NC2 Ash Disposal Area

Run-on and Run-off Control System Plan

Omaha Public Power District

Nebraska City Station

Nebraska City, Nebraska

October 17, 2016

OPPD NC2 Ash Disposal Area
Run-On and Run-Off Control System Plan

Table of Contents

Appendices

OPPD NC2 Ash Disposal Area
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Professional Engineer Certification

"I hereby certify that this Run-on and Run-off Control System Plan for the CCR landfill known as the NC2 Ash Disposal Area at the Nebraska City Generating Station, owned and operated by the Omaha Public Power District, meets the requirements of the Coal Combustion Residual Rule 40 CFR 257.81. I am a duly licensed Professional Engineer under the laws of the State of Nebraska."

Print Name: Garrett M. Williams

Signature:

Date: October 17, 2016

License #: E-15124

My license renewal date is December 31, 2016.

I. Introduction

A. Purpose

On April 17, 2015 the U.S. Environmental Protection Agency (EPA) published the final rule for the regulation and management of coal combustion residuals (CCR) under the Resource Conservation and Recovery Act (RCRA). Section 40 CFR 257.81 requires that an owner or operator of a CCR landfill must prepare an initial run-on and run-off control system plan. The plan must document how the control systems have been designed and constructed to meet the applicable requirements of the CCR rule, supported by appropriate engineering calculations. In accordance with the CCR rule 40 CFR 257.81, the intent of stormwater management is to design, construct, operate, and maintain:

- A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and
- A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm. Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under 40 CFR 257.3-3.

B. Facility Background

OPPD has a two-unit (Unit 1 and Unit 2) fossil fuel-fired generating plant at the Nebraska City Station (Station) located 5.5 miles southeast of Nebraska City, Nebraska, along the west shore of the Missouri River. This Station has two (2) existing CCR landfills that are permitted under the current Nebraska Department of Environmental Quality (NDEQ) Title 132 regulations for fossil fuel combustion ash disposal area; the NC1 Ash Disposal Area and NC2 Ash Disposal Area. This initial run-on and run-off control system plan is for the NC2 Ash Disposal Area (NDEQ Permit No. NE0204421, Facility ID 58343). Under the CCR rule, the NC2 Ash Disposal Area is an existing CCR landfill since it has and will receive CCR both before and after October 19, 2015 – the effective date of the CCR rule.

The NC2 Ash Disposal Area is an existing CCR landfill with a composite liner and leachate collection system, containing approximately 40.7 acres permitted disposal area. Cell 1 (approximately 14.4 acres) began accepting CCR in July 2009. Notification to the NDEQ and construction on NC2 Ash Disposal Area Cells 2 and 3 began prior to October 19, 2015.

The NDEQ Title 132 permit for the NC2 Ash Disposal Area also includes descriptions, calculations and figures of run-on and run-off control system features. This plan checks, expands and confirms compliance with the CCR rule for run-on and run-off controls from the active areas of the NC2 Ash Disposal Area.

II. Run-On Control System

The run-on control system for the NC2 Ash Disposal Area consists of perimeter berm roads, ditches and grading sloped away from the CCR landfill to prevent stormwater run-on. As shown on the drawing in Appendix B, run-on to the NC2 Ash Disposal Area is prevented on the east, south and west sides by constructed berms and roadways. Along the north side, potential run-on would come from the railroad loop embankment. Perimeter ditches intercept, divert and prevent potential storm water run-on to the NC2 Ash Disposal Area. Calculations confirming the ditch and culvert capacities are included in Appendix A.

III. Run-Off Control System

The run-off control system for the NC2 Ash Disposal Area consists of interior collection channels, culverts and leachate retention pond. When ash elevations in the Cell(s) reach the perimeter road berms elevation, an interior perimeter drainage ditch within the disposal area, appropriately sized, will be constructed at the edge of the CCR to collect and control the storm water run-off from the active portions of the NC2 Ash Disposal Area. These temporary interior channels will be constructed within the CCR disposal area footprint and will be graded to gravity drain storm water run-off through constructed culverts to the leachate retention pond. The CCR fill within the NC2 Ash Disposal Area has been and will be graded to facilitate surface water run-off towards the interior channels.

The side-slopes of the Cell(s) are planned to be constructed no steeper than 3 horizontal to 1 vertical grade. Run-off from the NC2 Ash Disposal Area side-slopes will be conveyed via an interior collection channel that will direct the water to the discharge point. Storm water will be generated from two sub-basin areas as shown in the drawing in Appendix B. Sub-basin 1 will generally consist of the stormwater runoff from the north side-slope that is captured by the interior northern perimeter channel. Sub-basin 2 will generally consist of the stormwater runoff from the west side-slope, also collected in an interior perimeter channel. Sub-basin 1 will be directed into the Sub-basin 2 perimeter channel. Storm water collected in the interior perimeter channels eventually flows south into the leachate pond via three 24-inch HDPE culverts. The three HDPE culverts are approximately 46-feet in length and have an inlet invert elevation of 917.0 ft.

The remainder of the surface runoff consists of runoff from the Cells, and the eastern and southern side-slopes. The runoff from these areas will flow generally in the southern direction and will discharge into the leachate pond via three additional 24-inch HDPE culverts.

The contributing volume of runoff was modeled for a 25-year, 24-hour storm event. The Rainfall depths were obtained from NOAA Atlas 14. The results of the hydrologic modeling, with a sub-basin schematic, are found in Appendix B.

The interior collection channels were also sized to convey runoff for a 25-year, 24-hour storm event. The north collection channel was sized to convey runoff from Sub-basin 1 and the west collection channel was sized to contain runoff from both Sub-basin 1 and Sub-basin 2. Both channels will have bottom width of 2-feet, be graded at minimum slope of 0.5% and have a depth of 2.5-feet. The bottom width and depth of the channel will be consistent along the length of both channels. The channel side-slope towards the interior of the cell will be 1.5 horizontal to 1 vertical up to the intersection with the CCR fill side-slope of 3 horizontal to 1 vertical. The channel side-slope towards the outer perimeter of the cell is planned to be constructed at 3 horizontal to 1 vertical.

The south collection channel was sized to convey runoff from Sub-basin 3a, Sub-basin 4a and Sub-basin 4b to multiple culverts which drain to the leachate pond. The channel will have bottom width of 2-feet, graded to a minimum 0.5% slope and depth of 3 feet. The area in front of the culvert inlets will have a constructed pad to facilitate clean-out of settled CCR sediment.

Calculations checking the capacity of the interior channels are included in Appendix C.

The leachate retention pond located south of Cell 3 is being constructed as part of Cells 2 and 3 liner construction. This leachate retention pond is sized to adequately contain surface water run-off, leachate, and storm water from the 25-year, 24-hour storm event. The leachate retention pond has a capacity of approximately 735,000 cubic feet. In order to contain run-off for the 25-year, 24-hour storm event and provide 1-foot of freeboard, the pond water surface elevation must be maintained at 912.2 feet or lower. The pond has a bottom elevation of 911.0 feet with 1-foot of riprap and a top elevation of 919.0 feet. The pond has side-slopes at a 3 horizontal to 1 vertical grade.

Contact water generated from the 25-year, 24-hour storm (and lesser storms) will be collected, controlled and conveyed to the leachate retention pond for management in accordance with existing surface water requirements of the Station's National Pollution Discharge Elimination System (NPDES) permit.

Calculations, figures and management of stormwater run-off from the active portion of the NC2 Ash Disposal Area are contained in Appendices B and C of this plan.

Appendix A
Stormwater Run-On Calculations

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Aug 23 2016

North Culvert

Invert Elev Dn (ft)	=	923.11
Pipe Length (ft)	=	84.13
Slope (%)	=	-2.51
Invert Elev Up (ft)	=	921.00
Rise (in)	=	30.0
Shape	=	Circular
Span (in)	=	30.0
No. Barrels	=	2
n-Value	=	0.012
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

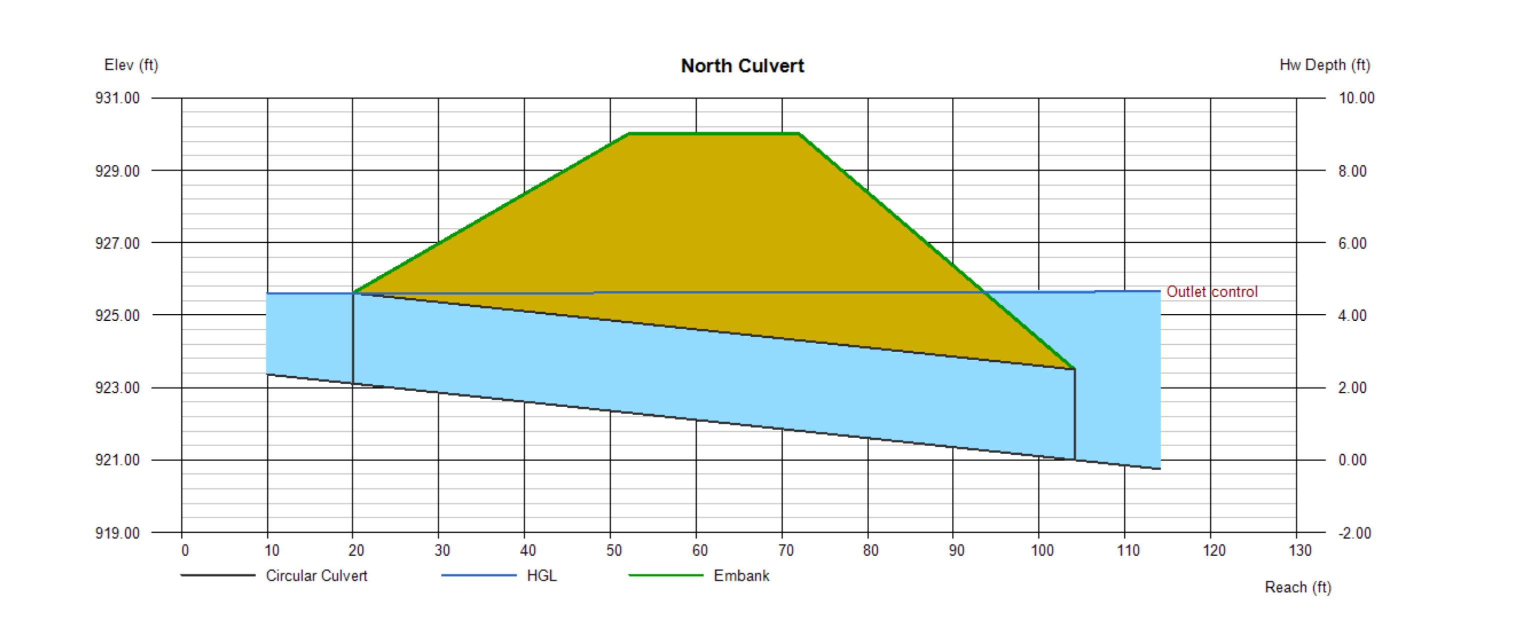
Top Elevation (ft)	=	930.00
Top Width (ft)	=	20.00
Crest Width (ft)	=	40.00

Calculations

Qmin (cfs)	=	0.00
Qmax (cfs)	=	15.00
Tailwater Elev (ft)	=	Normal

Highlighted

Qtotal (cfs)	=	13.00
Qpipe (cfs)	=	13.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	1.32
Veloc Up (ft/s)	=	1.32
HGL Dn (ft)	=	925.61
HGL Up (ft)	=	925.63
Hw Elev (ft)	=	925.67
Hw/D (ft)	=	1.87
Flow Regime	=	Outlet Control



Culvert Report

West Culvert

Invert Elev Dn (ft)	=	914.00
Pipe Length (ft)	=	70.00
Slope (%)	=	-1.43
Invert Elev Up (ft)	=	913.00
Rise (in)	=	30.0
Shape	=	Circular
Span (in)	=	30.0
No. Barrels	=	2
n-Value	=	0.012
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

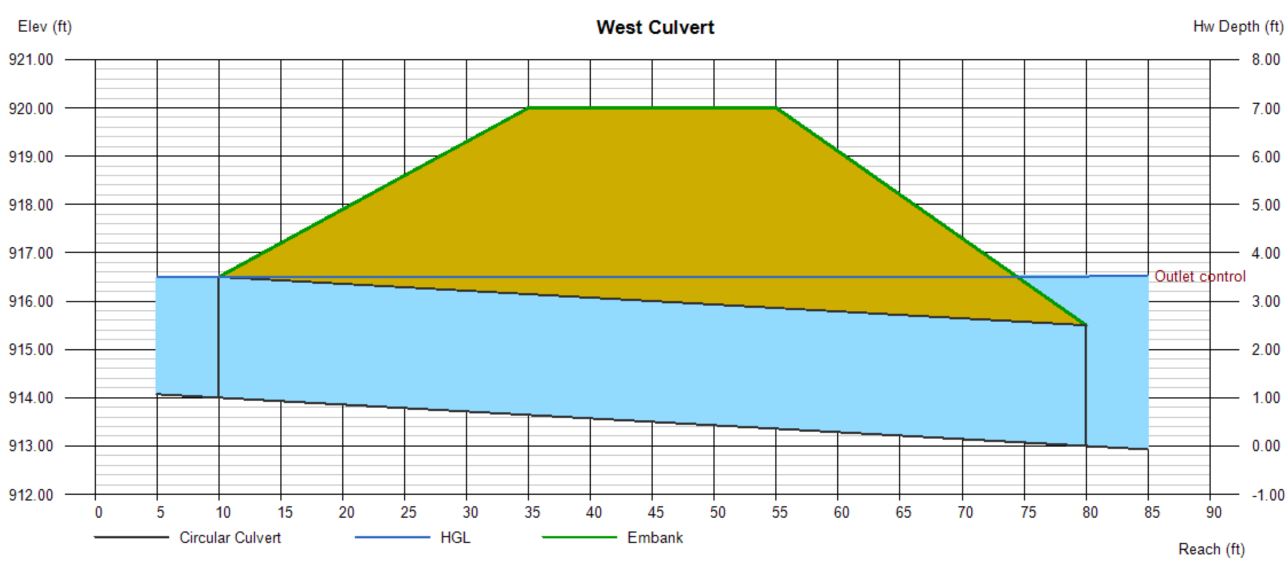
Top Elevation (ft)	=	920.00
Top Width (ft)	=	20.00
Crest Width (ft)	=	50.00

Calculations

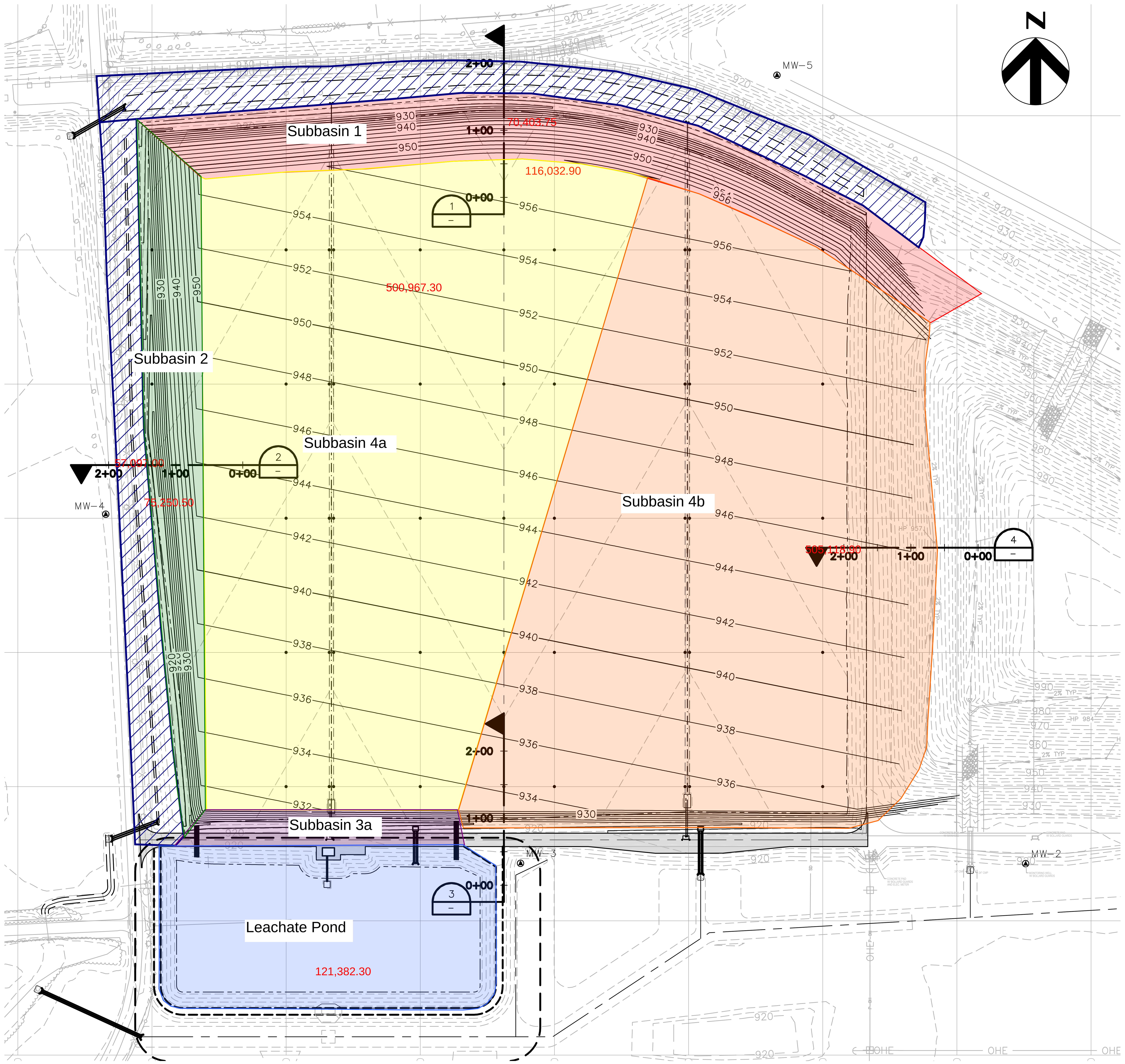
Qmin (cfs)	=	0.00
Qmax (cfs)	=	15.00
Tailwater Elev (ft)	=	Normal

Highlighted

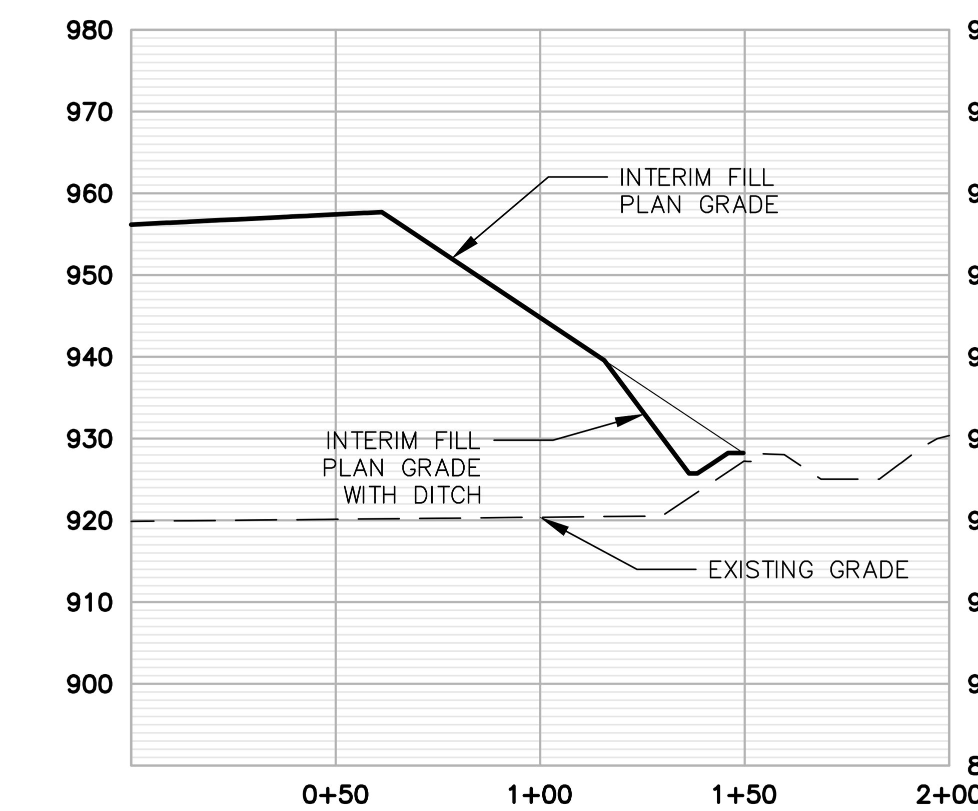
Qtotal (cfs)	=	10.00
Qpipe (cfs)	=	10.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	1.02
Veloc Up (ft/s)	=	1.02
HGL Dn (ft)	=	916.50
HGL Up (ft)	=	916.51
Hw Elev (ft)	=	916.53
Hw/D (ft)	=	1.41
Flow Regime	=	Outlet Control



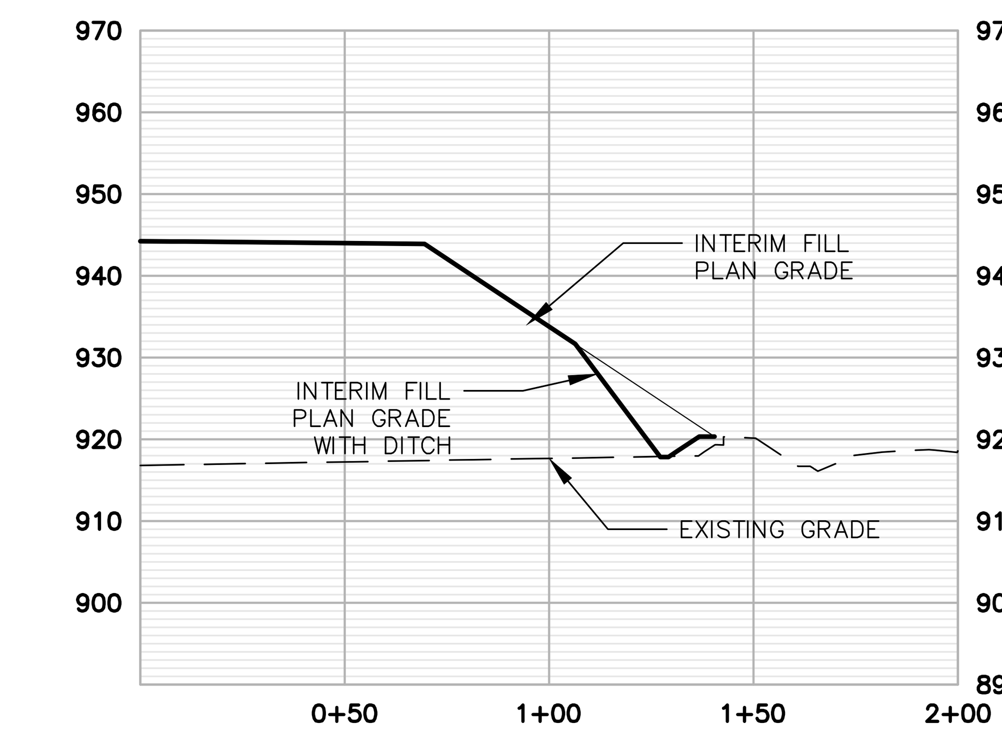
Appendix B
Stormwater Run-Off Calculations and Figure



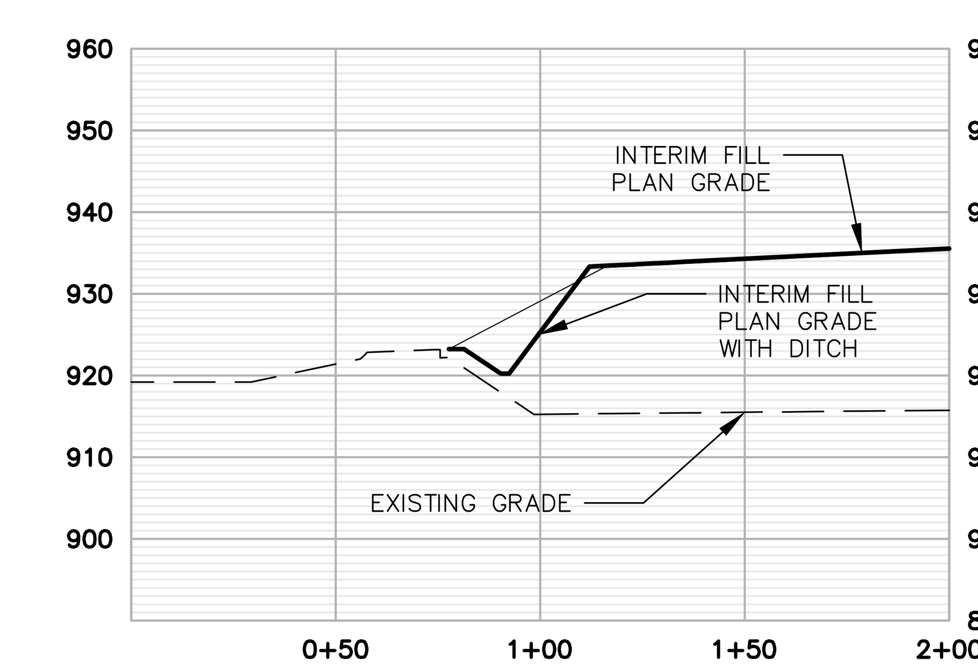
INTERIM FILL PLAN #1 – TOP OF COVER GRADES
1" = 100'



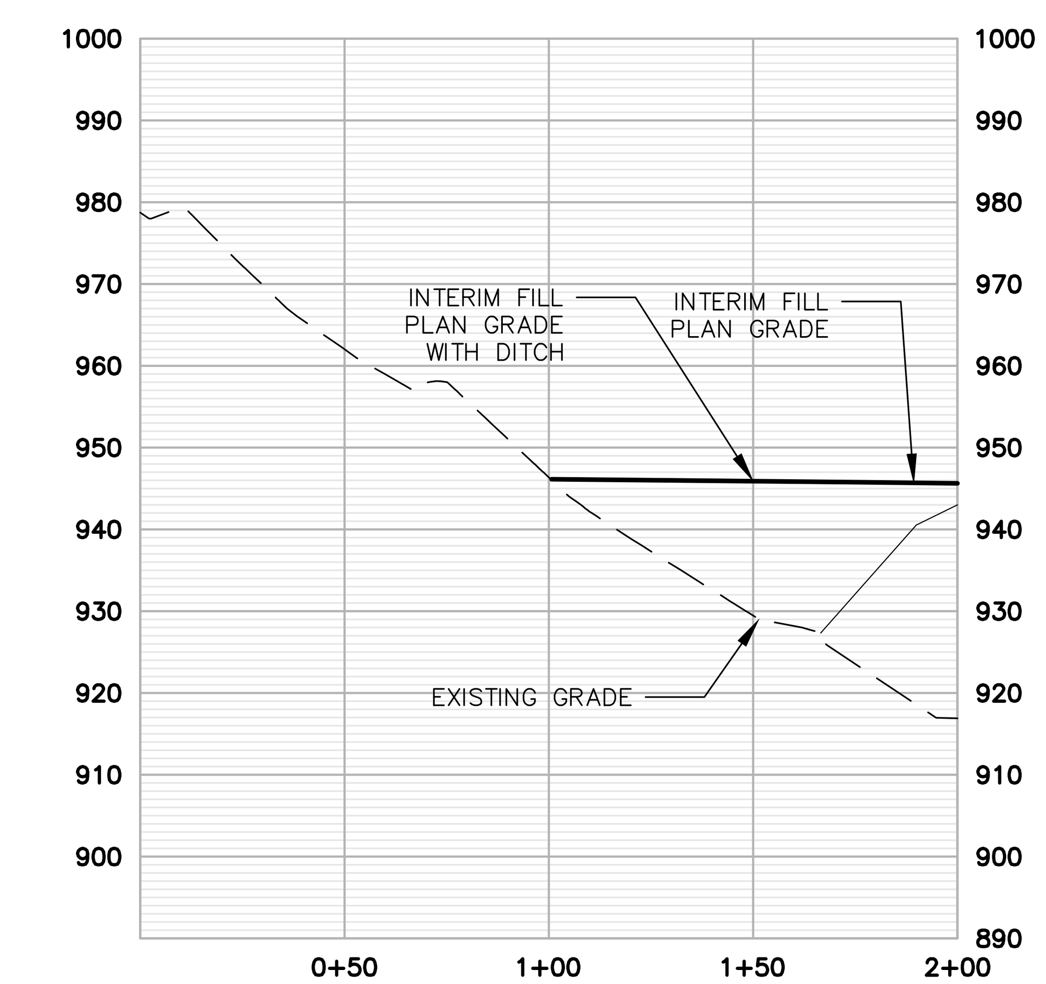
CROSS SECTION – NORTH
1" = 40' HORIZONTAL
1" = 20' VERTICAL



CROSS SECTION – WEST
1" = 40' HORIZONTAL
1" = 20' VERTICAL



CROSS SECTION – SOUTH
1" = 40' HORIZONTAL
1" = 20' VERTICAL



CROSS SECTION – EAST
1" = 40' HORIZONTAL
1" = 20' VERTICAL

HDR

		PROJECT MANAGER	G. WILLIAMS
		CIVIL	G. WILLIAMS
0			
ISSUE	DATE	DESCRIPTION	
		PROJECT NUMBER	10028555

OPPD
Omaha Public Power District
OPPD Nebraska City Station Unit 2
Ash Landfill Expansion

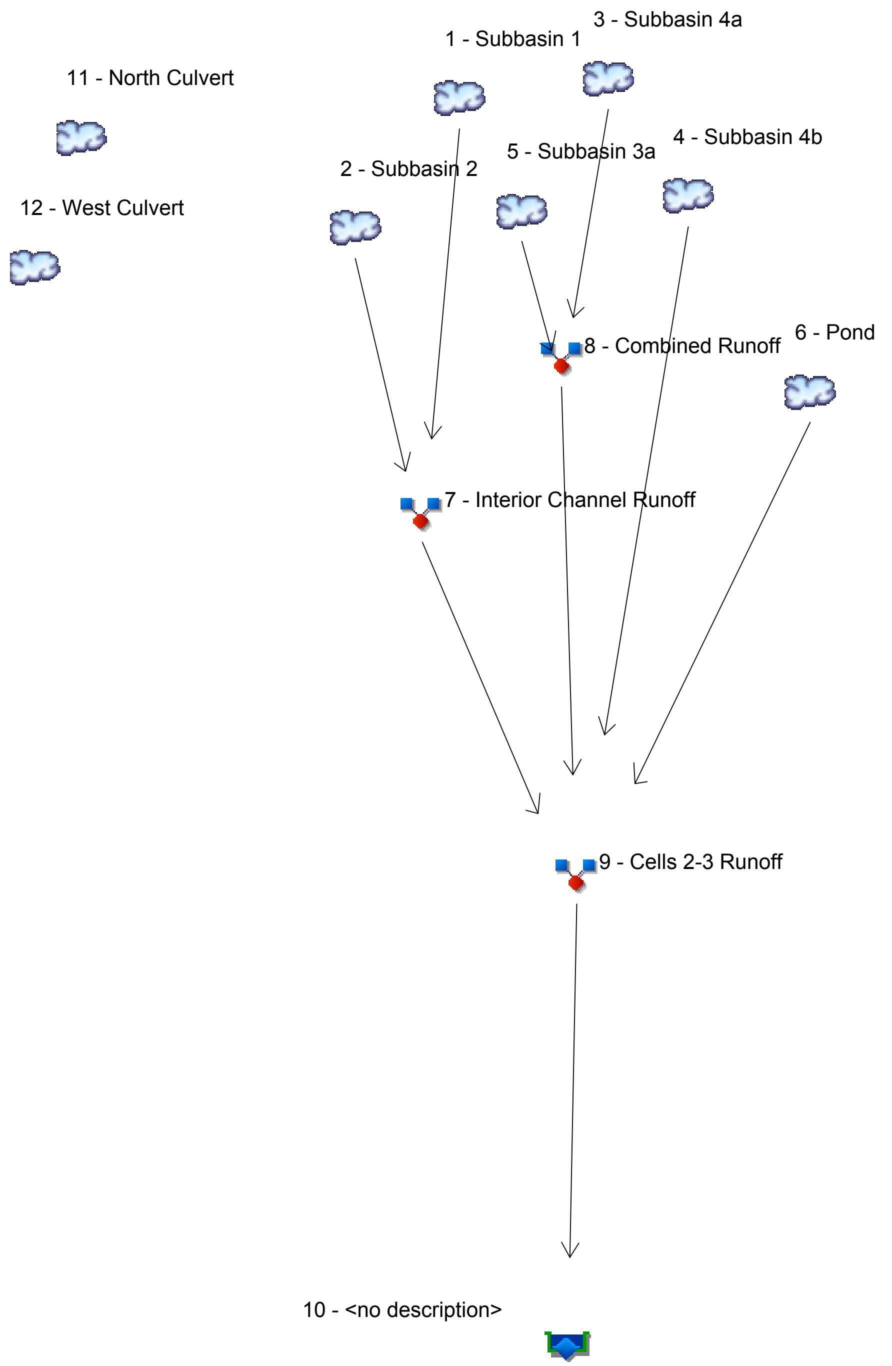
CELLS 2 AND 3 LINER
INTERIM FILL PLAN #1
PLAN AND CROSS-SECTIONS

0 1" 2"

FILENAME #1A.3 Plan.dwg
SCALE AS SHOWN
SHEET 1

Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3



Project: NC_Runoff-SMW Updated.gpw	Tuesday, 08 / 23 / 2016

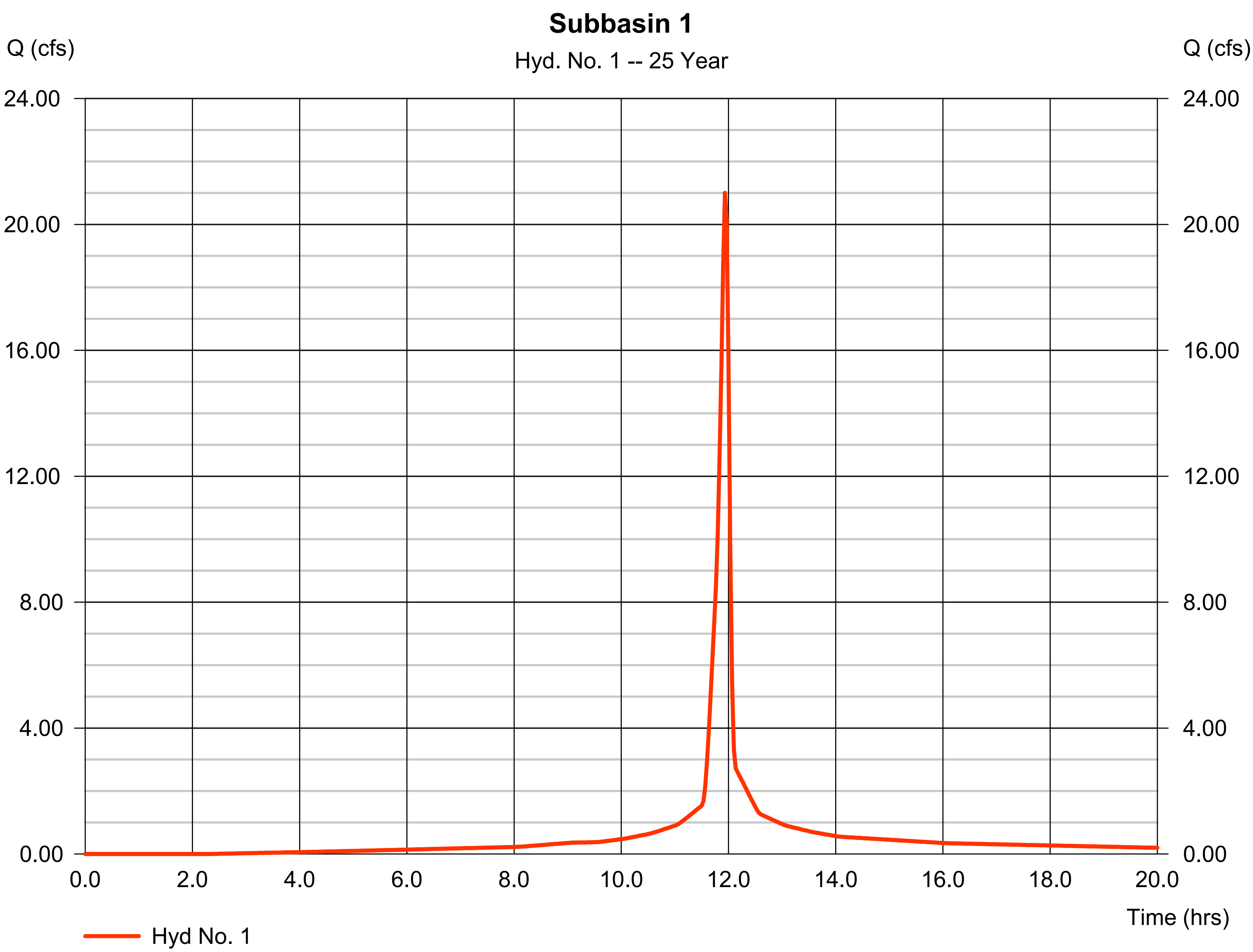
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 — Tuesday, 08 / 23 / 2016

Hyd. No. 1

Subbasin 1

Hydrograph type	= SCS Runoff	Peak discharge	= 21.00 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 47,093 cuft
Drainage area	= 2.660 ac	Curve number	= 93
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



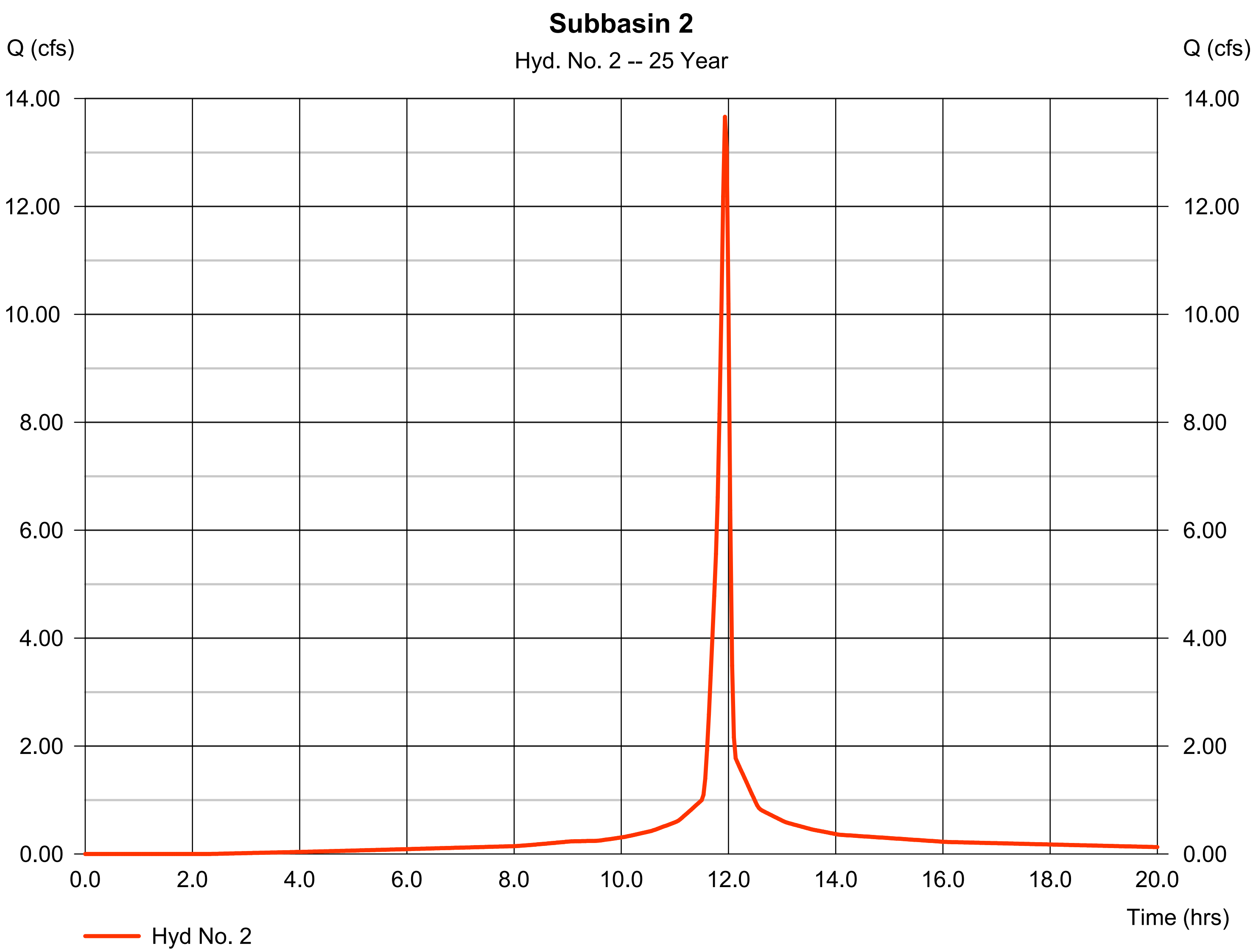
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 — Tuesday, 08 / 23 / 2016

Hyd. No. 2

Subbasin 2

Hydrograph type	= SCS Runoff	Peak discharge	= 13.66 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 30,628 cuft
Drainage area	= 1.730 ac	Curve number	= 93
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



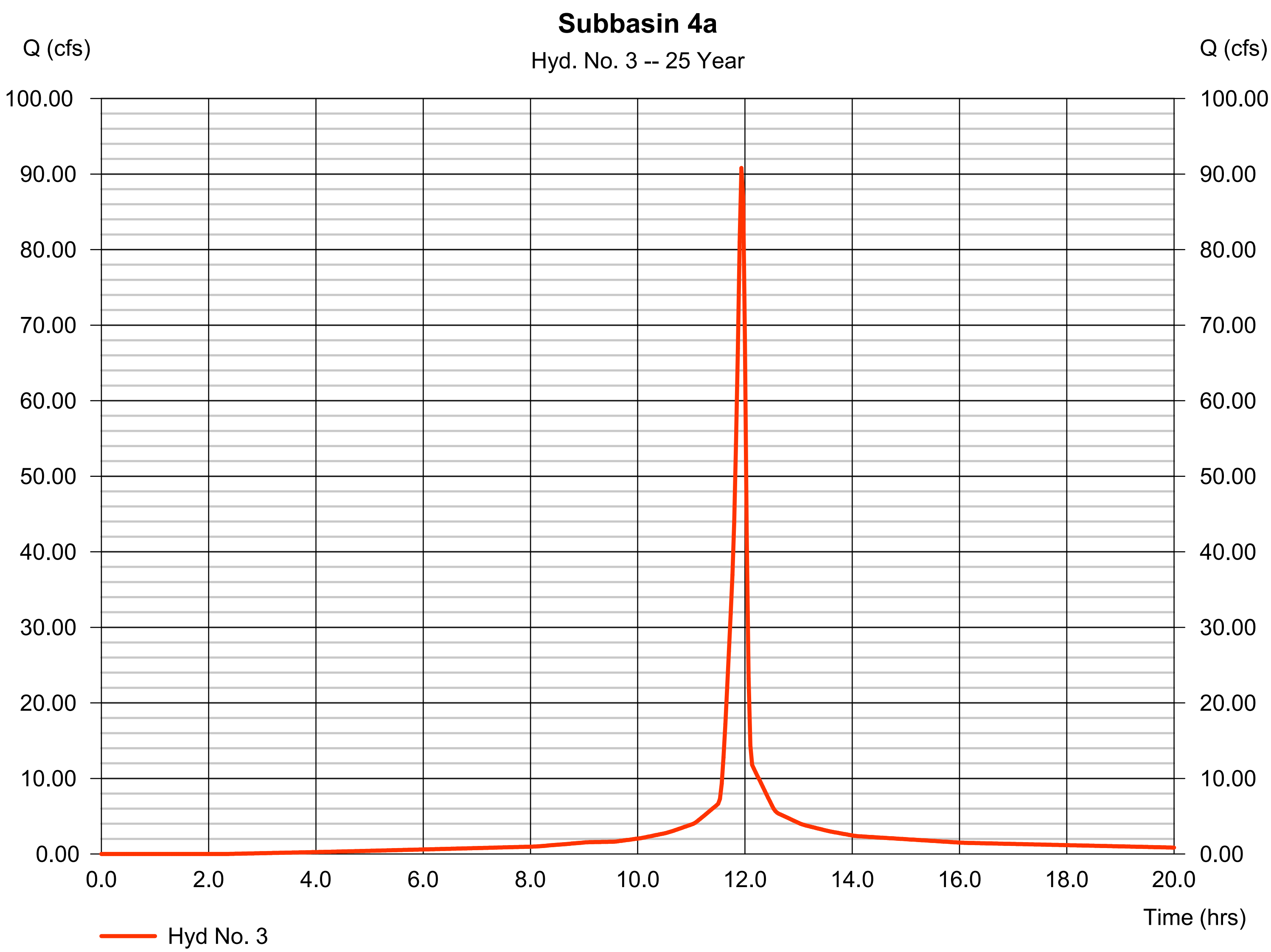
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 Tuesday, 08 / 23 / 2016

Hyd. No. 3

Subbasin 4a

Hydrograph type	= SCS Runoff	Peak discharge	= 90.80 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 203,598 cuft
Drainage area	= 11.500 ac	Curve number	= 93
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



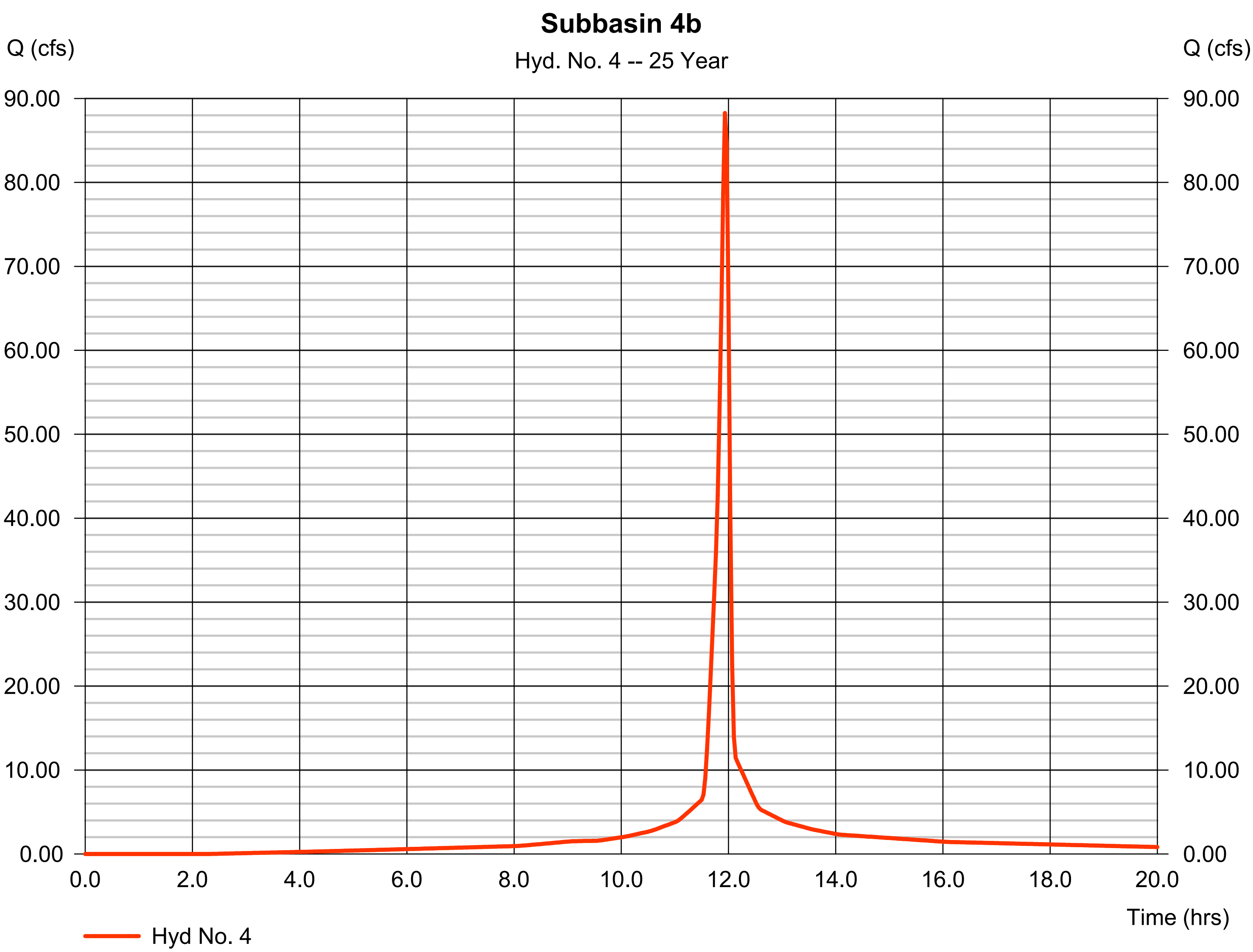
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 Tuesday, 08 / 23 / 2016

Hyd. No. 4

Subbasin 4b

Hydrograph type	= SCS Runoff	Peak discharge	= 88.27 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 197,932 cuft
Drainage area	= 11.180 ac	Curve number	= 93
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

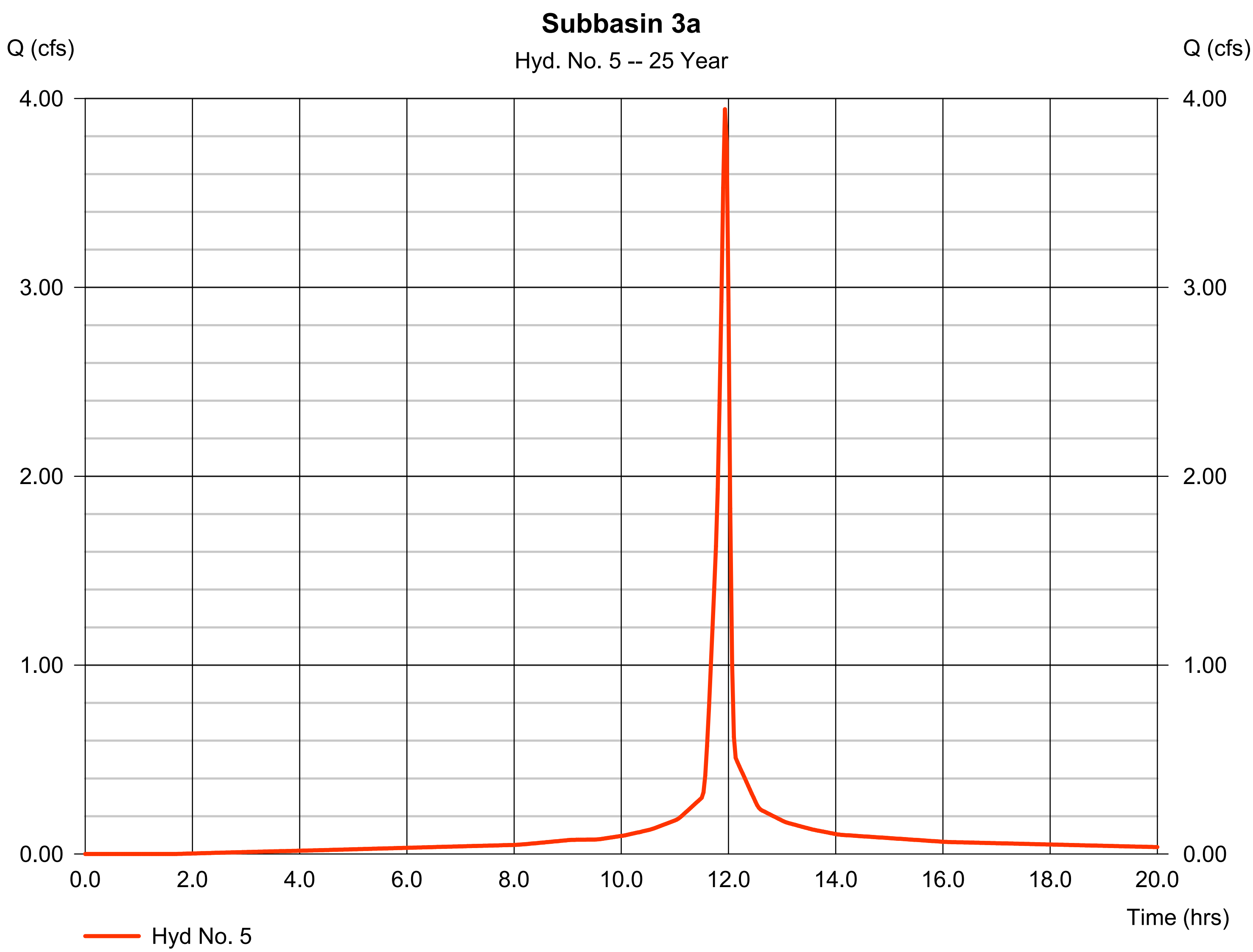


Hydrograph Report

Hyd. No. 5

Subbasin 3a

Hydrograph type	= SCS Runoff	Peak discharge	= 3.943 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 9,057 cuft
Drainage area	= 0.490 ac	Curve number	= 95
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

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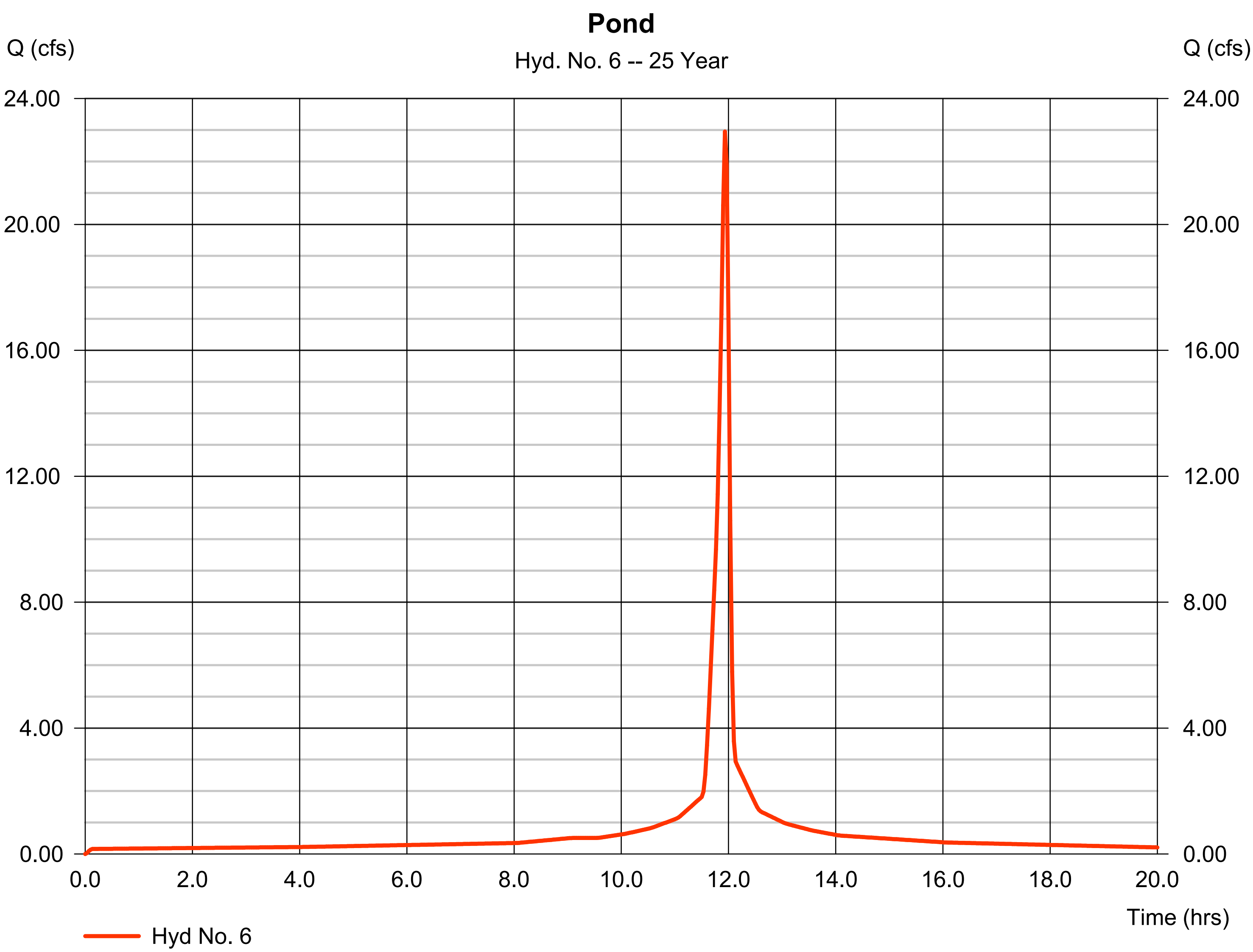
Hyd. No. 6

Pond

Hydrograph type	= SCS Runoff	Peak discharge	= 22.95 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 57,158 cuft
Drainage area	= 2.790 ac	Curve number	= 100
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



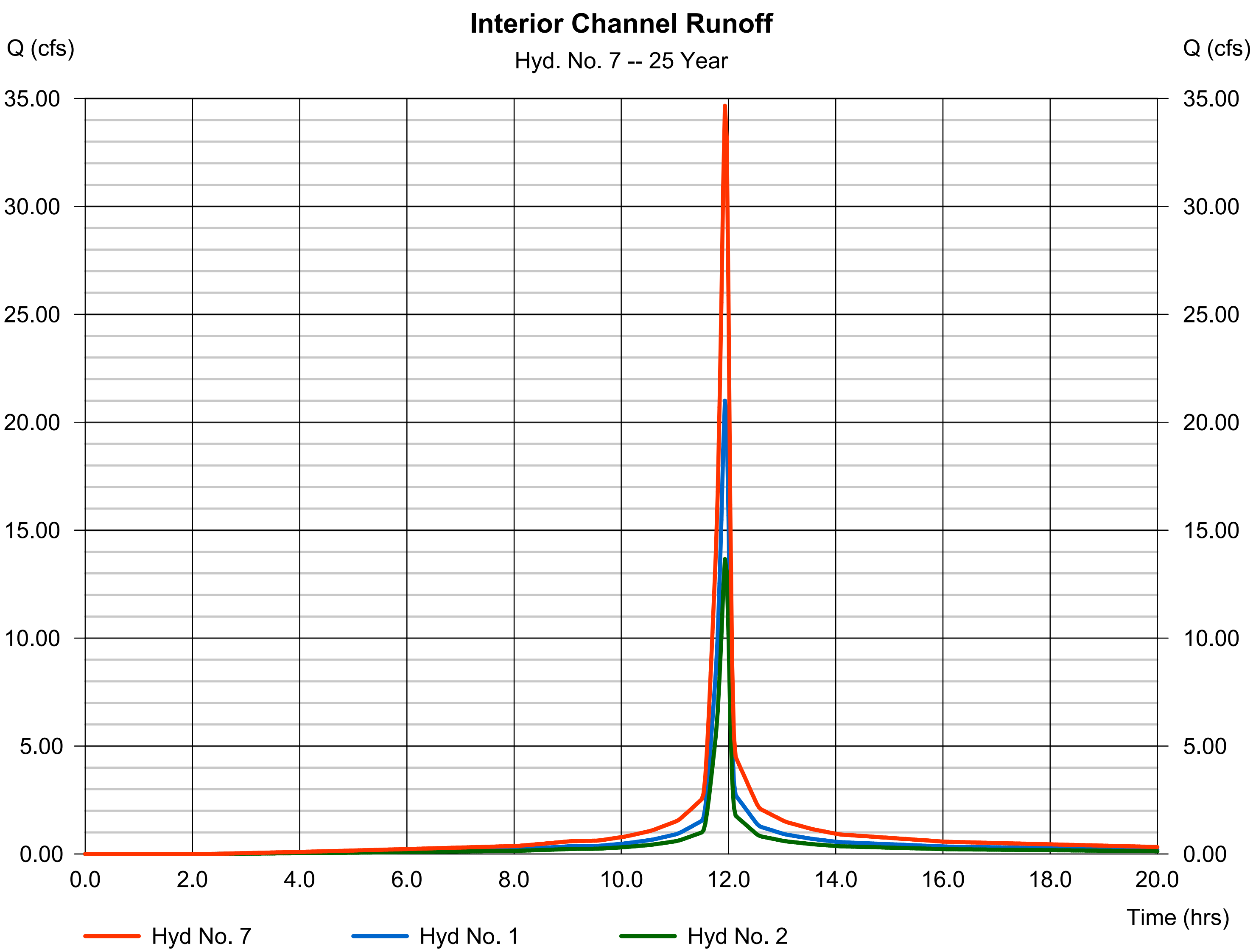
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 Tuesday, 08 / 23 / 2016

Hyd. No. 7

Interior Channel Runoff

Hydrograph type	= Combine	Peak discharge	= 34.66 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 77,721 cuft
Inflow hyds.	= 1, 2	Contrib. drain. area	= 4.390 ac



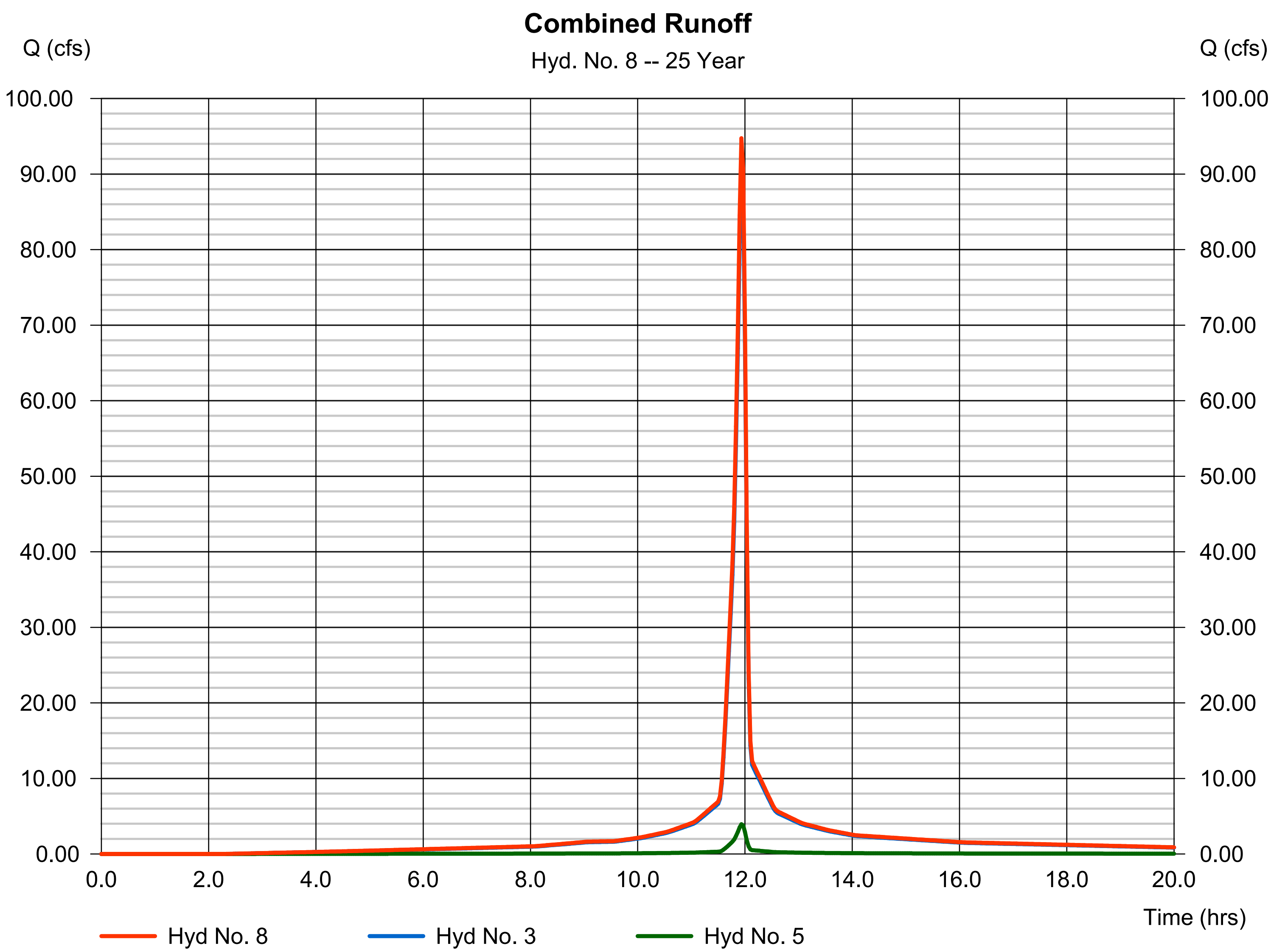
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 Tuesday, 08 / 23 / 2016

Hyd. No. 8

Combined Runoff

Hydrograph type	= Combine	Peak discharge	= 94.74 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 212,655 cuft
Inflow hyds.	= 3, 5	Contrib. drain. area	= 11.990 ac



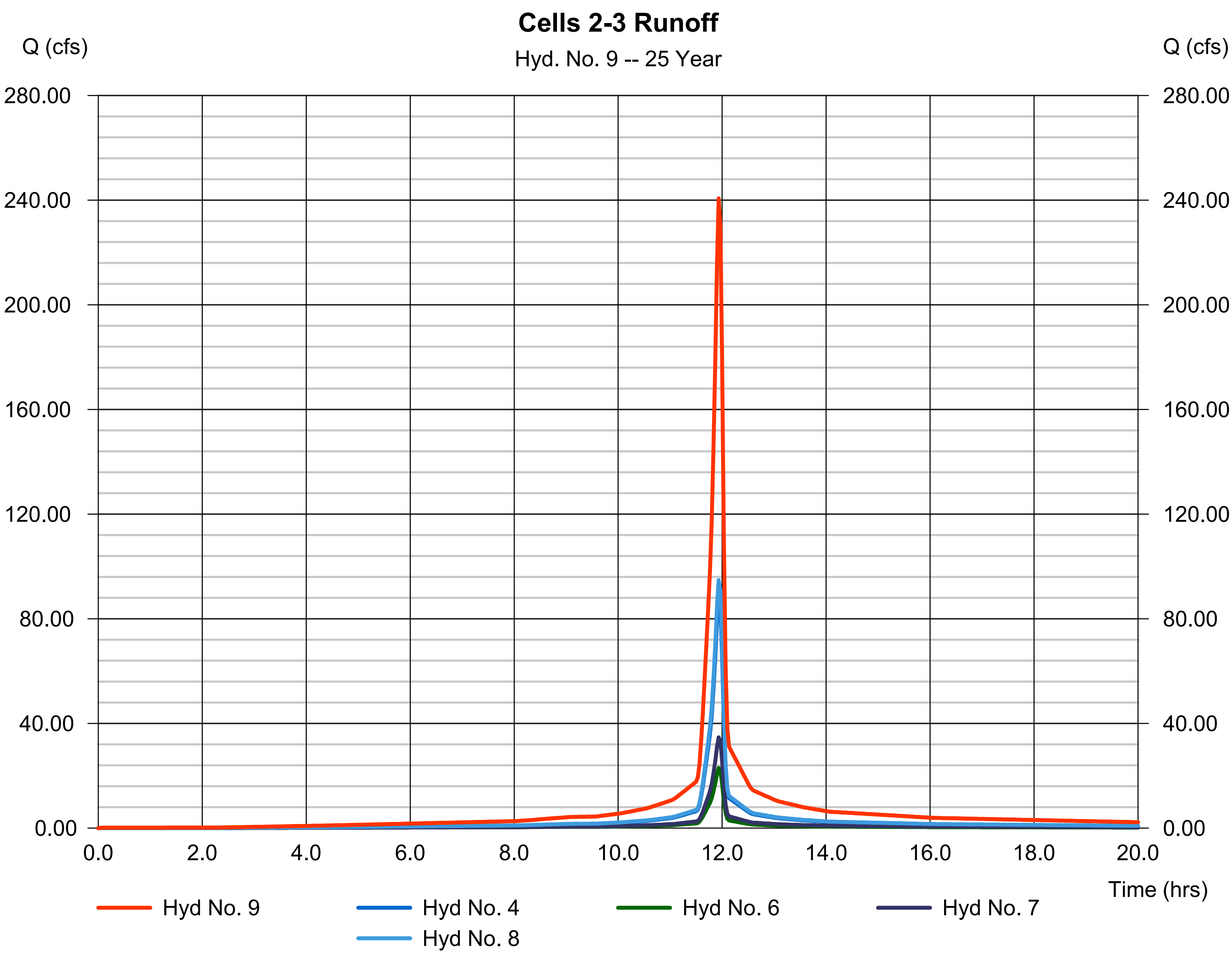
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 Tuesday, 08 / 23 / 2016

Hyd. No. 9

Cells 2-3 Runoff

Hydrograph type	= Combine	Peak discharge	= 240.63 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 545,467 cuft
Inflow hyds.	= 4, 6, 7, 8	Contrib. drain. area	= 13.970 ac



Hydrograph Report

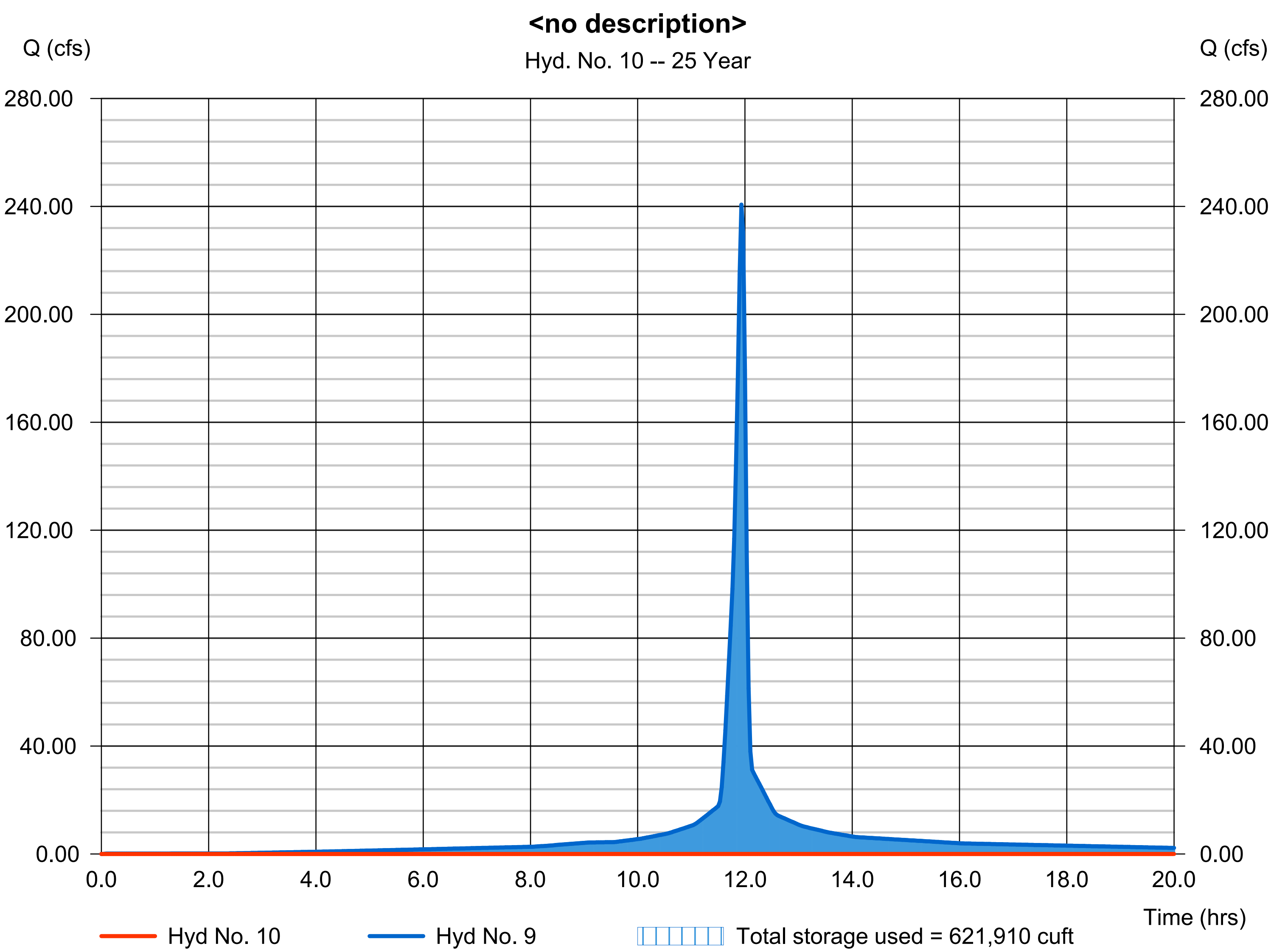
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 Tuesday, 08 / 23 / 2016

Hyd. No. 10

<no description>

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 25 yrs	Time to peak	= n/a
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 9 - Cells 2-3 Runoff	Max. Elevation	= 917.95 ft
Reservoir name	= Permit West Pond	Max. Storage	= 621,910 cuft

Storage Indication method used. Wet pond routing start elevation = 912.20 ft.



Pond Report

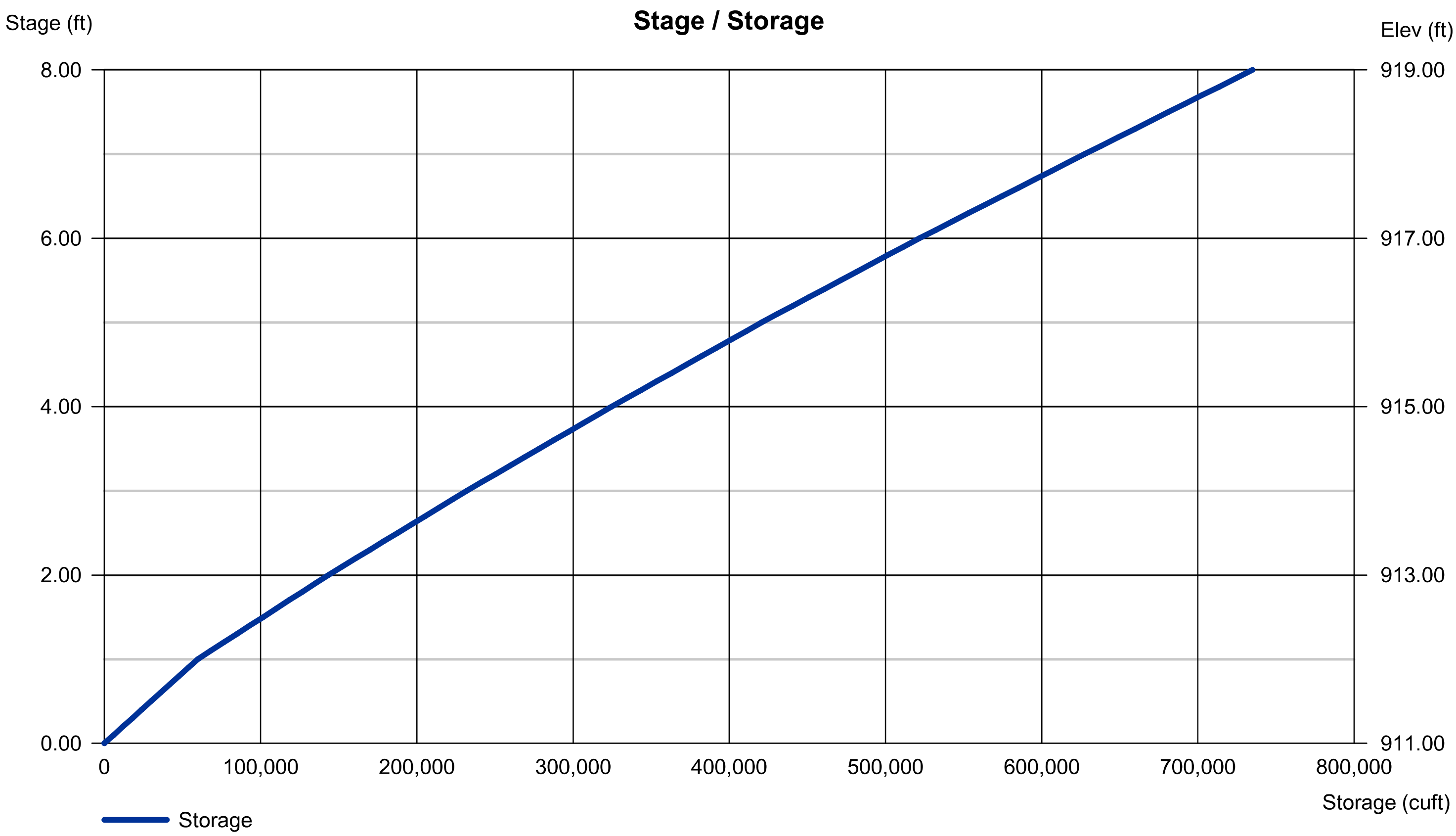
Pond No. 1 - Permit West Pond

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 911.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	911.00	40,000	0	0
1.00	912.00	81,891	59,702	59,702
2.00	913.00	85,549	83,705	143,407
3.00	914.00	91,523	88,510	231,917
4.00	915.00	93,969	92,734	324,651
5.00	916.00	98,132	96,033	420,685
6.00	917.00	103,814	100,950	521,634
7.00	918.00	107,626	105,704	627,338
8.00	919.00	107,626	107,615	734,953



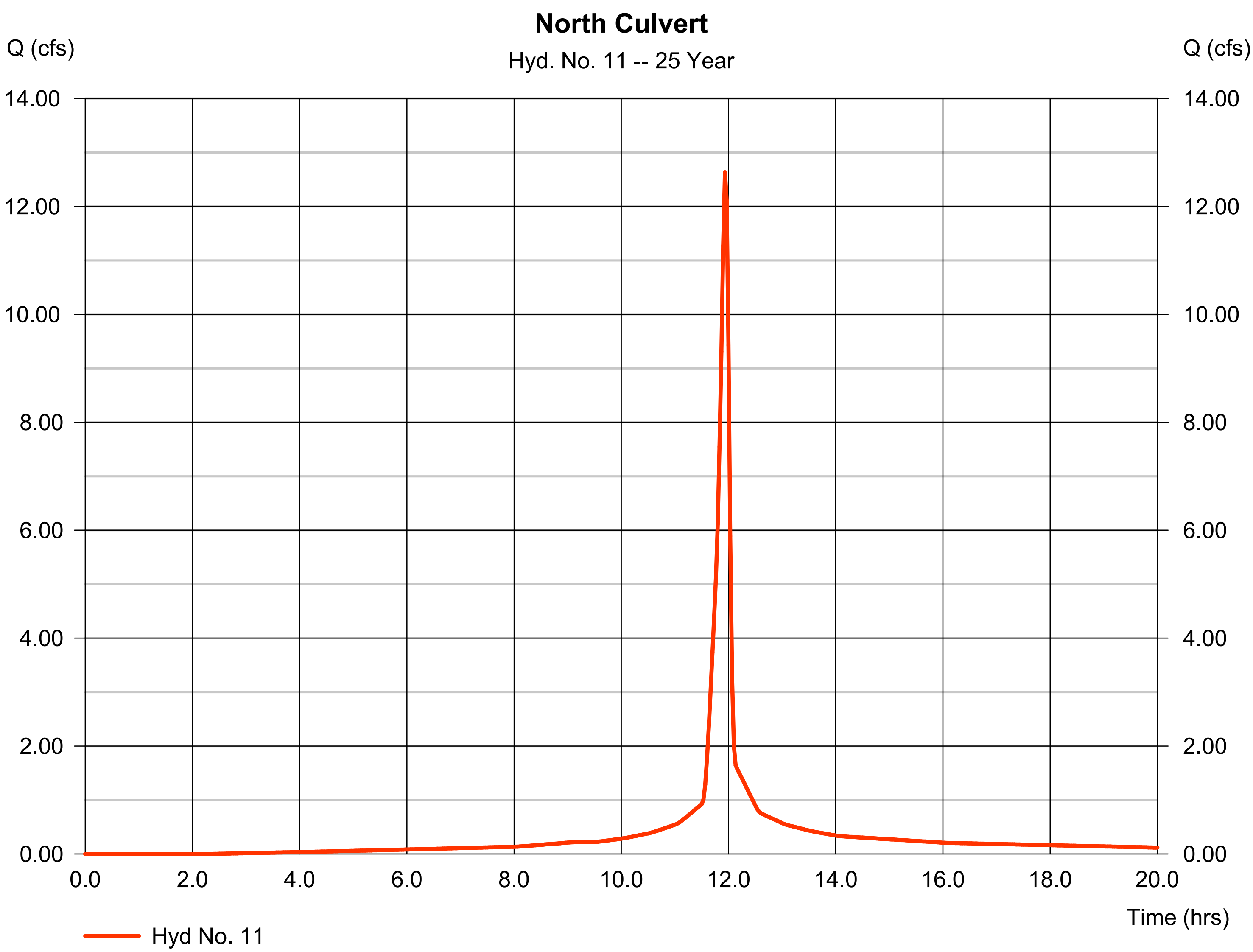
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 Tuesday, 08 / 23 / 2016

Hyd. No. 11

North Culvert

Hydrograph type	= SCS Runoff	Peak discharge	= 12.63 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 28,327 cuft
Drainage area	= 1.600 ac	Curve number	= 93
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



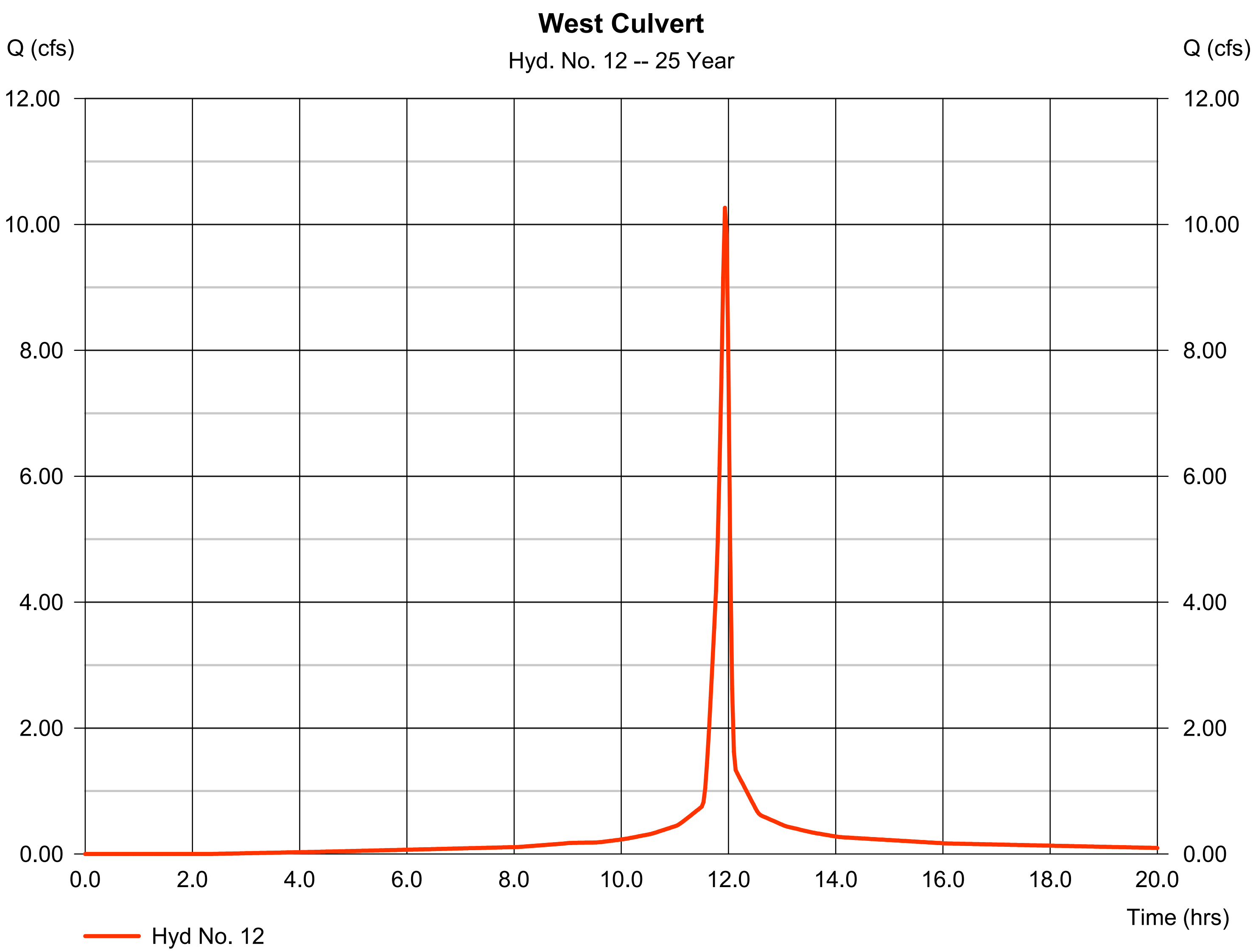
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2014 by Autodesk, Inc. v10.3 — Tuesday, 08 / 23 / 2016

Hyd. No. 12

West Culvert

Hydrograph type	= SCS Runoff	Peak discharge	= 10.26 cfs
Storm frequency	= 25 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 23,015 cuft
Drainage area	= 1.300 ac	Curve number	= 93
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 6.02 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



NOAA Atlas 14, Volume 8, Version 2
Location name: Nebraska City, Nebraska, US*
Latitude: 40.6188°, Longitude: -95.7842°
Elevation: 931 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

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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	0.405 (0.324–0.517)	0.476 (0.381–0.608)	0.595 (0.475–0.761)	0.697 (0.553–0.893)	0.841 (0.647–1.10)	0.955 (0.717–1.25)	1.07 (0.779–1.43)	1.19 (0.832–1.61)	1.36 (0.911–1.85)	1.49 (0.971–2.04)
10-min	0.593 (0.475–0.757)	0.697 (0.558–0.890)	0.872 (0.696–1.12)	1.02 (0.810–1.31)	1.23 (0.947–1.61)	1.40 (1.05–1.84)	1.57 (1.14–2.09)	1.75 (1.22–2.35)	1.99 (1.33–2.71)	2.18 (1.42–2.99)
15-min	0.723 (0.579–0.923)	0.850 (0.681–1.09)	1.06 (0.848–1.36)	1.25 (0.988–1.60)	1.50 (1.16–1.96)	1.71 (1.28–2.24)	1.91 (1.39–2.54)	2.13 (1.49–2.87)	2.43 (1.63–3.31)	2.65 (1.73–3.64)
30-min	1.02 (0.820–1.31)	1.21 (0.968–1.55)	1.52 (1.21–1.94)	1.78 (1.42–2.29)	2.16 (1.66–2.82)	2.45 (1.84–3.22)	2.75 (2.00–3.66)	3.06 (2.14–4.12)	3.49 (2.34–4.75)	3.81 (2.49–5.23)
60-min	1.33 (1.06–1.69)	1.57 (1.25–2.00)	1.98 (1.58–2.53)	2.34 (1.85–2.99)	2.86 (2.21–3.75)	3.29 (2.47–4.33)	3.73 (2.72–4.98)	4.20 (2.94–5.67)	4.86 (3.26–6.64)	5.38 (3.51–7.38)
2-hr	1.63 (1.32–2.05)	1.92 (1.55–2.42)	2.43 (1.96–3.07)	2.89 (2.31–3.65)	3.56 (2.78–4.64)	4.12 (3.14–5.38)	4.71 (3.47–6.23)	5.34 (3.77–7.16)	6.23 (4.23–8.46)	6.94 (4.58–9.45)
3-hr	1.81 (1.47–2.26)	2.13 (1.73–2.66)	2.70 (2.19–3.38)	3.22 (2.60–4.04)	4.01 (3.16–5.20)	4.67 (3.58–6.08)	5.38 (3.99–7.09)	6.15 (4.37–8.21)	7.24 (4.95–9.81)	8.13 (5.39–11.0)
6-hr	2.12 (1.74–2.61)	2.48 (2.04–3.07)	3.16 (2.59–3.91)	3.78 (3.08–4.70)	4.75 (3.79–6.11)	5.57 (4.32–7.19)	6.46 (4.84–8.44)	7.43 (5.34–9.85)	8.83 (6.10–11.9)	9.97 (6.67–13.4)
12-hr	2.43 (2.02–2.96)	2.85 (2.37–3.48)	3.62 (3.00–4.43)	4.34 (3.57–5.31)	5.43 (4.38–6.91)	6.36 (4.99–8.12)	7.37 (5.58–9.53)	8.47 (6.15–11.1)	10.0 (7.01–13.4)	11.3 (7.66–15.1)
24-hr	2.78 (2.34–3.35)	3.24 (2.72–3.90)	4.07 (3.41–4.91)	4.84 (4.03–5.86)	6.02 (4.90–7.57)	7.03 (5.56–8.86)	8.11 (6.20–10.4)	9.29 (6.81–12.1)	11.0 (7.73–14.5)	12.4 (8.43–16.3)
2-day	3.21 (2.72–3.81)	3.69 (3.13–4.38)	4.57 (3.87–5.44)	5.39 (4.53–6.43)	6.63 (5.45–8.22)	7.69 (6.15–9.58)	8.83 (6.82–11.2)	10.1 (7.46–13.0)	11.9 (8.44–15.5)	13.3 (9.18–17.5)
3-day	3.48 (2.98–4.10)	4.03 (3.44–4.75)	5.00 (4.25–5.90)	5.88 (4.97–6.96)	7.19 (5.94–8.83)	8.30 (6.67–10.2)	9.47 (7.35–11.9)	10.7 (7.99–13.7)	12.5 (8.96–16.3)	14.0 (9.69–18.2)
4-day	3.72 (3.20–4.36)	4.31 (3.70–5.06)	5.35 (4.57–6.28)	6.27 (5.33–7.38)	7.63 (6.32–9.30)	8.76 (7.07–10.7)	9.96 (7.75–12.4)	11.2 (8.39–14.3)	13.0 (9.35–16.9)	14.5 (10.1–18.8)
7-day	4.40 (3.81–5.09)	5.02 (4.35–5.83)	6.12 (5.28–7.11)	7.10 (6.09–8.27)	8.54 (7.12–10.3)	9.72 (7.90–11.8)	11.0 (8.61–13.5)	12.3 (9.26–15.5)	14.2 (10.2–18.2)	15.7 (11.0–20.2)
10-day	5.01 (4.36–5.76)	5.69 (4.95–6.55)	6.87 (5.96–7.92)	7.91 (6.82–9.15)	9.45 (7.92–11.3)	10.7 (8.75–12.9)	12.0 (9.50–14.8)	13.5 (10.2–16.8)	15.4 (11.2–19.7)	17.0 (12.0–21.9)
20-day	6.74 (5.94–7.65)	7.69 (6.77–8.72)	9.28 (8.14–10.6)	10.7 (9.29–12.2)	12.6 (10.7–14.8)	14.2 (11.7–16.8)	15.8 (12.6–19.1)	17.5 (13.3–21.6)	19.8 (14.5–25.0)	21.6 (15.4–27.6)
30-day	8.19 (7.26–9.21)	9.36 (8.29–10.5)	11.3 (9.98–12.7)	12.9 (11.4–14.6)	15.2 (12.9–17.7)	17.0 (14.1–20.0)	18.8 (15.0–22.5)	20.6 (15.8–25.3)	23.1 (17.0–29.0)	25.0 (17.9–31.8)
45-day	10.0 (8.95–11.2)	11.4 (10.2–12.8)	13.8 (12.2–15.4)	15.7 (13.8–17.6)	18.2 (15.5–20.9)	20.2 (16.8–23.5)	22.1 (17.8–26.3)	24.1 (18.5–29.3)	26.7 (19.7–33.1)	28.6 (20.6–36.0)
60-day	11.6 (10.4–12.9)	13.2 (11.8–14.6)	15.8 (14.1–17.5)	17.8 (15.8–19.9)	20.6 (17.6–23.4)	22.6 (18.9–26.1)	24.6 (19.9–29.0)	26.6 (20.5–32.1)	29.1 (21.6–35.9)	30.9 (22.4–38.9)

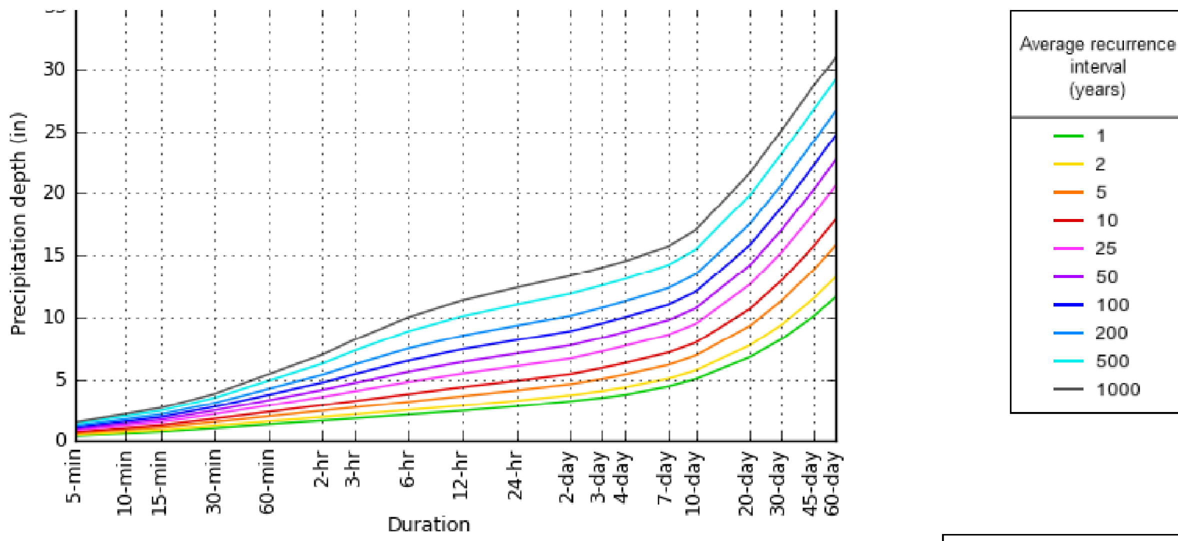
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

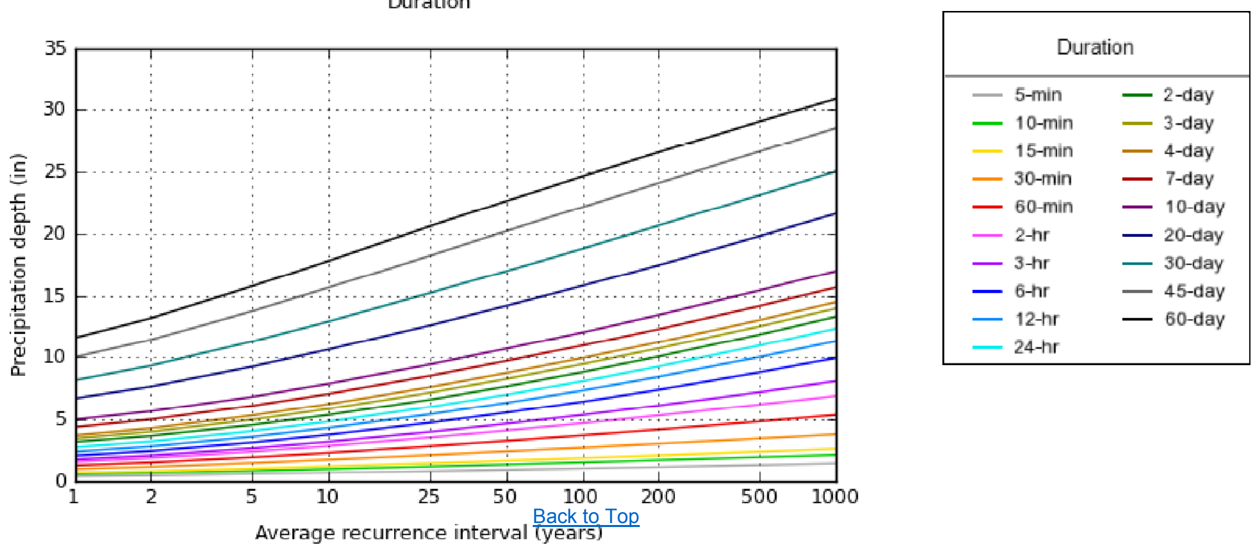
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper 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

PF graphical





Back to Top

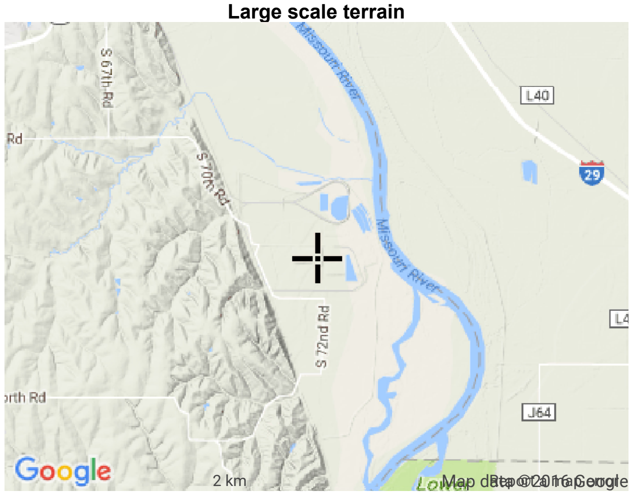
NOAA Atlas 14, Volume 8, Version 2

Maps & aerials

Created (GMT): Mon Aug 15 18:24:35 2016

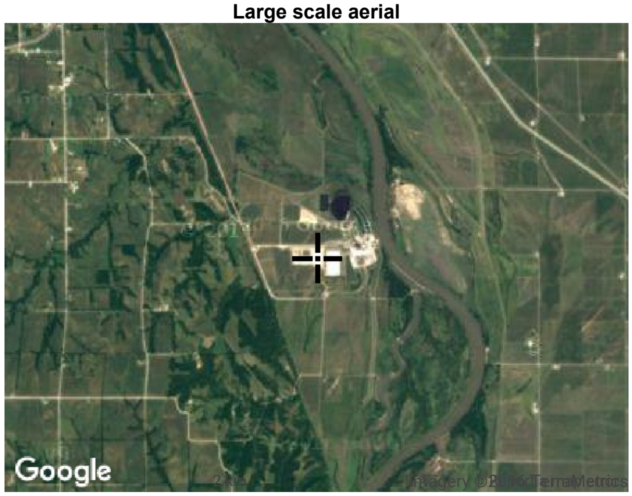
Small scale terrain

Large scale terrain



Large scale map

Large scale aerial



Back to Top

Questions?: HDSC.Questions@noaa.gov

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Appendix C
Interior Collection Channel Calculations

Channel Report

North Perimeter Ditch

Trapezoidal

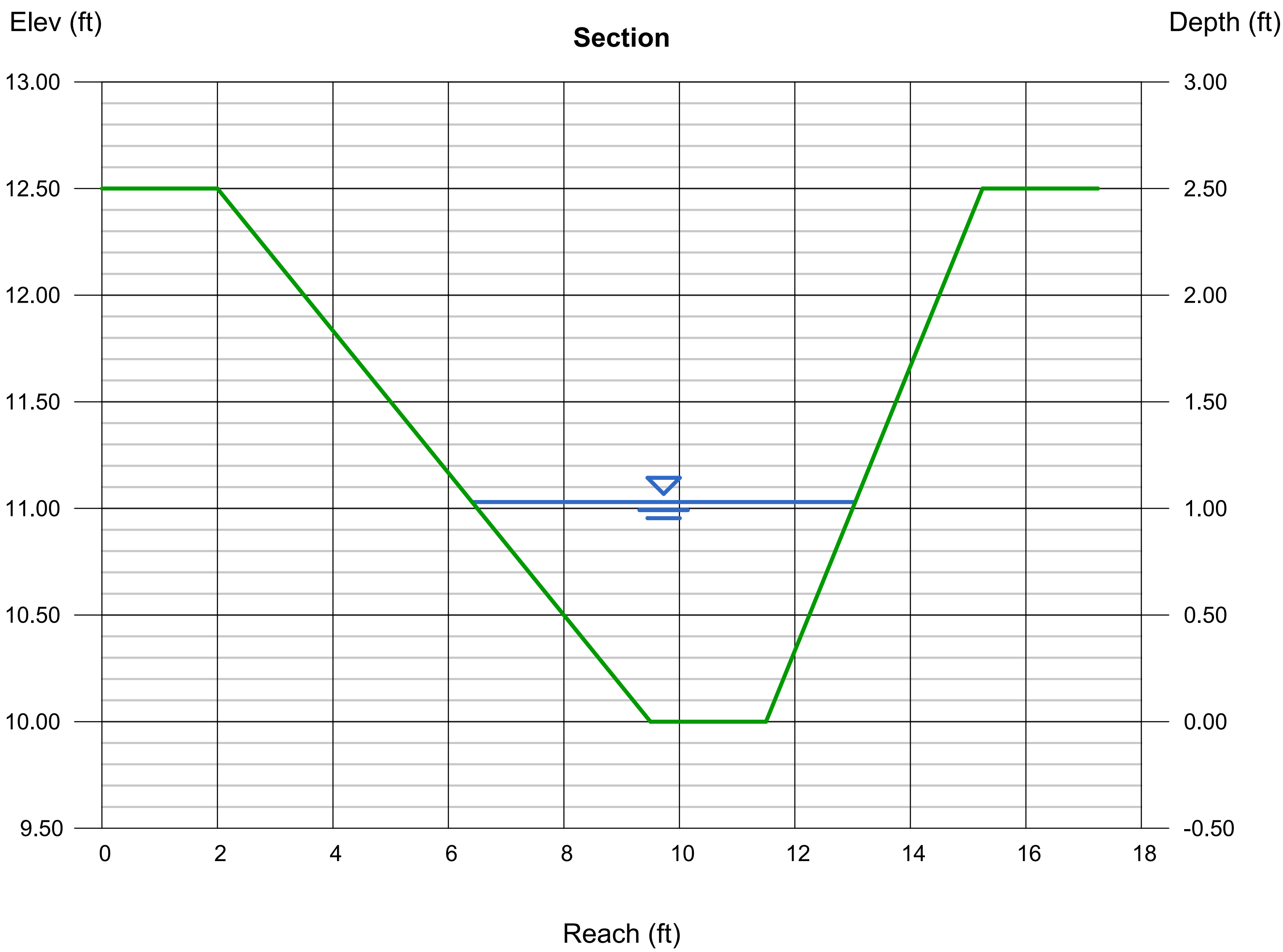
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 3.00, 1.50
Total Depth (ft)	= 2.50
Invert Elev (ft)	= 10.00
Slope (%)	= 0.50
N-Value	= 0.016

Calculations

Compute by:	Known Q
Known Q (cfs)	= 21.00

Highlighted

Depth (ft)	= 1.03
Q (cfs)	= 21.00
Area (sqft)	= 4.45
Velocity (ft/s)	= 4.72
Wetted Perim (ft)	= 7.11
Crit Depth, Yc (ft)	= 1.04
Top Width (ft)	= 6.63
EGL (ft)	= 1.38

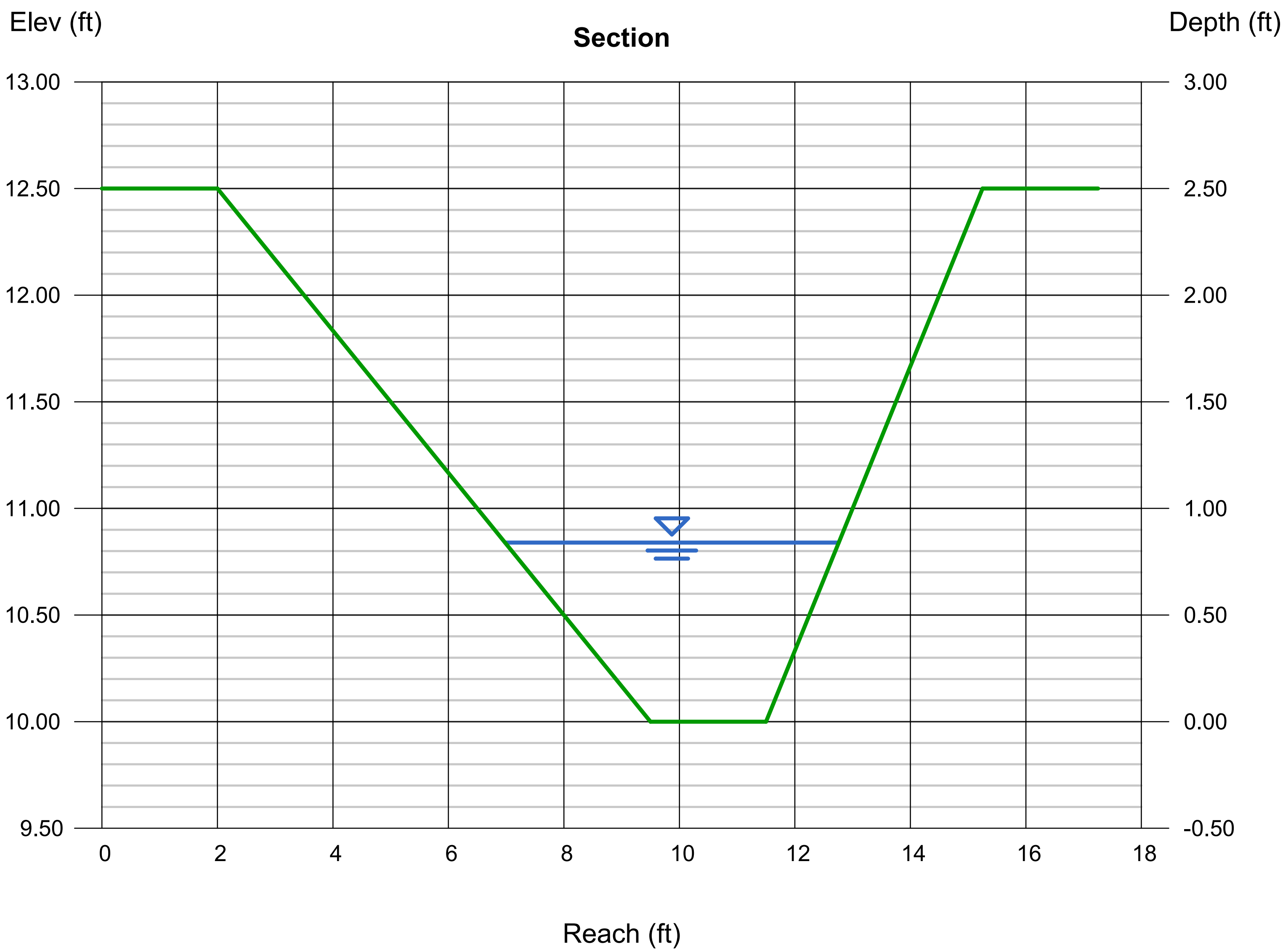


Channel Report

West Perimeter Ditch

Trapezoidal	
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 3.00, 1.50
Total Depth (ft)	= 2.50
Invert Elev (ft)	= 10.00
Slope (%)	= 0.50
N-Value	= 0.016
Calculations	
Compute by:	Known Q
Known Q (cfs)	= 14.00

Highlighted	
Depth (ft)	= 0.84
Q (cfs)	= 14.00
Area (sqft)	= 3.27
Velocity (ft/s)	= 4.28
Wetted Perim (ft)	= 6.17
Crit Depth, Yc (ft)	= 0.85
Top Width (ft)	= 5.78
EGL (ft)	= 1.13

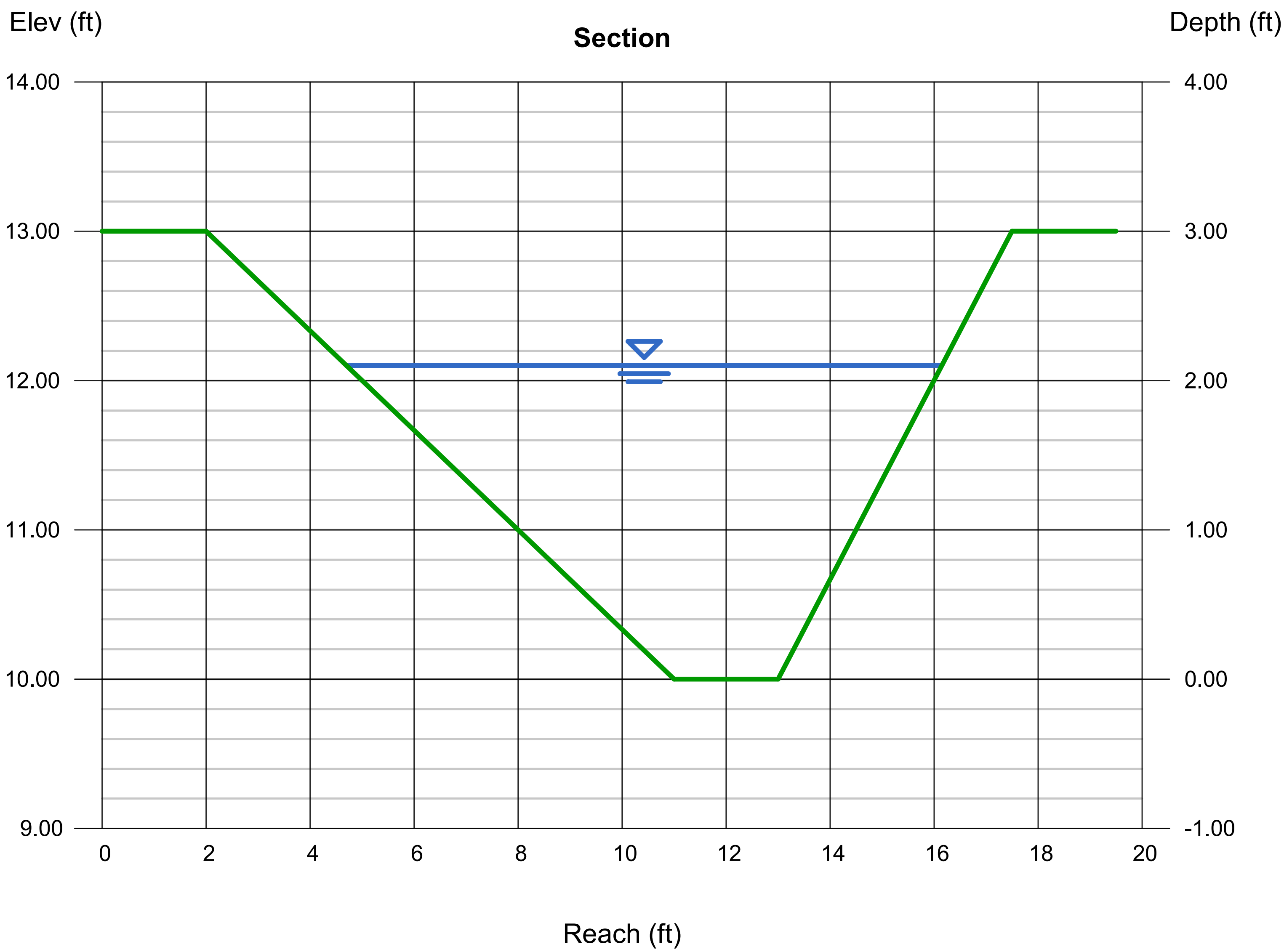


Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Oct 17 2016

South Interior Channel

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 2.00	Depth (ft)	= 2.10
Side Slopes (z:1)	= 3.00, 1.50	Q (cfs)	= 100.00
Total Depth (ft)	= 3.00	Area (sqft)	= 14.12
Invert Elev (ft)	= 10.00	Velocity (ft/s)	= 7.08
Slope (%)	= 0.50	Wetted Perim (ft)	= 12.43
N-Value	= 0.016	Crit Depth, Yc (ft)	= 2.22
		Top Width (ft)	= 11.45
Calculations		EGL (ft)	= 2.88
Compute by:	Known Q		
Known Q (cfs)	= 100.00		



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Oct 17 2016

East Culvert From Cell to Leachate Pond

Invert Elev Dn (ft)	=	916.00
Pipe Length (ft)	=	57.00
Slope (%)	=	1.75
Invert Elev Up (ft)	=	917.00
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	3
n-Value	=	0.012
Culvert Type	=	Circular Culvert
Culvert Entrance	=	Smooth tapered inlet throat
Coeff. K,M,c,Y,k	=	0.534, 0.555, 0.0196, 0.9, 0.2

Embankment

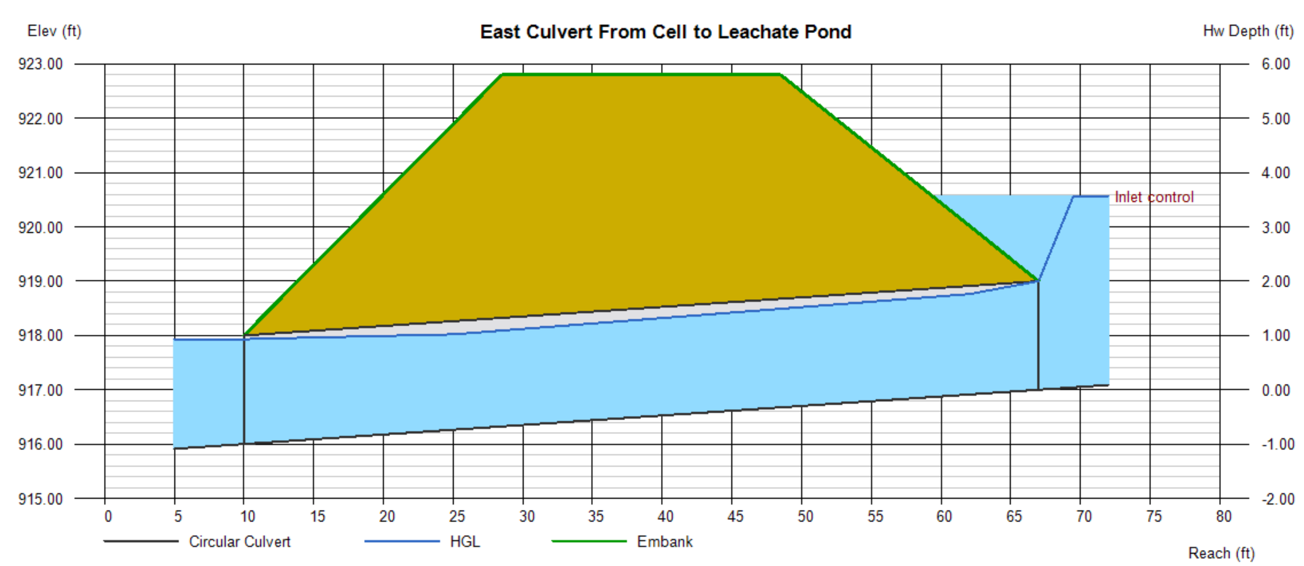
Top Elevation (ft)	=	922.80
Top Width (ft)	=	20.00
Crest Width (ft)	=	20.00

Calculations

Qmin (cfs)	=	90.00
Qmax (cfs)	=	90.00
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	90.00
Qpipe (cfs)	=	90.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	9.65
Veloc Up (ft/s)	=	9.85
HGL Dn (ft)	=	917.93
HGL Up (ft)	=	918.86
Hw Elev (ft)	=	920.57
Hw/D (ft)	=	1.78
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. — Monday, Oct 17 2016

West Culvert From Cell to Leachate Pond

Invert Elev Dn (ft)	=	915.00
Pipe Length (ft)	=	46.00
Slope (%)	=	4.35
Invert Elev Up (ft)	=	917.00
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	3
n-Value	=	0.012
Culvert Type	=	Circular Culvert
Culvert Entrance	=	Smooth tapered inlet throat
Coeff. K,M,c,Y,k	=	0.534, 0.555, 0.0196, 0.9, 0.2

Embankment

Top Elevation (ft)	=	920.75
Top Width (ft)	=	20.00
Crest Width (ft)	=	20.00

Calculations

Qmin (cfs)	=	95.00
Qmax (cfs)	=	95.00
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	95.00
Qpipe (cfs)	=	95.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	10.16
Veloc Up (ft/s)	=	10.32
HGL Dn (ft)	=	916.94
HGL Up (ft)	=	918.89
Hw Elev (ft)	=	920.75
Hw/D (ft)	=	1.87
Flow Regime	=	Inlet Control