

**DRAINAGE &
STORMWATER MANAGEMENT
CALCULATIONS**

FOR

**GLENWOOD GOLF CLUB
CELL TOWER SITE**

*LOCATED AT
3100 CREIGHTON ROAD
RICHMOND, VA 23223*

*HENRICO COUNTY, VIRGINIA
TAX PARCEL No. 804-726-5470*

PREPARED FOR

BC ARCHITECTS ENGINEERS, PLC

**DATE: OCTOBER 6, 2017
COMM. #2017-224**



**LUMSDEN ASSOCIATES, P.C.
ENGINEERS-SURVEYORS-PLANNERS
ROANOKE, VIRGINIA**

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LUMSDEN ASSOCIATES, P.C.
ENGINEERS-SURVEYORS-PLANNERS
ROANOKE, VIRGINIA

INTRODUCTION AND PROJECT DESCRIPTION

The subject property is located within Glenwood Golf Club at 3100 Creighton Road (Henrico County Tax Parcel No. 804-726-5470). The proposed development for this site includes the construction of a 12-foot-wide gravel access road to a 45-foot by 55-foot fenced compound containing a gravel pad for a 150-foot monopole cell tower. This site is located on an existing 124.3 acre parcel of which 0.056 acres will be leased and accessed by 0.268 acres of access/utility easement. The existing site parcel is home to Glenwood Golf Club and contains sparse impervious area with the majority of the land cover being turf. The terrain is rolling with most of the property draining towards the center of the parcel to an existing FEMA mapped watercourse (Gilles Creek) flowing from northwest to southeast. An existing conditions map is included within Appendix "A".

Please note, efforts will be made to provide construction using low impact methods, including limiting the amount of disturbed area, preserving existing trees, and locating the access road to limit the disruption of the existing runoff characteristics of the site to maintain existing runoff patterns. In total, this project proposes an approximate disturbance of 0.30 acres. The proposed grades for the construction of this project will be as close to existing grade as possible to minimize the impact on the existing drainage shed and allow for continued sheet flow of stormwater runoff.

STORMWATER MANAGEMENT – WATER QUALITY

Stormwater management calculations for water quality were based on Virginia's Stormwater Management Program Permit Regulations, Technical Criteria Part IIB. The most current (version 3.0) Virginia Runoff Reduction Method Spreadsheet for New Development was used to determine the amount of total phosphorus treatment required based on the area of disturbance. A summary is provided below with accompanying calculations provided within Appendix "B".

The total phosphorous load of new development projects shall not exceed 0.41 pounds per acre per year. The applicable area of the site is the limits of disturbance being 0.30 acres. In utilizing the Runoff Reduction New Development spreadsheet, water quality phosphorus treatment required for this project is 0.29 lbs/yr.

Post-Development Land Characteristics

Total Area (Disturbed) = 0.30 Ac.

Turf Area = 0.14 Ac.

Impervious Area = 0.16 Ac.

Wooded/Open Area = 0.00 Ac.

*Hydrologic Soil Group "C" for total disturbed area. See Appendix "E" for NRCS soil verification data.

Water quality compliance is achieved for this project by the purchase of offsite nutrient credits. Chesapeake Bay Nutrient Land Trust (CBNLT) has provided confirmation of 0.29 lbs/yr of

nutrient credit is available for purchase through the Cranston's Mill Pond Nutrient Bank. This nutrient bank is located within the same eight-digit hydrologic unit code as the project site. See Appendix "B" for verification of eight-digit hydrologic unit code and availability letter provided by CBNLT. Please note, the client will provide documentation of the acquisition of such credits prior to plan approval and/or issuance of Land Disturbance Permit by Henrico County.

STORMWATER MANAGEMENT – WATER QUANTITY

Pre-development and post-development hydrographs for stormwater management calculations were based on the NRCS TR-55, 24-hour rainfall distribution model. The 24-hour rainfall data was taken from the NOAA Atlas 14, Volume 2, Version 3.

The construction project area naturally drains towards the FEMA mapped floodplain of Gilles Creek located to the northeast and east of the proposed area of disturbance. Analysis of water quantity was conducted by using two points of analysis. Please note the discharge from these sheds are over broad discharge points.

Point of Analysis (POA 1) includes the drainage shed of the upper portion of the existing paved parking lot, portion of existing maintenance building, and the area of the proposed cell tower pad. A pre-development and post-development drainage was conducted and has been shown to have a negligible increase in both peak flow and volume. Additionally, the post-development condition proposes the flows to pass through the cell tower gravel pad area which allows the runoff to remain in a sheet flow condition prior to continuing it's travel through the existing wooded land cover prior to entering the Gilles Creek watercourse.

Point of Analysis (POA 2) includes the drainage shed of the lower portion of the existing paved parking lot and access road. Again, a pre-development and post-development drainage was conducted and has also been shown to have a negligible increase in both peak flow and volume. Additionally, this drainage shed (approximately 0.75 acres) is allowed to discharge off the proposed access road, allowing a broad (260 linear feet of access road) discharge point and thus promoting sheet flow release back to pre-development land cover conditions. Once the runoff has passed the access road, the remaining travel is through the recently re-developed areas of the Creighton Road improvements project prior to entering the Gilles Creek watercourse.

A small increase in post-development runoff is expected within both drainage sheds with this project since approximately 0.16 acres of new impervious area is proposed. Due to the small increase in runoff peak flow and volume, in conjunction with the discharge at sheet flow conditions, no water quantity detention best management practices are warranted for this project. Also, Appendix "C" contains detailed information pertaining to the peak runoff calculation and runoff volume calculation.

Point of Analysis 1 Summary:

Storm Event	Pre-Development Peak Flow	Post-Development Peak Flow	Post-Development Sheet Flow Volume Increase
1 Year	2.01 cfs	2.19 cfs	0.010 Ac-Ft
2 Year	2.67 cfs	2.86 cfs	0.010 Ac-Ft
10 Year	4.70 cfs	4.90 cfs	0.013 Ac-Ft

Point of Analysis 2 Summary:

Storm Event	Pre-Development Peak Flow	Post-Development Peak Flow	Post-Development Sheet Flow Volume Increase
1 Year	2.38 cfs	2.47 cfs	0.005 Ac-Ft
2 Year	3.06 cfs	3.15 cfs	0.005 Ac-Ft
10 Year	5.09 cfs	5.18 cfs	0.006 Ac-Ft

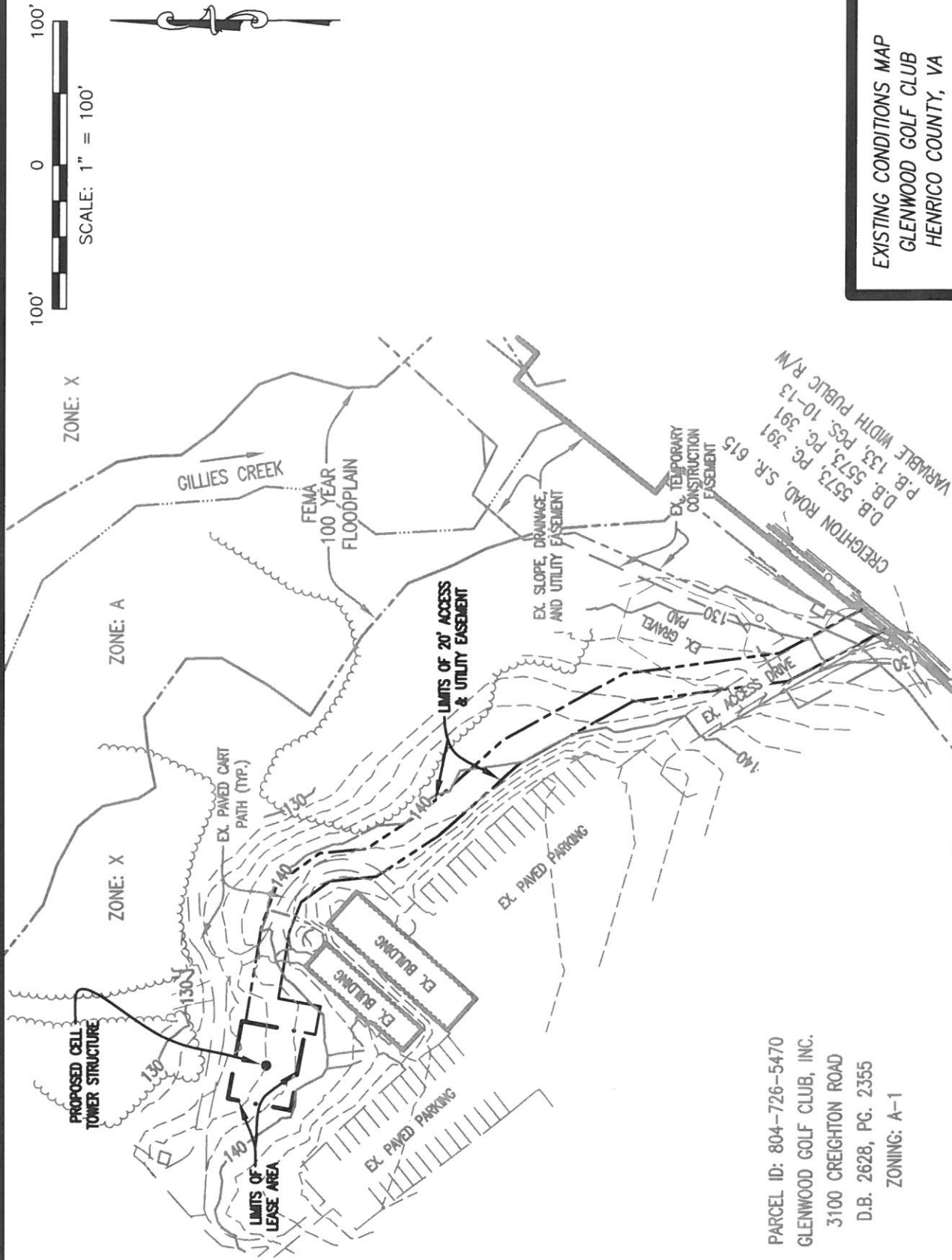
SITE SOILS AND FEMA FLOOD ZONE ANALYSIS

The soils within this project were identified using the NRCS Websoil Survey. The vast majority of the site soils were found to be Ochrepts and Udults (OUF) which has characteristics of soil type hydrologic soil group "C" which was utilized in both water quality and water quantity calculations. See Appendix "E" for NRCS soils report.

The property contains a FEMA mapped flood plain being Gilles Creek. Although, no portion of the proposed development lays within the FEMA floodplain as designated on Panel Number 51087C0145C. Additionally, the closest point of disturbance is approximately 100 linear feet from the FEMA floodplain. See Appendix "D" for site location within this FEMA map.

APPENDIX "A"

EXISTING SITE CONDITIONS



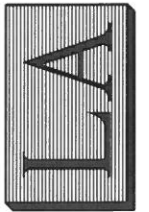
PARCEL ID: 804-726-5470
 GLENWOOD GOLF CLUB, INC.
 3100 CREIGHTON ROAD
 D.B. 2628, P.G. 2355
 ZONING: A-1

EXISTING CONDITIONS MAP
 GLENWOOD GOLF CLUB
 HENRICO COUNTY, VA

4664 BRAMBLETON AVENUE
 P.O. BOX 20669
 ROANOKE, VIRGINIA 24018
 PHONE: (540) 774-4411
 FAX: (540) 772-9445
 E-MAIL: MAIL@LUMSDENPC.COM

LUMSDEN ASSOCIATES, P.C.
 ENGINEERS-SURVEYORS-PLANNERS
 ROANOKE, VIRGINIA

DATE: October 6, 2017
 SCALE: 1" = 100'
 COMM. NO.: 17-224



APPENDIX “B”

WATER QUALITY CALCULATIONS

data input cells
constant values
calculation cells
final results

CLEAR ALL

Project Name: Glenwood Golf Club - Cell Tower
Date: 9/11/2017

BMP Design Specifications List: 2013 Draft Stds & Specs

Site Information

Post-Development Project (Treatment Volume and Loads)

Land Cover (acres)	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land			0.00		0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			0.14		0.14
Impervious Cover (acres)			0.16		0.16
					0.30

Constants

Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Total Phosphorus (TP) EMC (mg/L)	0.26
Total Nitrogen (TN) EMC (mg/L)	1.86
Target TP Load (lb/acre/yr)	0.41
P _i (unitless correction factor)	0.90

Runoff Coefficients (Rv)

	A Soils	B Soils	C Soils	D Soils
Forest/Open Space	0.02	0.03	0.04	0.05
Managed Turf	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr) 0.29

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary		Treatment Volume and Nutrient Loads	
Forest/Open Space Cover (acres)	0.00	Treatment Volume (acre-ft)	0.0152
Weighted Rv (forest)	0.00	Treatment Volume (cubic feet)	664
% Forest	0%	TP Load (lb/yr)	0.42
Managed Turf Cover (acres)	0.14	TN Load (lb/yr)	2.98
Weighted Rv (turf)	0.22	(Informational Purposes Only)	
% Managed Turf	47%		
Impervious Cover (acres)	0.16		
Rv (Impervious)	0.95		
% Impervious	53%		
Site Area (acres)	0.30		
Site Rv	0.61		

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: 2013 Draft Stds & Specs

Site Summary

Total Rainfall = 43 inches

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	0.00	0.00	0.00	0.00	0
Managed Turf (acres)	0.00	0.00	0.14	0.00	0.14	47
Impervious Cover (acres)	0.00	0.00	0.16	0.00	0.16	53
					0.30	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.61
Treatment Volume (ft ³)	664
TP Load (lb/yr)	0.42
TN Load (lb/yr)	2.98

Total TP Load Reduction Required (lb/yr)	0.29
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Site Compliance Summary

Total Runoff Volume Reduction (ft ³)	0
Total TP Load Reduction Achieved (lb/yr)	0.00
Total TN Load Reduction Achieved (lb/yr)	0.00
Remaining Post Development TP Load (lb/yr)	0.42
Remaining TP Load Reduction (lb/yr) Required	0.29

Chesapeake Bay Nutrient Land Trust, LLC.

September 11, 2017

Andrew P. Lumsden, P.E.
Lumsden Associates, P.C.
4664 Brambleton Avenue, SW
Roanoke, VA 24018

**RE: CBNLT/Cranston's Mill Pond – Nutrient Credit Availability
Chesapeake Bay Nutrient Land Trust, LLC**

Project Reference: Glenwood Golf Club

Attention Mr. Lumsden:

This letter is to confirm the availability of authorized Nutrient Credits sufficient to meet your project requirements at our Cranston's Mill Pond facility, which is registered with the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Conservation and Recreation (DCR). These Nutrient Credits are generated and managed under the terms of the Cranston's Mill Pond Nutrient Reduction Implementation Plan dated April 20, 2010 which was authorized by the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Conservation and Recreation (DCR) on July 13, 2010.

The Cranston's Mill Pond project has been authorized to provide Nutrient Credits for use in the James River watershed. These Credits are transferable to those entities regulated under DEQ's Stormwater Management Program in accordance with VA Code § 62.1-44.15:35. Currently our Cranston's Mill Pond facility has 381.63 pounds of Phosphorus Credits available and will be able to meet your project's phosphorus requirement of up to 0.29 pounds.

If we can provide further assistance please feel free to contact our office.

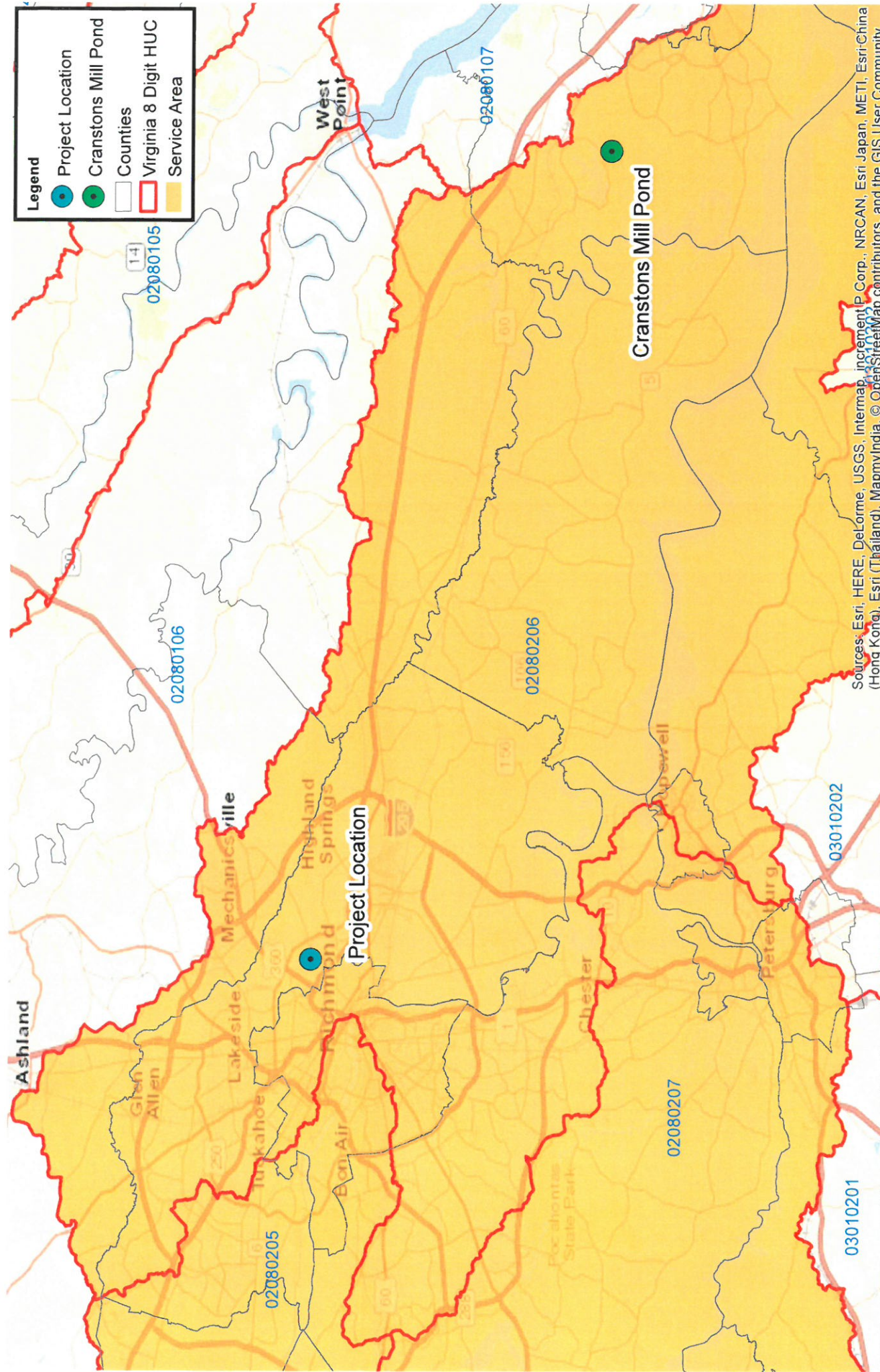
Sincerely,

Chesapeake Bay Nutrient Land Trust, LLC

By Its Manager
EarthSource Solutions, Inc.

Scott A. Reed

Scott A. Reed
Vice President



Legend

- Project Location
- Cranston's Mill Pond
- Counties
- Virginia 8 Digit HUC
- Service Area

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

CBNLT

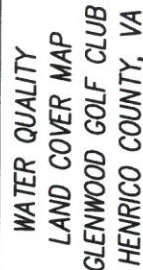
Chesapeake Bay
Nutrient Land Trust, LLC
5735 S. Laburnum Avenue
Richmond, VA 23231

"Tomorrow's Natural Resources Today"
Drawn By: CJJ



Cranston's Mill Pond Service Area (Glenwood Golf Club)

Date: 9/12/2017
Scale: 1 Inch : 6 Miles
Location: James City County, Va



4664 BRAMBLETON AVENUE
P.O. BOX 20669
ROANOKE, VIRGINIA 24018
PHONE: (540) 774-4411
FAX: (540) 772-9445
E-MAIL: MAIL@LUMSDENPC.COM

LUMSDEN ASSOCIATES, P.C.
ENGINEERS-SURVEYORS-PLANNERS
ROANOKE, VIRGINIA

DATE:	October 6, 2017
SCALE:	1" = 100'
COMM. NO.:	17-224

APPENDIX "C"

WATER QUANTITY CALCULATIONS



NOAA Atlas 14, Volume 2, Version 3
 Location name: Richmond, Virginia, USA*
 Latitude: 37.5523°, Longitude: -77.3904°
 Elevation: 146.85 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 & 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	0.374 (0.339-0.412)	0.443 (0.403-0.488)	0.519 (0.472-0.572)	0.582 (0.526-0.641)	0.653 (0.588-0.717)	0.707 (0.635-0.776)	0.757 (0.677-0.832)	0.803 (0.714-0.882)	0.857 (0.756-0.943)	0.900 (0.788-0.992)
10-min	0.597 (0.541-0.658)	0.709 (0.644-0.781)	0.832 (0.755-0.916)	0.930 (0.841-1.02)	1.04 (0.938-1.14)	1.13 (1.01-1.24)	1.20 (1.08-1.32)	1.27 (1.13-1.40)	1.36 (1.20-1.49)	1.42 (1.24-1.56)
15-min	0.746 (0.677-0.823)	0.891 (0.810-0.982)	1.05 (0.955-1.16)	1.18 (1.06-1.30)	1.32 (1.19-1.45)	1.43 (1.28-1.57)	1.52 (1.36-1.67)	1.61 (1.43-1.76)	1.71 (1.51-1.88)	1.78 (1.56-1.96)
30-min	1.02 (0.928-1.13)	1.23 (1.12-1.36)	1.49 (1.36-1.65)	1.71 (1.54-1.88)	1.95 (1.76-2.15)	2.15 (1.93-2.36)	2.33 (2.08-2.56)	2.50 (2.22-2.75)	2.72 (2.39-2.99)	2.88 (2.52-3.17)
60-min	1.28 (1.16-1.41)	1.54 (1.40-1.70)	1.92 (1.74-2.11)	2.22 (2.01-2.45)	2.60 (2.34-2.86)	2.91 (2.61-3.19)	3.21 (2.87-3.53)	3.51 (3.12-3.85)	3.90 (3.44-4.29)	4.21 (3.68-4.63)
2-hr	1.52 (1.38-1.69)	1.84 (1.67-2.04)	2.31 (2.08-2.56)	2.70 (2.44-2.99)	3.22 (2.89-3.56)	3.65 (3.24-4.02)	4.09 (3.61-4.50)	4.54 (3.98-4.99)	5.15 (4.47-5.66)	5.64 (4.86-6.22)
3-hr	1.65 (1.48-1.84)	1.99 (1.79-2.22)	2.49 (2.24-2.78)	2.92 (2.62-3.25)	3.49 (3.11-3.87)	3.96 (3.51-4.38)	4.45 (3.91-4.91)	4.94 (4.32-5.45)	5.62 (4.86-6.21)	6.18 (5.29-6.82)
6-hr	1.99 (1.78-2.24)	2.40 (2.15-2.69)	3.00 (2.68-3.37)	3.54 (3.15-3.96)	4.26 (3.78-4.76)	4.88 (4.29-5.44)	5.54 (4.83-6.16)	6.23 (5.39-6.93)	7.21 (6.15-8.00)	8.03 (6.77-8.91)
12-hr	2.38 (2.14-2.68)	2.87 (2.58-3.23)	3.61 (3.23-4.07)	4.29 (3.82-4.81)	5.23 (4.62-5.85)	6.06 (5.29-6.77)	6.95 (6.01-7.73)	7.92 (6.76-8.78)	9.32 (7.83-10.3)	10.5 (8.73-11.7)
24-hr	2.75 (2.50-3.04)	3.33 (3.03-3.68)	4.26 (3.88-4.72)	5.06 (4.59-5.59)	6.24 (5.61-6.87)	7.26 (6.49-7.97)	8.38 (7.43-9.19)	9.63 (8.45-10.5)	11.5 (9.95-12.6)	13.1 (11.2-14.3)
2-day	3.20 (2.91-3.53)	3.88 (3.53-4.28)	4.95 (4.49-5.45)	5.83 (5.28-6.43)	7.13 (6.41-7.84)	8.23 (7.35-9.05)	9.41 (8.35-10.3)	10.7 (9.43-11.8)	12.6 (11.0-13.9)	14.2 (12.2-15.6)
3-day	3.38 (3.08-3.73)	4.10 (3.73-4.51)	5.22 (4.75-5.74)	6.14 (5.58-6.76)	7.50 (6.77-8.24)	8.64 (7.75-9.49)	9.88 (8.81-10.8)	11.2 (9.92-12.3)	13.2 (11.5-14.5)	14.8 (12.8-16.3)
4-day	3.56 (3.25-3.92)	4.31 (3.94-4.75)	5.49 (5.01-6.04)	6.45 (5.88-7.09)	7.87 (7.13-8.64)	9.06 (8.16-9.93)	10.3 (9.26-11.3)	11.7 (10.4-12.8)	13.8 (12.1-15.1)	15.5 (13.4-17.0)
7-day	4.10 (3.76-4.50)	4.94 (4.52-5.42)	6.18 (5.65-6.78)	7.21 (6.59-7.90)	8.70 (7.91-9.51)	9.94 (8.99-10.9)	11.3 (10.1-12.3)	12.7 (11.4-13.9)	14.8 (13.1-16.2)	16.5 (14.4-18.1)
10-day	4.67 (4.29-5.10)	5.59 (5.15-6.11)	6.92 (6.36-7.55)	8.00 (7.34-8.72)	9.54 (8.72-10.4)	10.8 (9.82-11.7)	12.1 (11.0-13.2)	13.5 (12.2-14.8)	15.5 (13.8-17.0)	17.1 (15.1-18.8)
20-day	6.27 (5.80-6.79)	7.48 (6.92-8.10)	9.04 (8.35-9.79)	10.3 (9.48-11.1)	12.0 (11.0-12.9)	13.3 (12.2-14.4)	14.7 (13.4-15.9)	16.0 (14.6-17.4)	17.9 (16.2-19.5)	19.4 (17.4-21.1)
30-day	7.80 (7.26-8.37)	9.24 (8.60-9.92)	10.9 (10.2-11.8)	12.3 (11.4-13.2)	14.0 (13.0-15.0)	15.3 (14.2-16.4)	16.6 (15.3-17.9)	17.9 (16.4-19.2)	19.6 (17.9-21.1)	20.9 (19.0-22.5)
45-day	9.82 (9.16-10.5)	11.6 (10.8-12.4)	13.6 (12.6-14.5)	15.0 (14.0-16.1)	16.9 (15.8-18.1)	18.4 (17.1-19.6)	19.8 (18.3-21.1)	21.1 (19.5-22.6)	22.8 (21.0-24.4)	24.0 (22.1-25.8)
60-day	11.6 (10.9-12.4)	13.7 (12.9-14.5)	15.8 (14.9-16.8)	17.4 (16.3-18.5)	19.5 (18.2-20.6)	21.0 (19.6-22.2)	22.4 (20.9-23.7)	23.7 (22.1-25.2)	25.5 (23.6-27.1)	26.7 (24.7-28.5)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
 Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
 Please refer to NOAA Atlas 14 document for more information.

[Back to Top](#)

File name: montgomery corrected for cf.idf

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4.31	3.45	2.89	2.50	2.21	1.98	1.80	1.65	1.53	1.42	1.33	1.25
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	5.15	4.15	3.51	3.05	2.72	2.45	2.24	2.07	1.92	1.80	1.69	1.59
10	5.67	4.60	3.90	3.41	3.04	2.76	2.53	2.34	2.18	2.04	1.92	1.82
25	7.20	5.79	4.91	4.31	3.86	3.52	3.24	3.01	2.82	2.66	2.51	2.39
50	8.46	6.84	5.85	5.15	4.64	4.25	3.93	3.66	3.44	3.25	3.09	2.94
100	9.60	7.68	6.55	5.80	5.24	4.82	4.48	4.20	3.96	3.76	3.58	3.43

Precip. file name: T:\hydraflow\idf files\henrico.pcp

[illegible]

WEIGHTED CN VALUES

Project Name: Glenwood Golf Club - Cell Tower Site Locality: Chesterfield
 Sub-Area: Pre-Development Drainage to POA 1

Cover	Area	CN	Area *CN
			0.000
Impervious Cover, Type C Soil	0.37	98	36.260
Grass/Managed Turf, Type C Soil	0.38	74	28.120
Forest/Open Space, Type C Soil	0.00	70	0.000
			0.000
			0.000
			0.000
			0.000
Σ Area	0.75	Σ	64.380

Weighted CN = 86

Time of Concentration:

Sheet Flow:

Length of Flow : 150 (ft.)

"C" Value: 0.65

Slope : 3.5 (%)

$T_{\text{sheet}} =$ 5.4 min.

Shallow Concentrated Flow:

Length of Travel : 110 (ft.)

Δ Height : 12 (ft.)

$T_{\text{travel}} =$ 0.7 min.

Channel Flow:

Length of Travel : 0 (ft.)

Δ Height : 0 (ft.)

$T_{\text{travel}} =$ 0.0 min.

$T_c =$ 6.1 min.

USE $T_c =$ 6.0 min.

Hydrograph Report

1

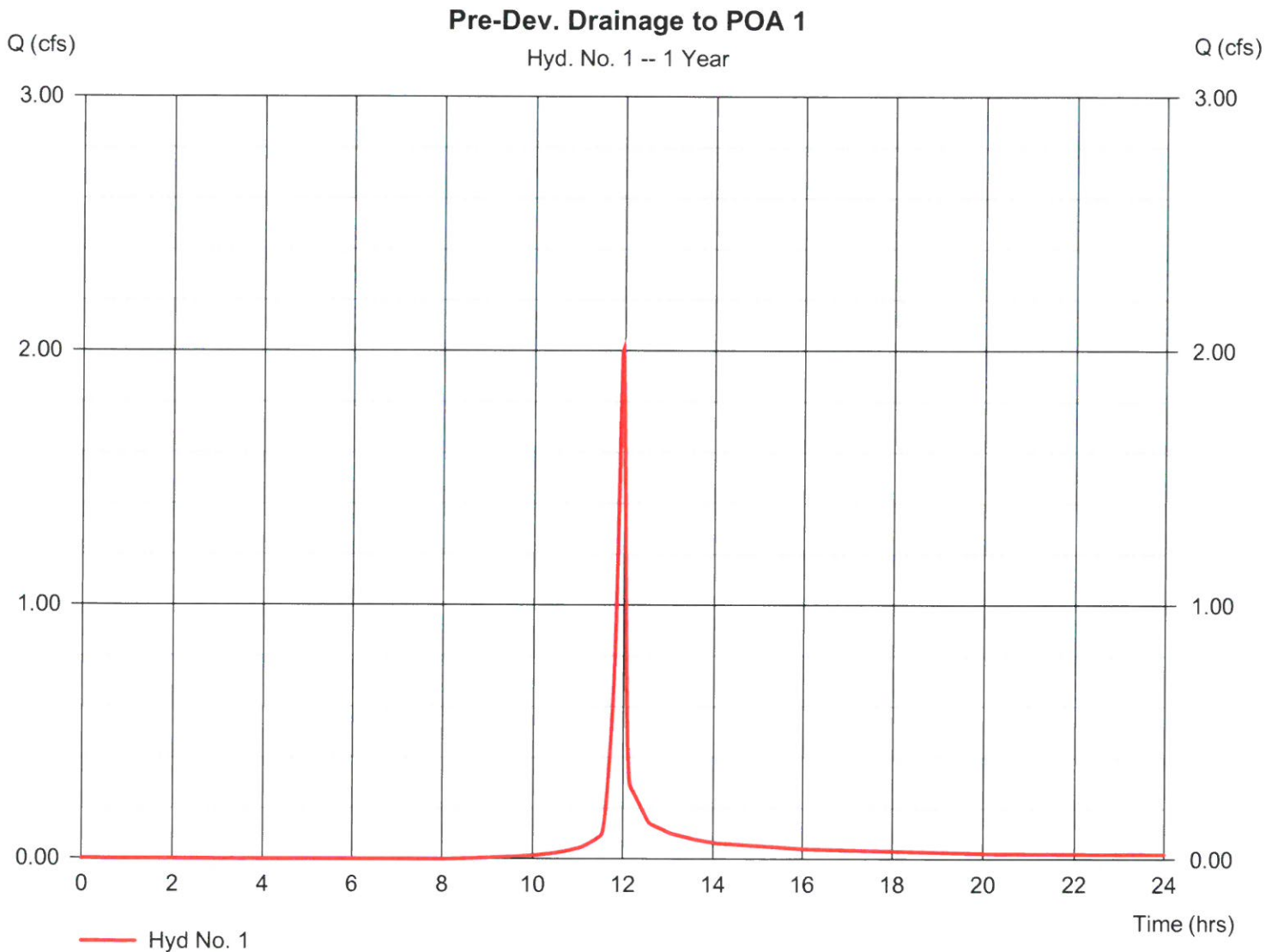
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Tuesday, 09 / 12 / 2017

Hyd. No. 1

Pre-Dev. Drainage to POA 1

Hydrograph type	= SCS Runoff	Peak discharge	= 2.008 cfs
Storm frequency	= 1 yrs	Time to peak	= 11.97 hrs
Time interval	= 1 min	Hyd. volume	= 4,072 cuft
Drainage area	= 0.750 ac	Curve number	= 86
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.00 min
Total precip.	= 2.75 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

6

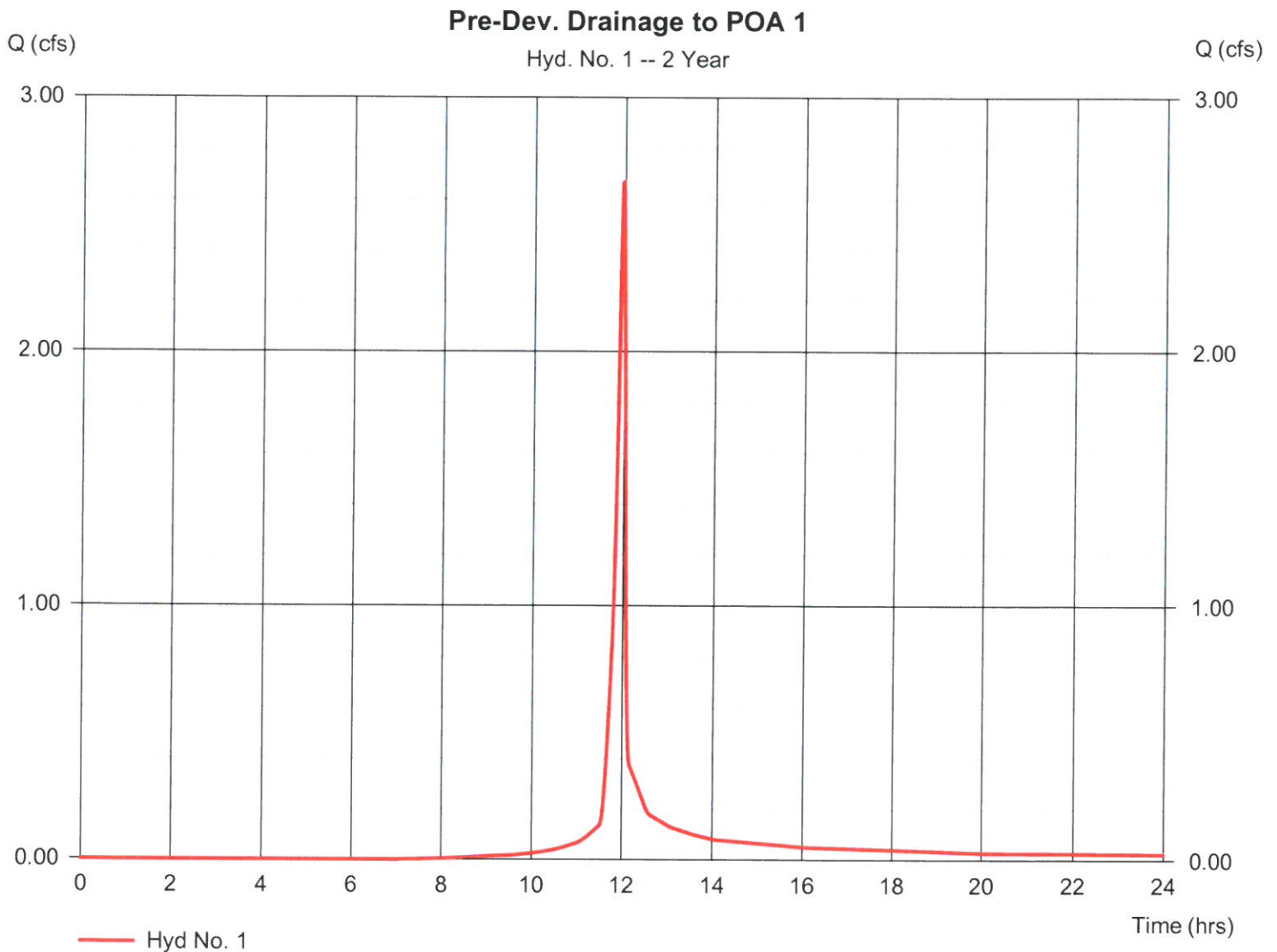
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Tuesday, 09 / 12 / 2017

Hyd. No. 1

Pre-Dev. Drainage to POA 1

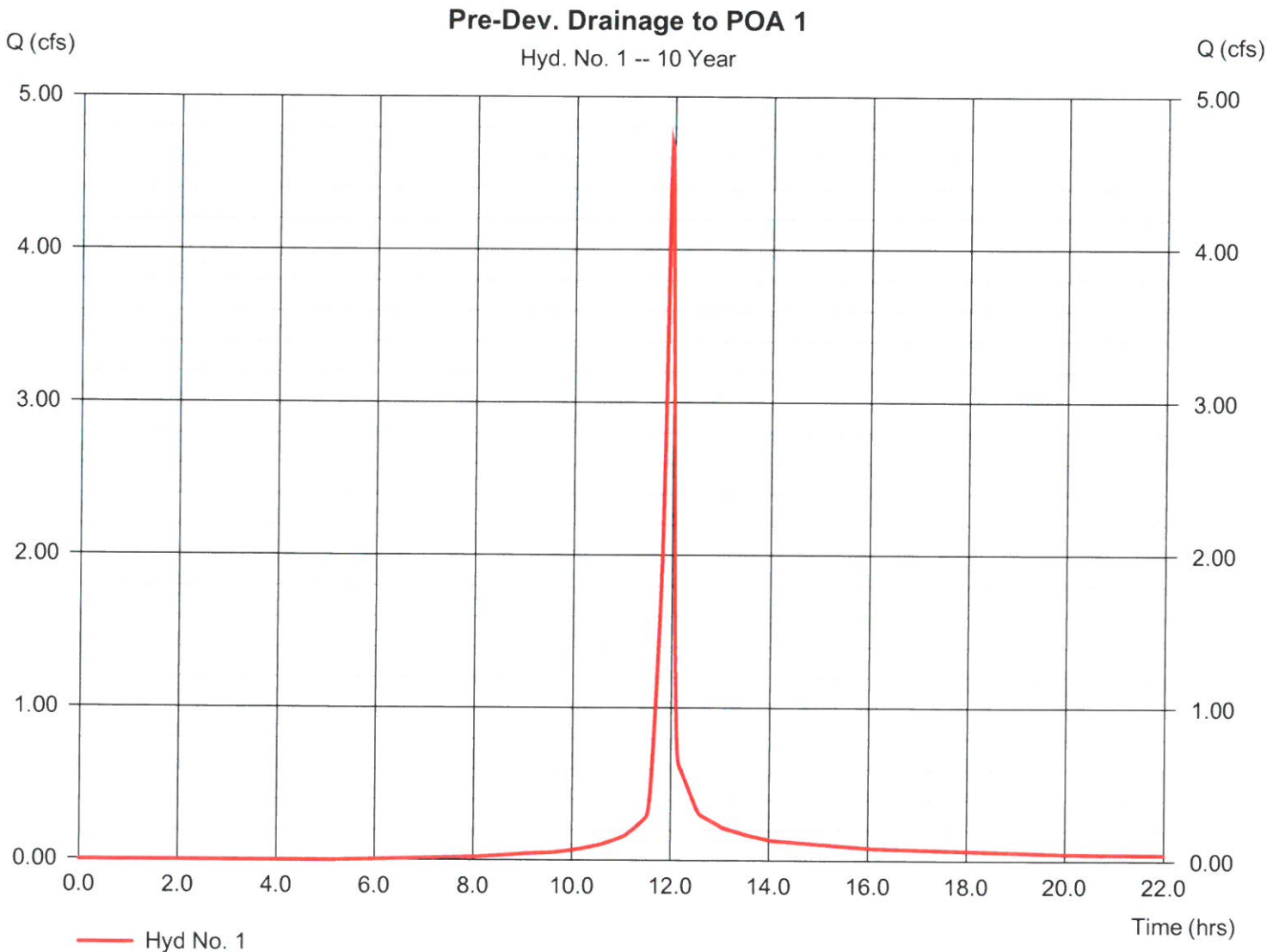
Hydrograph type	= SCS Runoff	Peak discharge	= 2.667 cfs
Storm frequency	= 2 yrs	Time to peak	= 11.97 hrs
Time interval	= 1 min	Hyd. volume	= 5,471 cuft
Drainage area	= 0.750 ac	Curve number	= 86
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.00 min
Total precip.	= 3.33 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hyd. No. 1

Pre-Dev. Drainage to POA 1

Hydrograph type	= SCS Runoff	Peak discharge	= 4.696 cfs
Storm frequency	= 10 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 9,891 cuft
Drainage area	= 0.750 ac	Curve number	= 86
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.00 min
Total precip.	= 5.06 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



WEIGHTED CN VALUES

Project Name: Glenwood Golf Club - Cell Tower Site Locality: Chesterfield
 Sub-Area: Pre-Development Drainage to POA 2

Cover	Area	CN	Area *CN
			0.000
Impervious Cover, Type C Soil	0.50	98	49.000
Grass/Managed Turf, Type C Soil	0.25	74	18.500
Forest/Open Space, Type C Soil	0.00	70	0.000
			0.000
			0.000
			0.000
			0.000
Σ Area	0.75	Σ	67.500

Weighted CN = 90

Time of Concentration:

Sheet Flow:

Length of Flow : 150 (ft.)

"C" Value: 0.90

Slope : 3.5 (%)

$T_{\text{sheet}} =$ 3.9 min.

Shallow Concentrated Flow:

Length of Travel : 85 (ft.)

Δ Height : 12 (ft.)

$T_{\text{travel}} =$ 0.6 min.

Channel Flow:

Length of Travel : 0 (ft.)

Δ Height : 0 (ft.)

$T_{\text{travel}} =$ 0.0 min.

$T_c =$ 5.0 min.

USE $T_c =$ 5.0 min.

Hydrograph Report

3

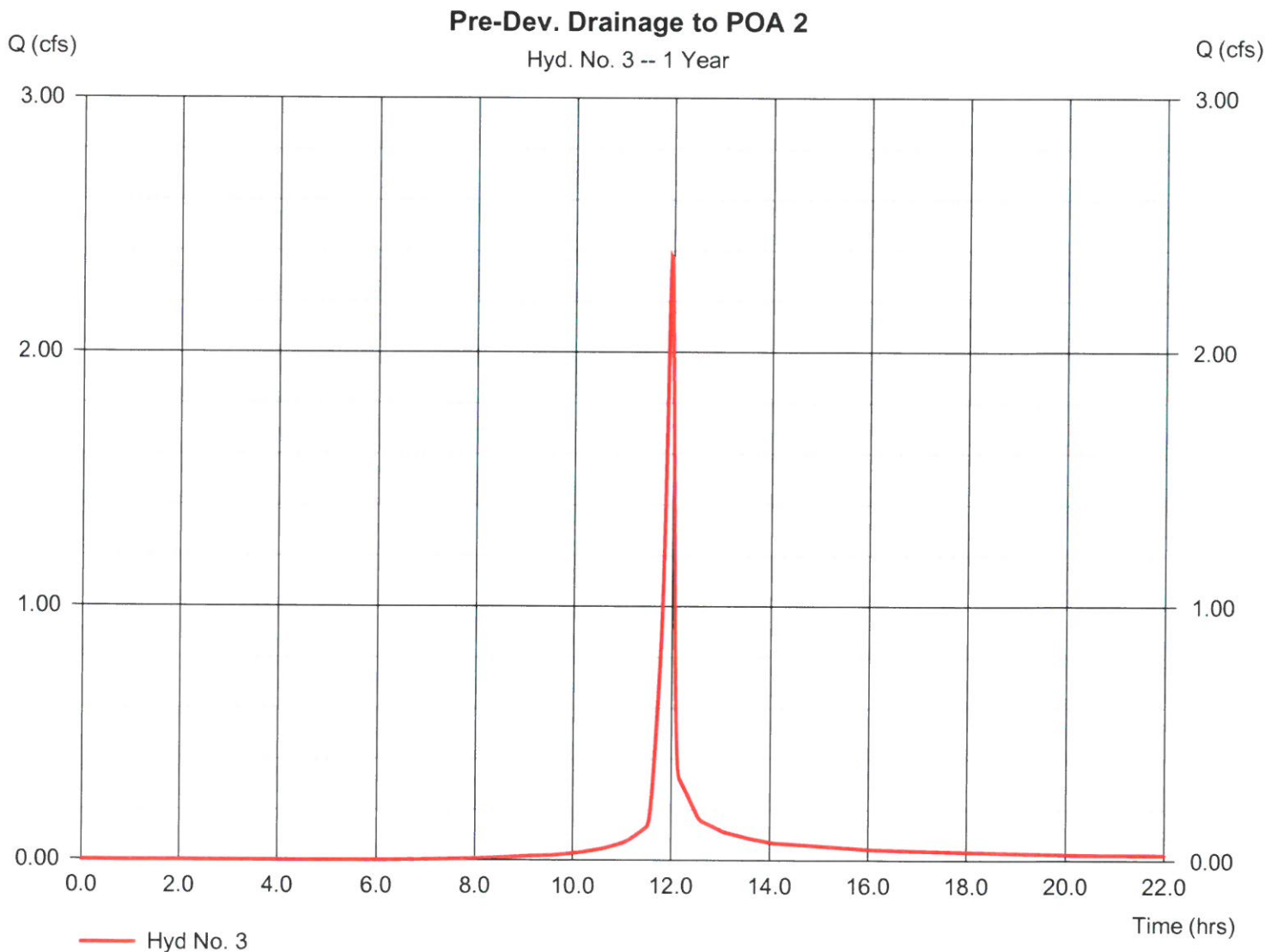
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Tuesday, 09 / 12 / 2017

Hyd. No. 3

Pre-Dev. Drainage to POA 2

Hydrograph type	= SCS Runoff	Peak discharge	= 2.377 cfs
Storm frequency	= 1 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 4,930 cuft
Drainage area	= 0.750 ac	Curve number	= 90
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 2.75 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

8

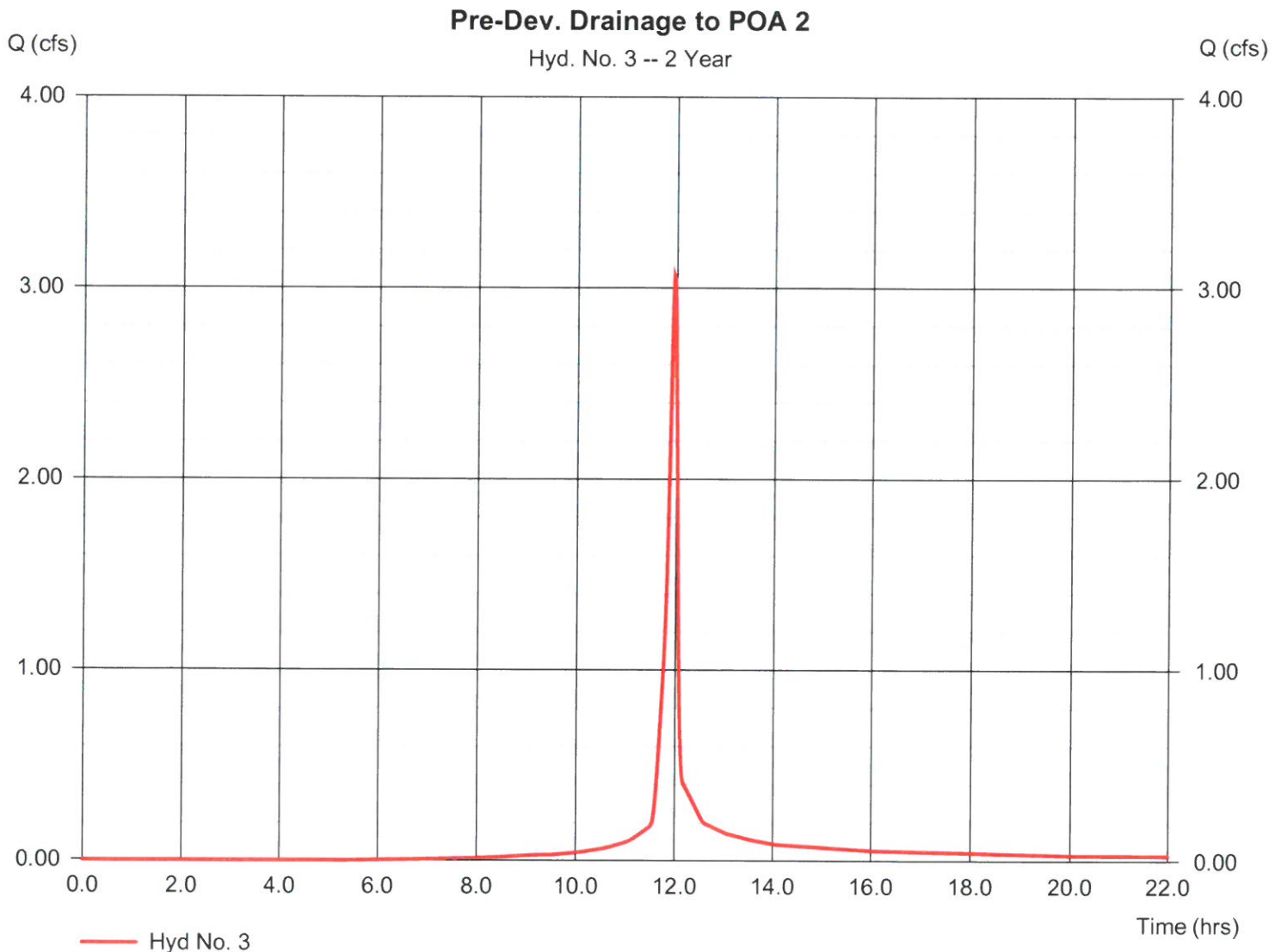
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Tuesday, 09 / 12 / 2017

Hyd. No. 3

Pre-Dev. Drainage to POA 2

Hydrograph type	= SCS Runoff	Peak discharge	= 3.059 cfs
Storm frequency	= 2 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 6,427 cuft
Drainage area	= 0.750 ac	Curve number	= 90
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 3.33 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

13

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

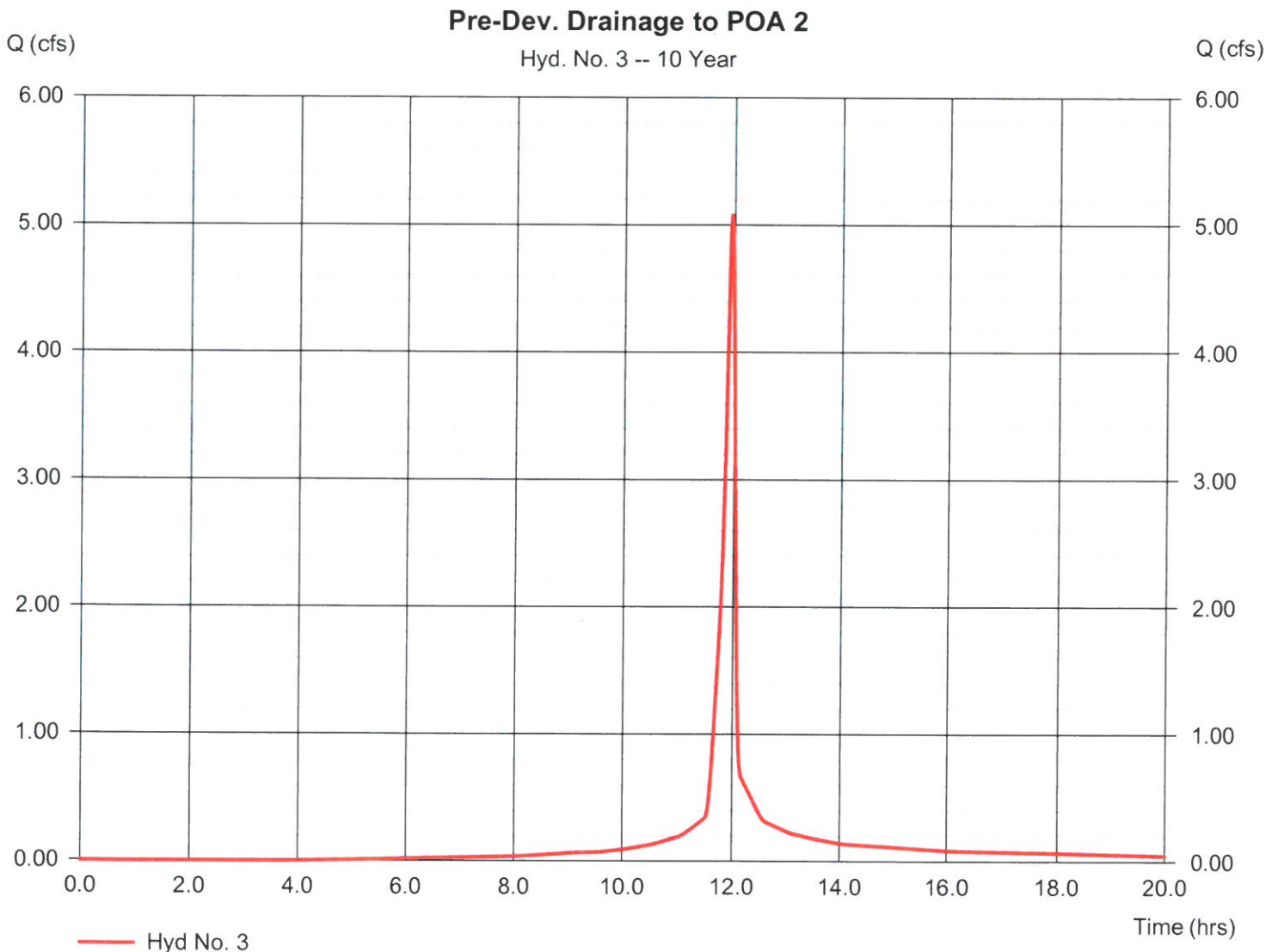
Tuesday, 09 / 12 / 2017

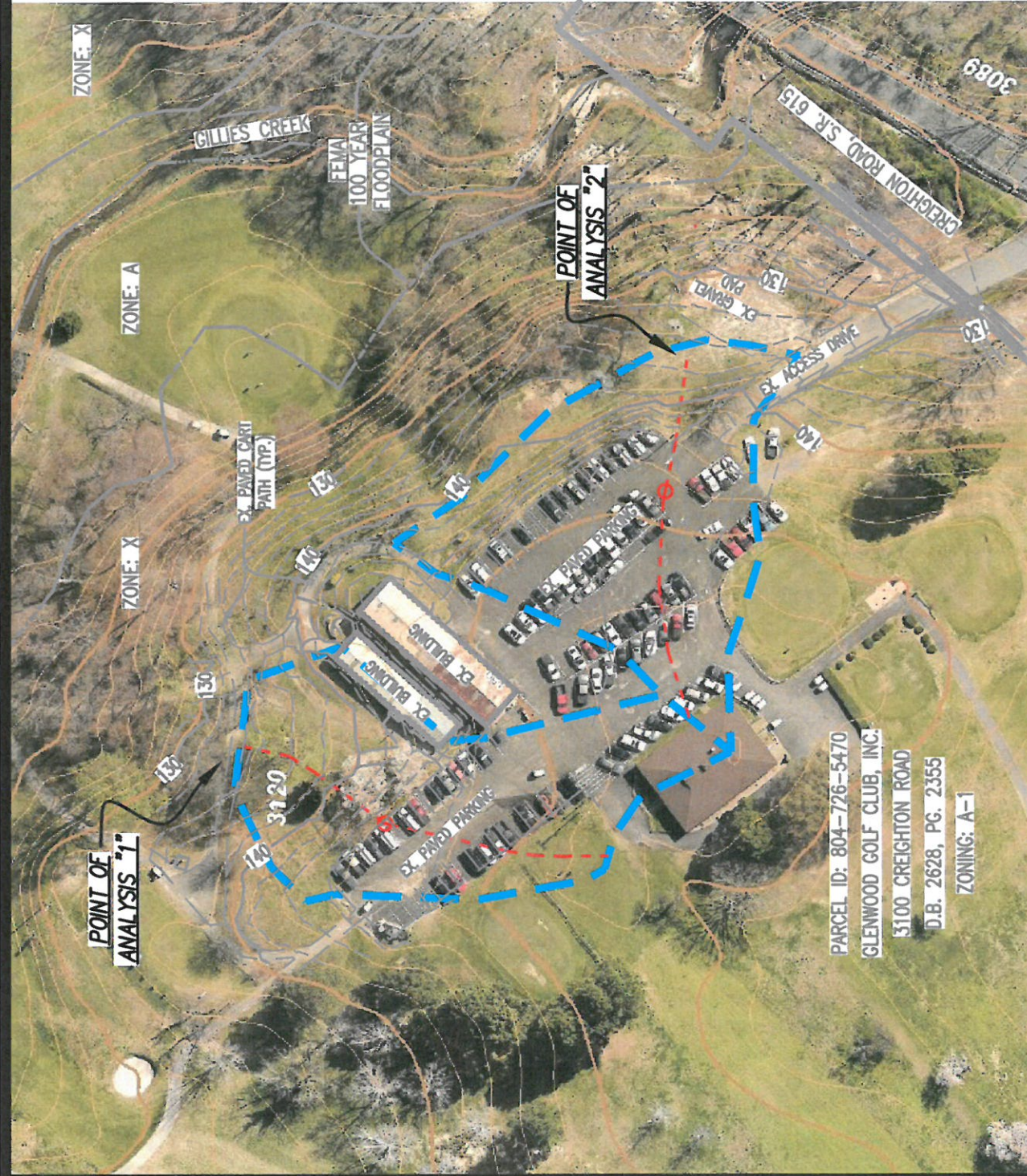
Hyd. No. 3

Pre-Dev. Drainage to POA 2

Hydrograph type = SCS Runoff
Storm frequency = 10 yrs
Time interval = 1 min
Drainage area = 0.750 ac
Basin Slope = 0.0 %
Tc method = User
Total precip. = 5.06 in
Storm duration = 24 hrs

Peak discharge = 5.091 cfs
Time to peak = 11.95 hrs
Hyd. volume = 11,046 cuft
Curve number = 90
Hydraulic length = 0 ft
Time of conc. (Tc) = 5.00 min
Distribution = Type II
Shape factor = 484





(DISCHARGE TO SHEET FLOW)
PRE-DEVELOPMENT DRAINAGE
TO POINT OF ANALYSIS "1"

D.A. = 0.75 Ac.
CN = 86
Tc = 6.0 Min.

(DISCHARGE TO SHEET FLOW)
PRE-DEVELOPMENT DRAINAGE
TO POINT OF ANALYSIS "2"

D.A. = 0.75 Ac.
CN = 90
Tc = 5.0 Min.



PRE-DEVELOPMENT
DRAINAGE



Tc

PRE-DEVELOPMENT
DRAINAGE AREA MAP
GLENWOOD GOLF CLUB
HENRICO COUNTY, VA

4664 BRAMBLETON AVENUE
P.O. BOX 20669
ROANOKE, VIRGINIA 24018
PHONE: (540) 774-4411
FAX: (540) 772-9445
E-MAIL: MAIL@LUMSDENPC.COM

DATE: October 6, 2017
SCALE: 1" = 100'
COMM. NO.: 17-224

LUMSDEN ASSOCIATES, P.C.
ENGINEERS-SURVEYORS-PLANNERS
ROANOKE, VIRGINIA



WEIGHTED CN VALUES

Project Name: Glenwood Golf Club - Cell Tower Site Locality: Chesterfield
 Sub-Area: Post-Development Drainage to POA 1

Cover	Area	CN	Area *CN
			0.000
Impervious Cover, Type C Soil	0.45	98	44.100
Grass/Managed Turf, Type C Soil	0.30	74	22.200
Forest/Open Space, Type C Soil	0.00	70	0.000
			0.000
			0.000
			0.000
			0.000
Σ Area	0.75	Σ	66.300

Weighted CN = 88

Time of Concentration:

Sheet Flow:

Length of Flow : 150 (ft.)

"C" Value: 0.65

Slope : 3.5 (%)

$T_{\text{sheet}} =$ 5.4 min.

Shallow Concentrated Flow:

Length of Travel : 110 (ft.)

Δ Height : 12 (ft.)

$T_{\text{travel}} =$ 0.7 min.

Channel Flow:

Length of Travel : 0 (ft.)

Δ Height : 0 (ft.)

$T_{\text{travel}} =$ 0.0 min.

$T_c =$ 6.1 min.

USE $T_c =$ 6.0 min.

Hydrograph Report

2

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

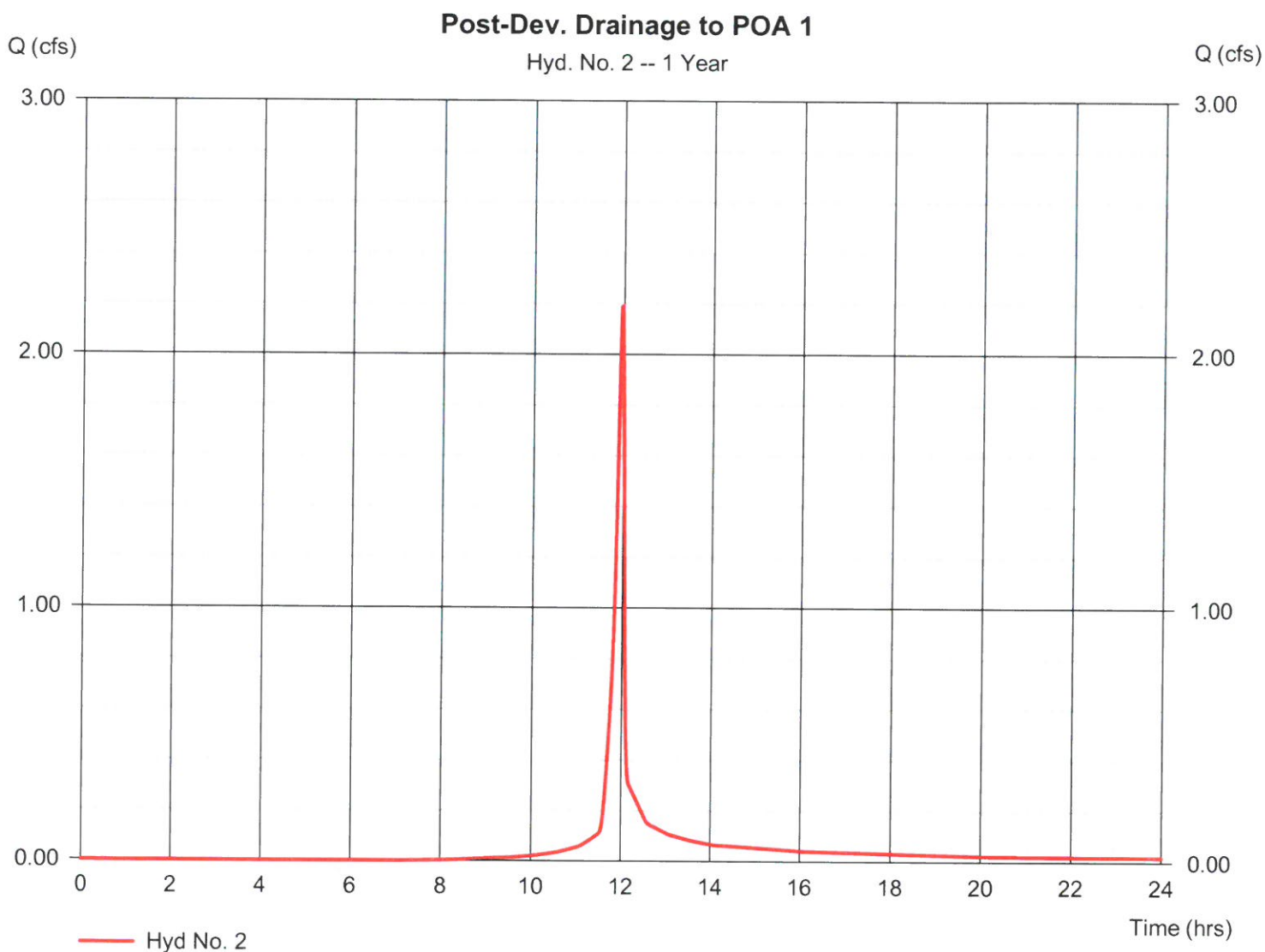
Tuesday, 09 / 12 / 2017

Hyd. No. 2

Post-Dev. Drainage to POA 1

Hydrograph type = SCS Runoff
Storm frequency = 1 yrs
Time interval = 1 min
Drainage area = 0.750 ac
Basin Slope = 0.0 %
Tc method = User
Total precip. = 2.75 in
Storm duration = 24 hrs

Peak discharge = 2.189 cfs
Time to peak = 11.97 hrs
Hyd. volume = 4,486 cuft
Curve number = 88
Hydraulic length = 0 ft
Time of conc. (Tc) = 6.00 min
Distribution = Type II
Shape factor = 484



Hydrograph Report

7

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

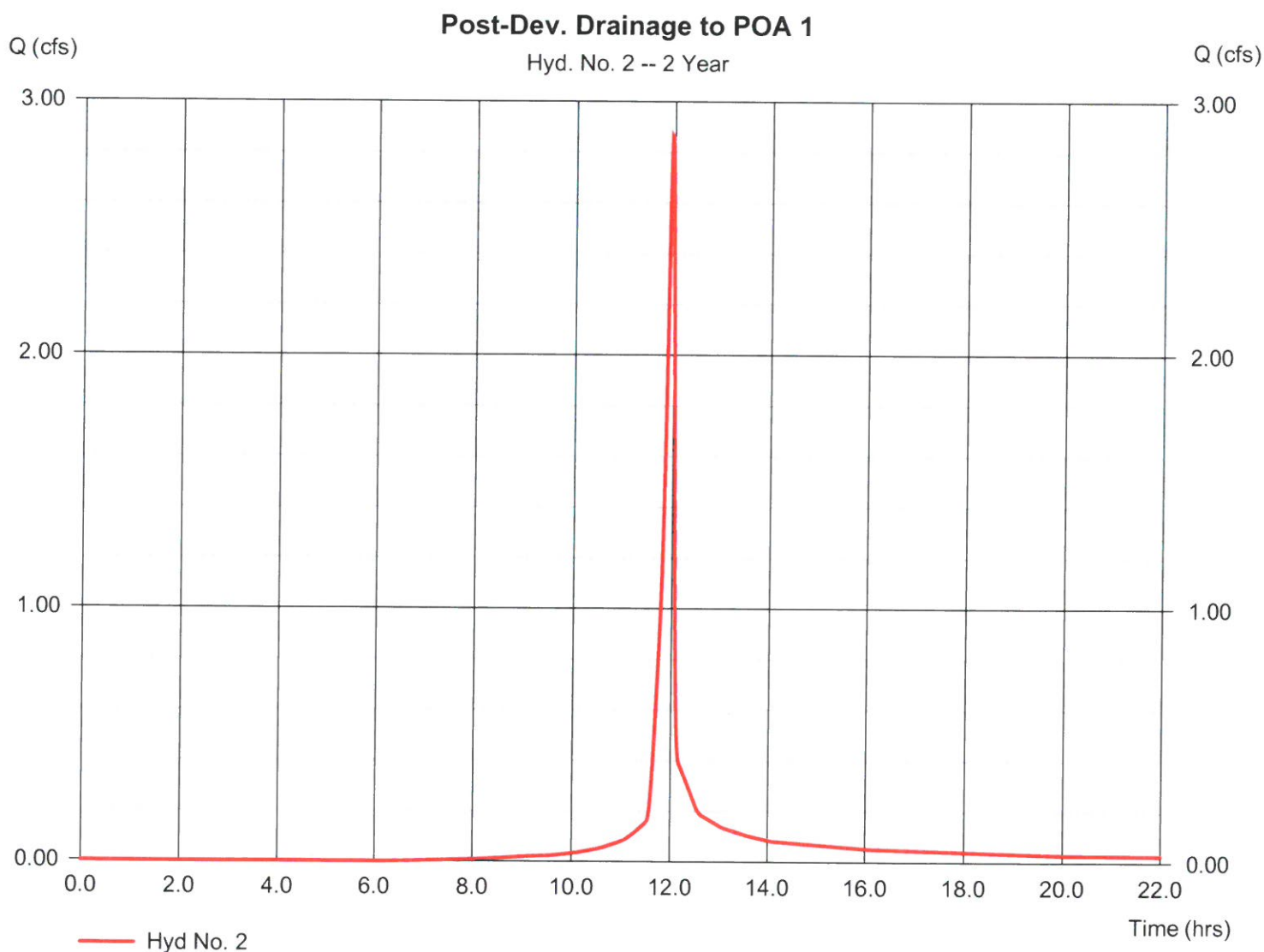
Tuesday, 09 / 12 / 2017

Hyd. No. 2

Post-Dev. Drainage to POA 1

Hydrograph type = SCS Runoff
Storm frequency = 2 yrs
Time interval = 1 min
Drainage area = 0.750 ac
Basin Slope = 0.0 %
Tc method = User
Total precip. = 3.33 in
Storm duration = 24 hrs

Peak discharge = 2.864 cfs
Time to peak = 11.95 hrs
Hyd. volume = 5,936 cuft
Curve number = 88
Hydraulic length = 0 ft
Time of conc. (Tc) = 6.00 min
Distribution = Type II
Shape factor = 484



Hydrograph Report

12

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

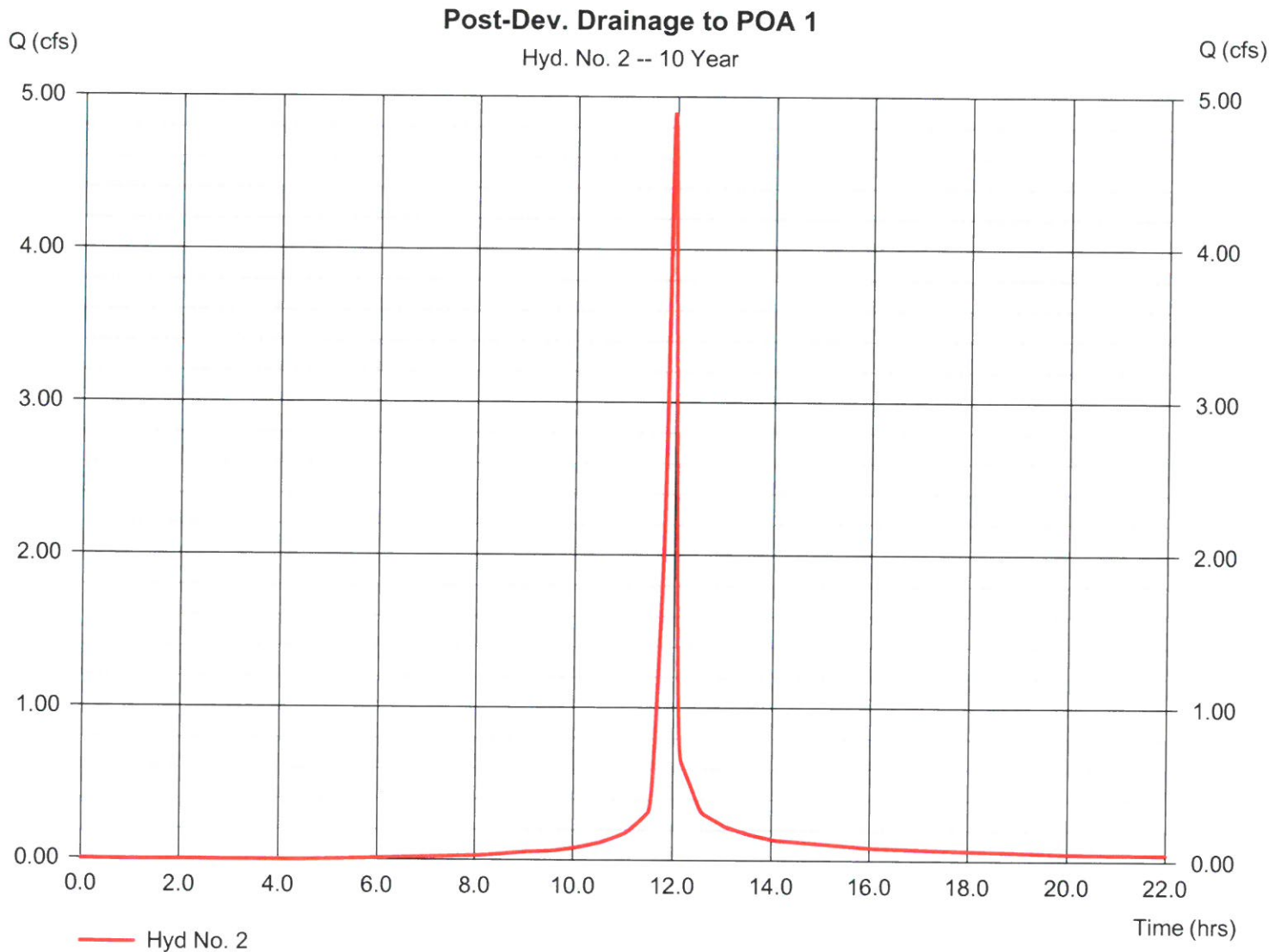
Tuesday, 09 / 12 / 2017

Hyd. No. 2

Post-Dev. Drainage to POA 1

Hydrograph type = SCS Runoff
Storm frequency = 10 yrs
Time interval = 1 min
Drainage area = 0.750 ac
Basin Slope = 0.0 %
Tc method = User
Total precip. = 5.06 in
Storm duration = 24 hrs

Peak discharge = 4.900 cfs
Time to peak = 11.95 hrs
Hyd. volume = 10,461 cuft
Curve number = 88
Hydraulic length = 0 ft
Time of conc. (Tc) = 6.00 min
Distribution = Type II
Shape factor = 484



WEIGHTED CN VALUES

Project Name: Glenwood Golf Club - Cell Tower Site Locality: Chesterfield
 Sub-Area: Post-Development Drainage to POA 2

Cover	Area	CN	Area *CN
			0.000
Impervious Cover, Type C Soil	0.54	98	52.920
Grass/Managed Turf, Type C Soil	0.21	74	15.540
Forest/Open Space, Type C Soil	0.00	70	0.000
			0.000
			0.000
			0.000
			0.000
Σ Area	0.75	Σ	68.460

Weighted CN = 91

Time of Concentration:

Sheet Flow:

Length of Flow : 150 (ft.)

"C" Value: 0.90

Slope : 3.5 (%)

$T_{\text{sheet}} =$ 3.9 min.

Shallow Concentrated Flow:

Length of Travel : 85 (ft.)

Δ Height : 12 (ft.)

$T_{\text{travel}} =$ 0.6 min.

Channel Flow:

Length of Travel : 0 (ft.)

Δ Height : 0 (ft.)

$T_{\text{travel}} =$ 0.0 min.

$T_c =$ 5.0 min.

USE $T_c =$ 5.0 min.

Hydrograph Report

4

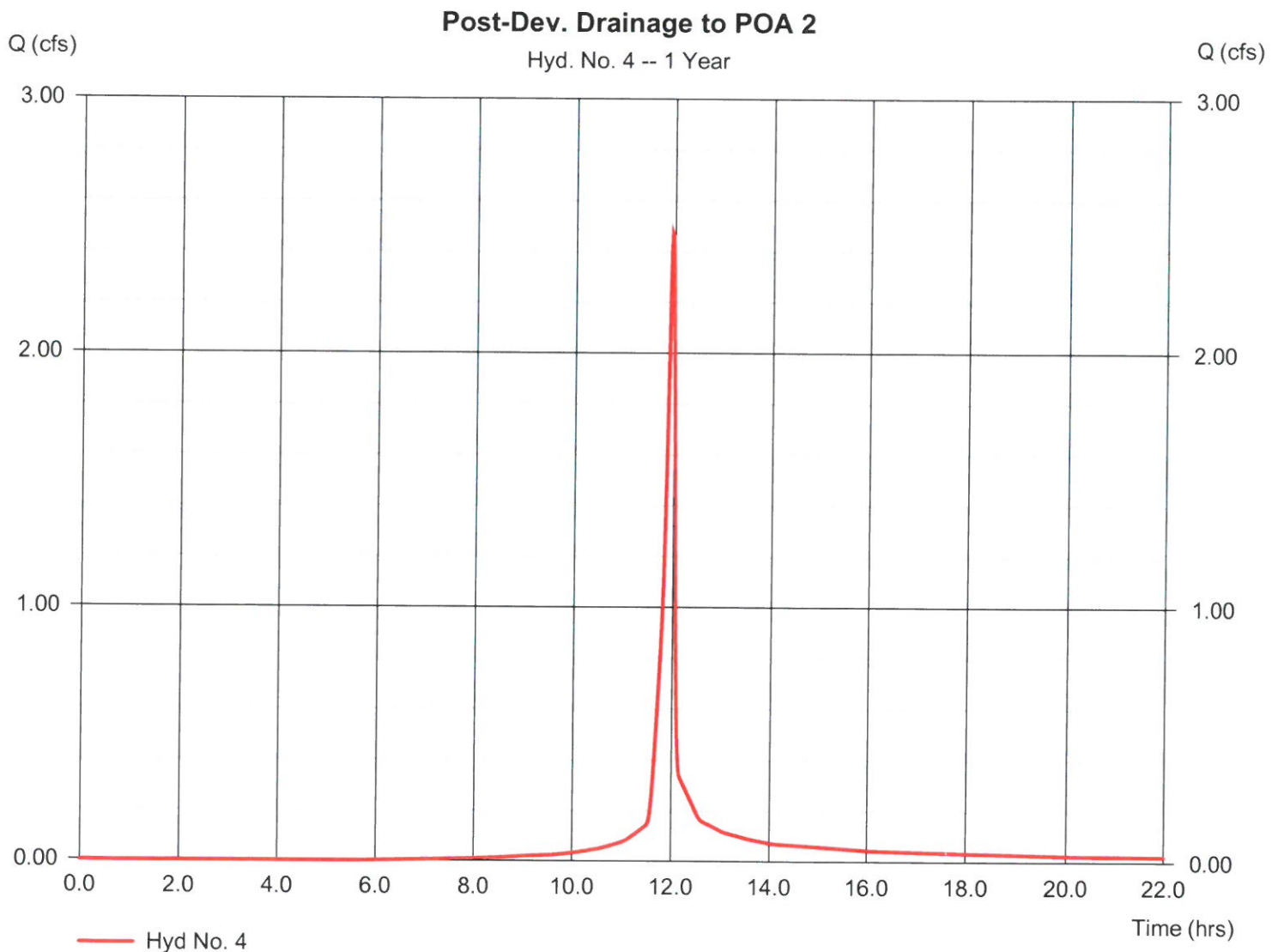
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Tuesday, 09 / 12 / 2017

Hyd. No. 4

Post-Dev. Drainage to POA 2

Hydrograph type	= SCS Runoff	Peak discharge	= 2.471 cfs
Storm frequency	= 1 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 5,164 cuft
Drainage area	= 0.750 ac	Curve number	= 91
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 2.75 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

9

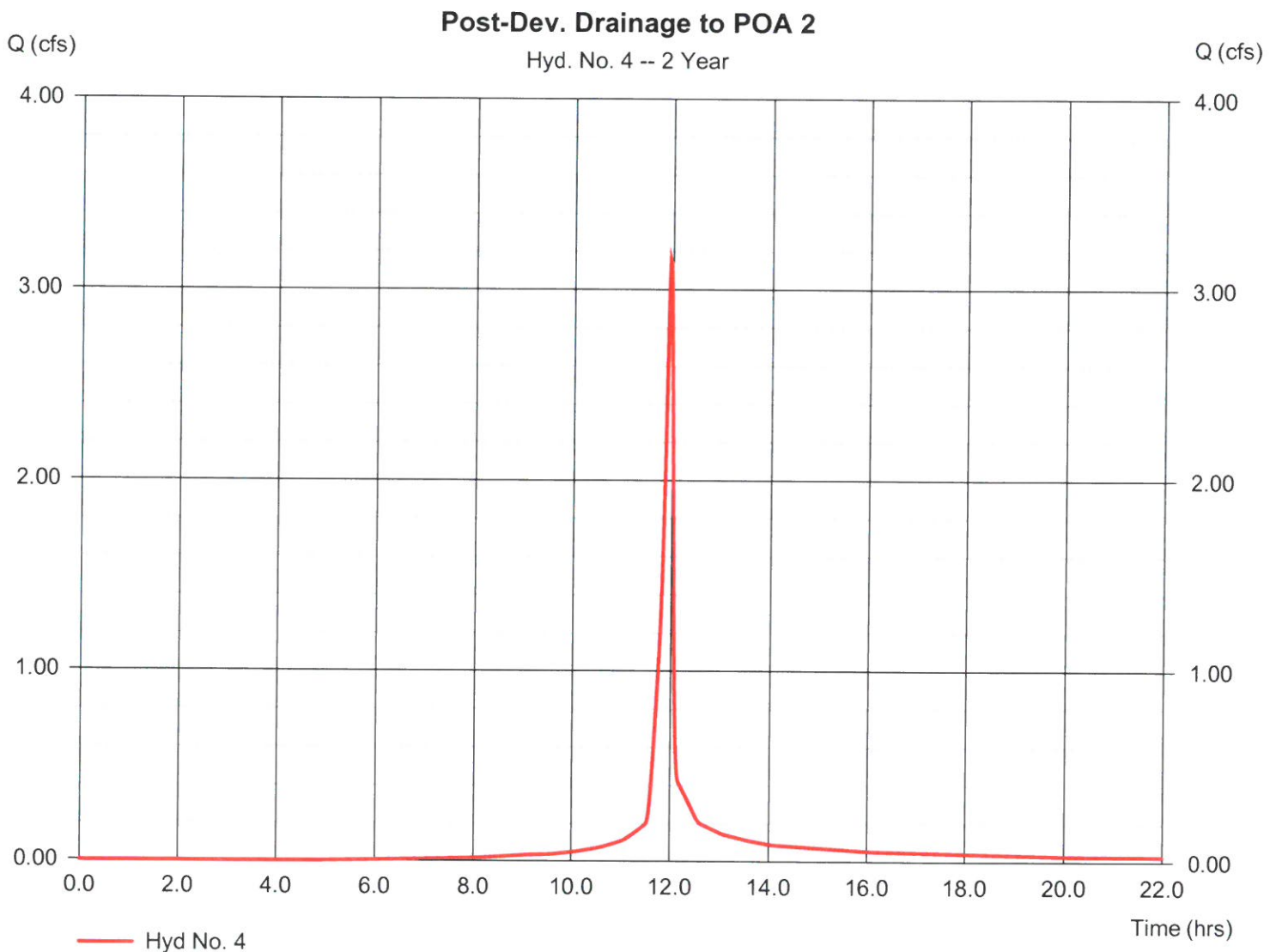
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Tuesday, 09 / 12 / 2017

Hyd. No. 4

Post-Dev. Drainage to POA 2

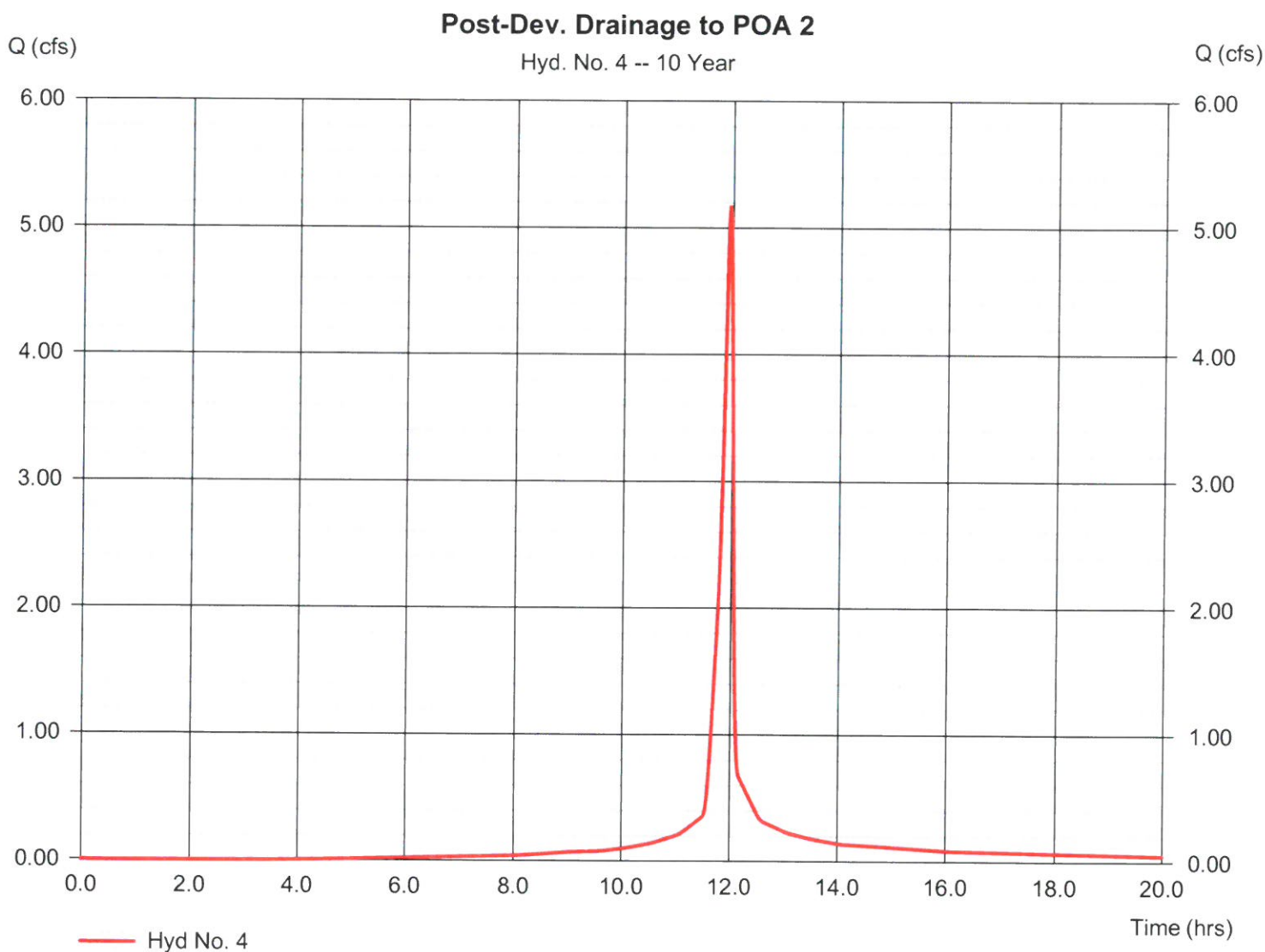
Hydrograph type	= SCS Runoff	Peak discharge	= 3.154 cfs
Storm frequency	= 2 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 6,684 cuft
Drainage area	= 0.750 ac	Curve number	= 91
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 3.33 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

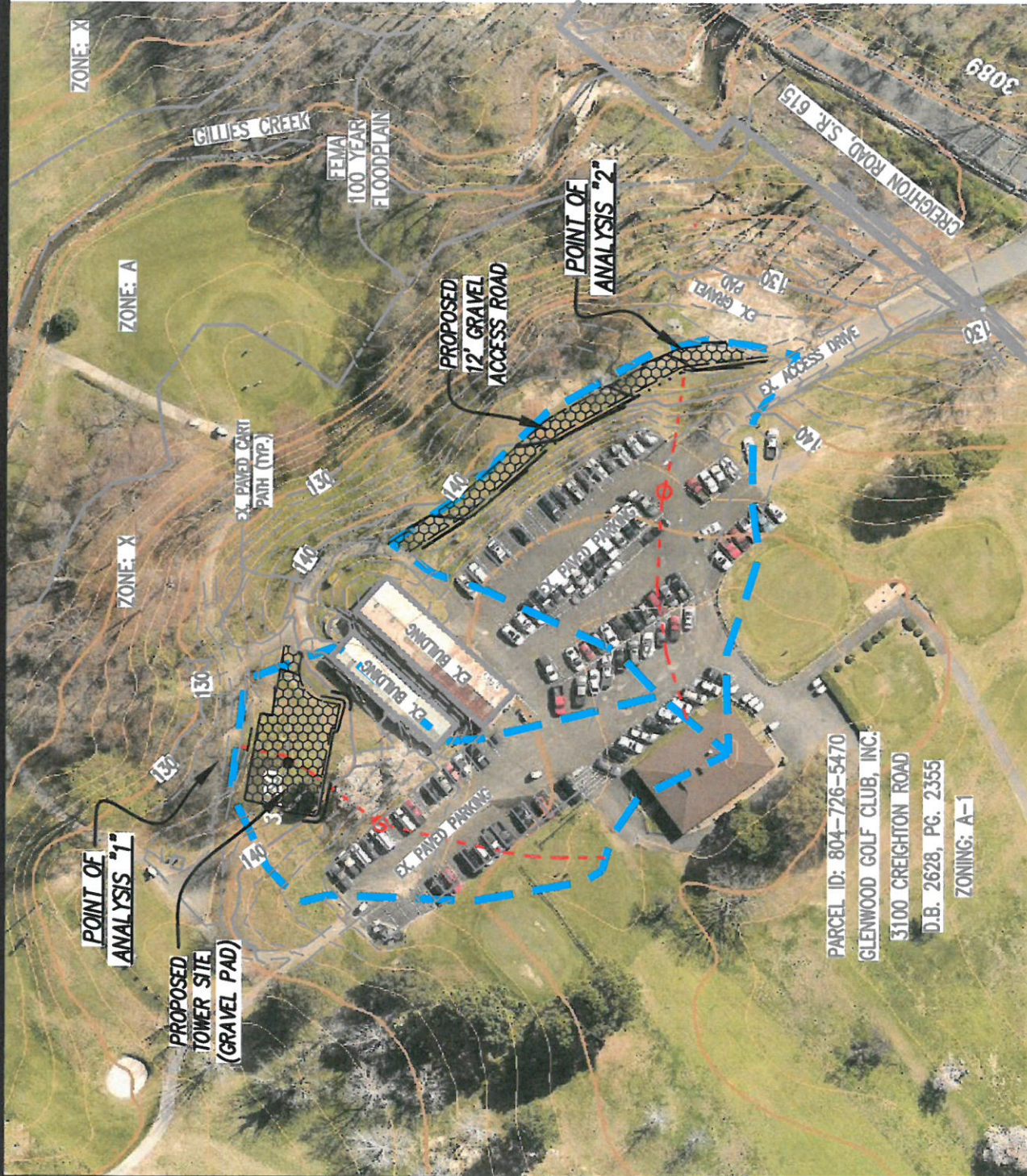


Hyd. No. 4

Post-Dev. Drainage to POA 2

Hydrograph type	= SCS Runoff	Peak discharge	= 5.180 cfs
Storm frequency	= 10 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 11,344 cuft
Drainage area	= 0.750 ac	Curve number	= 91
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 5.06 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484





100' 0 100'
SCALE: 1" = 100'

(DISCHARGE TO SHEET FLOW)
POST-DEVELOPMENT DRAINAGE
TO POINT OF ANALYSIS "1"
D.A. = 0.75 Ac.
CN = 88
Tc = 6.0 Min.

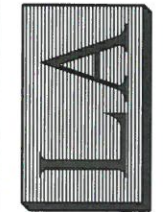
(DISCHARGE TO SHEET FLOW)
POST-DEVELOPMENT DRAINAGE
TO POINT OF ANALYSIS "2"
D.A. = 0.75 Ac.
CN = 91
Tc = 5.0 Min.

POST-DEVELOPMENT
DRAINAGE
Tc

POST-DEVELOPMENT
DRAINAGE AREA MAP
GLENWOOD GOLF CLUB
HENRICO COUNTY, VA

4664 BRAMBLETON AVENUE
P.O. BOX 20669
ROANOKE, VIRGINIA 24018
PHONE: (540) 774-4411
FAX: (540) 772-9445
E-MAIL: MAIL@LUMSDENPC.COM

LUMSDEN ASSOCIATES, P.C.
ENGINEERS-SURVEYORS-PLANNERS
ROANOKE, VIRGINIA

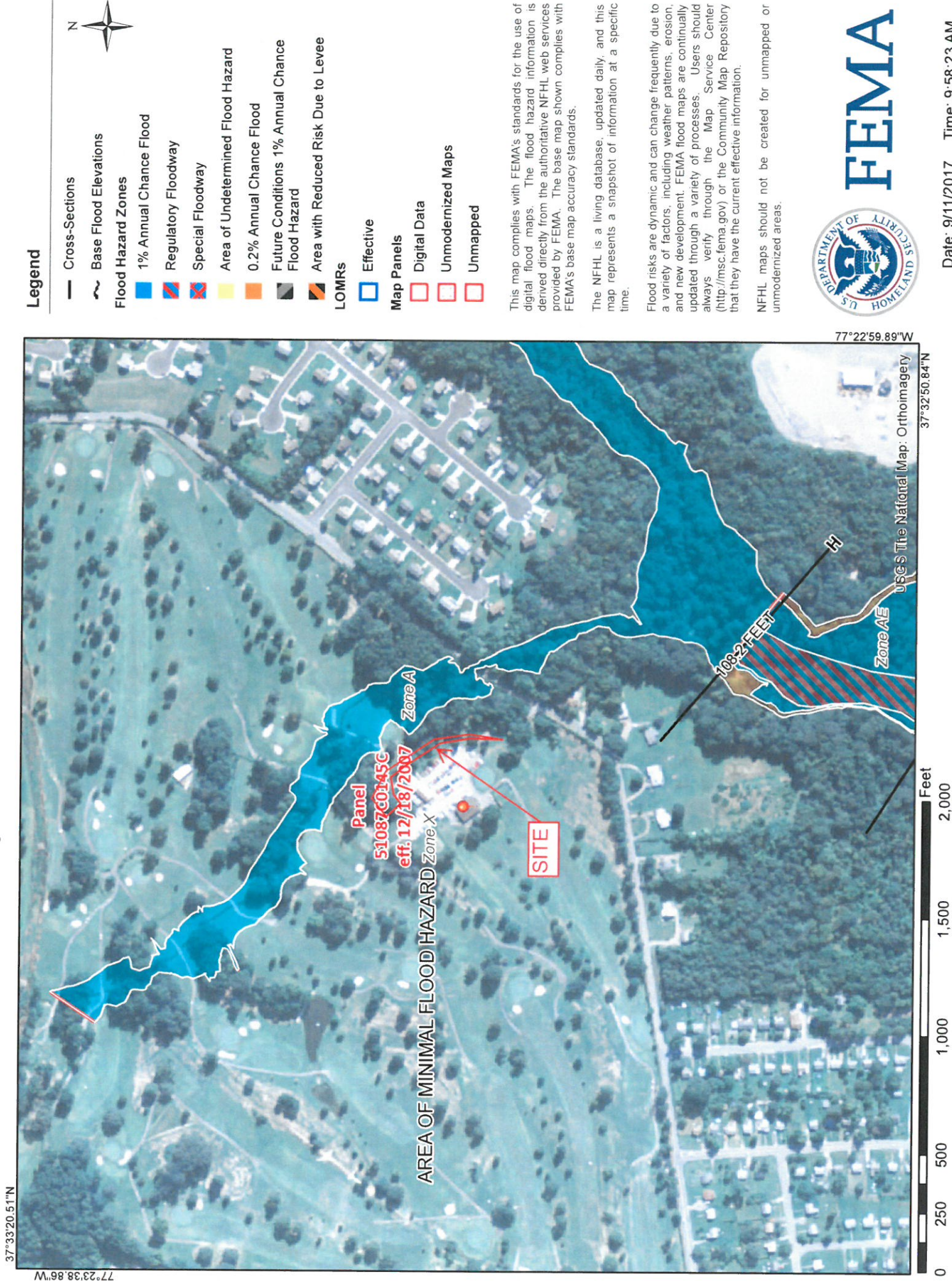


DATE: October 6, 2017
SCALE: 1" = 100'
COMM. NO.: 17-224

APPENDIX “D”

FEMA FLOODZONE VERIFICATION

National Flood Hazard Layer FIRMette



This map complies with FEMA's standards for the use of digital flood maps. The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. The base map shown complies with FEMA's base map accuracy standards.

The NFHL is a living database, updated daily, and this map represents a snapshot of information at a specific time.

Flood risks are dynamic and can change frequently due to a variety of factors, including weather patterns, erosion, and new development. FEMA flood maps are continually updated through a variety of processes. Users should always verify through the Map Service Center (<http://msc.fema.gov>) or the Community Map Repository that they have the current effective information.

NFHL maps should not be created for unmapped or unmodernized areas.



FEMA

APPENDIX “E”

NRCS SOILS REPORT AND ANALYSIS

Custom Soil Resource Report Map—Hydrologic Soil Group



Soil Map may not be valid at this scale.

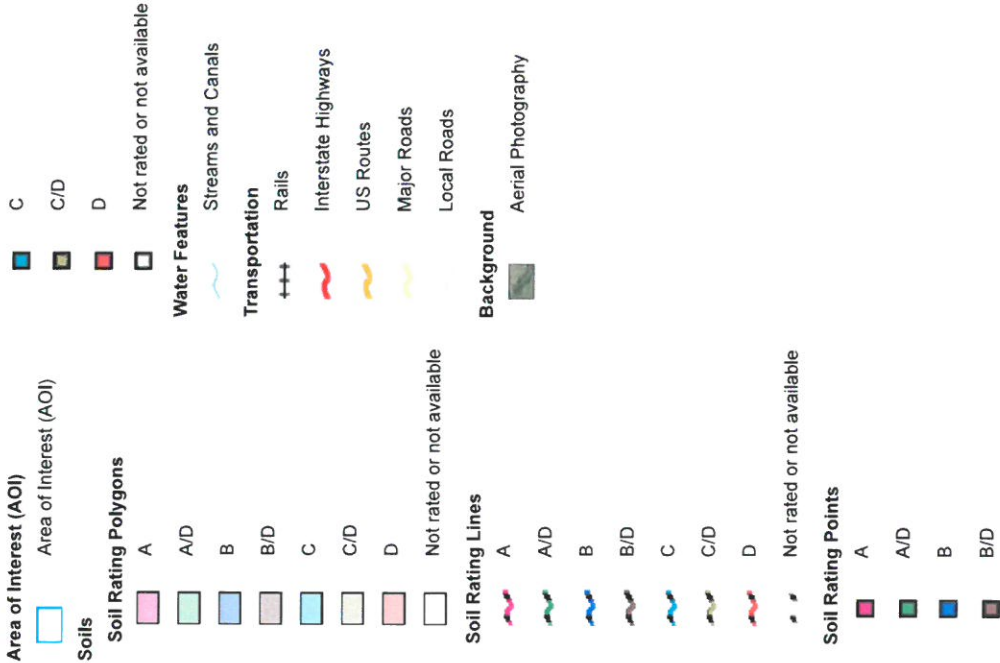
Map Scale: 1:2,560 if printed on A portrait (8.5" x 11") sheet.

0 35 70 140 210 Meters

0 100 200 400 600 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND



MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Henrico County, Virginia
Survey Area Data: Version 9, Dec 13, 2013

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

Date(s) aerial images were photographed: Aug 31, 2013—Oct 1, 2013

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

Table—Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Henrico County, Virginia (VA087)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CaB2	Caroline very fine sandy loam, 2 to 6 percent slopes, eroded	B	0.9	3.1%
Cm	Chewacla and Riverview soils	C	6.2	21.4%
DuB2	Duplin very fine sandy loam, 2 to 6 percent slopes, eroded	C	6.4	22.3%
DuC2	Duplin very fine sandy loam, 6 to 10 percent slopes, eroded	C	5.3	18.2%
NoB	Norfolk fine sandy loam, 2 to 6 percent slopes	B	2.6	8.9%
NoC	Norfolk fine sandy loam, 6 to 10 percent slopes	B	0.1	0.2%
ODU	Ochrepts and Udults, sloping	C	1.7	5.8%
OUF	Ochrepts and Udults, steep	C	5.8	20.0%
UR	Urban land		0.0	0.1%
Totals for Area of Interest			28.9	100.0%

Rating Options—Hydrologic Soil Group*Aggregation Method: Dominant Condition**Component Percent Cutoff: None Specified**Tie-break Rule: Higher*

APPENDIX “F”

STORMWATER OUTFALL TABLE AND COMPLIANCE TABLE

Stormwater Outfall Table									
Site Area (acres)			0.30						
Drainage Area (Acres)			Outfall 1					Outfall 2	
Runoff Reduction (cf)			0.75					0.75	
Receiving Channel Type (Natural, Restored, or Manmade)			0					0	
Channel Protection Compliance Method			NATURAL					NATURAL	
Flood Protection Compliance Method			SHEET FLOW					SHEET FLOW	
			SHEET FLOW					SHEET FLOW	
CN Existing		1-year	2-year	10-year	1-year	2-year	10-year		
		86	86	86	90	90	90		
RV _{Existing} (AC-FT)		0.093	0.126	0.227	0.113	0.148	0.254		
Q _{Existing} (CFS)		2.01	2.67	4.70	2.38	3.06	5.09		
RV _{Forecast} (AC-FT)									
Q _{Forecast} (CFS)									
CN Developed		88	88	88	91	91	91		
RV _{Developed} (AC-FT)		0.103	0.136	0.240	0.118	0.153	0.260		
Q _{Developed} (CFS)		2.19	2.86	4.90	2.47	3.15	5.18		
Q _{Allowed} (CFS)		2.01	2.67	4.70	2.38	3.06	5.09		
Outfall Location (Lats/Longs)		37.552355	-77.388701	37.551464	-77.387837				