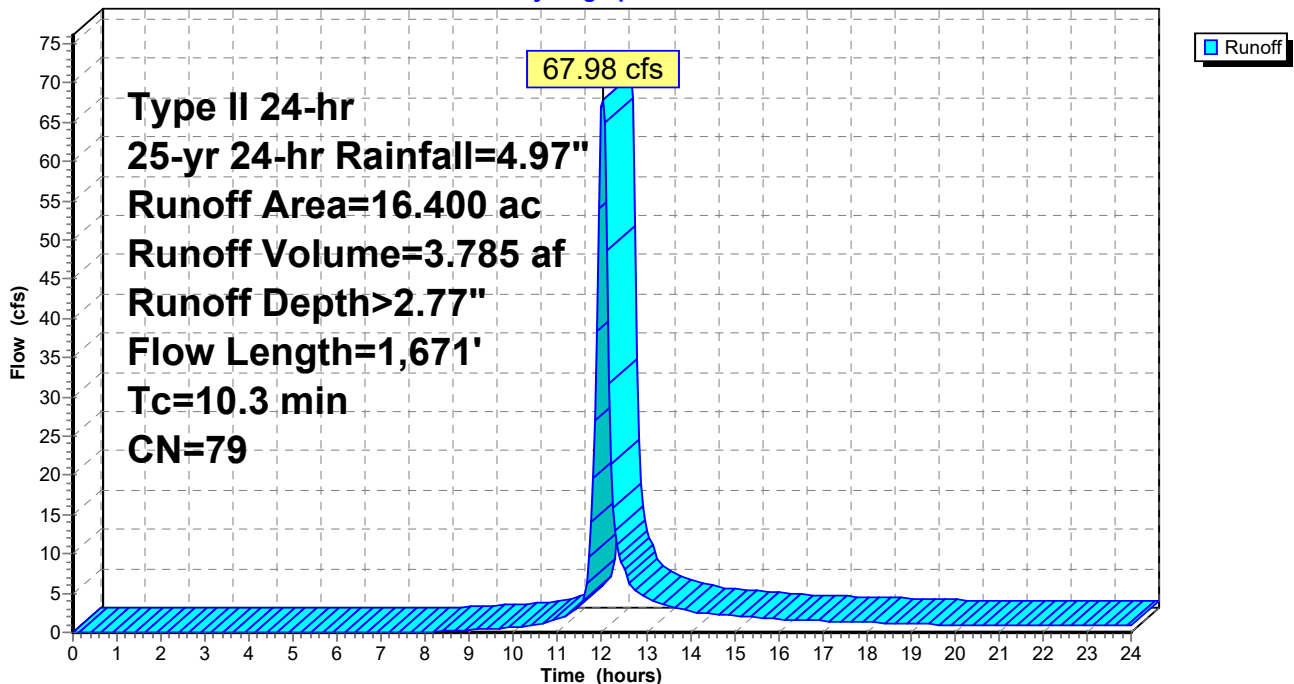
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
* 16.400	79	fly ash
16.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.6	100	0.2500	1.01		Sheet Flow, Fallow n= 0.050 P2= 2.60"
0.2	100	0.2500	8.05		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.5	1,471	0.0200	2.87		Shallow Concentrated Flow, Paved Kv= 20.3 fps
10.3	1,671	Total			

Subcatchment 5S: Active Cell 1-2

Hydrograph



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Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Subcatchment 7S: A - Active Cells 4-5

[49] Hint: $T_c < 2dt$ may require smaller dt

Runoff = 17.77 cfs @ 11.95 hrs, Volume= 0.805 af, Depth> 2.68"

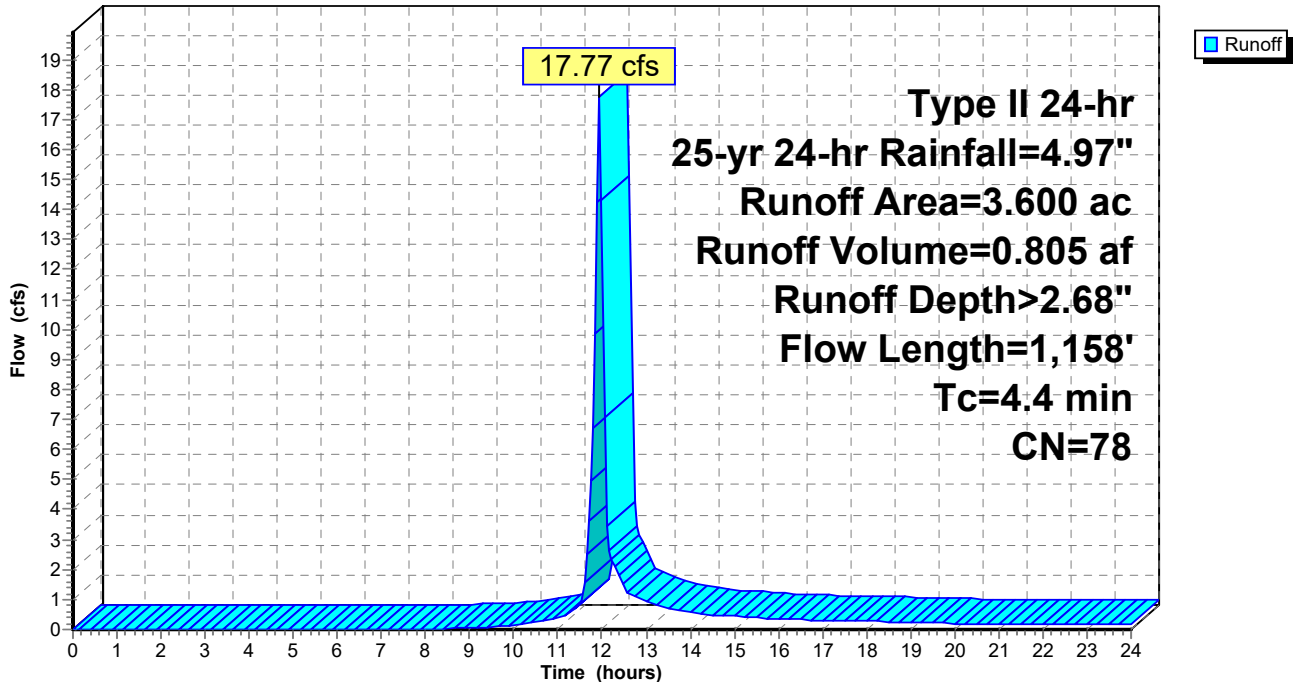
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
* 3.600	78	fly ash and sand
3.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	160	0.3330	4.20		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
0.5	80	0.0250	2.55		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
3.1	850	0.0150	4.59	1.60	Pipe Channel, 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.012
0.2	68	0.0150	4.59	1.60	Pipe Channel, 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.012
4.4	1,158	Total			

Subcatchment 7S: A - Active Cells 4-5

Hydrograph



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Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Subcatchment 10S: B- Active Cells 4-5

[49] Hint: $T_c < 2dt$ may require smaller dt

Runoff = 14.55 cfs @ 11.96 hrs, Volume= 0.693 af, Depth> 2.77"

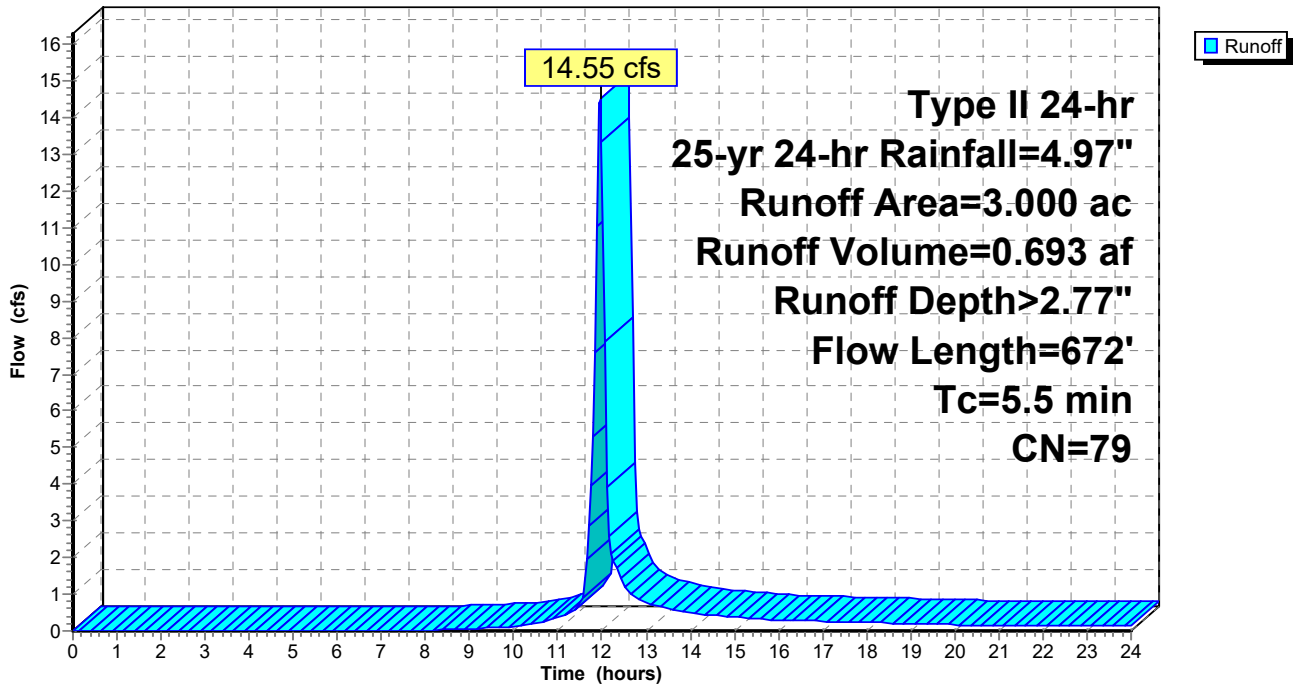
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
* 3.000	79	fly ash
3.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	244	0.0200	1.48		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
2.8	428	0.0150	2.51	0.87	Pipe Channel, 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.022 Earth, clean & straight
5.5	672	Total			

Subcatchment 10S: B- Active Cells 4-5

Hydrograph



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Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Subcatchment 11S: C - Active Cells 4-5

Runoff = 21.61 cfs @ 11.97 hrs, Volume= 1.051 af, Depth> 2.77"

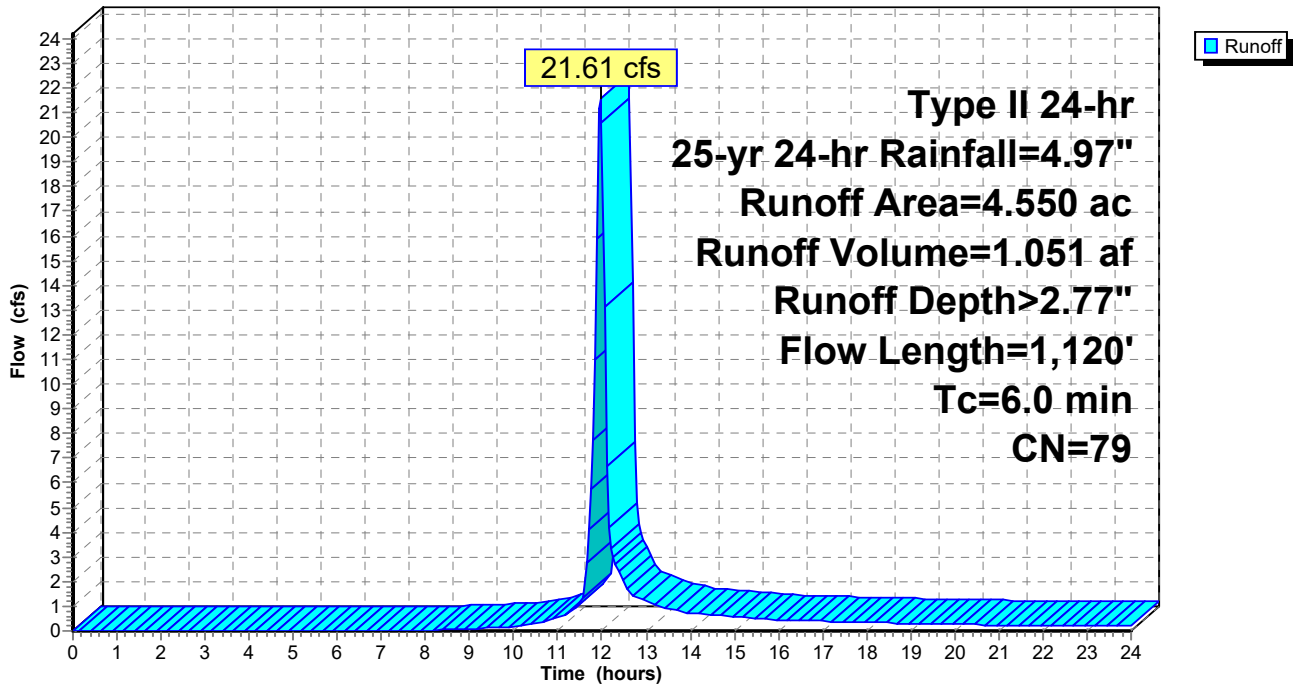
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
* 4.550	79	fly ash
4.550		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.2	300	0.0200	1.54		Sheet Flow, Smooth surfaces n= 0.011 P2= 2.60"
1.1	191	0.0200	2.87		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.3	203	0.2500	10.15		Shallow Concentrated Flow, Paved Kv= 20.3 fps
1.4	426	0.0120	4.93	1.72	Pipe Channel, 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.010 PVC, smooth interior
6.0	1,120	Total			

Subcatchment 11S: C - Active Cells 4-5

Hydrograph



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Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Subcatchment 12S: D - Active Cells 4-5

[49] Hint: $T_c < 2dt$ may require smaller dt

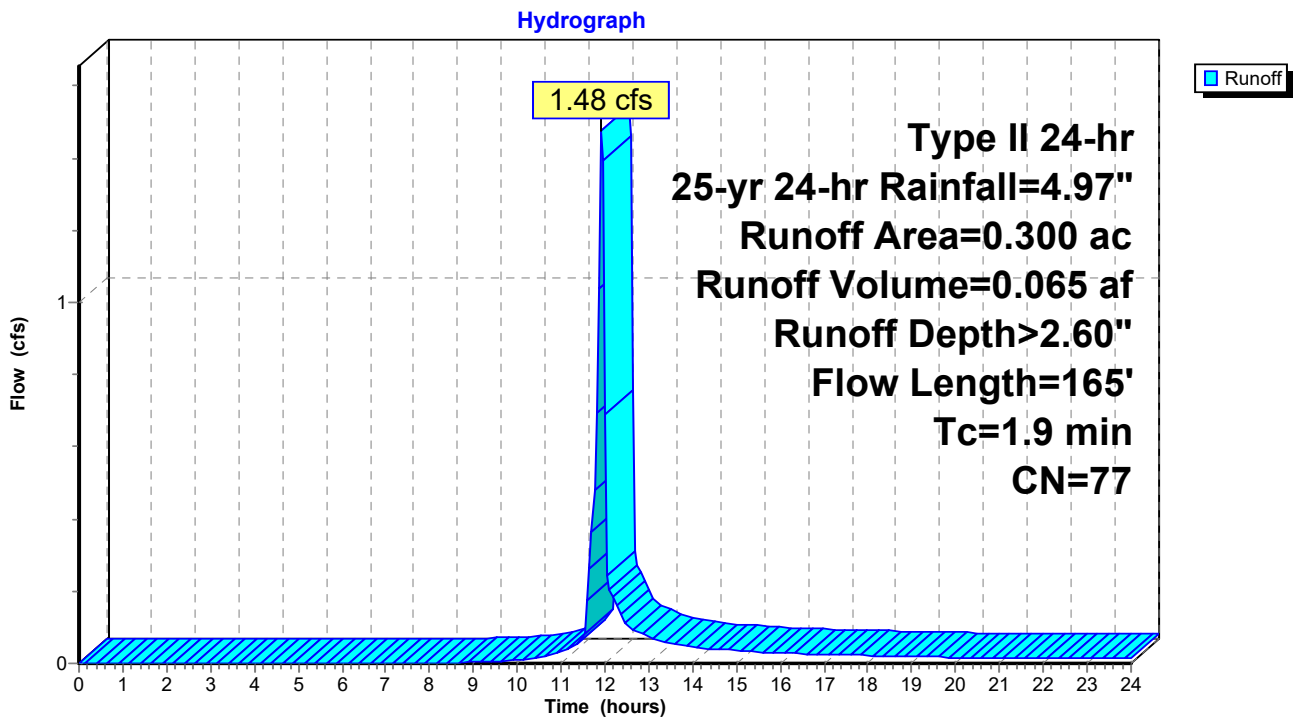
Runoff = 1.48 cfs @ 11.92 hrs, Volume= 0.065 af, Depth> 2.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
* 0.300	77	sand
0.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	72	0.3330	1.07		Sheet Flow, Fallow n= 0.050 P2= 2.60"
0.8	93	0.0150	1.97		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.9	165	Total			

Subcatchment 12S: D - Active Cells 4-5



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Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Reach 2R: West Drainage Ditch

[55] Hint: Peak inflow is 116% of Manning's capacity

Inflow Area = 27.200 ac, 0.00% Impervious, Inflow Depth > 2.76" for 25-yr 24-hr event
Inflow = 90.68 cfs @ 12.10 hrs, Volume= 6.266 af
Outflow = 65.89 cfs @ 12.42 hrs, Volume= 6.173 af, Atten= 27%, Lag= 19.4 min

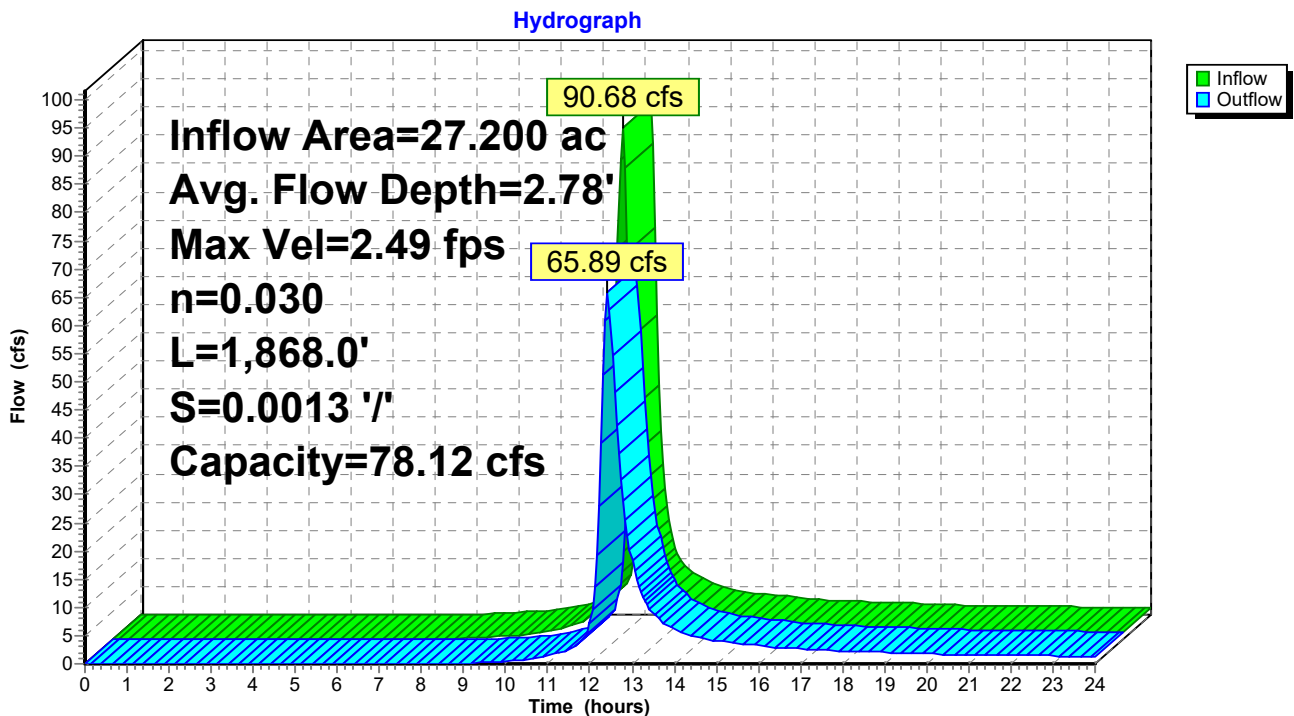
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.49 fps, Min. Travel Time= 12.5 min
Avg. Velocity = 0.95 fps, Avg. Travel Time= 32.8 min

Peak Storage= 49,585 cf @ 12.21 hrs
Average Depth at Peak Storage= 2.78'
Bank-Full Depth= 3.00' Flow Area= 30.0 sf, Capacity= 78.12 cfs

4.00' x 3.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 16.00'
Length= 1,868.0' Slope= 0.0013 '/'
Inlet Invert= 606.00', Outlet Invert= 603.50'



Reach 2R: West Drainage Ditch



Run-On& Run-Off System

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Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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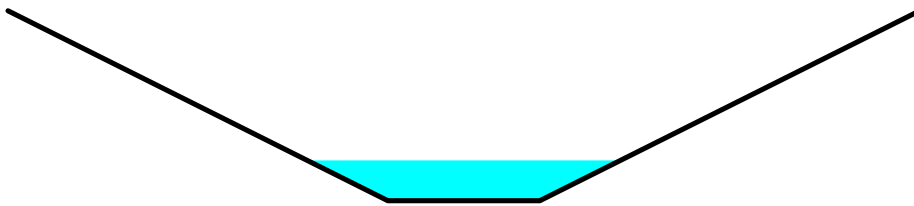
Summary for Reach 4R: South Drainage Ditch

Inflow Area = 50.180 ac, 0.00% Impervious, Inflow Depth > 2.77" for 25-yr 24-hr event
Inflow = 186.78 cfs @ 12.06 hrs, Volume= 11.571 af
Outflow = 105.57 cfs @ 12.53 hrs, Volume= 11.266 af, Atten= 43%, Lag= 28.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.10 fps, Min. Travel Time= 20.2 min
Avg. Velocity = 1.49 fps, Avg. Travel Time= 55.5 min

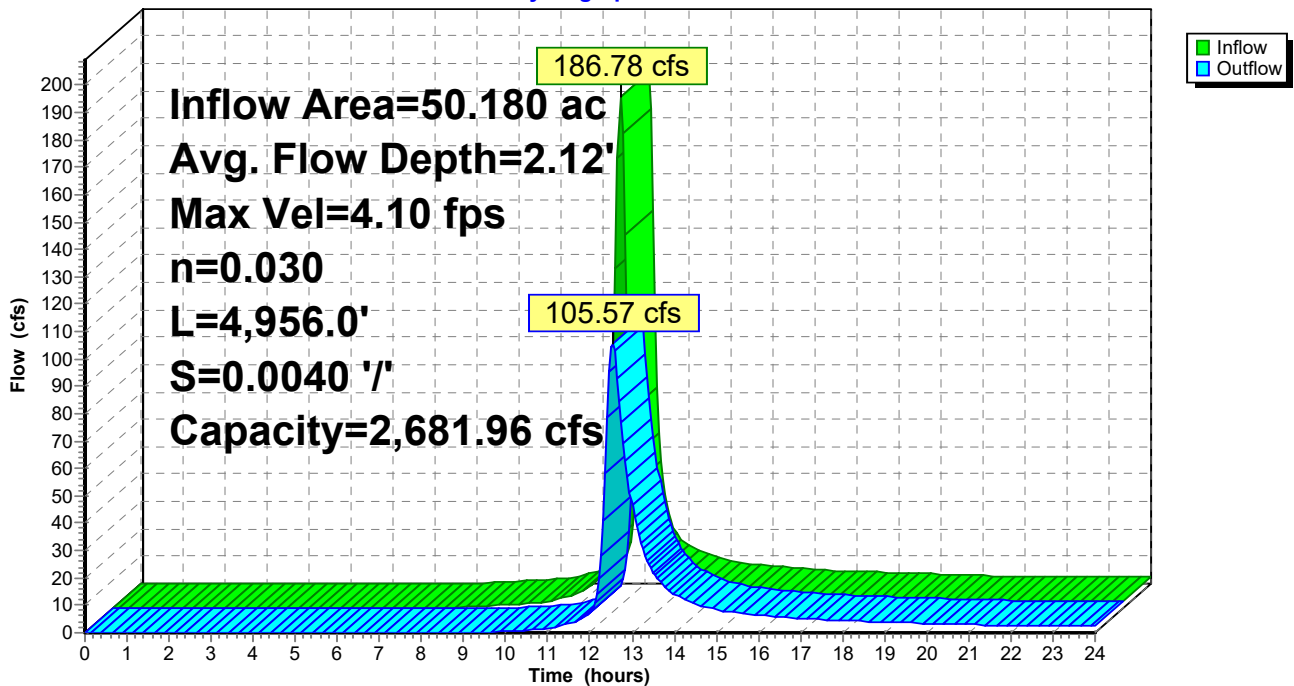
Peak Storage= 128,661 cf @ 12.19 hrs
Average Depth at Peak Storage= 2.12'
Bank-Full Depth= 10.00' Flow Area= 280.0 sf, Capacity= 2,681.96 cfs

8.00' x 10.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 48.00'
Length= 4,956.0' Slope= 0.0040 '/'
Inlet Invert= 610.00', Outlet Invert= 590.00'



Reach 4R: South Drainage Ditch

Hydrograph



Run-On& Run-Off System

Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Pond 8P: Active Cell 1-2

Inflow Area = 16.400 ac, 0.00% Impervious, Inflow Depth > 2.77" for 25-yr 24-hr event
 Inflow = 67.98 cfs @ 12.02 hrs, Volume= 3.785 af
 Outflow = 0.30 cfs @ 9.05 hrs, Volume= 0.387 af, Atten= 100%, Lag= 0.0 min
 Primary = 0.30 cfs @ 9.05 hrs, Volume= 0.387 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 615.74' @ 24.00 hrs Surf.Area= 1.360 ac Storage= 3.397 af

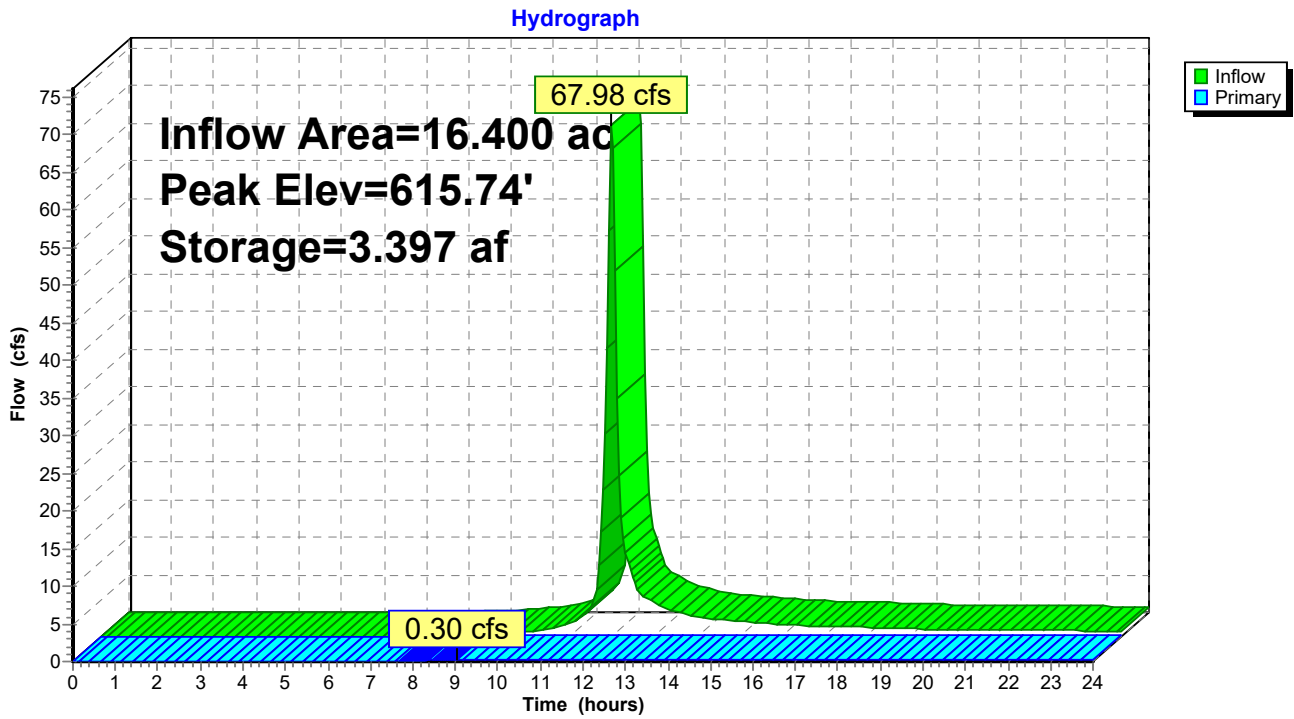
Plug-Flow detention time= 313.6 min calculated for 0.386 af (10% of inflow)
 Center-of-Mass det. time= 149.3 min (973.4 - 824.2)

Volume	Invert	Avail.Storage	Storage Description
#1	610.00'	3.761 af	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
610.00	0.009	0.000	0.000
611.00	0.105	0.057	0.057
612.00	0.381	0.243	0.300
613.00	0.596	0.488	0.788
614.00	0.832	0.714	1.502
615.00	1.121	0.977	2.479
616.00	1.444	1.282	3.761

Device	Routing	Invert	Outlet Devices
#1	Primary	610.00'	0.30 cfs Exfiltration when above 610.00'

Primary OutFlow Max=0.30 cfs @ 9.05 hrs HW=610.06' (Free Discharge)
 ↑1=Exfiltration (Exfiltration Controls 0.30 cfs)

Pond 8P: Active Cell 1-2



Run-On& Run-Off System

Type II 24-hr 25-yr 24-hr Rainfall=4.97"

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Summary for Pond 9P: Active Cells 4-5

Inflow Area = 11.450 ac, 0.00% Impervious, Inflow Depth > 2.74" for 25-yr 24-hr event
 Inflow = 54.98 cfs @ 11.96 hrs, Volume= 2.615 af
 Outflow = 0.32 cfs @ 10.05 hrs, Volume= 0.393 af, Atten= 99%, Lag= 0.0 min
 Primary = 0.32 cfs @ 10.05 hrs, Volume= 0.393 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 613.69' @ 24.00 hrs Surf.Area= 0.000 ac Storage= 2.221 af

Plug-Flow detention time= 321.4 min calculated for 0.392 af (15% of inflow)
 Center-of-Mass det. time= 173.4 min (994.7 - 821.3)

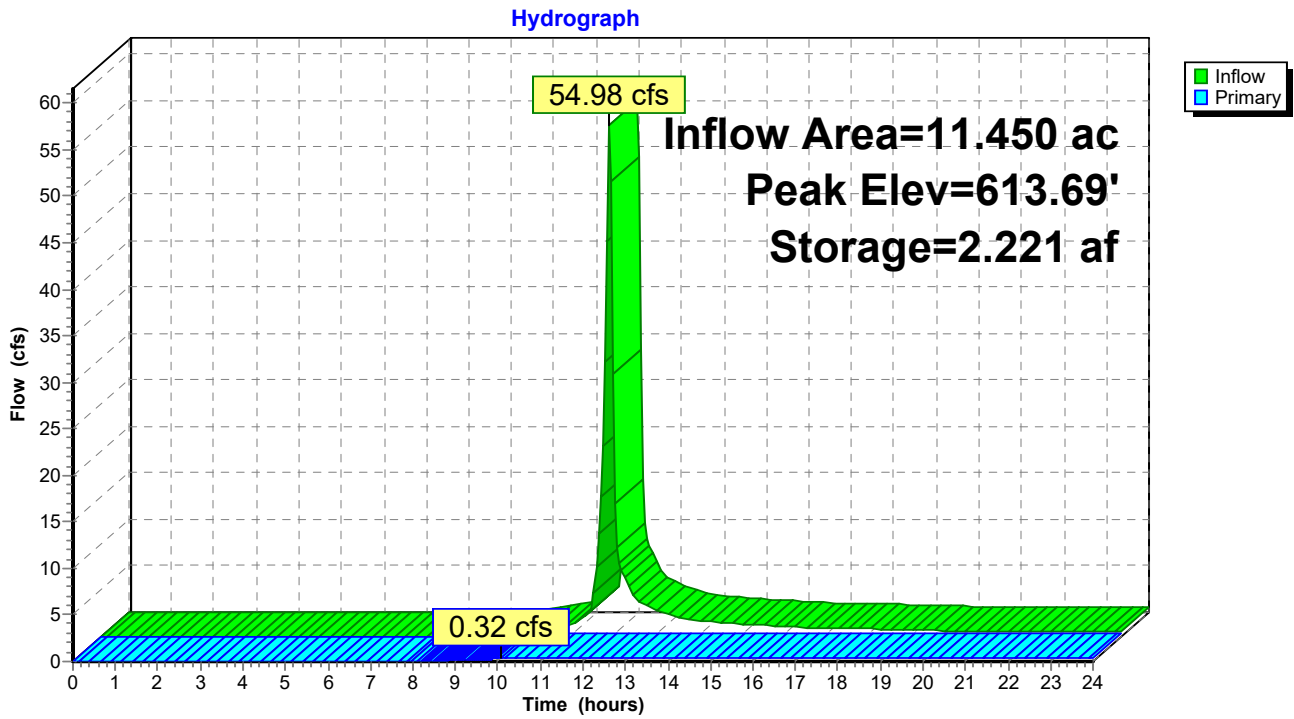
Volume	Invert	Avail.Storage	Storage Description
#1	609.00'	4.700 af	Custom Stage Data Listed below

Elevation (feet)	Cum.Store (acre-feet)
609.00	0.000
610.00	0.200
611.00	0.500
612.00	1.000
613.00	1.600
614.00	2.500
615.00	3.500
616.00	4.700

Device	Routing	Invert	Outlet Devices
#1	Primary	609.00'	0.32 cfs Exfiltration when above 609.00'

Primary OutFlow Max=0.32 cfs @ 10.05 hrs HW=609.07' (Free Discharge)
 ↑1=Exfiltration (Exfiltration Controls 0.32 cfs)

Pond 9P: Active Cells 4-5





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