INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN – REVISION 1
40 C.F.R. PART 257.82
PLANT BOWEN ASH POND 1 (AP-1)
GEORGIA POWER COMPANY

EPA's "Disposal of Coal Combustion Residuals from Electric Utilities" Final Rule (40 C.F.R. Part 257 and Part 261), §257.82, requires the owner or operator of an existing or new CCR surface impoundment or any lateral expansion of a CCR surface impoundment to design, construct, operate and maintain an inflow design flood control system capable of adequately managing flow during and following the peak discharge of the specified inflow design flood. The owner or operator must prepare an inflow design flood system written plan documenting how the inflow design flood control system has been designed and constructed to meet the requirements of 40 C.F.R. Part 257 §257.82.

The existing CCR surface impoundment known as AP-1 is located west of Cartersville, Georgia on property at Plant Bowen. The facility consists of a 257.4-acre CCR storage area. The northern 128.6 acres is a dry stack area with ash stacked above the normal full pond elevation. Water does not impound in this area. In the southern 128.8 acres of the pond, there are areas that do impound water, including the lined gypsum dewatering cells, the lined ash dewatering cells and the recycle pond. The perimeter dike's inboard slope for the Recycle Pond area is lined with a HDPE geomembrane. The remaining inboard slope of the dike does not impound water. A perimeter drainage ditch in the southwestern portion of the pond is lined with a HDPE geomembrane. The inflow design flood consists primarily of the rainfall that falls within the limits of AP-1, along with a nominal amount (relative to the rainfall) of process flows. Stormwater is temporarily stored within the limits of the Recycle Pond until it is pumped back into the plant as process water. There are also emergency discharge valves located upstream of the pumps that can be manually opened to discharge to a tributary to Euharlee Creek.

The inflow design flood has been calculated using the Natural Resources Conservation Service method (also known as the Soil Conservation Service (SCS) method) using the 1000-yr storm event required for a Significant Hazard Potential facility. Runoff curve number data was determined using Table 2-2A from the Urban Hydrology for Small Watersheds (TR-55). Appendix A and B from the TR-55 were used to determine the rainfall distribution methodology. Precipitation values were determined from NOAA's Precipitation Frequency Data Server (Atlas-14).

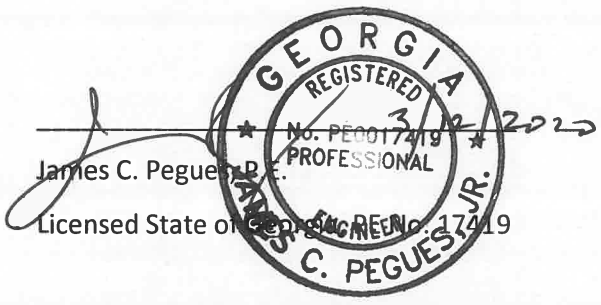
The NRCS provided information on the soil characteristics and hydrologic groups present at the site. It was determined that the hydrological group "B" should be used to best reflect the characteristics of the soils on site. This information was placed into Hydraflow Hydrographs 2013 and used to generate appropriate precipitation curves, storm basin routing information, and resulting rating curves to evaluate surface impoundment capacity.

The existing water management systems, except for certain sections of the perimeter toe ditch for the northern stack area, are designed, constructed, operated and maintained to adequately manage flow during and following the peak discharge from the 1000-year storm. The sections that cannot manage the design storm are the perimeter toe ditch Basin Section 1 and Sections 3-7 (basin sections as defined in the calculation). This toe drain ditch receives and manages only stormwater that falls on the outside of the surface impoundment, does not transport water that comes in contact with ash and does not impact the flood routing of stormwater through the interior of the surface impoundment. In an effort to improve capacity of the toe ditch, several options were considered including, but not limited to, additional, or larger, drainage pipes from the ditch, or construction of an auxiliary spillway through the dike at multiple points. At this time, the decision has been made to manage flows, as needed, with temporary pumps rather than permanent ditch improvements given AP-1 will be moving into closure in the coming months. These pumps are readily available at Plant Bowen.

This plan is supported by appropriate engineering calculations which are attached.

The facility is operated subject to and in accordance with § 257.3-3 of EPA's regulations.

I hereby certify that the inflow design flood control system plan meets the requirements of 40 C.F.R. Part 257.82.



3/12/2020

James C. Pegues, P.E.

Licensed State of Georgia PE No. 17419

Purpose of Calculation

The purpose of this calculation is to determine if the existing storm water management system in the ash pond can safely manage and pass the design storm event per federal storm water requirements (Title 40 CFR Part 257.82) and to further assure that the pond does not present a life safety or flooding issue to the surrounding area.

Project Narrative

The Plant Bowen Ash Pond site is located on Georgia Power Company property in Bartow County and is approximately 1.5 miles East of Euharlee, Georgia and 6 miles southwest of Cartersville, Georgia. The pond is bordered on the north, west and south by an earthen dike and on the east by Old Covered Bridge Road.

The ash pond covers 257.37 acres and is divided into two sections (See Attached Map). The northern section of the pond is inactive and capped with a soil and grass cover and consists of 128.57 acres. The southern portion of the pond is active and consists of 128.80 acres.

The northern section of the ash pond is divided into 8 basins (See Attached Map). Basins 1-7 drain to their own outlet pipe that discharges outside the ash pond dike. Basin 8 drains to a set of 4 – 54" diameter HDPE pipes that discharges outside the ash pond dike as well. The northern section of the ash pond receives only storm water that fall within its footprint. Following pages will show the analysis for each basin within the northern section of the ash pond.

The southern section of the ash pond (See Attached Map) drains to the recycle pond within the ash pond dike. The recycle pond is controlled by a set of 4 – 6,200 gpm pumps. The pumps are used to pull water from the recycle pond where it is sent back to the plant for reuse. The southern section of the ash pond receives both the storm water that falls within its footprint and process flows from the plant. Following pages will show the analysis for the southern section of the ash pond.

Methodology

The ash pond storm water flows were calculated using the National Resources Conservation Service method (also known as the Soil Conservation Service (SCS) method) using a 1000-yr, 24-hr design storm event while the process flows that contribute to the ash pond were gathered from the 2014 plant water balance.

Storm basin calculation information was gathered from a number of sources to include the Georgia Stormwater Manual and Technical Release 55.

The National Resources Conservation Service (NCRS) provided information on the soil characteristics and hydrologic groups. The soil types found on the site are Etowah Loam, Shady Loam, Steadman Silt Loam, and Waynesboro Clay Loam (See Attached Soils Map). It was determined that the hydrological group "B" should be used to best reflect the characteristics of the soils on site.

Runoff curve number data was determined using Table 2.1.5-1 from the Georgia Stormwater Management Manual. Runoff coefficient data was determined by utilizing Table 2.1.5-2 from the Georgia Stormwater Management Manual and Manning's n for Channels (Chow, 1959).

Appendix B from the TR-55 was used to determine the rain distribution for Plant Bowen is Type II. (See Attached Map)

NOAA Atlas 14 was used to determine the 24 hour precipitation for the design storm event of 1,000-yr for Plant Bowen is 9.98 in. (See Attached Table)

Assumptions and Criteria

- Refer to Title 40 CFR Part 257.82 Hydrologic and hydraulic capacity requirements for CCR surface impoundments.
- All process flows entering into the southern portion of the ash pond are at their maximum flow rate.
- The 4 – 6,200 gpm pumps will be functioning at full capacity when the design storm event occurs.
- Other assumptions are listed on attached calculation sheets.

Design Inputs

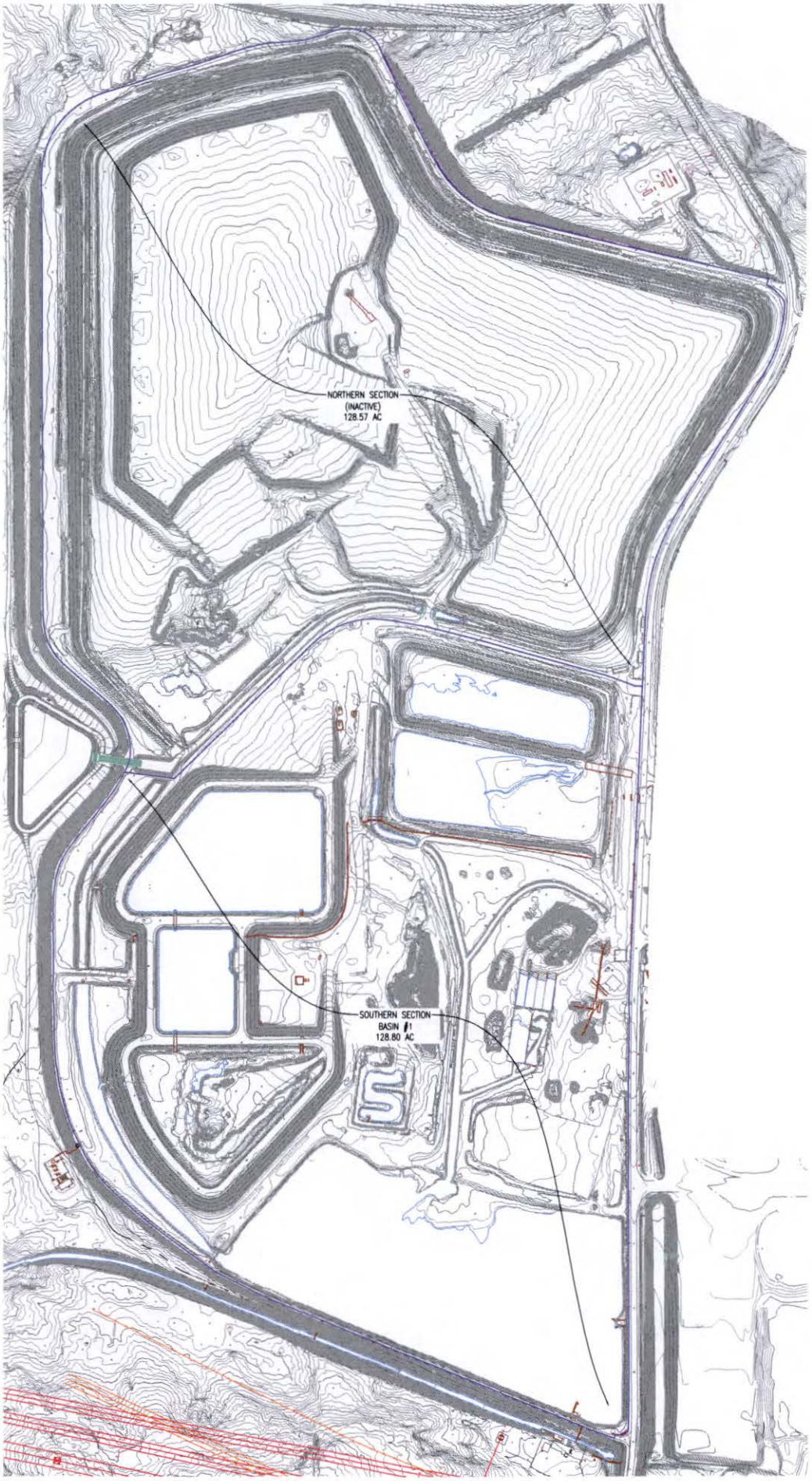
- AutoCad Civil 3D 2013, Autodesk, Inc.
- Hydraflow Hydrographs Extenstion for AutoCad Civil 3D 2013, Autodesk, Inc.
- Hydraflow Express Extenstion for AutoCad Civil 3D 2013, Autodesk, Inc.
- NOAA Atlas 14, Volume 9, Version 2 for Taylorsville, GA.
- TR-55 – Urban Hydrology for Small Watersheds, Appendix B, National Resources Conservation Service, Conservation Engineering Division, 1986.
- Metro Engineering & Surveying Co., Inc. – Georgia Power Plant Bowen Recycle Pond Relocation topographic map dated July 1, 2014.
- Georgia Power Company – Plant Bowen – Ash Pond Northern Berm Drawings E52823 through E52847.

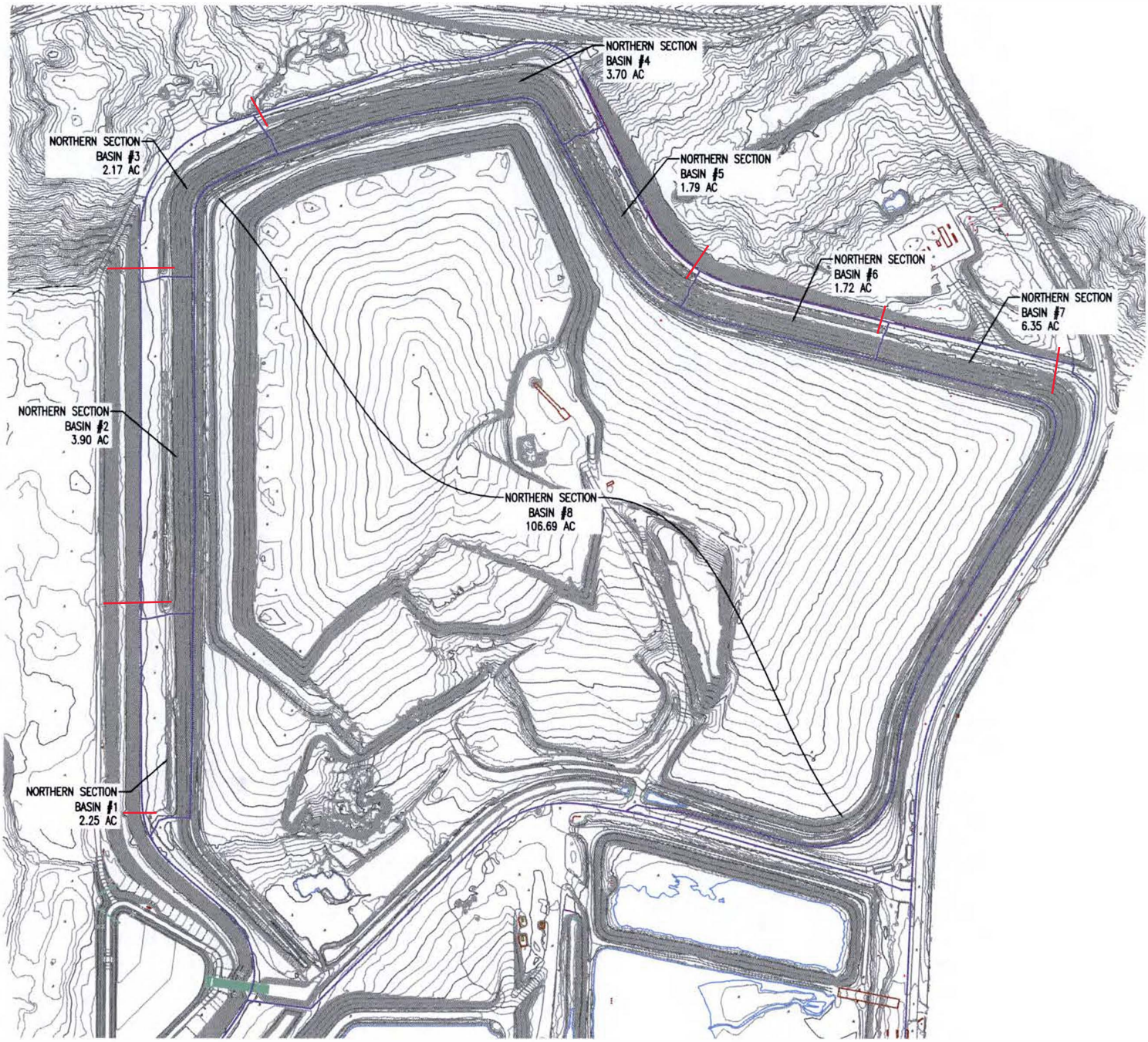
Summary of Conclusions

Section	Basin	Top Basin Elevation	High Water Elevation	Action Needed
Northern	1	713.00	NS	Yes, see recommendations
	2	713.00	712.46	No
	3	713.00	NS	Yes, see recommendations
	4	713.00	NS	Yes, see recommendations
	5	714.00	NS	Yes, see recommendations
	6	714.00	NS	Yes, see recommendations
	7	714.00	NS	Yes, see recommendations
	8	714.00	711.97	No
Southern	1	715.00	713.38	No

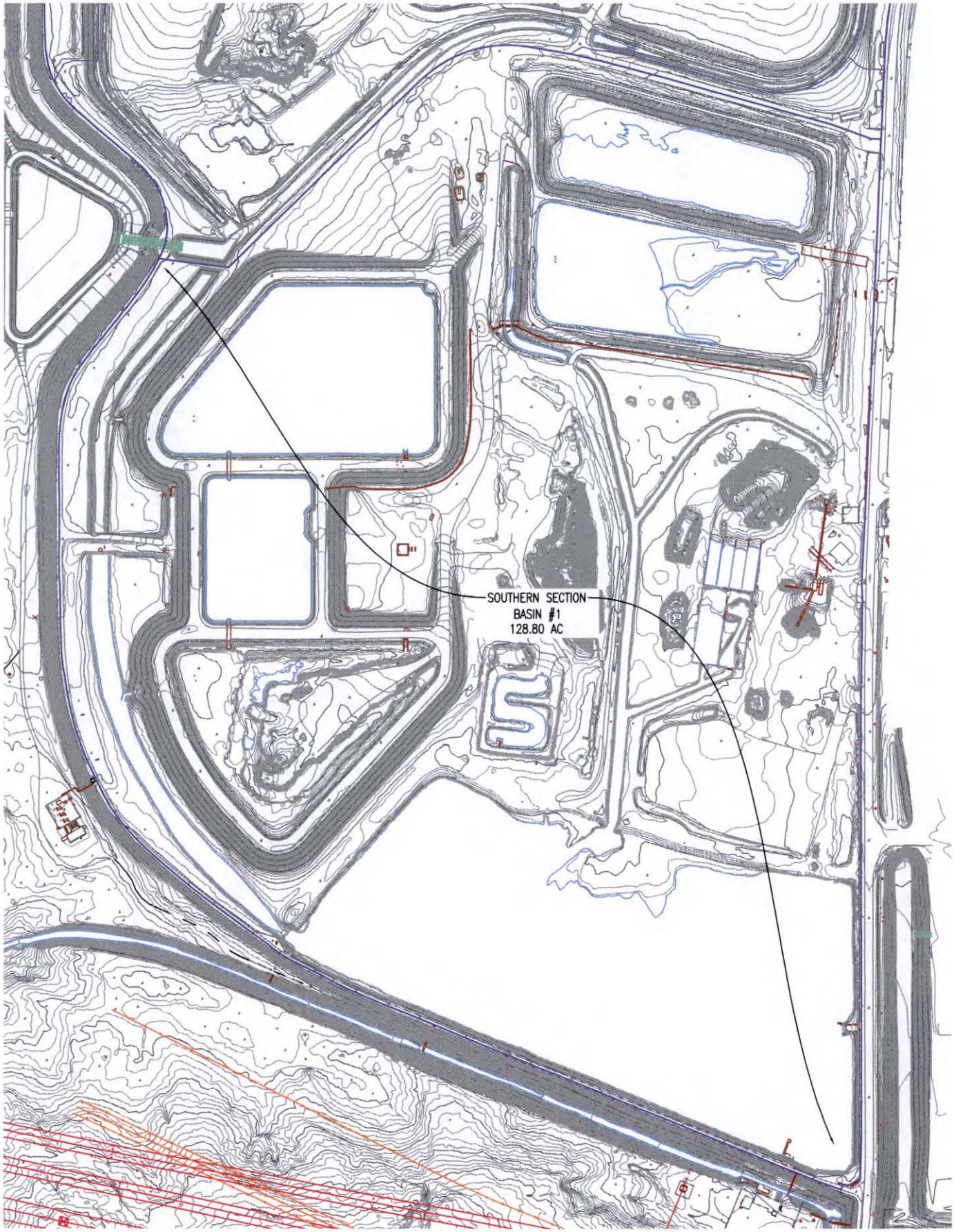
Recommendations

For a basin to be able to manage and pass the 1,000-yr, 24-hr storm event several options are available. One option would be to add an additional outlet pipe or increase the size of the existing outlet pipe to prevent overtopping of the basin. The second options would be to add a spillway to allow for the discharge of storm water runoff that cannot be passed through the existing outlet pipe. The third option would be to provide additional storage within the basin. Also, it may be necessary to use a combination of these three options.


NORTHERN SECTION
(INACTIVE)
128.57 AC
SOUTHERN SECTION
BASIN #1
128.80 AC



Outlet Pipe (Approximate)


SOUTHERN SECTION
BASIN #1
128.80 AC

Map Scale: 1:3,100 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 45 90 180 270

Feet: 0 150 300 600 900

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

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: http://websoilsurvey.nrcs.usda.gov
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: Bartow County, Georgia
Survey Area Data: Version 7, Sep 23, 2014

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

Date(s) aerial images were photographed: Dec 31, 2011—Jan 4, 2012

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bartow County, Georgia (GA015)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
EtB	Etowah loam, 2 to 6 percent slopes	B	0.0	0.0%
EtC	Etowah loam, 6 to 10 percent slopes	B	3.8	17.4%
ShB	Shady loam, 2 to 6 percent slopes	B	0.1	0.2%
StA	Steadman silt loam, 0 to 2 percent slopes, occasionally flooded	C	3.4	15.6%
WbB2	Waynesboro clay loam, 2 to 6 percent slopes, moderately eroded	B	13.8	63.7%
WbC2	Waynesboro clay loam, 6 to 10 percent slopes, moderately eroded	B	0.6	3.0%
Totals for Area of Interest			**21.6**	**100.0%**

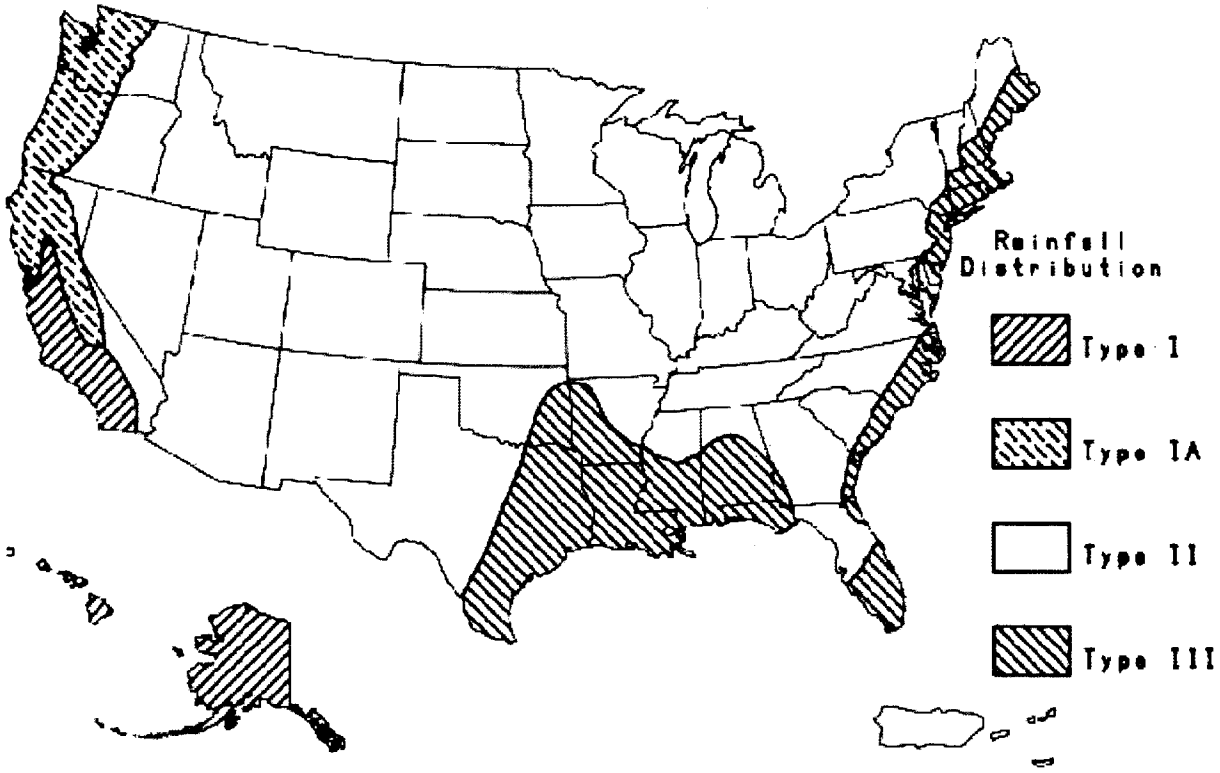


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions

NOAA Atlas 14, Volume 9, Version 2
TAYLORSVILLE
Station ID: 09-8600
Location name: Taylorsville, Georgia, US*
Latitude: 34.0861°, Longitude: -84.9828°
Elevation:
Elevation (station metadata): 721 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.406 (0.321-0.518)	0.464 (0.367-0.593)	0.568 (0.448-0.726)	0.662 (0.520-0.849)	0.804 (0.619-1.06)	0.924 (0.695-1.23)	1.05 (0.768-1.42)	1.19 (0.838-1.62)	1.39 (0.943-1.92)	1.55 (1.02-2.14)
10-min	0.594 (0.471-0.759)	0.679 (0.537-0.868)	0.831 (0.655-1.06)	0.969 (0.761-1.24)	1.18 (0.907-1.56)	1.35 (1.02-1.80)	1.54 (1.12-2.07)	1.75 (1.23-2.38)	2.03 (1.38-2.81)	2.27 (1.50-3.14)
15-min	0.725 (0.574-0.926)	0.828 (0.655-1.06)	1.01 (0.799-1.30)	1.18 (0.928-1.52)	1.44 (1.11-1.90)	1.65 (1.24-2.19)	1.88 (1.37-2.53)	2.13 (1.50-2.90)	2.48 (1.68-3.43)	2.77 (1.83-3.83)
30-min	1.02 (0.811-1.31)	1.17 (0.924-1.49)	1.43 (1.13-1.83)	1.66 (1.31-2.13)	2.02 (1.56-2.68)	2.33 (1.75-3.09)	2.65 (1.94-3.57)	3.01 (2.12-4.11)	3.52 (2.39-4.86)	3.93 (2.60-5.44)
60-min	1.33 (1.05-1.70)	1.52 (1.20-1.94)	1.85 (1.46-2.36)	2.15 (1.69-2.76)	2.61 (2.01-3.45)	3.00 (2.25-3.98)	3.41 (2.49-4.58)	3.86 (2.71-5.26)	4.49 (3.05-6.21)	5.01 (3.31-6.93)
2-hr	1.64 (1.31-2.06)	1.86 (1.49-2.35)	2.27 (1.81-2.86)	2.64 (2.10-3.34)	3.20 (2.49-4.17)	3.66 (2.79-4.79)	4.16 (3.08-5.52)	4.70 (3.36-6.33)	5.47 (3.77-7.46)	6.09 (4.09-8.32)
3-hr	1.84 (1.49-2.30)	2.10 (1.69-2.62)	2.55 (2.05-3.19)	2.96 (2.37-3.71)	3.56 (2.80-4.60)	4.07 (3.12-5.28)	4.60 (3.43-6.05)	5.18 (3.73-6.91)	6.00 (4.17-8.12)	6.66 (4.51-9.04)
6-hr	2.27 (1.86-2.79)	2.57 (2.10-3.17)	3.10 (2.53-3.83)	3.57 (2.90-4.41)	4.26 (3.38-5.41)	4.82 (3.75-6.16)	5.42 (4.10-7.02)	6.05 (4.42-7.96)	6.94 (4.90-9.27)	7.65 (5.27-10.3)
12-hr	2.79 (2.32-3.39)	3.15 (2.61-3.83)	3.77 (3.12-4.58)	4.31 (3.54-5.25)	5.08 (4.08-6.34)	5.70 (4.49-7.17)	6.36 (4.87-8.10)	7.04 (5.21-9.11)	7.99 (5.72-10.5)	8.73 (6.11-11.6)
24-hr	3.34 (2.81-3.99)	3.79 (3.18-4.53)	4.54 (3.80-5.44)	5.18 (4.32-6.21)	6.07 (4.93-7.43)	6.77 (5.40-8.36)	7.48 (5.81-9.38)	8.22 (6.17-10.5)	9.21 (6.70-11.9)	9.98 (7.10-13.0)
2-day	3.87 (3.29-4.55)	4.43 (3.77-5.21)	5.34 (4.54-6.30)	6.10 (5.16-7.22)	7.14 (5.88-8.60)	7.95 (6.42-9.65)	8.75 (6.88-10.8)	9.56 (7.27-12.0)	10.6 (7.84-13.6)	11.4 (8.27-14.8)
3-day	4.24 (3.64-4.95)	4.81 (4.13-5.62)	5.76 (4.93-6.73)	6.56 (5.59-7.68)	7.66 (6.37-9.16)	8.53 (6.95-10.3)	9.40 (7.47-11.5)	10.3 (7.92-12.8)	11.5 (8.57-14.6)	12.4 (9.06-15.9)
4-day	4.56 (3.94-5.28)	5.14 (4.43-5.96)	6.10 (5.25-7.08)	6.92 (5.93-8.06)	8.07 (6.76-9.61)	8.98 (7.38-10.8)	9.92 (7.94-12.1)	10.9 (8.43-13.5)	12.2 (9.16-15.4)	13.2 (9.72-16.8)
7-day	5.37 (4.69-6.14)	5.99 (5.22-6.86)	7.04 (6.13-8.07)	7.94 (6.88-9.14)	9.24 (7.84-10.9)	10.3 (8.56-12.2)	11.3 (9.21-13.7)	12.5 (9.80-15.3)	14.0 (10.7-17.5)	15.2 (11.3-19.2)
10-day	6.07 (5.34-6.89)	6.74 (5.92-7.66)	7.88 (6.91-8.97)	8.87 (7.74-10.1)	10.3 (8.79-12.0)	11.4 (9.58-13.5)	12.6 (10.3-15.1)	13.8 (11.0-16.8)	15.5 (11.9-19.3)	16.8 (12.7-21.1)
20-day	8.08 (7.21-9.03)	8.91 (7.95-9.96)	10.3 (9.17-11.5)	11.5 (10.2-12.9)	13.2 (11.5-15.2)	14.6 (12.4-16.9)	16.0 (13.3-18.8)	17.4 (14.0-20.9)	19.4 (15.2-23.7)	21.0 (16.1-25.9)
30-day	9.86 (8.87-10.9)	10.8 (9.75-12.0)	12.5 (11.2-13.8)	13.9 (12.4-15.4)	15.8 (13.8-17.9)	17.3 (14.9-19.8)	18.8 (15.8-22.0)	20.4 (16.6-24.2)	22.5 (17.8-27.3)	24.1 (18.7-29.6)
45-day	12.2 (11.1-13.4)	13.5 (12.2-14.8)	15.4 (14.0-17.0)	17.1 (15.4-18.8)	19.3 (16.9-21.6)	20.9 (18.1-23.7)	22.6 (19.1-26.1)	24.3 (19.9-28.5)	26.4 (21.1-31.7)	28.1 (22.0-34.1)
60-day	14.4 (13.1-15.6)	15.8 (14.4-17.2)	18.1 (16.5-19.8)	19.9 (18.1-21.8)	22.4 (19.8-24.9)	24.2 (21.0-27.2)	25.9 (22.0-29.7)	27.7 (22.8-32.2)	29.8 (23,9-35.5)	31.4 (24.8-37.9)

[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.

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PF graphical

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
BASIN #1	Calculation Number DC-BN-601666-001	Sheet 12 of 128

DRAINAGE AREA = 2.25 AC (SEE ATTACHED MAP)

CURVE NUMBER = 73 (SEE ATTACHED TABLE)

1.14 AC @ CN 61 (GRASS)

1.11 AC @ CN 85 (GRAVEL)

$$\frac{(1.14 \times 61) + (1.11 \times 85)}{2.25} = 72.84 = 73$$

TIME OF CONCENTRATION = 5.30 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 77 L.F.

LAND SLOPE = $\frac{732.25 - 713.00}{77} = 0.25 = 25\%$

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

GRASS LINED 3' WIDE DITCH WITH 2:1 SIDE SLOPES AND 3' DEEP

CROSS SECTIONAL AREA = 7.36 S.F.

WETTED PERIMETER = 8.86 L.F.

CHANNEL SLOPE = $\frac{713.00 - 709.00}{583} = 0.0069 = 0.69\%$

MANNING'S n-VALUE = 0.030 (VEGETAL LINING)

FLOW LENGTH = 583 L.F.

TIME INTERVAL = 1 MIN

Tc x 0.1333 = 5.30 x 0.1333 = 0.71 = 1

STORM DISTRIBUTION = TYPE II

Q_{1000} = 26.65 CFS (SEE ATTACHED HYDROGRAPH REPORT)

Design Calculations

SOUTHERN COMPANY

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
BASIN #1	Calculation Number DC-BN-601666-001	Sheet 13 of 128

TO EVALUATE THE STORAGE CAPACITY OF BASIN 1, TREAT THE DITCH IN BASIN 1 AS A POND.

ELEVATION	AREA	VOLUME
709	Ø	Ø
710	26	8
711	518	229
712	2,505	1,616
713	7,667	6,467

OUTLET IS A 12"Ø HDPE PIPE @ 1% SLOPE

∴ THE STORAGE CAPACITY IN BASIN 1 IS UNABLE TO CONTAIN THE 1000YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT)

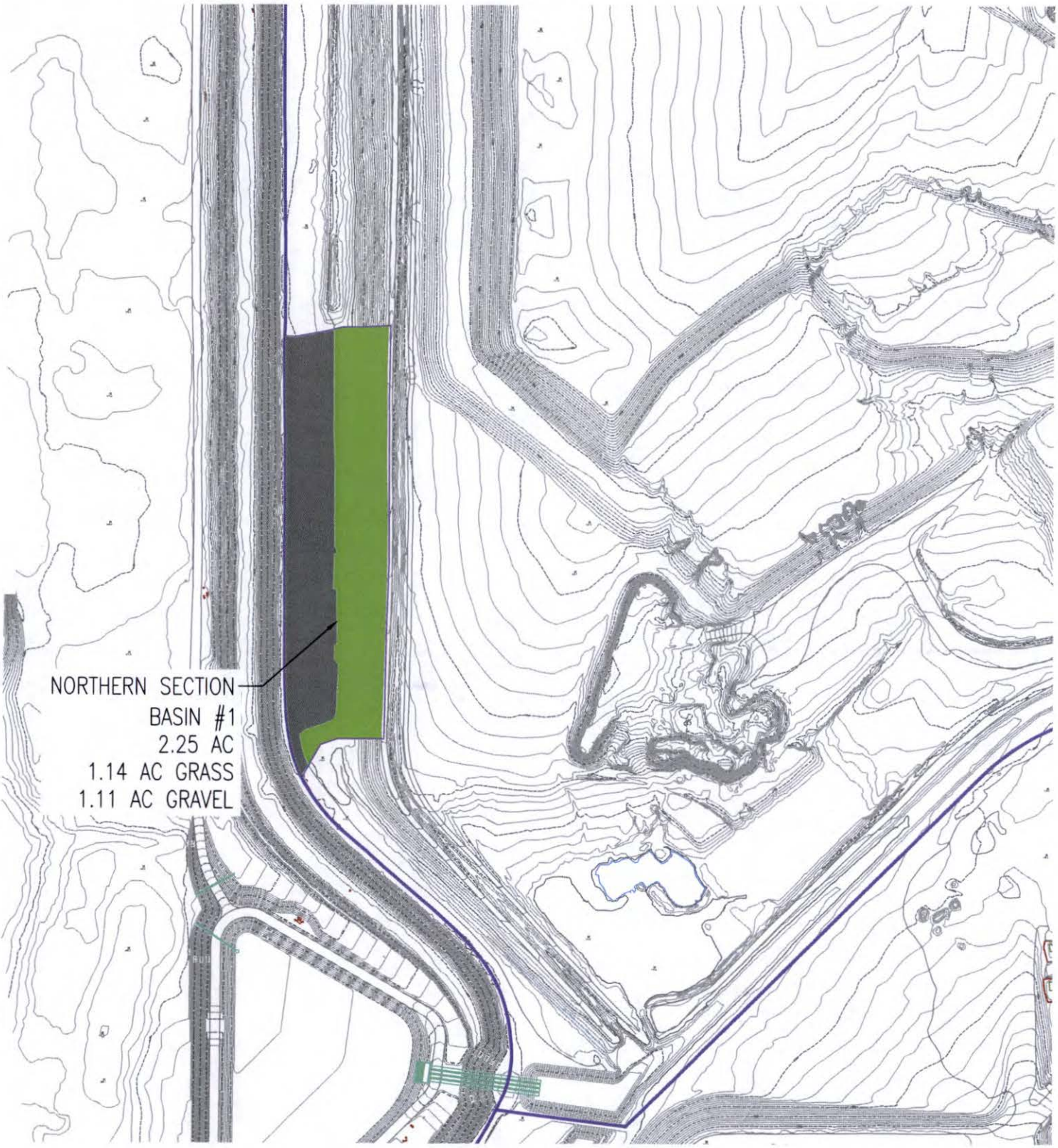

NORTHERN SECTION
BASIN #1
2.25 AC
1.14 AC GRASS
1.11 AC GRAVEL

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

TR55 Tc Worksheet

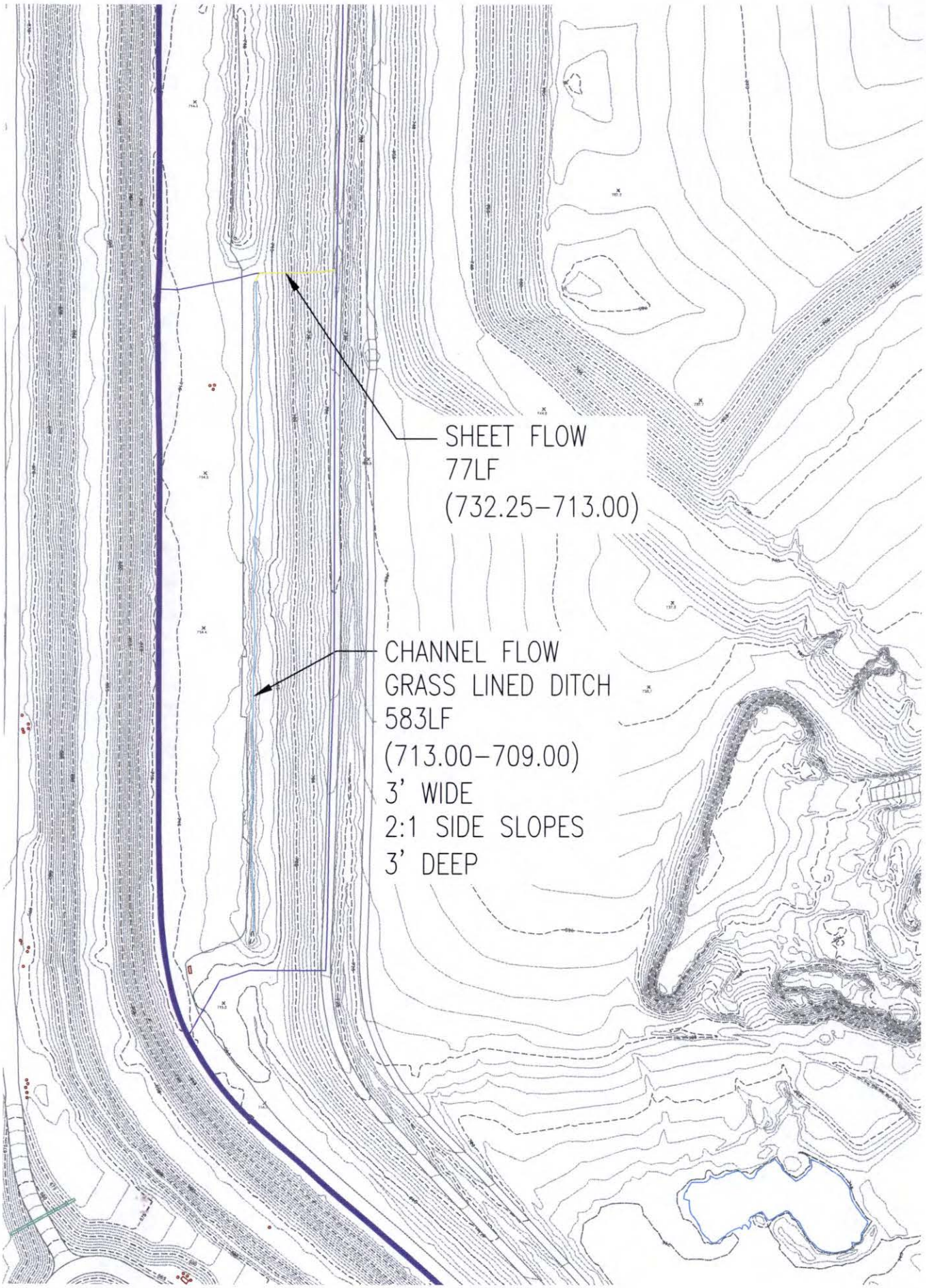
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 1

Basin 1

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 77.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 25.00		0.00		0.00		
Travel Time (min)	**= 2.66**	**+**	**0.00**	**+**	**0.00**	**=**	**2.66**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 7.36		0.00		0.00		
Wetted perimeter (ft)	= 8.86		0.00		0.00		
Channel slope (%)	= 0.69		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=3.64						
			0.00				
					0.00		
Flow length (ft)	({0})583.0		0.0		0.0		
Travel Time (min)	**= 2.67**	**+**	**0.00**	**+**	**0.00**	**=**	**2.67**

Total Travel Time, Tc ..... **5.33 min**


SHEET FLOW
77LF
(732.25–713.00)
CHANNEL FLOW
GRASS LINED DITCH
583LF
(713.00–709.00)
3' WIDE
2:1 SIDE SLOPES
3' DEEP

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t= travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ **(2.1.10)**

Paved $V = 20.33(S)^{0.5}$ **(2.1.11)**

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Jul 14 2016

Basin 1 Ditch

Trapezoidal

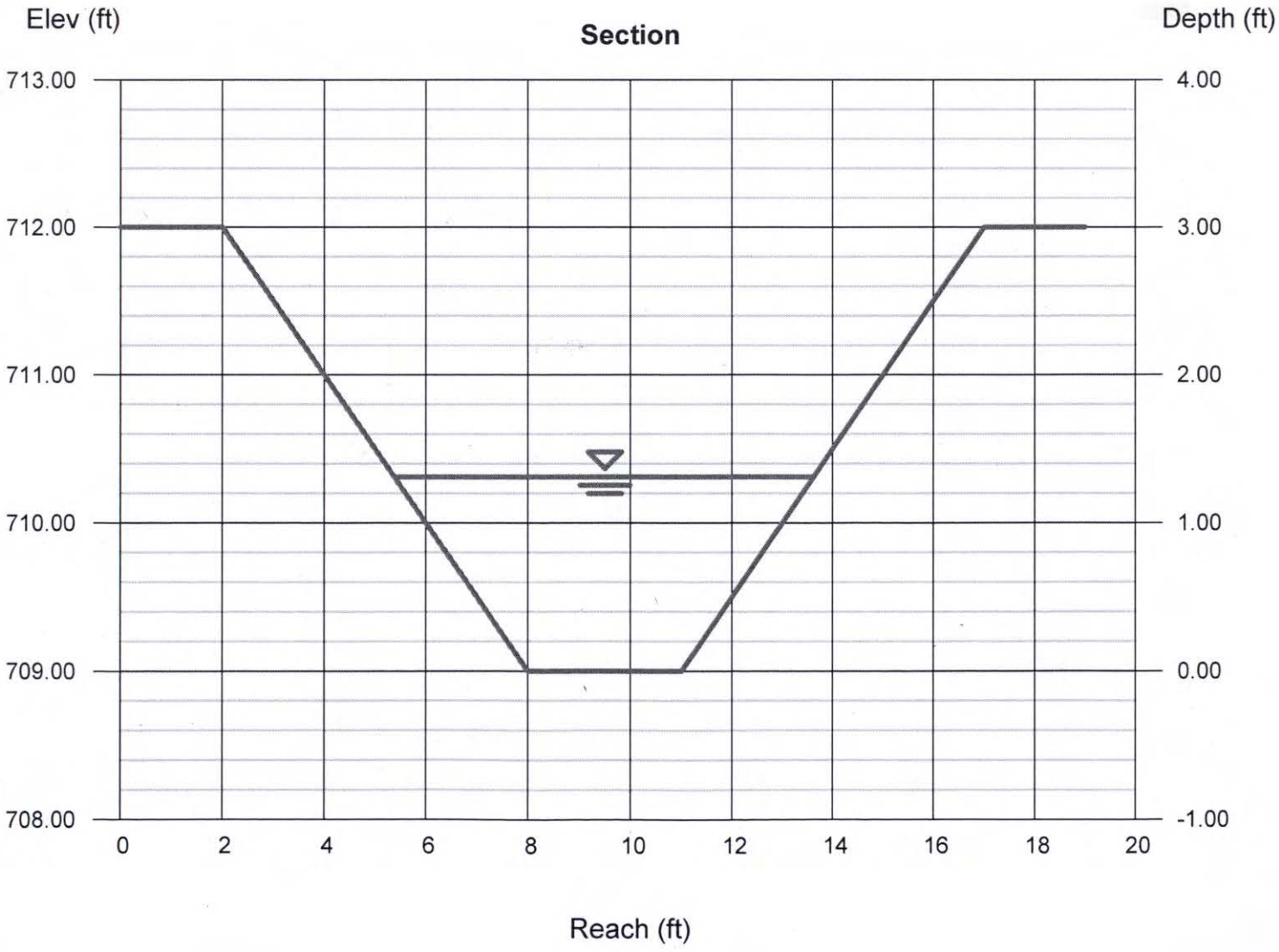
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 709.00
Slope (%)	= 0.69
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 26.65

Highlighted

Depth (ft)	= 1.31
Q (cfs)	= 26.65
Area (sqft)	= 7.36
Velocity (ft/s)	= 3.62
Wetted Perim (ft)	= 8.86
Crit Depth, Yc (ft)	= 1.07
Top Width (ft)	= 8.24
EGL (ft)	= 1.51



3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015

Hydrograph Report

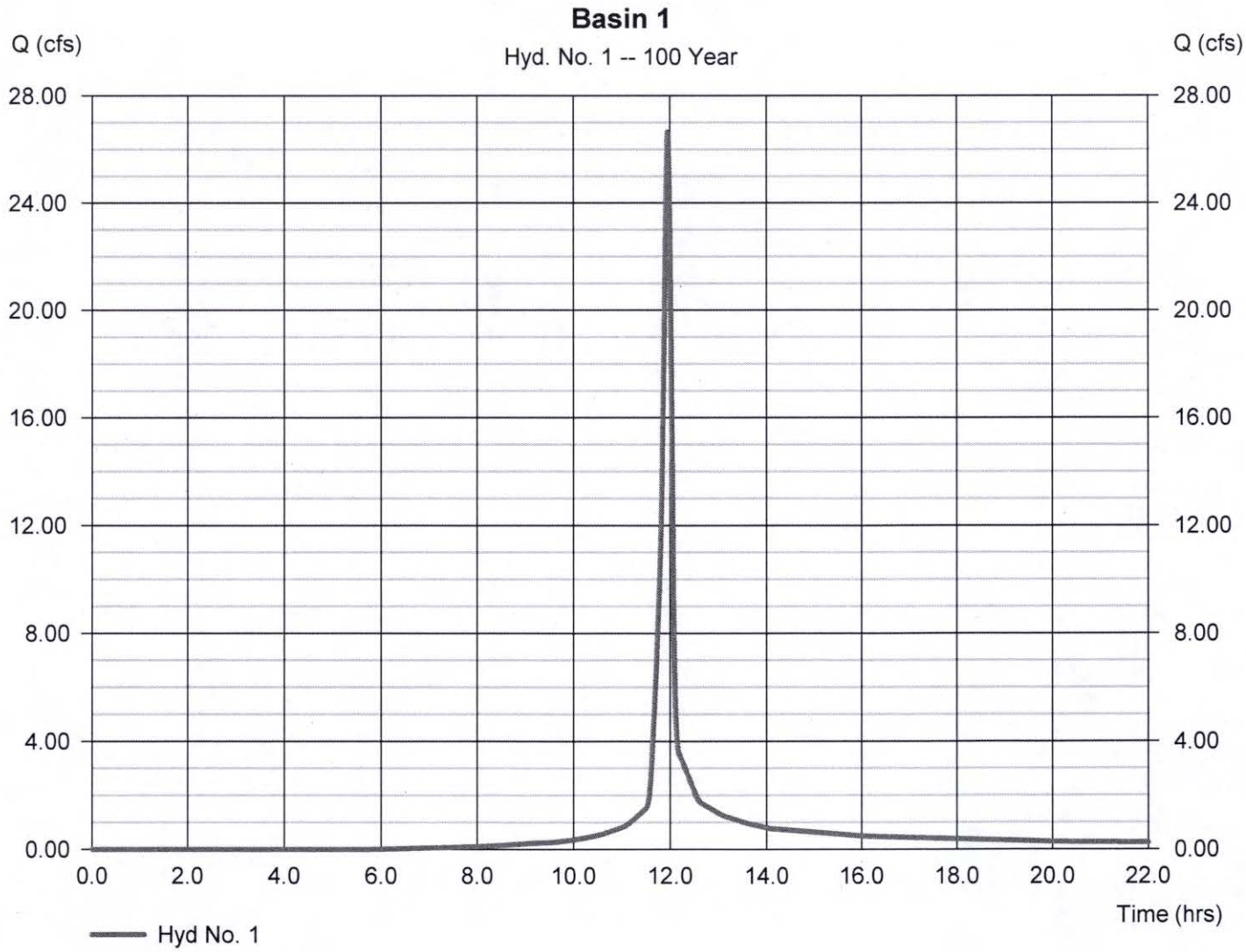
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Hyd. No. 1

Basin 1

Hydrograph type	= SCS Runoff	Peak discharge	= 26.65 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 55,581 cuft
Drainage area	= 2.250 ac	Curve number	= 73*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 5.30 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.140 x 61) + (1.110 x 85)] / 2.250



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Pond No. 1 - Basin 1

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 709.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	709.00	00	0	0
1.00	710.00	26	9	9
2.00	711.00	518	220	229
3.00	712.00	2,505	1,387	1,616
4.00	713.00	7,667	4,851	6,467

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 12.00	0.00	0.00	0.00
Span (in)	= 12.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 709.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

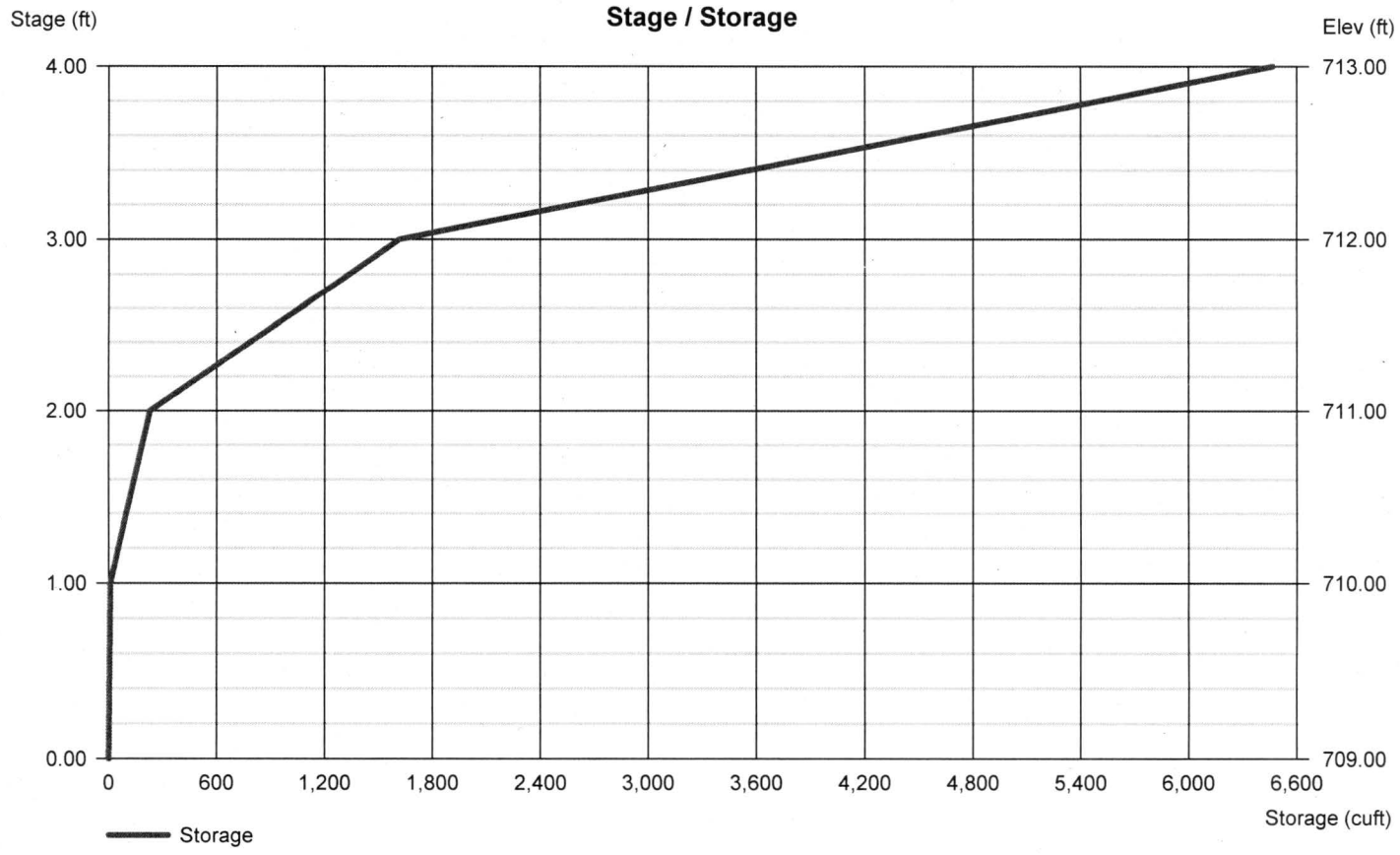
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 1 - Basin 1

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

Storage Estimate

Inflow Hyd. No. = 1 - SCS Runoff - Basin 1

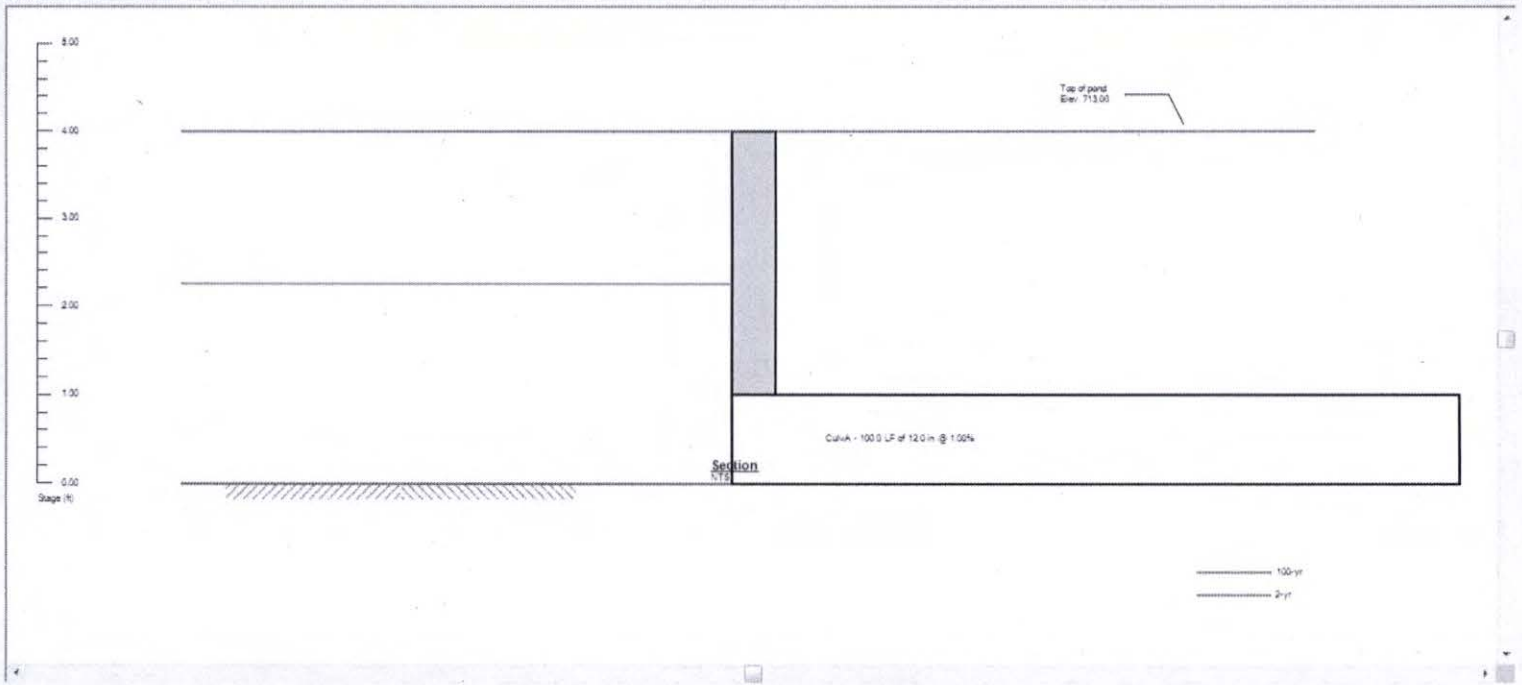
Event (yrs)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	11,789	5.859	0.000	11,789*
3				
5				
10				
25				
50				
100	55,581	26.65	0.000	55,581*

Estimated storage required. Read only.

*Exceeds available storage!

Estimate Storage

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

Culv/Orif | A | B | C | PR | Weir | A | B | C | D

Select | Active

Diameter (in) = 12.00 | Crest Len (ft) = 0.00

Invert EL. (ft) = 709.00 | Crest Elev (ft) = 0.00

Update | Auto Update | Trial Route | Auto Route

Actuals			
Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	4.407	711.25	574
100	NS	NS	NS

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AFS	7/22/16
	Calculation Number	**Sheet**
BASIN #2	TC-BN-601666-001	24 of 128

DRAINAGE AREA = 3.90 AC (SEE ATTACHED MAP)

CURVE NUMBER = 71 (SEE ATTACHED TABLE)

2.28 AC @ CN 61 (GRASS)

1.62 AC @ CN 85 (GRAVEL)

$\frac{(2.28 \times 61) + (1.62 \times 85)}{3.90} = 70.97 = 71$

TIME OF CONCENTRATION = 7.60 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 98 L.F.

LAND SLOPE = $\frac{736.25 - 713.00}{98} = 0.2372 = 23.72\%$

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

GRASS LINED 3' WIDE DITCH WITH 2:1 SIDE SLOPES AND 3' DEEP

CROSS SECTIONAL AREA = 10.59 S.F.

WETTED PERIMETER = 10.47 L.F.

CHANNEL SLOPE = $\frac{713.00 - 707.00}{998} = 0.0060 = 0.60\%$

MANNING'S n-VALUE = 0.030 (VEGETAL LINING)

FLOW LENGTH = 998 L.F.

TIME INTERVAL = 1 MIN

$T_C \times 0.1333 = 7.60 \times 0.1333 = 1.01 = 1$

STORM DISTRIBUTION = TYPE II

$Q_{1000} = 40.57$ CFS (SEE ATTACHED HYDROGRAPH REPORT)

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN # 2	DC-BN-601666-001	25 of 128

TO EVALUATE THE STORAGE CAPACITY OF BASIN 2, TREAT THE DITCH IN BASIN 2 AS A POND.

ELEVATION	AREA	VOLUME
707	Ø	Ø
708	389	130
709	934	772
710	3,773	2,966
711	8,114	8,772
712	13,841	19,622
713	23,699	38,170

OUTLET IS A 12"Ø HDPE PIPE @ 1% SLOPE

∴ STORAGE CAPACITY IN BASIN 2 IS ABLE TO CONTAIN THE 1000YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT) MAXIMUM ELEVATION IS 712.46.

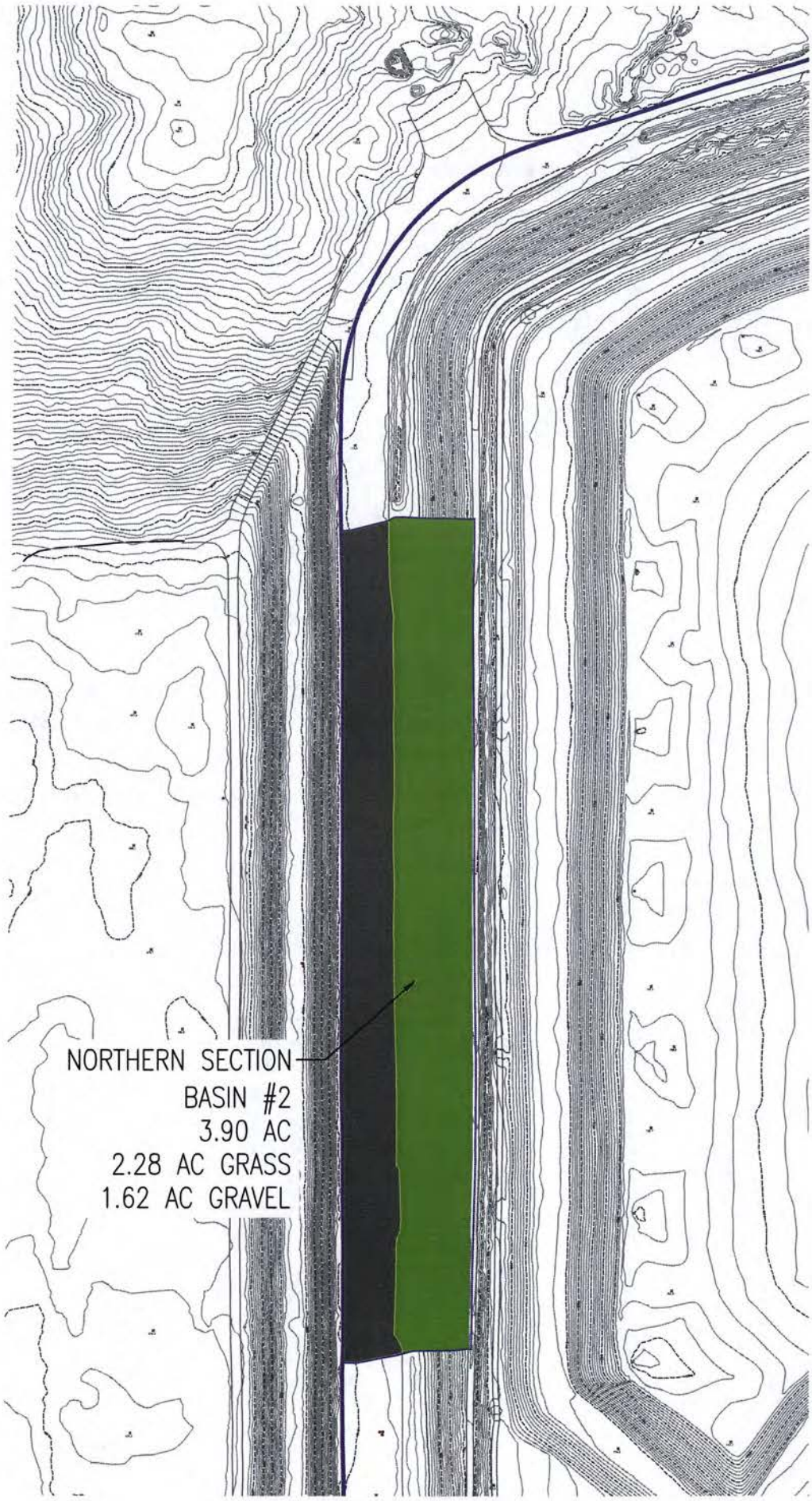

NORTHERN SECTION
BASIN #2
3.90 AC
2.28 AC GRASS
1.62 AC GRAVEL

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

TR55 Tc Worksheet

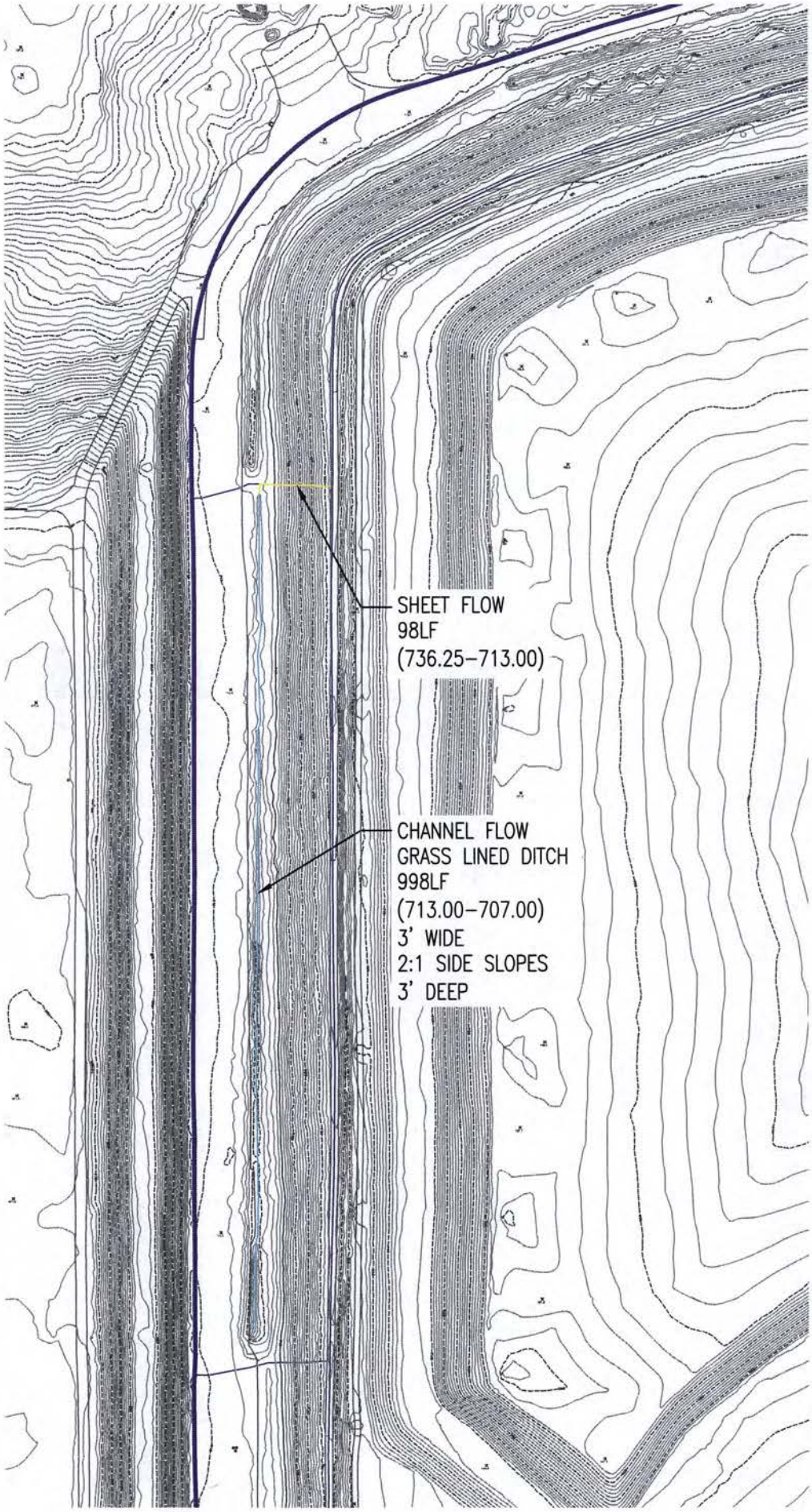
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 4

Basin 2

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 98.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 23.72		0.00		0.00		
Travel Time (min)	**= 3.29**	**+**	**0.00**	**+**	**0.00**	**=**	**3.29**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 10.59		0.00		0.00		
Wetted perimeter (ft)	= 10.47		0.00		0.00		
Channel slope (%)	= 0.60		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=3.88						
			0.00				
					0.00		
Flow length (ft)	({0})998.0		0.0		0.0		
Travel Time (min)	**= 4.29**	**+**	**0.00**	**+**	**0.00**	**=**	**4.29**

Total Travel Time, Tc ..... **7.58 min**


SHEET FLOW
98LF
(736.25–713.00)
CHANNEL FLOW
GRASS LINED DITCH
998LF
(713.00–707.00)
3' WIDE
2:1 SIDE SLOPES
3' DEEP

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t= travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ (2.1.10)

Paved $V = 20.33(S)^{0.5}$ (2.1.11)

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Friday, Jul 22 2016

Basin 2 Ditch

Trapezoidal

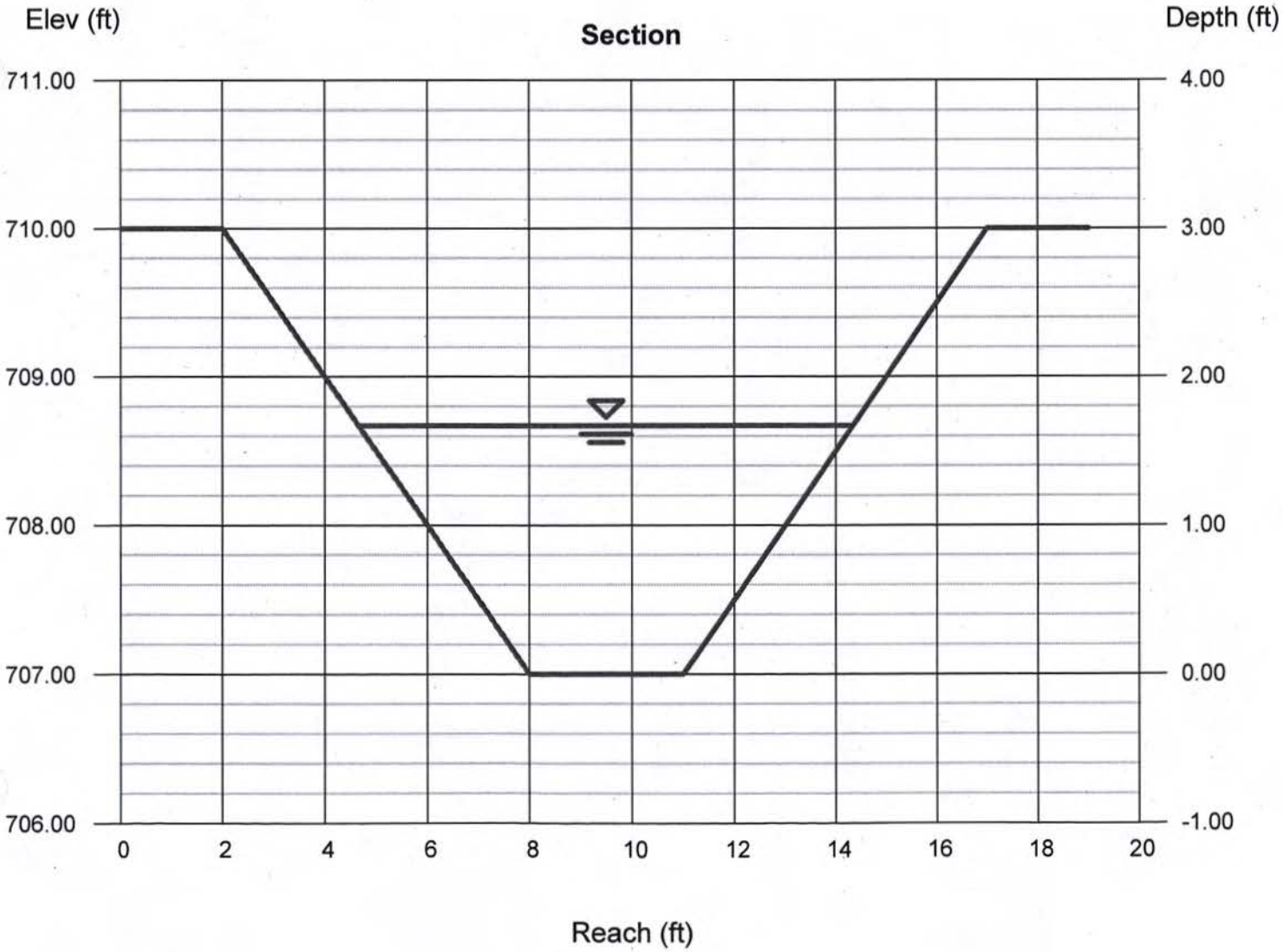
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 707.00
Slope (%)	= 0.60
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 40.57

Highlighted

Depth (ft)	= 1.67
Q (cfs)	= 40.57
Area (sqft)	= 10.59
Velocity (ft/s)	= 3.83
Wetted Perim (ft)	= 10.47
Crit Depth, Yc (ft)	= 1.33
Top Width (ft)	= 9.68
EGL (ft)	= 1.90



3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015

Hydrograph Report

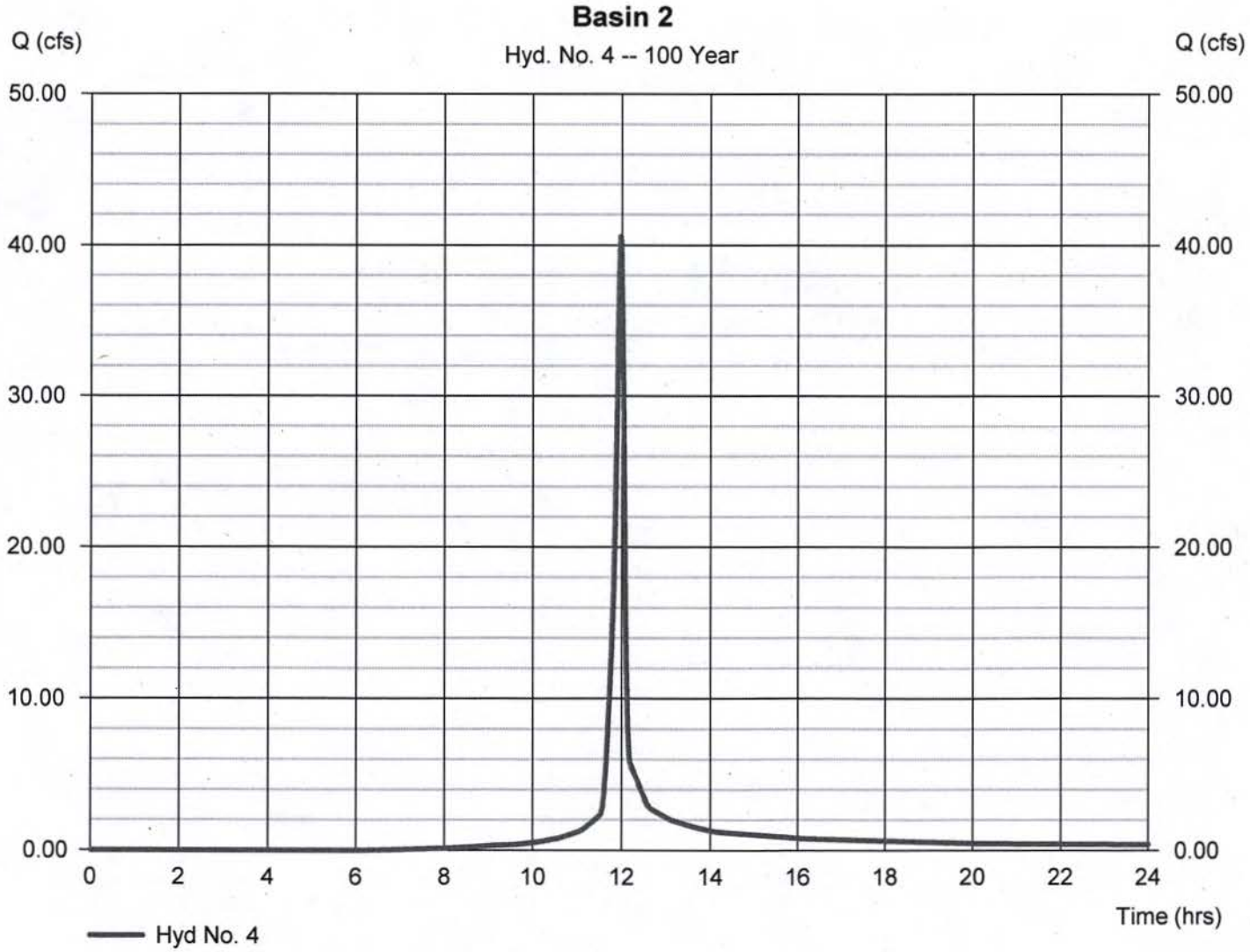
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Hyd. No. 4

Basin 2

Hydrograph type	= SCS Runoff	Peak discharge	= 40.57 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.97 hrs
Time interval	= 1 min	Hyd. volume	= 87,483 cuft
Drainage area	= 3.900 ac	Curve number	= 71*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.60 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(2.280 x 61) + (1.620 x 85)] / 3.900



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 Thursday, 07 / 14 / 2016

Pond No. 2 - Basin 2

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 707.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	707.00	00	0	0
1.00	708.00	389	130	130
2.00	709.00	934	642	772
3.00	710.00	3,773	2,195	2,966
4.00	711.00	8,114	5,806	8,772
5.00	712.00	13,841	10,850	19,622
6.00	713.00	23,699	18,549	38,170

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 12.00	0.00	0.00	0.00
Span (in)	= 12.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 707.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

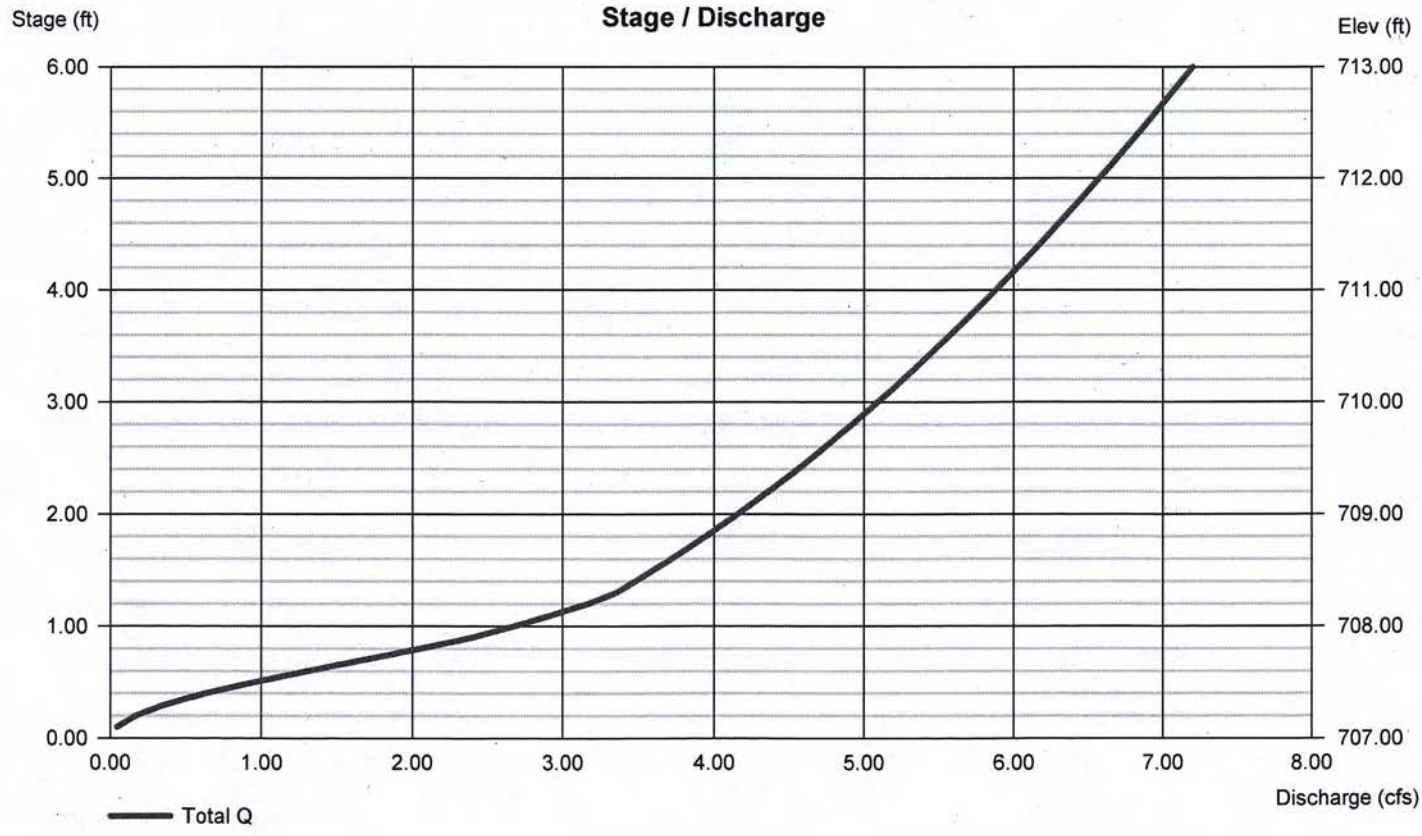
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 2 - Basin 2

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

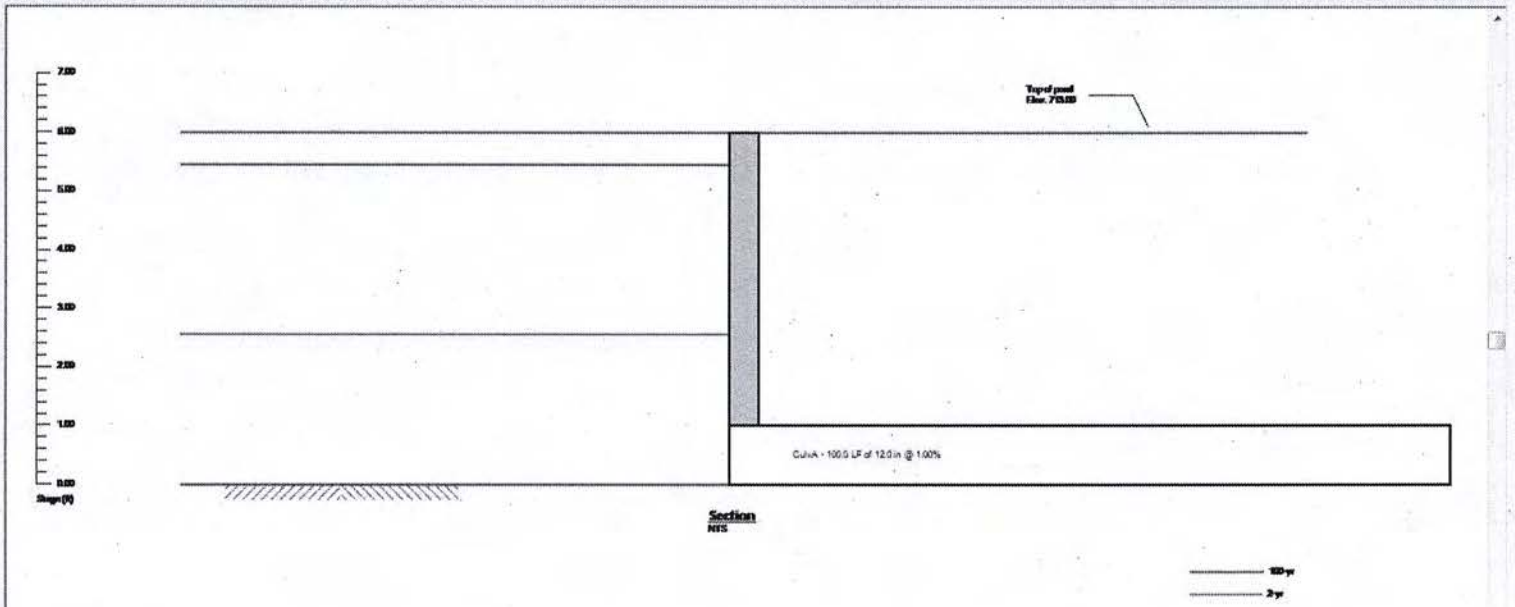
Storage Estimate

Inflow Hyd. No. = 4 - SCS Runoff - Basin 2

Event (yrs)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	17,564	8.261	0.000	
3				
5				
10				
25				
50				
100	87,483	40.57	0.000	

Estimate Storage

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

1.0 | 0.01 | 0.01

Culv/Orif	A	B	C	PR	Weir	A	B	C	D
Select	◉	○	○	○	Select	◉	○	○	○
Active	☑	☑	☑	☑	Active	☑	☑	☑	☑

Diameter (in) = 12.00 | Crest Len (ft) = 0.00

Invert El. (ft) = 707.00 | Crest Elev (ft) = 0.00

Update | ☑ Auto Update | Trial Route | ☐ Auto Route

Actuals			
Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	4.695	709.55	1,984
100	6.866	712.46	28,119

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AFS	7/22/16
BASIN #3	Calculation Number DC-BN-601666-001	Sheet 36 of 128

DRAINAGE AREA = 2.17AC (SEE ATTACHED MAP)

CURVE NUMBER = 70 (SEE ATTACHED TABLE)

1.39AC @ CN 61 (GRASS)

0.77AC @ CN 85 (GRAVEL)

0.01AC @ CN 98 (CONCRETE)

$\frac{(1.39\times61)+(0.77\times85)+(0.01\times98)}{2.17} = 69.69 = 70$

TIME OF CONCENTRATION = 6.60 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 115 L.F.

LAND SLOPE = $\frac{738.50-713.00}{115} = 0.2217 = 22.17\%$

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

GRASS LINED 3' WIDE DITCH WITH 2:1 SIDE SLOPES AND 3' DEEP

CROSS SECTIONAL AREA = 6.955S.F.

WETTED PERIMETER = 8.63 L.F.

CHANNEL SLOPE = $\frac{713.00-709.00}{587} = 0.0068 = 0.68\%$

MANNING'S n-VALUE = 0.030 (VEGETAL LINING)

FLOW LENGTH = 587 L.F

TIME INTERVAL = 2MIN

$T_c \times 0.1333 = 6.60 \times 0.1333 = 0.88 = 2$

STORM DISTRIBUTION = TYPE II

Q_{1000} = 24.40 CFS (SEE ATTACHED HYDROGRAPH REPORT)

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #3	DC-BN-601666-001	37 of 128

TO EVALUATE THE STORAGE CAPACITY OF BASIN 3, TREAT THE DITCH IN BASIN 3 AS A POND.

ELEVATION	AREA	VOLUME
709	Ø	Ø
710	302	101
711	1,413	890
712	3,731	3,370
713	7,228	8,753

OUTLET IS A 12"Ø HDPE PIPE @ 1% SLOPE

∴ THE STORAGE CAPACITY IN BASIN 3 IS UNABLE TO CONTAIN THE 1000YR - 24HR STORM EVENT. (SEE ATTACHED POND REPORT)

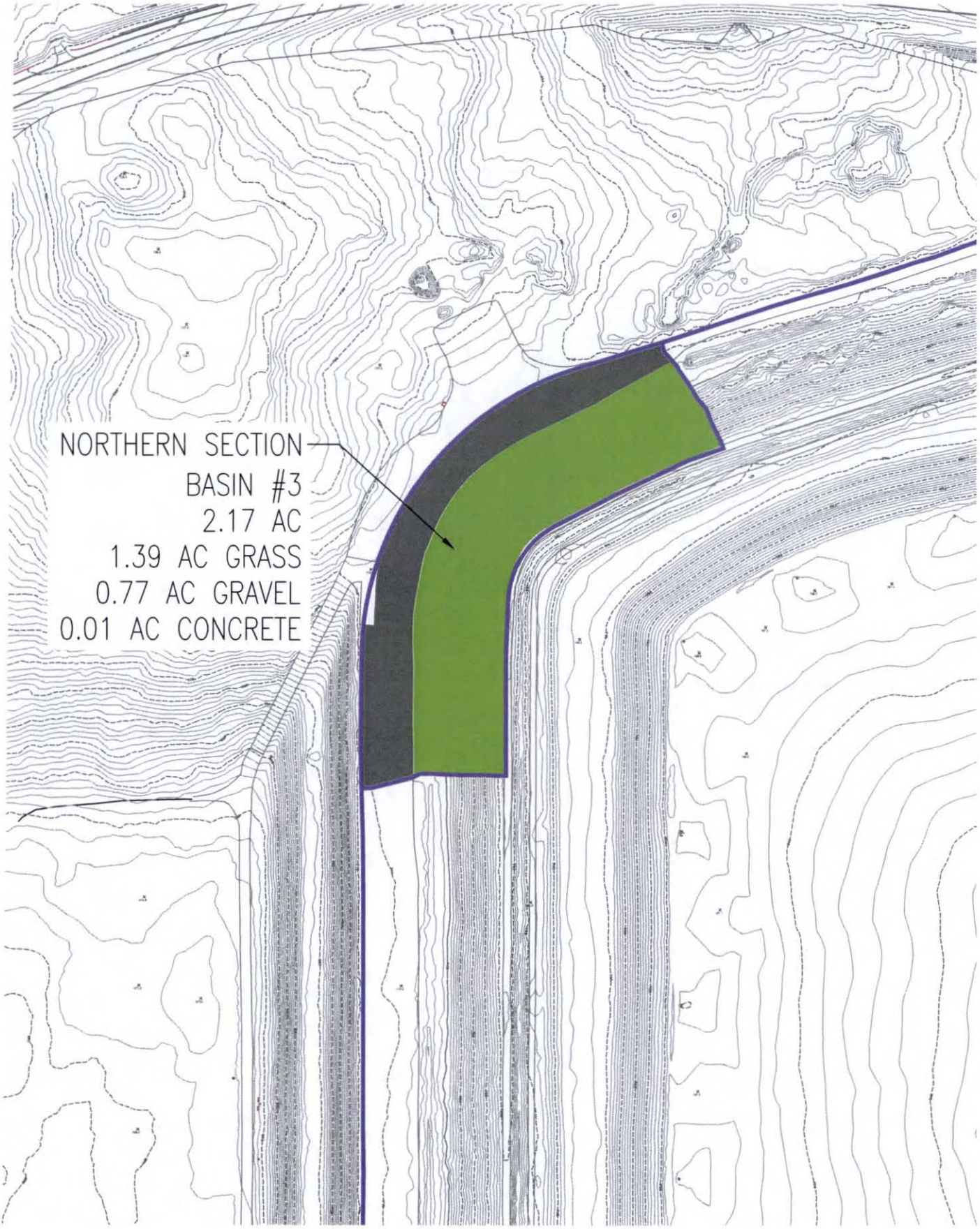

NORTHERN SECTION
BASIN #3
2.17 AC
1.39 AC GRASS
0.77 AC GRAVEL
0.01 AC CONCRETE

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

TR55 Tc Worksheet

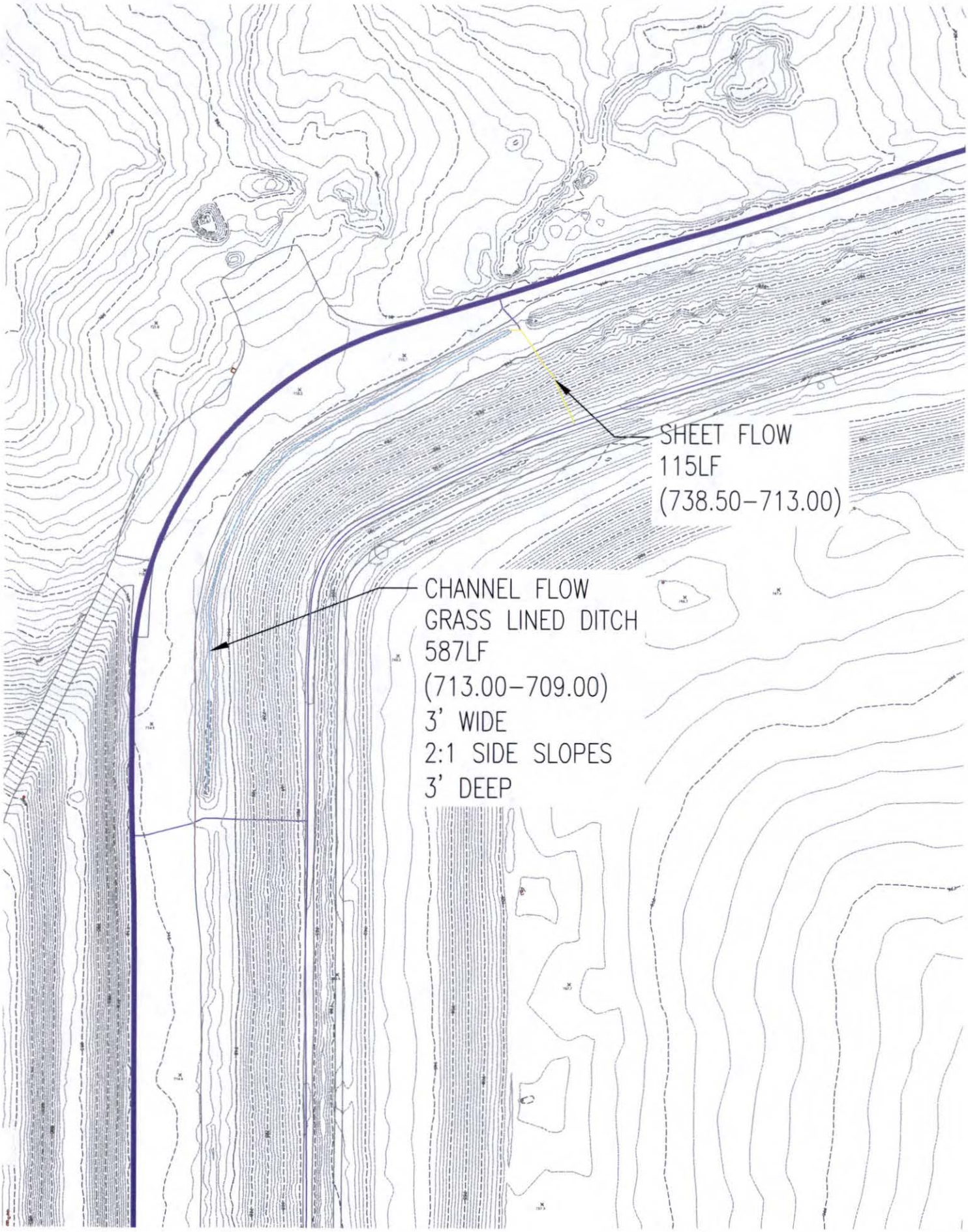
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 7

Basin 3

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 115.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 22.17		0.00		0.00		
Travel Time (min)	**= 3.85**	**+**	**0.00**	**+**	**0.00**	**=**	**3.85**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 6.99		0.00		0.00		
Wetted perimeter (ft)	= 8.63		0.00		0.00		
Channel slope (%)	= 0.68		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=3.56						
			0.00				
					0.00		
Flow length (ft)	({0})587.0		0.0		0.0		
Travel Time (min)	**= 2.75**	**+**	**0.00**	**+**	**0.00**	**=**	**2.75**

Total Travel Time, Tc ..... 6.60 min


SHEET FLOW
115LF
(738.50–713.00)
CHANNEL FLOW
GRASS LINED DITCH
587LF
(713.00–709.00)
3' WIDE
2:1 SIDE SLOPES
3' DEEP

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t= travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ **(2.1.10)**

Paved $V = 20.33(S)^{0.5}$ **(2.1.11)**

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Jul 14 2016

Basin 3 Ditch

Trapezoidal

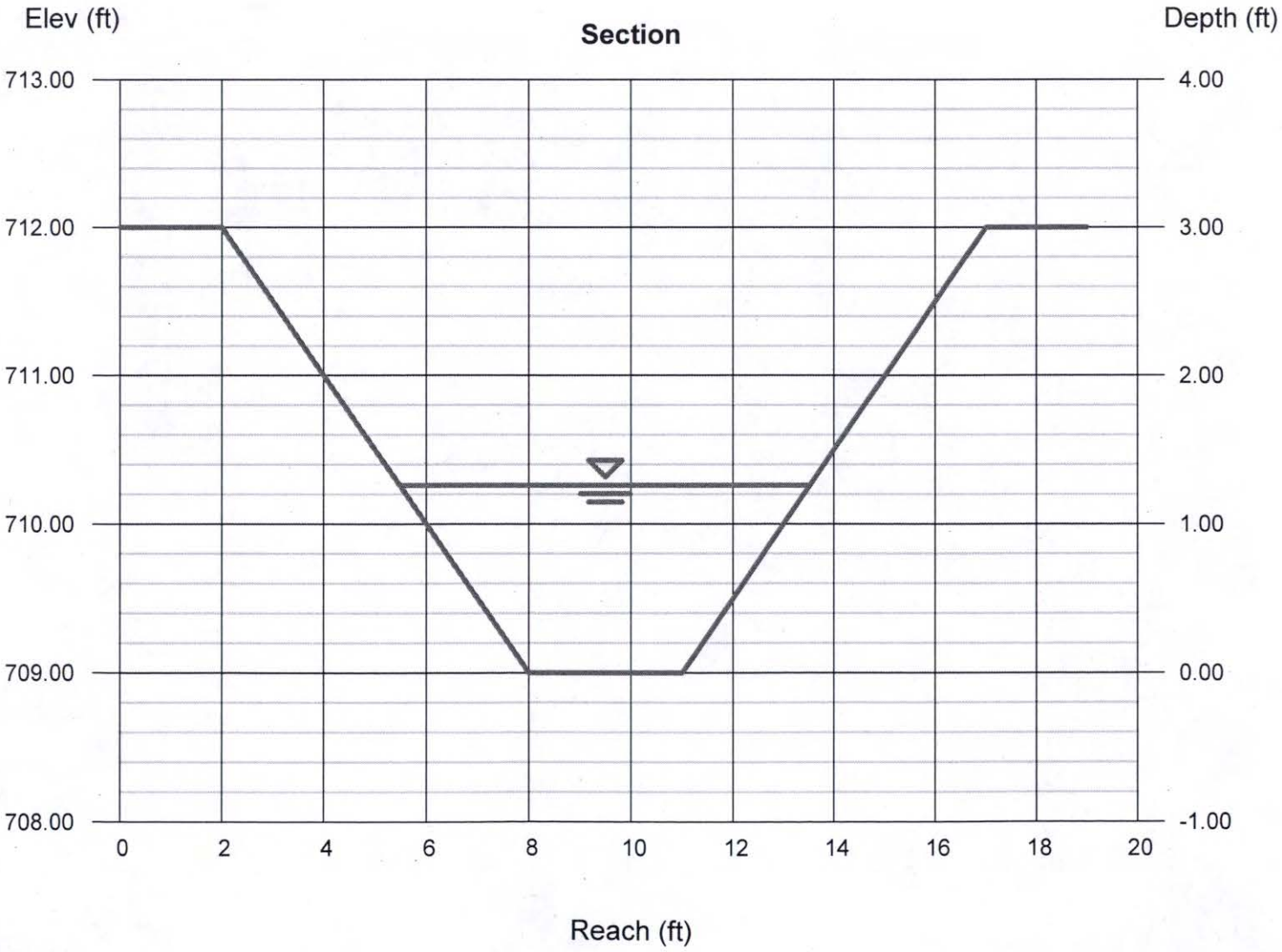
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 709.00
Slope (%)	= 0.68
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 24.40

Highlighted

Depth (ft)	= 1.26
Q (cfs)	= 24.40
Area (sqft)	= 6.96
Velocity (ft/s)	= 3.51
Wetted Perim (ft)	= 8.63
Crit Depth, Yc (ft)	= 1.01
Top Width (ft)	= 8.04
EGL (ft)	= 1.45



3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015

Hydrograph Report

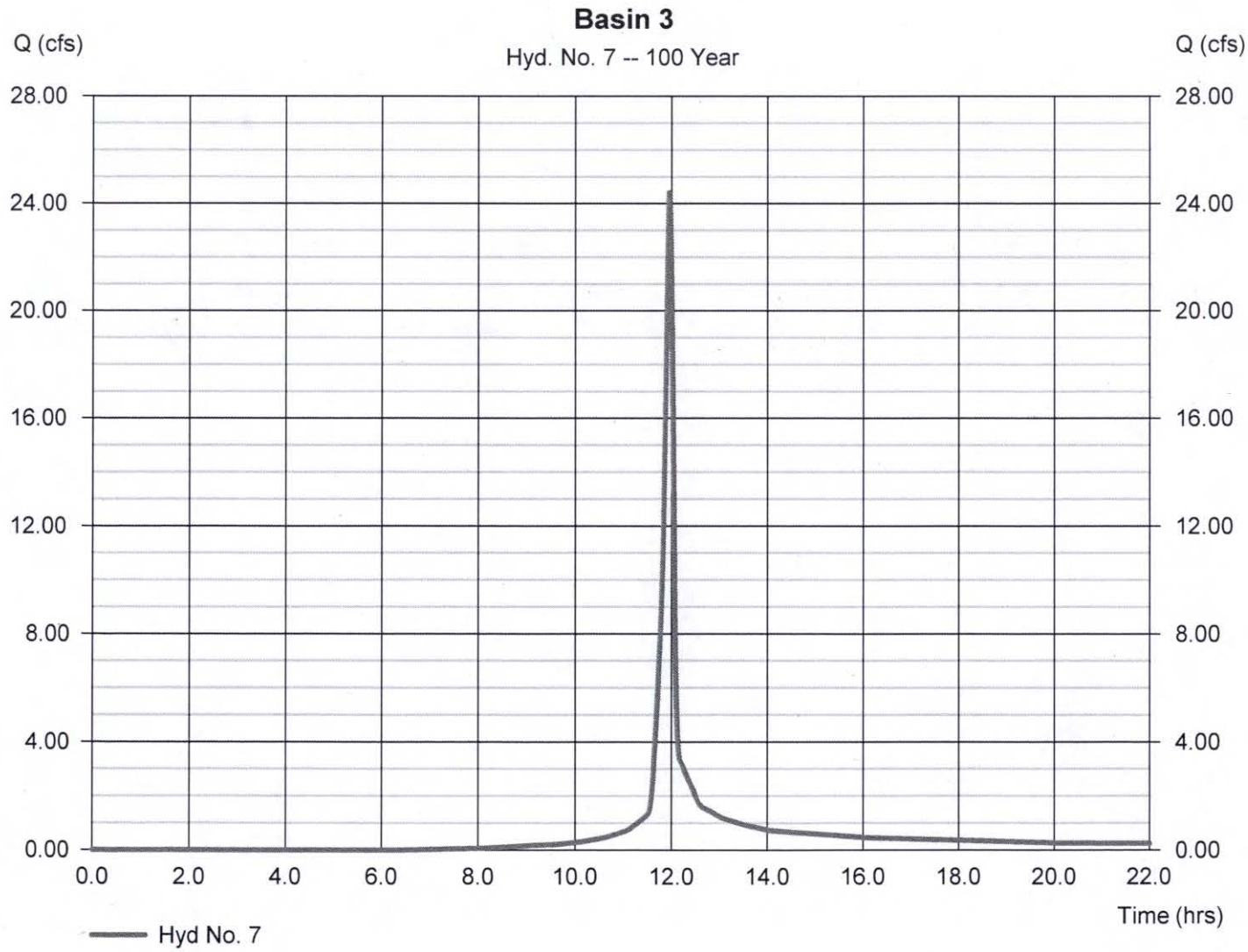
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Hyd. No. 7

Basin 3

Hydrograph type	= SCS Runoff	Peak discharge	= 24.40 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.95 hrs
Time interval	= 1 min	Hyd. volume	= 50,421 cuft
Drainage area	= 2.170 ac	Curve number	= 70*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.60 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.390 x 61) + (0.770 x 85) + (0.010 x 98)] / 2.170



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Pond No. 3 - Basin 3

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 709.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	709.00	00	0	0
1.00	710.00	302	101	101
2.00	711.00	1,413	789	890
3.00	712.00	3,731	2,480	3,370
4.00	713.00	7,228	5,383	8,753

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 12.00	0.00	0.00	0.00
Span (in)	= 12.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 709.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

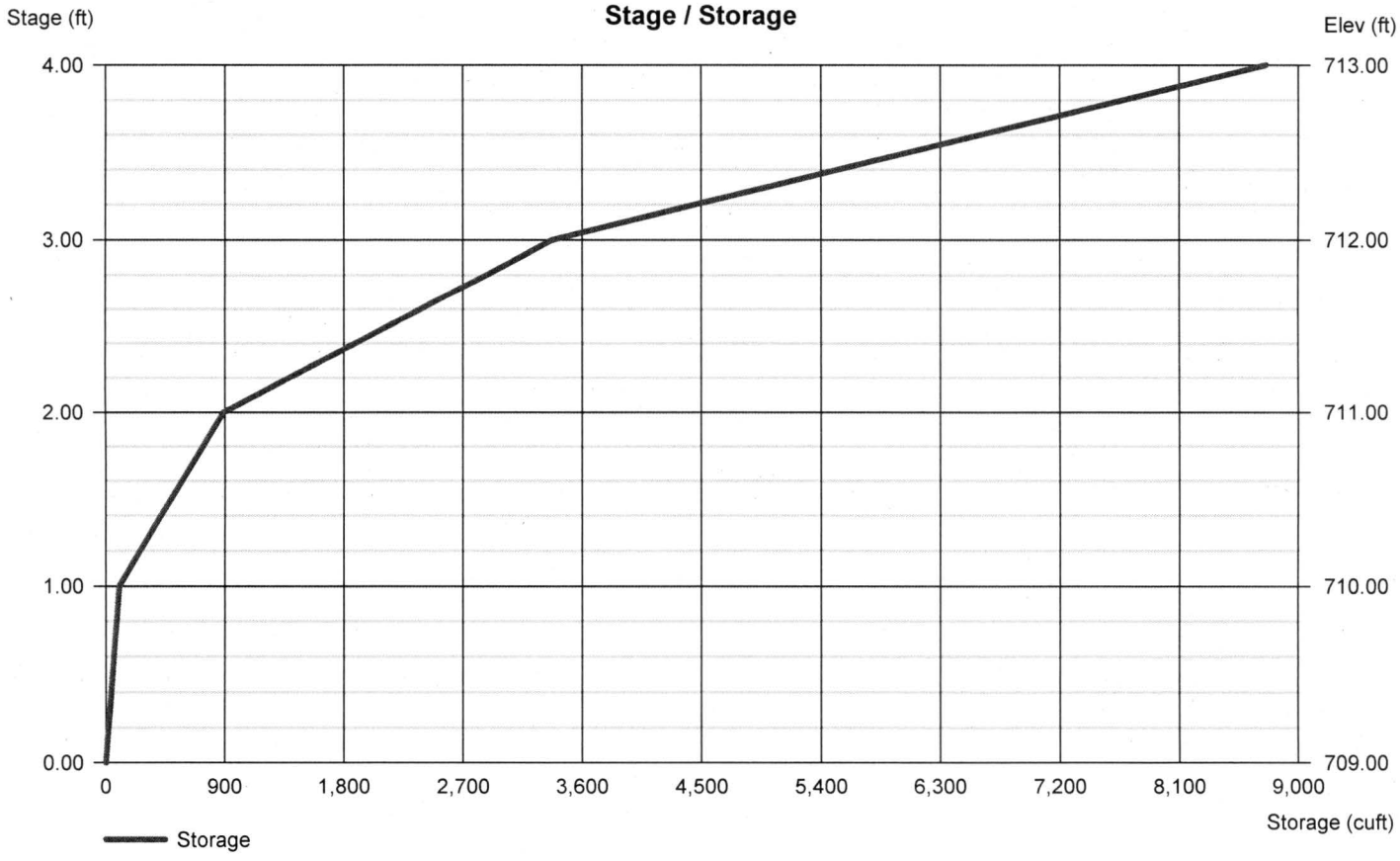
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 3 - Basin 3

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

Storage Estimate

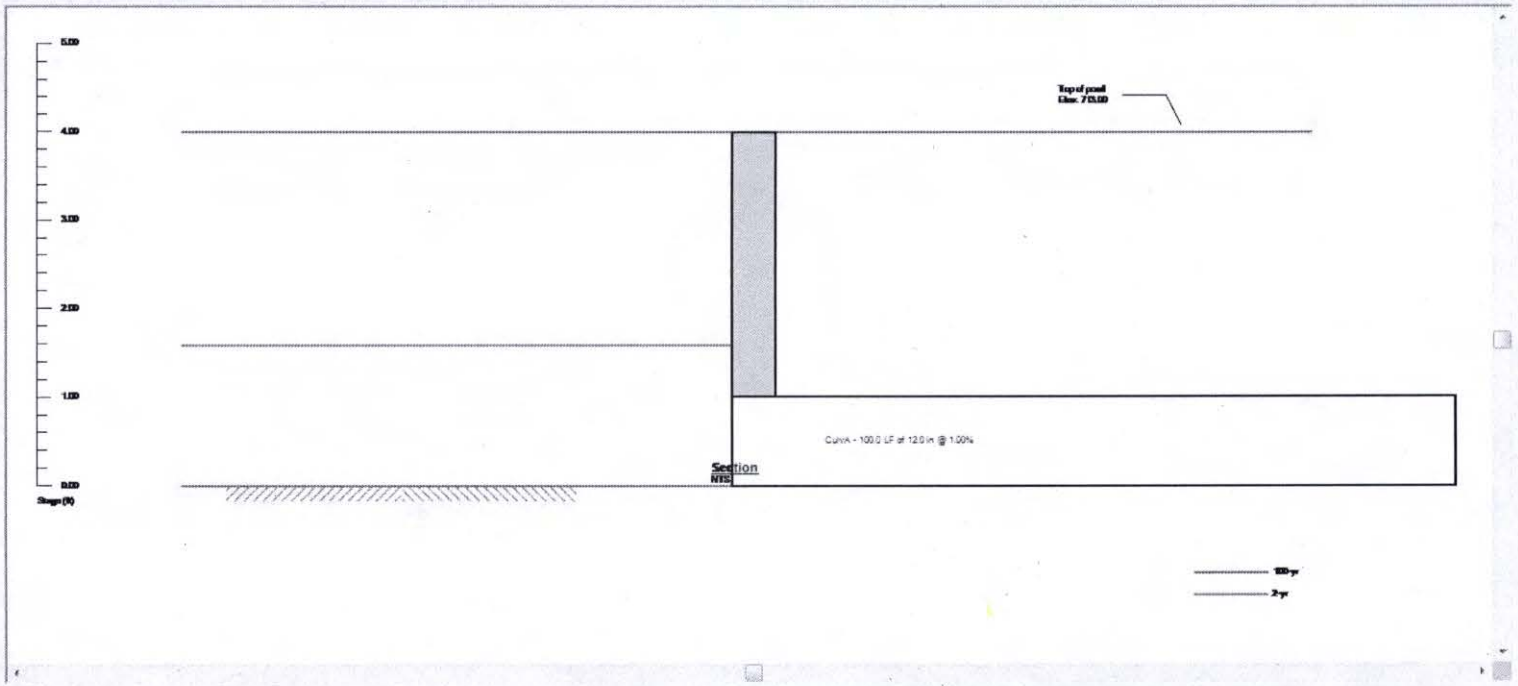
Inflow Hyd. No. = 7 - SCS Runoff - Basin 3

Event (yr)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	9,838	4.847	0.000	9,838*
3				
5				
10				
25				
50				
100	50,421	24.40	0.000	50,421*

Estimate Storage

*Exceeds available storage!

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

Culv/Orif	A	B	C	PR	Weir	A	B	C	D
Select	◉	○	○	○	Select	◉	○	○	○
Active	☑	☑	☑	☑	Active	☑	☑	☑	☑

Diameter (in) = 12.00 | Crest Len (ft) = 0.00

Invert El. (ft) = 709.00 | Crest Elev (ft) = 0.00

Update | ☑ Auto Update | Trial Route | ☐ Auto Route

Actuals			
Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	3.697	710.58	560
100	NS	NS	NS

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	Reviewed By	Date
NORTHERN SECTION	AES	7/22/16
BASIN #4	Calculation Number DC-BN-601666-001	Sheet 48 of 128

DRAINAGE AREA = 3.70 AC (SEE ATTACHED MAP)

CURVE NUMBER = 64 (SEE ATTACHED TABLE)

3.22 AC @ CN 61 (GRASS)

0.48 AC @ CN 85 (GRAVEL)

$\frac{(3.22 \times 61) + (0.48 \times 85)}{3.70} = 64.11 = 64$

TIME OF CONCENTRATION = 8.90 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 106 L.F.

LAND SLOPE = $\frac{741.25 - 715.00}{106} = 0.2476 = 24.76\%$

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

GRASS LINED 3' WIDE DITCH WITH 2:1 SIDE SLOPES AND 3' DEEP

CROSS SECTIONAL AREA = 9.272 S.F.

WETTED PERIMETER = 9.84 L.F.

CHANNEL SLOPE = $\frac{715.00 - 709.00}{1127} = 0.0053 = 0.53\%$

MANNING'S n-VALUE = 0.030 (VEGETAL LINING)

FLOW LENGTH = 1127 L.F.

TIME INTERVAL = 2 MIN

Tc × 0.1333 = 8.90 × 0.1333 = 1.19 = 2

STORM DISTRIBUTION = TYPE II

Q_{1000} = 31.76 CFS (SEE ATTACHED HYDROGRAPH REPORT)

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #4	DC-BN-601666-001	49 of 128

TO EVALUATE THE STORAGE CAPACITY OF BASIN 4, TREAT THE DITCH IN BASIN 4 AS A POND.

ELEVATION	AREA	VOLUME
709	Ø	Ø
710	10	3
711	550	215
712	1,734	1,301
713	4,701	4,398

OUTLET IS A 12"Ø HDPE PIPE @ 1% SLOPE

∴ THE STORAGE CAPACITY IN BASIN 4 IS UNABLE TO CONTAIN THE 1000YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT)


NORTHERN SECTION
BASIN #4
3.70 AC
3.22 AC GRASS
0.48 AC GRAVEL

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

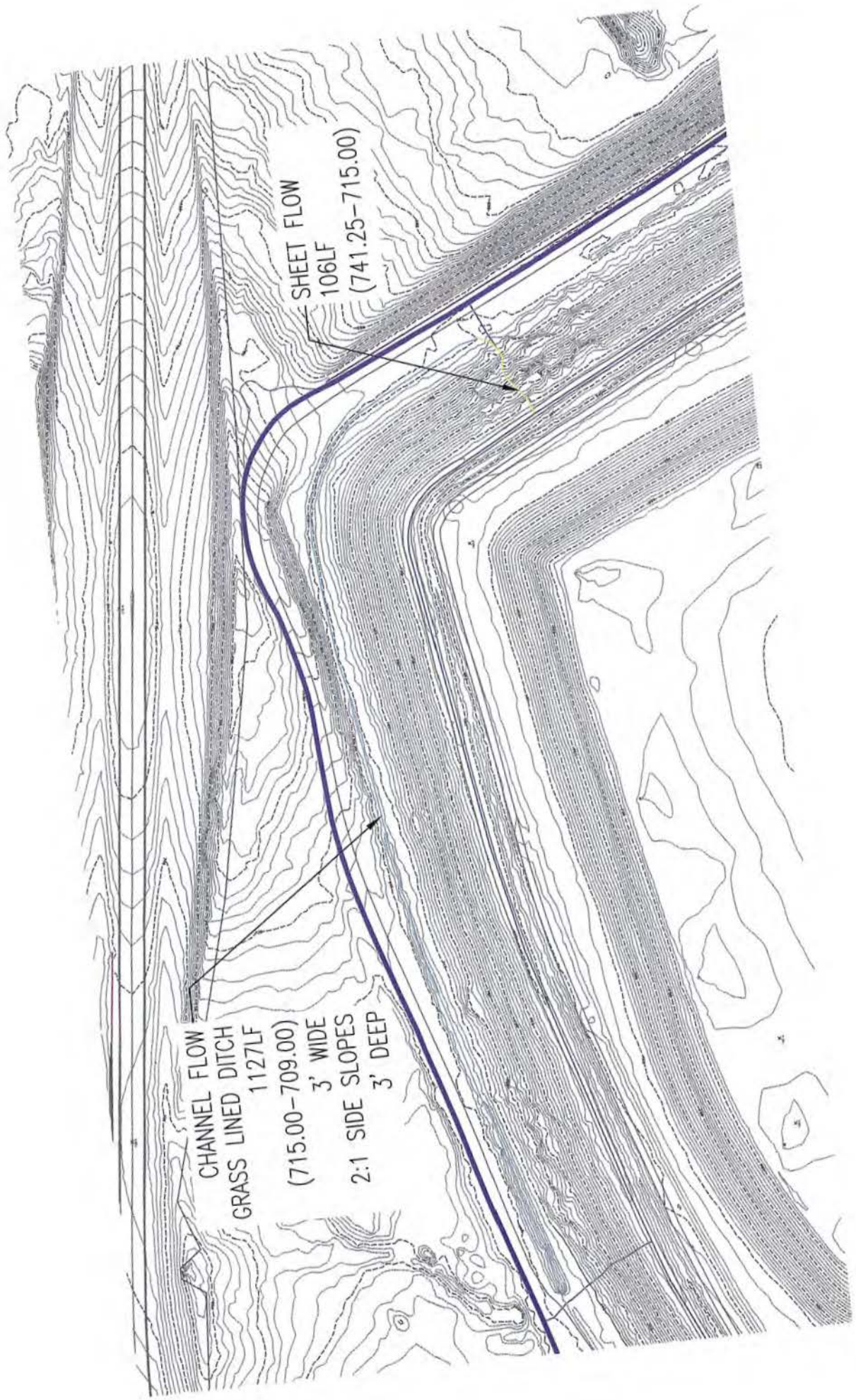
TR55 Tc Worksheet

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 10

Basin 4

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 106.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 24.76		0.00		0.00		
Travel Time (min)	**= 3.45**	**+**	**0.00**	**+**	**0.00**	**=**	**3.45**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 9.27		0.00		0.00		
Wetted perimeter (ft)	= 9.84		0.00		0.00		
Channel slope (%)	= 0.53		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=3.47						
			0.00				
					0.00		
Flow length (ft)	({0})1127.0		0.0		0.0		
Travel Time (min)	**= 5.41**	**+**	**0.00**	**+**	**0.00**	**=**	**5.41**
Total Travel Time, Tc							**8.85 min**


SHEET FLOW
106LF
(741.25–715.00)
CHANNEL FLOW
GRASS LINED DITCH
1127LF
(715.00–709.00)
3' WIDE
2:1 SIDE SLOPES
3' DEEP

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t= travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ **(2.1.10)**

Paved $V = 20.33(S)^{0.5}$ **(2.1.11)**

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Friday, Jul 22 2016

Basin 4 Ditch

Trapezoidal

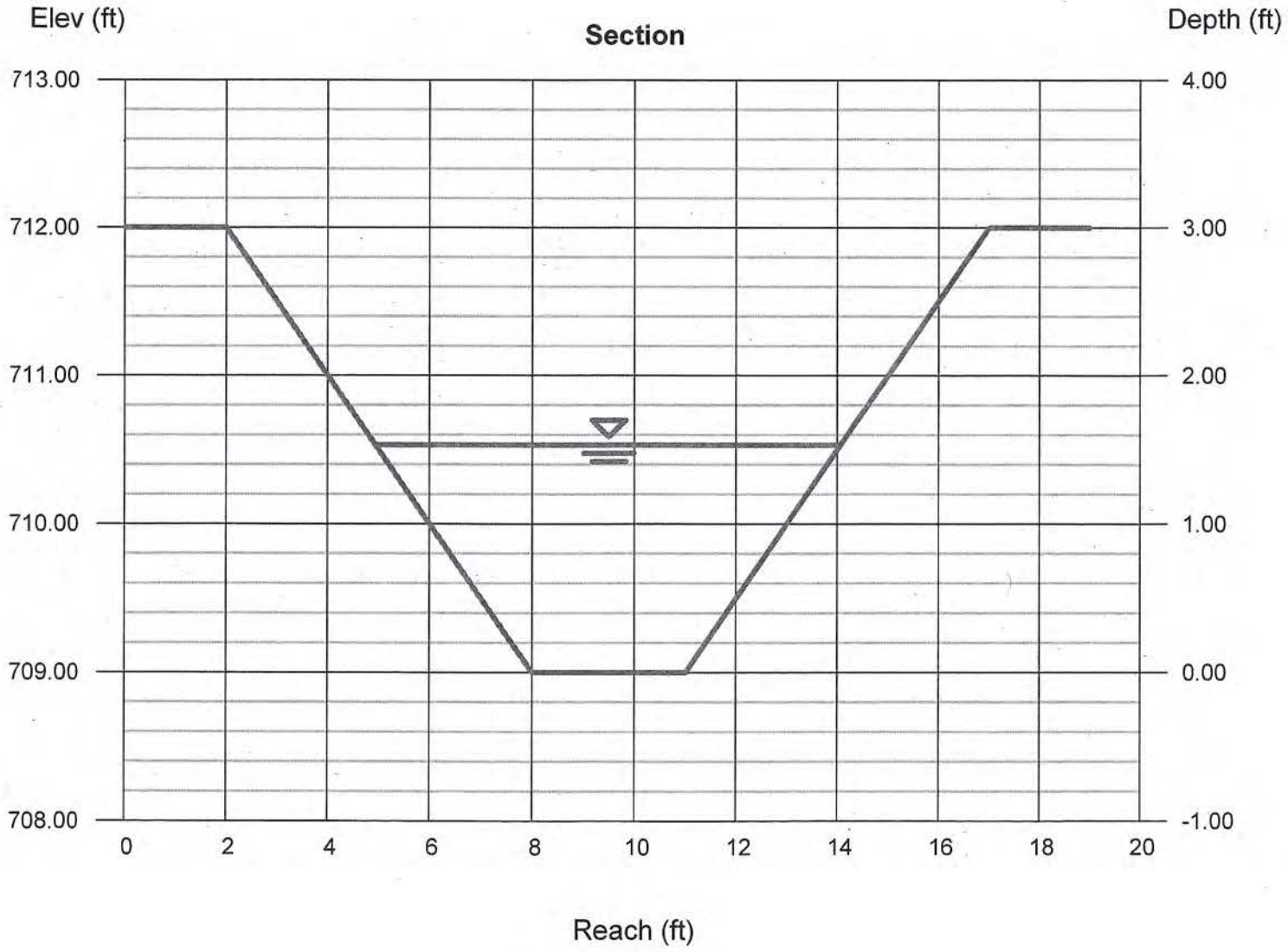
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 709.00
Slope (%)	= 0.53
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 31.76

Highlighted

Depth (ft)	= 1.53
Q (cfs)	= 31.76
Area (sqft)	= 9.27
Velocity (ft/s)	= 3.43
Wetted Perim (ft)	= 9.84
Crit Depth, Yc (ft)	= 1.17
Top Width (ft)	= 9.12
EGL (ft)	= 1.71



3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015

Hydrograph Report

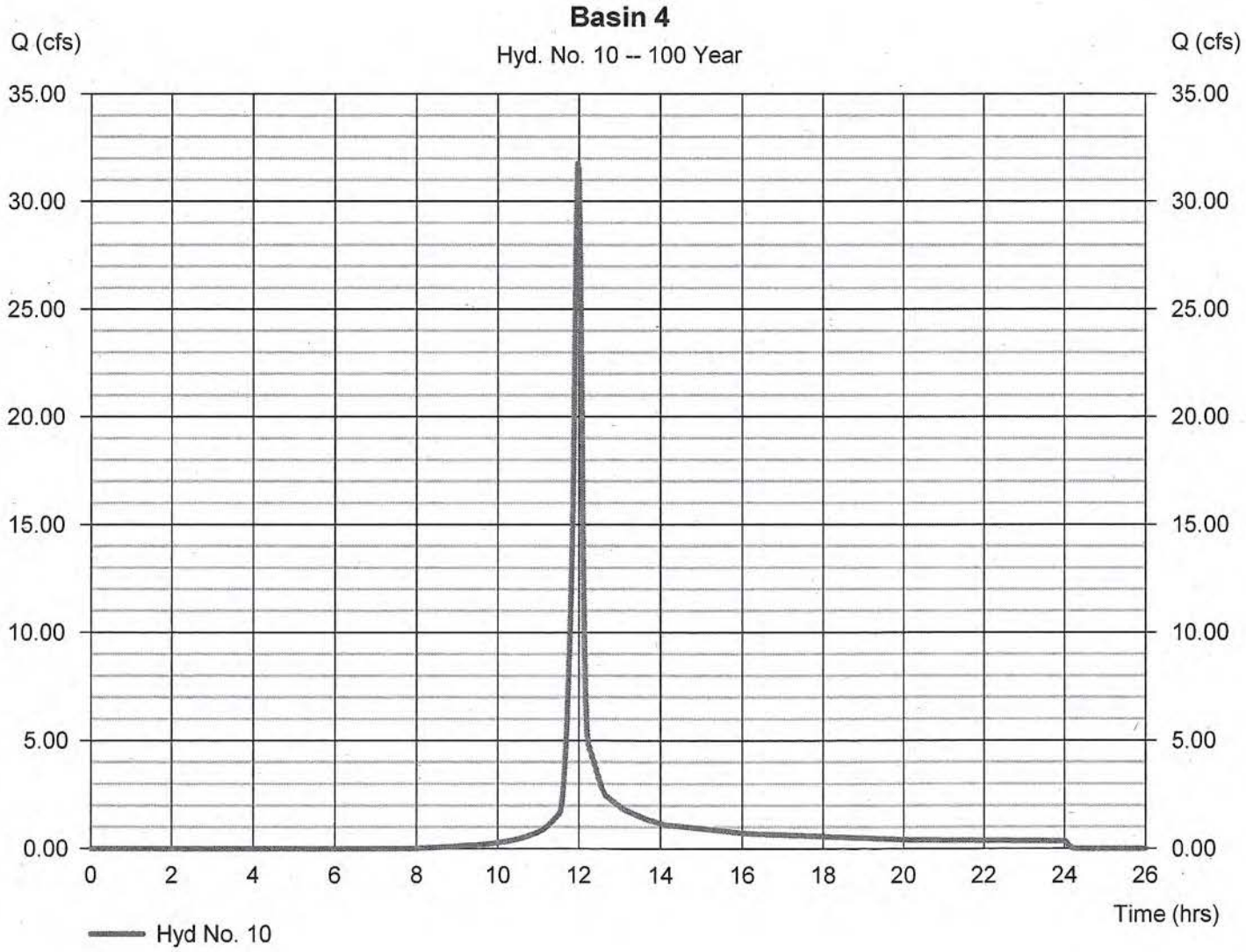
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Hyd. No. 10

Basin 4

Hydrograph type	= SCS Runoff	Peak discharge	= 31.76 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.97 hrs
Time interval	= 2 min	Hyd. volume	= 72,731 cuft
Drainage area	= 3.700 ac	Curve number	= 64*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.90 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(3.220 x 61) + (0.480 x 85)] / 3.700



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Pond No. 4 - Basin 4

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 709.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	709.00	00	0	0
1.00	710.00	10	3	3
2.00	711.00	550	211	215
3.00	712.00	1,734	1,087	1,301
4.00	713.00	4,701	3,096	4,398

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 12.00	0.00	0.00	0.00
Span (in)	= 12.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 709.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

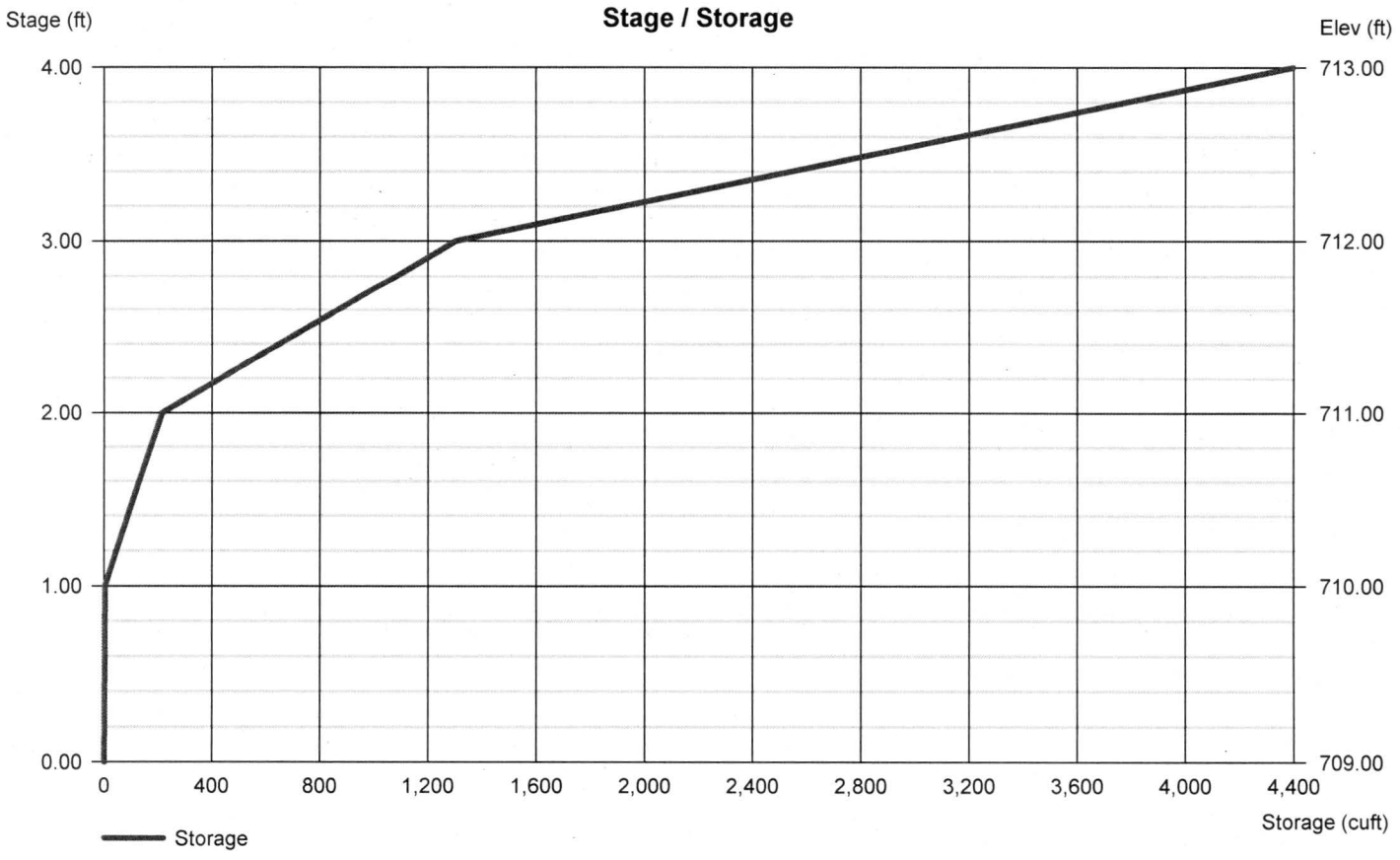
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 4 - Basin 4

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

Storage Estimate

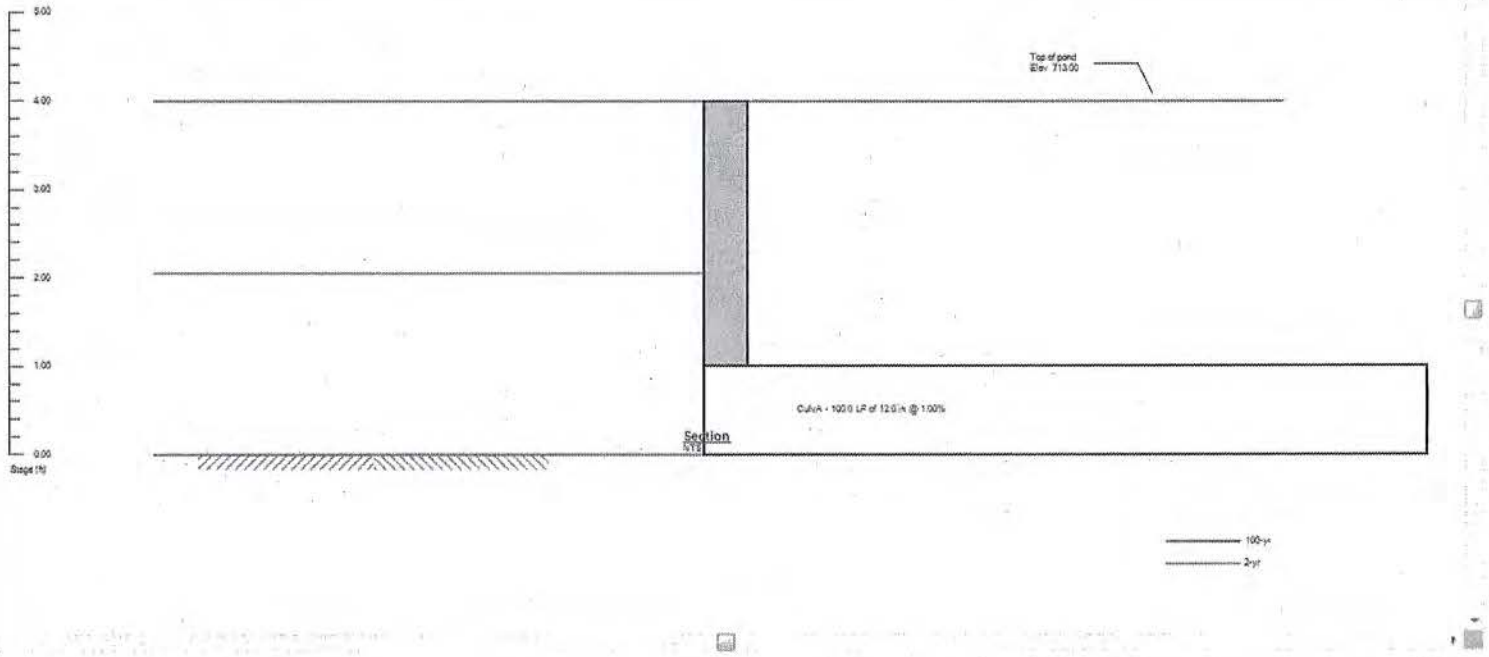
Inflow Hyd. No. = 10 - SCS Runoff - Basin 4

Event (yrs)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	11,725	4.799	0.000	11,725*
3				
5				
10				
25				
50				
100	72,731	31.76	0.000	72,731*

Estimated storage required. Read only. Estimate Storage

*Exceeds available storage!

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

1.0 / 0.01 / 0.01

Culv/Orif	A	B	C	PR	Weir	A	B	C	D
Select	◉	○	○	○	Select	◉	○	○	○
Active	☑	☑	☑	☑	Active	☑	☑	☑	☑

Diameter (in) = 12.00 | Crest Len (ft) = 0.00

Invert EL. (ft) = 709.00 | Crest Elev (ft) = 0.00

Update | ☑ Auto Update | Trial Route | ☐ Auto Route

Actuals			
Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	4.202	711.04	263
100	NS	NS	NS

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #5	DC-BN-601666-001	60 of 128

DRAINAGE AREA = 1.79 AC (SEE ATTACHED MAP)

CURVE NUMBER = 64 (SEE ATTACHED TABLE)

1.57 AC @ CN61 (GRASS)

0.22 AC @ CN85 (GRAVEL)

$\frac{(1.57 \times 61)+(0.22 \times 85)}{1.79} = 63.95 = 64$

TIME OF CONCENTRATION = 6.00 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 109 L.F.

LAND SLOPE = $\frac{741.25 - 715.00}{109} = 0.2408 = 24.08\%$

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

GRASS LINED 3' WIDE DITCH WITH 2:1 SIDE SLOPES AND 3' DEEP

CROSS SECTIONAL AREA = 5.00 S.F.

WETTED PERIMETER = 7.47 L.F.

CHANNEL SLOPE = $\frac{715.00 - 710.00}{541} = 0.0092 = 0.92\%$

MANNING'S n-VALUE = 0.030 (VEGETAL LINING)

FLOW LENGTH = 541 L.F.

TIME INTERVAL = 1 MIN

$Tc \times 0.1333 = 6.00 \times 0.1333 = 0.80 = 1$

STORM DISTRIBUTION = TYPE II

$Q_{1000} = 17.85$ CFS (SEE ATTACHED HYDROGRAPH REPORT)

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #5	DC-BN-601666-001	61 of 128

TO EVALUATE THE STORAGE CAPACITY OF BASIN 5, TREAT THE DITCH IN BASIN 5 AS A POND.

ELEVATION	AREA	VOLUME
710	Ø	Ø
711	56	18
712	940	427
713	2,517	2,092
714	4,847	5,711

OUTLET IS A 12"Ø HDPE PIPE @ 1% SLOPE

∴ THE STORAGE CAPACITY IN BASIN 5 IS UNABLE TO CONTAIN THE 100YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT)

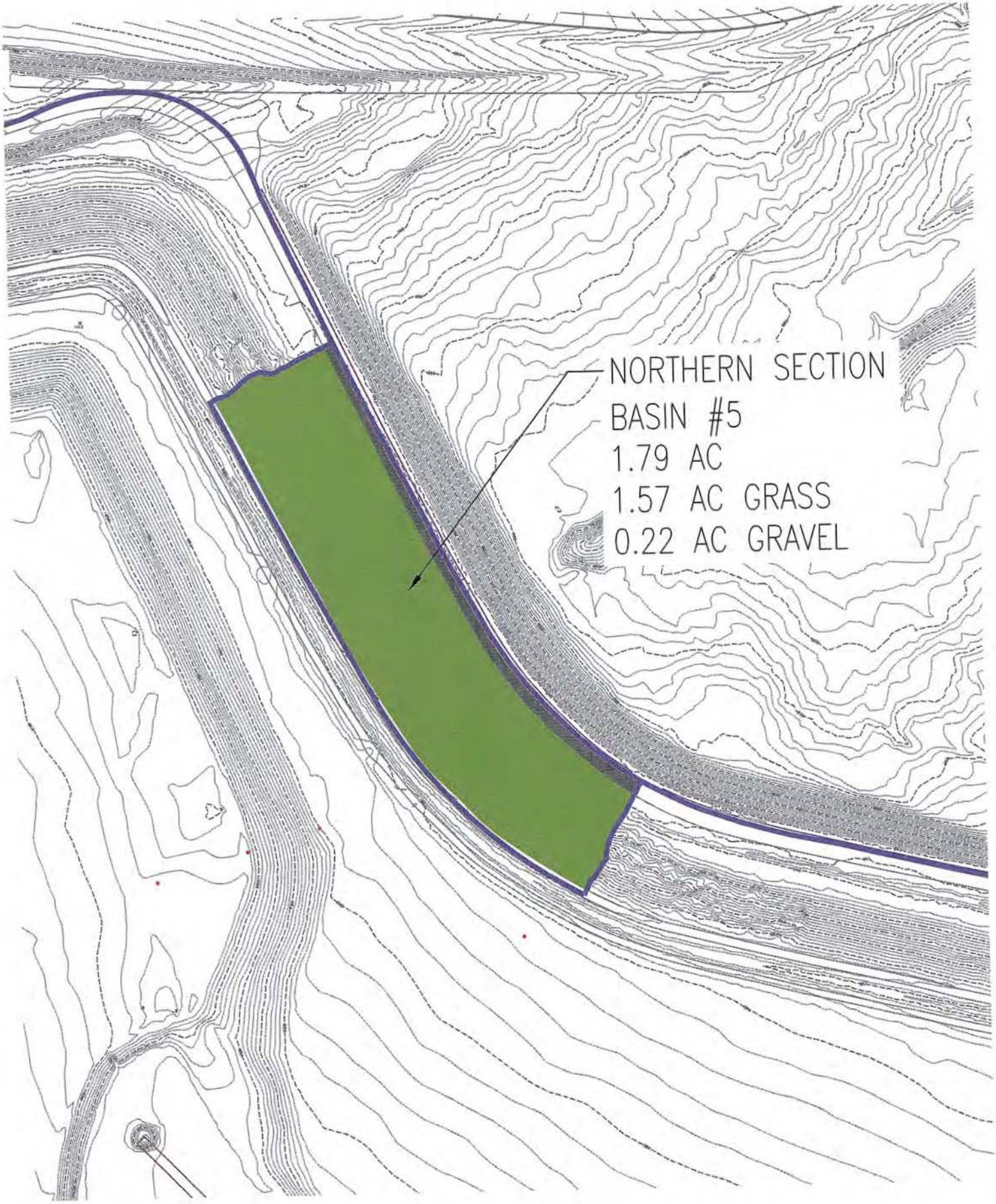

NORTHERN SECTION
BASIN #5
1.79 AC
1.57 AC GRASS
0.22 AC GRAVEL

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

TR55 Tc Worksheet

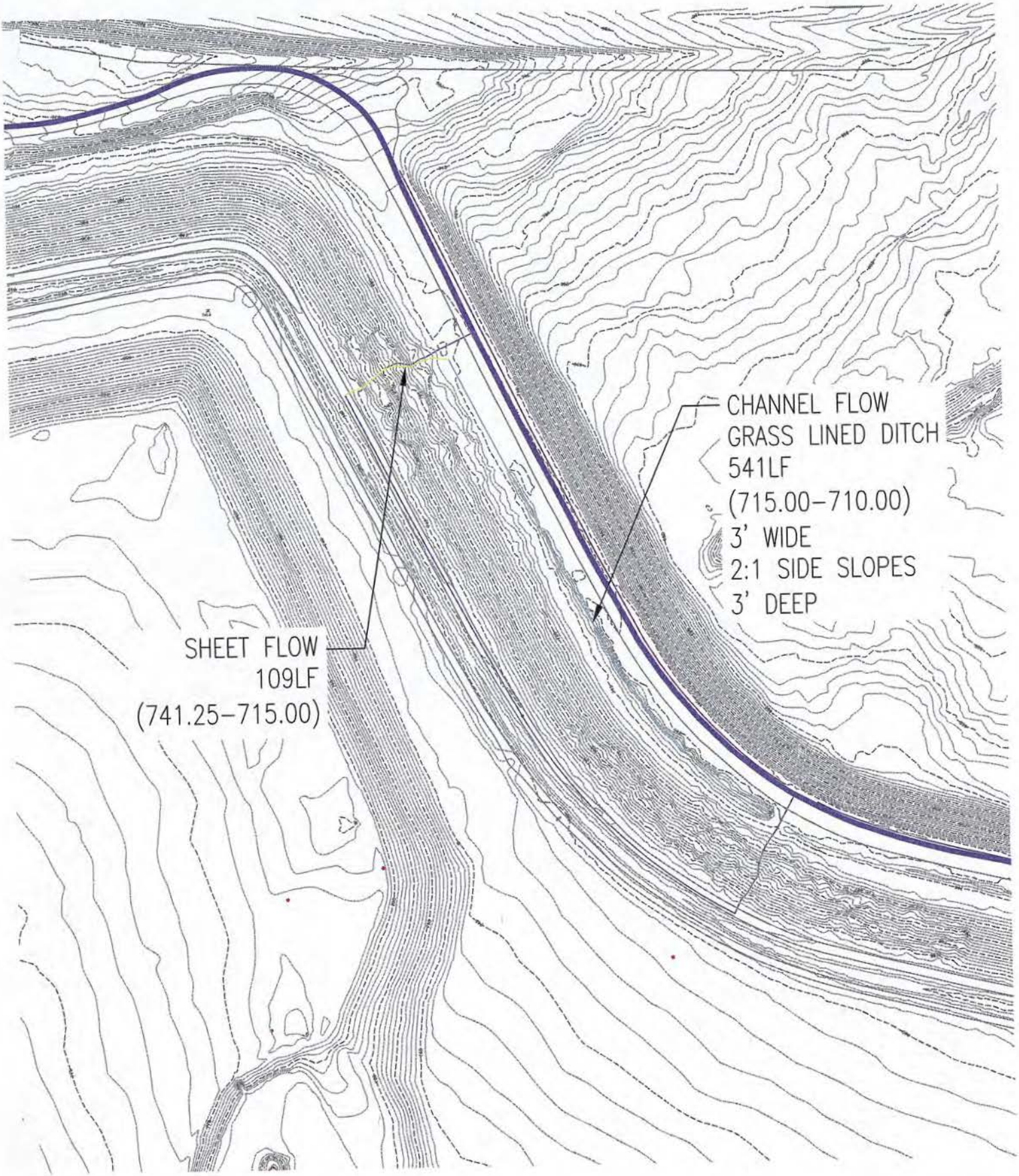
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 13

Basin 5

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 109.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 24.08		0.00		0.00		
Travel Time (min)	**= 3.57**	**+**	**0.00**	**+**	**0.00**	**=**	**3.57**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 5.00		0.00		0.00		
Wetted perimeter (ft)	= 7.47		0.00		0.00		
Channel slope (%)	= 0.92		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=3.64						
			0.00				
					0.00		
Flow length (ft)	({0})541.0		0.0		0.0		
Travel Time (min)	**= 2.48**	**+**	**0.00**	**+**	**0.00**	**=**	**2.48**

Total Travel Time, Tc ..... 6.04 min


CHANNEL FLOW
GRASS LINED DITCH
541LF
(715.00-710.00)
3' WIDE
2:1 SIDE SLOPES
3' DEEP
SHEET FLOW
109LF
(741.25-715.00)

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t= travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ (2.1.10)

Paved $V = 20.33(S)^{0.5}$ (2.1.11)

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Jul 14 2016

Basin 5 Ditch

Trapezoidal

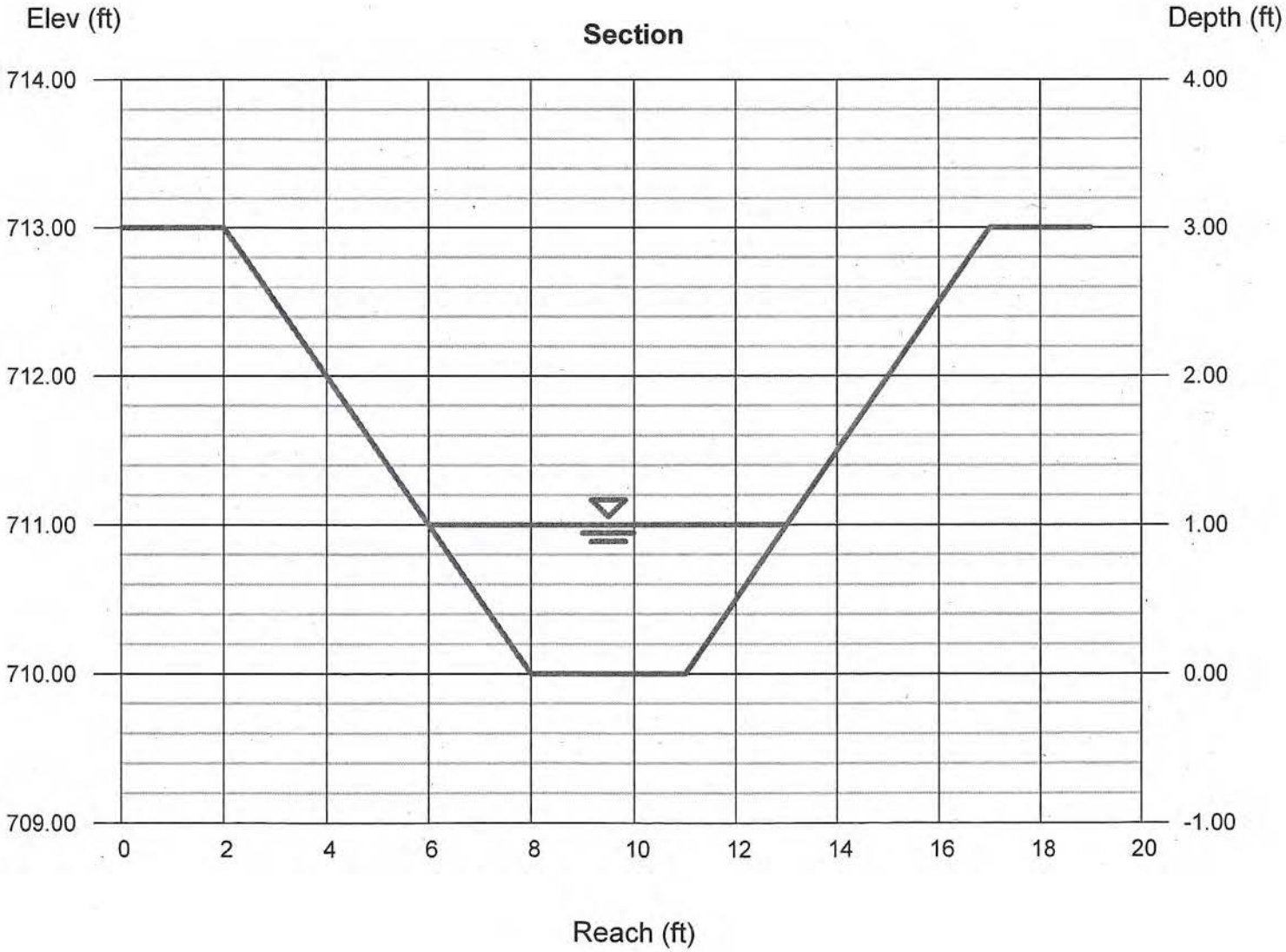
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 710.00
Slope (%)	= 0.92
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 17.85

Highlighted

Depth (ft)	= 1.00
Q (cfs)	= 17.85
Area (sqft)	= 5.00
Velocity (ft/s)	= 3.57
Wetted Perim (ft)	= 7.47
Crit Depth, Yc (ft)	= 0.85
Top Width (ft)	= 7.00
EGL (ft)	= 1.20



3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015

Hydrograph Report

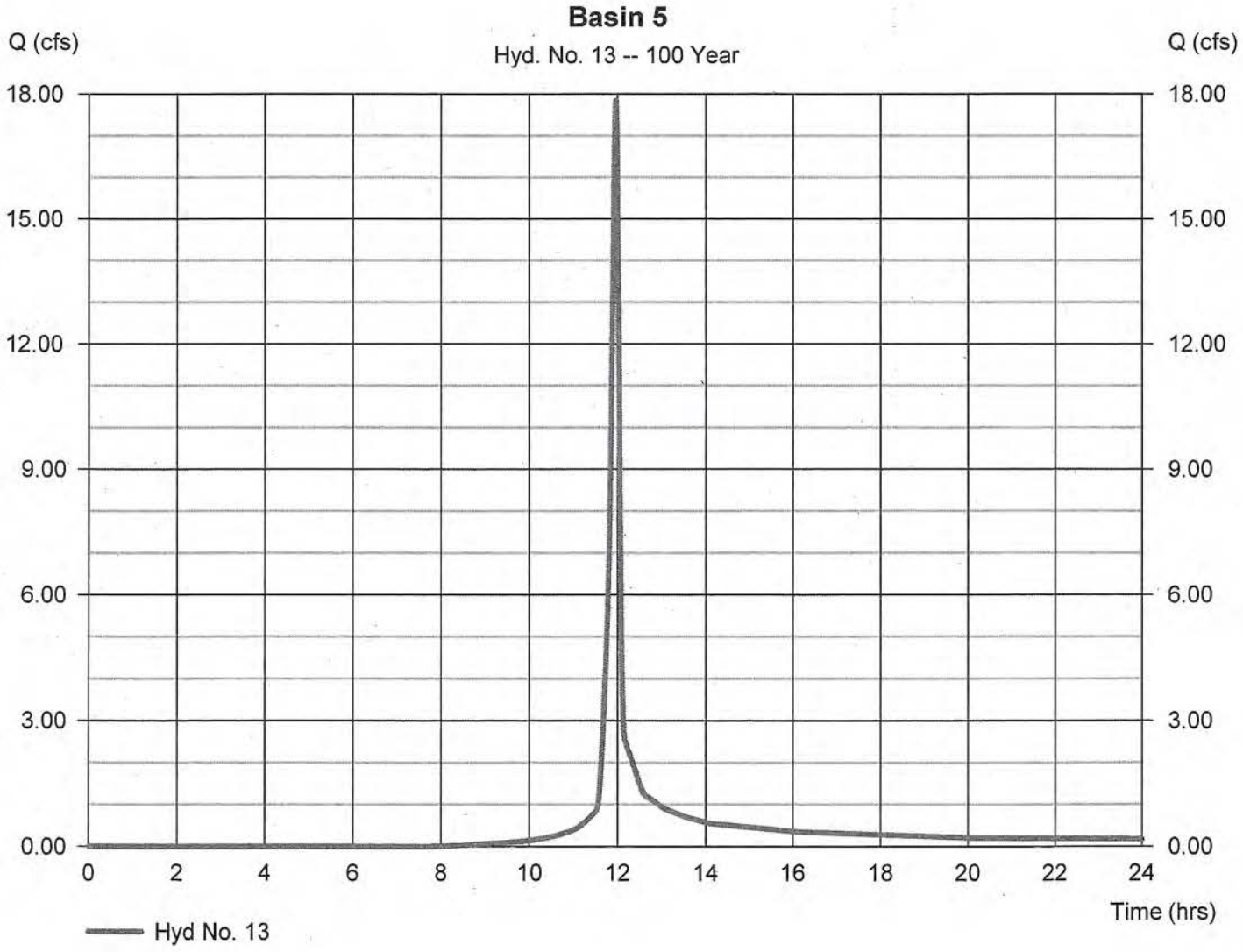
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Hyd. No. 13

Basin 5

Hydrograph type	= SCS Runoff	Peak discharge	= 17.85 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.97 hrs
Time interval	= 1 min	Hyd. volume	= 36,285 cuft
Drainage area	= 1.790 ac	Curve number	= 64*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.00 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.570 x 61) + (0.220 x 85)] / 1.790



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 Thursday, 07 / 14 / 2016

Pond No. 5 - Basin 5

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 710.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	710.00	00	0	0
1.00	711.00	56	19	19
2.00	712.00	940	408	427
3.00	713.00	2,517	1,665	2,092
4.00	714.00	4,847	3,619	5,711

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 12.00	0.00	0.00	0.00
Span (in)	= 12.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 710.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

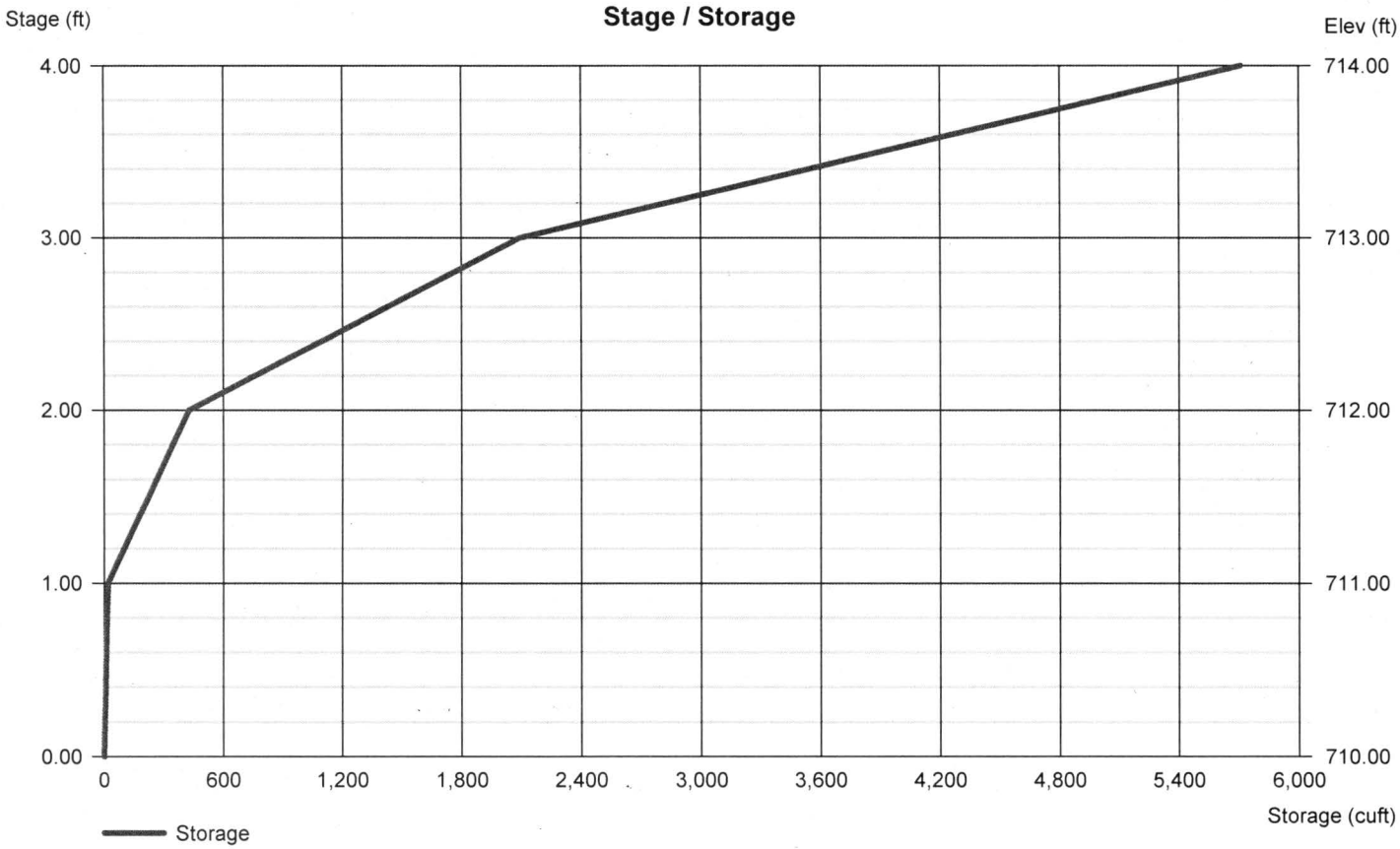
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 5 - Basin 5

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

Storage Estimate

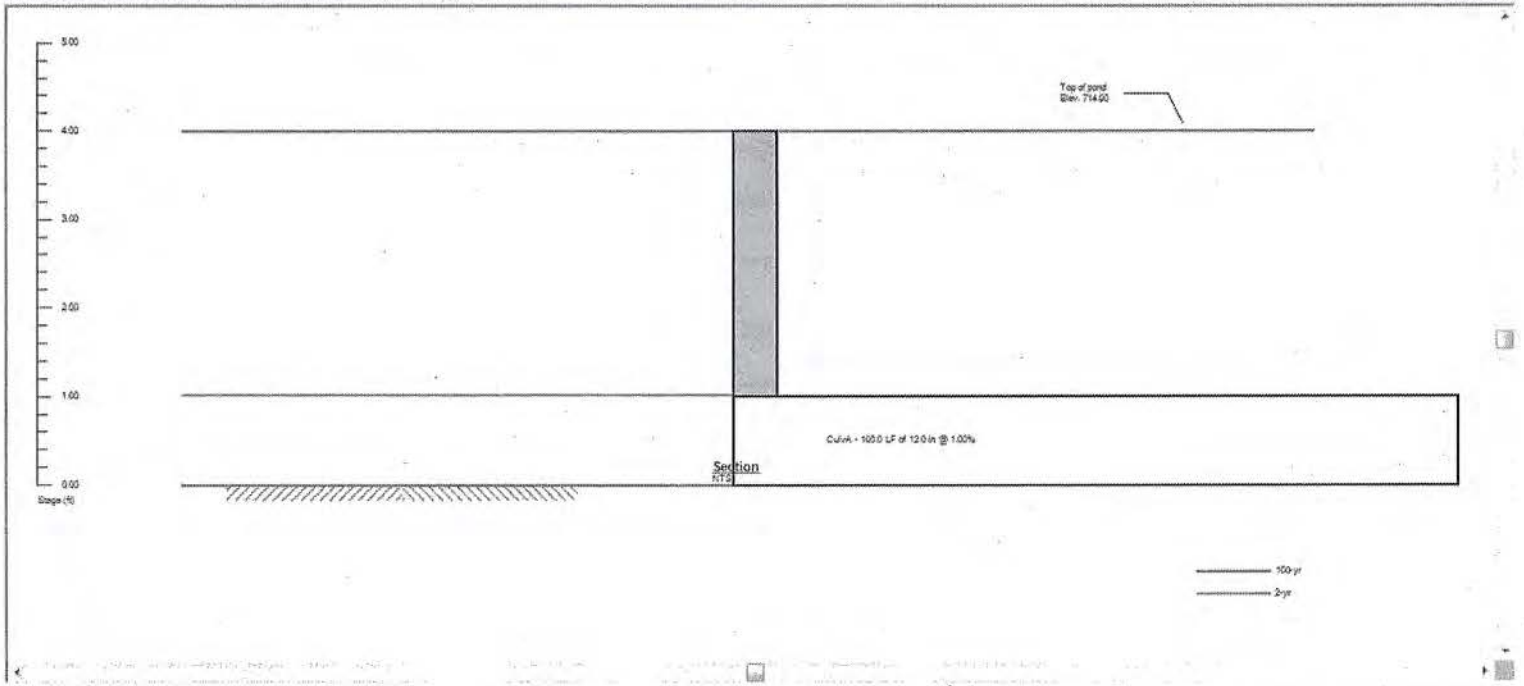
Inflow Hyd. No. = 13 - SCS Runoff - Basin 5

Event (yrs)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	5,849	2.745	0.000	5,849*
3				
5				
10				
25				
50				
100	36,285	17.85	0.000	36,285*

Estimated storage required. Read only. Estimate Storage

*Exceeds available storage!

Stage vs Q | Sect | Front | Labels | Hgt Off



Interactive

Culv/Orif	A	B	C	PR
Select	◉	○	○	○
Active	☑	☑	☑	☑

Weir	A	B	C	D
Select	◉	○	○	○
Active	☑	☑	☑	☑

Diameter (in) = 12.00 | Crest Len (ft) = 0.00

Invert EL. (ft) = 710.00 | Crest Elev (ft) = 0.00

Update | ☑ Auto Update | Trial Route | ☐ Auto Route

Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	2.697	711.01	22
100	NS	NS	NS

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #6	DC-BN-601666-001	72 of 128

DRAINAGE AREA = 1.72 AC (SEE ATTACHED MAP)

CURVE NUMBER = 65 (SEE ATTACHED TABLE)

1.43 AC @ CN 61 (GRASS)

0.29 AC @ CN 85 (GRAVEL)

$\frac{(1.43 \times 61) + (0.29 \times 85)}{1.72} = 65.05 = 65$

TIME OF CONCENTRATION = 6.30 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 98 L.F.

LAND SLOPE = $\frac{738.25 - 714.00}{98} = 0.2474 = 24.74\%$

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

GRASS LINED 3' WIDE DITCH WITH 2:1 SIDE SLOPES AND 3' DEEP

CROSS SECTIONAL AREA = 6.09 S.F.

WETTED PERIMETER = 8.14 L.F.

CHANNEL SLOPE = $\frac{714.00 - 711.00}{594} = 0.0051 = 0.51\%$

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 594 L.F.

TIME INTERVAL = 1 MIN

Tc x 0.1333 = 16.30 x 0.1333 = 0.84 = 1

STORM DISTRIBUTION = TYPE II

Q_{1000} = 17.52 CFS (SEE ATTACHED HYDROGRAPH REPORT)

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #6	DC-BN-601666-01	73 of 128

TO EVALUATE THE STORAGE CAPACITY OF BASIN 6, TREAT THE DITCH IN BASIN 6 AS A POND.

ELEVATION	AREA	VOLUME
711	Ø	Ø
712	936	312
713	2,752	2,076
714	5,716	6,220

OUTLET IS A 12"Ø HDPE PIPE @ 1% SLOPE

∴ THE STORAGE CAPACITY IN BASIN 6 IS UNABLE TO CONTAIN THE 1000YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT)


NORTHERN SECTION
BASIN #6
1.72 AC
1.43 AC GRASS
0.29 AC GRAVEL

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

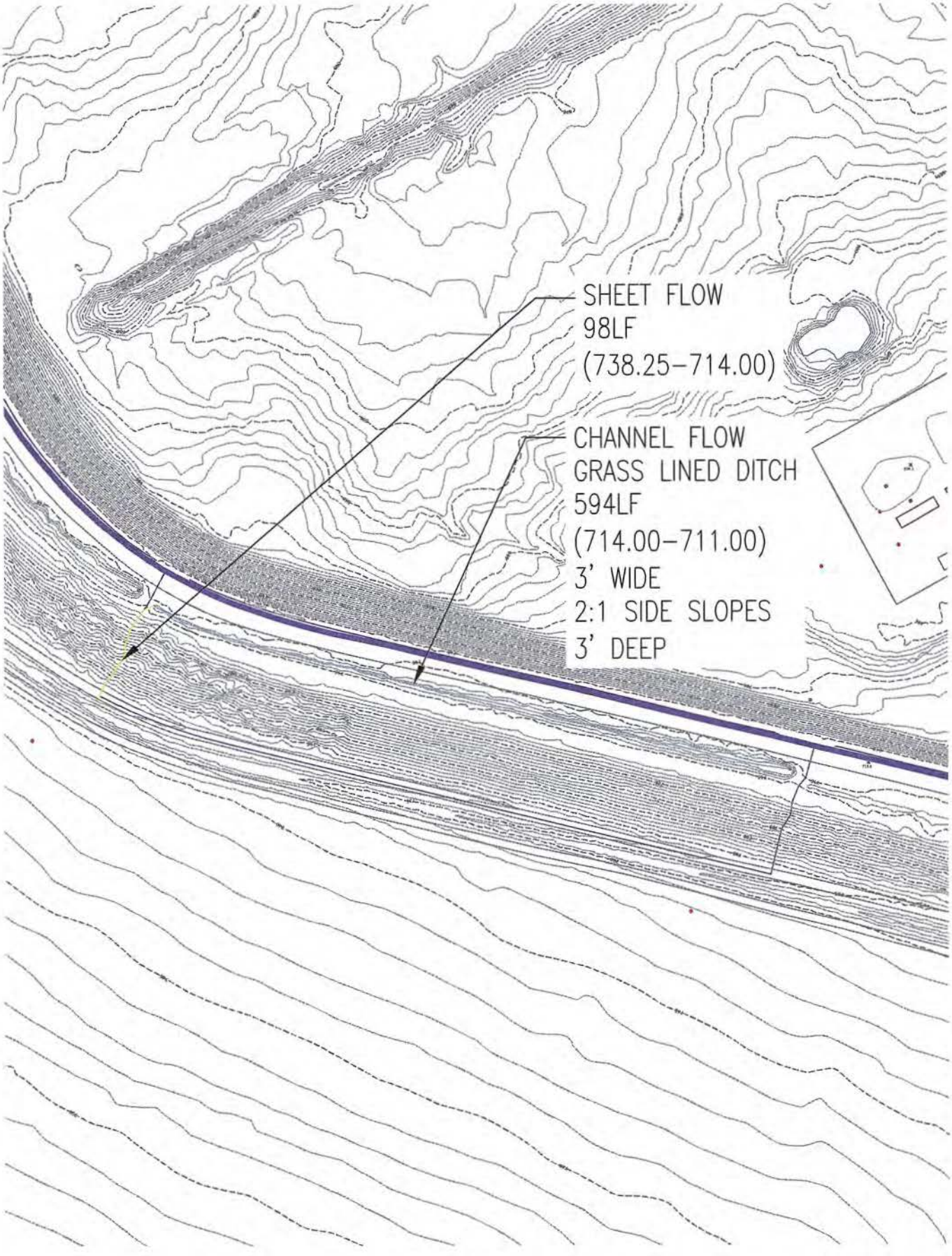
TR55 Tc Worksheet

Hyd. No. 16

Basin 6

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 98.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 24.74		0.00		0.00		
Travel Time (min)	**= 3.24**	**+**	**0.00**	**+**	**0.00**	**=**	**3.24**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 6.09		0.00		0.00		
Wetted perimeter (ft)	= 8.14		0.00		0.00		
Channel slope (%)	= 0.51		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=2.92						
			0.00				
					0.00		
Flow length (ft)	({0})541.0		0.0		0.0		
Travel Time (min)	**= 3.09**	**+**	**0.00**	**+**	**0.00**	**=**	**3.09**

Total Travel Time, Tc ..... 6.32 min


SHEET FLOW
98LF
(738.25–714.00)
CHANNEL FLOW
GRASS LINED DITCH
594LF
(714.00–711.00)
3' WIDE
2:1 SIDE SLOPES
3' DEEP

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t = travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ (2.1.10)

Paved $V = 20.33(S)^{0.5}$ (2.1.11)

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Jul 14 2016

Basin 6 Ditch

Trapezoidal

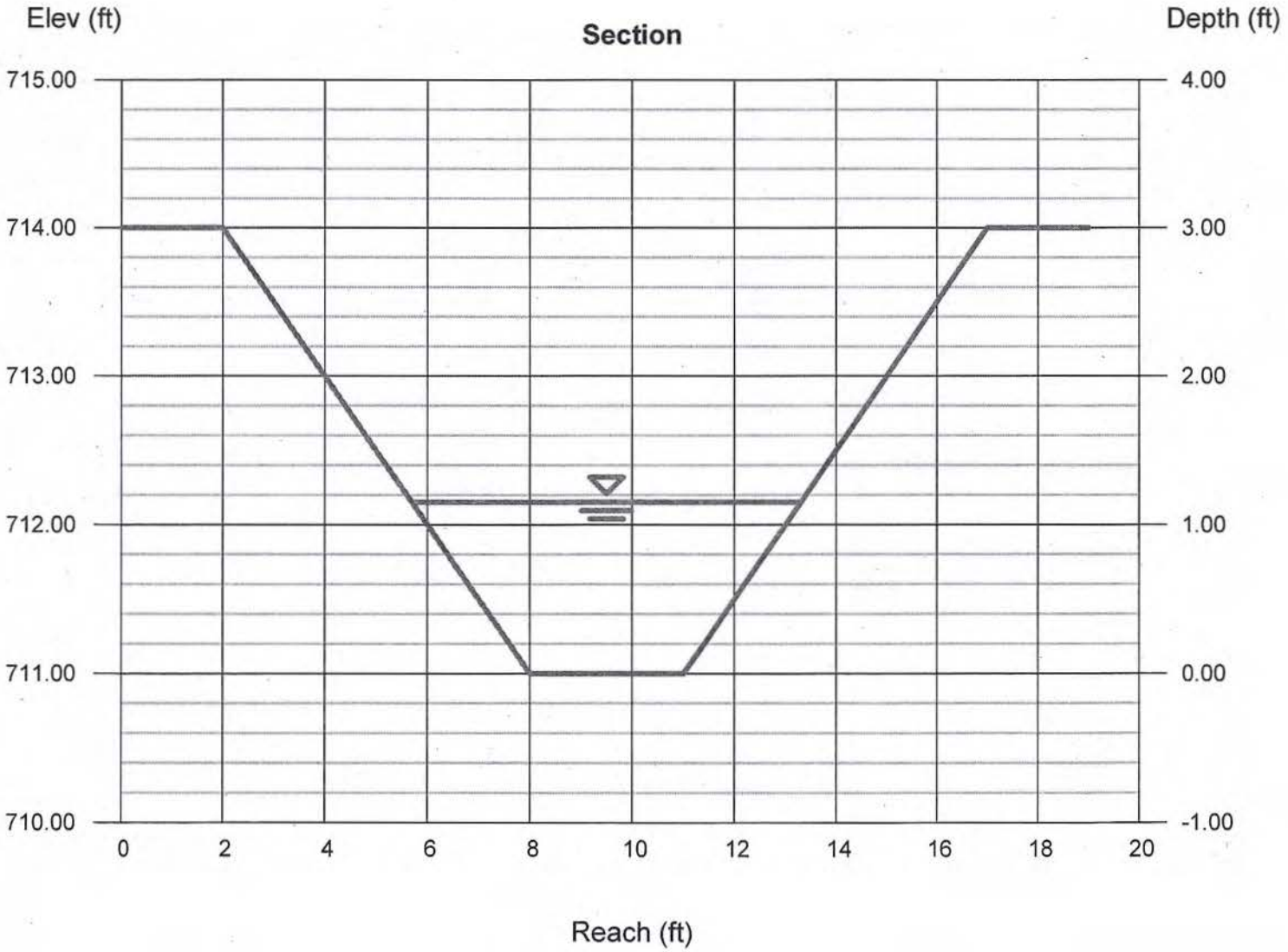
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 711.00
Slope (%)	= 0.51
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 17.52

Highlighted

Depth (ft)	= 1.15
Q (cfs)	= 17.52
Area (sqft)	= 6.09
Velocity (ft/s)	= 2.87
Wetted Perim (ft)	= 8.14
Crit Depth, Yc (ft)	= 0.84
Top Width (ft)	= 7.60
EGL (ft)	= 1.28



3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015

Hydrograph Report

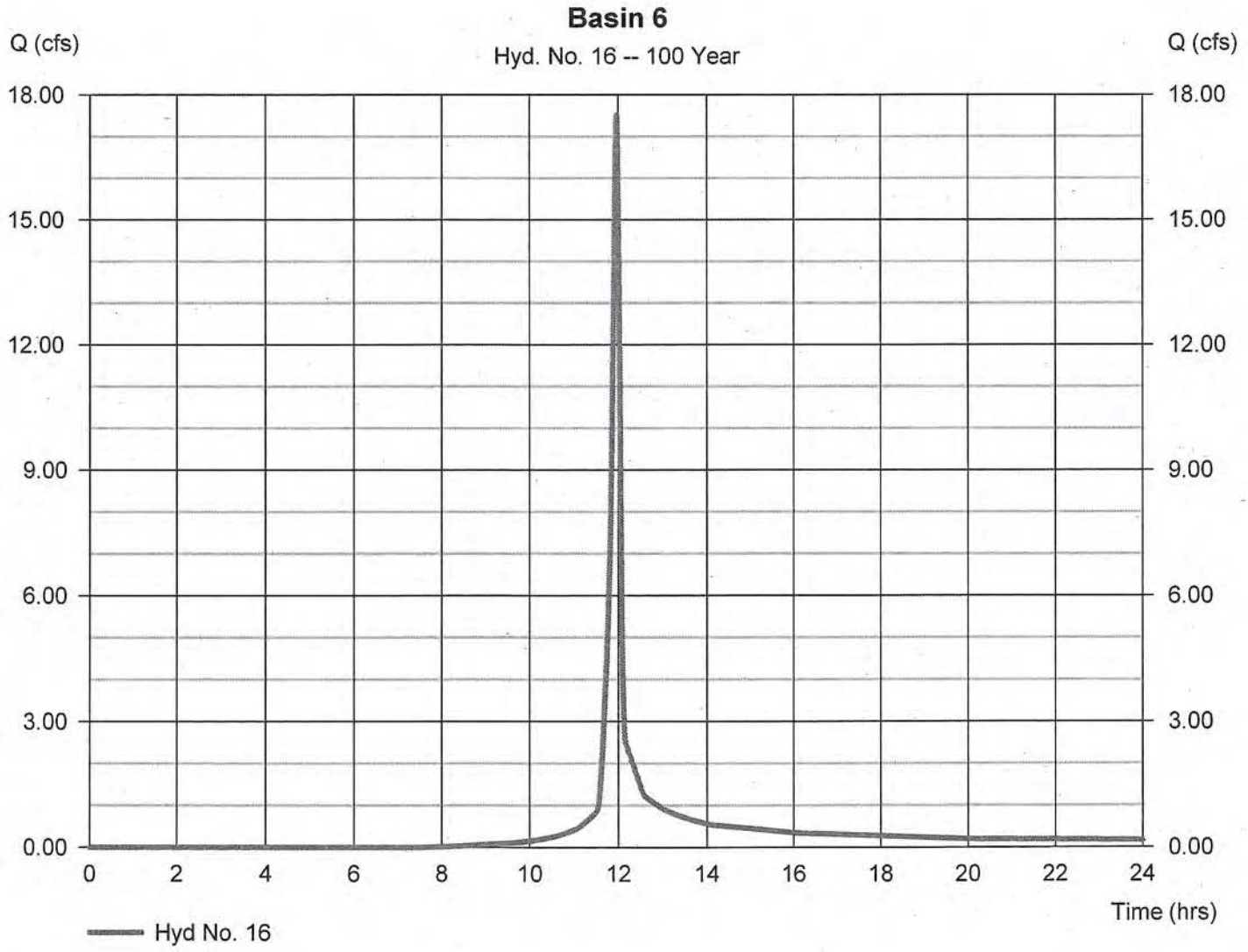
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 Thursday, 07 / 14 / 2016

Hyd. No. 16

Basin 6

Hydrograph type	= SCS Runoff	Peak discharge	= 17.52 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.97 hrs
Time interval	= 1 min	Hyd. volume	= 35,720 cuft
Drainage area	= 1.720 ac	Curve number	= 65*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 6.30 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.430 x 61) + (0.290 x 85)] / 1.720



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Pond No. 6 - Basin 6

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 711.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	711.00	00	0	0
1.00	712.00	936	312	312
2.00	713.00	2,752	1,764	2,076
3.00	714.00	5,716	4,144	6,220

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 12.00	0.00	0.00	0.00
Span (in)	= 12.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 711.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

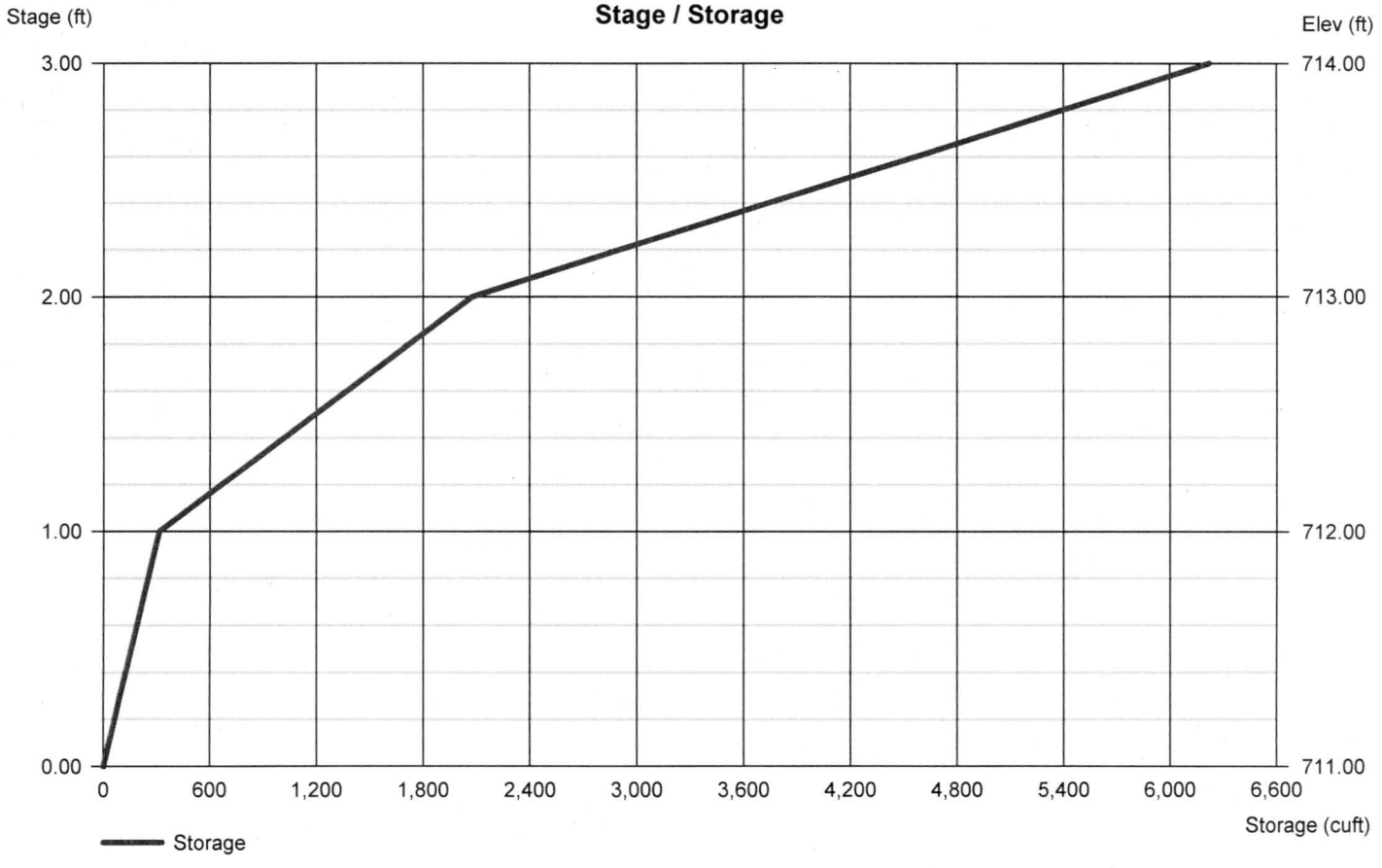
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 6 - Basin 6

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

Storage Estimate

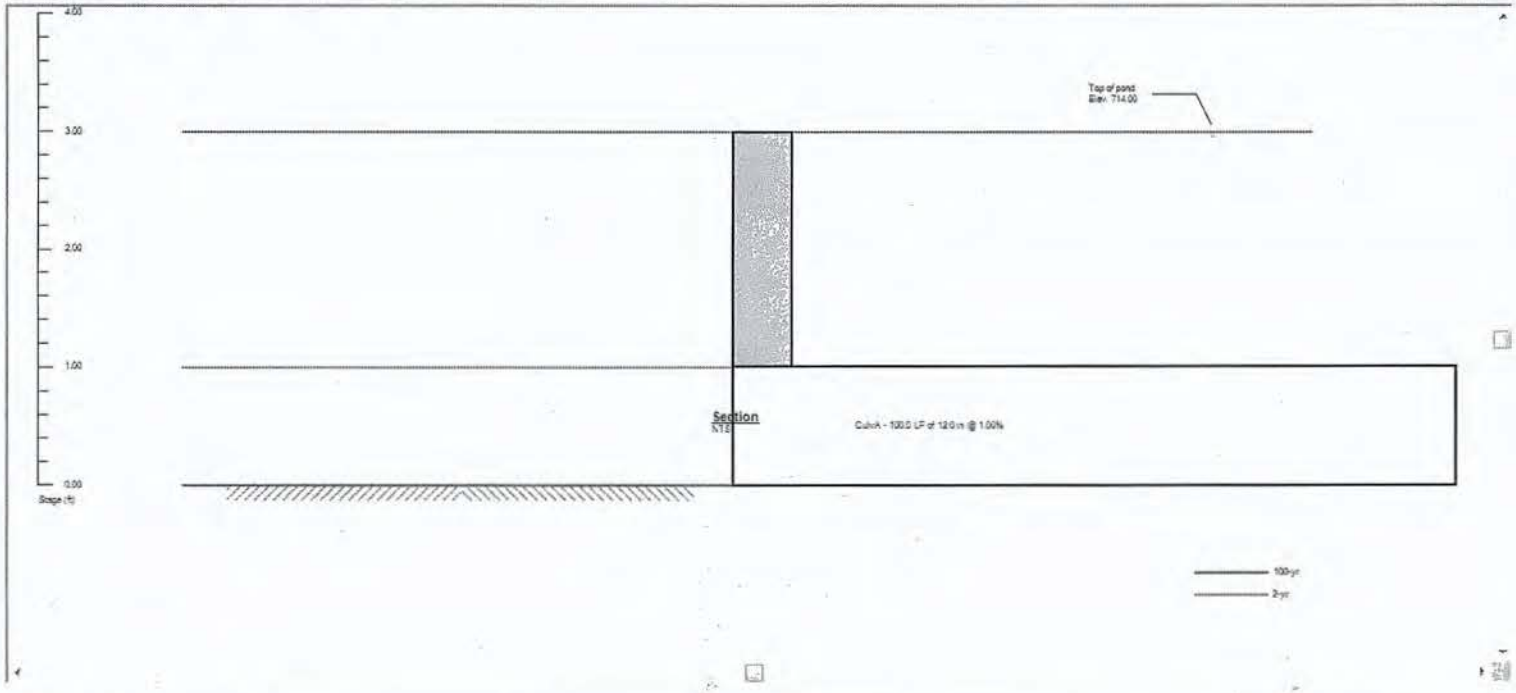
Inflow Hyd. No. = 16 - SCS Runoff - Basin 6

Event (yrs)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	5,961	2.832	0.000	5,961
3				
5				
10				
25				
50				
100	35,720	17.52	0.000	35,720*

Estimated storage required. Read only. Estimate Storage

*Exceeds available storage!

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

Culv/Orif	A	B	C	PR	Weir	A	B	C	D
Select	◉				Select	◉			
Active	☑	☑	☑	☑	Active	☑	☑	☑	☑

Diameter (in) = 12.00 | Crest Len (ft) = 0.00

Invert EL. (ft) = 711.00 | Crest Elev (ft) = 0.00

Update | ☑ Auto Update | Trial Route | ☐ Auto Route

Actuals

Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	2.656	711.99	310
100	NS	NS	NS

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SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #7	DC-BN-601666-001	84 of 128

DRAINAGE AREA = 6.35 AC (SEE ATTACHED MAP)

CURVE NUMBER = 65 (SEE ATTACHED TABLE)

5.40 AC @ CN61 (GRASS)

0.95 AC @ CN85 (GRAVEL)

$\frac{(5.40 \times 61) + (0.95 \times 85)}{6.35} = 64.59 = 65$

TIME OF CONCENTRATION = 11.60 MIN (SEE ATTACHED TR 55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 88 L.F.

LAND SLOPE = $\frac{726.25 - 718.00}{88} = 0.0938 = 9.38\%$

SHALLOW CONCENTRATED FLOW

FLOW LENGTH = 174 L.F.

WATERCOURSE SLOPE = $\frac{718.00 - 717.00}{174} = 0.0057 = 0.57\%$

SURFACE IS UNPAVED

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

GRASS LINED V-DITCH WITH 3:1 & 5:1 SIDE SLOPES AND 3' DEEP

CROSS SECTIONAL AREA = 36.00 S.F.

WETTED PERIMETER = 24.78 L.F.

CHANNEL SLOPE = $\frac{717.00 - 710.00}{1348} = 0.0052 = 0.52\%$

MANNING'S n-VALUE = 0.030 (VEGETAL LINING)

FLOW LENGTH = 1348 L.F.

TIME INTERVAL = 2 MIN

Tc x 0.1333 = 11.60 x 0.1333 = 1.55 = 2

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #7	DC-BN-601666-001	85 of 128

STORM DISTRIBUTION = TYPE II

Q_{1000} = 50.85 CFS (SEE ATTACHED HYDROGRAPH REPORT)

T. EVALUATE THE STORAGE CAPACITY OF BASIN 7, TREAT THE DITCH IN BASIN 7 AS A POND.

ELEVATION	AREA	VOLUME
710	Ø	Ø
711	209	69
712	2,204	1,100
713	7,496	5,688
714	21,203	19,455

OUTLET IS A 15"Ø HDPE PIPE @ 1% SLOPE

∴ THE STORAGE CAPACITY IN BASIN 7 IS UNABLE TO CONTAIN THE 1000YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT)


NORTHERN SECTION
BASIN #7
6.35 AC
5.40 AC GRASS
0.95 AC GRAVEL

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

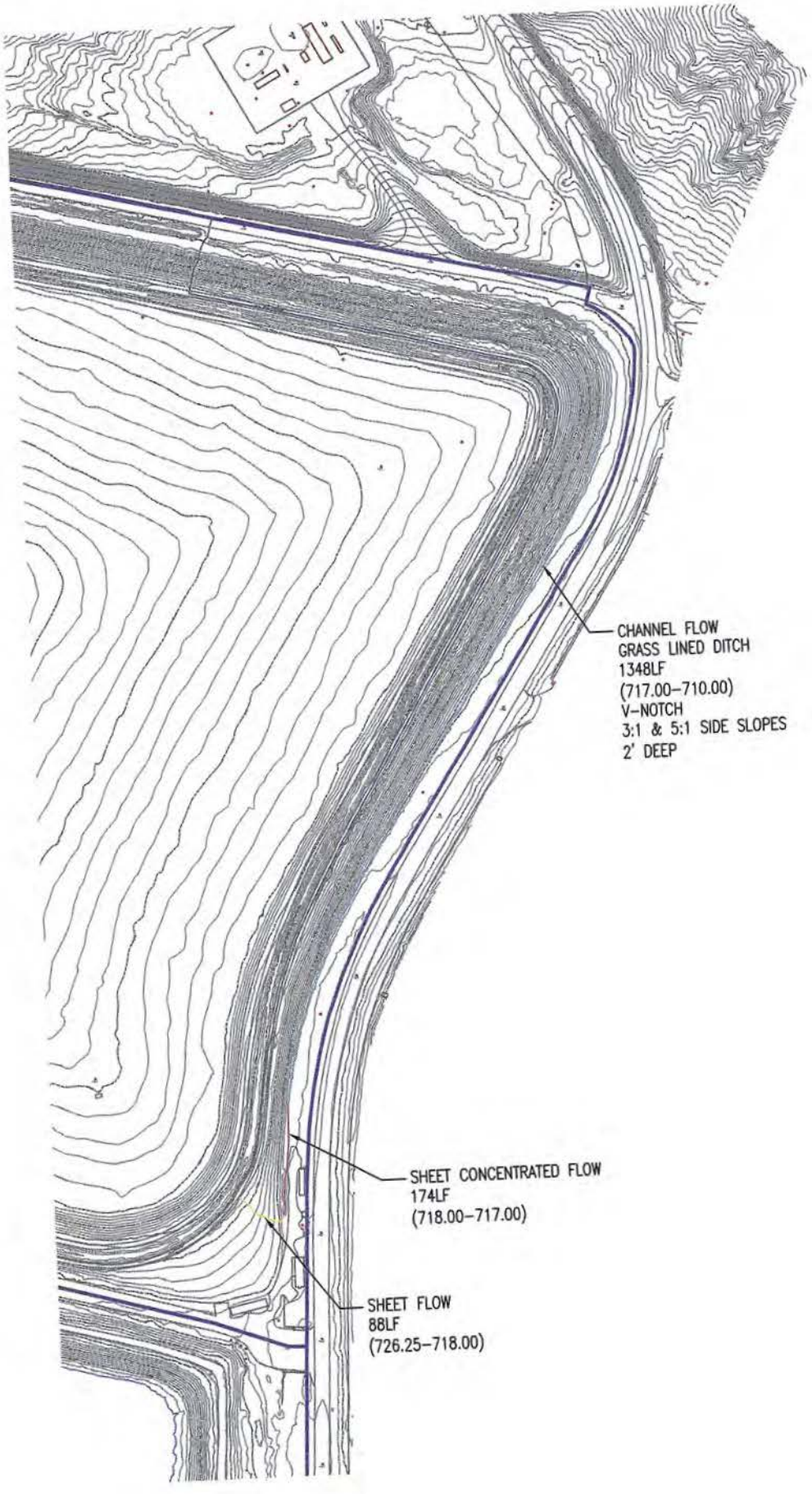
TR55 Tc Worksheet

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 19

Basin 7

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 88.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 9.38		0.00		0.00		
Travel Time (min)	**= 4.38**	**+**	**0.00**	**+**	**0.00**	**=**	**4.38**
Shallow Concentrated Flow							
Flow length (ft)	= 174.00		0.00		0.00		
Watercourse slope (%)	= 0.57		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=1.22		0.00		0.00		
Travel Time (min)	**= 2.38**	**+**	**0.00**	**+**	**0.00**	**=**	**2.38**
Channel Flow							
X sectional flow area (sqft)	= 36.00		0.00		0.00		
Wetted perimeter (ft)	= 24.78		0.00		0.00		
Channel slope (%)	= 0.52		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=4.60						
			0.00				
					0.00		
Flow length (ft)	({0})1348.0		0.0		0.0		
Travel Time (min)	**= 4.88**	**+**	**0.00**	**+**	**0.00**	**=**	**4.88**
Total Travel Time, Tc							**11.65 min**


CHANNEL FLOW
GRASS LINED DITCH
1348LF
(717.00–710.00)
V–NOTCH
3:1 & 5:1 SIDE SLOPES
2' DEEP
SHEET CONCENTRATED FLOW
174LF
(718.00–717.00)
SHEET FLOW
88LF
(726.25–718.00)

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t = travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ (2.1.10)

Paved $V = 20.33(S)^{0.5}$ (2.1.11)

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Friday, Jul 22 2016

Basin 7 Ditch

Triangular

Side Slopes (z:1)	= 3.00, 5.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 710.00
Slope (%)	= 0.52
N-Value	= 0.300

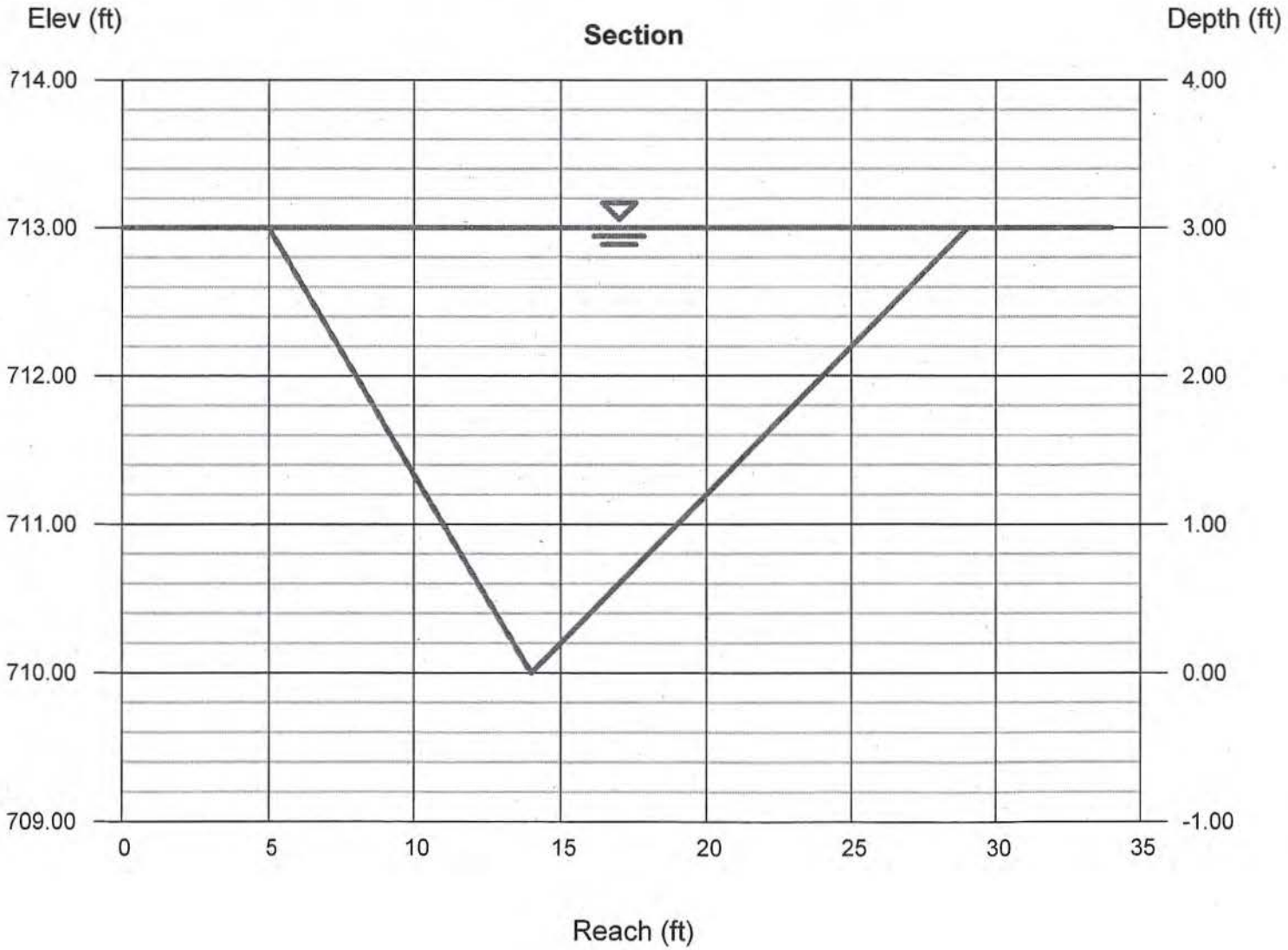
Calculations

Compute by:	Known Q
Known Q (cfs)	= 16.35 *

Highlighted

Depth (ft)	= 3.00
Q (cfs)	= 16.35
Area (sqft)	= 36.00
Velocity (ft/s)	= 0.45
Wetted Perim (ft)	= 24.78
Crit Depth, Yc (ft)	= 1.01
Top Width (ft)	= 24.00
EGL (ft)	= 3.00

* DITCH IS FULL @ 16.35 CFS BUT DESIGN Q = 50.85 CFS.



3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015

Hydrograph Report

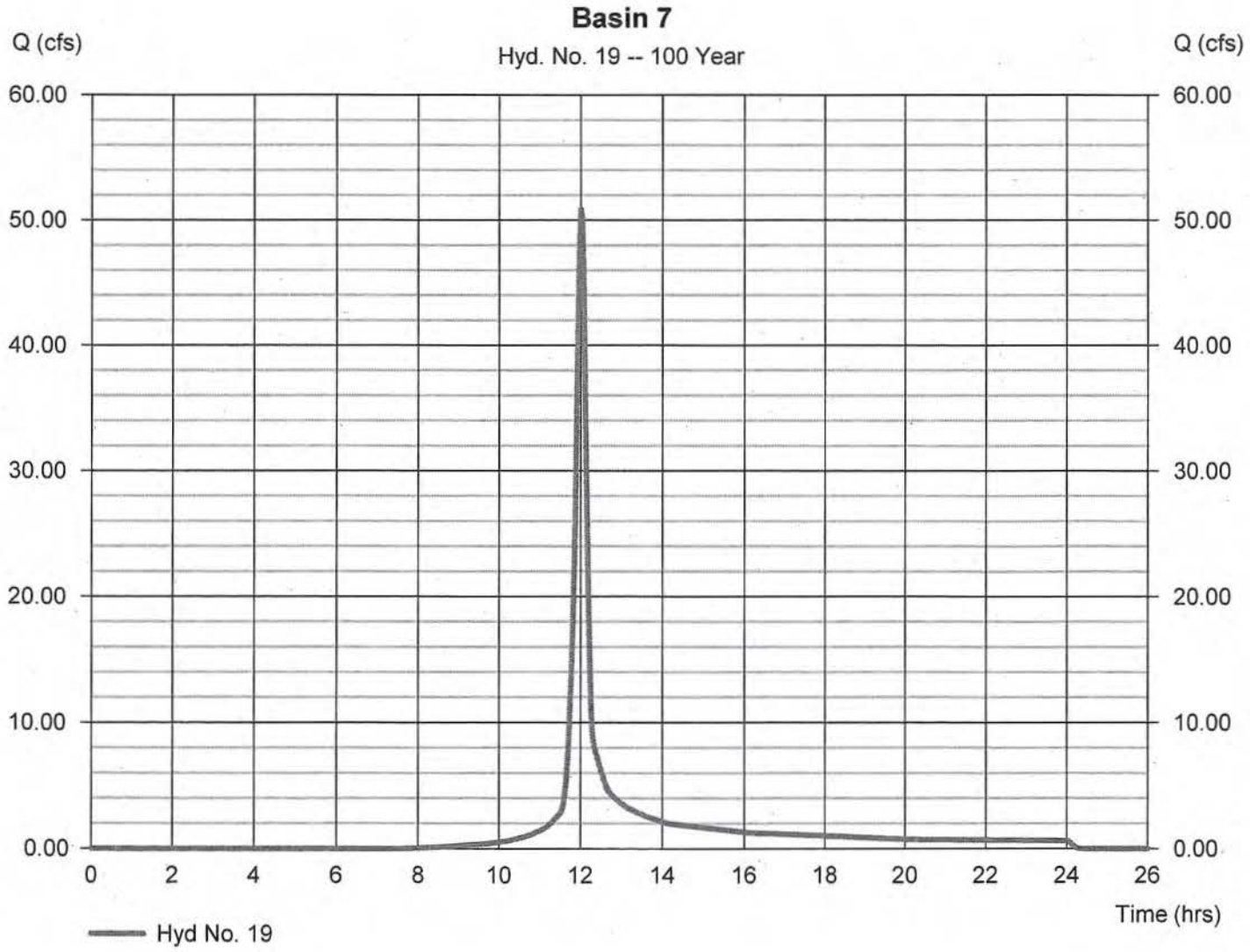
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Friday, 07 / 22 / 2016

Hyd. No. 19

Basin 7

Hydrograph type	= SCS Runoff	Peak discharge	= 50.85 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.00 hrs
Time interval	= 2 min	Hyd. volume	= 131,875 cuft
Drainage area	= 6.350 ac	Curve number	= 65*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.60 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(5.400 x 61) + (0.950 x 85)] / 6.350



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Pond No. 7 - Basin 7

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 710.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	710.00	00	0	0
1.00	711.00	209	70	70
2.00	712.00	2,204	1,030	1,100
3.00	713.00	7,496	4,588	5,688
4.00	714.00	21,203	13,767	19,455

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 15.00	0.00	0.00	0.00
Span (in)	= 15.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 710.00	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

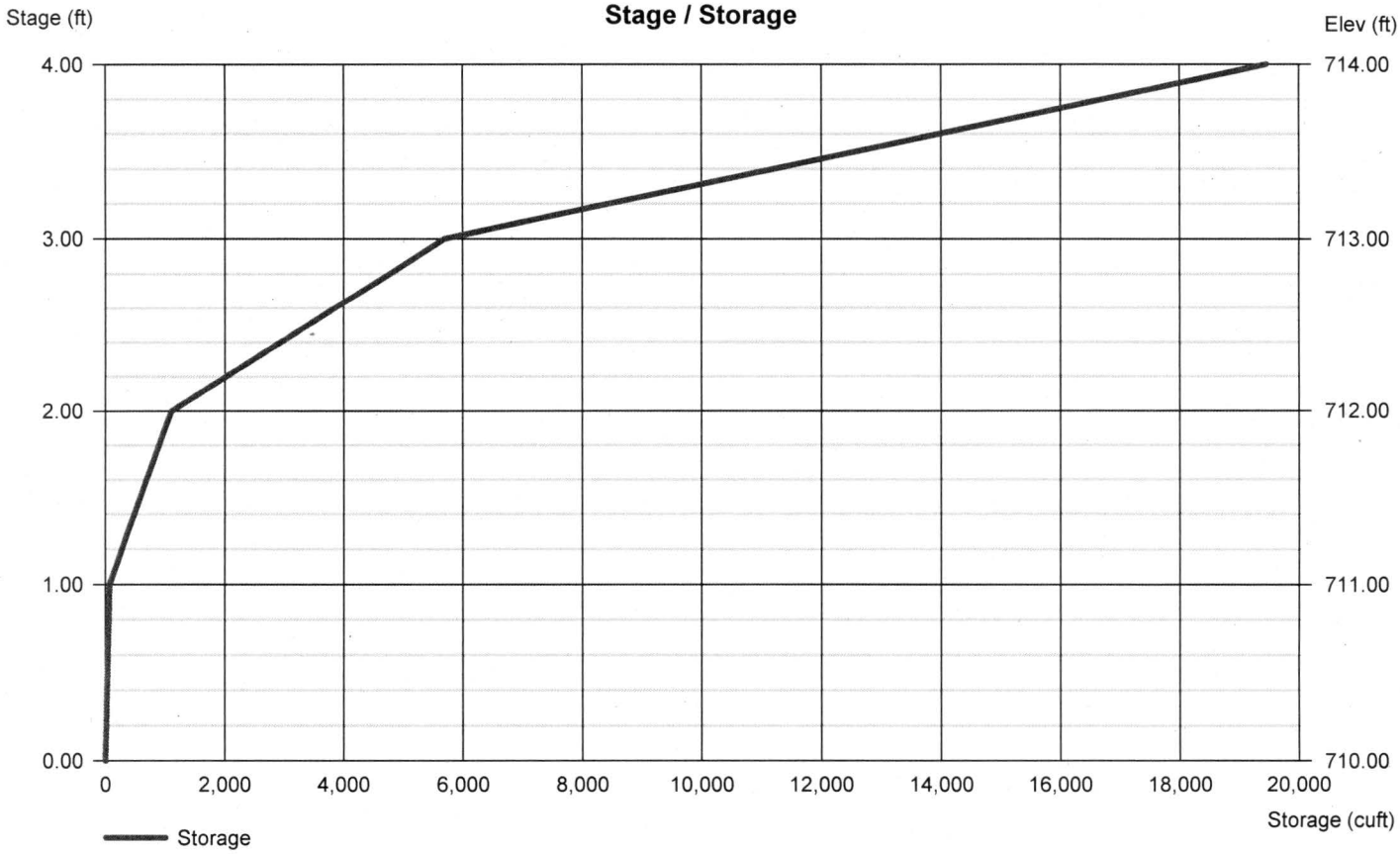
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 7 - Basin 7

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

Storage Estimate

Inflow Hyd. No. = 19 - SCS Runoff - Basin 7

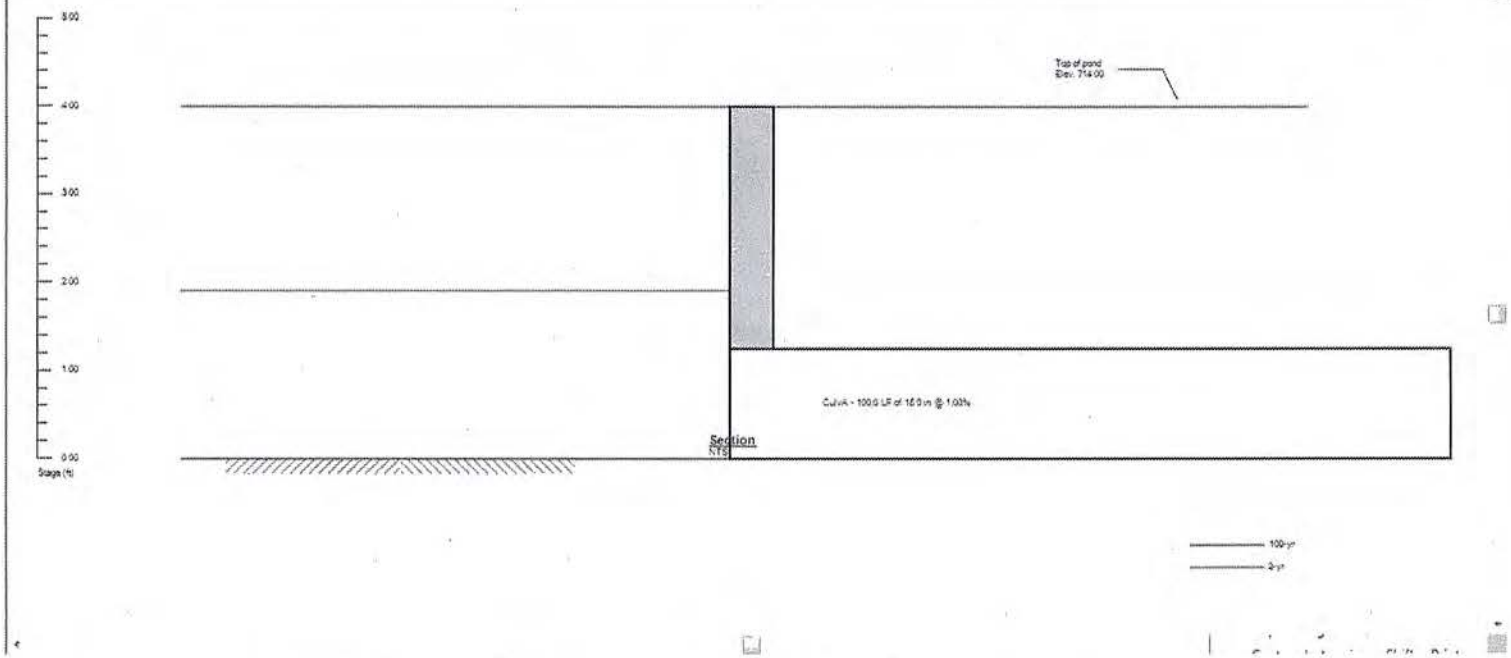
Event (yrs)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	22,007	7.794	0.000	22,007
3				
5				
10				
25				
50				
100	131,875	50.85	0.000	131,875*

Estimated storage required. Read only.

*Exceeds available storage!

Estimate Storage

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

Culv/Orif	A	B	C	PR	Weir	A	B	C	D
Select	◉	○	○	○	Select	◉	○	○	○
Active	☑	☑	☑	☑	Active	☑	☑	☑	☑

Update | Auto Update | Trial Route | Auto Route

Diameter (in) = 15.00 | Crest Len (ft) = 0.00

Invert EL. (ft) = 710.00 | Crest Elev (ft) = 0.00

Actuals			
Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	6.488	711.90	998
100	NS	NS	NS

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
BASIN #8	Calculation Number DC-BN-601666-001	Sheet 96 of 128

DRAINAGE AREA = 106.69 AC (SEE ATTACHED MAP)

CURVE NUMBER = 63 (SEE ATTACHED TABLE

98.89 AC @ CN 61 (GRASS)

3.43 AC @ CN 85 (GRAVEL)

4.37 AC @ CN 98 (LINED DITCH)

$$\frac{(98.89 \times 61) + (3.43 \times 85) + (4.37 \times 98)}{106.69} = 63.29 = 63$$

TIME OF CONCENTRATION = 26.90 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNING'S n-VALUE = 0.15 (SHORT GRASS)

FLOW LENGTH = 100 L.F.

LAND SLOPE = $\frac{780.50 - 779.75}{100}$ = 0.0075 = 0.75 %

SHALLOW CONCENTRATED

FLOW LENGTH = 722 L.F.

WATERCOURSE SLOPE = $\frac{779.75 - 765.50}{722}$ = 0.0197 = 1.97%

SURFACE IS UNPAVED

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

DOWNDRAIN PIPE 12" Ø HDPE (SEE ATTACHED HYDROGRAPH REPORT)

CROSS SECTIONAL AREA = 0.038 S.F.

WETTED PERIMETER = 1.55 L.F.

CHANNEL SLOPE = $\frac{765.50 - 739.00}{168}$ = 0.1577 = 15.77%

MANNING'S n-VALUE = 0.013 (HDPE PIPE)

FLOW LENGTH = 168 L.F.

Design Calculations

SOUTHERN COMPANY

Project	Prepared By	Date
PLANT BOWEN H&H	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
BASIN #8	Calculation Number DC-BN-601666-001	Sheet 97 of 128

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

LINED 5' WIDE DITCH WITH 2:1 SIDE SLOPES AND 3' DEEP (SEE ATTACHED HYDROGRAPH REPORT)

CROSS SECTIONAL AREA = 21.94 S.F.

WETTED PERIMETER = 15.24 L.F.

CHANNEL SLOPE = $\frac{739.00 - 718.00}{4137}$ = 0.0051 = 0.51%

MANNING's n-VALUE = 0.013 (HDPE LINER)

FLOW LENGTH = 4,137 L.F.

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

LINED 15' WIDE DITCH WITH 3:1 SIDE SLOPES AND 5' DEEP (SEE ATTACHED HYDROGRAPH REPORT)

CROSS SECTIONAL AREA = 39.07 S.F.

WETTED PERIMETER = 26.95 L.F.

CHANNEL SLOPE = $\frac{718.00 - 710.00}{1135}$ = 0.0070 = 0.70%

MANNING's n-VALUE = 0.013 (HDPE LINER)

FLOW LENGTH = 1,135 L.F.

TIME INTERVAL = 4MIN

$T_c \times 0.1333 = 26.90 \times 0.1333 = 3.59 = 4$

STORM DISTRIBUTION = TYPE II

Q_{1000} = 4752 CFS (SEE ATTACHED HYDROGRAPH REPORT)

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
NORTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
BASIN #8		98 of 128

TO EVALUATE THE STORAGE CAPACITY OF BASIN 8, TREAT THE DITCH IN BASIN 8 AS A POND.

ELEVATION	AREA	VOLUME
706	Ø	Ø
707	5,897	1,965
708	7,165	8,486
709	8,444	16,281
710	10,154	25,565
711	12,965	37,095
712	16,069	51,583
713	22,001	70,539
714	37,375	99,886

OUTLET IS 4- 54"Ø (O.D.) PE4710 DR21 HDPE PIPES @ 0.50% SLOPE

∴ THE STORAGE CAPACITY IN BASIN 8 IS ABLE TO CONTAIN THE 1000YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT) HIGHEST WATER ELEVATION IS 711.97


NORTHERN SECTION
BASIN #8
106.69 AC
98.89 AC GRASS
3.43 AC GRAVEL
4.37 AC LINER

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description: *Cover type and hydrologic condition*	*Average percent impervious area*[2]	Curve numbers for hydrologic soil groups: A	B	C	D
Cultivated land: without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or forest land: thin stand, poor cover		45	66	77	83
good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm drains (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Urban districts:					
Commercial and business	85%	89	92	94	95
Industrial	72%	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65%	77	85	90	92
1/4 acre	38%	61	75	83	87
1/3 acre	30%	57	72	81	86
1/2 acre	25%	54	70	80	85
1 acre	20%	51	68	79	84
2 acres	12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)		77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

TR55 Tc Worksheet

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 22

Basin 8

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.150		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 0.75		0.00		0.00		
Travel Time (min)	**= 13.33**	**+**	**0.00**	**+**	**0.00**	**=**	**13.33**
Shallow Concentrated Flow							
Flow length (ft)	= 722.00		0.00		0.00		
Watercourse slope (%)	= 1.97		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=2.26		0.00		0.00		
Travel Time (min)	**= 5.31**	**+**	**0.00**	**+**	**0.00**	**=**	**5.31**
Channel Flow							
X sectional flow area (sqft)	= 0.38		21.94		39.07		
Wetted perimeter (ft)	= 1.55		15.24		26.95		
Channel slope (%)	= 15.77		0.51		0.70		
Manning's n-value	= 0.013		0.013		0.013		
Velocity (ft/s)	=17.90						
			10.45				
					12.30		
Flow length (ft)	({0})168.0		4137.0		1135.0		
Travel Time (min)	**= 0.16**	**+**	**6.60**	**+**	**1.54**	**=**	**8.29**

Total Travel Time, Tc ..... 26.94 min


CHANNEL FLOW
12"ø HDPE PIPE
168LF
(765.50–739.00)
SHALLOW CONCENTRATED
722LF
(779.75–765.50)
SHEET FLOW
100LF
(780.50–779.75)
CHANNEL FLOW
LINED DITCH
4137LF
(739.00–718.00)
5' WIDE
2:1 SIDE SLOPES
3' DEEP
CHANNEL FLOW
LINED DITCH
1135LF
(718.00–710.00)
15' WIDE
3:1 SIDE SLOPES
5' DEEP

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t = travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ (2.1.10)

Paved $V = 20.33(S)^{0.5}$ (2.1.11)

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Jul 14 2016

Basin 8 Downdrain

Circular

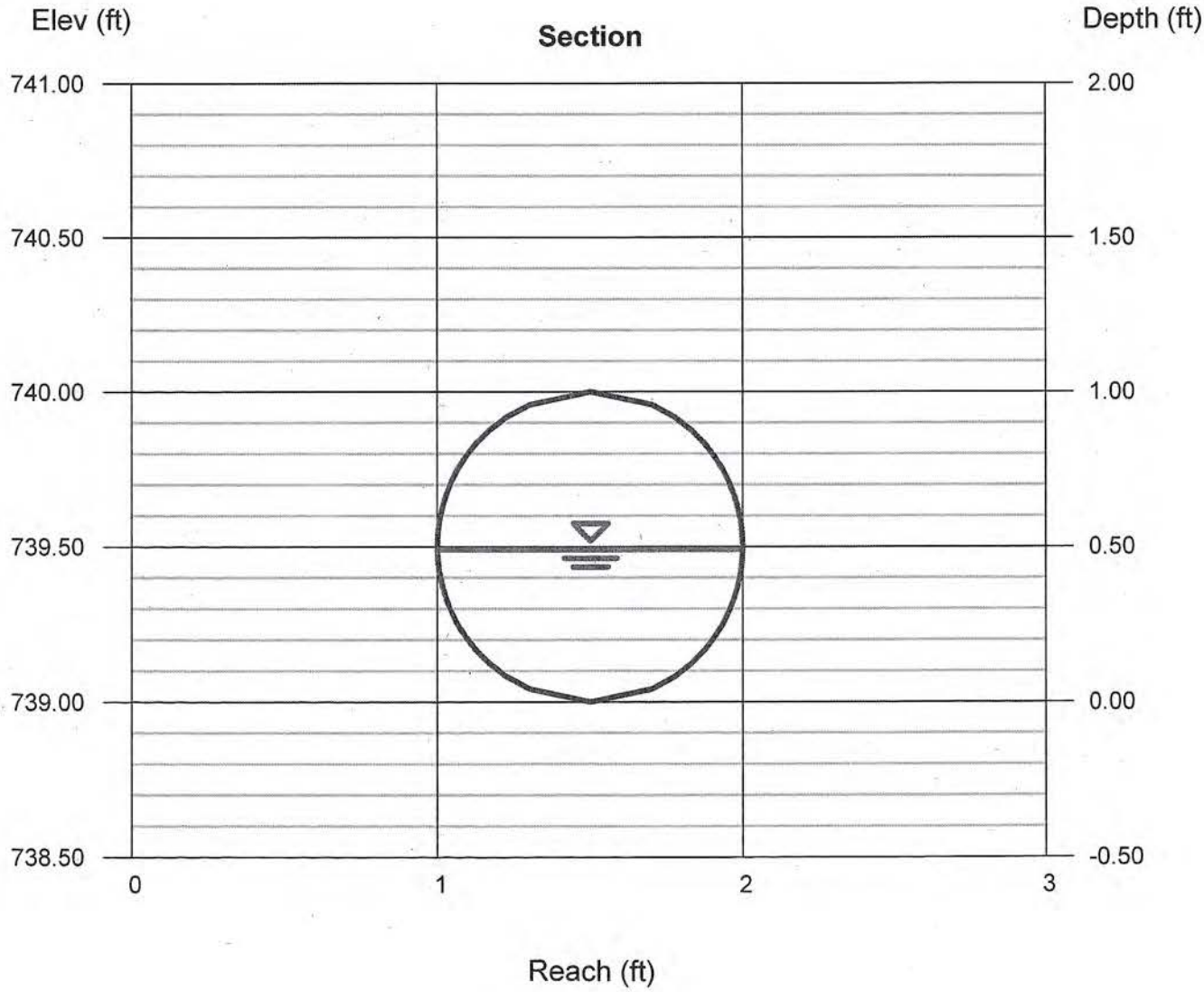
Diameter (ft)	= 1.00
Invert Elev (ft)	= 739.00
Slope (%)	= 15.77
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 6.79

Highlighted

Depth (ft)	= 0.49
Q (cfs)	= 6.790
Area (sqft)	= 0.38
Velocity (ft/s)	= 17.65
Wetted Perim (ft)	= 1.55
Crit Depth, Yc (ft)	= 0.98
Top Width (ft)	= 1.00
EGL (ft)	= 5.33



Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Jul 14 2016

Basin 8 Ditch 1

Trapezoidal

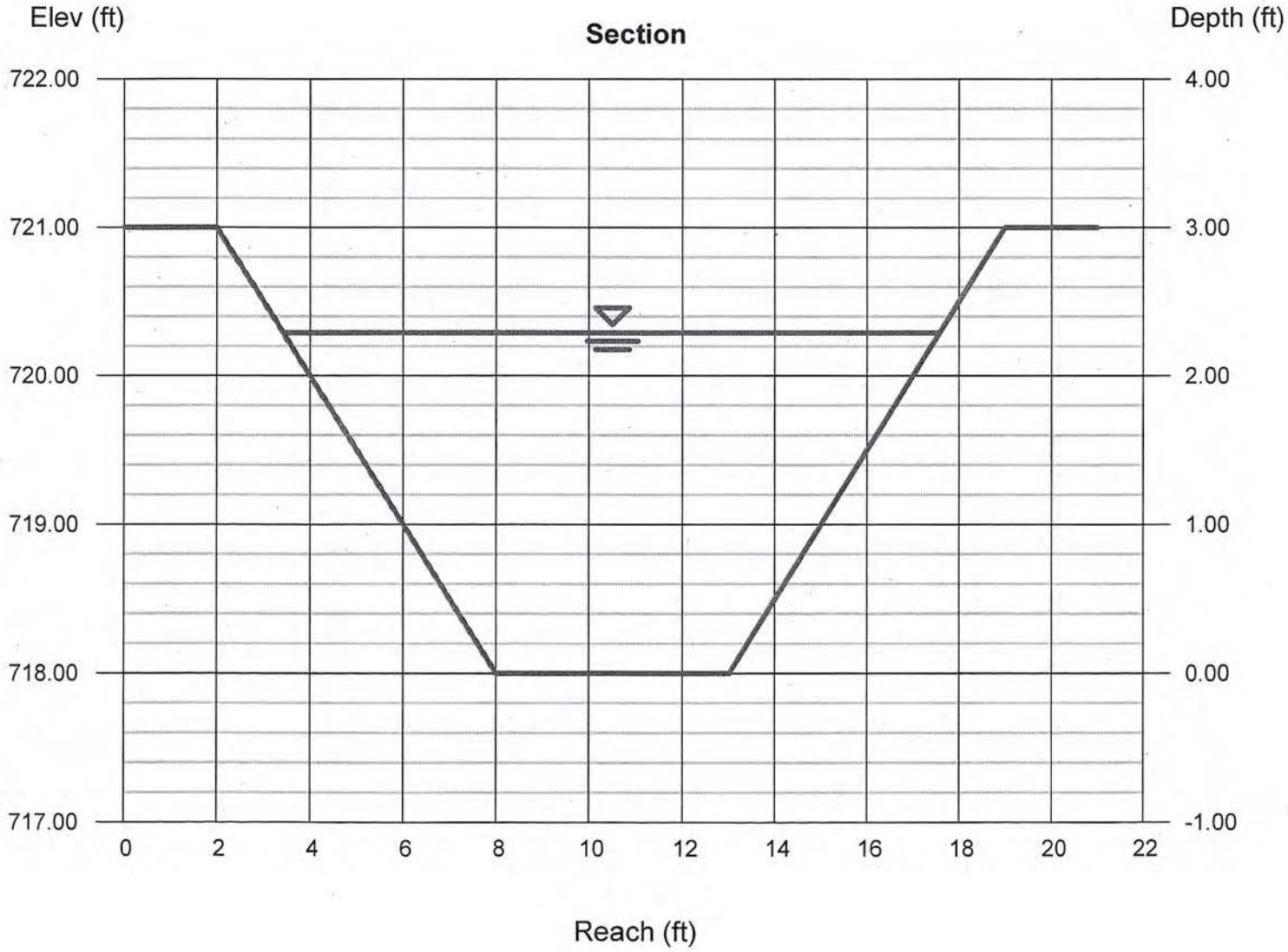
Bottom Width (ft)	= 5.00
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 718.00
Slope (%)	= 0.51
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 227.65

Highlighted

Depth (ft)	= 2.29
Q (cfs)	= 227.65
Area (sqft)	= 21.94
Velocity (ft/s)	= 10.38
Wetted Perim (ft)	= 15.24
Crit Depth, Yc (ft)	= 2.80
Top Width (ft)	= 14.16
EGL (ft)	= 3.96



Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Thursday, Jul 14 2016

Basin 8 Ditch 2

Trapezoidal

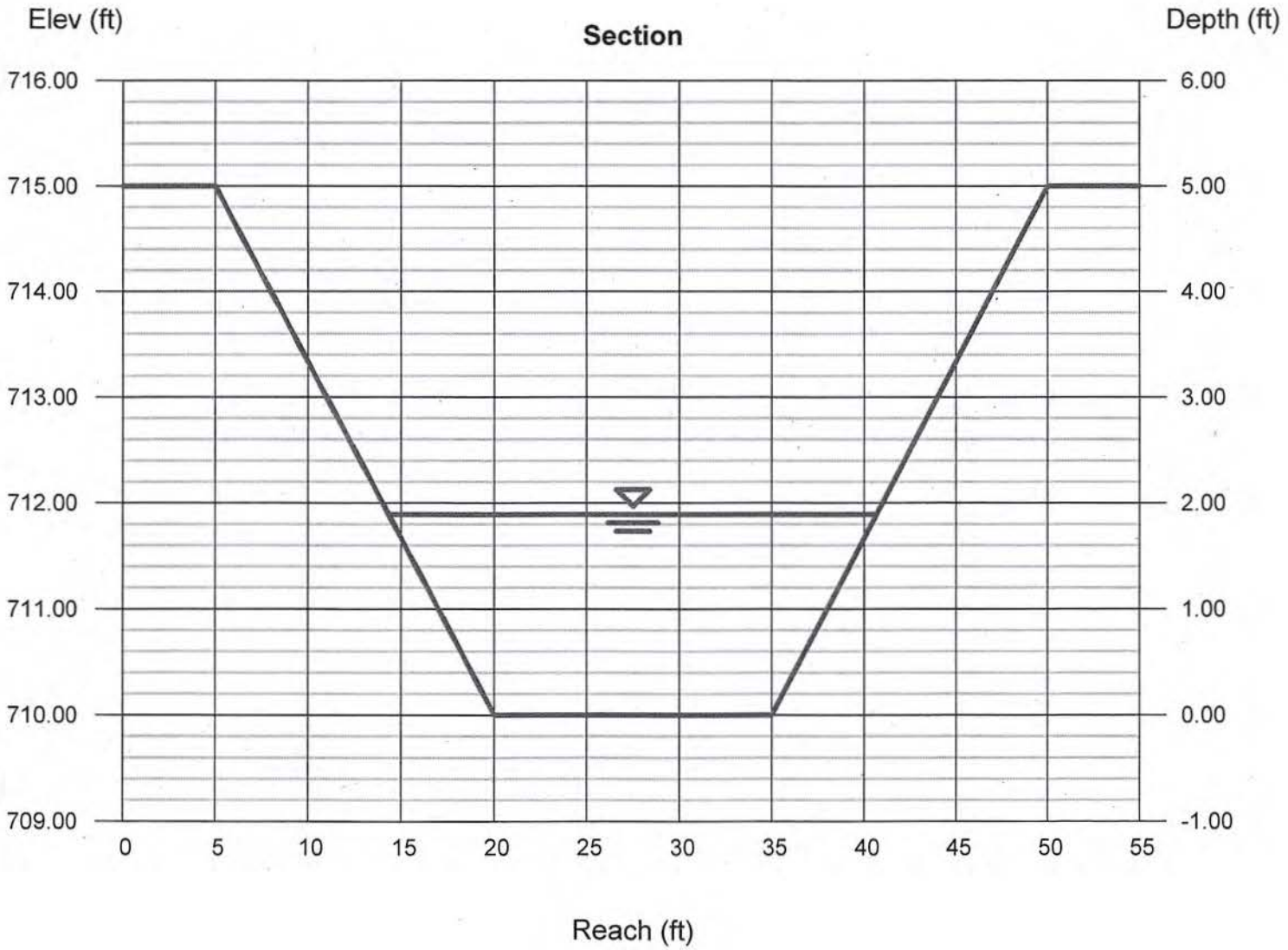
Bottom Width (ft)	= 15.00
Side Slopes (z:1)	= 3.00, 3.00
Total Depth (ft)	= 5.00
Invert Elev (ft)	= 710.00
Slope (%)	= 0.70
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 475.12

Highlighted

Depth (ft)	= 1.89
Q (cfs)	= 475.12
Area (sqft)	= 39.07
Velocity (ft/s)	= 12.16
Wetted Perim (ft)	= 26.95
Crit Depth, Yc (ft)	= 2.63
Top Width (ft)	= 26.34
EGL (ft)	= 4.19



3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.020
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.030
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.030
2. grass, some weeds	0.025	0.030	0.033
3. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. earth bottom and rubble sides	0.028	0.030	0.035
5. stony bottom and weedy banks	0.025	0.035	0.040
6. cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.040
2. jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.010	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.010	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016

Hydrograph Report

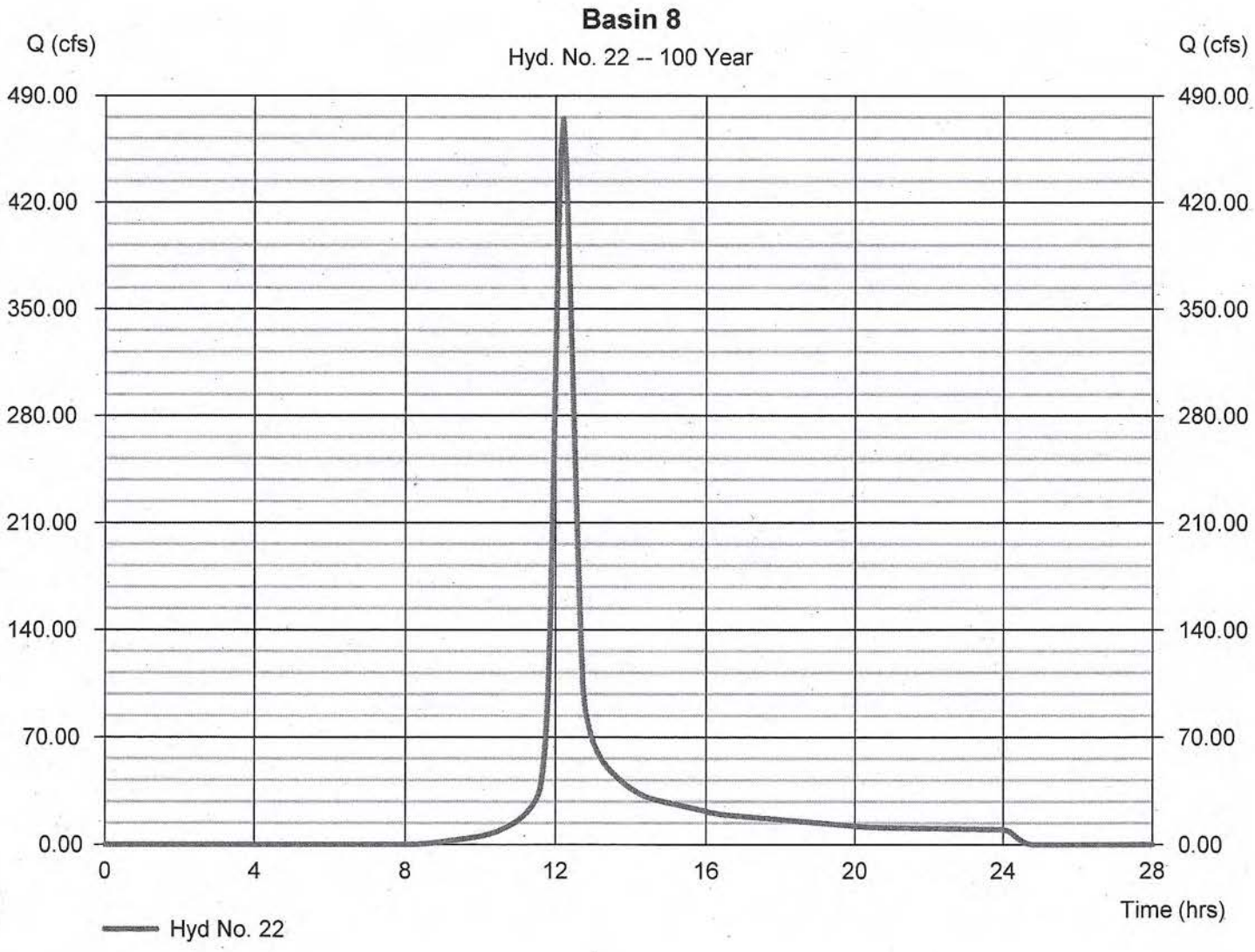
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Hyd. No. 22

Basin 8

Hydrograph type	= SCS Runoff	Peak discharge	= 475.12 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.20 hrs
Time interval	= 4 min	Hyd. volume	= 1,994,588 cuft
Drainage area	= 106.690 ac	Curve number	= 63*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 26.90 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(98.890 x 61) + (3.430 x 85) + (4.370 x 98)] / 106.690



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Thursday, 07 / 14 / 2016

Pond No. 8 - Basin 8

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 706.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	706.00	00	0	0
1.00	707.00	5,897	1,965	1,965
2.00	708.00	7,165	6,520	8,486
3.00	709.00	8,444	7,795	16,281
4.00	710.00	10,154	9,285	25,565
5.00	711.00	12,965	11,530	37,095
6.00	712.00	16,069	14,488	51,583
7.00	713.00	22,001	18,956	70,539
8.00	714.00	37,375	29,348	99,886

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.86	0.00	0.00	0.00
Span (in)	= 48.86	0.00	0.00	0.00
No. Barrels	= 4	0	0	0
Invert El. (ft)	= 706.00	0.00	0.00	0.00
Length (ft)	= 75.00	0.00	0.00	0.00
Slope (%)	= 0.50	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

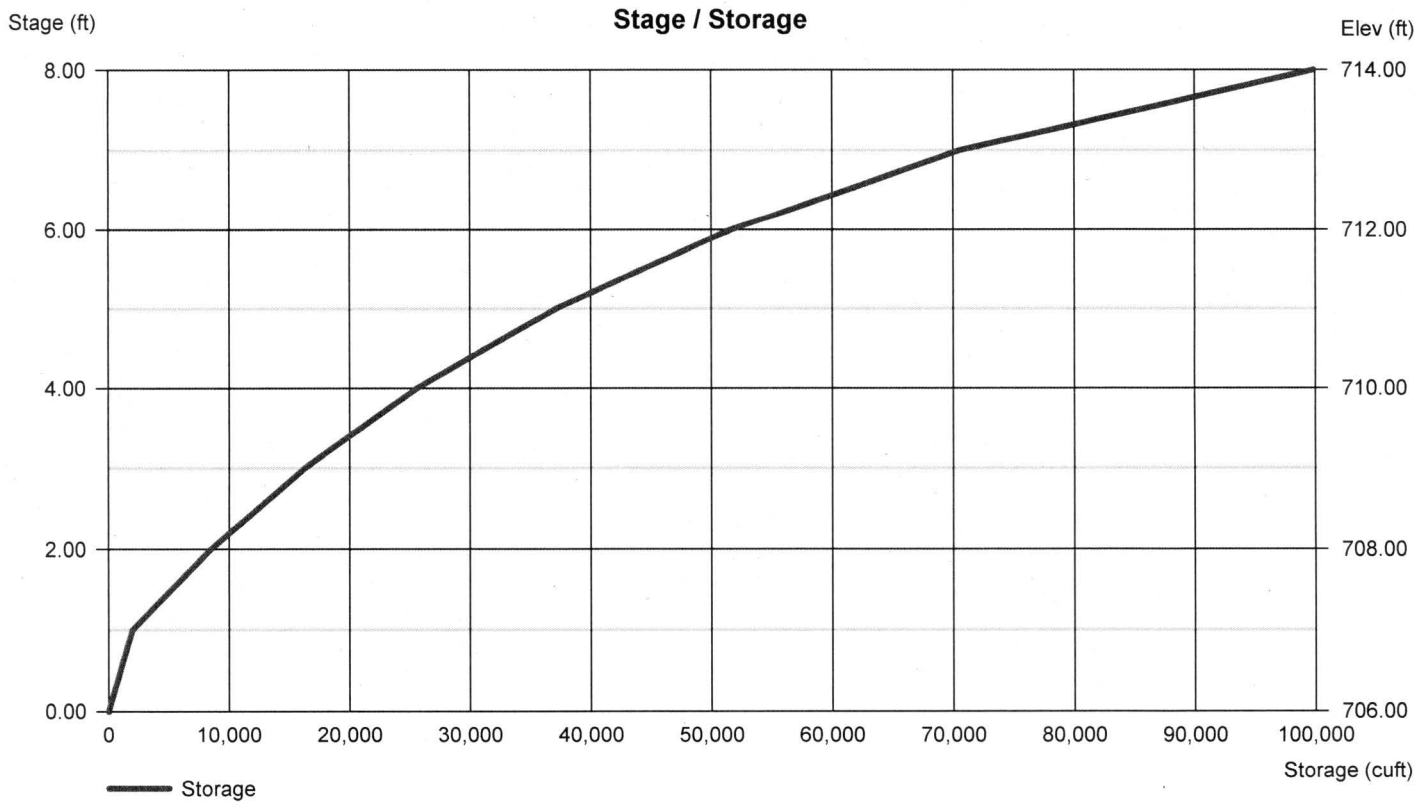
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 8 - Basin 8

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

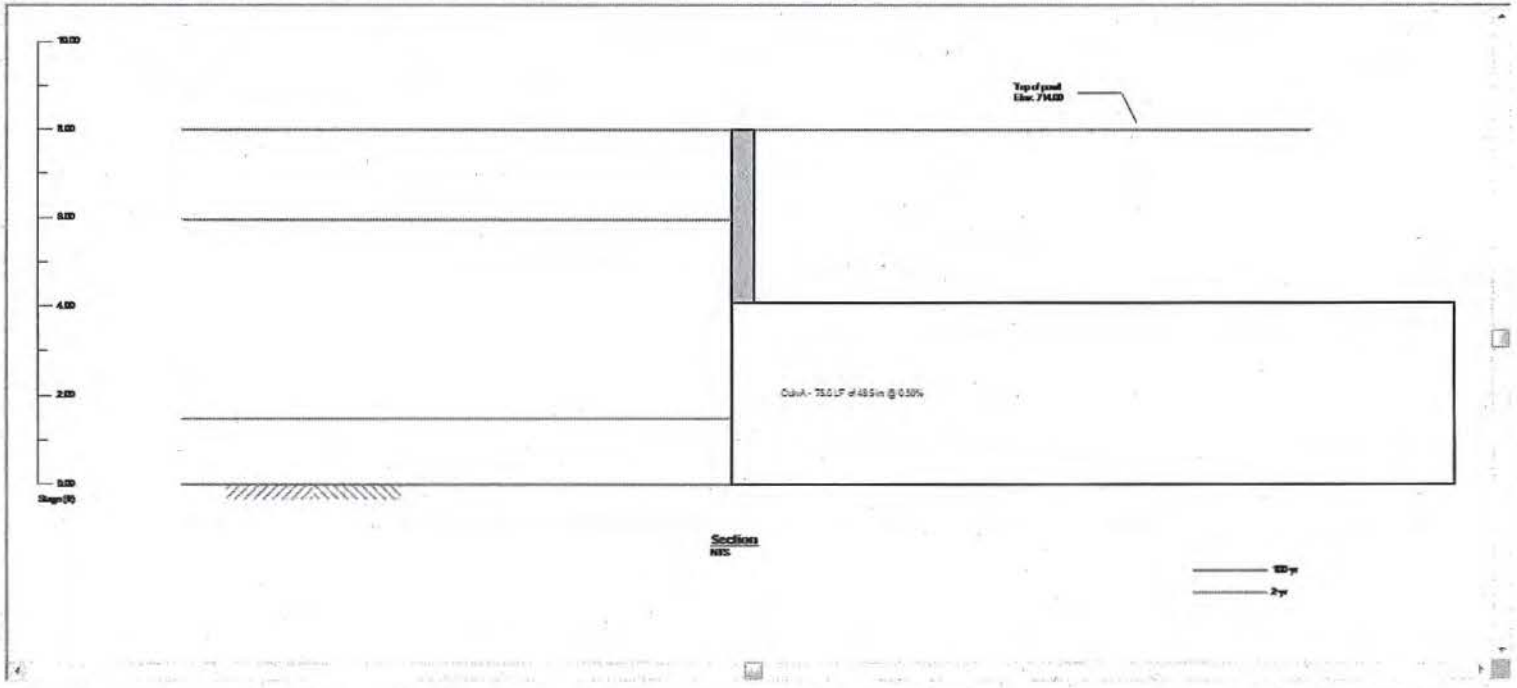
Storage Estimate

Inflow Hyd. No. = 22 - SCS Runoff - Basin 8

Event (yrs)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	310,211	59.38	0.000	0
3				
5				
10				
25				
50				
100	1,994,588	475.12	0.000	0

Estimate Storage

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

Culv/Orif	A	B	C	PR	Weir	A	B	C	D
Select	◉	○	○	○	Select	◉	○	○	○
Active	☑	☑	☑	☑	Active	☑	☑	☑	☑

Diameter (in) = 48.86 | Crest Len (ft) = 0.00

Invert El. (ft) = 706.00 | Crest Elev (ft) = 0.00

Update | ☑ Auto Update | Trial Route | ☐ Auto Route

Actuals			
Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	59.45	707.47	5,063
100	461.64	711.97	51,083

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
SOUTHERN SECTION	AES	7/22/16
	Calculation Number	**Sheet**
	DC-BN-60166-001	111 of 128

DRAINAGE AREA = 128.80 AC (SEE ATTACHED MAP)

CURVE NUMBER = 89 (SEE ATTACHED TABLE)

16.38AC @ CN 61 (GRASS)

16.87AC @ CN 85 (GRAVEL)

36.60AC @ CN 86 (ASH) ASSUMED ASH TO BE THE SAME AS BARE SOIL.

7.92AC @ CN 98 (LINER) ASSUMED LINER AS IMPERVIOUS

51.03AC @ CN 100 (WATER) ASSUMED WATER AS COMPLETELY IMPERVIOUS

$$\frac{(16.38\times61)+(16.87\times85)+(36.60\times86)+(7.92\times98)+(51.03\times100)}{128.80} = 88.97 = 89$$

TIME OF CONCENTRATION = 18.50 MIN (SEE ATTACHED TR55 WORKSHEET)

SHEET FLOW

MANNINGS n-VALUE = 0.011 (GRAVEL)

FLOW LENGTH = 300 L.F.

LAND SLOPE = $\frac{737.00-724.75}{300} = 0.0408 = 4.08\%$

SHALLOW CONCENTRATED FLOW

FLOW LENGTH = 885 L.F.

WATERCOURSE SLOPE = $\frac{724.75-714.00}{885} = 0.0121 = 1.21\%$

SURFACE IS UNPAVED

SHALLOW CONCENTRATED FLOW

FLOW LENGTH = 66 L.F.

WATERCOURSE SLOPE = $\frac{714.00-707.00}{66} = 0.1061 = 10.61\%$

SURFACE IS PAVED

Design Calculations

SOUTHERN COMPANY

Project	Prepared By	Date
PLANT BOWEN H&H STUDY	JKB	7/19/16
Subject/Title	Reviewed By	Date
SOUTHERN SECTION	AES	7/22/16
	Calculation Number	Sheet
	DC-BN-601666-001	112 of 128

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

HDPE LINED 25' WIDE DITCH WITH 2.5:1 SIDE SLOPES AND 6' DEEP

CROSS SECTIONAL AREA = 61.40 S.F.

WETTED PERIMETER = 35.99 L.F.

CHANNEL SLOPE = $\frac{707.00 - 706.50}{823}$ = 0.0006 = 0.06%

MANNING'S n-VALUE = 0.013 (HDPE LINER)

FLOW LENGTH = 823 L.F.

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

4 - 48"Ø HDPE PIPES @ 0.25% SLOPE

CROSS SECTIONAL AREA = 9.58 S.F.

WETTED PERIMETER = 8.04 L.F.

CHANNEL SLOPE = $\frac{706.50 - 706.35}{60}$ = 0.0025 = 0.25%

MANNING'S n-VALUE = 0.013 (HDPE PIPE)

FLOW LENGTH = 60 L.F.

CHANNEL FLOW (SEE ATTACHED EXPRESS REPORT)

HDPE LINED 25' WIDE DITCH WITH 2.5:1 SIDE SLOPES AND 6' DEEP

CROSS SECTIONAL AREA = 83.42 S.F.

WETTED PERIMETER = 39.22 L.F.

CHANNEL SLOPE = $\frac{706.35 - 705.61}{1233}$ = 0.0006 = 0.06%

MANNING'S n-VALUE = 0.013 (HDPE LINER)

FLOW LENGTH = 1233 L.F.

TIME INTERVAL = 3MIN

Tc x 0.1333 = 18.50 x 0.1333 = 2.47 = 3

STORM DISTRIBUTION = TYPE II

Q_{1000} (STORM) = 1225.25 CFS (SEE ATTACHED HYDROGRAPH REPORT)

Design Calculations

SOUTHERN COMPANY

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	**Reviewed By**	**Date**
SOUTHERN SECTION	AES	7/22/16
	Calculation Number DC-BN-601666-001	**Sheet** 113 of 128

PROCESS FLOWS ENTERING INTO SOUTHERN SECTION OF ASH POND PER WATER BALANCE STUDY. (SEE ATTACHED WATER BALANCE FLOW CHART)

EAST + WEST COAL PILE RUNOFF	1,000
UNITS 3+4 BUILDING SUMPS	8,620
UNITS 1+2 BUILDING SUMPS	13,000
SEWAGE TREATMENT	7
UNITS 1-4 POLISHING UNIT	240
HEADWATERS	70
ASH TRANSPORT	5,000
TOTAL PROCESS FLOW	27,937 GPM

$$\frac{27{,}937\ \text{GAL}}{1\ \text{MIN}} \left| \frac{1\ \text{CF}}{7.480\ \text{GAL}} \right| \frac{1\ \text{MIN}}{60\ \text{SEC}} = 62.24\ \text{CFS}$$

Q_{1000} (PROCESS FLOW) = 62.24 CFS (SEE ATTACHED HYDROGRAPH REPORT)

Q_{1000} (TOTAL) = Q_{1000} (STORM) + Q (PROCESS FLOW)

= 1225.24 + 62.24 = 1287.49 CFS (SEE ATTACHED HYDROGRAPH REPORT)

SOUTHERN COMPANY

Design Calculations

Project	Prepared By	Date
PLANT BOWEN H+H STUDY	JKB	7/19/16
Subject/Title	Reviewed By	Date
SOUTHERN SECTION	AES	7/22/16
	Calculation Number	Sheet
	DC-BN-601666-001	114 of 128

TO EVALUATE THE STORAGE CAPACITY OF THE SOUTHERN SECTION OF THE ASH POND THE FOLLOWING ASSUMPTIONS WERE APPLIED.

1) THE RECYCLE POND IS AT A NORMAL POOL LEVEL OF 707.50
2) ALL 4-6,200 GPM PUMP CAN BE USED TO DRAW DOWN WATER FROM THE RECYCLE POND
3) TREAT THE LINED DITCHES AS PART OF THE RECYCLE FOR CAPACITY
4) TOP OF DIKE ELEVATION IS 715.00

ELEVATION	RECYCLE POND AREA	UPPER DITCH AREA	WEST DITCH AREA	TOTAL AREA	VOLUME
707.5	1,000,669	Ø	Ø	1,000,669	Ø
708	1,015,315	Ø	Ø	1,015,315	503,941
709	1,045,253	Ø	Ø	1,045,253	1,534,086
710	1,087,103	Ø	39,593	1,126,696	2,619,698
711	1,188,875	Ø	44,330	1,233,205	3,799,129
712	1,216,991	Ø	49,849	1,266,840	5,048,989
713	1,336,189	10,608	62,393	1,409,190	6,386,239
714	1,521,405	15,417	94,134	1,630,956	7,904,810
715	1,730,963	19,302	140,181	1,890,446	9,663,739

∴ THE STORAGE CAPACITY IN THE SOUTHERN SECTION OF THE ASH POND IS ABLE TO CONTAIN THE 1000YR-24HR STORM EVENT. (SEE ATTACHED POND REPORT)

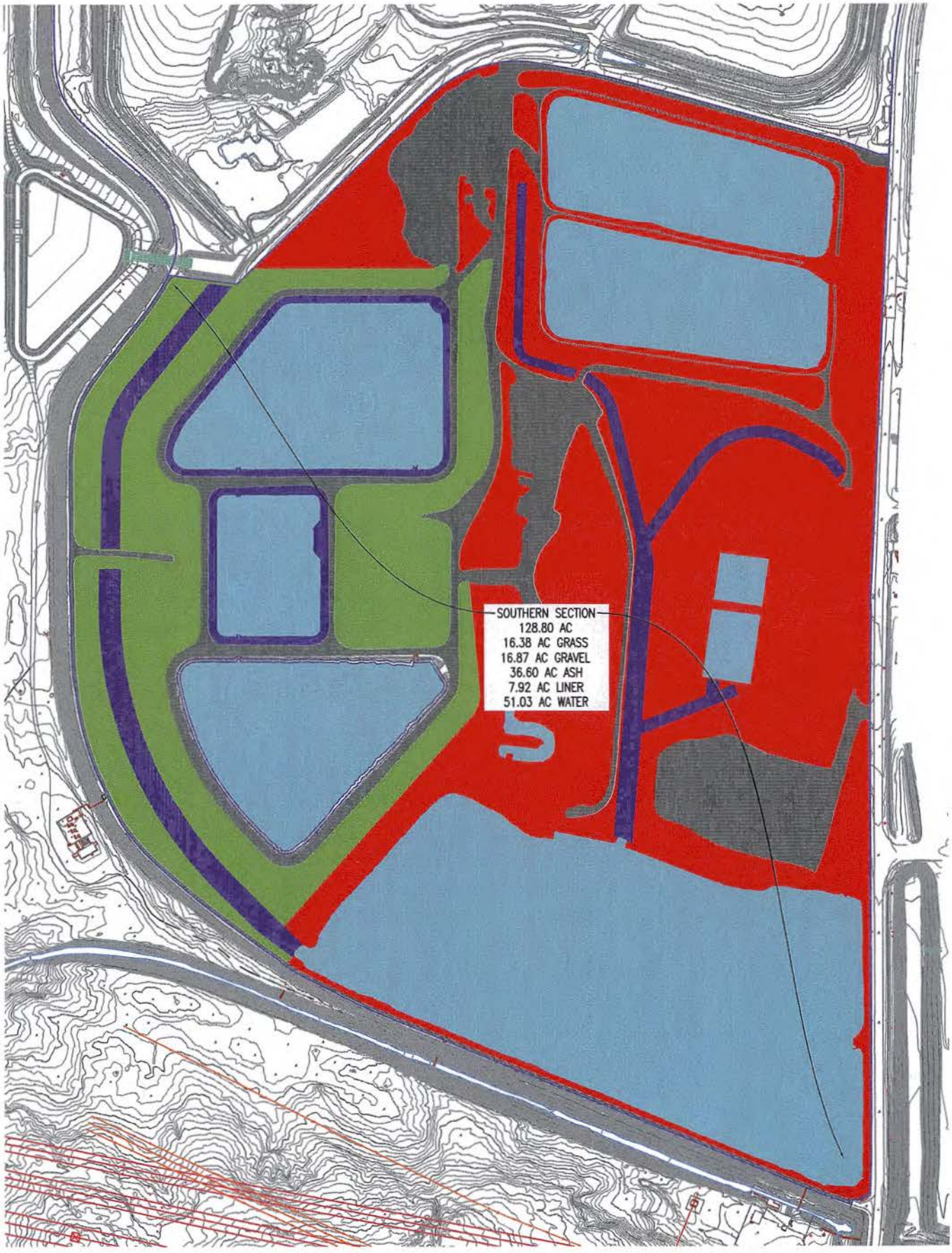

SOUTHERN SECTION
128.80 AC
16.38 AC GRASS
16.87 AC GRAVEL
36.60 AC ASH
7.92 AC LINER
51.03 AC WATER

Table 2.1.5-1 Runoff Curve Numbers[1]

Cover description			Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition		*Average percent impervious area*[2]	A	B	C	D
Cultivated land:	without conservation treatment		72	81	88	91
	with conservation treatment		62	71	78	81
Pasture or range land:	poor condition		68	79	86	89
	good condition		39	61	74	80
Meadow: good condition			30	58	71	78
Wood or forest land:	thin stand, poor cover		45	66	77	83
	good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]						
Poor condition (grass cover <50%)			68	79	86	89
Fair condition (grass cover 50% to 75%)			49	69	79	84
Good condition (grass cover > 75%)			39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm drains (excluding right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Urban districts:						
Commercial and business		85%	89	92	94	95
Industrial		72%	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65%	77	85	90	92
1/4 acre		38%	61	75	83	87
1/3 acre		30%	57	72	81	86
1/2 acre		25%	54	70	80	85
1 acre		20%	51	68	79	84
2 acres		12%	46	65	77	82
Developing urban areas and Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

TR55 Tc Worksheet

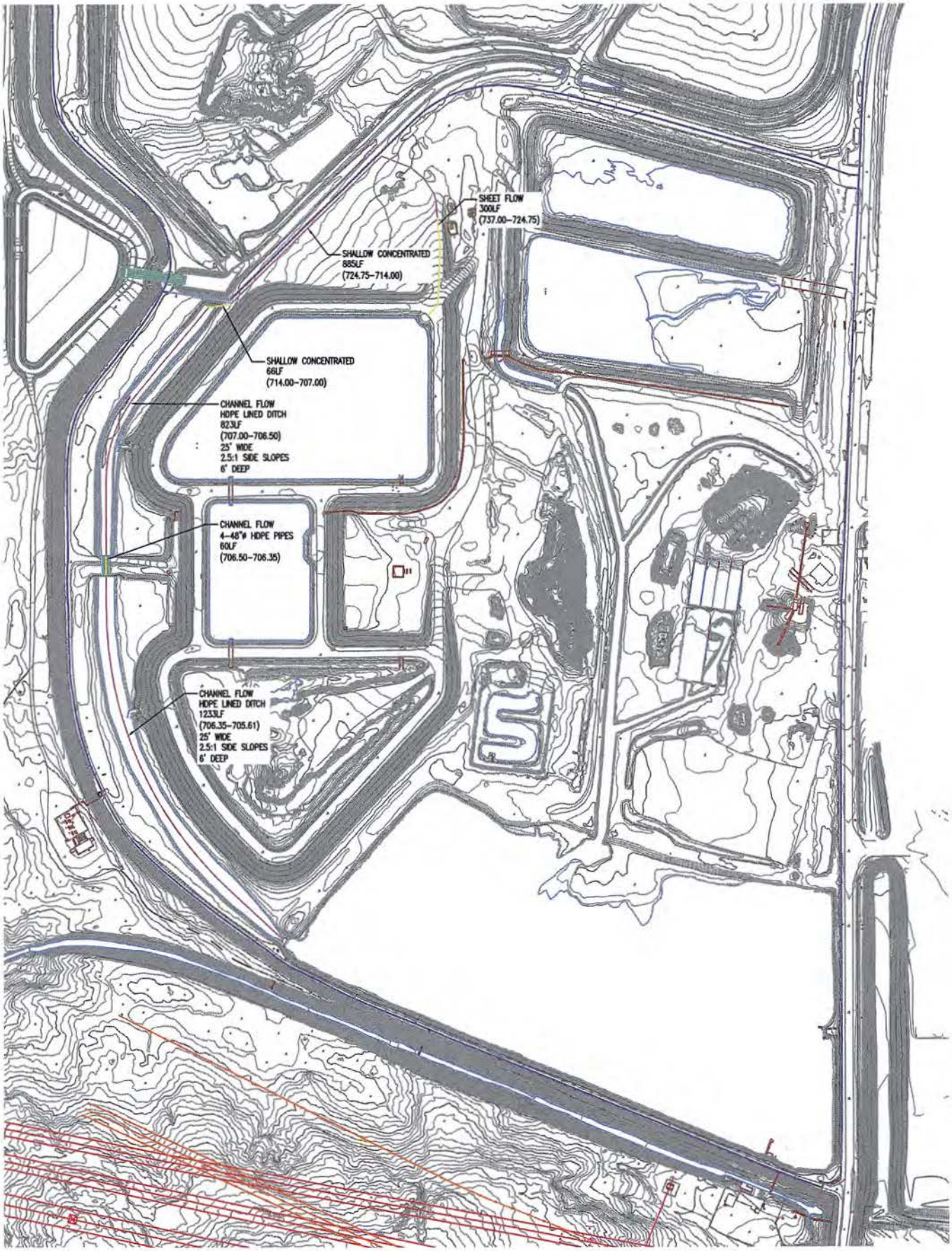
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No. 28

Southern Storm

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.011		0.011		0.011		
Flow length (ft)	= 300.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.79		0.00		0.00		
Land slope (%)	= 4.08		0.00		0.00		
Travel Time (min)	**= 2.02**	**+**	**0.00**	**+**	**0.00**	**=**	**2.02**
Shallow Concentrated Flow							
Flow length (ft)	= 885.00		66.00		0.00		
Watercourse slope (%)	= 1.21		10.61		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=1.77		6.62		0.00		
Travel Time (min)	**= 8.31**	**+**	**0.17**	**+**	**0.00**	**=**	**8.48**
Channel Flow							
X sectional flow area (sqft)	= 61.40		9.58		83.42		
Wetted perimeter (ft)	= 35.99		8.04		39.22		
Channel slope (%)	= 0.06		0.25		0.06		
Manning's n-value	= 0.013		0.013		0.013		
Velocity (ft/s)	=4.02						
			6.44				
					4.65		
Flow length (ft)	({0})823.0		60.0		1233.0		
Travel Time (min)	**= 3.42**	**+**	**0.16**	**+**	**4.41**	**=**	**7.99**

Total Travel Time, Tc ..... 18.48 min


SHEET FLOW
300LF
(737.00-724.75)
SHALLOW CONCENTRATED
885LF
(724.75-714.00)
SHALLOW CONCENTRATED
66LF
(714.00-707.00)
CHANNEL FLOW
HDPE LINED DITCH
823LF
(707.00-706.50)
25' WIDE
2.5:1 SIDE SLOPES
6' DEEP
CHANNEL FLOW
4-48"ø HDPE PIPES
60LF
(706.50-706.35)
CHANNEL FLOW
HDPE LINED DITCH
1233LF
(706.35-705.61)
25' WIDE
2.5:1 SIDE SLOPES
6' DEEP

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}\,(S)^{0.4}} \qquad (2.1.9)$$

Where: T_t= travel time (hr)
n = Manning roughness coefficient (see Table 2.1.5-2)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table 2.1.5-2 Roughness Coefficients (Manning's n) for Sheet Flow[1]

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: SCS, TR-55, Second Edition, June 1986.

Shallow Concentrated Flow

After a maximum of 50 to 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 2.1.5-5, in which average velocity is a function of watercourse slope and type of channel.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using Figure 2.1.5-5, or the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $V = 16.13(S)^{0.5}$ (2.1.10)

Paved $V = 20.33(S)^{0.5}$ (2.1.11)

Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Tuesday, Jul 19 2016

Southern Section Ditch 1

Trapezoidal

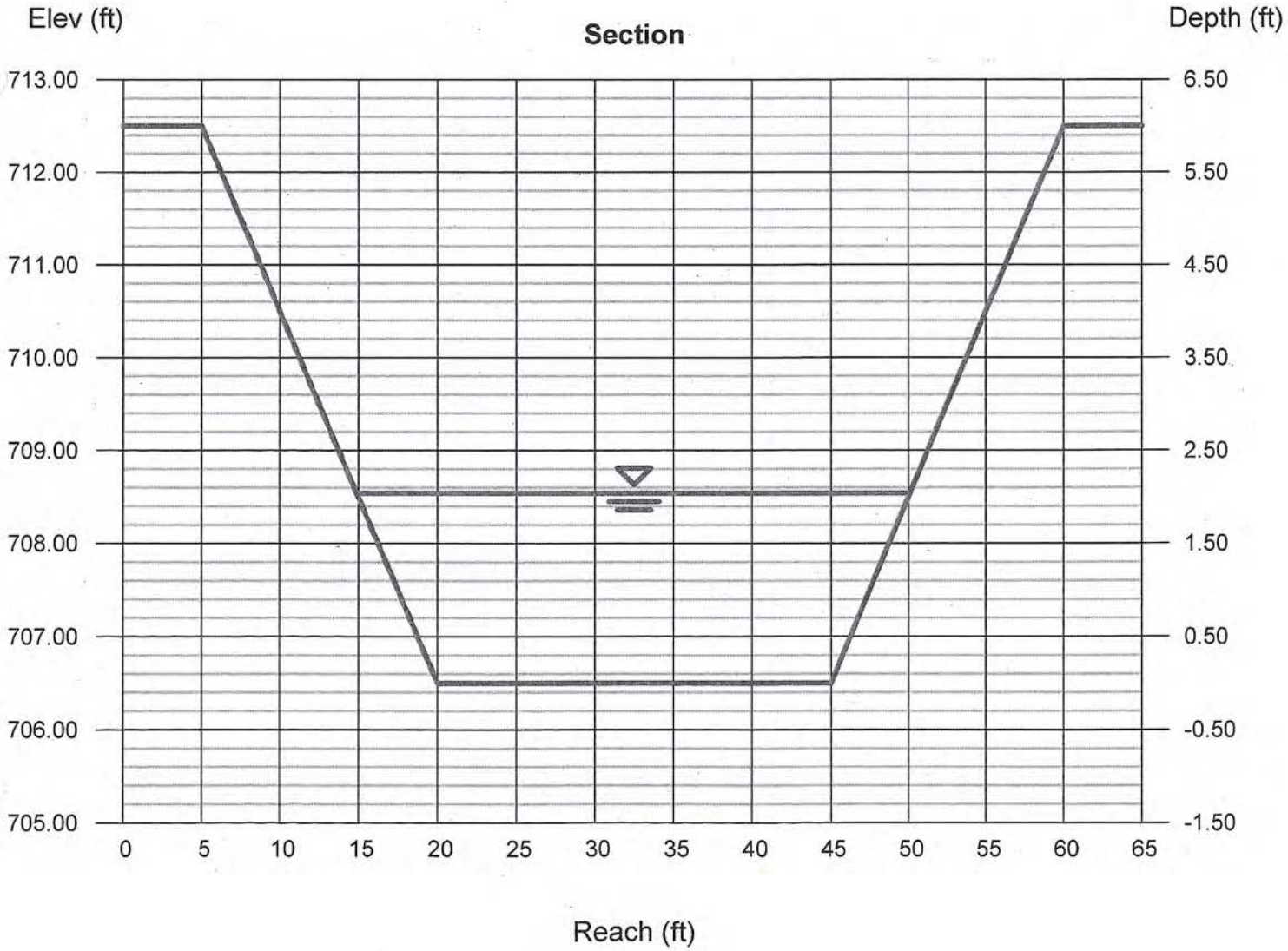
Bottom Width (ft)	= 25.00
Side Slopes (z:1)	= 2.50, 2.50
Total Depth (ft)	= 6.00
Invert Elev (ft)	= 706.50
Slope (%)	= 0.06
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 245.43

Highlighted

Depth (ft)	= 2.04
Q (cfs)	= 245.43
Area (sqft)	= 61.40
Velocity (ft/s)	= 4.00
Wetted Perim (ft)	= 35.99
Crit Depth, Yc (ft)	= 1.38
Top Width (ft)	= 35.20
EGL (ft)	= 2.29



Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Friday, Jul 22 2016

Southern Section Pipes

Circular

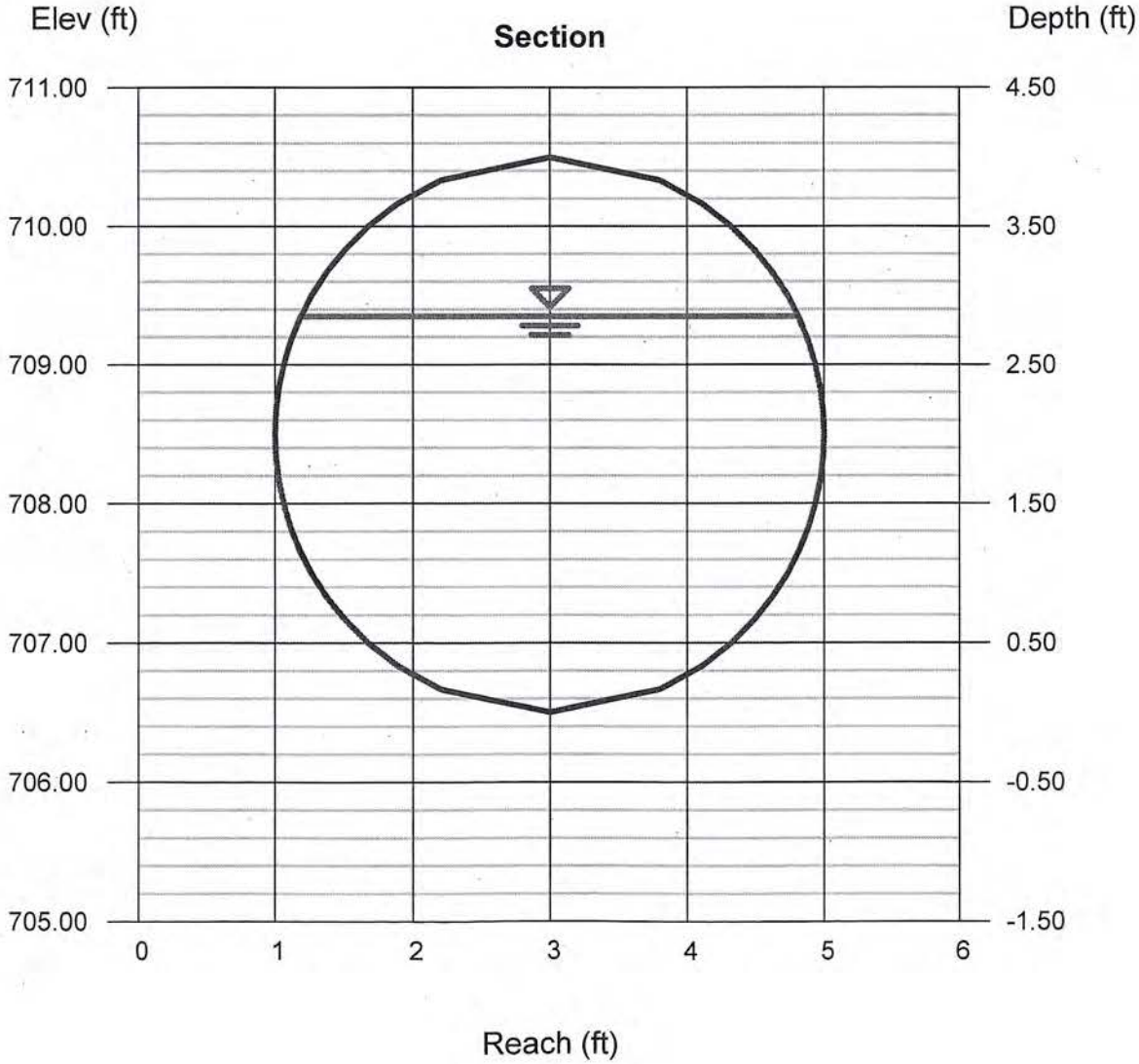
Diameter (ft)	= 4.00
Invert Elev (ft)	= 706.50
Slope (%)	= 0.25
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 61.36

Highlighted

Depth (ft)	= 2.85
Q (cfs)	= 61.36
Area (sqft)	= 9.58
Velocity (ft/s)	= 6.41
Wetted Perim (ft)	= 8.04
Crit Depth, Yc (ft)	= 2.36
Top Width (ft)	= 3.62
EGL (ft)	= 3.49



Channel Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. Tuesday, Jul 19 2016

Southern Section Ditch 2

Trapezoidal

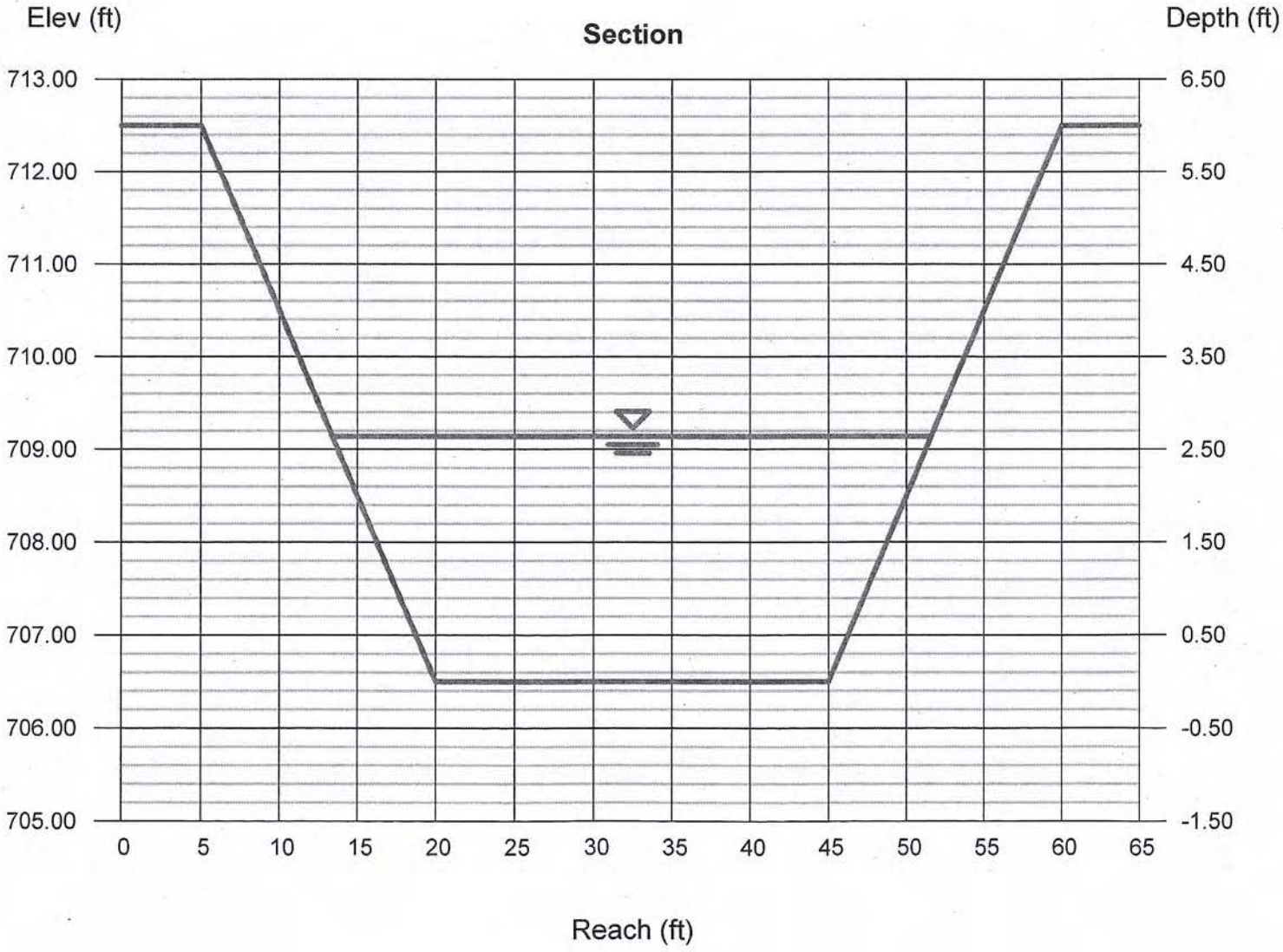
Bottom Width (ft)	= 25.00
Side Slopes (z:1)	= 2.50, 2.50
Total Depth (ft)	= 6.00
Invert Elev (ft)	= 706.50
Slope (%)	= 0.06
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 386.30

Highlighted

Depth (ft)	= 2.64
Q (cfs)	= 386.30
Area (sqft)	= 83.42
Velocity (ft/s)	= 4.63
Wetted Perim (ft)	= 39.22
Crit Depth, Yc (ft)	= 1.83
Top Width (ft)	= 38.20
EGL (ft)	= 2.97



3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.020
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.030
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.030
2. grass, some weeds	0.025	0.030	0.033
3. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. earth bottom and rubble sides	0.028	0.030	0.035
5. stony bottom and weedy banks	0.025	0.035	0.040
6. cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.040
2. jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.010	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.010	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016

Hydrograph Report

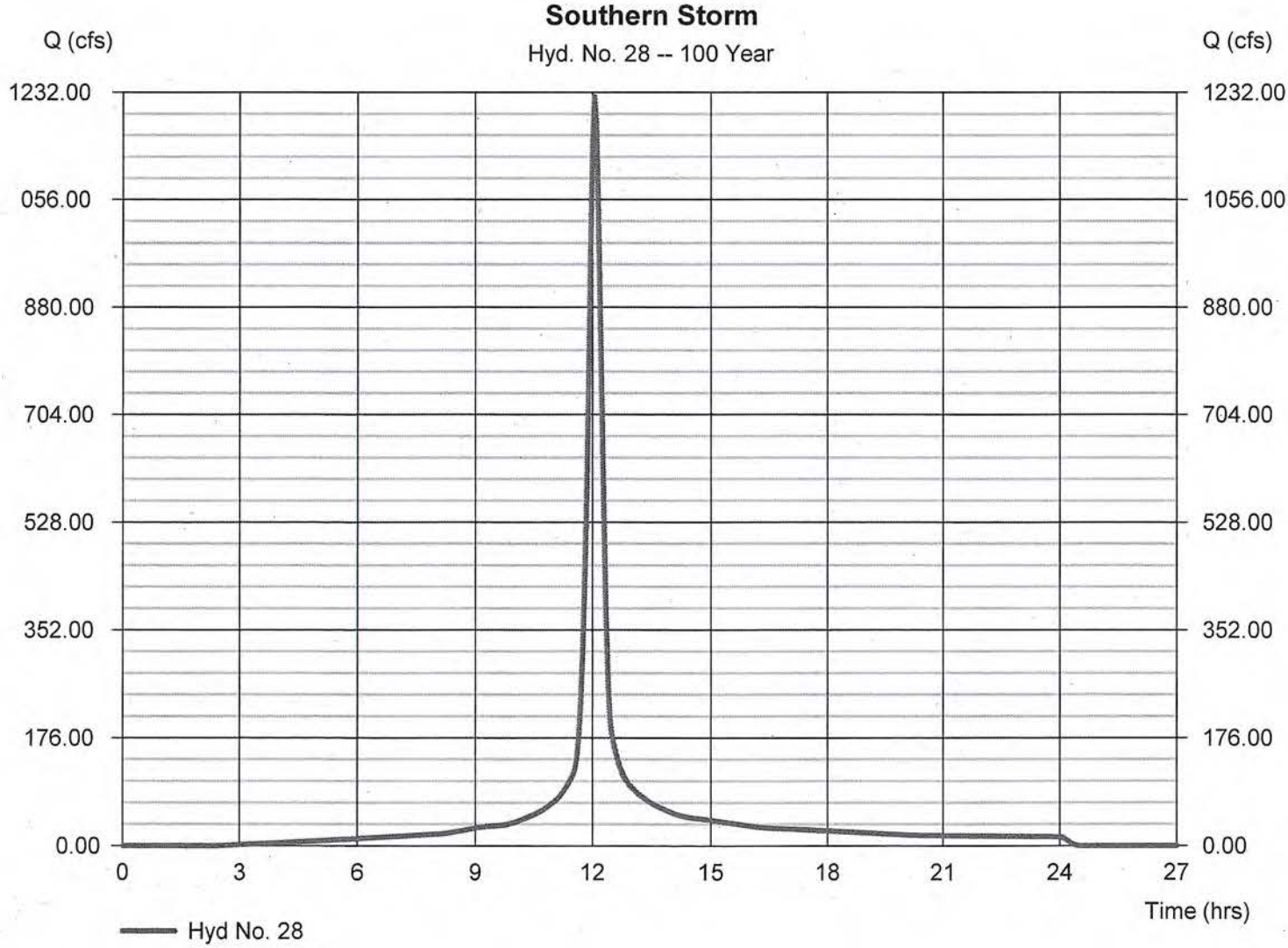
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Friday, 07 / 22 / 2016

Hyd. No. 28

Southern Storm

Hydrograph type	= SCS Runoff	Peak discharge	= 1225.25 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.05 hrs
Time interval	= 3 min	Hyd. volume	= 4,163,944 cuft
Drainage area	= 128.800 ac	Curve number	= 89*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 18.50 min
Total precip.	= 9.98 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(16.380 x 61) + (16.870 x 85) + (36.600 x 86) + (7.920 x 98) + (51.030 x 100)] / 128.800



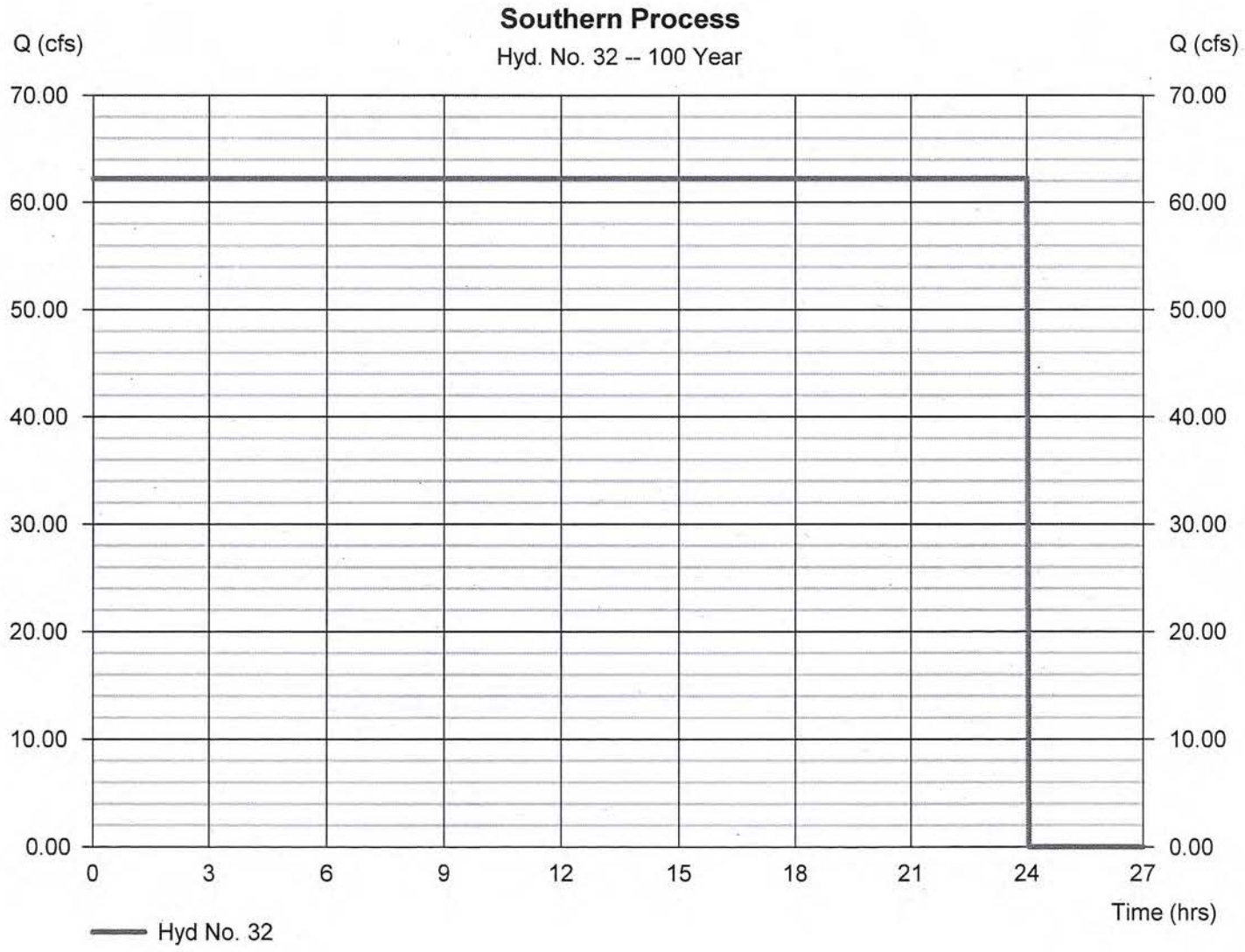
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Tuesday, 07 / 19 / 2016

Hyd. No. 32

Southern Process

Hydrograph type	= Manual	Peak discharge	= 62.24 cfs
Storm frequency	= 100 yrs	Time to peak	= 0.00 hrs
Time interval	= 3 min	Hyd. volume	= 5,388,731 cuft



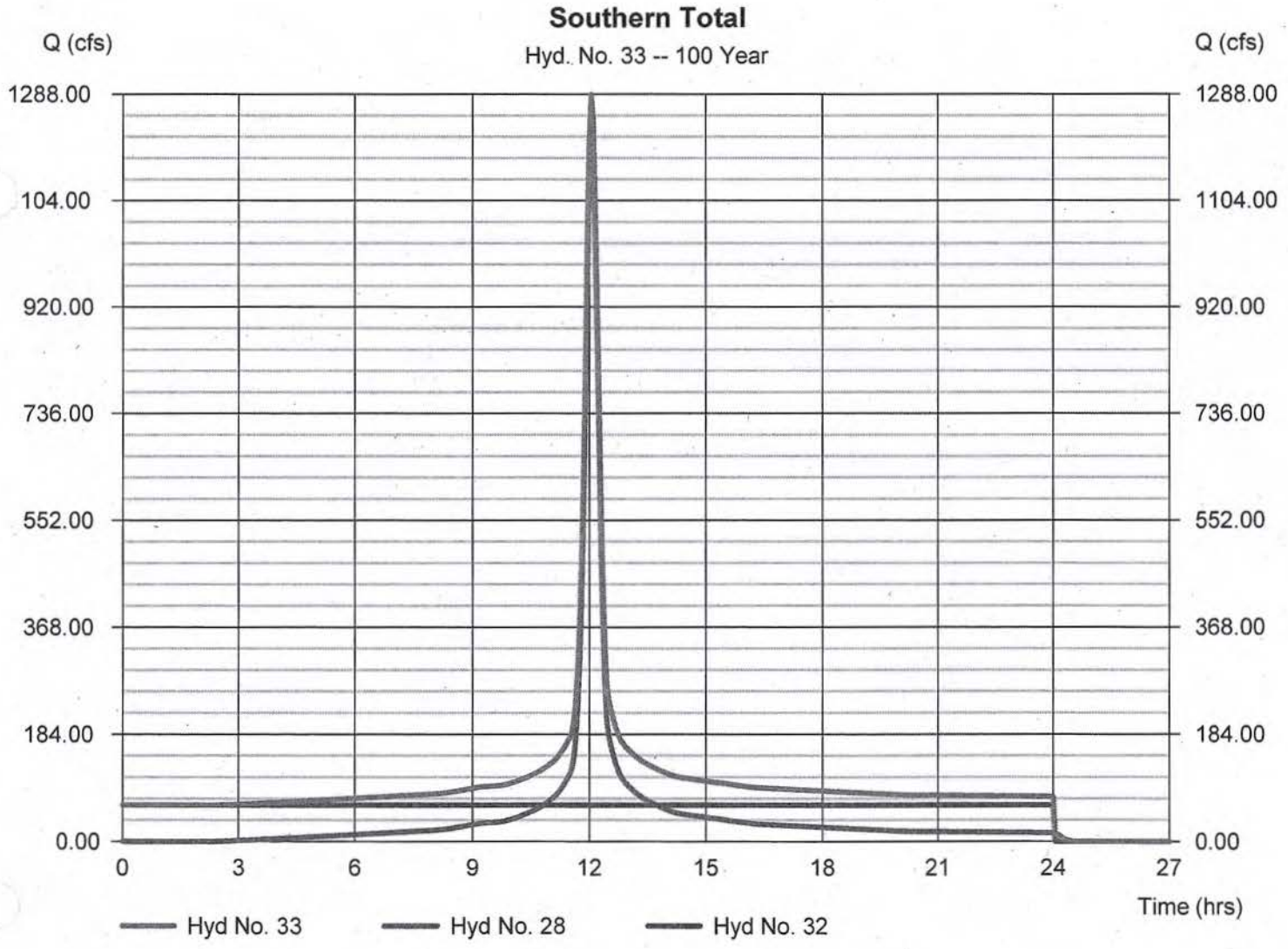
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Friday, 07 / 22 / 2016

Hyd. No. 33

Southern Total

Hydrograph type	= Combine	Peak discharge	= 1287.49 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.05 hrs
Time interval	= 3 min	Hyd. volume	= 9,552,681 cuft
Inflow hyds.	= 28, 32	Contrib. drain. area	= 128.800 ac



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10 — Tuesday, 07 / 19 / 2016

Pond No. 10 - Southern Section

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 707.50 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	707.50	1,000,669	0	0
0.50	708.00	1,015,315	503,941	503,941
1.50	709.00	1,045,253	1,030,145	1,534,086
2.50	710.00	1,126,696	1,085,612	2,619,698
3.50	711.00	1,233,205	1,179,431	3,799,129
4.50	712.00	1,266,840	1,249,860	5,048,989
5.50	713.00	1,409,190	1,337,250	6,386,239
6.50	714.00	1,630,956	1,518,571	7,904,810
7.50	715.00	1,890,446	1,758,929	9,663,739

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 30.00	0.00	0.00	0.00
Span (in)	= 30.00	0.00	0.00	0.00
No. Barrels	= 1	0	0	0
Invert El. (ft)	= 707.50	0.00	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 1.50	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

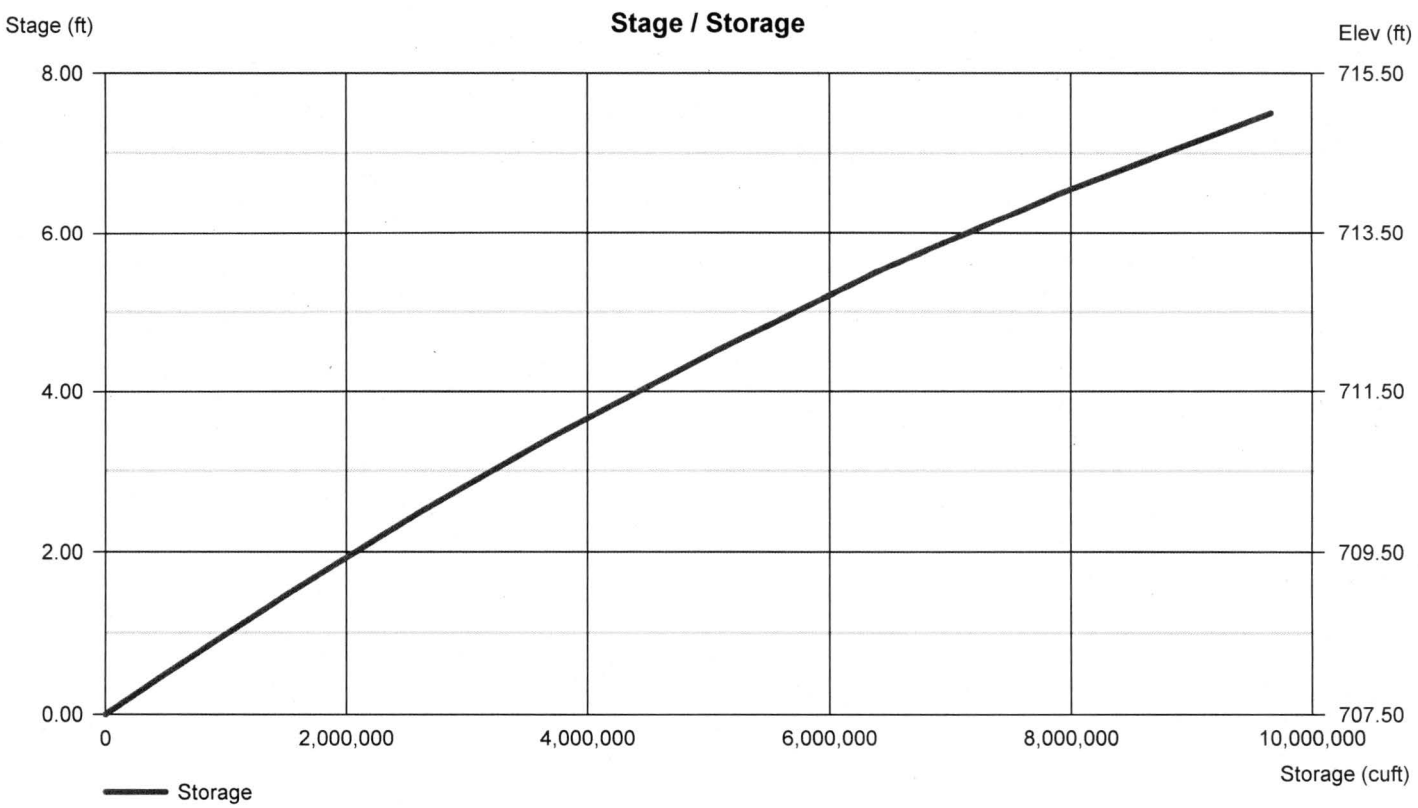
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 0.00	0.00	0.00	0.00
Crest El. (ft)	= 0.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= ---	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Stage / Storage / Discharge Setup - Pond No. 10 - Southern Section

Exit | Export | Print | Help

Storage | Outlets | Pond Tools | Graphs | Table

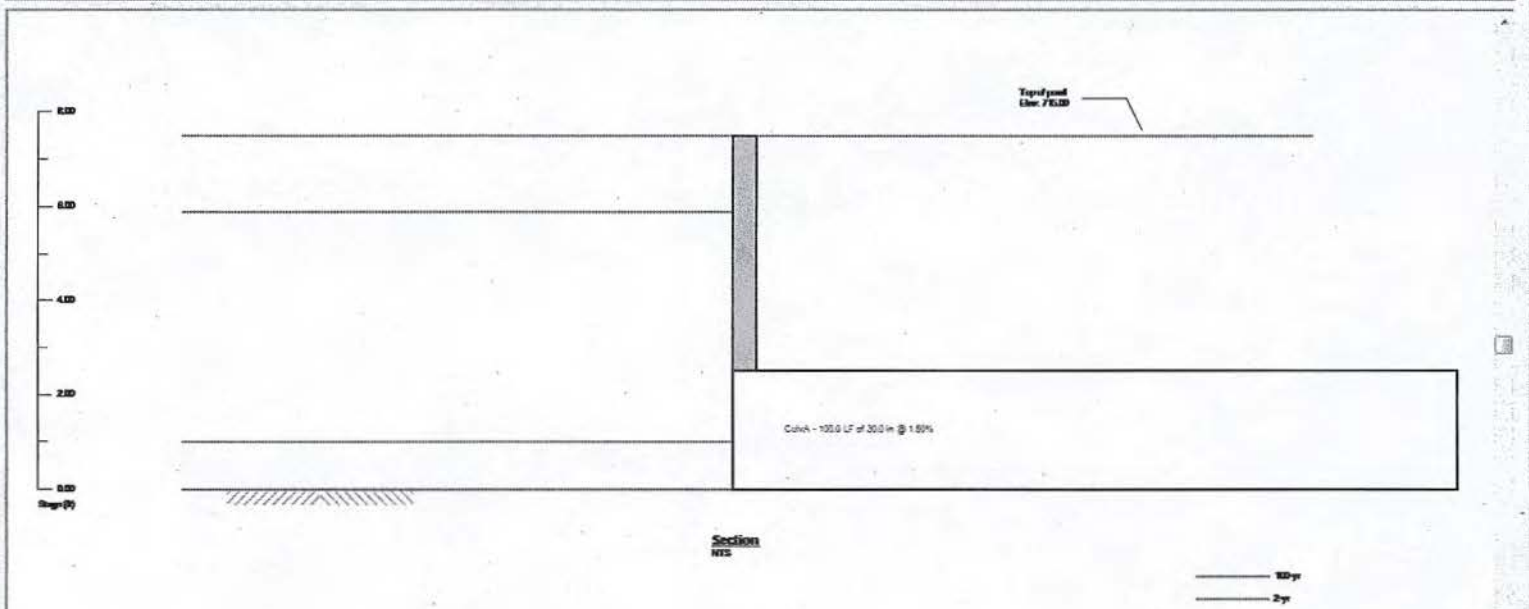
Storage Estimate

Inflow Hyd. No. = 33 - Combine - Southern Total

Event (yr)	Vol In (cuft)	Qp In (cfs)	Target (cfs)	Req. Stor (cuft)
1				
2	1,266,387	393.36	0.000	
3				
5				
10				
25				
50				
100	9,552,681	1287.49	0.000	

Estimate Storage

Stage vs Q | Sect | Front | Labels | Hgl Off



Interactive

1.0 / 0.01 / 0.01

Culv/Orif	A	B	C	PR	Weir	A	B	C	D
Select	◉	○	○	○	Select	◉	○	○	○
Active	☑	☑	☑	☑	Active	☑	☑	☑	☑

Diameter (in) = 30.00 | Crest Len (ft) = 0.00

Invert EL. (ft) = 707.50 | Crest Elev (ft) = 0.00

Update | ☑ Auto Update | Trial Route | ☐ Auto Route

Actuals			
Event (yrs)	Qp (cfs)	Max El (ft)	Max Stor (cuft)
2	6.265	708.50	1,020,741
100	50.84	713.38	6,959,859