ARCHITECTS. ENGINEERS. PLANNERS.

OHM Advancing Communities®

Stormwater Management Plan

Deer Run Subarea B

City of Dublin, Ohio

July 2016

OHM Advisors
580 NORTH FOURTH STREET, SUITE 610
COLUMBUS, OH 43215

T 614.418.0600
F 614.418.0614

OHM-Advisors.com

ARCHITECTS. ENGINEERS. PLANNERS.

OHM Advancing Communities

Stormwater Management Plan

Deer Run
Subarea B

City of Dublin, Ohio

Prepared By:

OHM Advisors
580 North Fourth Street, Suite 610
Columbus, Ohio 43215

I hereby certify that the calculation contained herein are accurate to the best of my knowledge and belief.

STATE OF OHIO
SCOTT R. BICKLEY
E-71470
REGISTERED PROFESSIONAL ENGINEER

Scott R. Bickley, P.E.

7/8/16
Date

Table of Contents

TABLES

APPENDICES

EXHIBITS

I. Project Summary

Project Name: Deer Run Subarea B
Location: Dublin, Ohio
Type: Stormwater Management Plan
Reviewing Agency: City of Dublin

Hydrological Analysis Method:

This report uses the unit hydrograph method described in the National Engineering Handbook (NEH) using the Natural Resources Conservation Service (NRCS) Type II 24-hr design storm. Requirements for the post construction quantity/quality control are per the City of Dublin Stormwater Management Design Manual, June 2013. Post construction quality control shall be designed according to the Ohio EPA General Permit Authorization for Storm Water Discharges Associated with Construction Activity Under the National Pollutant Discharge Elimination System (NPDES). HydroCAD Version 10.00 was the design software used for the analysis.

Rainfall data used (per the City of Dublin Stormwater Management Design Manual):

Rainfall Depths						
1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
2.20 in.	2.63 in.	3.24 in.	3.74 in.	4.44 in.	5.02 in.	5.63 in.

Proposed Design Overview:

Water Quantity: Not Applicable per the City of Dublin Stormwater Management Design Manual, Chapter 2, Section 2.A.1.a
Water Quality: Bioretention Swale
Receiving Body of Water: Subarea B – Deer Run

II. Introduction

The design and analysis described within the contents of this Stormwater Management Report is for the construction project of Deer Run Road Subarea B in which private road is being constructed to provide access to proposed estate lots located in this area. The overall project construction consists of one subarea, Subarea B. The overall development areas for Subarea B is 16.1 acres that will allow for the development of 5 total estate lots. The Deer Run Subarea B project development consists of the construction of the roadway to provide access to these proposed estate lots, still yet to be designed and developed. In Subarea B, the roadway construction consists of 2.17 acres of the overall 16.1 acres (4.07 acres is still available for proposed estate lots development). The project is located off of Dublin Rd on the existing Deer Run Rd. with Subarea A located north of Deer Run and Subarea B located south of Deer Run. The intent of the project is to develop the existing wooded areas into several proposed estate lots for residential use.

The runoff from the roadway will be collected in a Bioretention swale to address quality requirements. In Subarea B, the runoff is collected in a bioretention swale and outlets to Deer Run.

III. Hydrologic Analysis Method

The design and analysis of the stormwater plan were completed using the unit hydrograph method described in the National Engineering Handbook (NEH) using the Natural Resources Conservation Service (NRCS) Type II 24-hr design storm. From the NRCS tables provided, the runoff curve number was determined as well as the method of calculating the time of concentration. From this, the 1, 2, 5, 10, 25, 50, and 100-year storm discharges were calculated using the Hydraflow Hydrographs program.

IV. Pre Developed Conditions

The overall pre-developed condition for Subarea B consists of 16.1 acres to be rezoned. This land consists of wooded area with moderate ground cover in Type “D” Soils (Glynwood Clay Loam and End Moraine) which corresponds to the runoff Curve Number 83. The time of concentration for the pre-developed area is 5.08 minutes. Calculations for the time of concentration can be found in Appendix D. The information for the pre developed site conditions are shown in Table 1.

Table 1: Pre Developed Subarea Characteristics

	Area (acres)	Land Usage	Impervious Area (%)	Weighted CN	Time of Concentration (minutes)
Subarea B	2.17	Wooded, Impervious	0.02%	83	5.08

In Subarea B, the pre developed area for the roadway is located in Sub-basins 10 and 20 of the Deer Run Watershed per the City of Dublin Stormwater Master Plan. It should be noted that portions of 3 of the proposed estate lots are located outside of this watershed in the unstudied areas and shall comply with the release rates specified in Chapter 2, Section C.1.b. This shall be considered when the separate construction plans and stormwater management plans are submitted for these development lots. The approximate acreage of the proposed roadway development between the two sub-basins are listed in Table 2, as well as the respective allowable release rates.

Table 2: Allowable Release Rates

Deer Run Watershed Release Rate Requirements (from the City of Dublin Stormwater Master Plan)							
	Design Storm (CFS/ac.)						
Sub-Basin	1-year	2-year	5-year	10-year	25-year	50-year	100-year
10	0.10	0.10	0.10	0.30	0.80	1.80	2.80
20	0.10	0.10	0.10	0.40	1.60	3.10	4.40
Unstudied	< 2.0 acres, 0.20						

Allowable Release Rates per Acre								
		Design Storm (CFS/ac.)						
Sub-Basin	Area (ac.)	1-year	2-year	5-year	10-year	25-year	50-year	100-year
Subarea A								
10	0.10	0.01	0.01	0.01	0.03	0.08	0.18	0.28
Unstudied	0.59	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Subarea B								
10	0.66	0.07	0.07	0.07	0.20	0.53	1.19	1.85
20	0.47	0.05	0.05	0.05	0.19	0.75	1.46	2.07

V. Post Developed Conditions

The proposed roadway construction area is shown in Exhibit 2. For subarea B, this includes a total of 2.17-acre development of which 0.48 acres is comprised of the roadway with a gravel top course and the remaining development is the proposed grading including the bioretention swales on both sides of the roadway. Composite runoff numbers were calculated in Hydraflow and are summarized in Table 3.

Exhibits 2 shows the design of the proposed roadway in Subarea B that will provide access to the future estate lots. The remaining estate lots will be designed and will provide separate construction design plans and stormwater management plans. This project will utilize a Bioretention Swale that runs parallel to the roadway and will provide quality treatment for the project.

Table 3: Post Developed Subarea Characteristics

	Area (acres)	Land Usage	Impervious Area (%)	Weighted CN	Time of Concentration (minutes)
Subarea B	2.17	Impervious Area, Wooded Area, Grass Cover	39%	84	*Refer to the Time of Concentration Calcs in Appendix D for the respective drainage areas.

VI. Outlet Design

For Subarea B, there are three outlets for the system. Two outlets are graded to discharge to Deer Run and the last outlet is collected into a proposed storm system and discharge to a proposed swale to grade to Deer Run. All outlets are provided to minimize disturbance of the existing ground.

VII. Maintenance and Inspection

The city shall be responsible for the inspection and maintenance of the bioretention swales located alongside the proposed roadway. Inspections and maintenance that are conducted shall be documented by the city. For initial sediment control, please refer to the City of Dublin,

Stormwater Management Design Manual, Chapter 8 and the Sediment and Erosion control submitted with the proposed construction plans. The following procedures should be followed for the bioretention swales. Inspection of the storm structures to remove debris or sediment that has accumulated at the catch basins or outlet shall occur once a year. Maintenance (mowing or removal of excess sediment or debris) of the bioretention swales shall occur at a minimum on a monthly basis or more frequently if needed. More frequent maintenance may need required during the months of April through September, or during heavy rainfalls where runoff might carry debris into the swale and where grass might grow at a much higher rate. Adjustments may be made to this plan upon review of the 1st year inspection results.

VIII. Post Construction Water Quality

The project is a new construction project so water quality treatment is required for a 0.75-inch event. Water Quantity treatment is not required since the project location is located within the River Corridor as per the City of Dublin Stormwater Management Design Manual, Chapter 2, Section 2.A.1.a. For Subarea B it was 0.02% pre development and is 22% post development. By utilizing Vegetated Bioretention Swale alongside the roadway this will allow the proposed soil media to improve the water quality and will also reduce runoff rates, even though quantity treatment is not required. The 12“soil layer under the finished grade of the ditch bottom, provides enhanced infiltration and pollutant removal. Therefore, we are able to treat the required 0.75-inch event for the project. Calculations that show the required volume storage to treat this rainfall event and the storage provided for each bioretention swale are shown in the calculations for the water quality conditions can be found in Appendix B.

Appendix A

Storm Sewer Calculation Sheets

Project Name: Deer Run

Storm Sewer Calculations

Project Number: Deer Run
Date: 11/09/2015
Calculated By: ACF

STRUCTURE DATA | **PIPE CALCULATIONS** | **HYDRAULIC GRADE CALCULATIONS**

DESIGN STORM (year) = 25
ROUGHNESS COEFFICIENT n = 0.012

HYDRAULIC GRADE (year) = 10
PERCENT FULL AT OUTLET = 93%
TAILWATER ELEVATION = 834.00

STRUC. NO.	STRUC. TYPE	TOP OF CASTING FT.	INVERT IN ELEV. FT.	INVERT OUT ELEV. FT.	DEPTH OF STRUC. FT.	DRAINAGE AREA A ACRES	SUM A ACRES	C	CA ACRES	SUM CA ACRES	TIME T MIN.	SUM T MIN.	RAINFALL INTENSITY I IN. / HR.	DISCHARGE Q C.F.S.	LENGTH OF PIPE FT.	SLOPE OF PIPE FT. / FT.	SIZE OF PIPE IN.	MEAN VELOCITY F.P.S.	CAPACITY FLOWING FULL C.F.S.	PERCENT FULL %	TIME SUM T MIN.	HYDRAULIC RAINFALL INTENSITY I IN. / HR.	HYDRAULIC DISCHARGE Q C.F.S.	HYDRAULIC GRADE SLOPE FT. / FT.	HEAD LOSS COEFF. K	MINOR HEAD LOSS Hm FT.	HYDRAULIC GRADE DOWNHILL ELEV. FT.	HYDRAULIC GRADE UPHILL ELEV. FT.	DEPTH OF HYDRAULIC GRADE FT.
CB-1		837.24		834.24	3.00	1.180	1.180	0.55	0.649	0.649	10															0.0000	834.00		3.24
												10.00	6.98	4.53	75.00	0.0075	15	4.95	6.08	74.55	10.00	6.98	4.53	0.0042					

Appendix B

Post- Construction Water Quality Calculations

Deer Run Project - Dublin, OH

Functional Classification : Local Road

Subarea B RT DITCH #1

Stormwater Management Requirements

Location of Project: River Corridor
Quantity Requirements: Not applicable
Quality Requirements: 0.75 inch event

Type of Drainage System: Open Channel
Hydrologic Soil Group: D

Ditches shall be designed to carry the 10 year, 24 hr storm.
Open Channels shall be designed with one foot of freeboard above the design water surface elevation for the 10 year, 24-hour storm.
The 100 yr, 24 hour storm shall not encroach into proposed or existing residential dwellings or places of business.

Method of treating water quality for the project: *Bioretention Swale*

Pre Construction Imprevious Area	0	acres
Post Construction Impervious Area	0.11	acres
Total Area	0.47	acres
% of impervious area	23.40%	

Time of Concentration

tc = 0.12 hr

Water Quality Volume (WQv)

$$WQ_V = C * \left({}^{P}/_{12}\right) * A$$

Where,
$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$
$i = fraction\ of\ post - const.\ impervious\ surface$
P = 0.75 Precipitation Depth
A = Area tributary to basin, acres

C = 0.189423
I = 0.2340
P = 0.75 inches
A = 0.6811 acre

WQ_V = 0.008064 ac-ft 351.2464 CU FT
WQ_V Elevation = 0.09 ft water depth in swale
Available Depth in Ditch: 1.00 FT
Available Storage in Ditch: 1,290 CU FT

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Jul 8 2016

B-RT1

Trapezoidal

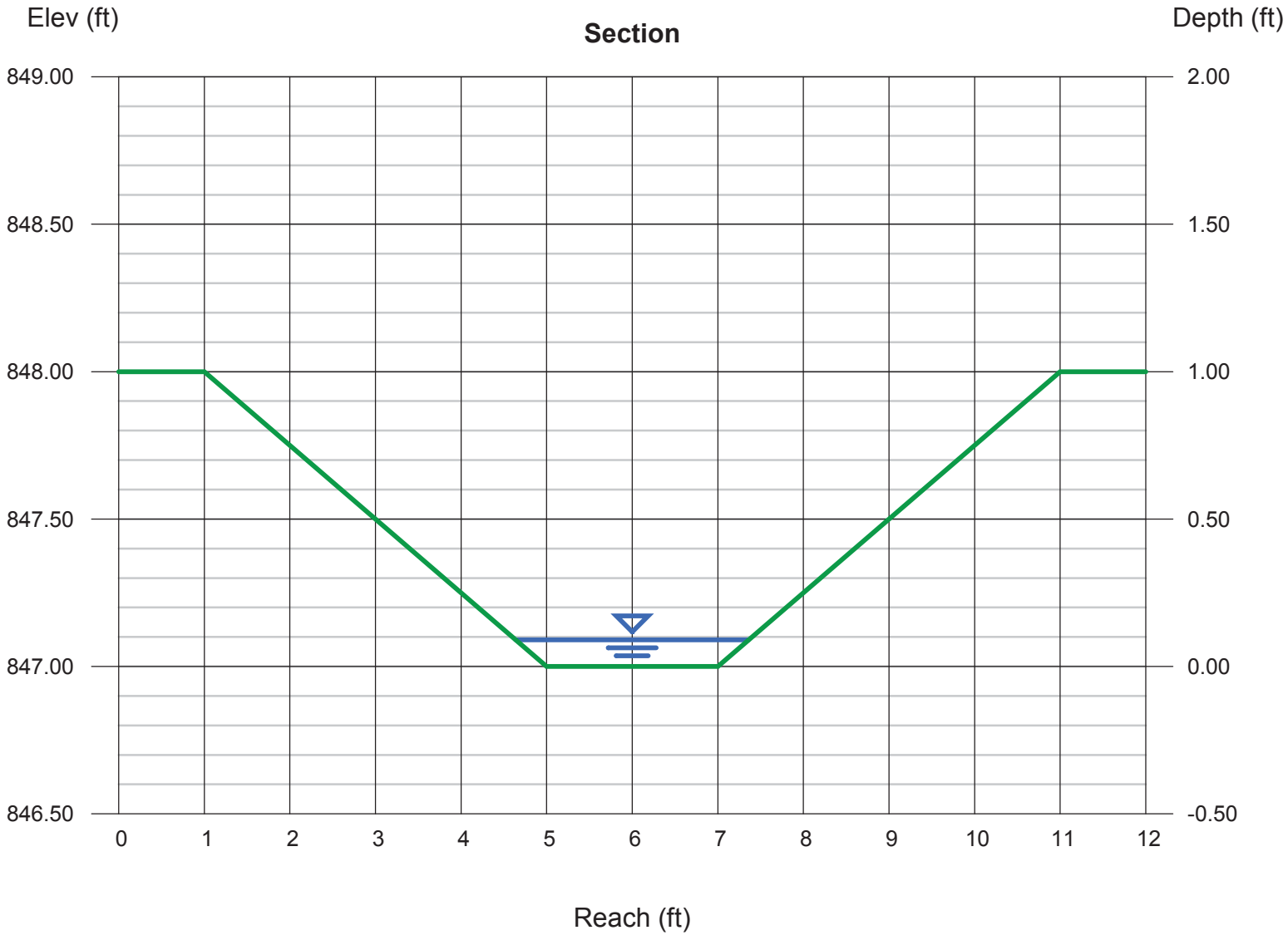
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 847.00
Slope (%)	= 9.25
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 0.54

Highlighted

Depth (ft)	= 0.09
Q (cfs)	= 0.535
Area (sqft)	= 0.21
Velocity (ft/s)	= 2.52
Wetted Perim (ft)	= 2.74
Crit Depth, Yc (ft)	= 0.12
Top Width (ft)	= 2.72
EGL (ft)	= 0.19



Deer Run Project - Dublin, OH

Functional Classification : Local Road

Subarea B LT DITCH #1

Stormwater Management Requirements

Location of Project: River Corridor
Quantity Requirements: Not applicable
Quality Requirements: 0.75 inch event

Type of Drainage System: Open Channel
Hydrologic Soil Group: D

Ditches shall be designed to carry the 10 year, 24 hr storm.
Open Channels shall be designed with one foot of freeboard above the design water surface elevation for the 10 year, 24-hour storm.
The 100 yr, 24 hour storm shall not encroach into proposed or existing residential dwellings or places of business.

Method of treating water quality for the project: *Bioretention Swale*

Pre Construction Imprevious Area	0.028	acres
Post Construction Impervious Area	0.13	acres
Total Area	0.61	acres
% of impervious area	21.31%	

Time of Concentration

tc = 0.17 hr

Water Quality Volume (WQv)

$$WQ_V = C * \left({}^{P}/_{12}\right) * A$$

$Where,$
$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$
$i = fraction\ of\ post - const.\ impervious\ surface$
$\mathrm{P} = 0.75\mathrm{Precipitation\ Depth}$
$\mathrm{A} = \mathrm{Area\ tributary\ to\ basin, acres}$

C =	0.17783	
I =	0.2131	
P =	0.75	inches
A =	0.1534	acre

WQ_V = 0.001705 ac-ft 74.26726 CU FT

WQ_V Elevation = 0.12 ft water depth in swale

Available Depth in Ditch: 1.00 FT

Available Storage in Ditch: 5(1,500 CF

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Jul 8 2016

B-LT1

Trapezoidal

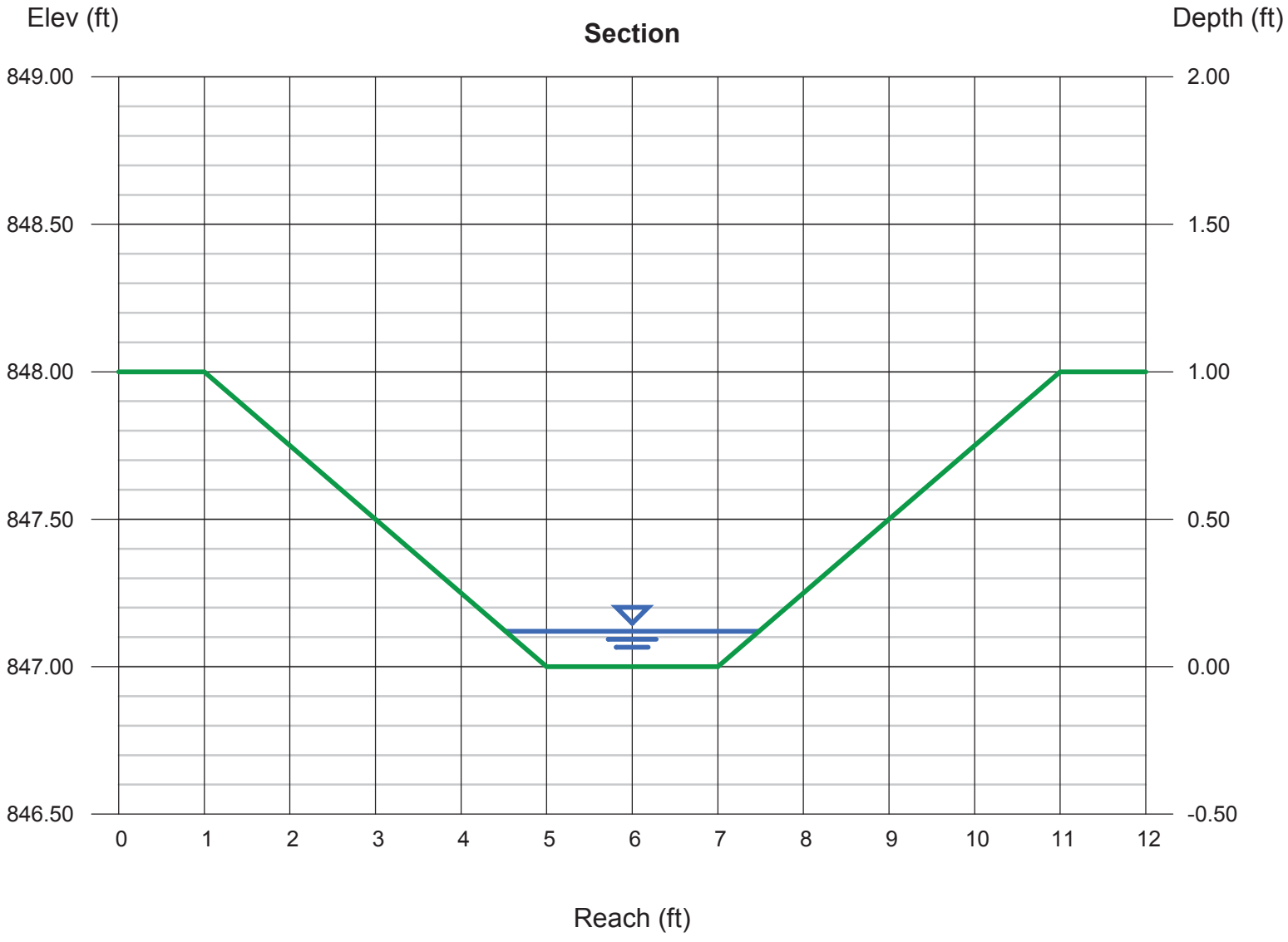
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 847.00
Slope (%)	= 4.50
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 0.66

Highlighted

Depth (ft)	= 0.12
Q (cfs)	= 0.660
Area (sqft)	= 0.30
Velocity (ft/s)	= 2.22
Wetted Perim (ft)	= 2.99
Crit Depth, Yc (ft)	= 0.14
Top Width (ft)	= 2.96
EGL (ft)	= 0.20



Deer Run Project - Dublin, OH

Functional Classification : Local Road

Subarea B LT DITCH #2

Stormwater Management Requirements

Location of Project: River Corridor
Quantity Requirements: Not applicable
Quality Requirements: 0.75 inch event

Type of Drainage System: Open Channel
Hydrologic Soil Group: D

Ditches shall be designed to carry the 10 year, 24 hr storm.
Open Channels shall be designed with one foot of freeboard above the design water surface elevation for the 10 year, 24-hour storm.
The 100 yr, 24 hour storm shall not encroach into proposed or existing residential dwellings or places of business.

Method of treating water quality for the project: *Bioretention Swale*

Pre Construction Imprevious Area	0	acres
Post Construction Impervious Area	0.098	acres
Total Area	0.39	acres
% of impervious area	25.13%	

Time of Concentration

tc = 0.33 hr

Water Quality Volume (WQv)

$$WQ_V = C * ({}^{P}/_{12}) * A$$

$Where,$
$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$
$i = fraction\ of\ post - const.impervious\ surface$
$\mathrm{P} = 0.75\mathrm{Precipitation\ Depth}$
$\mathrm{A} = \mathrm{Area\ tributary\ to\ basin, acres}$

C = 0.1989
I = 0.2513
P = 0.75 inches
A = 0.3471 acre

WQ_V = 0.0043 ac-ft 187.91 CU FT
WQ_V Elevation = 0.10 ft water depth in swale
Available Depth in Ditch: 1.00 FT
Available Storage in Ditch: 5(1,680 CF

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Jul 8 2016

B-LT2

Trapezoidal

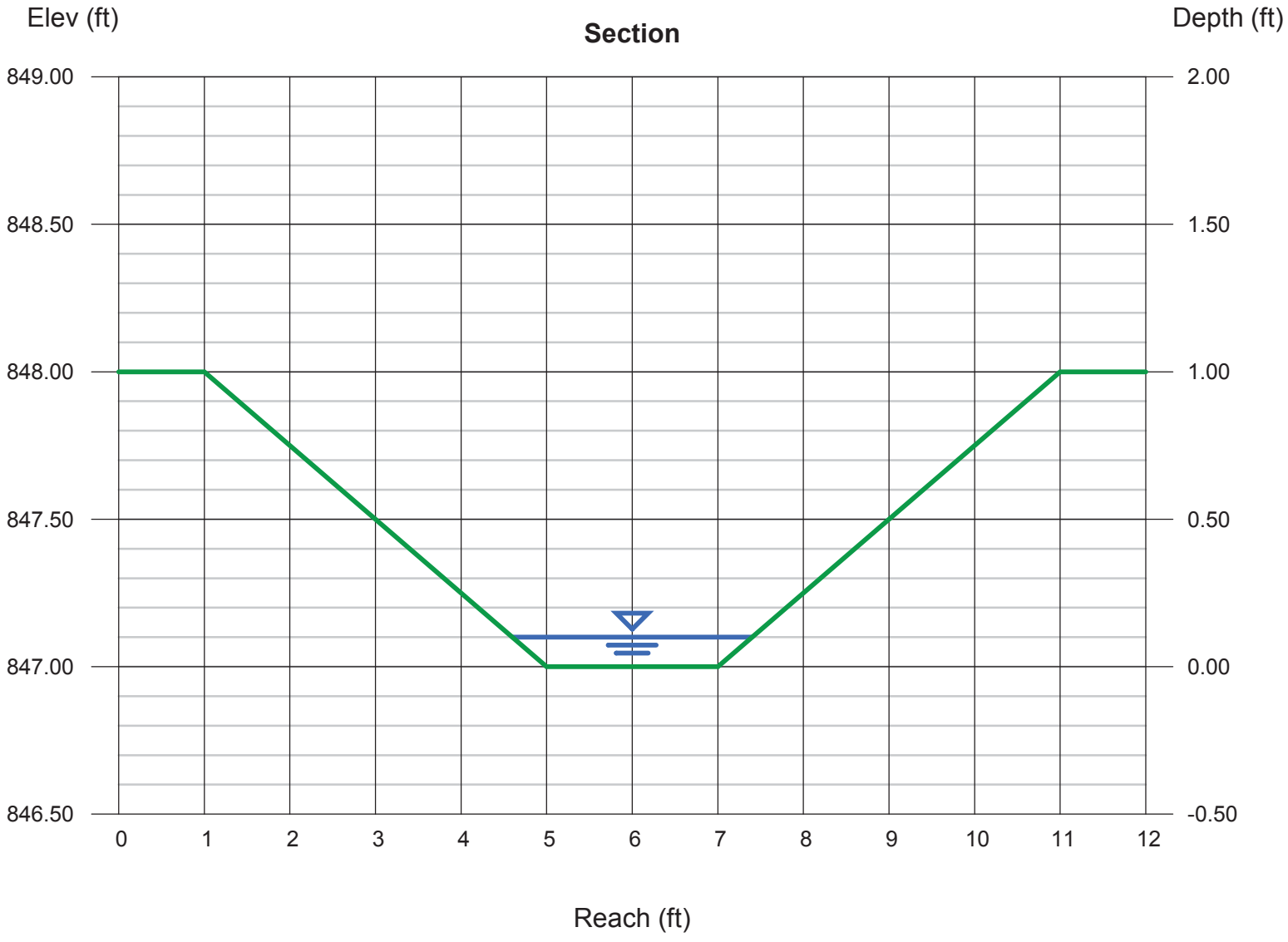
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 847.00
Slope (%)	= 3.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 0.40

Highlighted

Depth (ft)	= 0.10
Q (cfs)	= 0.395
Area (sqft)	= 0.24
Velocity (ft/s)	= 1.65
Wetted Perim (ft)	= 2.82
Crit Depth, Yc (ft)	= 0.10
Top Width (ft)	= 2.80
EGL (ft)	= 0.14



Deer Run Project - Dublin, OH

Functional Classification : Local Road

Subarea B LT DITCH #3

Stormwater Management Requirements

Location of Project: River Corridor
Quantity Requirements: Not applicable
Quality Requirements: 0.75 inch event

Type of Drainage System: Open Channel
Hydrologic Soil Group: D

Ditches shall be designed to carry the 10 year, 24 hr storm.
Open Channels shall be designed with one foot of freeboard above the design water surface elevation for the 10 year, 24-hour storm.
The 100 yr, 24 hour storm shall not encroach into proposed or existing residential dwellings or places of business.

Method of treating water quality for the project: *Bioretention Swale*

Pre Construction Imprevious Area	0	acres
Post Construction Impervious Area	0.15	acres
Total Area	0.71	acres
% of impervious area	21.13%	

Time of Concentration

tc = 0.33 hr

Water Quality Volume (WQv)

$$WQ_V = C * ({}^{P}/_{12}) * A$$

$Where,$
$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$
$i = fraction\ of\ post - const.impervious\ surface$
$\mathrm{P} = 0.75\mathrm{Precipitation\ Depth}$
$\mathrm{A} = \mathrm{Area\ tributary\ to\ basin, acres}$

C = 0.1768
I = 0.2113
P = 0.75 inches
A = 0.3471 acre

WQ_V = 0.0038 ac-ft 167.07 CU FT
WQ_V Elevation = 0.13 ft water depth in swale
Available Depth in Ditch: 1.00 FT
Available Storage in Ditch: 5(1,655 CF

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Jul 8 2016

B-LT3

Trapezoidal

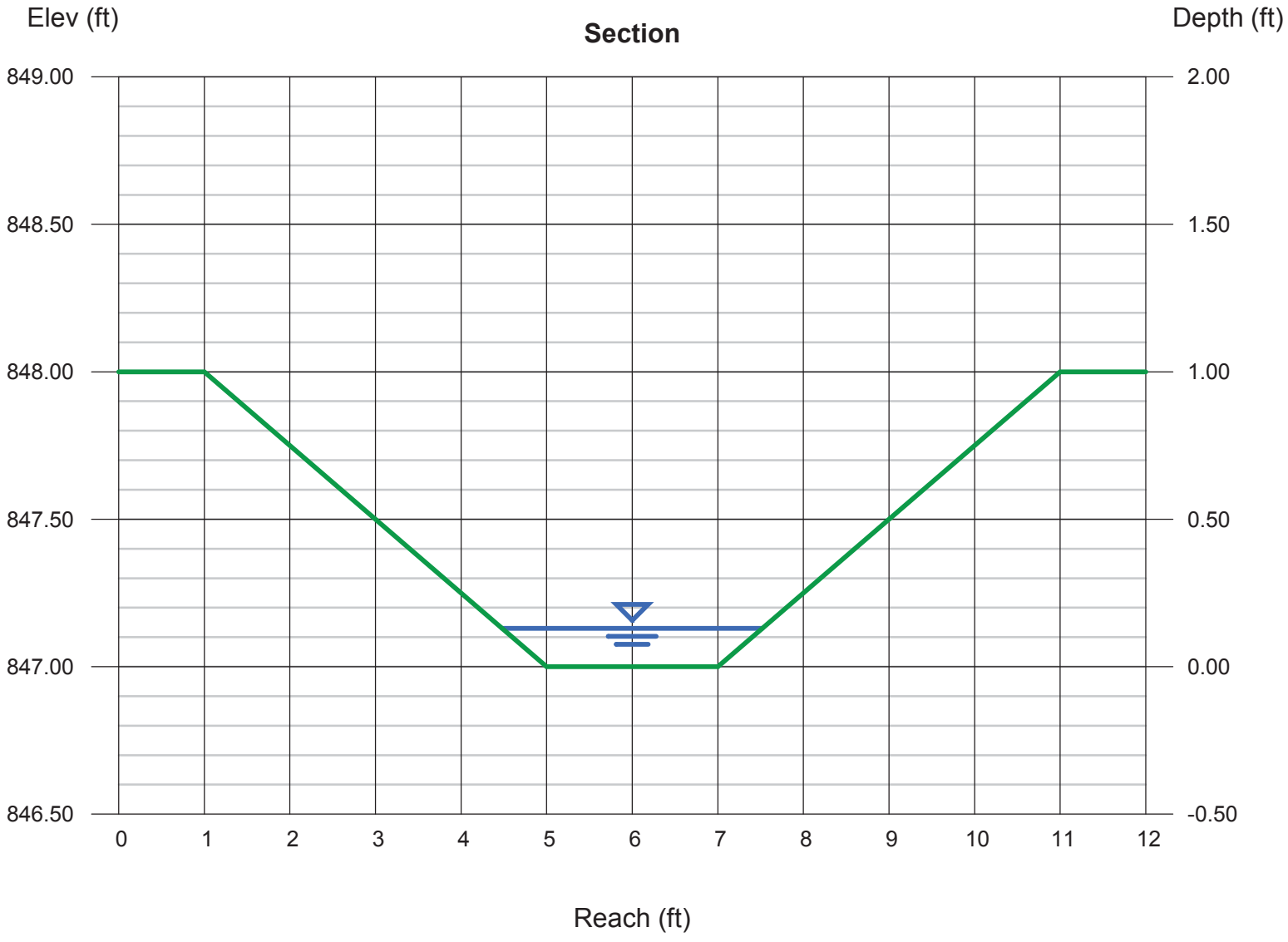
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 847.00
Slope (%)	= 5.75
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 0.81

Highlighted

Depth (ft)	= 0.13
Q (cfs)	= 0.809
Area (sqft)	= 0.33
Velocity (ft/s)	= 2.47
Wetted Perim (ft)	= 3.07
Crit Depth, Yc (ft)	= 0.16
Top Width (ft)	= 3.04
EGL (ft)	= 0.22



Appendix C

Hydraflow Reports

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.664	1	718	1,371	------	------	------	B-LT1 - Pre
2	SCS Runoff	0.660	1	720	1,524	------	------	------	B-LT1 - Post
3	SCS Runoff	0.392	1	718	817	------	------	------	B-LT2 - Pre
4	SCS Runoff	0.395	1	722	1,024	------	------	------	B-LT2 - Post
5	SCS Runoff	0.713	1	718	1,487	------	------	------	B-LT3 - Pre
6	SCS Runoff	0.809	1	719	1,729	------	------	------	B-LT3 - Post
7	SCS Runoff	0.472	1	718	985	------	------	------	B-RT1 - Pre
8	SCS Runoff	0.535	1	719	1,145	------	------	------	B-RT1 - Post

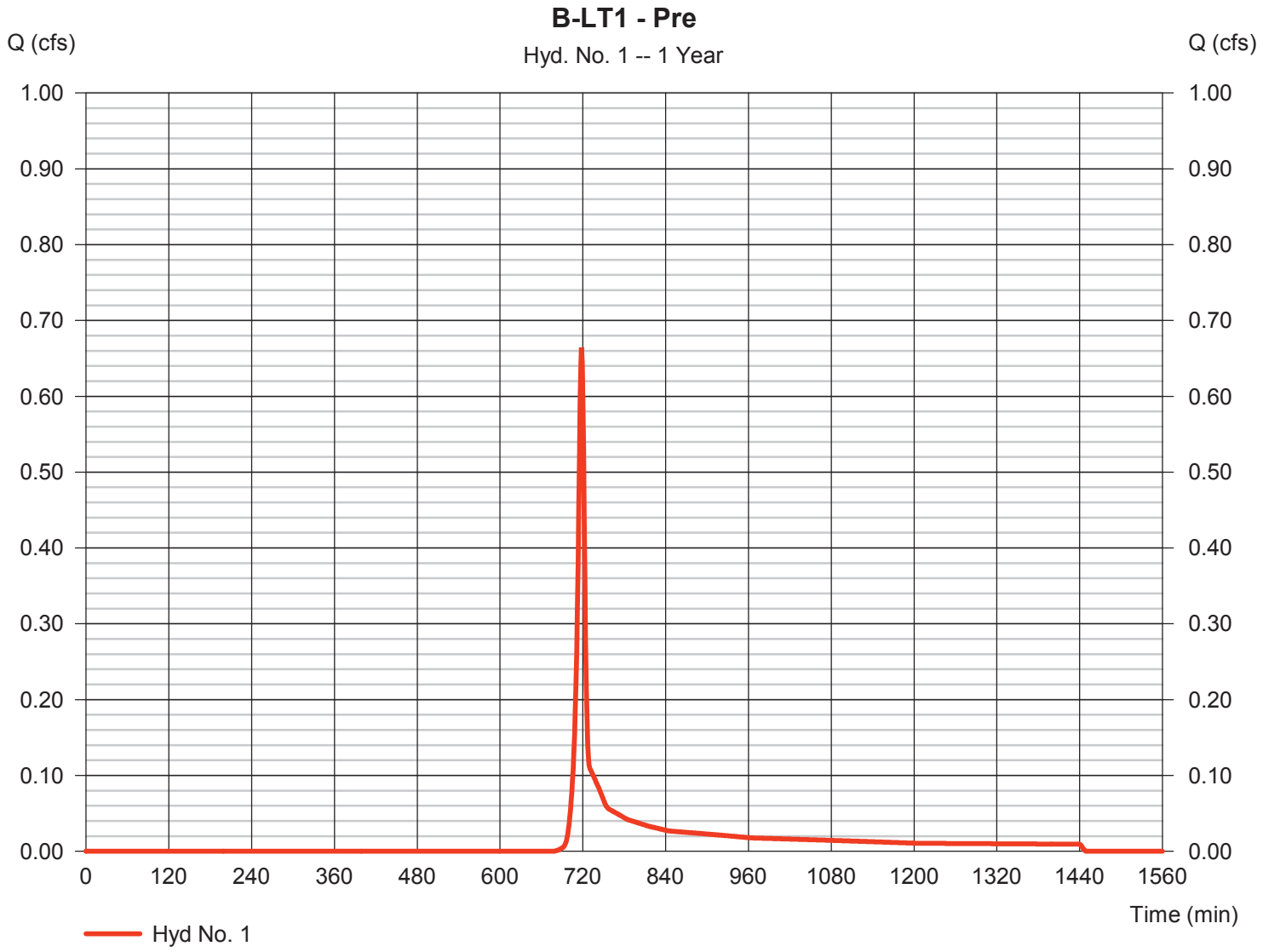
Hydrograph Report

Hyd. No. 1

B-LT1 - Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.664 cfs
Storm frequency	= 1 yrs	Time to peak	= 718 min
Time interval	= 1 min	Hyd. volume	= 1,371 cuft
Drainage area	= 0.610 ac	Curve number	= 78*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.32 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.028 x 91) + (0.582 x 77)] / 0.610



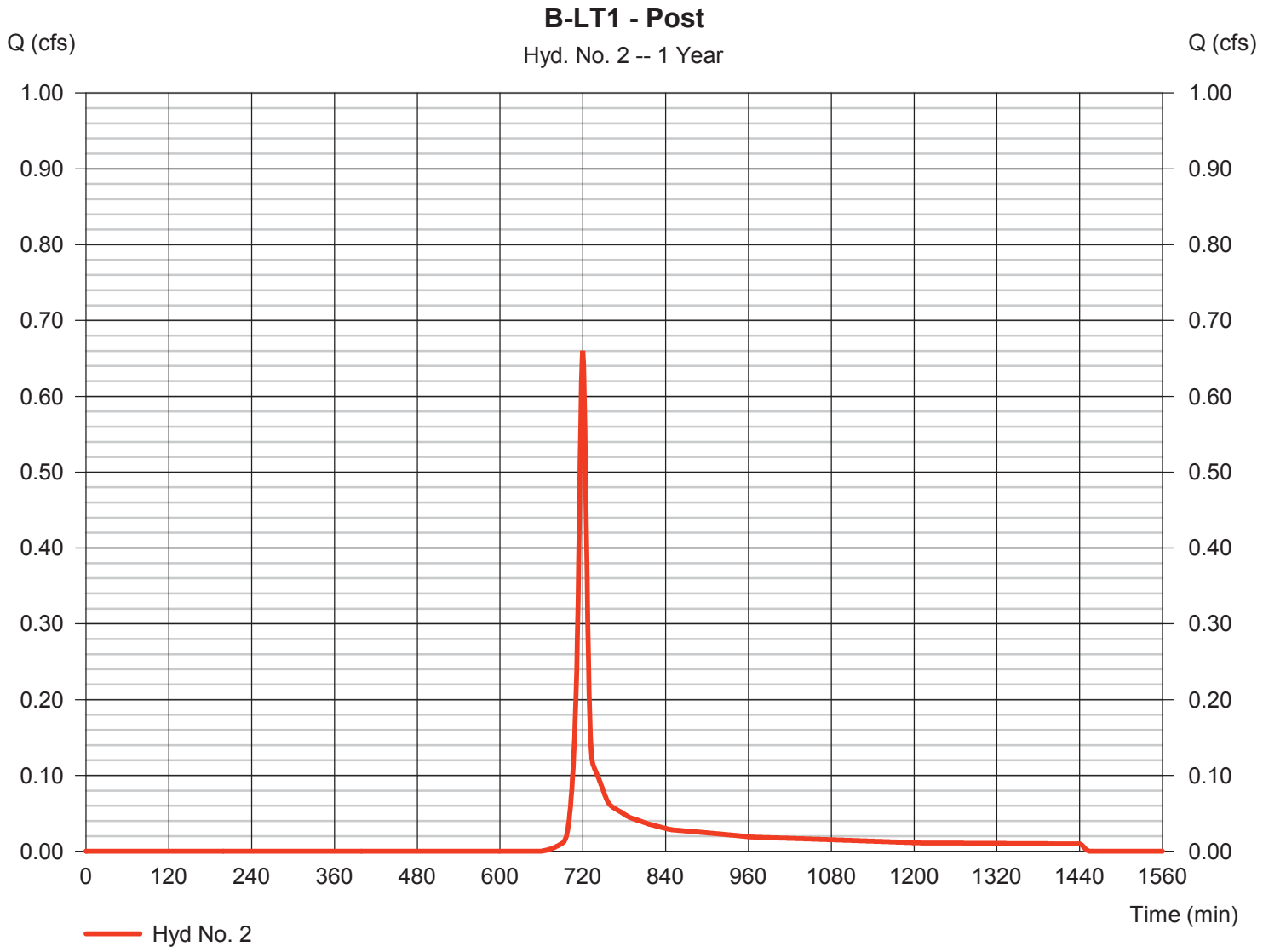
Hydrograph Report

Hyd. No. 2

B-LT1 - Post

Hydrograph type	= SCS Runoff	Peak discharge	= 0.660 cfs
Storm frequency	= 1 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 1,524 cuft
Drainage area	= 0.610 ac	Curve number	= 80*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 9.40 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.130 x 91) + (0.480 x 77)] / 0.610



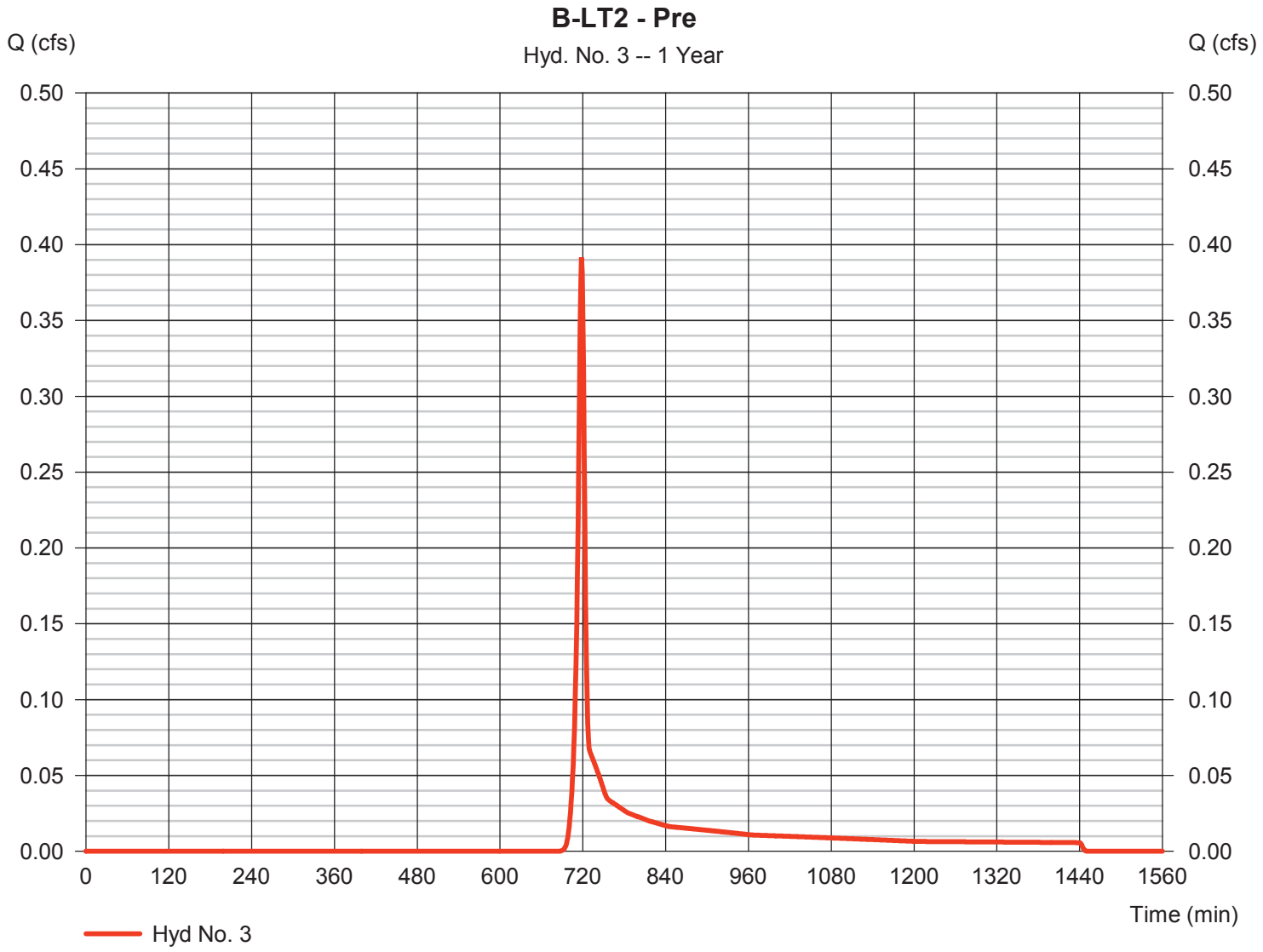
Hydrograph Report

Hyd. No. 3

B-LT2 - Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.392 cfs
Storm frequency	= 1 yrs	Time to peak	= 718 min
Time interval	= 1 min	Hyd. volume	= 817 cuft
Drainage area	= 0.390 ac	Curve number	= 77*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.10 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.390 x 77)] / 0.390



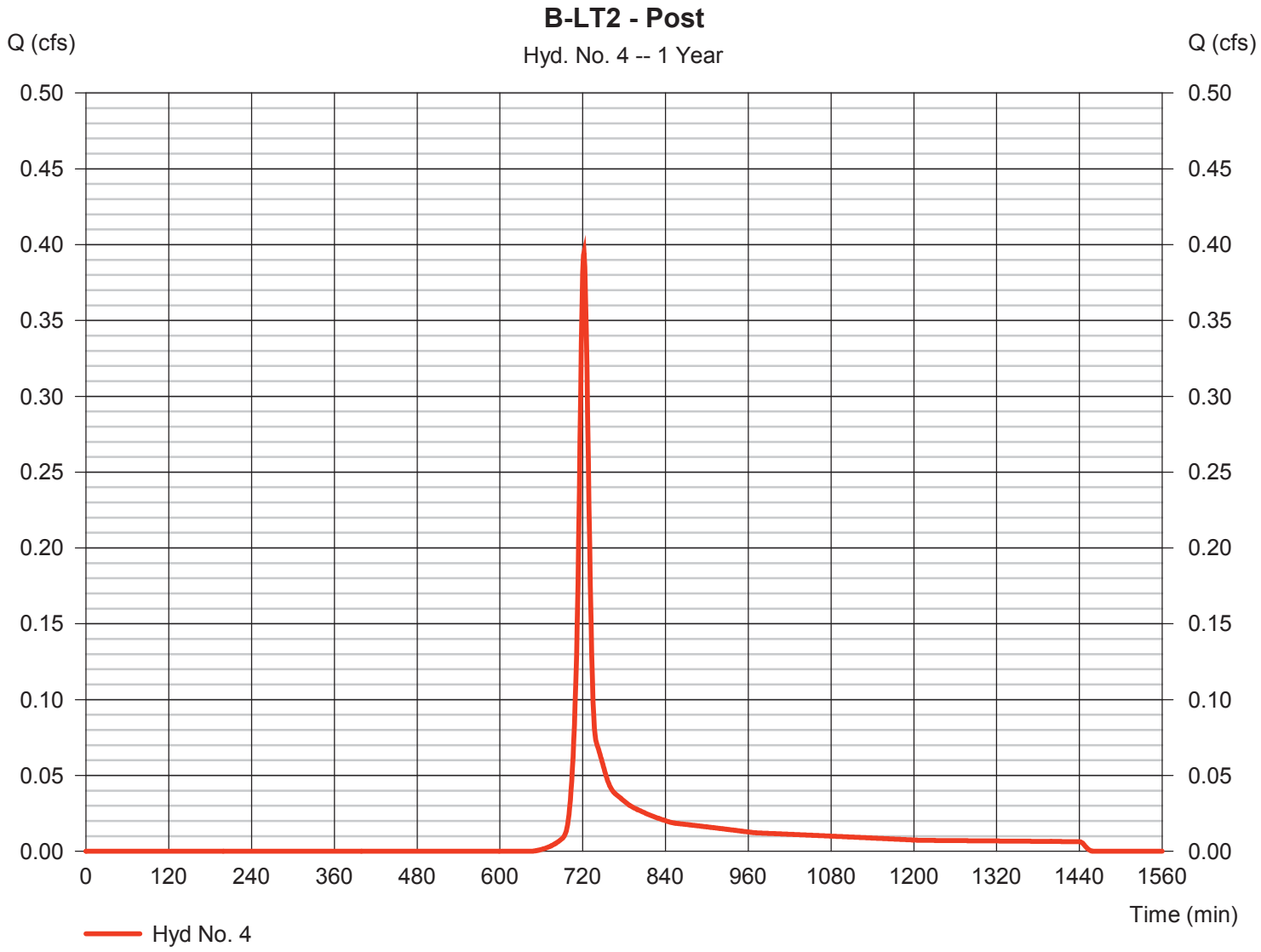
Hydrograph Report

Hyd. No. 4

B-LT2 - Post

Hydrograph type	= SCS Runoff	Peak discharge	= 0.395 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 1,024 cuft
Drainage area	= 0.390 ac	Curve number	= 81*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 13.43 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.100 x 91) + (0.290 x 77)] / 0.390



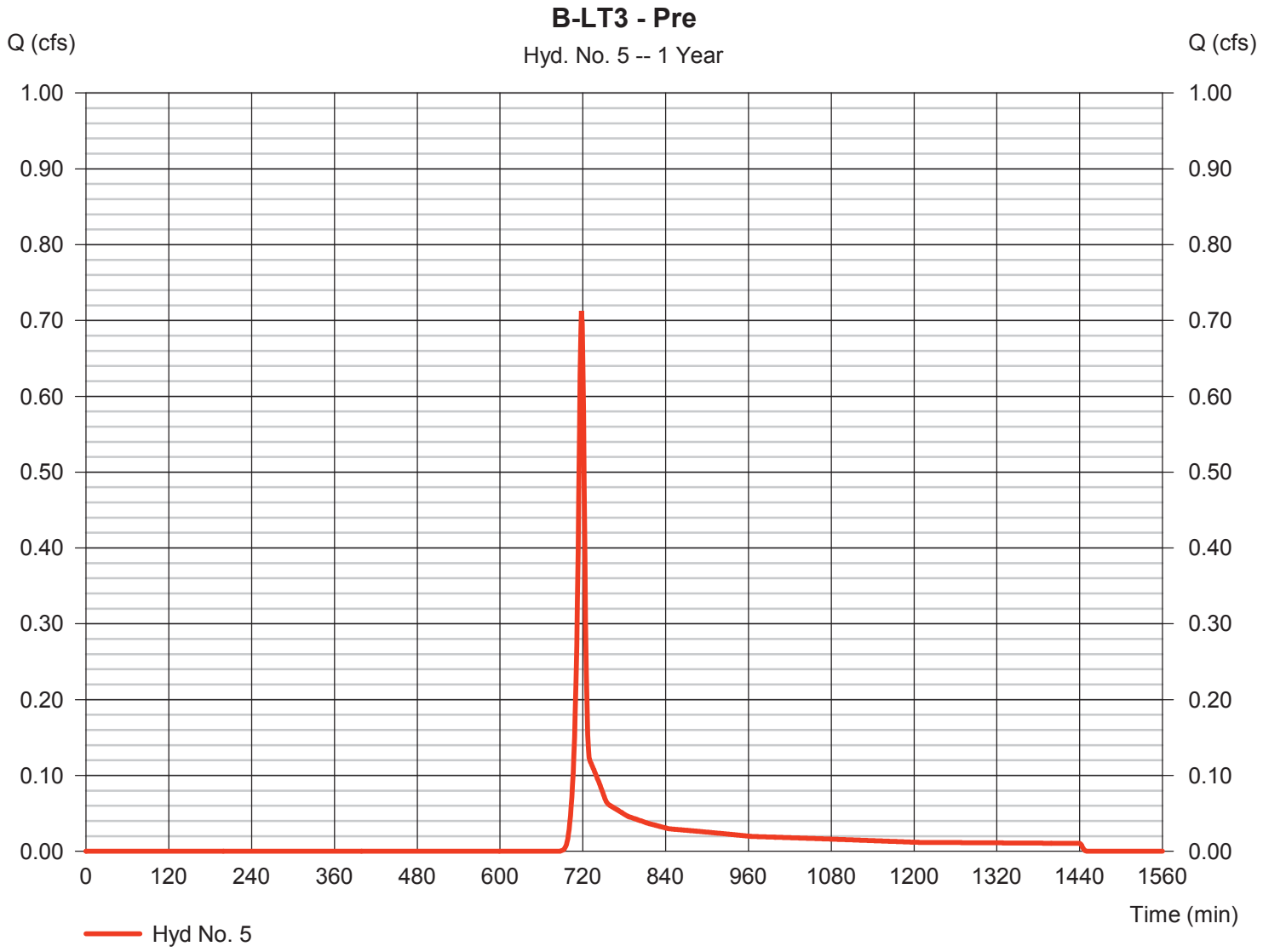
Hydrograph Report

Hyd. No. 5

B-LT3 - Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.713 cfs
Storm frequency	= 1 yrs	Time to peak	= 718 min
Time interval	= 1 min	Hyd. volume	= 1,487 cuft
Drainage area	= 0.710 ac	Curve number	= 77*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.08 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.710 x 77)] / 0.710



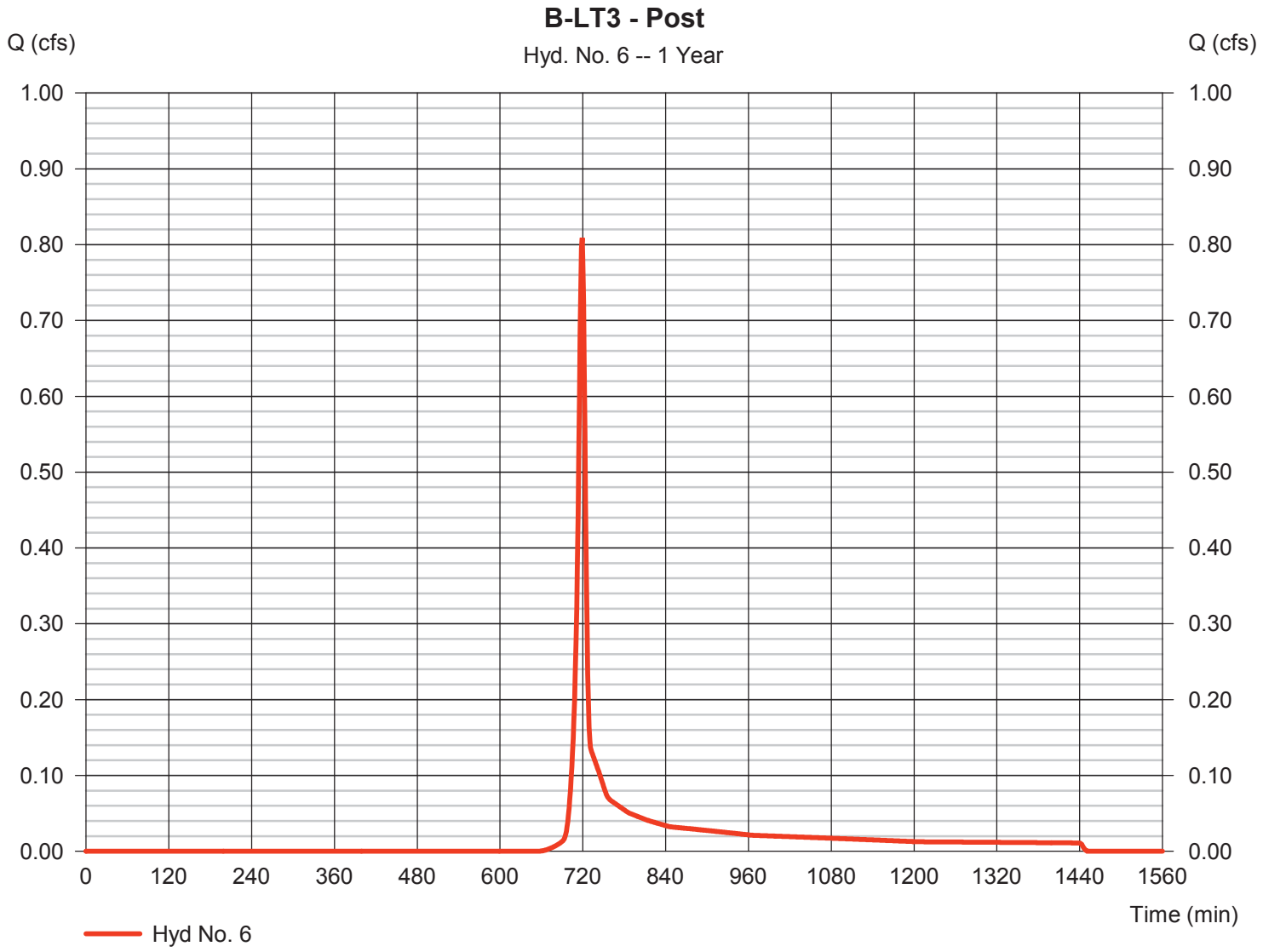
Hydrograph Report

Hyd. No. 6

B-LT3 - Post

Hydrograph type	= SCS Runoff	Peak discharge	= 0.809 cfs
Storm frequency	= 1 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 1,729 cuft
Drainage area	= 0.710 ac	Curve number	= 80*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 7.89 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.150 x 91) + (0.560 x 77)] / 0.710



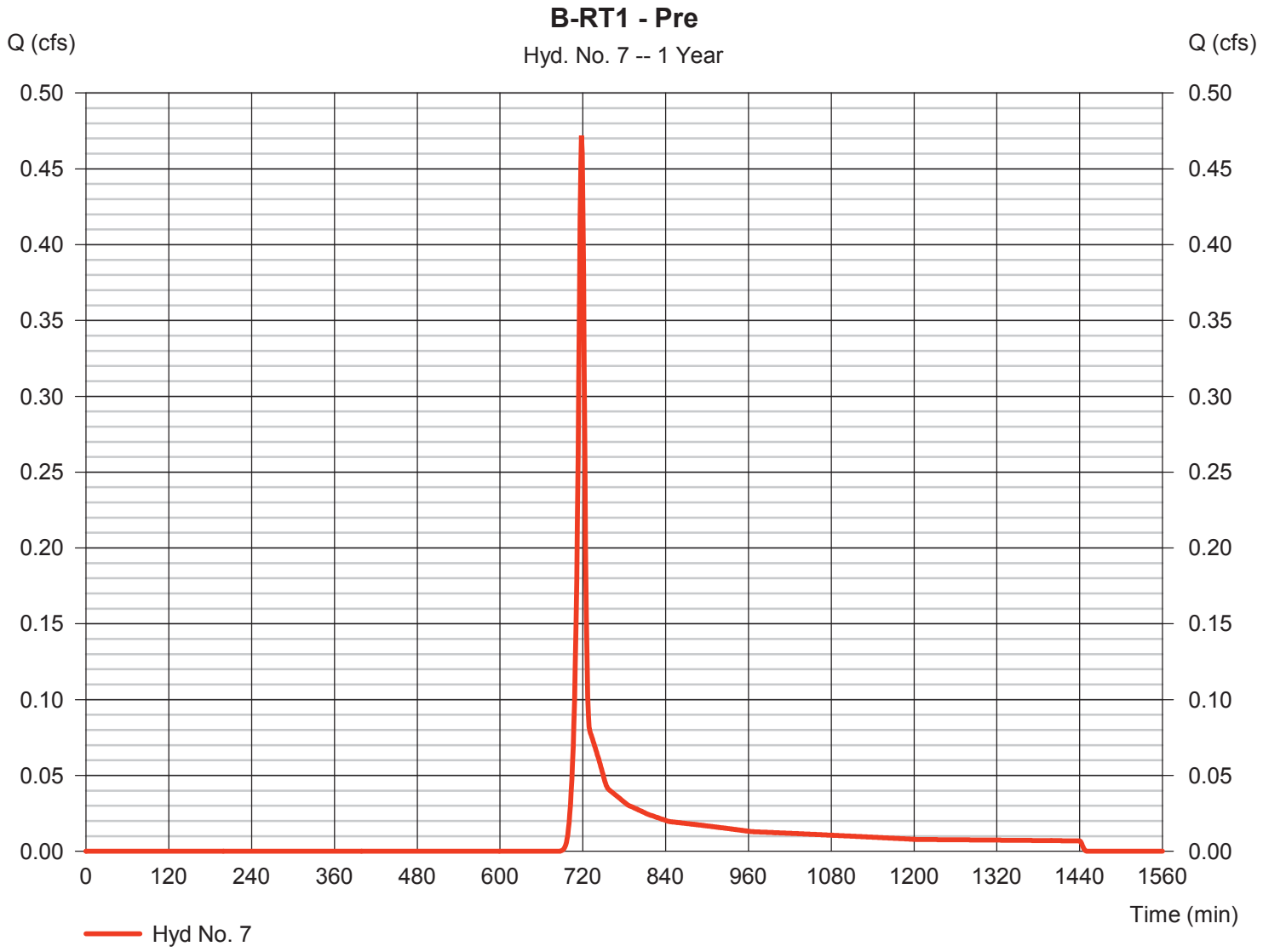
Hydrograph Report

Hyd. No. 7

B-RT1 - Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.472 cfs
Storm frequency	= 1 yrs	Time to peak	= 718 min
Time interval	= 1 min	Hyd. volume	= 985 cuft
Drainage area	= 0.470 ac	Curve number	= 77*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.08 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.470 x 77)] / 0.470



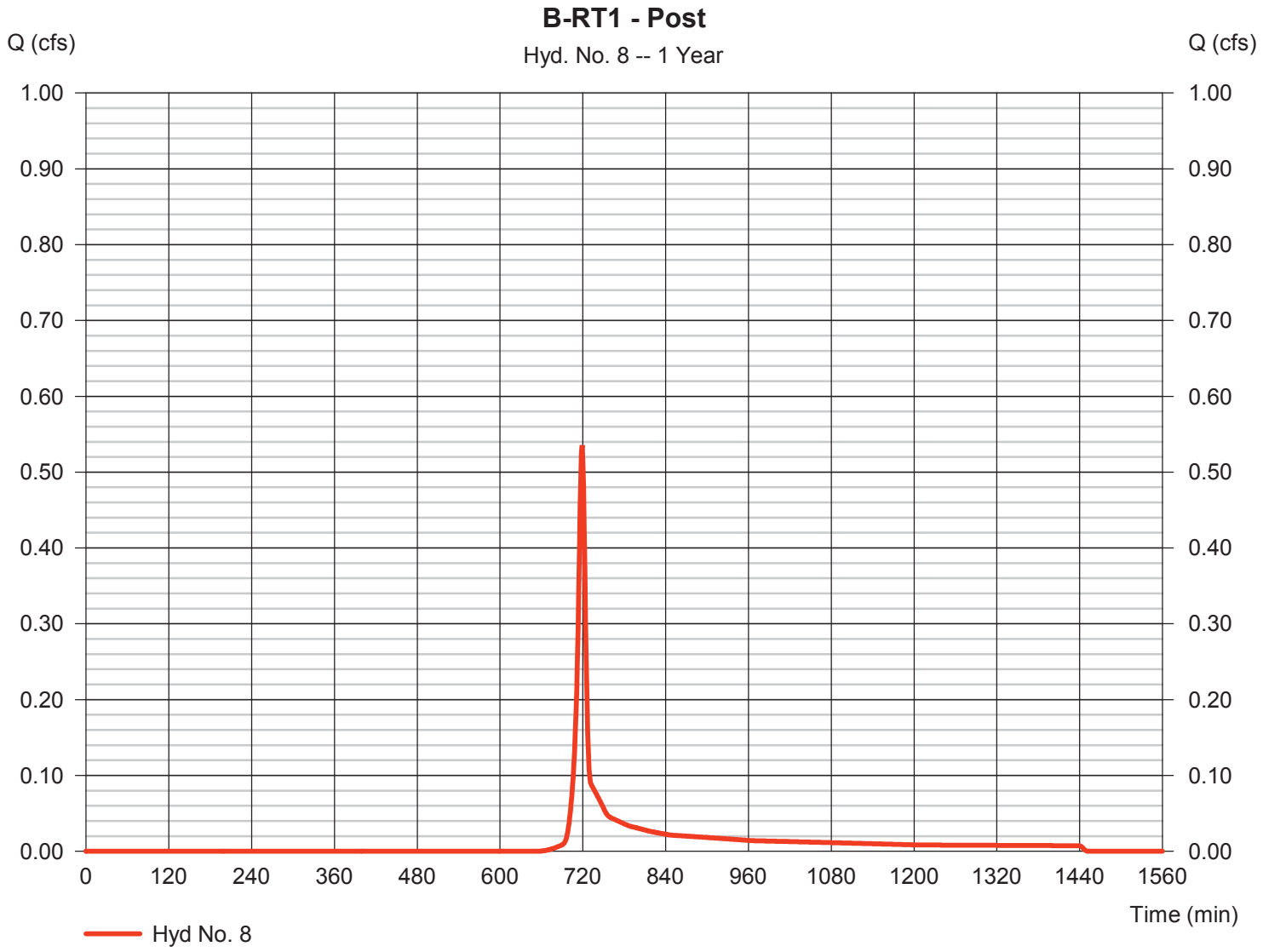
Hydrograph Report

Hyd. No. 8

B-RT1 - Post

Hydrograph type	= SCS Runoff	Peak discharge	= 0.535 cfs
Storm frequency	= 1 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 1,145 cuft
Drainage area	= 0.470 ac	Curve number	= 80*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 7.20 min
Total precip.	= 2.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.110 x 91) + (0.360 x 77)] / 0.470



Appendix D

Time of Concentration Calculations

Time of Concentration - Pre Conditions Subarea B Right Ditch #1

Overland (Sheet Flow) Time of Concentration

			OR
to =		**0.03 hr**	1.51 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.4
L (Sheet flow Length)	125
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.096

Shallow Time of Concentration

			Depth	Manning's n	Velocity
Flow Type	Minimum tillage cultivation, contour or strip-cropped, and woodlands		0.2	0.101	Use Figure 15-4 to determine Velocity
Slope	0.0267	ft/ft			
Velocity from Chart	0.7	ft/s			
Length	150	ft			
t =	**0.06**	**hr**		3.57 minutes	

t_{open} =	**0.00**	**hr**
TOTAL TIME OF CONCENTRATION =	**0.08**	**hr**
	OR	
	5.08	**minutes**

Time of Concentration - Post Conditions Subarea B Right Ditch #1

Overland (Sheet Flow) Time of Concentration

to =		**0.02 hr**	OR 1.36 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.4
L (Sheet flow Length)	50
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.02

Open Channel Flow

			Calc Check
Area =	0.02	ft^2	*0.02*
Radius =	0.01	ft	*0.01*
Slope(ft/ft) =	0.0925		
n =	0.03		
V (velocity)	0.57	ft/sec	
Drainage Area (acres) =	0.47	acres	
C (Coefficient of Runoff) =	0.3		
I =	0.11		
Q = CiA	0.016	cfs	
Ditch Width =	2	ft	
Foreslope/Backslope =	4		

Depth of water in Ditch = 0.09 **in inches*

Length of Ditch = (in feet) 215

t_{open} = 0.10 hr

TOTAL TIME OF CONCENTRATION = 0.13 hr OR 7.62 minutes

Time of Concentration - Pre Conditions Subarea B Left Ditch #1

Overland (Sheet Flow) Time of Concentration

to =	**0.03**	**hr**	OR 1.75 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.4
L (Sheet flow Length)	150
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.096

Shallow Time of Concentration

			Depth	Manning's n	Velocity
Flow Type	Minimum tillage cultivation, contour or strip-cropped, and woodlands		0.2	0.101	Use Figure 15-4 to determine Velocity
Slope	0.0267	ft/ft			
Velocity from Chart	0.7	ft/s			
Length	150	ft			
t =	**0.06**	**hr**		3.57 minutes	

t_{open} =	**0.00**	**hr**

TOTAL TIME OF CONCENTRATION =	**0.09**	**hr**
	OR	
	5.32	**minutes**

Time of Concentration - Post Conditions Subarea B Left Ditch #1

Overland (Sheet Flow) Time of Concentration

to =		**0.00 hr**	OR 0.08 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.03
L (Sheet flow Length)	16
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.0156

Open Channel Flow

			Calc Check
Area =	0.02	ft^2	*0.02*
Radius =	0.01	ft	*0.01*
Slope(ft/ft) =	0.045		
n =	0.03		
V (velocity)	0.48	ft/sec	
Drainage Area (acres) =	0.61	acres	
C (Coefficient of Runoff) =	0.3		
I =	0.11		
Q = CiA	0.020	cfs	
Ditch Width =	2	ft	
Foreslope/Backslope =	4		

Depth of water in Ditch = 0.12 **in inches*

Length of Ditch = 255

t_{open} = 0.15 hr

TOTAL TIME OF CONCENTRATION = 0.15 hr OR 8.89 minutes

Time of Concentration - Pre Conditions Subarea B Left Ditch #2

Overland (Sheet Flow) Time of Concentration

to =	**0.03**	**hr**	OR 1.51 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.4
L (Sheet flow Length)	125
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.096

Shallow Time of Concentration

			Depth	Manning's n	Velocity
Flow Type	Minimum tillage cultivation, contour or strip-cropped, and woodlands		0.2	0.101	Use Figure 15-4 to determine Velocity
Slope	0.0267	ft/ft			
Velocity from Chart	0.7	ft/s			
Length	150	ft			
t =	**0.06**	**hr**		3.57 minutes	

t_{open} =	**0.00**	**hr**

TOTAL TIME OF CONCENTRATION =	**0.08**	**hr**
	OR	
	5.08	**minutes**

Time of Concentration - Post Conditions Subarea B Left Ditch #2

Overland (Sheet Flow) Time of Concentration

to =	**0.00**	**hr**	OR 0.08 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.03
L (Sheet flow Length)	16
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.0156

Open Channel Flow

			Calc Check
Area =	0.02	ft^2	*0.02*
Radius =	0.01	ft	*0.01*
Slope(ft/ft) =	0.03		
n =	0.03		
V (velocity)	0.35	ft/sec	
Drainage Area (acres) =	0.39	acres	
C (Coefficient of Runoff) =	0.3		
I =	0.11		
Q = CiA	0.013	cfs	
Ditch Width =	2	ft	
Foreslope/Backslope =	4		

Depth of water in Ditch =	0.10
**in inches*	
Length of Ditch =	280

t_{open} = 0.22 hr

TOTAL TIME OF CONCENTRATION = 0.22 hr OR 13.43 minutes

Time of Concentration - Pre Conditions Subarea B Left Ditch #3

Overland (Sheet Flow) Time of Concentration

to =	**0.03**	**hr**	OR 1.51 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.4
L (Sheet flow Length)	125
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.096

Shallow Time of Concentration

			Depth	Manning's n	Velocity
Flow Type	Minimum tillage cultivation, contour or strip-cropped, and woodlands		0.2	0.101	Use Figure 15-4 to determine Velocity
Slope	0.0267	ft/ft			
Velocity from Chart	0.7	ft/s			
Length	150	ft			
t =	**0.06**	**hr**		3.57 minutes	

t_{open} =	**0.00**	**hr**

TOTAL TIME OF CONCENTRATION =	**0.08**	**hr**
	OR	
	5.08	**minutes**

Time of Concentration - Post Conditions Subarea B Left Ditch #3

Overland (Sheet Flow) Time of Concentration

to =	**0.00**	**hr**	OR 0.08 minutes

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where,

n (Manning's roughness coefficient)	0.03
L (Sheet flow Length)	16
P_2 (2yr, 24hr rainfall, inches)	2.63
S (slope of land surface, ft/ft)	0.0156

Open Channel Flow

			Calc Check
Area =	0.02	ft^2	*0.02*
Radius =	0.01	ft	*0.01*
Slope(ft/ft) =	0.06		
n =	0.03		
V (velocity)	0.59	ft/sec	
Drainage Area (acres) =	0.71	acres	
C (Coefficient of Runoff) =	0.3		
I =	0.11		
Q = CiA	0.023	cfs	
Ditch Width =	2	ft	
Foreslope/Backslope =	4		

Depth of water in Ditch = 0.13 **in inches*

Length of Ditch = 275

t_{open} = 0.13 hr

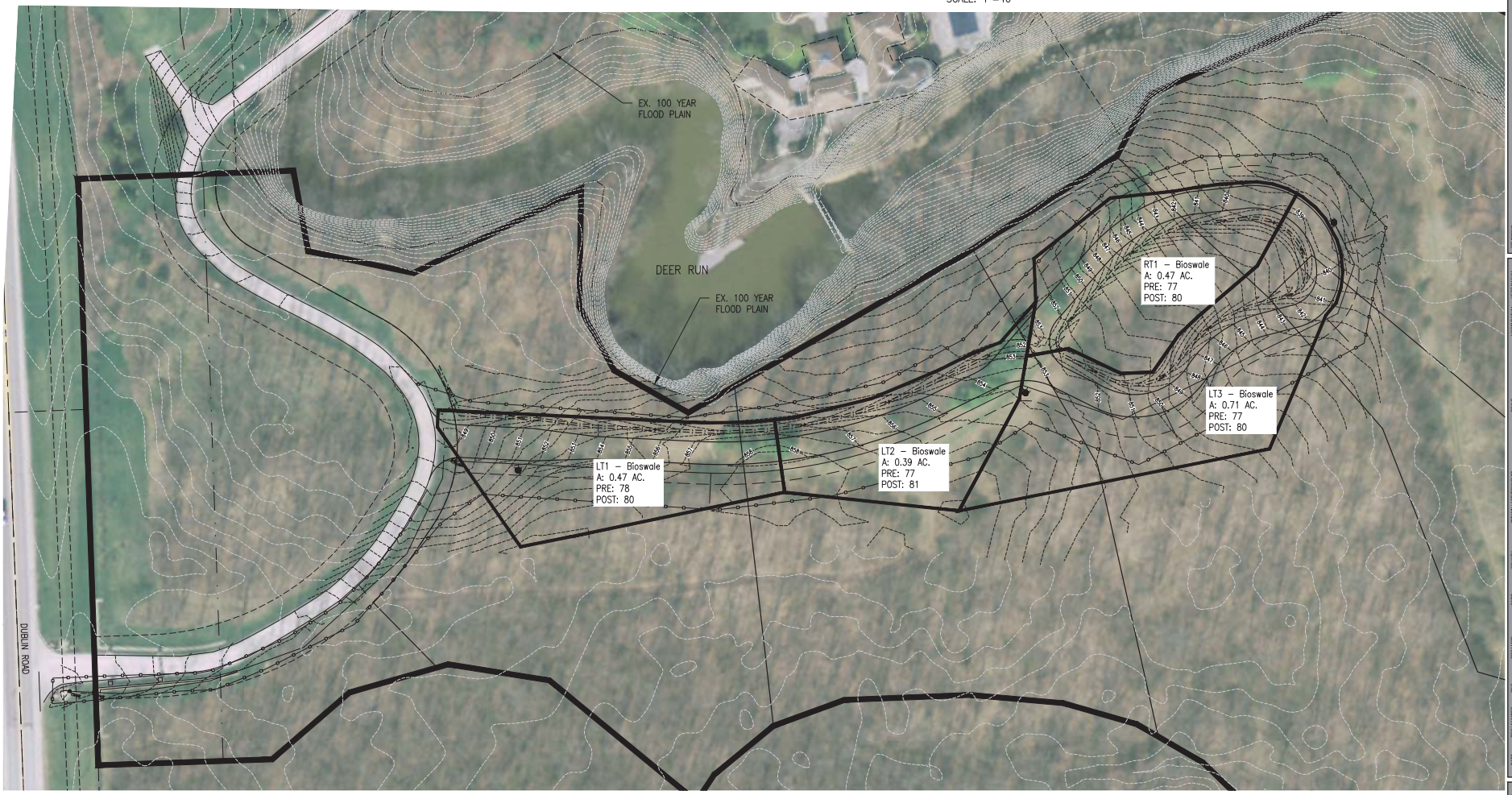
TOTAL TIME OF CONCENTRATION = 0.13 hr OR 7.89 minutes

Appendix E

Exhibits

SUBAREA B

SCALE: 1"=40'



N

0 40 80 FEET

OHM
ARCHITECTS ENGINEERS PLANNERS
580 North Fourth Street, SUITE 630
Columbus, Ohio 43215
P (614) 416-5921 | F (614) 418-0514
OHM-ADVISORS.COM

REVISIONS
01/04/2016 - REVISIONS PER CITY OF DUBLIN COMMENTS

DEER RUN LAND, LLC
DEER RUN - SUBAREA B FINAL DEVELOPMENT PLAN

EXHIBIT 2 - DRAINAGE MAP

SHEET 1 OF 1

COPYRIGHT 2015 OHM ALL DRAWINGS AND WRITTEN MATERIALS APPEARING HEREIN CONSTITUTE THE ORIGINAL AND UNPUBLISHED WORK OF OHM AND THE SAME MAY NOT BE DUPLICATED, DISTRIBUTED, OR USED OTHERWISE WITHOUT PRIOR WRITTEN CONSENT OF OHM

DRAWING PATH: C:\Users\dickley\Desktop\Deer Run\6481550RD_B - Drainage Mapdwg Jul 06, 2016 - 11:19am