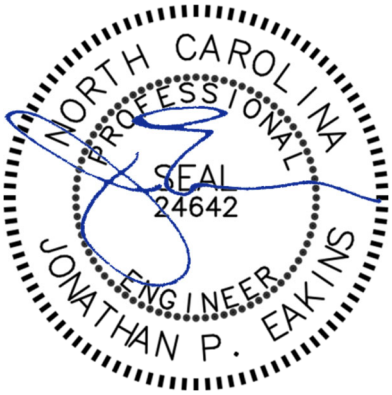
STORMWATER CALCULATIONS

401 WEST GANNON AVENUE

Zebulon, North Carolina

July 10, 2023
Revised September 13, 2023
Revised December 20, 2023



Prepared By:
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INTRODUCTION AND GENERAL INFORMATION

This report presents calculations for the stormwater impacts for the proposed 401 West Gannon Avenue project located at the intersection of West Gannon Avenue and North Rotary Drive in Zebulon, North Carolina.

The proposed development is comprised of approximately 0.99 acres of land and is currently vacant. At full build out the project will consist of 11 condominium units with infrastructure to support the proposed development as well as one SCM to meet the Town's stormwater requirements.

REQUIREMENTS

Sections 151.35.D and 151.36 of the Zebulon Code of Ordinances specify the stormwater requirements for high density development. The relevant requirements of the Code are summarized below:

- The measures shall control and treat runoff from the first inch of rain. Runoff volume drawdown time shall be a minimum of 48 hours, but not more than 120 hours.
- All structural stormwater treatment systems used to meet these requirements shall be designed to have a minimum of 85% average annual removal for total suspended solids (TSS).
- All development and redevelopment projects shall provide permanent on-site BMPs to lower the nitrogen export amounts as part of the stormwater management plan and accompany the land-disturbing plan submittal. BMPs are to be in accordance with and as specified in the Design Manual.
- Structural and non-structural BMPs shall be used to ensure there is no net increase in peak flow leaving the site from the pre-development conditions for the one-year, 24-hour storm. Runoff volume drawdown time shall be a minimum of 48 hours, but not more than 120 hours.
- The downstream impact analysis must be performed in accordance with the "10% rule"

METHODOLOGY

Drainage Areas and SCS Curve Numbers

Drainage areas were delineated based on proposed and existing topography using CAD software. Land use types were measured using CAD software and SCS curve numbers were applied to each land use type within the drainage area to calculate a weighted, composite SCS Curve Number. Curve numbers for the various land use types were taken from NRCS TR-55 and are included as an appendix to this report.

Drainage areas, curve number, times of concentration as well as design pond contour data for the overall drainage area to the analysis point and SCM bypass are the same as those presented in the design calculations for the preliminary plat.

Times of Concentration

The minimum time of concentration used for calculation of peak flows was 5 minutes. For times of concentration more than 5 minutes, a simplified TR-55 method was used. The simplified method calculates the time of concentration only using sheet flow time and channel flow time – shallow concentrated flow time is disregarded. Since channel dimensions vary along the channel flow path,

channel parameters were selected for the entire length of channel flow that yield a flow velocity of approximately 4.5 feet per second. A flow velocity of 4.5 feet per second is greater than or equal to actual flow velocities expected in the pipes or open channels along the flow path and therefore will yield a runoff higher than what would be expected at the analysis point.

Runoff and Pond Routing

Runoff flowrates and volumes for the proposed SCM were calculated using the Hydrology Studio software program. The software utilizes the SCS Methodology to determine peak flow rates and performs routing calculations to determine detention results by the Storage-Indication method.

Rainfall Depths

The following rainfall depths used in the calculations for this report were taken from the NOAA Precipitation Frequency Data Server (PFDS). A printout of this rainfall data is included as an appendix to this report.

Rainfall event	Rainfall Depth (inches)
1-year, 24-hour	2.83
2-year, 24-hour	3.42
10-year, 24-hour	4.94
25-year, 24-hour	5.84
100-year, 24-hour	7.27

Notes:

1. Only the 1-year and 10-year rainfall events were analyzed for runoff flowrates. Additional rainfall events were used to check for pond overtopping.

Pre-Development and Post-Development Drainage Areas

Drainage area maps showing the pre-development and post-development drainage areas are included as an attachment to this report. Note that the drainage areas are based on GIS topography.

RESULTS

Peak Flow Attenuation

Peak flow attenuation is required for the 1-year, 24-hour storm and 10-year 24-hour storm. The tables below summarize the pre-development and post-development data for these design storms. Detailed routing information can be found in the appendix to this report.

Project Site					
Development condition	Drainage area (acres)	SCS CN	Time of concentration (min(	Q(1) cfs	Q10 (cfs)
Pre-Development discharge	0.99	61	5.0	0.4	2.4
Post-Development SCM bypass	0.31	68	5.0	0.3	1.1
Post-Development to SCM	0.69	80	5.0	1.4	3.6
Post-Development SCM outflow				0.1	0.1
Post-Development discharge				0.3	2.0

SCM Surface Area

The required bioretention surface area was determined based on a maximum ponding depth of 12 inches and a volume determined by the simple method. The SCM surface area data is summarized in the table below.

Drainage area	0.69 acres
Impervious area	0.36 acres
Impervious percentage	52.3%
Runoff volume	1,298 CF
Ponding depth	12 inches
Required bioretention area	1,298 SF
Bioretention area provided	1,603 SF

SCM surface area calculations are included in the Appendix to this report.

Riser Anti-Flotation Device

An anti-flotation device was designed to counteract the buoyant forces on the pond riser. The riser anti-flotation block was sized to provide a factor of safety for buoyancy of at least 1.5. Calculations for the anti-flotation block are included in the Appendix to the report.

Nutrient Loading

Nutrient loading calculations were performed with the Wake County Municipal Stormwater Tool, which is provided by Wake County. The output from this tool is included in the Appendix to this report.

The weighted average calculated by the spreadsheet for nutrient loading is summarized in the table below:

Post-Development TN Loading Before SCMs	9.34 lbs/ac/yr
Post-Development TN Loading After SCMs	6.18 lbs/ac/yr

CONCLUSION

Based on the results of this analysis, we believe that the Town of Zebulon requirements will be met for the proposed development. Additional details can be found in the Appendix.

APPENDICES

Appendix A – Drainage Area Maps

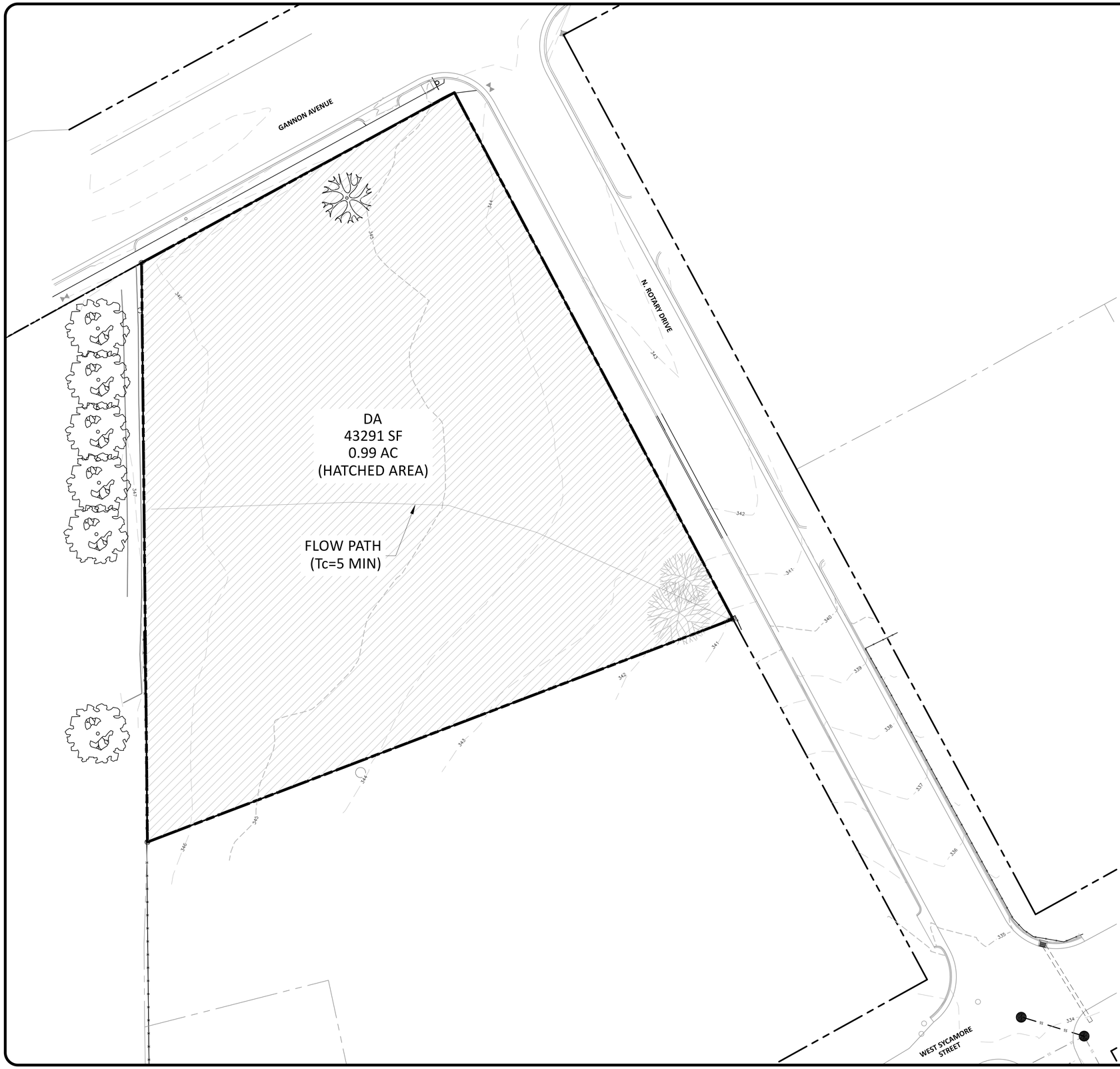
Appendix B – Hydrology Studio Output

Appendix C – Bioretention Area Calculations

Appendix D – Wake County Municipal Tool Output

Appendix E – Supporting Documentation

APPENDIX A
DRAINAGE AREA MAPS



N

20 0 10 20 40

SCALE: 1"=20'

PRELIMINARY DRAWING - NOT RELEASED FOR CONSTRUCTION

The Nau Company
Consulting Civil Engineers
PO Box 810 Rolesville, NC 27571
919-435-6395
NCBELS License P-0751

OWNER/DEVELOPER:

MERIDIAN PROPERTIES GROUP, LLC
4030 WAKE FOREST ROAD, SUITE 100
RALEIGH, NC 27609
919-621-4648

REVISIONS

401 GANNON AVENUE
SCM DRAINAGE AREA MAPS

ZEBULON, NC

PRE-DEVELOPMENT DRAINAGE AREA MAP

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 24042 JONATHAN P. EWING

9/13/2023

PROJECT NO: ---

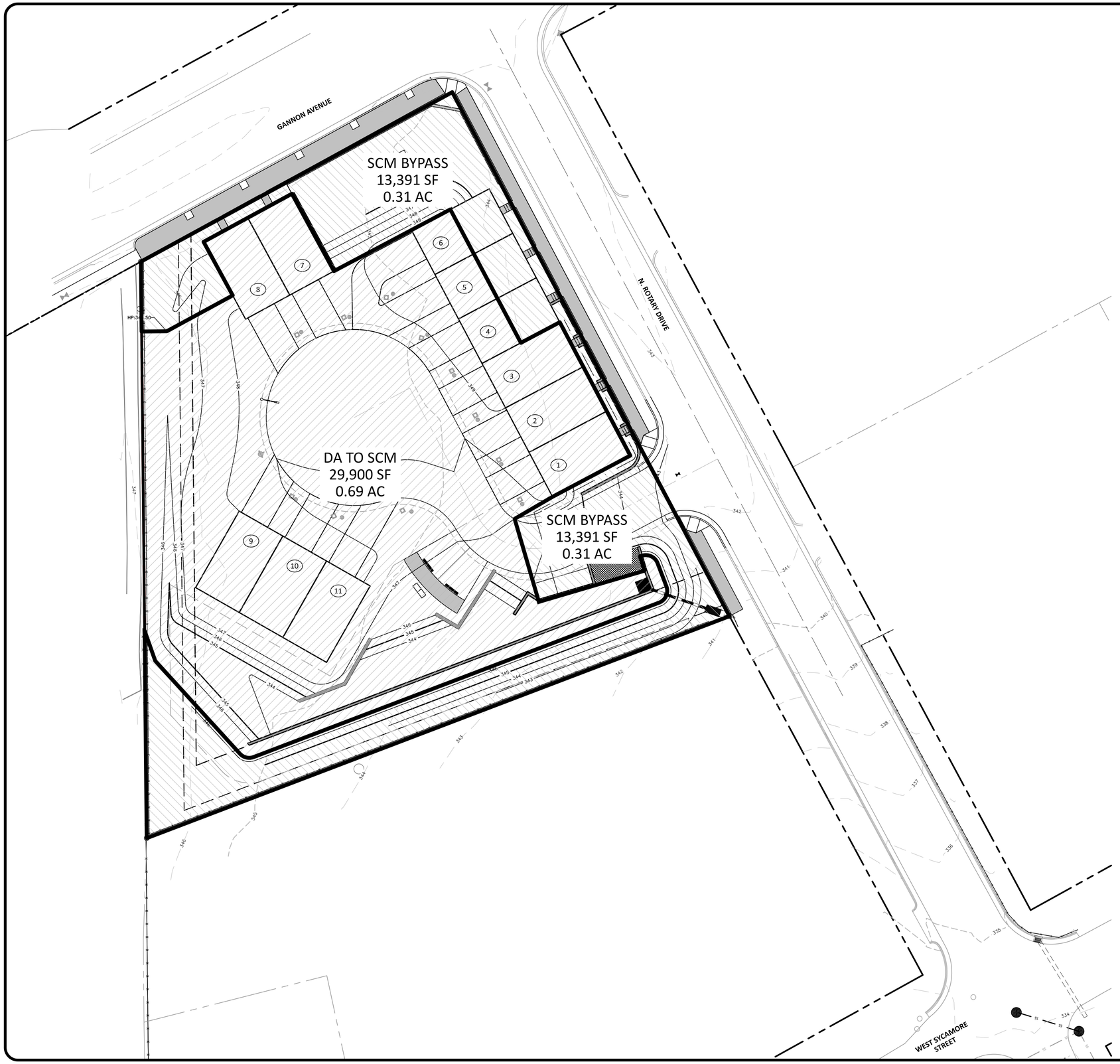
DESIGN BY: JPE

DRAWN BY: JPE

SCALE: 1"=20'

DATE: 7/10/2023

SHEET NO: **SCM1.0**



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20 0 10 20 40

SCALE: 1"=20'

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REVISIONS

401 GANNON AVENUE
SCM DRAINAGE AREA MAPS
ZEBULON, NC

POST-DEVELOPMENT DRAINAGE AREA MAP

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 049482 JONATHAN P. EAKINS
7/10/2023

PROJECT NO: ---
DESIGN BY: JPE
DRAWN BY: JPE
SCALE: 1"=20'
DATE: 7/10/2023
SHEET NO: SCM2.0

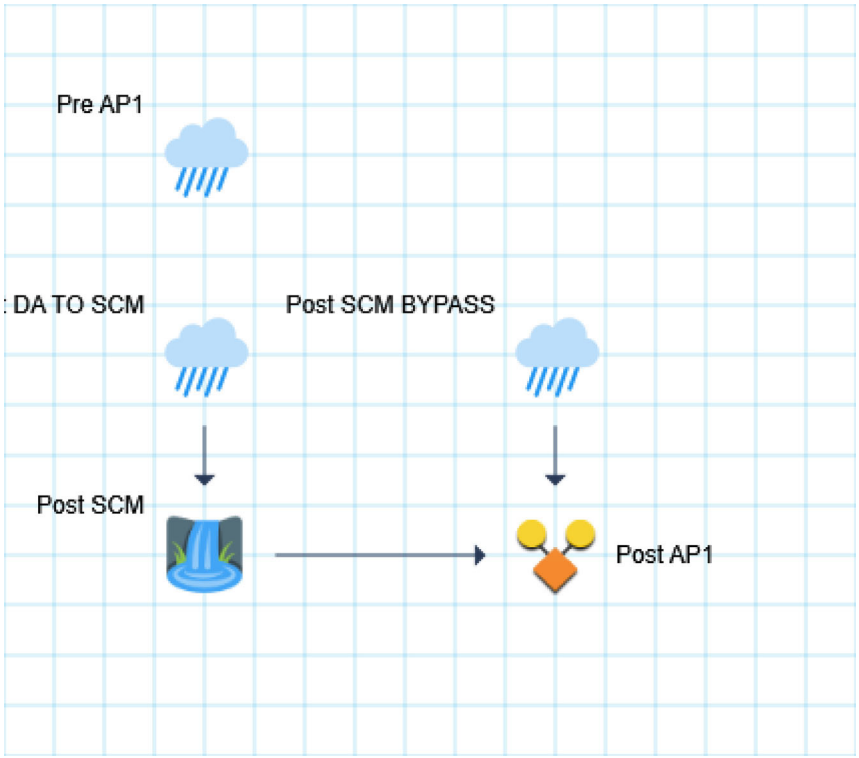
APPENDIX B
HYDROLOGY STUDIO OUTPUT

Basin Model

Hydrology Studio v 3.0.0.29

Project Name:

12-20-2023



Hydrograph by Return Period

Project Name:

12-20-2023

Hydrology Studio v 3.0.0.29

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Outflow (cfs)							
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
1	NRCS Runoff	Pre AP1	0.369	0.828			2.390			5.348
2	NRCS Runoff	Post DA TO SCM	1.445	2.020			3.585			6.092
3	Pond Route	Post SCM	0.049	0.089			1.510			5.819
4	NRCS Runoff	Post SCM BYPASS	0.280	0.474			1.060			2.085
5	Junction	Post AP1	0.322	0.520			2.042			7.829

Hydrograph 1-yr Summary

Project Name:

12-20-2023

Hydrology Studio v 3.0.0.29

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre AP1	0.369	12.00	1,123	----		
2	NRCS Runoff	Post DA TO SCM	1.445	11.97	2,903	----		
3	Pond Route	Post SCM	0.049	14.23	2,901	2	344.31	1,537
4	NRCS Runoff	Post SCM BYPASS	0.280	11.97	628	----		
5	Junction	Post AP1	0.322	11.97	3,529	3, 4		

Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

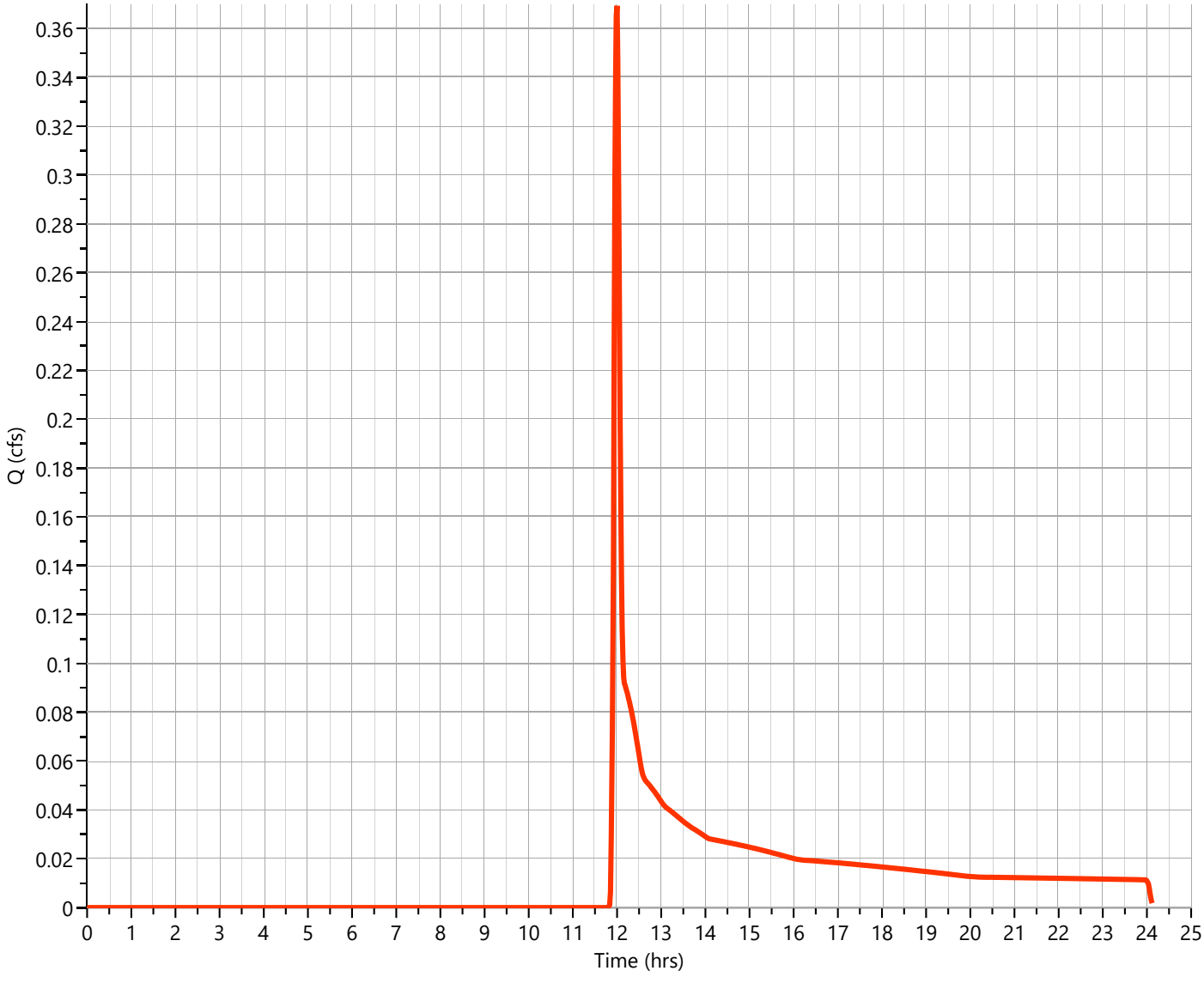
Pre AP1

Hyd. No. 1

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.369 cfs
Storm Frequency	= 1-yr	Time to Peak	= 12.00 hrs
Time Interval	= 1 min	Runoff Volume	= 1,123 cuft
Drainage Area	= 0.99 ac	Curve Number	= 61*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 2.83 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.99	61	Composite CN
0.99	**61**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

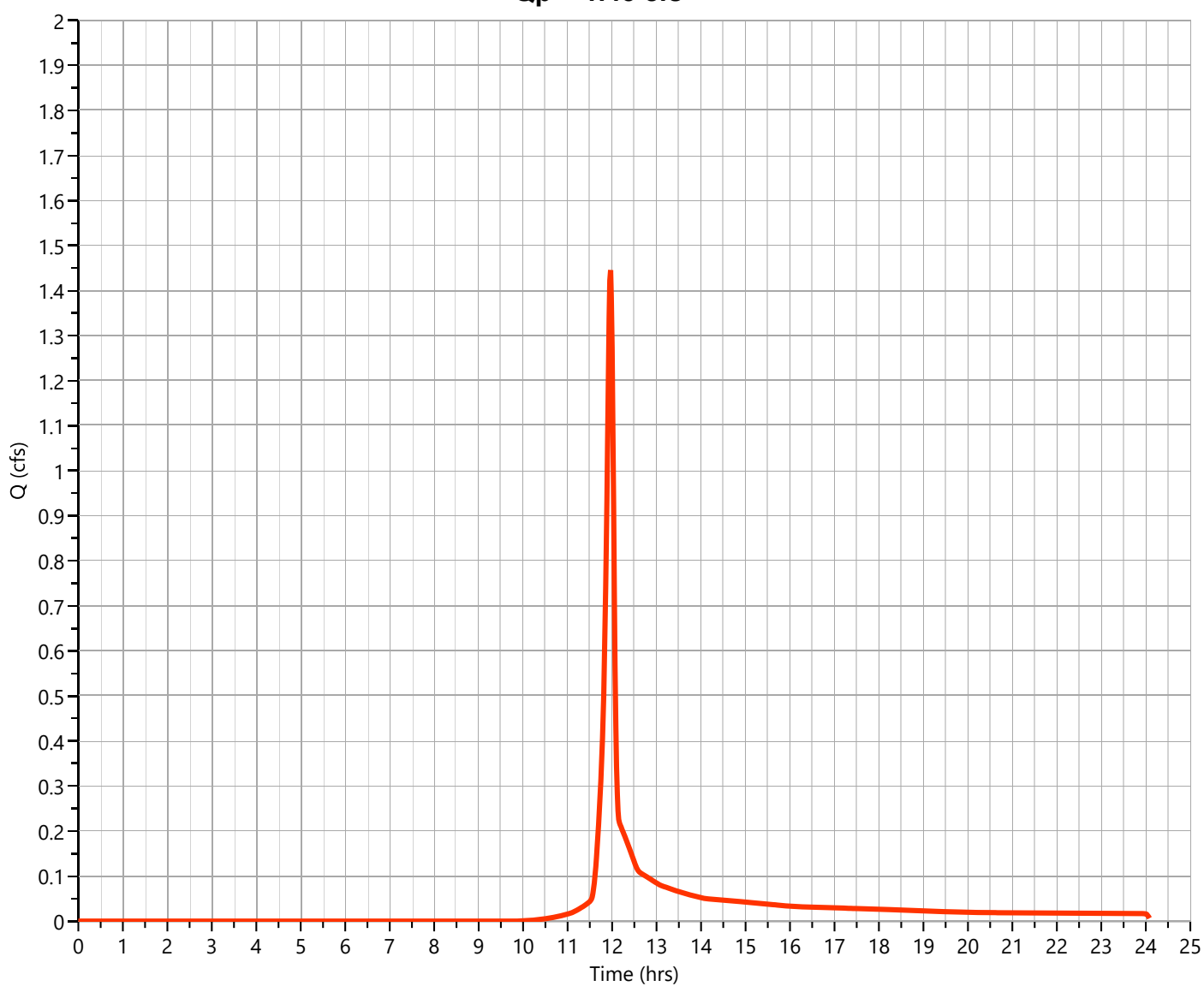
Post DA TO SCM

Hyd. No. 2

Hydrograph Type	= NRCS Runoff	Peak Flow	= 1.445 cfs
Storm Frequency	= 1-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 2,903 cuft
Drainage Area	= 0.69 ac	Curve Number	= 80*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 2.83 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.69	80	Composite CN
0.69	**80**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

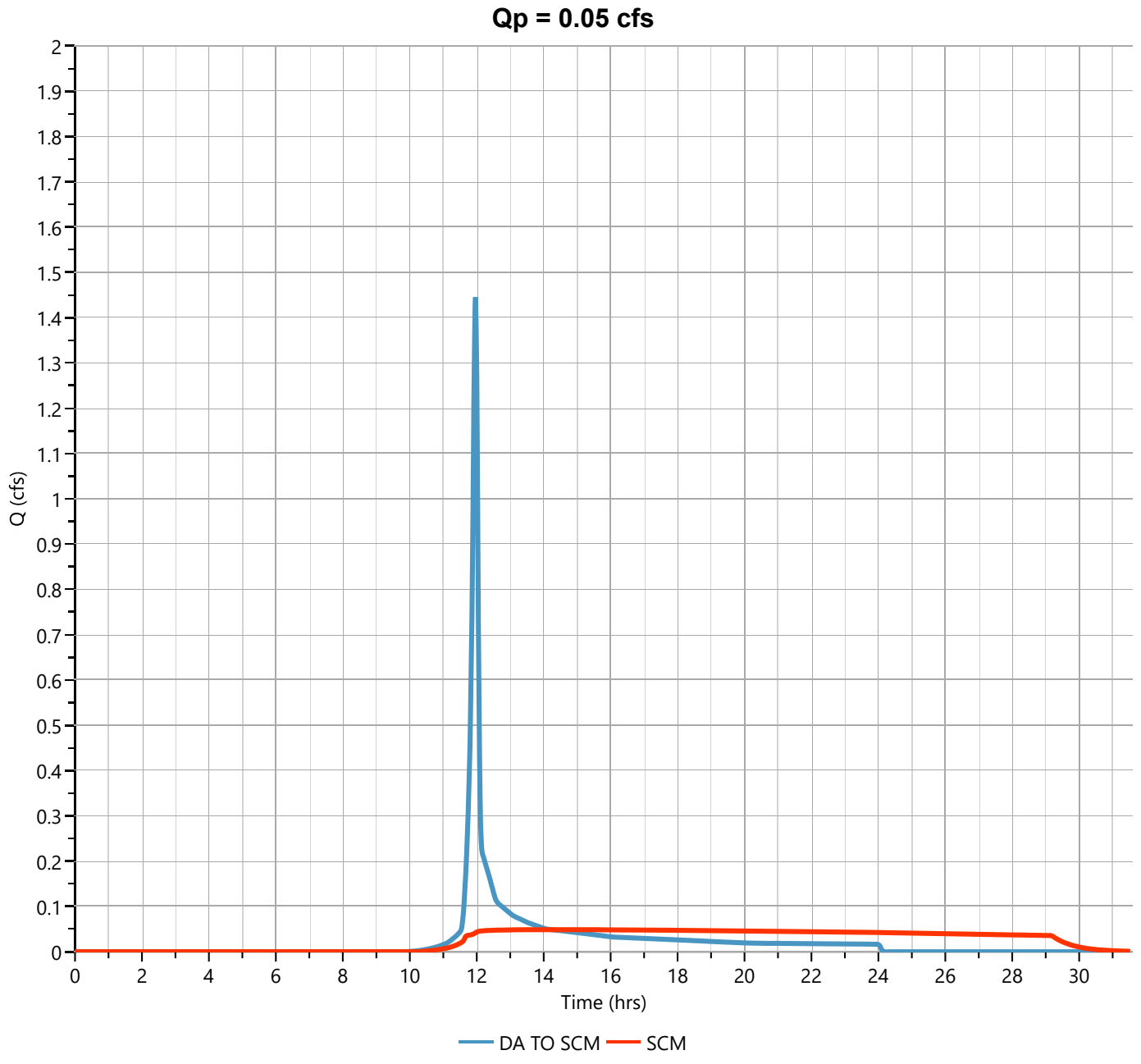
Post SCM

Hyd. No. 3

Hydrograph Type	= Pond Route	Peak Flow	= 0.049 cfs
Storm Frequency	= 1-yr	Time to Peak	= 14.23 hrs
Time Interval	= 1 min	Hydrograph Volume	= 2,901 cuft
Inflow Hydrograph	= 2 - DA TO SCM	Max. Elevation	= 344.31 ft
Pond Name	= Bioretention	Max. Storage	= 1,537 cuft
Routing Option	= Wet Pond	Wet Pond Elevation	= 343.50 ft

Pond Routing by Storage Indication Method

Center of mass detention time = 6.11 hrs



Pond Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

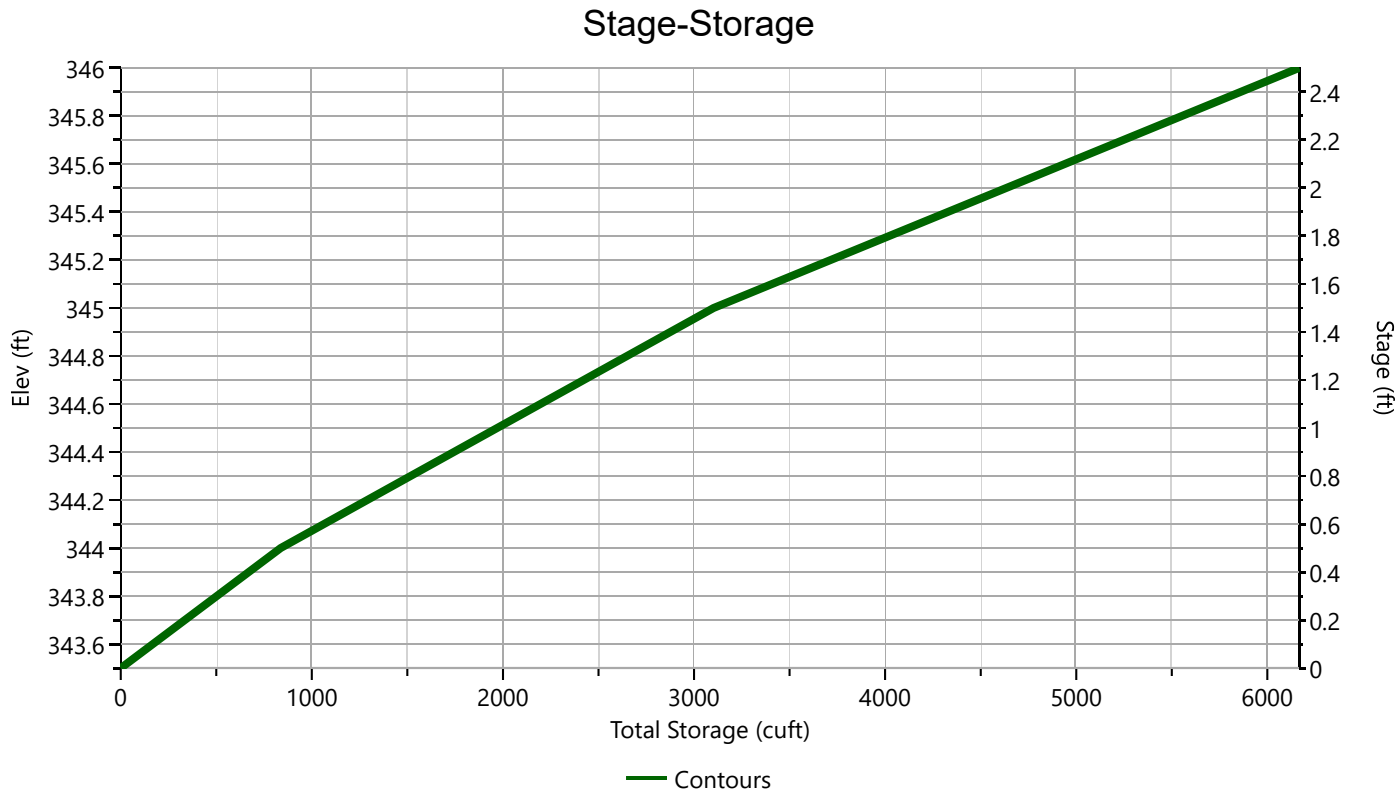
Bioretention

Stage-Storage

User Defined Contours	
Description	**Input**
Bottom Elevation, ft	343.50
Voids (%)	100.00
Volume Calc	None

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour Area (sqft)	Incr. Storage (cuft)	Total Storage (cuft)
0.00	343.50	1,505	0.000	0.000
0.50	344.00	1,844	837	837
1.50	345.00	2,685	2,265	3,102
2.50	346.00	3,447	3,066	6,168



Pond Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

Bioretention

Stage-Discharge

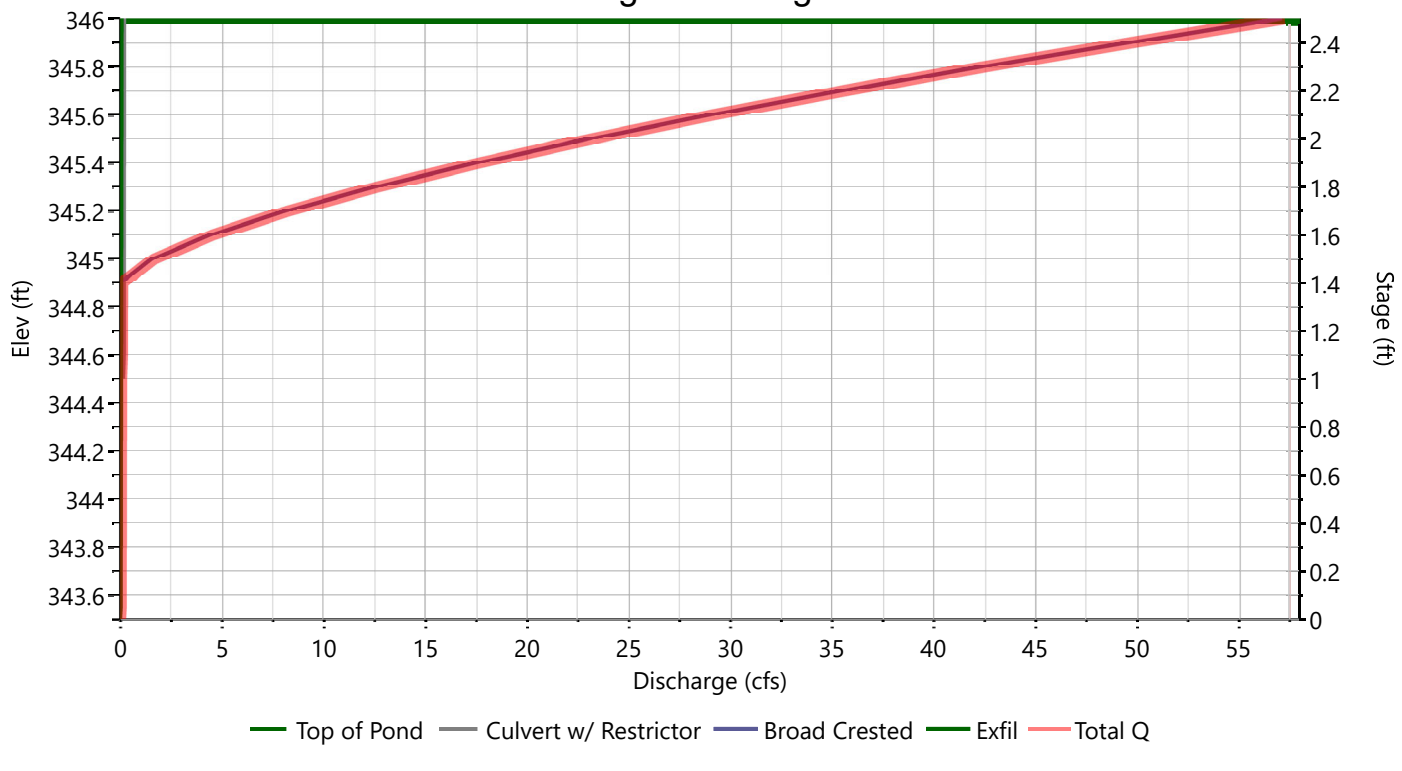
Culvert / Orifices	Culvert w/ Restrictor Plate	Orifices		
		1	2	3
Rise, in	12			
Span, in	12			
No. Barrels	1			
Invert Elevation, ft	Culv: 341.90 1 in Orif: 341.90			
Orifice Coefficient, Co	0.60			
Length, ft	28			
Barrel Slope, %	.5			
N-Value, n	0.013			

Orifice Plate	
Orifice Dia, in	
No. Orifices	
Invert Elevation, ft	
Height, ft	
Orifice Coefficient, Co	

Weirs	Riser*	Weirs		
		1	2	3
Shape / Type	Box	Broad Crested		
Crest Elevation, ft	344.5	344.9		
Crest Length, ft	8	15		
Angle, deg				
Weir Coefficient, Cw	3.3	3.3		

Ancillary	
Exfiltration, in/hr	1.00**

**Routes through Culvert. **Rate applied to contours.*



Pond Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

Bioretention

Stage-Storage-Discharge Summary

Stage (ft)	Elev. (ft)	Storage (cuft)	Culvert (cfs)	Orifices, cfs			Riser (cfs)	Weirs, cfs			Pf Riser (cfs)	Exfil (cfs)	User (cfs)	Total (cfs)
				1	2	3		1	2	3				
0.00	343.50	0.000	0.000				0.000	0.000				0.000		0.000
0.50	344.00	837	0.000 ic				0.000	0.000				0.043		0.043
1.50	345.00	3,102	0.046 ic				0.000	1.565				0.062		1.674
2.50	346.00	6,168	0.053 ic				0.000	57.11				0.080		57.24

Suffix key: ic = inlet control, oc = outlet control, s = submerged weir

Pond Report

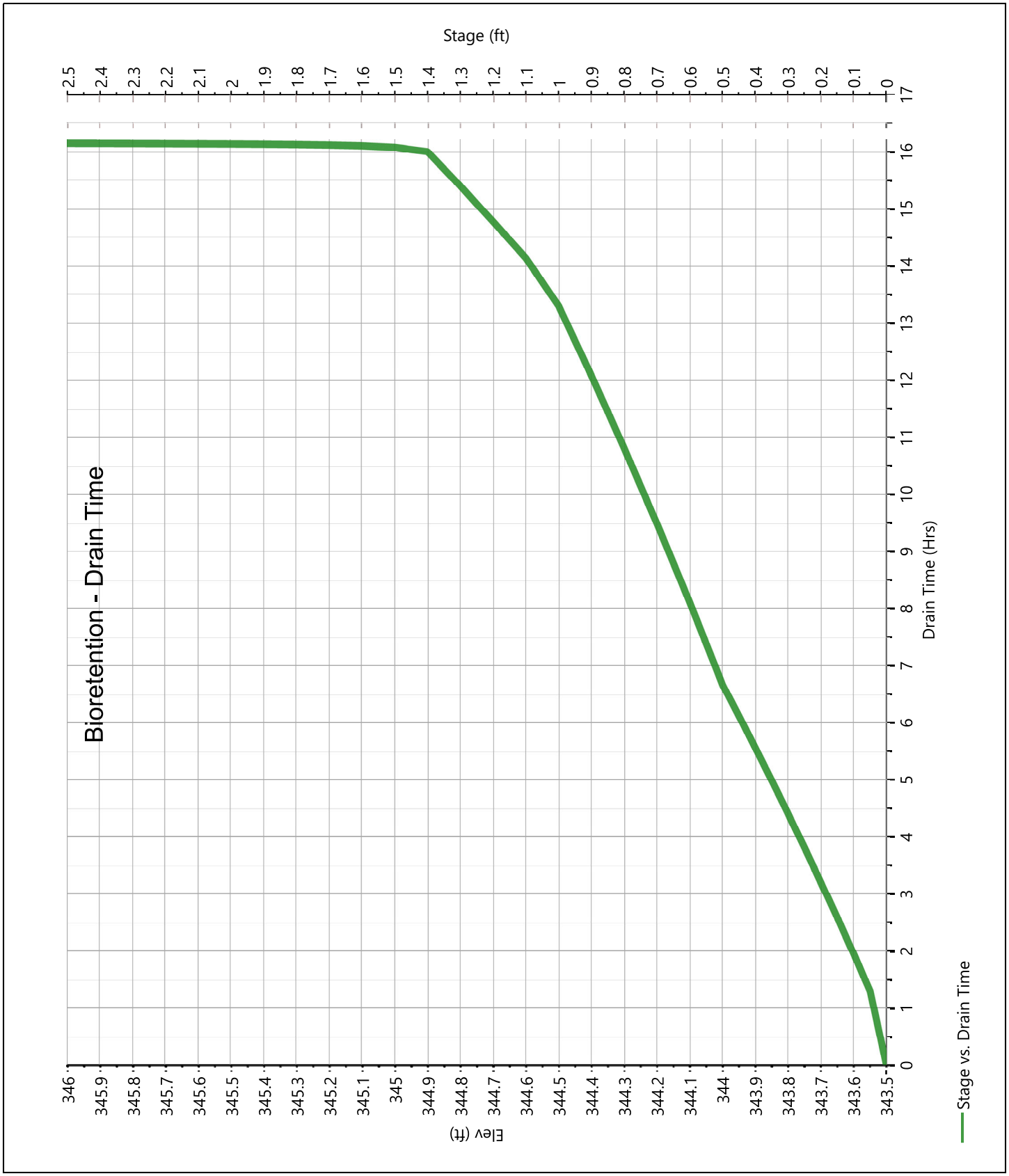
Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

Bioretention

Pond Drawdown



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

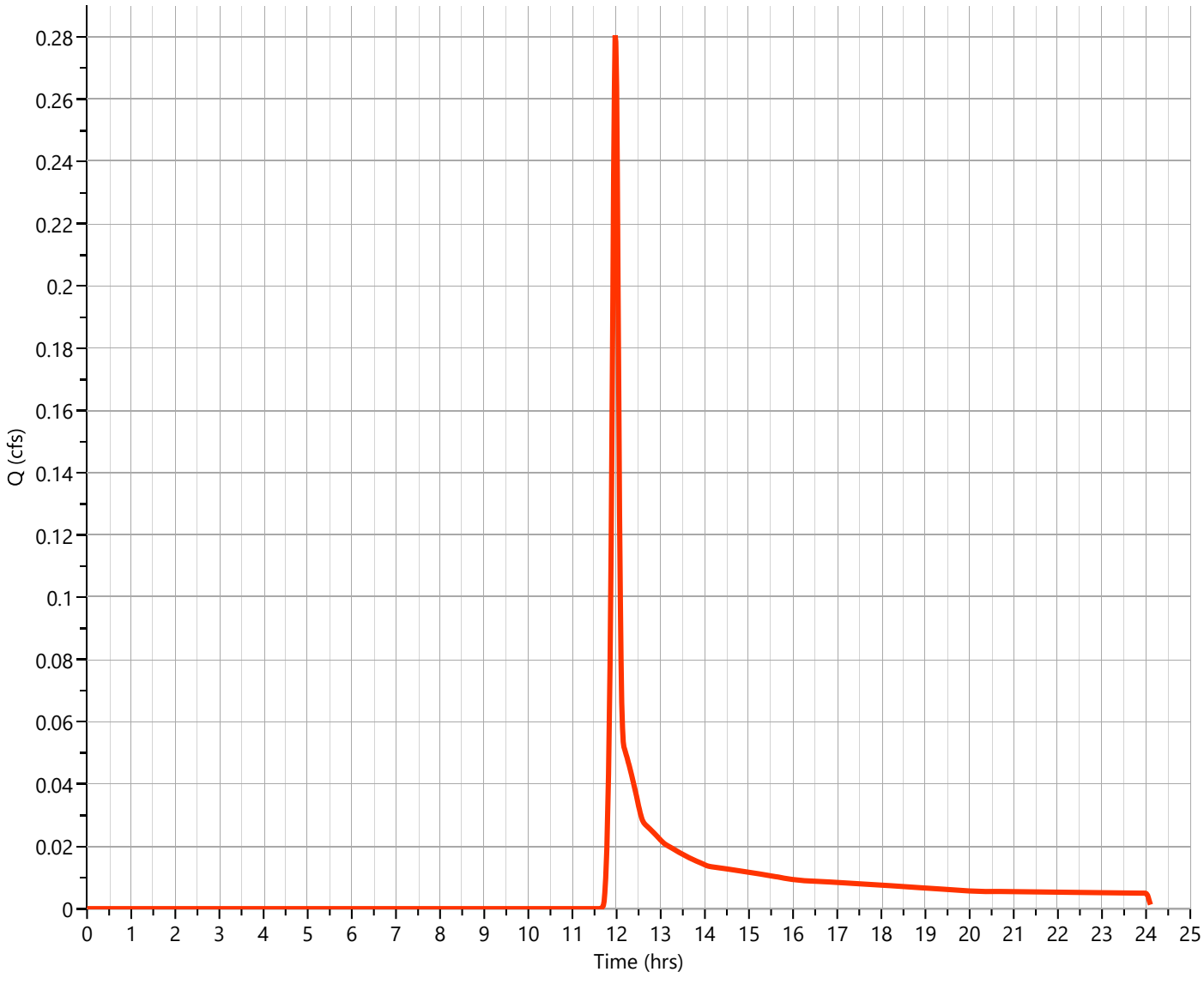
Post SCM BYPASS

Hyd. No. 4

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.280 cfs
Storm Frequency	= 1-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 628 cuft
Drainage Area	= 0.31 ac	Curve Number	= 68*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 2.83 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.31	68	Composite CN
0.31	**68**	Weighted CN Method Employed



Hydrograph Report

Project Name:

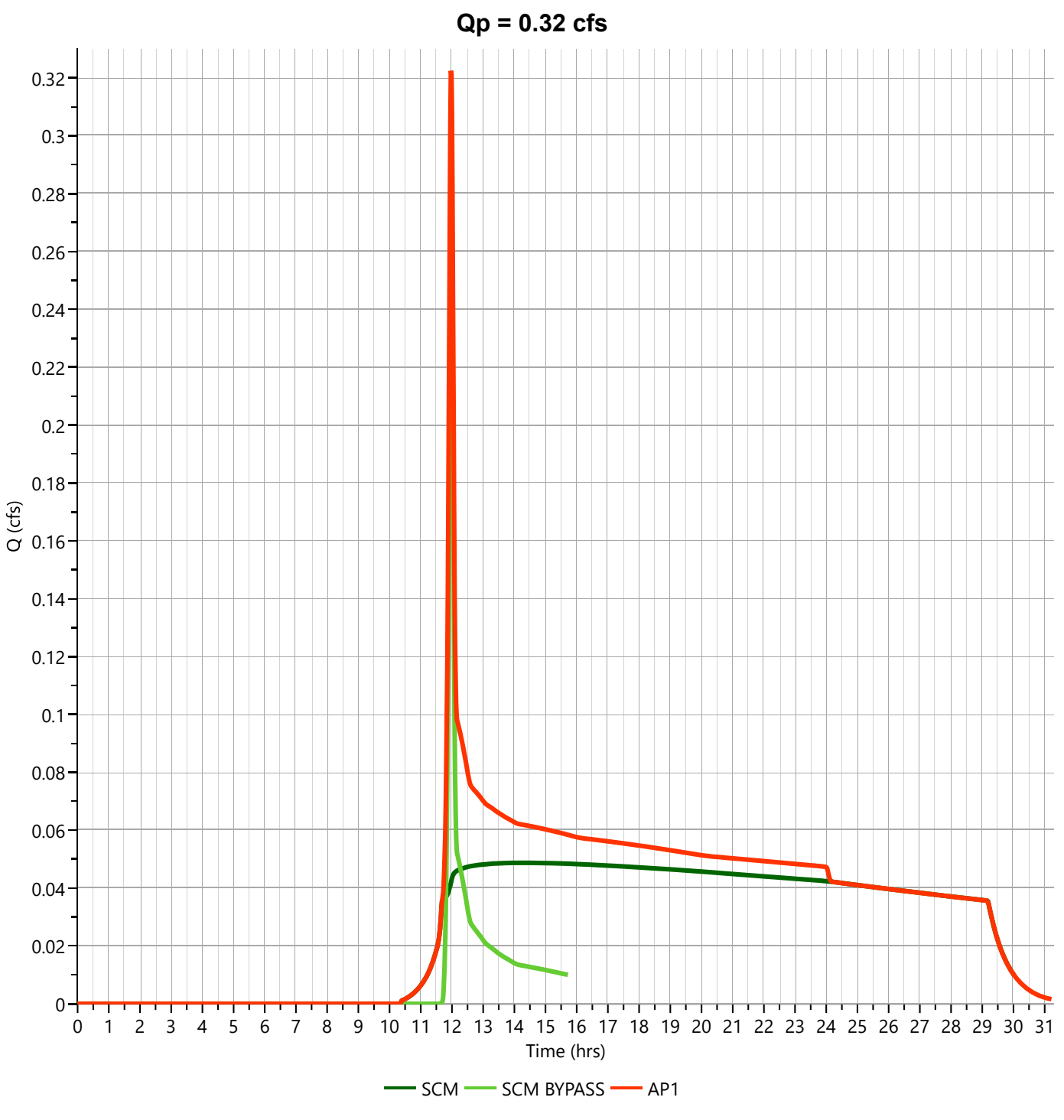
Hydrology Studio v 3.0.0.29

12-20-2023

Post AP1

Hyd. No. 5

Hydrograph Type	= Junction	Peak Flow	= 0.322 cfs
Storm Frequency	= 1-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Hydrograph Volume	= 3,529 cuft
Inflow Hydrographs	= 3, 4	Total Contrib. Area	= 0.31 ac



Hydrograph 2-yr Summary

Project Name:

12-20-2023

Hydrology Studio v 3.0.0.29

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre AP1	0.828	11.98	1,991	----		
2	NRCS Runoff	Post DA TO SCM	2.020	11.97	4,063	----		
3	Pond Route	Post SCM	0.089	13.45	4,061	2	344.58	2,155
4	NRCS Runoff	Post SCM BYPASS	0.474	11.97	992	----		
5	Junction	Post AP1	0.520	11.97	5,053	3, 4		

Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

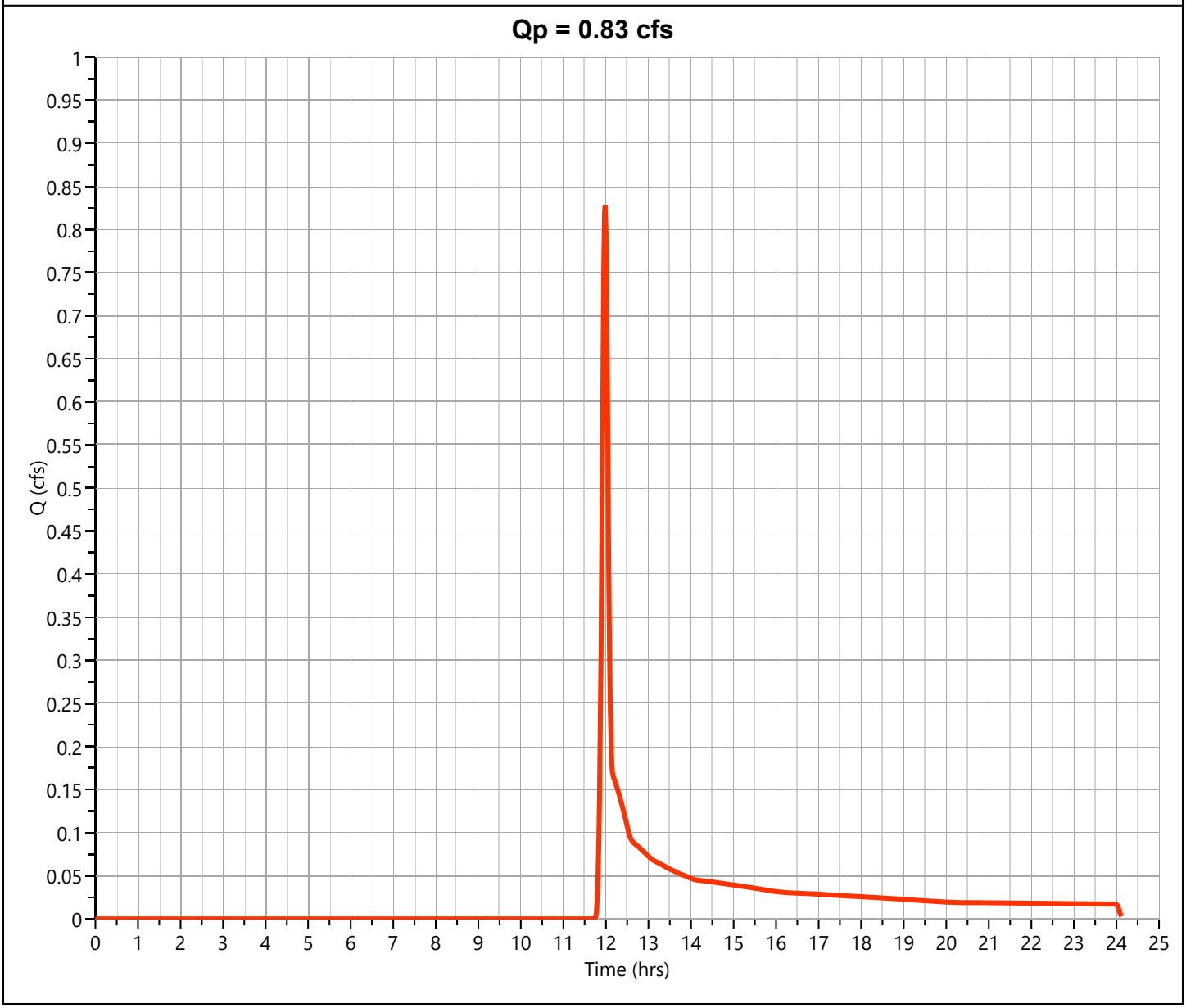
Pre AP1

Hyd. No. 1

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.828 cfs
Storm Frequency	= 2-yr	Time to Peak	= 11.98 hrs
Time Interval	= 1 min	Runoff Volume	= 1,991 cuft
Drainage Area	= 0.99 ac	Curve Number	= 61*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 3.42 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.99	61	Composite CN
0.99	**61**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

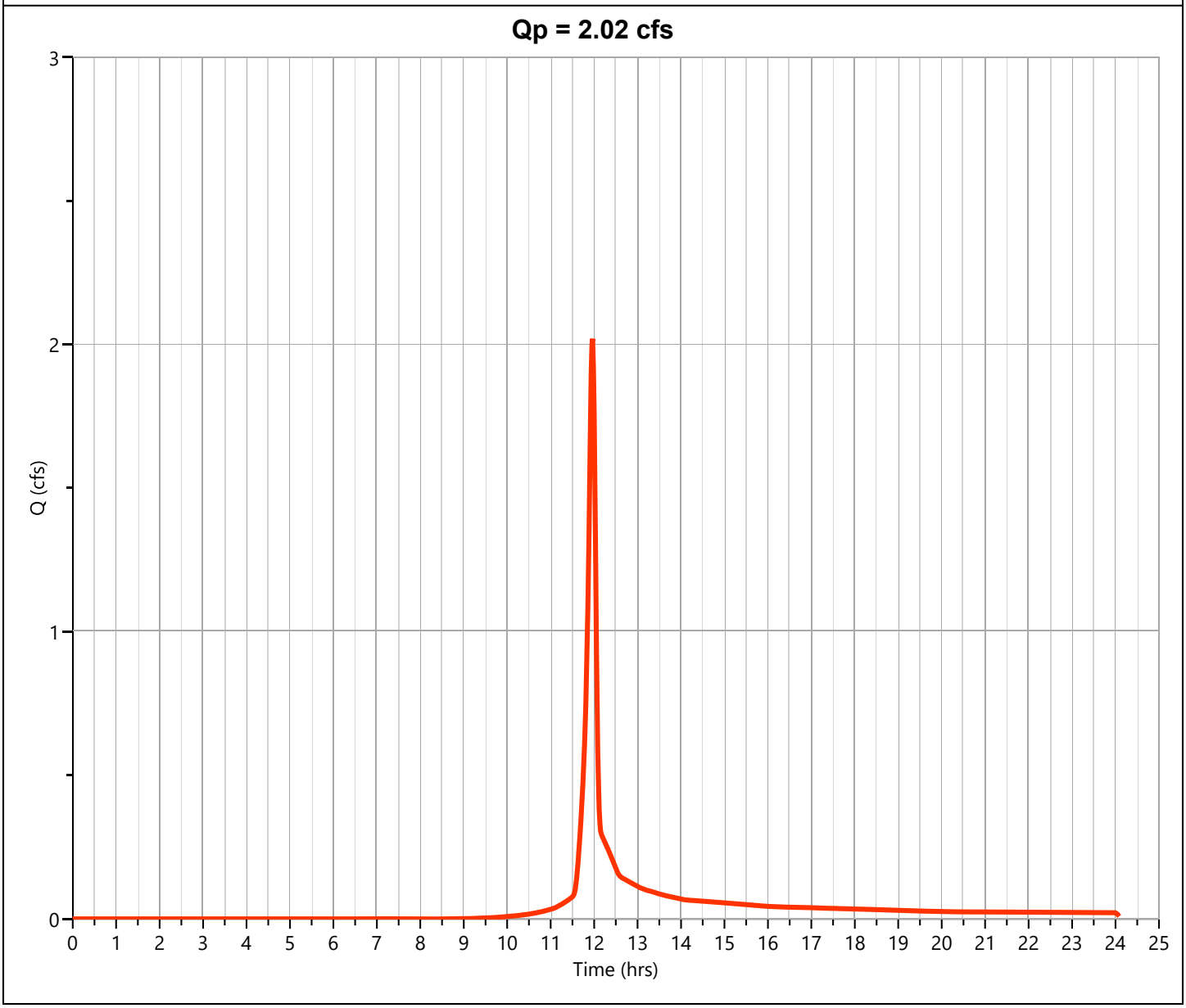
Post DA TO SCM

Hyd. No. 2

Hydrograph Type	= NRCS Runoff	Peak Flow	= 2.020 cfs
Storm Frequency	= 2-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 4,063 cuft
Drainage Area	= 0.69 ac	Curve Number	= 80*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 3.42 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.69	80	Composite CN
0.69	**80**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

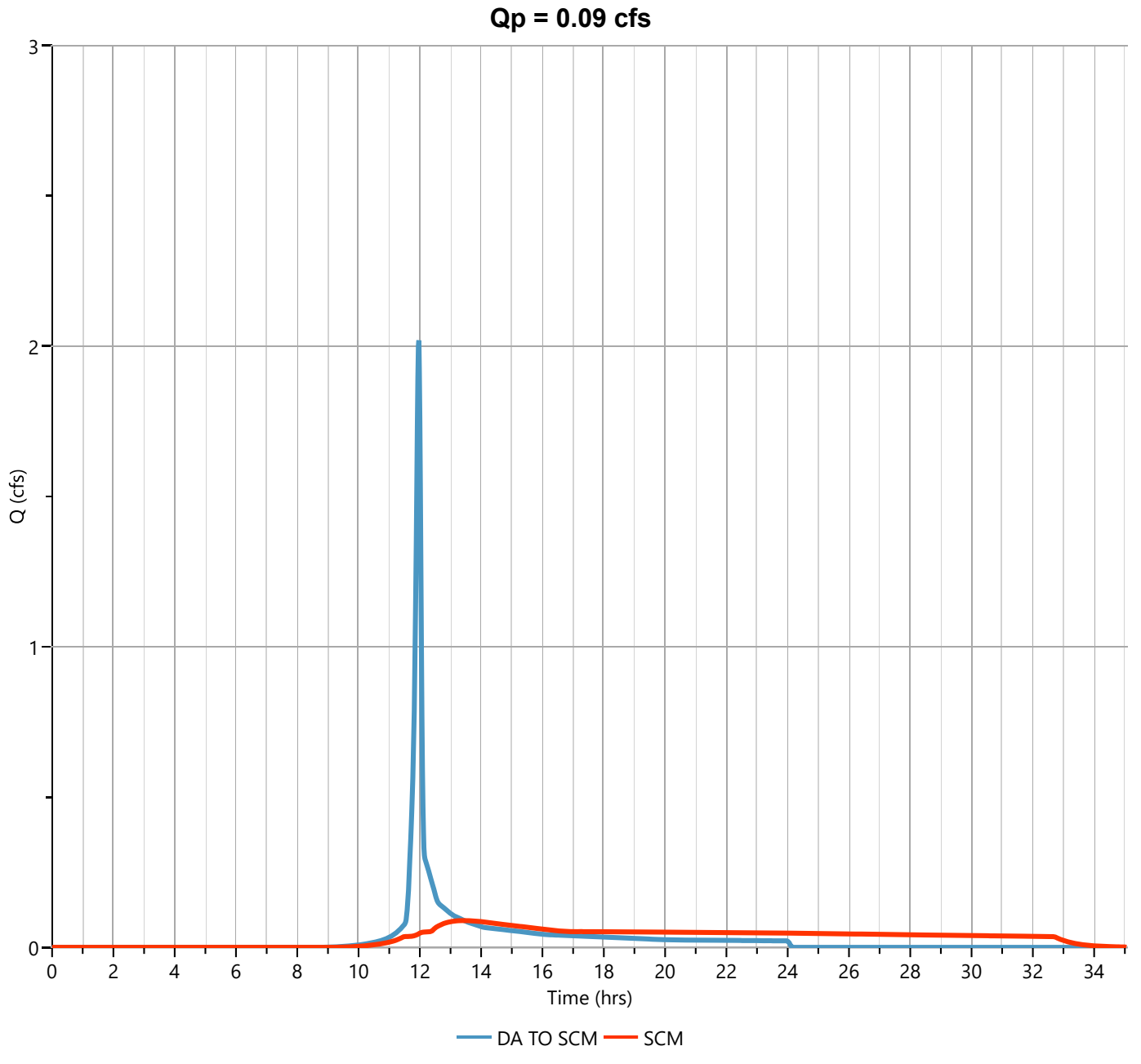
Post SCM

Hyd. No. 3

Hydrograph Type	= Pond Route	Peak Flow	= 0.089 cfs
Storm Frequency	= 2-yr	Time to Peak	= 13.45 hrs
Time Interval	= 1 min	Hydrograph Volume	= 4,061 cuft
Inflow Hydrograph	= 2 - DA TO SCM	Max. Elevation	= 344.58 ft
Pond Name	= Bioretention	Max. Storage	= 2,155 cuft
Routing Option	= Wet Pond	Wet Pond Elevation	= 343.50 ft

Pond Routing by Storage Indication Method

Center of mass detention time = 7.01 hrs



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

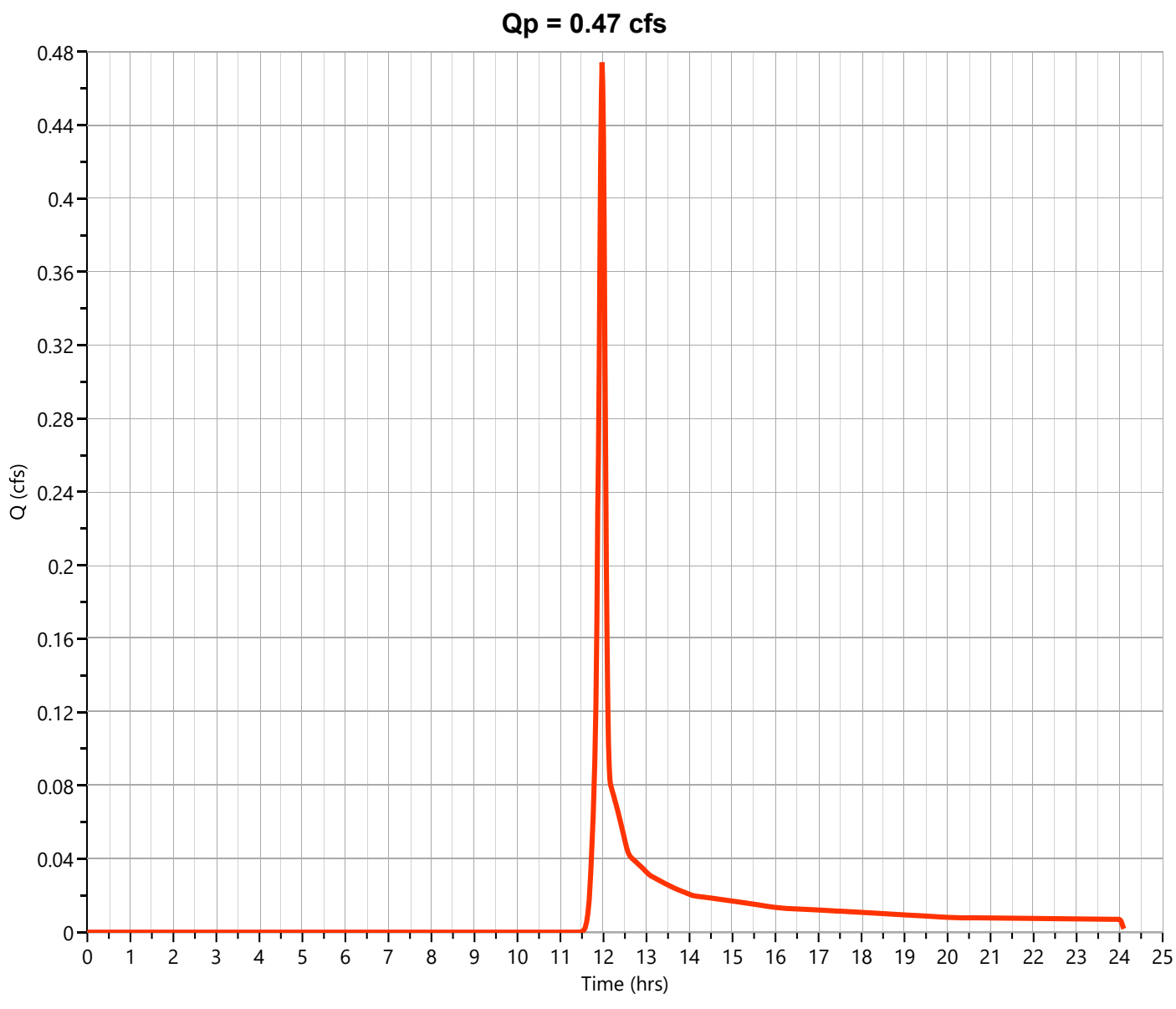
Post SCM BYPASS

Hyd. No. 4

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.474 cfs
Storm Frequency	= 2-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 992 cuft
Drainage Area	= 0.31 ac	Curve Number	= 68*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 3.42 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.31	68	Composite CN
0.31	**68**	Weighted CN Method Employed



Hydrograph Report

Project Name:

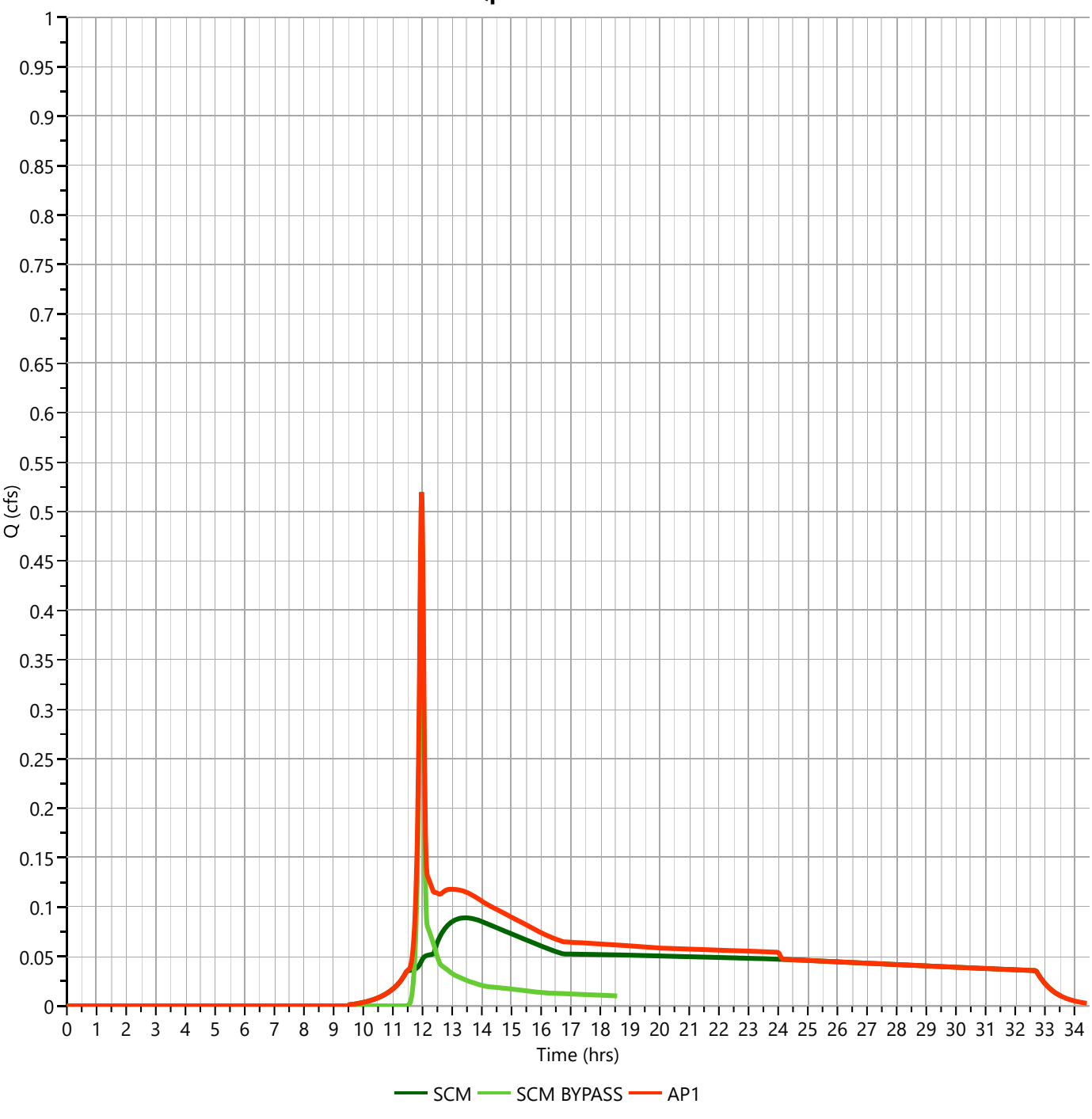
Hydrology Studio v 3.0.0.29

12-20-2023

Post AP1

Hyd. No. 5

Hydrograph Type	= Junction	Peak Flow	= 0.520 cfs
Storm Frequency	= 2-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Hydrograph Volume	= 5,053 cuft
Inflow Hydrographs	= 3, 4	Total Contrib. Area	= 0.31 ac



Hydrograph 10-yr Summary

Project Name:

12-20-2023

Hydrology Studio v 3.0.0.29

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre AP1	2.390	11.97	4,941	----		
2	NRCS Runoff	Post DA TO SCM	3.585	11.97	7,337	----		
3	Pond Route	Post SCM	1.510	12.07	7,335	2	344.99	3,078
4	NRCS Runoff	Post SCM BYPASS	1.060	11.97	2,132	----		
5	Junction	Post AP1	2.042	12.05	9,467	3, 4		

Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

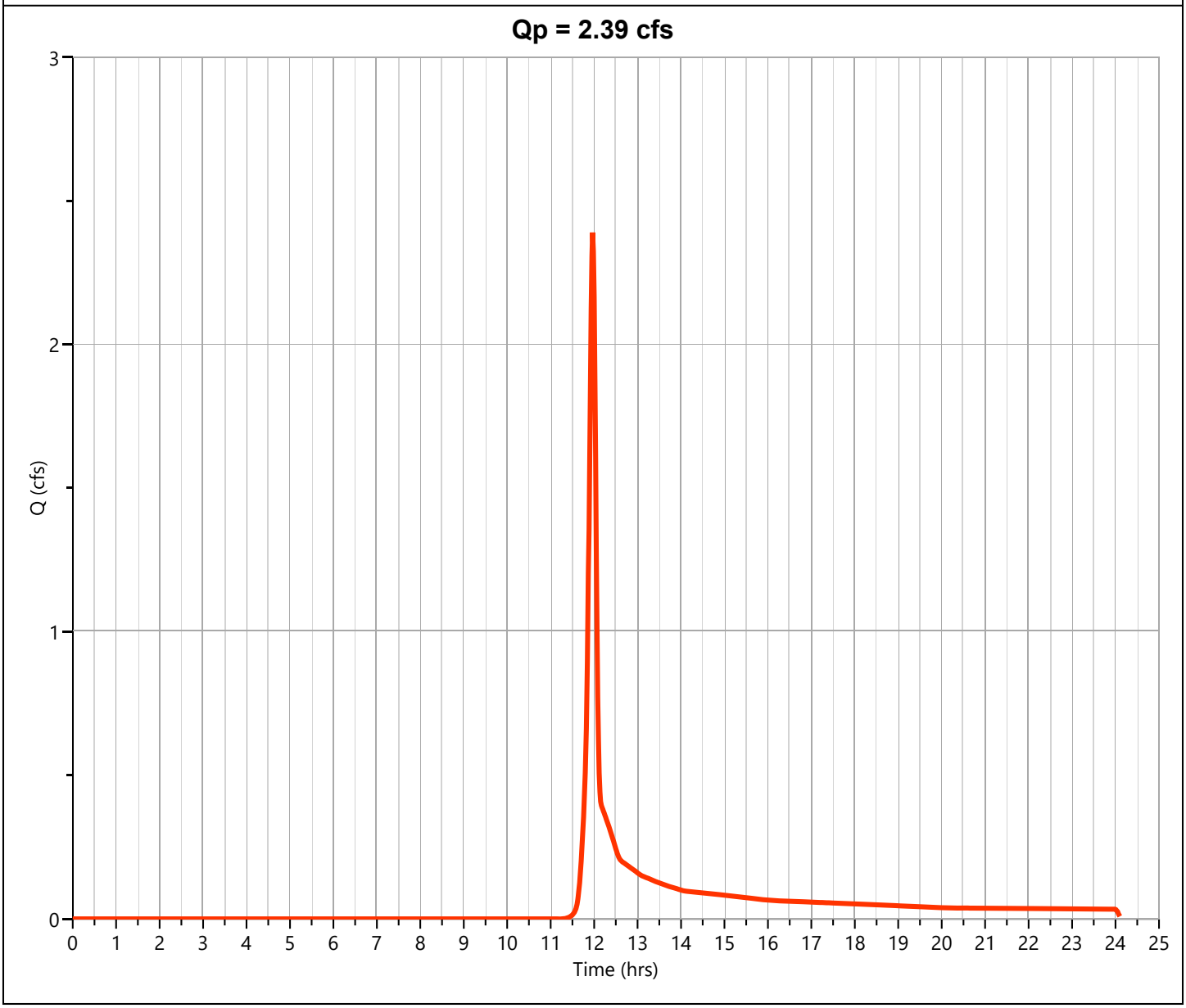
Pre AP1

Hyd. No. 1

Hydrograph Type	= NRCS Runoff	Peak Flow	= 2.390 cfs
Storm Frequency	= 10-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 4,941 cuft
Drainage Area	= 0.99 ac	Curve Number	= 61*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 4.94 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.99	61	Composite CN
0.99	**61**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

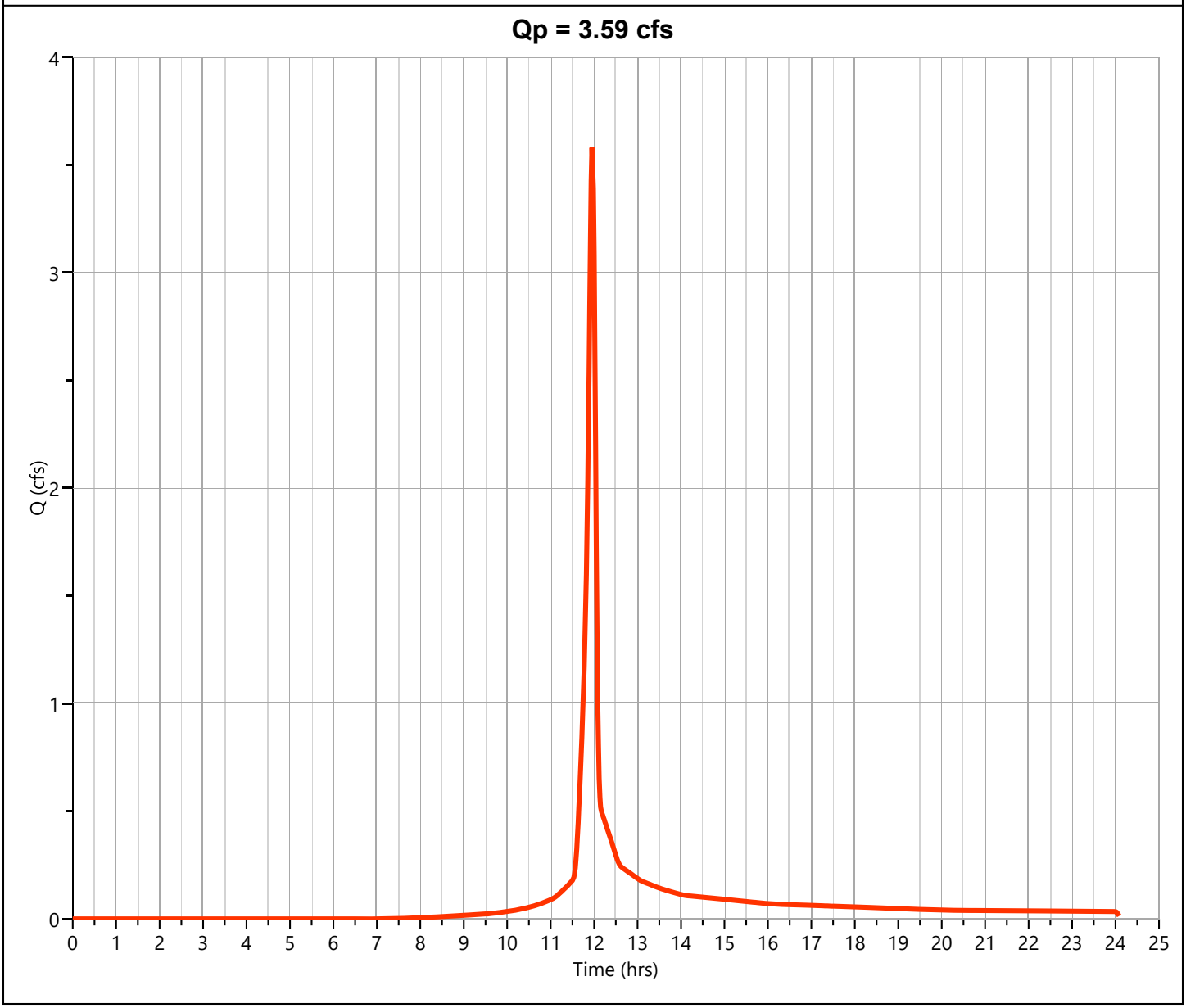
Post DA TO SCM

Hyd. No. 2

Hydrograph Type	= NRCS Runoff	Peak Flow	= 3.585 cfs
Storm Frequency	= 10-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 7,337 cuft
Drainage Area	= 0.69 ac	Curve Number	= 80*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 4.94 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.69	80	Composite CN
0.69	**80**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

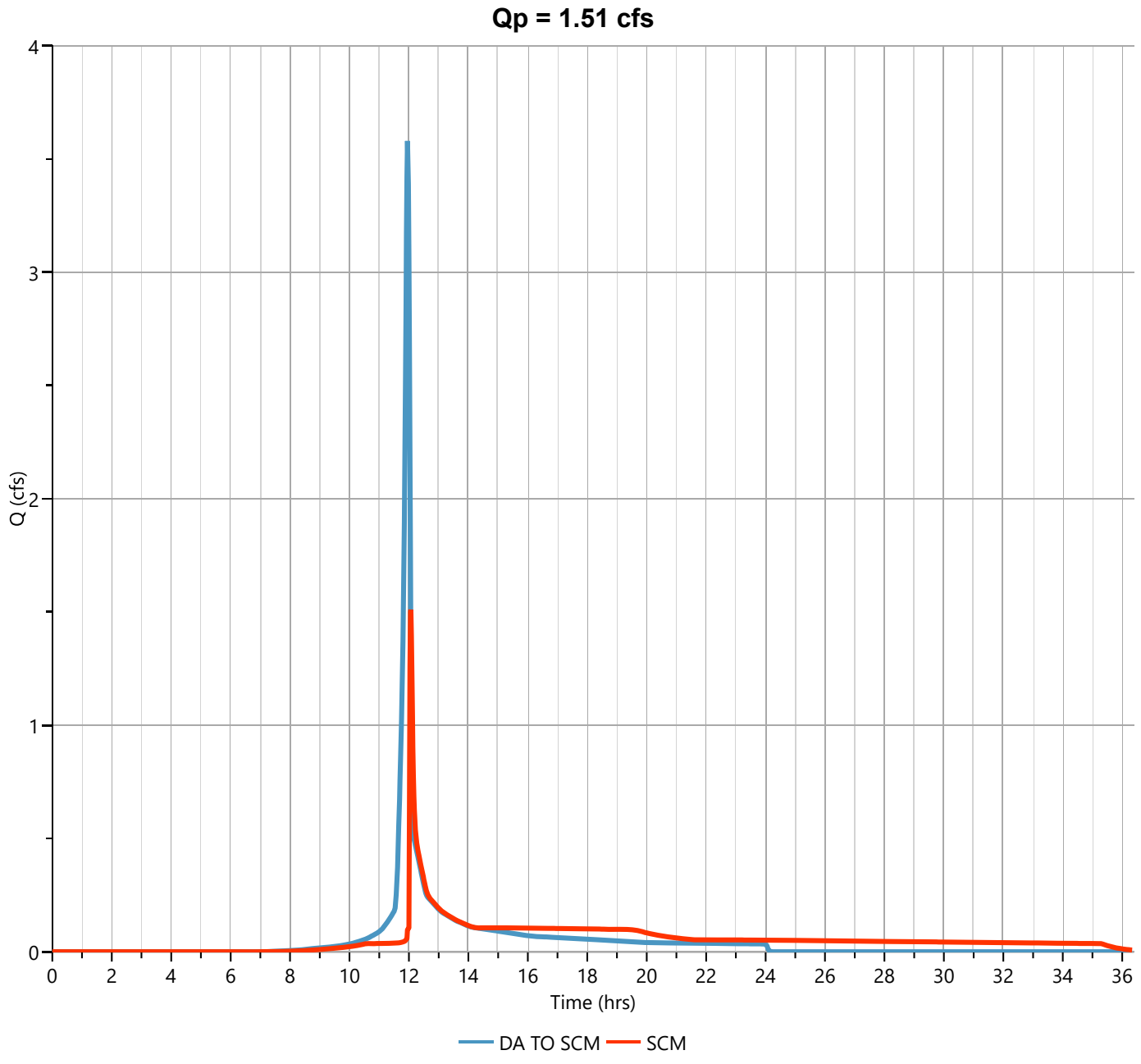
Post SCM

Hyd. No. 3

Hydrograph Type	= Pond Route	Peak Flow	= 1.510 cfs
Storm Frequency	= 10-yr	Time to Peak	= 12.07 hrs
Time Interval	= 1 min	Hydrograph Volume	= 7,335 cuft
Inflow Hydrograph	= 2 - DA TO SCM	Max. Elevation	= 344.99 ft
Pond Name	= Bioretention	Max. Storage	= 3,078 cuft
Routing Option	= Wet Pond	Wet Pond Elevation	= 343.50 ft

Pond Routing by Storage Indication Method

Center of mass detention time = 5.63 hrs



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

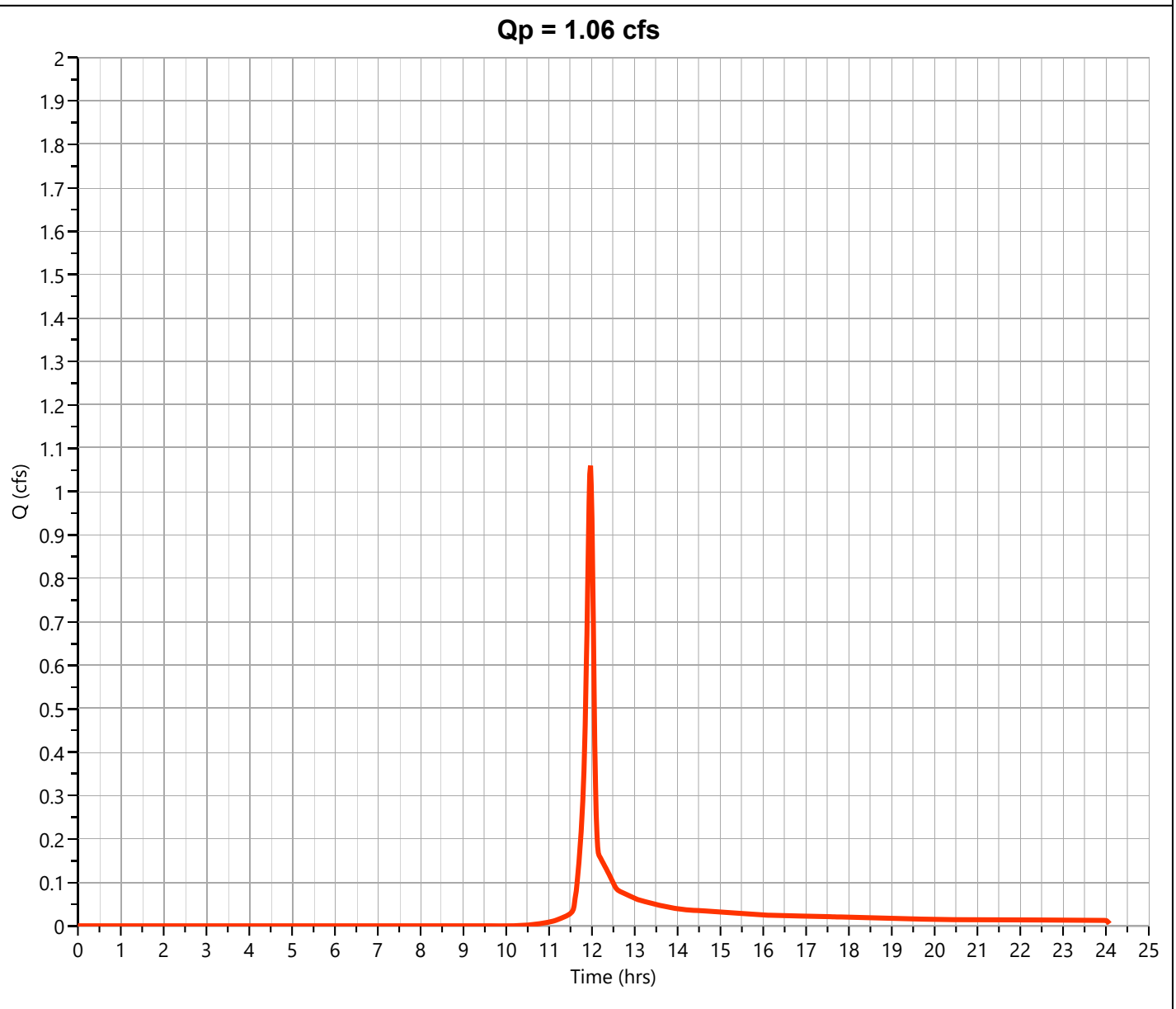
Post SCM BYPASS

Hyd. No. 4

Hydrograph Type	= NRCS Runoff	Peak Flow	= 1.060 cfs
Storm Frequency	= 10-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 2,132 cuft
Drainage Area	= 0.31 ac	Curve Number	= 68*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 4.94 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.31	68	Composite CN
0.31	**68**	Weighted CN Method Employed



Hydrograph Report

Project Name:

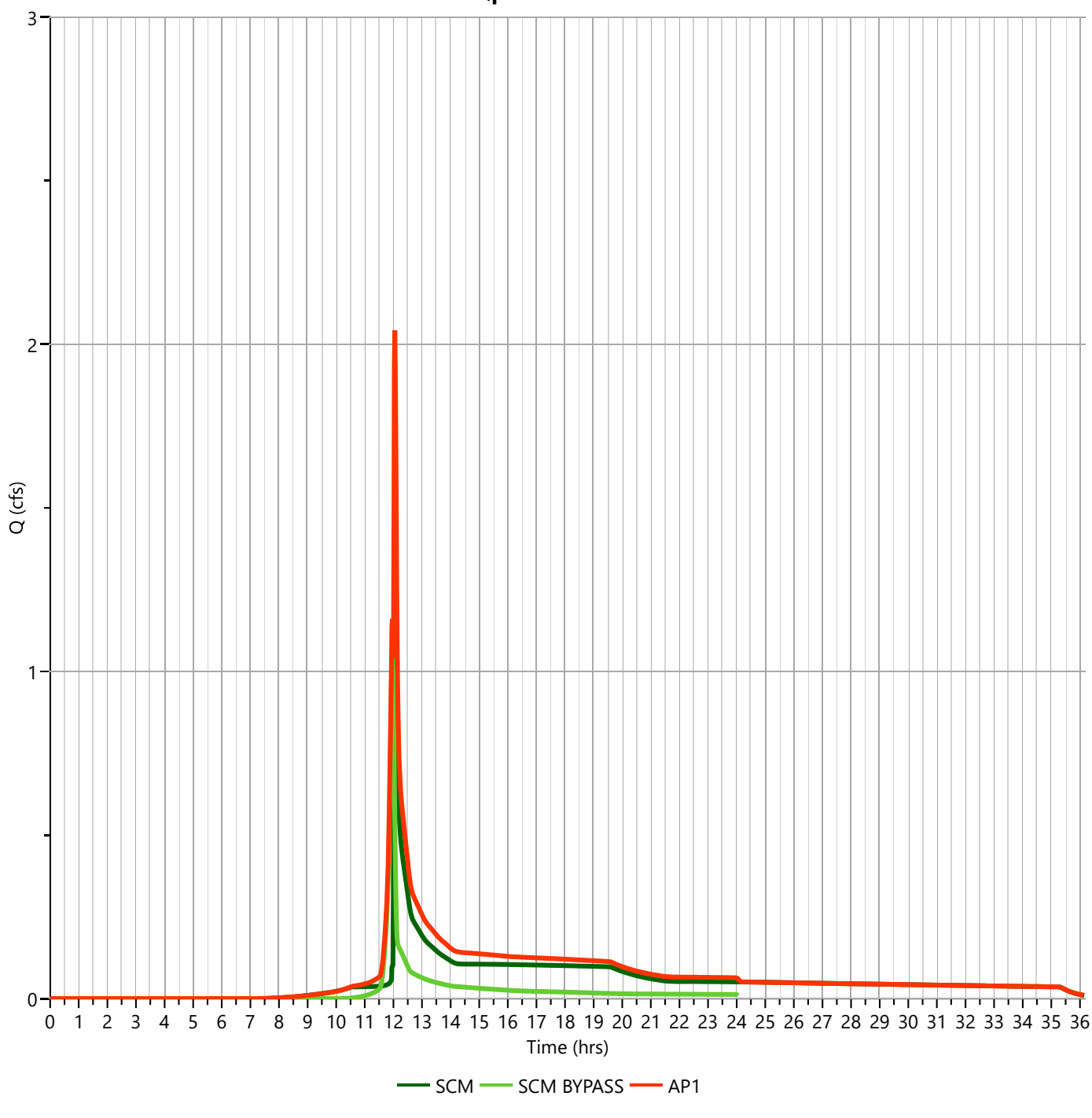
Hydrology Studio v 3.0.0.29

12-20-2023

Post AP1

Hyd. No. 5

Hydrograph Type	= Junction	Peak Flow	= 2.042 cfs
Storm Frequency	= 10-yr	Time to Peak	= 12.05 hrs
Time Interval	= 1 min	Hydrograph Volume	= 9,467 cuft
Inflow Hydrographs	= 3, 4	Total Contrib. Area	= 0.31 ac



Hydrograph 100-yr Summary

Project Name:

12-20-2023

Hydrology Studio v 3.0.0.29

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre AP1	5.348	11.97	10,741	----		
2	NRCS Runoff	Post DA TO SCM	6.092	11.95	12,771	----		
3	Pond Route	Post SCM	5.819	11.98	12,768	2	345.14	3,514
4	NRCS Runoff	Post SCM BYPASS	2.085	11.97	4,212	----		
5	Junction	Post AP1	7.829	11.97	16,981	3, 4		

Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

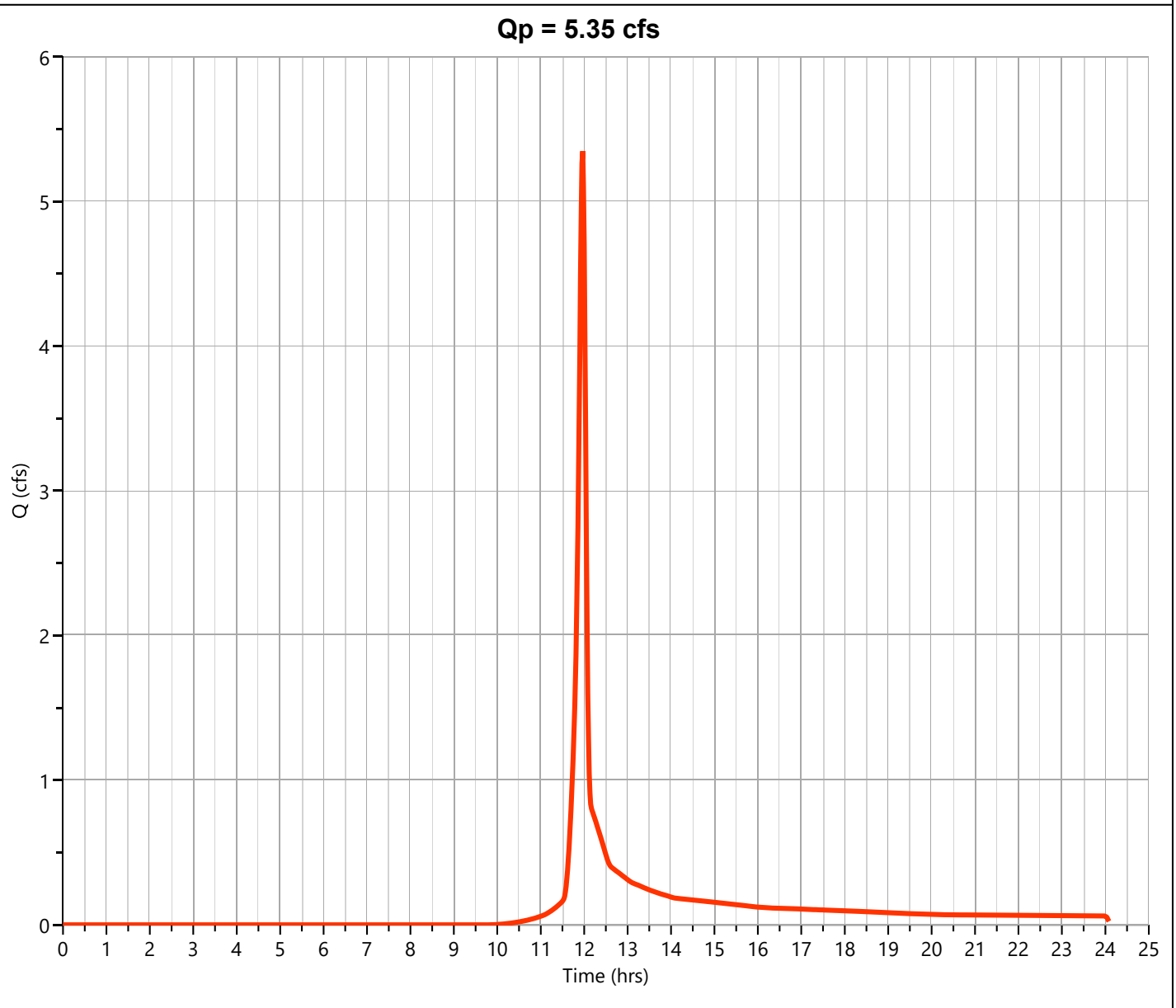
Pre AP1

Hyd. No. 1

Hydrograph Type	= NRCS Runoff	Peak Flow	= 5.348 cfs
Storm Frequency	= 100-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 10,741 cuft
Drainage Area	= 0.99 ac	Curve Number	= 61*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 7.27 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.99	61	Composite CN
0.99	**61**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

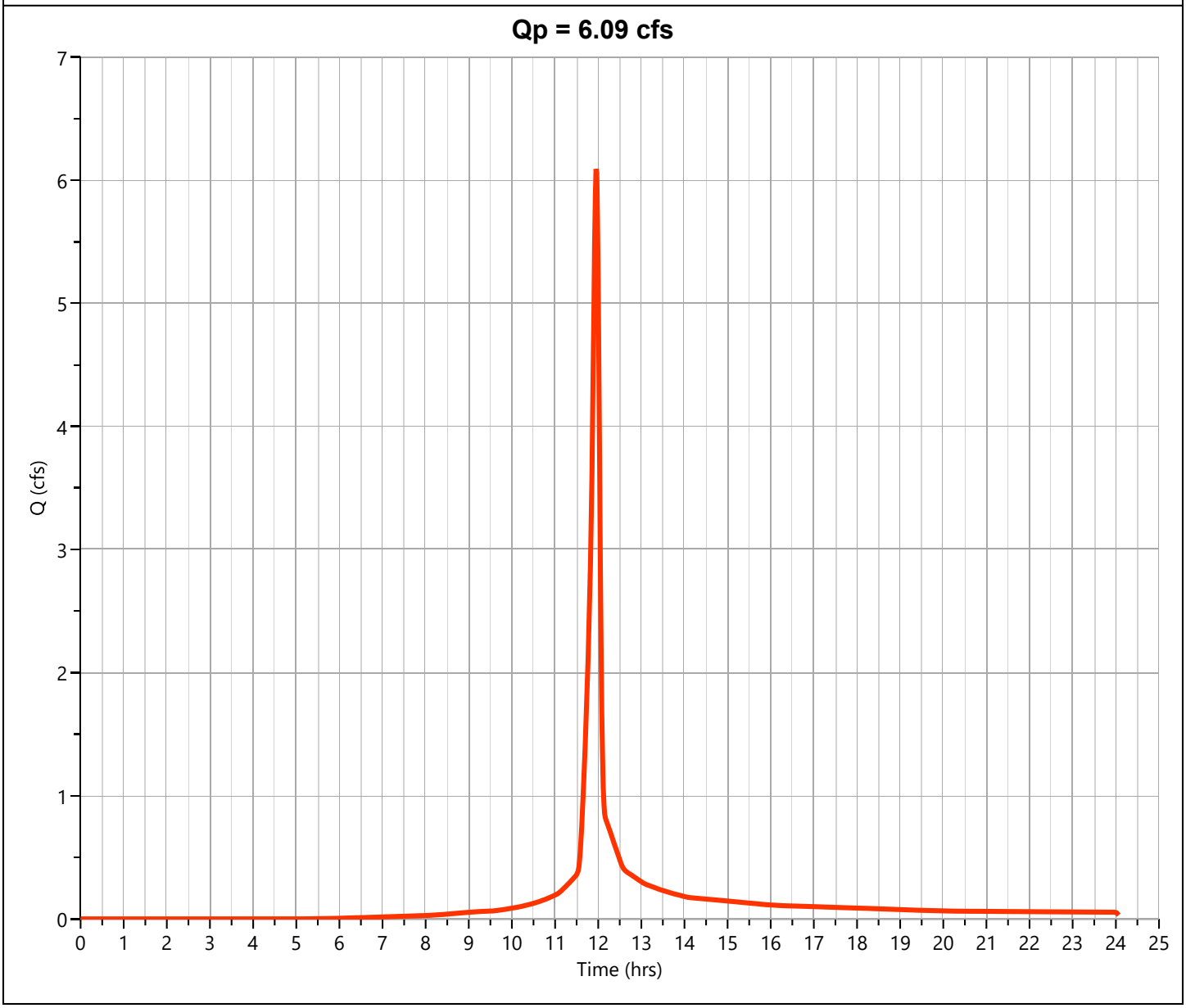
Post DA TO SCM

Hyd. No. 2

Hydrograph Type	= NRCS Runoff	Peak Flow	= 6.092 cfs
Storm Frequency	= 100-yr	Time to Peak	= 11.95 hrs
Time Interval	= 1 min	Runoff Volume	= 12,771 cuft
Drainage Area	= 0.69 ac	Curve Number	= 80*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 7.27 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.69	80	Composite CN
0.69	**80**	Weighted CN Method Employed



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

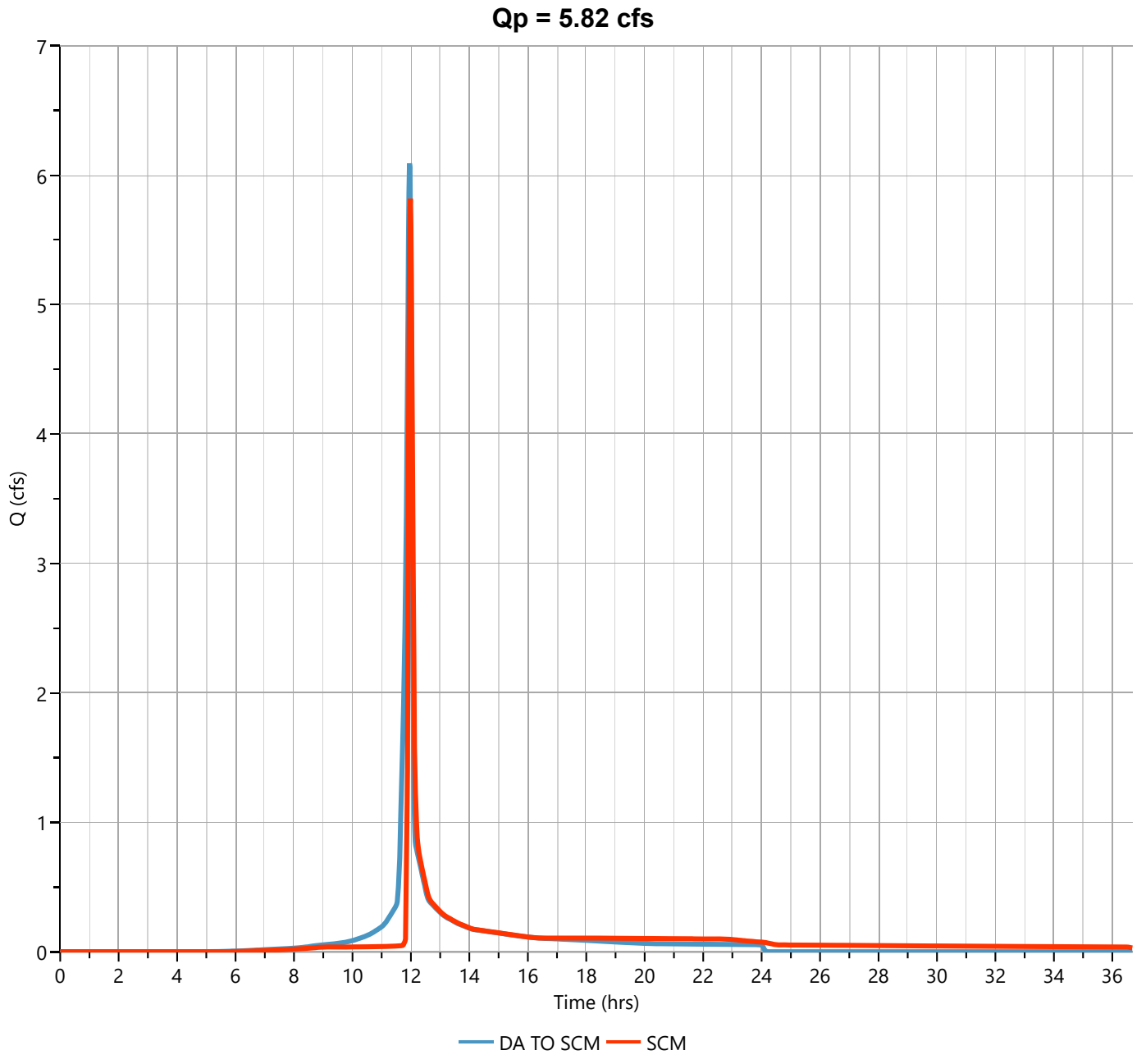
Post SCM

Hyd. No. 3

Hydrograph Type	= Pond Route	Peak Flow	= 5.819 cfs
Storm Frequency	= 100-yr	Time to Peak	= 11.98 hrs
Time Interval	= 1 min	Hydrograph Volume	= 12,768 cuft
Inflow Hydrograph	= 2 - DA TO SCM	Max. Elevation	= 345.14 ft
Pond Name	= Bioretention	Max. Storage	= 3,514 cuft
Routing Option	= Wet Pond	Wet Pond Elevation	= 343.50 ft

Pond Routing by Storage Indication Method

Center of mass detention time = 1.70 hrs



Hydrograph Report

Project Name:

Hydrology Studio v 3.0.0.29

12-20-2023

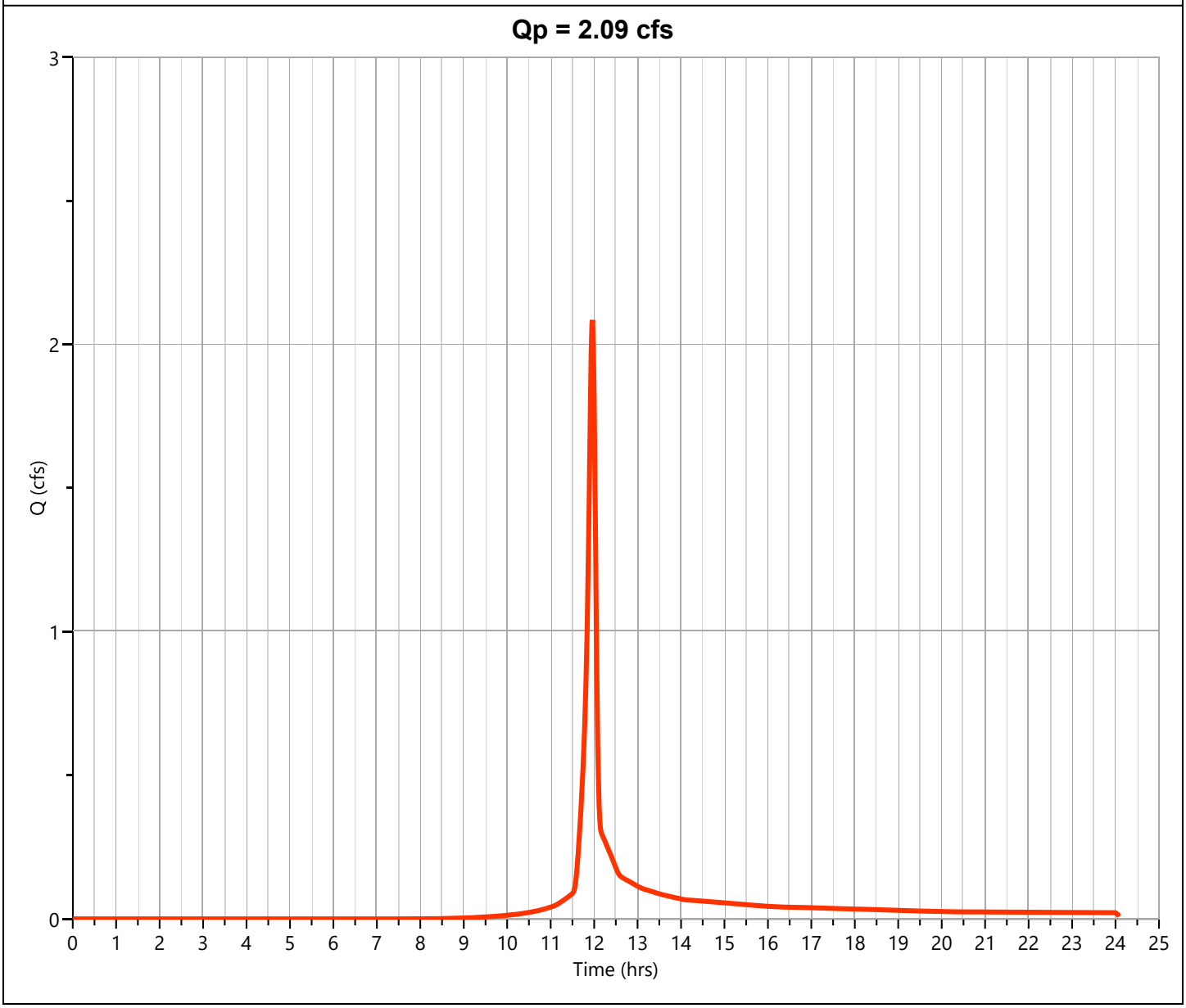
Post SCM BYPASS

Hyd. No. 4

Hydrograph Type	= NRCS Runoff	Peak Flow	= 2.085 cfs
Storm Frequency	= 100-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Runoff Volume	= 4,212 cuft
Drainage Area	= 0.31 ac	Curve Number	= 68*
Tc Method	= User	Time of Conc. (Tc)	= 5.0 min
Total Rainfall	= 7.27 in	Design Storm	= Type II
Storm Duration	= 24 hrs	Shape Factor	= 484

*** Composite CN Worksheet**

AREA (ac)	CN	DESCRIPTION
0.31	68	Composite CN
0.31	**68**	Weighted CN Method Employed



Hydrograph Report

Project Name:

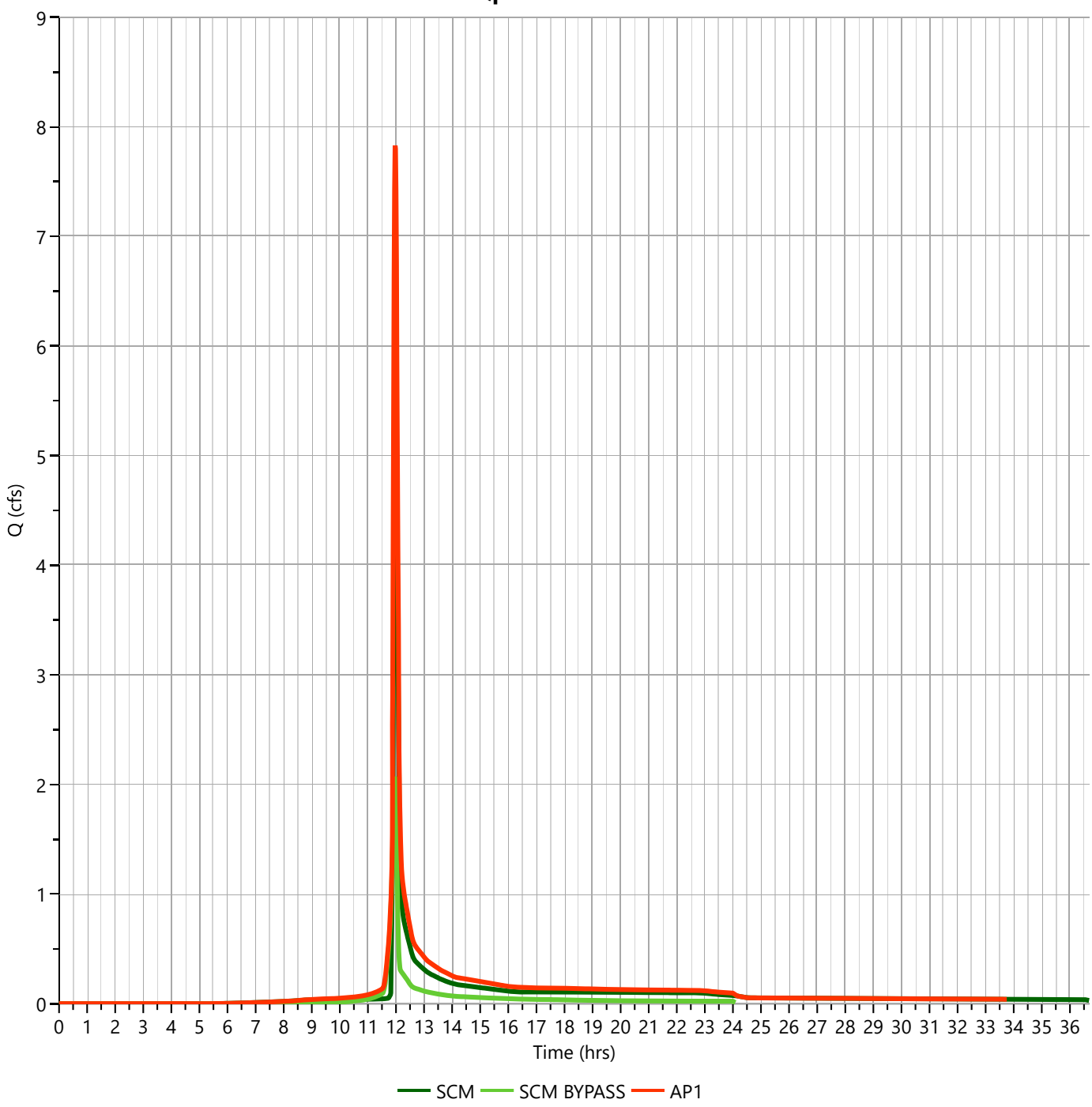
Hydrology Studio v 3.0.0.29

12-20-2023

Post AP1

Hyd. No. 5

Hydrograph Type	= Junction	Peak Flow	= 7.829 cfs
Storm Frequency	= 100-yr	Time to Peak	= 11.97 hrs
Time Interval	= 1 min	Hydrograph Volume	= 16,981 cuft
Inflow Hydrographs	= 3, 4	Total Contrib. Area	= 0.31 ac



APPENDIX C
BIORETENTION AREA CALCULATIONS

APPENDIX C

BIORETENTION AREA SUPPORTING CALCULATIONS

401 GANNON AVENUE

December 20, 2023

SCS CN CALCULATIONS

PRE-DEVELOPMENT

Entire Site

401 GANNON AVENUE

December 20, 2023

This data reflects the pre-development conditions of the entire site drainage area

Hydrologic Soil Group: B

ONSITE LAND COVERS

ONSITE DRAINAGE AREA

IMPERVIOUS LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Road (pavement only)	98		0	0.00	0
Parking			0	0.00	0
Roof			0	0.00	0
Driveway			0	0.00	0
Sidewalk			0	0.00	0
Deck/patio			0	0.00	0
Other impervious			0	0.00	0
Other impervious			0	0.00	0

PERVIOUS LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Lawn/grass/open space	61		0	0.00	0
Grass (within R/W)	61		43,291	0.99	61
Woods	55		0	0.00	0
Natural wetland	55		0	0.00	0
Riparian buffer	55		0	0.00	0
Other pervious	0		0	0.00	0
Other pervious	0		0	0.00	0

COMPOSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Commercial area	92	85	0	0.00	0
Industrial area	88	72	0	0.00	0
Residential area (<1/8 acre lot)	85	65	0	0.00	0
Residential (1/4 acre lot)	75	38	0	0.00	0
Residential (1/3 acre lot)	72	30	0	0.00	0
ONSITE TOTALS			**43,291**	**0.99**	**61**
TOTAL ONSITE IMPERVIOUS			0	0.00	

OTHER ONSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
SCM			0	0.00	
Open Water			0	0.00	

OFFSITE LAND COVERS

OFFSITE DRAINAGE AREA

COMPOSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Impervious	98		0	0.00	0
Pervious	74		0	0.00	0
Road R/W	98	100	0	0.00	0
Road R/W	96	90	0	0.00	0
Commercial area	93	80	0	0.00	0
Industrial area	91	70	0	0.00	0
Residential area (<1/8 acre lot)	88	60	0	0.00	0
Residential (1/4 acre lot)	86	50	0	0.00	0
Residential (1/3 acre lot)	84	40	0	0.00	0
OFFSITE TOTALS			**0**	**0.00**	**0**

TOTAL DRAINAGE ARA	Area [sq ft]	Area [ac]	Composite CN
	43,291	**0.99**	**61**

POST-DEVELOPMENT TOTAL POND DA

DA1.1

401 GANNON AVENUE

DA to SCM

December 20, 2023

Hydrologic Soil Group B

ONSITE LAND COVERS

ONSITE DRAINAGE AREA

IMPERVIOUS LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	[ac]	Weighted CN
Road (pavement only)	98		5,550	0.13	18
Parking			0	0.00	0
Roof			6,650	0.15	22
Driveway			3,275	0.08	11
Sidewalk			175	0.00	1
Deck/patio			0	0.00	0
All impervious			0	0.00	0
Other impervious			0	0.00	0

PERVIOUS LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	[ac]	Weighted CN
Lawn/grass/open space	61		14,250	0.33	29
Grass (within R/W)	61		0	0.00	0
Woods	55		0	0.00	0
Natural wetland	55		0	0.00	0
Riparian buffer	55		0	0.00	0
Other pervious	61		0	0.00	0
Other pervious	61		0	0.00	0

COMPOSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	[ac]	Weighted CN
Commercial area	92	85	0	0.00	0
Industrial area	88	72	0	0.00	0
Residential area (<1/8 acre lot)	85	65	0	0.00	0
Residential (1/4 acre lot)	75	38	0	0.00	0
Residential (1/3 acre lot)	72	30	0	0.00	0
ONSITE TOTALS			**29,900**	**0.69**	**80**
TOTAL ONSITE IMPERVIOUS			15,650	0.36	

OTHER ONSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	[ac]	Weighted CN
SCM			1,600	0.04	
Open Water			0	0.00	

OFFSITE LAND COVERS

OFFSITE DRAINAGE AREA

COMPOSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	[ac]	Weighted CN
Impervious	98		0	0.00	0
Pervious	61		0	0.00	0
Road R/W	98	100	0	0.00	0
Road R/W	94	90	0	0.00	0
Commercial area	91	80	0	0.00	0
Industrial area	87	70	0	0.00	0
Residential area (<1/8 acre lot)	83	60	0	0.00	0
Residential (1/4 acre lot)	80	50	0	0.00	0
Residential (1/3 acre lot)	76	40	0	0.00	0
OFFSITE TOTALS			**0**	**0.00**	**0**

TOTAL DRAINAGE ARA	Area [sq ft]	[ac]	Composite CN
	29,900	**0.69**	**80**

POST-DEVELOPMENT TOTAL POND DA

DA1.2

401 GANNON AVENUE

SCM Bypass

December 20, 2023

Hydrologic Soil Group B

ONSITE LAND COVERS

ONSITE DRAINAGE AREA

IMPERVIOUS LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Road (pavement only)			1,225	0.03	9
Parking			0	0.00	0
Roof			1,050	0.02	8
Driveway	98		0	0.00	0
Sidewalk			125	0.00	1
Deck/patio			0	0.00	0
All impervious			0	0.00	0
Other impervious			0	0.00	0

PERVIOUS LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Lawn/grass/open space	61		10,991	0.25	50
Grass (within R/W)	61			0.00	0
Woods	55		0	0.00	0
Natural wetland	55		0	0.00	0
Riparian buffer	55		0	0.00	0
Other pervious	61		0	0.00	0
Other pervious	61		0	0.00	0

COMPOSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Commercial area	92	85	0	0.00	0
Industrial area	88	72	0	0.00	0
Residential area (<1/8 acre lot)	85	65	0	0.00	0
Residential (1/4 acre lot)	75	38	0	0.00	0
Residential (1/3 acre lot)	72	30	0	0.00	0
ONSITE TOTALS			**13,391**	**0.31**	**68**
TOTAL ONSITE IMPERVIOUS			2,400	0.06	

OTHER ONSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
SCM			0	0.00	
Open Water			0	0.00	

OFFSITE LAND COVERS

OFFSITE DRAINAGE AREA

COMPOSITE LAND COVERS	SCS CN	Avg % Imp	Area [sq ft]	Area [ac]	Weighted CN
Impervious	98		0	0.00	0
Pervious	61		0	0.00	0
Road R/W	98	100	0	0.00	0
Road R/W	94	90	0	0.00	0
Commercial area	91	80	0	0.00	0
Industrial area	87	70	0	0.00	0
Residential area (<1/8 acre lot)	83	60	0	0.00	0
Residential (1/4 acre lot)	80	50	0	0.00	0
Residential (1/3 acre lot)	76	40	0	0.00	0
OFFSITE TOTALS			**0**	**0.00**	**0**

TOTAL DRAINAGE ARA	Area [sq ft]	Area [ac]	Composite CN
	13,391	**0.31**	**68**

RUNOFF VOLUME BY SIMPLE METHOD

WATER QUALITY RUNOFF VOLUME

December 20, 2023

401 GANNON AVENUE **Bioretention Area**

Runoff Volume by the Simple Method taken from NCDEQ Stormwater Design Manual Part B

Input Data

Impervious fraction	Ia	0.523
Drainage area	A	0.69 acres
Design storm rainfall depth	Rd	1.00 inches

Output

Runoff coefficient	Rv	*0.52*
Runoff volume	V	*1,298 cubic feet*

$$R_v = 0.05 + 0.9 \times I_A$$

$$V = 3630 \times R_D \times R_{V \times} A$$

BIORETENTION AREA SIZING

BIORETENTION AREA SIZING

December 20, 2023

401 GANNON AVENUE **Bioretention Area**

Drainage area	29,900 SF	
Impervious area	15,650 SF	
Percent impervious	52.3%	
Runoff volume to treat	1,298 CF	(from simple method)

Bioretention Cell Design Data

Design ponding depth	12.00 inches
Surface area of bioretention area	1,505 SF
Elev at bottom of bioretention cell	256.00
Elev at bottom of soil media	253.00
Elev of underdrain	252.00
Underdrain diameter	4.00 in.
Underdrain slope	0.0100 ft/ft
Underdrain manning's n	0.011
Underdrain flowrate factor of safety (FS)	10
Infiltration rate of cell media	2.0 in/hr
Void ratio of soil media	50.0%

Calculate Dewatering Flowrate Thru Soil Media

Volume above ground to dewater	1,505 CF
Volume in soil media to dewater	2,258 CF
Total volume to dewater	3,763 CF
Dewatering time from infiltration rate	24.0 hrs
Flowrate thru media to underdrain	0.04 cfs
Flowrate thru media to underdrain w/ FS	0.44 cfs

WATER SURFACE ELEVATION FOR WQ VOLUME

WATER SURFACE ELEVATION FOR WQ VOLUME

December 20, 2023

401 GANNON AVENUE **Bioretention Area**

Elevation at WQ Volume	344.2
Calculated surface pond surface area at above elevation	2,012 SF
Calculated pond volume at above elevation	1,290 CF
Calculated WQ Volume from simple method	1,298 CF

POND ELEVATION AND CONTOUR DATA				
343.5	1,505 SF	0.0	0	0
344	1,844 SF	0.5	*837 CF*	*837 CF*
345	2,685 SF	1.5	*2,265 CF*	*3,102 CF*
346	3,447 SF	2.5	*3,066 CF*	*6,168 CF*

ANTI FLOTATION BLOCK CALCULATIONS

ANTI FLOTATION BLOCK

December 20, 2023

401 GANNON AVENUE

Bioretention Area

Constants

Unit weight of water	62.4 lb/cf
Unit weight of concrete	144.0 lb/cf

Riser Data

	Length	Width	Area
Inside domensions	4.00 ft	4.00 ft	16.0 SF
Outside dimensions	5.00 ft	5.00 ft	25.0 SF

Cross sectional riser area	9.0 SF	
Riser inside height	3.5 ft	
Volume of concrete in riser	32 CF	
Riser base area	25.0 SF	(same as riser outside dimensions)
Riser base thickness	0.5 ft	
Volume of concrete in base	13 CF	
Total volume of concrete in riser+base	44 CF	
Total bouyant weight of riser	3,590 lbs	
Water displaced by riser	88 CF	
Weight of water displaced	5,460 lbs	

Anti-Flotation Block Data

Length of anti-flotation block	6.0 ft
Width of anti-flotation block	6.0 ft
Thickness of anti-flotation block	1.5 ft
Volume of anti-flotation block	54 CF
Total weight of anti-flotation block	7,776 lbs

Factor of Safety

Weight of riser+anti-flotation block	11,366 lbs
Weight of water displaced by riser	5,460 lbs
Factor of safety against flotation	2.08

APPENDIX D
WAKE COUNTY MUNICIPAL TOOL OUTPUT

SITE DATA

Project Information	
Project Name:	**West Gannon Townhomes**
Applicant:	The Nau Company, PLLC
Applicant Contact Name:	Jonathan Eakins, PE
Applicant Contact Number:	919-616-4716
Contact Email:	jeakins@thenauco.com
Municipal Jurisdiction (Select from dropdown menu):	Zebulon
Last Updated:	
Site Data:	
Total Site Area (Ac):	0.99
Existing Lake/Pond Area (Ac):	0.00
Proposed Disturbed Area (Ac):	0.99
Impervious Surface Area (acre):	0.42
Type of Development (Select from Dropdown menu):	Residential
Percent Built Upon Area (BUA):	42%
Project Density:	High
Is the proposed project a site expansion?	No
Number of Drainage Areas on Site:	1
NOAA — **1-Year, 24-Hour Storm (inches) (See NOAA Website):**	2.84
2-Year, 24-Hour Storm (inches) (See NOAA Website):	3.42
10-Year, 24-Hour Storm (inches) (See NOAA Website):	4.96
Lot Data (if applicable):	
Total Acreage in Lots:	0.99
Number of Lots:	11
Average Lot Size (SF):	0.00
Total Impervious Surface Area on Lots (SF):	0.42
Average Impervious Surface Area Per Lot (SF):	0.42

Stormwater Narrative (limit to 1,200 characters - attach additional pages with submittal if necessary):

The development will consist of 11 condo units on one lot. The site will be served by one private access drive with a road name. The site will utilize one bioretention area to meet the Town/County stormwater and nutrient removal requirements

Project Name: West Gannon Townhomes

DRAINAGE AREA 1
STORMWATER PRE-POST CALCULATIONS

LAND USE & SITE DATA	PRE-DEVELOPMENT				POST-DEVELOPMENT			
Drainage Area (Acres)=	0.99				0.99			
Site Acreage within Drainage=	0.99				0.99			
One-year, 24-hour rainfall (in)=	2.84							
Two-year, 24-hour rainfall (in)=	3.42							
Ten-year, 24-hour storm (in)=	4.96							
Total Lake/Pond Area (Acres)=	0.00				0.00			
Lake/Pond Area not in the Tc flow path (Acres)=	0.00				0.00			
Site Land Use (acres):	A	B	C	D	A	B	C	D
Pasture								
Woods, Poor Condition								
Woods, Fair Condition								
Woods, Good Condition								
Open Space, Poor Condition								
Open Space, Fair condition								
Open Space, Good Condition		0.99				0.57		
Reforestation (in dedicated OS)								
Connected Impervious						0.42		
Disconnected Impervious								

SITE FLOW	PRE-DEVELOPMENT T_c	POST-DEVELOPMENT Tc
Sheet Flow		
Length (ft)=		
Slope (ft/ft)=		
Surface Cover:		
n-value=		
T_t (hrs)=		
Shallow Flow		
Length (ft)=		
Slope (ft/ft)=		
Surface Cover:		
Average Velocity (ft/sec)=		
T_t (hrs)=		
Channel Flow 1		
Length (ft)=		
Slope (ft/ft)=		
Cross Sectional Flow Area (ft^2)=		
Wetted Perimeter (ft)=		
Channel Lining:		
n-value=		
Hydraulic Radius (ft)=		
Average Velocity (ft/sec)=		
T_t (hrs)=		

Project Name: West Gannon Townhomes

DRAINAGE AREA 1
STORMWATER PRE-POST CALCULATIONS

Channel Flow 2		
Length (ft)=		
Slope (ft/ft)=		
Cross Sectional Flow Area (ft^2)=		
Wetted Perimeter (ft)=		
Channel Lining:		
n-value=		
Hydraulic Radius (ft)=		
Average Velocity (ft/sec)=		
T_t (hrs)=		
Channel Flow 3		
Length (ft)=		
Slope (ft/ft)=		
Cross Sectional Flow Area (ft^2)=		
Wetted Perimeter (ft)=		
Channel Lining:		
n-value=		
Hydraulic Radius (ft)=		
Average Velocity (ft/sec)=		
T_t (hrs)=		
Tc (hrs)=	0.08	0.08
RESULTS	**PRE-DEVELOPMENT**	**POST-DEVELOPMENT**
Composite Curve Number=	61	77
Disconnected Impervious Adjustment		
Disconnected impervious area (acre) =		
$CN_{adjusted\ (1\text{-}year)}$=	**77**	
High Density Only		
Volume of runoff from 1" rainfall for DA HIGH DENSITY REQUIREMENT = (ft^3) =	1,552	
1-year, 24-hour storm (Peak Flow)		
Runoff (inches) = $Q^*_{1\text{-}year}$=	0.31	0.95
Volume of runoff (ft^3) =	1,101	3,398
Volume change (ft^3) =	2,297	
Peak Discharge (cfs)= $Q_{1\text{-}year}$=	0.361	1.470
2-year, 24-hour storm (LID)		
Runoff (inches) = $Q^*_{2\text{-}year}$=	0.54	1.35
Volume of runoff (ft^3) =	1,931	4,859
Peak Discharge (cfs)= $Q_{2\text{-}year}$=	0.633	2.101
10-year, 24-hour storm (DIA)		
Runoff (inches) = $Q^*_{10\text{-}year}$=	1.35	2.56
Volume of runoff (ft^3) =	4,834	9,212
Peak Discharge (cfs)= $Q_{10\text{-}year}$=	1.585	3.984

Project Name: West Gannon Townhomes

DRAINAGE AREA 1
BMP CALCULATIONS

DRAINAGE AREA 1 - BMP DEVICES AND ADJUSTMENTS				
DA1 Site Acreage=	0.99			
DA1 Off-Site Acreage=				
Total Required Storage Volume for Site TCN Requirement (ft^3)=	N/A			
Total Required Storage Volume for DA1 1" Rainfall for High Density (ft^3)=	1,552			
Will site use underground detention/cistern?	No	Enter % of the year water will be reused=	0%	Note: Supporting information/details should be submitted to demonstrate water usage.

ENTER ACREAGE FOR ALL SUB-DRAINAGE AREAS IN DA

HSG	Sub-DA1(a) (Ac)		Sub-DA1(b) (Ac)		Sub-DA1(c) (Ac)		Sub-DA1(d) (Ac)		Sub-DA1(e) (Ac)	
	Site	Off-site	Site	Off-site	Site	Off-site	Site	Off-site	Site	Off-site
Pasture										
Woods, Poor Condition										
Woods, Fair Condition										
Woods, Good Condition										
Open Space, Poor Condition										
Open Space, Fair Condition										
Open Space, Good Condition	0.33		0.24							
Reforestation (in dedicated OS)										
Impervious	0.36		0.06							

Sub-DA1(a) BMP(s)

Device Name (As Shown on Plan)	Device Type	Water Quality Volume for Sub-DA (ft^3)	Provided Volume that will drawdown 2-5 days (ft^3)	Nitrogen Removal Efficiency	Sub-DA Nitrogen (lbs)	Nitrogen Removed (lbs)	Drawdown Time (hours)
SCM1	Bioretention with IWS	945	2,560	40%	7.83	3.13	48
				0%	4.70	0.00	
				0%	4.70	0.00	
				0%	4.70	0.00	
				0%	4.70	0.00	
Total Nitrogen remaining leaving the subbasin (lbs):		**4.70**					

Sub-DA1(b) BMP(s)

If Sub-DA1(b) is connected to upstream subbasin(s), enter the nitrogen leaving the most upstream subbasin(lbs):

Device Name (As Shown on Plan)	Device Type	Water Quality Volume for Sub-DA (ft^3)	Provided Volume that will drawdown 2-5 days (ft^3)	Nitrogen Removal Efficiency	Sub-DA Nitrogen (lbs)	Nitrogen Removed (lbs)	Drawdown Time (hours)
		114		0%	1.42	0.00	
				0%	1.42	0.00	
				0%	1.42	0.00	
				0%	1.42	0.00	
				0%	1.42	0.00	
Total Nitrogen remaining leaving the subbasin (lbs):		**1.42**					

Sub-DA1 (c) BMP(s)

If Sub-DA1(c) is connected to upstream subbasin(s), enter the nitrogen leaving the most upstream subbasin(lbs):

Device Name (As Shown on Plan)	Device Type	Water Quality Volume for Sub-DA (ft^3)	Provided Volume that will drawdown 2-5 days (ft^3)	Nitrogen Removal Efficiency	Sub-DA Nitrogen (lbs)	Nitrogen Removed (lbs)	Drawdown Time (hours)
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
Total Nitrogen remaining leaving the subbasin (lbs):							

Project Name: West Gannon Townhomes

DRAINAGE AREA 1
BMP CALCULATIONS

Sub-DA1(d) BMP(s)							
If Sub-DA1(d) is connected to upstream subbasin(s), enter the nitrogen leaving the most upstream subbasin(lbs):							
Device Name (As Shown on Plan)	Device Type	Water Quality Volume for Sub-DA (ft^3)	Provided Volume that will drawdown 2-5 days (ft^3)	Nitrogen Removal Efficiency	Sub-DA Nitrogen (lbs)	Nitrogen Removed (lbs)	Drawdown Time (hours)
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
Total Nitrogen remaining leaving the subbasin (lbs):							

Sub-DA1(e) BMP(s)							
If Sub-DA1(e) is connected to upstream subbasin(s), enter the nitrogen leaving the most upstream subbasin(lbs):							
Device Name (As Shown on Plan)	Device Type	Water Quality Volume for Sub-DA (ft^3)	Provided Volume that will drawdown 2-5 days (ft^3)	Nitrogen Removal Efficiency	Sub-DA Nitrogen (lbs)	Nitrogen Removed (lbs)	Drawdown Time (hours)
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
				0%	0.00	0.00	
Total Nitrogen remaining leaving the subbasin (lbs):							

DA1 BMP SUMMARY	
Total Volume Treated (ft^3)=	2,560
Nitrogen Mitigated(lbs)=	3.13
1-year, 24-hour storm	
Post BMP Volume of Runoff (ft^3)$_{(1\text{-year})}$=	838
Post BMP Runoff (inches) = $Q^*_{(1\text{-year})}$=	0.23
Post BMP $CN_{(1\text{-year})}$=	58
Post BMP Peak Discharge (cfs)= $Q_{1\text{-year}}$=	0.050
2-year, 24-hour storm (LID)	
Post BMP Volume of Runoff (ft3)$_{(2\text{-year})}$=	2,299
Post BMP Runoff (inches) = $Q^*_{(2\text{-year})}$=	0.64
Post BMP $CN_{(2\text{-year})}$=	63
Post BMP Peak Discharge (cfs)= $Q_{(2\text{-year})}$=	0.070
10-year, 24-hour storm (DIA)	
Post BMP Volume of Runoff (ft^3)$_{(10\text{-year})}$=	6,652
Post BMP Runoff (inches) = $Q^*_{(10\text{-year})}$=	1.85
Post BMP $CN_{(10\text{-year})}$=	83
Post BMP Peak Discharge (cfs)= $Q_{(10\text{-year})}$=	0.120

Project Name: West Gannon Townhomes

DA SITE SUMMARY
BMP CALCULATIONS

BMP SUMMARY										
DRAINAGE AREA SUMMARIES										
DRAINAGE AREA:	DA1	DA2	DA3	DA4	DA5	DA6	DA7	DA8	DA9	DA10
Pre-Development (1-year, 24-hour storm)										
Runoff (in)=$Q^*_{1\text{-year}}$ =	0.31									
Peak Flow (cfs)=$Q_{1\text{-year}}$ =	0.361									
Post-Development (1-year, 24-hour storm)										
Target Curve Number (TCN) =	NA									
Post BMP Runoff (inches) = $Q^*_{(1\text{-year})}$=	0.23									
Post BMP Peak Discharge (cfs)= $Q_{1\text{-year}}$=	0.050									
Post BMP $CN_{(1\text{-year})}$=	58									
Post-BMP Nitrogen Loading										
TOTAL SITE NITROGEN MITIGATED (lbs)=	3.13									
SITE NITROGEN LOADING RATE (lbs/ac/yr)=	6.18									
TOTAL SITE NITROGEN LEFT TO MITIGATE_Wendell Only (lbs)=	**2.55**									

APPENDIX E
SUPPORTING DOCUMENTATION

NOAA Atlas 14, Volume 2, Version 3 RALEIGH
DURHAM WSFO AP
Station ID: 31-7069
Location name: Morrisville, North Carolina, USA*
Latitude: 35.8706°, Longitude: -78.7864°
Elevation:
Elevation (station metadata): 416 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

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	**0.394** (0.362-0.429)	**0.461** (0.423-0.503)	**0.530** (0.487-0.577)	**0.587** (0.539-0.639)	**0.647** (0.591-0.703)	**0.689** (0.626-0.748)	**0.727** (0.657-0.789)	**0.758** (0.682-0.825)	**0.792** (0.707-0.862)	**0.819** (0.724-0.892)
10-min	**0.630** (0.578-0.686)	**0.738** (0.677-0.804)	**0.848** (0.780-0.924)	**0.939** (0.861-1.02)	**1.03** (0.941-1.12)	**1.10** (0.998-1.19)	**1.16** (1.04-1.25)	**1.20** (1.08-1.31)	**1.25** (1.12-1.36)	**1.29** (1.14-1.41)
15-min	**0.787** (0.723-0.857)	**0.927** (0.850-1.01)	**1.07** (0.987-1.17)	**1.19** (1.09-1.29)	**1.31** (1.19-1.42)	**1.39** (1.26-1.51)	**1.46** (1.32-1.59)	**1.52** (1.36-1.65)	**1.58** (1.41-1.72)	**1.62** (1.43-1.76)
30-min	**1.08** (0.991-1.18)	**1.28** (1.18-1.40)	**1.53** (1.40-1.66)	**1.72** (1.58-1.87)	**1.94** (1.77-2.10)	**2.09** (1.90-2.27)	**2.24** (2.02-2.43)	**2.36** (2.12-2.57)	**2.51** (2.24-2.73)	**2.62** (2.32-2.86)
60-min	**1.35** (1.24-1.47)	**1.61** (1.47-1.75)	**1.96** (1.80-2.13)	**2.24** (2.06-2.44)	**2.58** (2.35-2.80)	**2.84** (2.58-3.08)	**3.08** (2.78-3.35)	**3.31** (2.98-3.60)	**3.60** (3.21-3.92)	**3.83** (3.38-4.17)
2-hr	**1.56** (1.42-1.71)	**1.86** (1.71-2.04)	**2.29** (2.09-2.51)	**2.65** (2.40-2.90)	**3.08** (2.78-3.36)	**3.43** (3.09-3.74)	**3.76** (3.36-4.11)	**4.09** (3.64-4.46)	**4.51** (3.97-4.92)	**4.84** (4.23-5.29)
3-hr	**1.65** (1.51-1.81)	**1.98** (1.81-2.17)	**2.44** (2.23-2.68)	**2.84** (2.59-3.10)	**3.33** (3.02-3.64)	**3.75** (3.38-4.09)	**4.15** (3.71-4.53)	**4.56** (4.06-4.97)	**5.11** (4.49-5.57)	**5.55** (4.83-6.06)
6-hr	**2.00** (1.84-2.18)	**2.39** (2.20-2.61)	**2.95** (2.72-3.22)	**3.44** (3.15-3.74)	**4.06** (3.70-4.40)	**4.57** (4.14-4.96)	**5.09** (4.57-5.51)	**5.62** (5.00-6.08)	**6.33** (5.56-6.85)	**6.92** (6.01-7.50)
12-hr	**2.37** (2.19-2.58)	**2.84** (2.62-3.09)	**3.52** (3.24-3.82)	**4.11** (3.78-4.47)	**4.89** (4.46-5.30)	**5.56** (5.03-5.98)	**6.22** (5.58-6.70)	**6.93** (6.13-7.45)	**7.88** (6.87-8.47)	**8.69** (7.46-9.35)
24-hr	**2.83** (2.65-3.04)	**3.42** (3.20-3.67)	**4.27** (3.99-4.58)	**4.94** (4.61-5.29)	**5.84** (5.43-6.25)	**6.55** (6.08-7.01)	**7.27** (6.73-7.80)	**8.01** (7.39-8.60)	**9.01** (8.28-9.69)	**9.79** (8.97-10.6)
2-day	**3.26** (3.04-3.50)	**3.92** (3.66-4.22)	**4.86** (4.53-5.23)	**5.58** (5.19-6.00)	**6.55** (6.08-7.05)	**7.31** (6.76-7.86)	**8.07** (7.45-8.70)	**8.85** (8.14-9.54)	**9.90** (9.06-10.7)	**10.7** (9.77-11.6)
3-day	**3.45** (3.22-3.70)	**4.14** (3.86-4.44)	**5.10** (4.76-5.48)	**5.86** (5.46-6.29)	**6.87** (6.38-7.38)	**7.67** (7.11-8.24)	**8.47** (7.83-9.12)	**9.29** (8.55-10.0)	**10.4** (9.53-11.2)	**11.2** (10.3-12.1)
4-day	**3.63** (3.40-3.90)	**4.35** (4.07-4.67)	**5.35** (5.00-5.73)	**6.13** (5.73-6.58)	**7.19** (6.69-7.72)	**8.03** (7.45-8.61)	**8.88** (8.21-9.54)	**9.73** (8.97-10.5)	**10.9** (9.99-11.7)	**11.8** (10.8-12.7)
7-day	**4.21** (3.96-4.50)	**5.02** (4.72-5.36)	**6.10** (5.73-6.51)	**6.95** (6.52-7.42)	**8.10** (7.57-8.65)	**9.01** (8.40-9.63)	**9.94** (9.23-10.6)	**10.9** (10.1-11.7)	**12.2** (11.2-13.1)	**13.2** (12.1-14.2)
10-day	**4.79** (4.50-5.11)	**5.69** (5.35-6.07)	**6.83** (6.41-7.29)	**7.72** (7.24-8.23)	**8.92** (8.35-9.52)	**9.86** (9.20-10.5)	**10.8** (10.1-11.6)	**11.8** (10.9-12.6)	**13.1** (12.1-14.0)	**14.1** (12.9-15.1)
20-day	**6.39** (6.01-6.82)	**7.54** (7.09-8.04)	**8.90** (8.36-9.50)	**9.98** (9.36-10.7)	**11.5** (10.7-12.2)	**12.6** (11.8-13.5)	**13.8** (12.8-14.8)	**15.0** (13.9-16.0)	**16.6** (15.3-17.8)	**17.8** (16.3-19.2)
30-day	**7.93** (7.48-8.44)	**9.33** (8.78-9.92)	**10.8** (10.2-11.5)	**12.0** (11.3-12.8)	**13.5** (12.7-14.4)	**14.7** (13.8-15.7)	**15.9** (14.8-17.0)	**17.1** (15.9-18.2)	**18.6** (17.3-20.0)	**19.8** (18.3-21.3)
45-day	**10.1** (9.61-10.7)	**11.8** (11.3-12.5)	**13.6** (12.9-14.3)	**14.9** (14.1-15.7)	**16.6** (15.7-17.5)	**17.9** (16.9-18.9)	**19.2** (18.1-20.4)	**20.5** (19.2-21.7)	**22.1** (20.7-23.5)	**23.4** (21.8-24.9)
60-day	**12.2** (11.6-12.8)	**14.2** (13.5-14.9)	**16.0** (15.2-16.8)	**17.4** (16.5-18.3)	**19.2** (18.2-20.2)	**20.5** (19.4-21.7)	**21.8** (20.6-23.1)	**23.1** (21.8-24.4)	**24.7** (23.2-26.2)	**25.9** (24.3-27.5)

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

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

Please refer to NOAA Atlas 14 document for more information.

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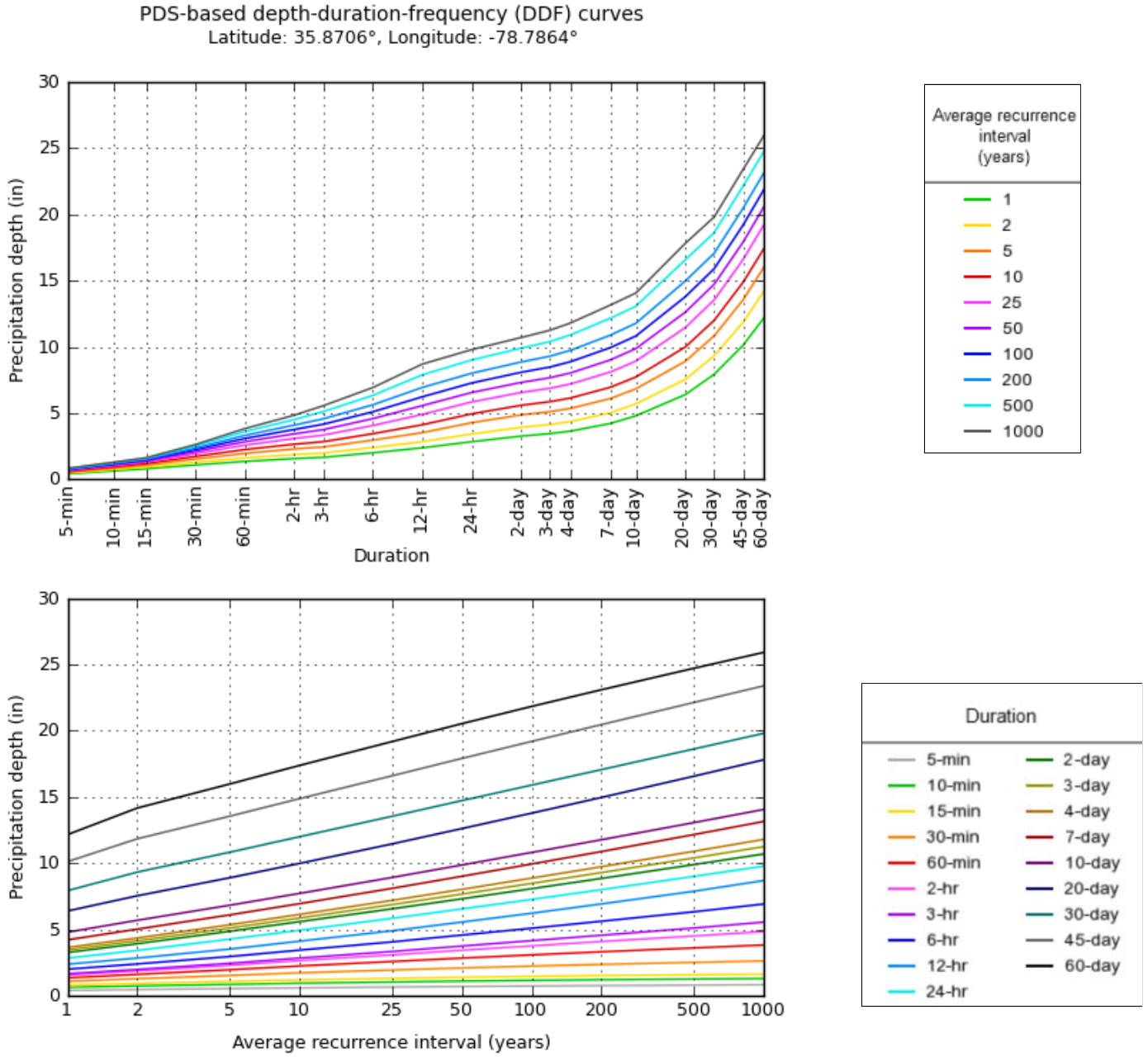
PF graphical



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Created (GMT): Fri Aug 16 18:48:37 2019

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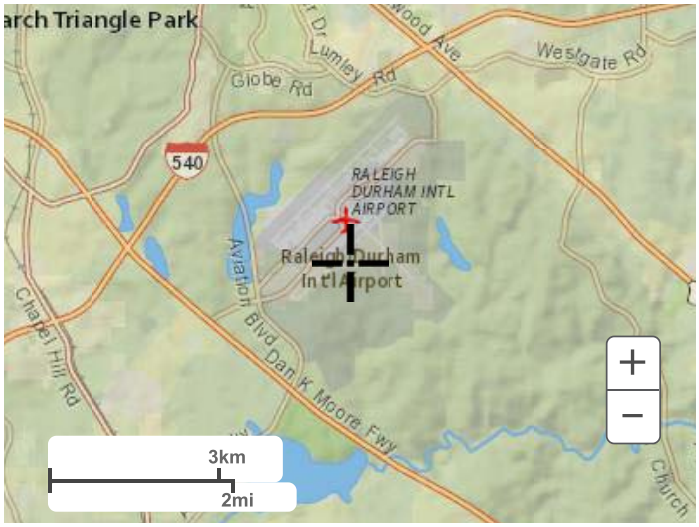
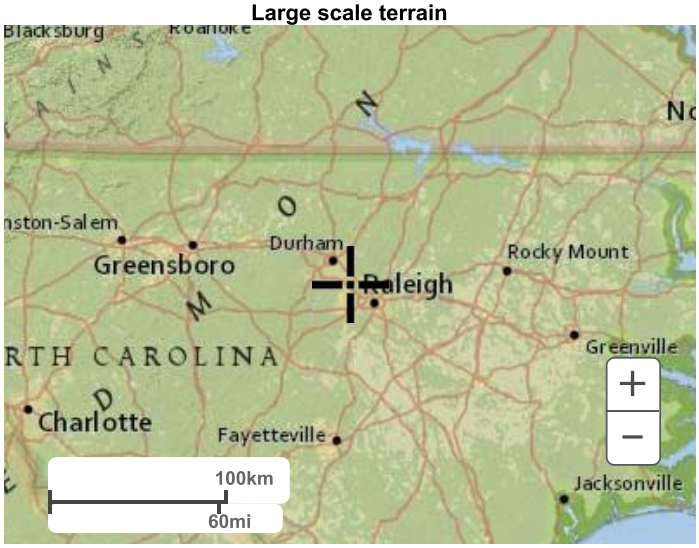
Maps & aerials

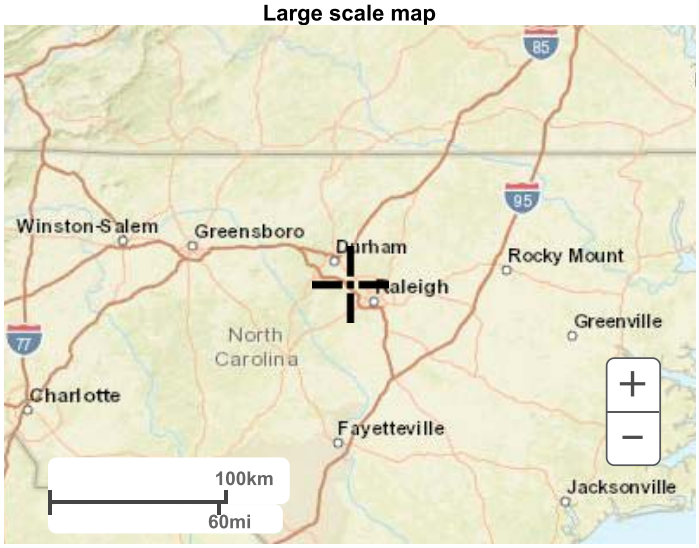
Small scale terrain



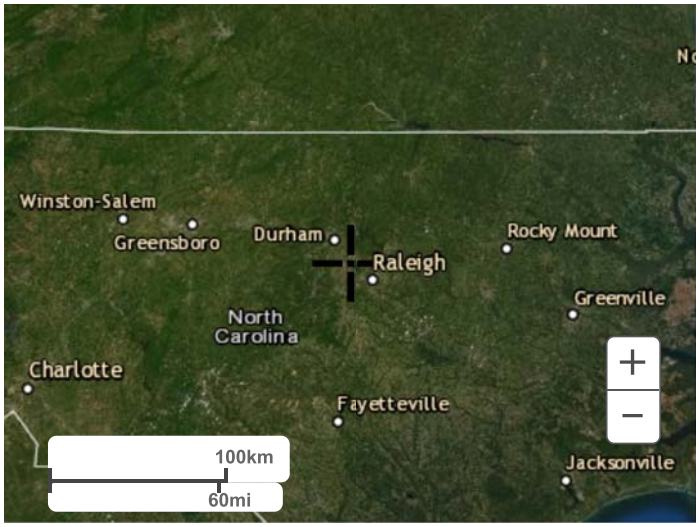
Large scale terrain



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

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2/]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor*: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.