OSAGE DEVELOPMENT
FINAL/FIRST PLAT MICRO STORMWATER DRAINAGE STUDY

Prepared for:

Clayton Properties Group Inc.
DBA Summit Homes
Lee's Summit, Missouri

Olsson Project No. A19-2339
March 2020

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1. GENERAL INFORMATION

Osage is a proposed single-family residential development on approximately 36 acres, including a pool, amenity tract reserved for open space, and stormwater detention basin. This project is in the southwest of the intersection of Northwest Pryor Road and Highway 150 in Lee's Summit, Missouri. The Osage development first plat is approximately 21 acres and consists of 41 single family residential lots, the detention facility, and the amenity tract. Figure 1 shows the Osage development and first plat boundaries.

This drainage study is an update to the previously approved preliminary drainage study and will evaluate the hydrologic impact generated by construction of the Osage development first plat (proposed conditions). This study will also evaluate future conditions, which include the full build-out of the Osage development. For the future condition's analysis, there are no major hydrologic changes from the previously approved preliminary drainage study; however, the City of Lee's Summit's criteria for final stormwater management studies requires more detail, so these details have been included in Appendix E.

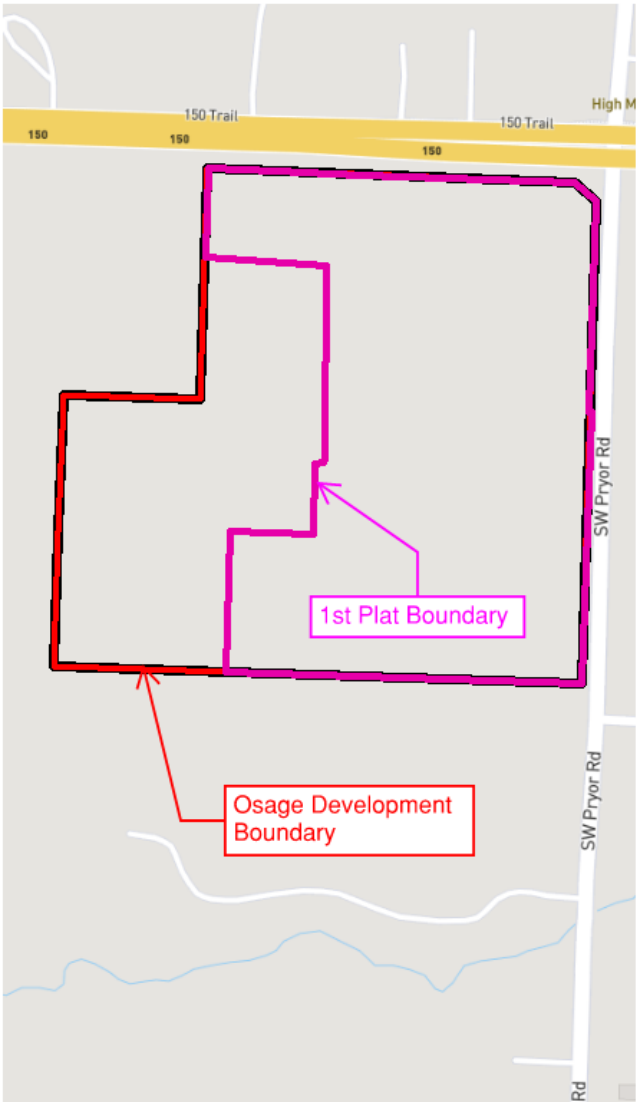


Figure 1. Location Map.

1.1 Federal Emergency Management Agency (FEMA) Floodplain Classification

FEMA Flood Boundary and Floodway Map Community Panel Number 29095C0531G classifies the Osage property as an unshaded “Zone X” area, which FEMA defines as an area of minimal flood hazard, usually above the 500-year flood level. See Exhibit 1 – Floodplain Map in Appendix A for the location of the site in relation to FEMA flood boundaries.

1.2 Soil Classifications

Soil maps published on the Natural Resources Conservation Service’s (NRCS) Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) categorize soils on the Osage property as shown in Table 1. See Exhibit 2 in Appendix A for a map of soils on the property.

Table 1. Soil Classifications.

Symbol	Name	Slopes	Hydrologic Soil Groups
10082	Arisburg-Urban Land Complex	1-5%	C
10116	Sampsel Silty Clay Loam	2-5%	C/D
10117	Sampsel Silty Clay Loam	5-9%	C/D
10122	Sharpsburg Silt Loam	5-9%	C

2. METHODOLOGY

The base data for the models prepared for this report has been obtained from available online maps and aerial imagery. Stormwater management is based upon methods and objectives defined in the Kansas City Metropolitan Chapter of the American Public Works Association's (KC-APWA) 2011 design guidance document called "Section 5600 Storm Drainage Systems & Facilities" (2011).

The following methods were used in this study to model existing and proposed conditions for stormwater runoff:

Hydraflow Hydrographs Extension Version 12

- Soil Conservation Survey (SCS) Unit Hydrograph Method
  - Two-year, 10-year, and 100-year Return Frequency Storms
  - Antecedent Moisture Conditions (AMC) II Soil Moisture Conditions
  - 24-Hour SCS Type II Rainfall Distribution
  - SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a – 2-2c)
  - SCS TR-55 methods for determination of time of concentration and travel time. Where specific data pertaining to channel geometry is not available, length and velocity estimates for channel flow travel time is used per Section 5600, KC-APWA Standard Specifications and Design Criteria.

Stormwater runoff models were created for the two-, 10-, and 100-year design storm events. The precipitation depths used in the analysis have been interpolated from the "Technical Paper No. 40 Rainfall Frequency Atlas of the United States" (TP-40) isopluvial maps (May 1961). Table 2 below summarizes the rainfall depths used in this analysis:

Table 2. Precipitation Depths.

Return Period	24-Hour Precipitation Depth (inches)
2-Year (50% Storm)	3.60
10-year (10% Storm)	5.34
100-Year (1% Storm)	7.90

3. EXISTING CONDITIONS

To quantify the effects of developing this project, the following areas and points of interest have been used for existing and proposed conditions analysis. See Exhibit 3 – Existing Conditions Drainage Map in Appendix A.

Drainage Area A represents the area in the southwestern corner of the site, which bypasses the proposed detention location. In existing conditions, drainage area A has an area of 5.16 acres.

Drainage Area B represents the majority of the site in both the existing and the proposed conditions models and drains to the southeastern corner of the site. In existing conditions, drainage area B has an area of 28.57 acres.

Drainage Area C is located in the northwestern corner of the site and drains north to Highway 150. In existing conditions, drainage area C has an area of 11.27 acres.

Three points of interest were chosen for comparison between existing and proposed conditions based on the three points of discharge from the site. These points can be found in both exhibits 3 and 4 in Appendix A.

Point of Interest A1 represents the southwestern corner of the site and compares drainage area A for both models. For the first plat, no area draining to this point of interest will be developed.

Point of Interest B1 represents a point near the southeastern corner of the site, just upstream of the triple, 30-inch corrugated metal pipe culverts crossing Northwest Pryor Road. Discharge to this point was compared between drainage area B in the existing conditions model and drainage areas B1 and B2 in the proposed conditions model at the outlet of the detention basin. Drainage area B2 bypasses the basin; flows from drainage areas B1 and B2 were combined before comparing with the existing conditions. See Exhibit 4 – Proposed Conditions Drainage Map in Appendix A and also Section 4 of this report for a more detailed discussion of the proposed conditions drainage areas.

Point of Interest C1 represents the northwestern corner of the site and compares drainage area C for existing and proposed conditions.

Bypass Area A was included in the model to account for area that does not pass through the site but drains to the culvert under Northwest Pryor Road near the southeastern corner of the development. This area was included in the model to calculate tailwater elevations for the proposed detention basin.

Tables 3, 4, and 5 below summarize the results of the existing conditions analysis. The proposed conditions data is compared to these results in Sections 4 of this report. Refer to Appendix B for output and a schematic for the existing conditions model and detailed calculations for the time of concentration.

Curve numbers were determined for existing and proposed conditions as shown in Table 3.

Table 3. Curve Numbers.

Land Use	Hydrologic Soil Group	Curve Number
Straight Row Crop	C	85
Straight Row Crop	D	89
Multifamily Residential	C	90
Multifamily Residential	D	92
Pasture	C	79
Pasture	D	84
Paved Open Ditches with Right-of-Way	C	92
Paved Open Ditched with Right-of-Way	D	93

Table 4. Existing Conditions Area Data.

Area Name	On-site Area (acres)	Off-site Area (acres)	Total Area (acres)	T_C (hours)	Weighted Curve Number
A	2.10	3.06	5.16	0.33	82
B	25.26	3.31	28.57	0.36	84
C	4.02	7.25	11.27	0.33	83
Bypass A	0	2.86	2.86	0.18	87

Table 5. Existing Conditions Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)*	Q_{10} (cfs)	Q_{100} (cfs)
A1	11.1	20.2	33.9
B1	61.8	109	179
C1	25.4	45.3	75.2

* cfs = cubic feet per second

Per APWA Section 5608.4 and the City of Lee's Summit criteria, the performance criteria for comprehensive control is to provide detention to limit peak flow rates at downstream points of interest to maximum release rates:

- 50 percent storm peak rate less than or equal to 0.5 cubic feet per second (cfs) per site acre
- 10 percent storm peak rate less than or equal to 2.0 cfs per site acre
- 1 percent storm peak rate less than or equal to 3.0 cfs per site acre

Extended detention of the 90 percent mean annual event is also required for comprehensive control per APWA Section 5608.4.

Allowable release rates were calculated for the points of interest, allowing that off-site peak discharges would be permitted to bypass the detention. Off-site bypass peak flow rates were calculated as the first plat's percentage of the existing conditions, relating to the percentage of off-site area flowing to each point. The release rates for the proposed development on the development site were calculated based on the detention criteria. The development release rates were added to the bypass peak flow rates to calculate an allowable peak flow rate for each point of interest as follows. These allowable release rates represent the first plat development only. Note that point of interest A1 will remain unaffected by first plat development; hence, the percent on-site is 0 percent, and no allowable release rate was calculated, as it is not applicable. Tables 6 and 7 below summarize the amount of area on-site and the allowable discharges for each storm event.

Table 6. Point of Interest On-site Area.

Point of Interest	Total Area (acres)	On-site Area (acres)	Percent (%) On-site
A1	5.16	0	0
B1	28.57	18.88	66.1
C1	11.27	2.28	20.2

Table 7. Allowable Peak Flow Rates.

Point of Interest	Allowable 2-Year (cfs)	Allowable 10-Year Q (cfs)	Allowable 100-Year Q (cfs)
B1	30.4	74.7	117.3
C1	21.4	40.7	66.8

4. PROPOSED CONDITIONS

The proposed conditions sections of this analysis assume completion of only the Osage development's first plat, including the construction of the detention facility. The difference between the existing conditions model and the proposed conditions model is a direct result of the Osage development first plat. Refer to Appendix A for the proposed conditions drainage area map.

4.1 Effects of Development

The proposed conditions analysis assumes completion of the first plat of the Osage development. The modeled subareas and points of interest are similar to the existing conditions model. However, throughout the site, some shifting of ridgelines will occur, accommodating proposed detention facilities and anticipated grading activities, which will change the relative areas draining to each point of interest. The following is a summary of the proposed conditions drainage areas. See Exhibit 4 – Proposed Conditions Drainage Map in Appendix A. Table 8 summarizes the proposed conditions area data.

Drainage Area A in proposed conditions is unaffected from existing conditions since it will not be developed with the first plat; hence, no further analysis is provided for proposed conditions.

Drainage Area B1 in proposed conditions is 28.87 acres and will drain to the proposed detention basin. For the first plat, 16.6 acres of this drainage area will be developed. Drainage area from existing conditions is shifted from drainage areas A and C to area B1.

Drainage Area B2 was previously part of drainage area B in existing conditions. This area was separated in the proposed conditions model, because it bypasses the detention basin. For consistency, the sum of drainage areas B1 and B2 were compared at the same point of interest as drainage area B in existing conditions. Drainage area B2 is 2.73 acres, which will be entirely developed with the first plat.

Drainage Area C in proposed conditions is 8.30 acres. Proposed grading shifts area from drainage area C to drainage area B1. Of this drainage area, 1.81 acres of this drainage area will be developed with the first plat.

The analysis provided in Section 3 established existing conditions of the development's drainage areas. The analysis in this section will provide guidance for configuring the detention basin to meet the objectives established in Section 3.

The following tables summarize the results of the proposed conditions analysis. Tables 9 and 10 assume no detention is provided, to demonstrate the effects of development for each drainage area. Refer to Appendix C for output from and a schematic of the proposed conditions Hydraflow Hydrographs model.

Table 8. Proposed Conditions Area Data.

Area Name	Area (ac.)	T_C (hr.)	Weighted CN
A1	5.16	0.33	82
B1	28.82	0.35	87
B2	2.73	0.10	90
C	8.30	0.32	85
Bypass A	2.86	0.18	87

Table 9. Proposed (No Detention) Conditions Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
B1	77.3	129.8	206.9
C1	20.3	35.1	57.1

Table 9 shows post-development peak discharge values points of interest assuming no detention is provided. Table 10 compares these to the existing conditions from Section 3 at the points of interest. Negative values indicate a reduction in peak flow rate, while positive values indicate an increase. Without detention, flow rates will increase at point B1, but decrease for C1. The decrease in flow rates at C1 is due to the proposed changes in grading, which shifts parts of the area areas to drainage area B1.

Table 10. Proposed (No Detention) vs. Existing Conditions.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
B1	15.5	20.8	27.9
C1	-5.1	-10.2	-18.1

4.2 Proposed Detention Facilities

To mitigate the increases in peak flows (shown in the previous table) and, where possible, to decrease further to the allowable release rates established in Section 3, detention will be provided for drainage area B1. This detention facility will be constructed as part of the first plat development.

Since the facility discharges directly to Pryor Road, the tailwater of the primary outlet pipe was set at the upstream elevation of the triple 30-inch corrugated metal pipe culverts during the appropriate storm event. Model results for the Pryor Road culverts can be found in Appendix D. These results assume that the culverts are clear with no sediment build up. Currently, the culverts have a heavy amount of silt deposition, which will need to be cleaned during the construction of the first plat.

The detention facility is designed to capture most of the site runoff and to mitigate increases in peak discharge from the site. The detention facility will be located near the southeastern corner of the site and will meet of the requirements outlined in Section 3. It will contain a multistage outlet structure and an independent 160-foot-long broad-crested weir graded into the eastern side of the berm. The following points summarize the multistage outlet structure and the emergency spillway:

- The structure itself will be a 5-foot-by-5-foot open-top concrete box with a top elevation of 1,017.1 feet, which generally controls the 100-year discharge.
- A 36-inch opening is present in the box at an elevation of 1,012.6 feet, which generally controls the 10-year and 100-year discharge.
- A 4.5-inch orifice is present in the box at the bottom elevation of the pond of 1010.0 feet. This helps control the 90 percent mean annual storm event. The two-year discharge is controlled by a combination of the 4.5-inch orifice and the 36-inch opening.
- The entire structure outlets to a 48-inch reinforced concrete pipe, which carries the water to Pryor Road.
- The emergency spillway will consist of a 160-foot-long broad-crested weir set at an elevation of 1,018.4 feet.

A 4.5-inch orifice will be set at the bottom of the multistage outlet structure. This orifice is sized to comply with the KC-AWPA requirement for 40-hour release of the 90 percent mean annual event for future conditions, which represents the entirety of the Osage development. To comply with the KC-APWA requirement for 40-hour release of the 90 percent mean annual event for the first plat development, this orifice could be partially covered with a steel plate to a 3.5-inch (+/-) diameter. The total inflow volume from the first plat 90 percent mean annual event is 1.40 acre-feet. This would then be released over 40 hours at a rate of 0.42 cfs given the 3.5-inch diameter. Upon completion of the entire development, the steel plate cover should be removed. Another option is not to cover the 4.5-inch opening, which will release the water quality volume faster than the 40-hour limit until the entirety of Osage is complete.

Table 11 includes a hydrologic summary of the proposed detention facility.

Table 11. Proposed Conditions Detention Flow and Volume Data.

	Peak Q In (cfs)	TP In (hr)	Peak Q Out (cfs)	TP Out (hr)	Peak W.S.E. (ft)	Stored Volume (ac-ft)
2-Year	70.0	12.10	4.2	13.83	1013.51	3.5
10-Year	118.1	12.10	27.4	12.50	1015.00	5.2
100-Year	188.8	12.10	56.3	12.43	1017.16	8.0

4.3 Effects of Proposed Detention

The following tables compare the results of the proposed conditions analysis with the detention described above to the existing conditions from Section 3 at the points of interest. Table 12 shows peak discharge values at peaks of interest for the completion of the first plat and detention facility. Tables 13 and 14 compare these discharge values to existing and allowable discharge values. In Tables 13 and 14, negative values indicate a reduction in peak flows, while positive values indicate an increase.

As shown in Table 14, with the addition of the detention facility, peak discharge at all three points of interest will be at or below the allowable release rates. As previously mentioned, no analysis is provided for point of interest A1, because no development will occur in this area for the first plat addition; therefore, discharge at point of interest A1 will be the same in proposed conditions and existing conditions.

Point of interest C1 shows a lower peak discharge for all storm events than the allowable release rate for two reasons. The first is that changes in the ridgeline move area from point of interest C1 to point of interest B1. The second is that the first plat addition does not develop the entire drainage area draining to C1. When the entirety of the Osage development is complete, a waiver will be required for point of interest C1 in the two-year event, which was documented in the preliminary stormwater drainage study. This study can be found in Appendix F.

Table 12. Proposed (with Detention) Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
B1	10.2	29.2	59.3
C1	20.2	34.9	56.7

Table 13. Proposed (with Detention) vs. Allowable Release Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
B1	-20.2	-45.5	-58.0
C1	-1.2	-5.8	-10.1

Table 14. Proposed (with Detention) vs. Existing Conditions.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
B1	-51.6	-79.8	-120
C1	-5.2	-10.4	-18.5

5. FUTURE CONDITIONS

Future conditions represent the built-out state of the Osage development. No changes that would affect hydrology have occurred since the preliminary stormwater drainage study was accepted in October 2018. Therefore, the final stormwater drainage study for the future conditions of the Osage development is the same as the proposed conditions analysis in the preliminary stormwater drainage study. The preliminary stormwater drainage study is included in Appendix F. While the basin outlet configuration, flow rates, etc. have not changed from the preliminary stormwater drainage study, the City requires additional hydrologic calculations to be included with the final stormwater drainage study. These calculations are present in Appendix E.

6. SUMMARY

This stormwater drainage study was prepared to evaluate the hydrologic impact generated by the first plat development of Osage and to provide recommendations for a comprehensive stormwater management plan for the future development. The first plat consists of 41 single-family residential lots, one detention facility, and the amenity called Tract E. The future built-out project is a single-family residential development on approximately 36 acres.

Increases in peak flow rates caused by the first plat development will be mitigated for all points of discharge through the site through a combination of dry detention and drainage area changes. The future conditions for the built-out Osage development remains hydrologically unchanged from the preliminary stormwater drainage study.

7. CONCLUSIONS AND RECOMMENDATIONS

This proposed first plat micro stormwater management plan and final stormwater management plan was designed to achieve compliance with current design criteria in effect for the City of Lee's Summit, Missouri; however, a waiver for point of interest C1 is still requested per the reasoning outlined in the preliminary stormwater drainage study for the future development of the second and third plats. That is, no waiver pertaining to the first plat alone is required, because the allowable discharge is met for all points of interest, but the originally requested waiver for the entire future development is still applicable. This waiver is submitted alongside this study for approval.

The results of the analysis demonstrate that the proposed first plat micro stormwater management plan for the project achieves compliance with design criteria, including extended detention of the 90 percent mean annual event, and that the final stormwater management plan likewise achieves compliance along with the requested waiver for drainage area C. We therefore request approval of this Final / First Plat Micro Osage Stormwater Drainage Study. This approval is conditional and should be substantiated with each future plat of Osage.

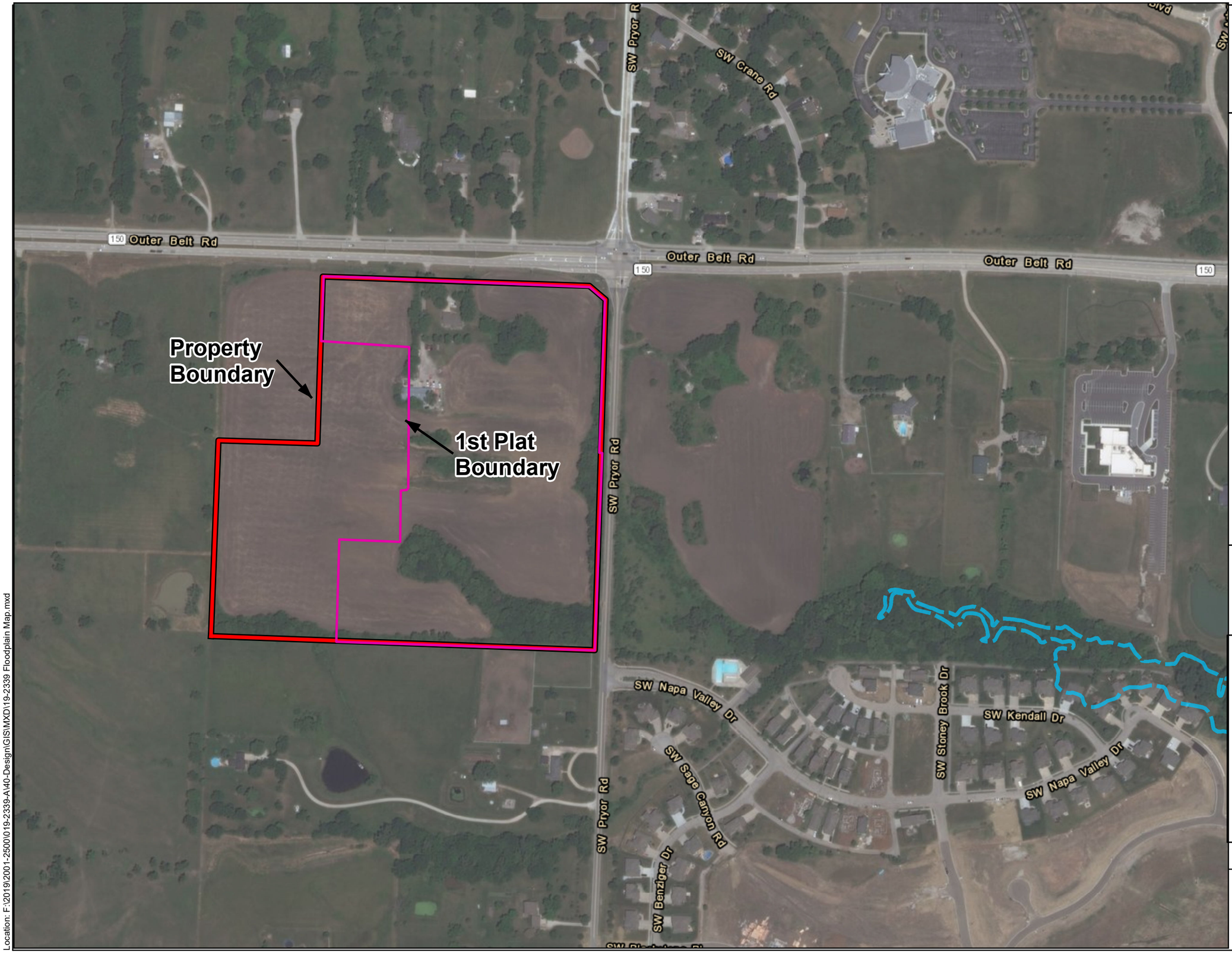
8. REFERENCES

KC-APWA (Kansas City Metropolitan Chapter of the American Public Works Association). (2011). “Section 5600 Storm Drainage & Facilities.”

United States Weather Bureau. “Technical Paper No. 40 Rainfall Frequency Atlas of the United States” (1961). Department of Commerce, Washington, D.C.

APPENDIX A

Site Maps



OSAGE

FLOODPLAIN MAP
EXHIBIT 1

LEGEND

- SITE BOUNDARY
- CURRENT EFFECTIVE ZONE X FLOODPLAIN
- 1ST PLAT BOUNDARY

Source:
FEMA Flood Boundary & Floodway Map
29095C0531G

Effective Date: 01/20/2017

N

0 300 600 Feet

1 ' = 300 "

Drawn: B. Fairchild 3/4/2020

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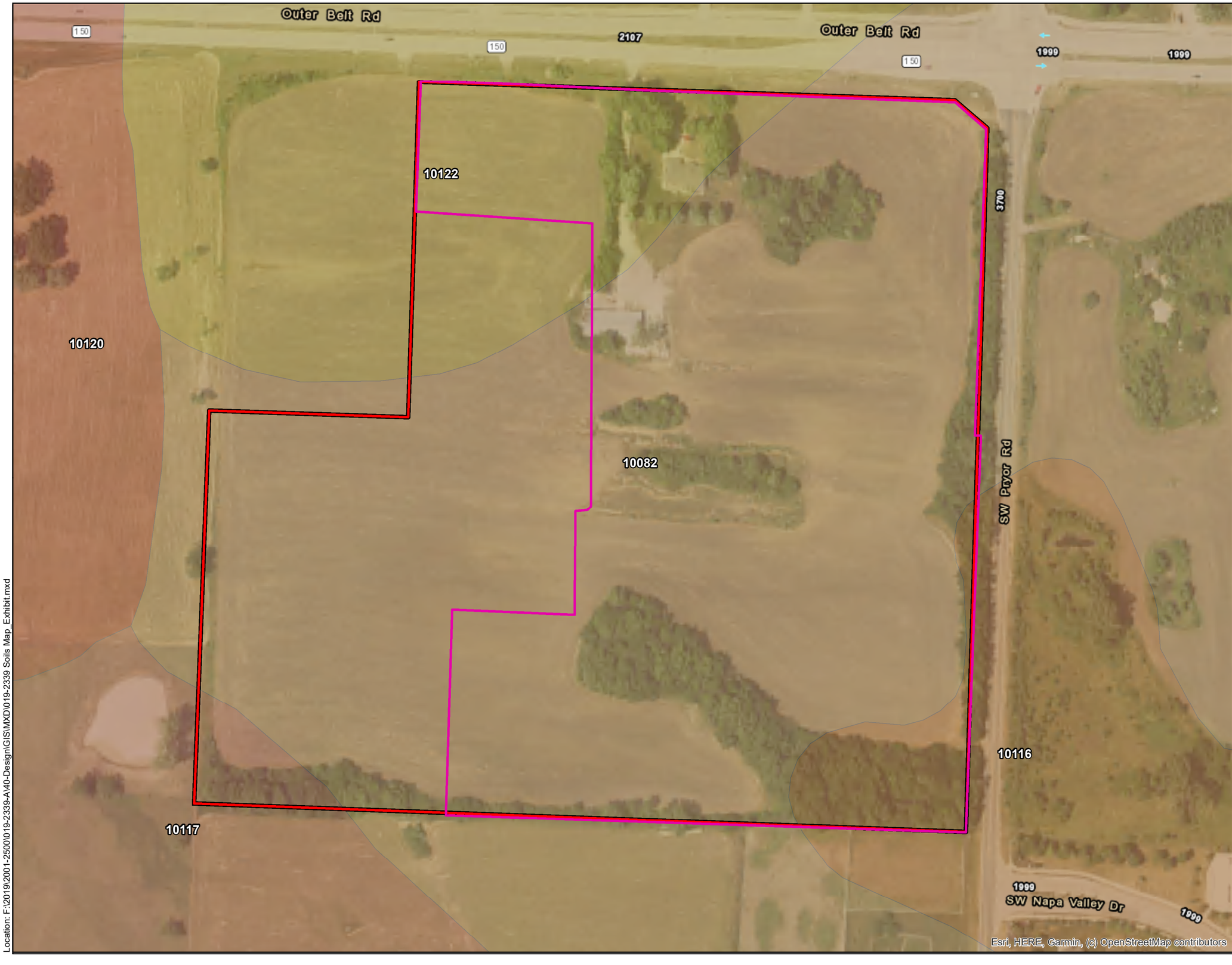
Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\19-2339 Floodplain Map.mxd



OSAGE

SOIL MAP

EXHIBIT 2

LEGEND

- 1ST PLAT BOUNDARY
- PROPERTY BOUNDARY
- *10000*
  ARISBURG SILT LOAM
  1 to 5% SLOPES
- *10082*
  ARISBURG LAND COMPLEX
  1 to 5% SLOPES
- *10016*
  SAMPSEL SILTY CLAY LOAM
  2 to 5% SLOPES
- *10017*
  SAMPSEL SILTY CLAY LOAM
  5 to 9% SLOPES
- *10120*
  SHARPSBURG SILT LOAM
  2 to 5% SLOPES
- *10122*
  SHARPSBURG SILT LOAM
  5 to 9% SLOPES

Source:
Soil Survey of Jackson County, Missouri

N

0 150 300

Feet

1 ' = 150 "

Drawn: B. Fairchild 3/4/2020

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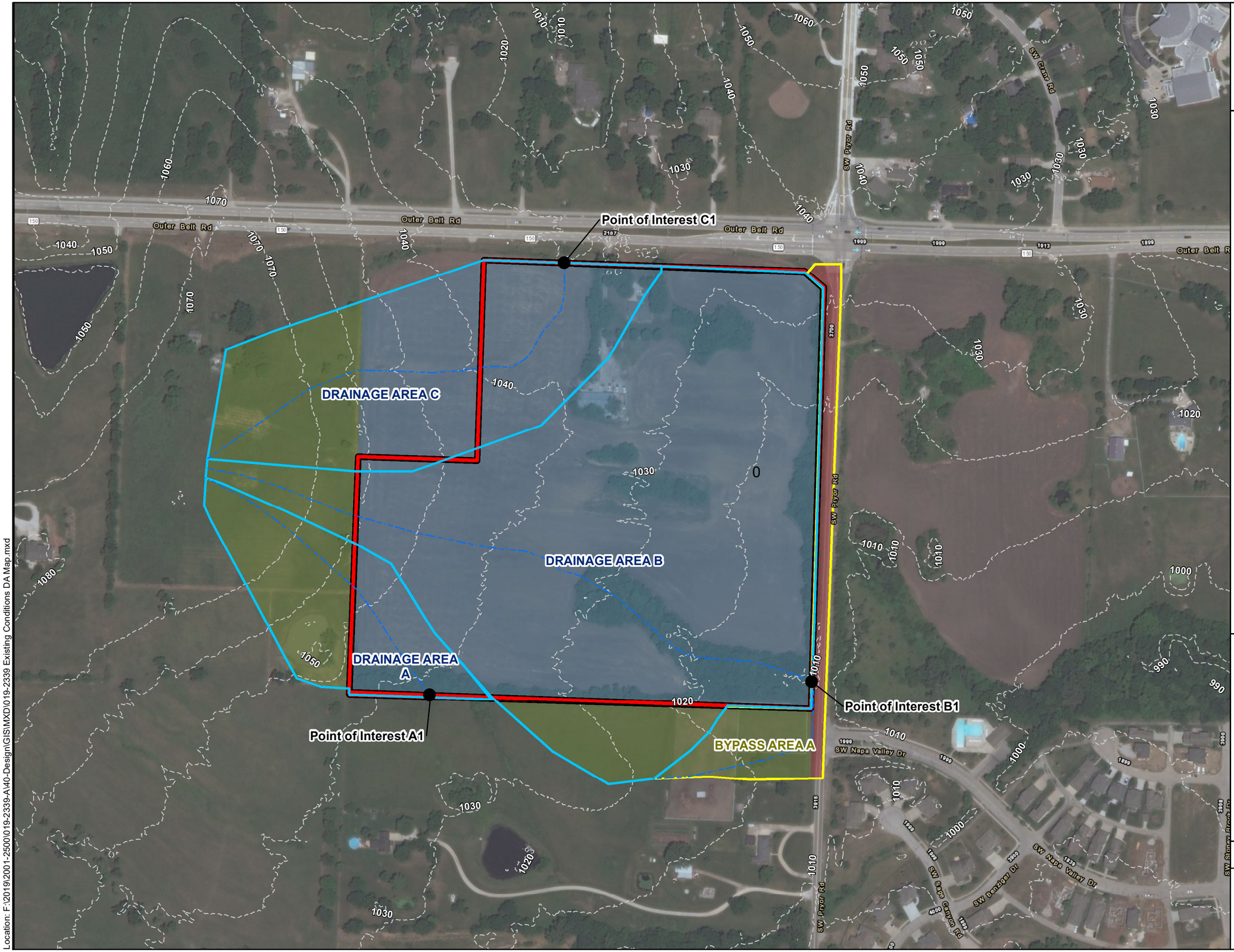
Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\019-2339 Soils Map_Exhibit.mxd

OSAGE

EXISTING CONDITIONS DRAINAGE MAP EXHIBIT 3



LEGEND

- SITE BOUNDARY
- EXISTING DRAINAGE AREA BOUNDARIES
- BYPASS AREA BOUNDARIES
- EXISTING 10-FT CONTOURS
- EXISTING FLOW PATH

LAND USE

- Multifamily Residential
- Pasture
- Paved Open Ditches w/ ROW
- Straight Row Crop

N

0 250 500 Feet

1 ' = 250 "

Drawn: B. Fairchild 3/4/2020

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Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\019-2339 Existing Conditions DA Map.mxd

OSAGE

PROPOSED CONDITIONS DRAINAGE MAP EXHIBIT 4

DRAINAGE AREA C

DRAINAGE AREA B1

DRAINAGE AREA B2

DRAINAGE AREA A

BYPASS AREA A

LEGEND

- 1ST PLAT BOUNDARY
- SITE BOUNDARY
- BYPASS AREA BOUNDARIES
- PROPOSED FLOW PATHS
- 1ST PLAT DRAINAGE BOUNDARIES
- PROPOSED 2-FT CONTOURS
- EXISTING 10-FT CONTOURS

1ST PLAT LAND USE

- Multifamily Residential
- Pasture
- Paved Open Ditches w/ ROW
- Straight Row Crop

N

0 250 500 Feet

1 ' = 250 "

Drawn: B. Fairchild 3/4/2020

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Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\018-2339 Proposed Conditions DA Map .mxd

APPENDIX B

Existing Conditions Hydraflow Hydrographs Model Input and Results

Subarea A

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.005	Grass-Range, Short (0.15)		0.272
Shallow Concentrated	778	0.052	Unpaved		0.059
Channel					
Total	878				0.331

Subarea B

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.005	Grass-Range, Short (0.15)		0.272
Shallow Concentrated	646	0.052	Unpaved		0.049
Channel	1,065			7	0.042
Total	1,811				0.363

Subarea C

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.005	Grass-Range, Short (0.15)		0.272
Shallow Concentrated	451	0.057	Unpaved		0.033
Channel	709			7	0.028
Total	1,260				0.333

Bypass Area A

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.030	Grass-Range, Short (0.15)		0.133
Shallow Concentrated	472	0.035	Unpaved		0.044
Channel					
Total	572				0.177

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	-------	11.16	-------	-------	20.21	-------	-------	33.87	Existing Conditions Area A
2	SCS Runoff	------	-------	61.82	-------	-------	108.92	-------	-------	179.23	Existing Conditions Area B
3	SCS Runoff	------	-------	25.41	-------	-------	45.33	-------	-------	75.19	Existing Conditions Area C
4	SCS Runoff	------	-------	9.322	-------	-------	15.64	-------	-------	24.90	Bypass Area A
5	Combine	2, 4	-------	68.77	-------	-------	120.39	-------	-------	197.29	Pryor Culvert

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

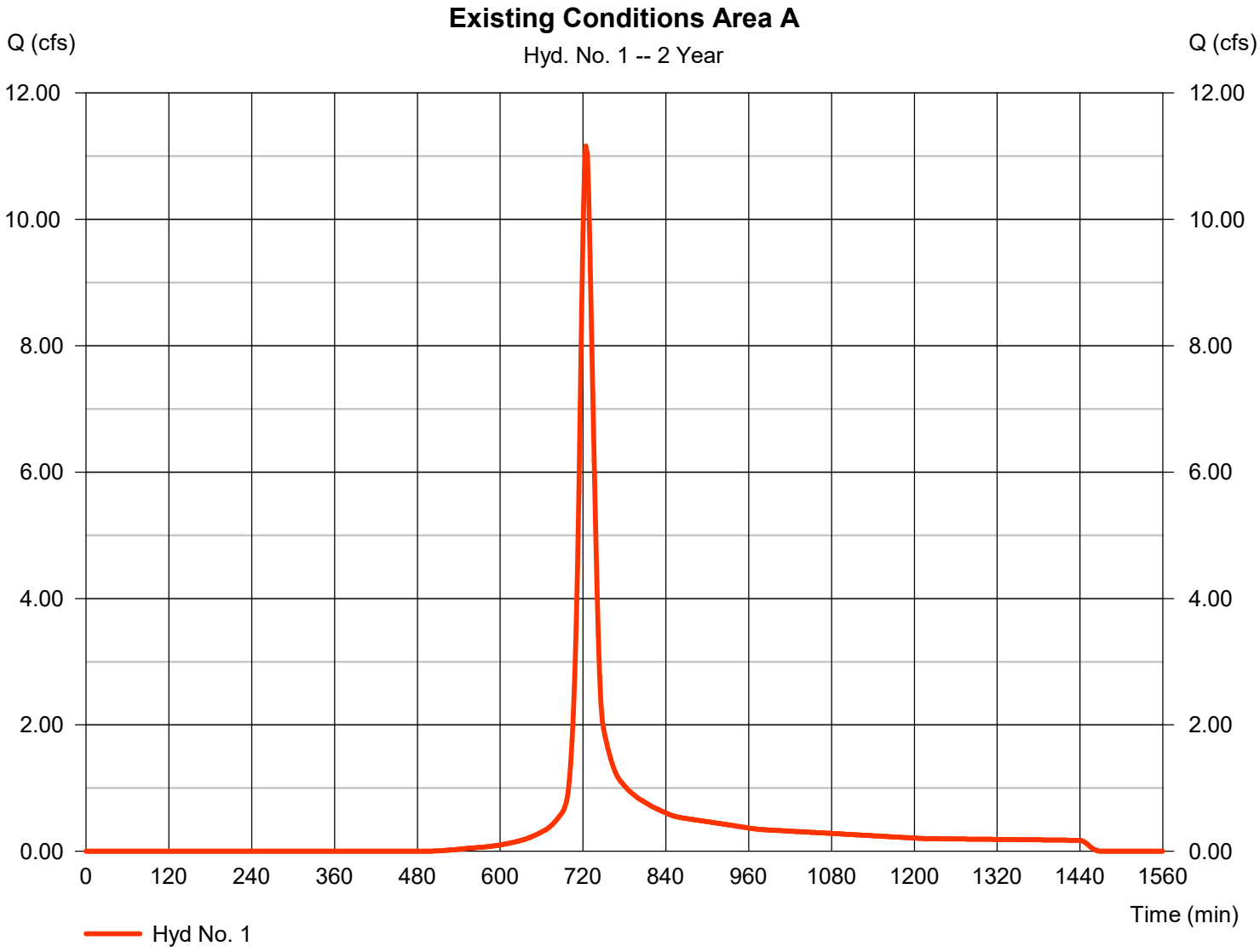
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	11.16	2	724	34,942	------	------	------	Existing Conditions Area A
2	SCS Runoff	61.82	2	726	213,484	------	------	------	Existing Conditions Area B
3	SCS Runoff	25.41	2	724	79,488	------	------	------	Existing Conditions Area C
4	SCS Runoff	9.322	2	720	24,330	------	------	------	Bypass Area A
5	Combine	68.77	2	726	237,814	2, 4	------	------	Pryor Culvert

Hydrograph Report

Hyd. No. 1

Existing Conditions Area A

Hydrograph type	= SCS Runoff	Peak discharge	= 11.16 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 34,942 cuft
Drainage area	= 5.160 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 20.00 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

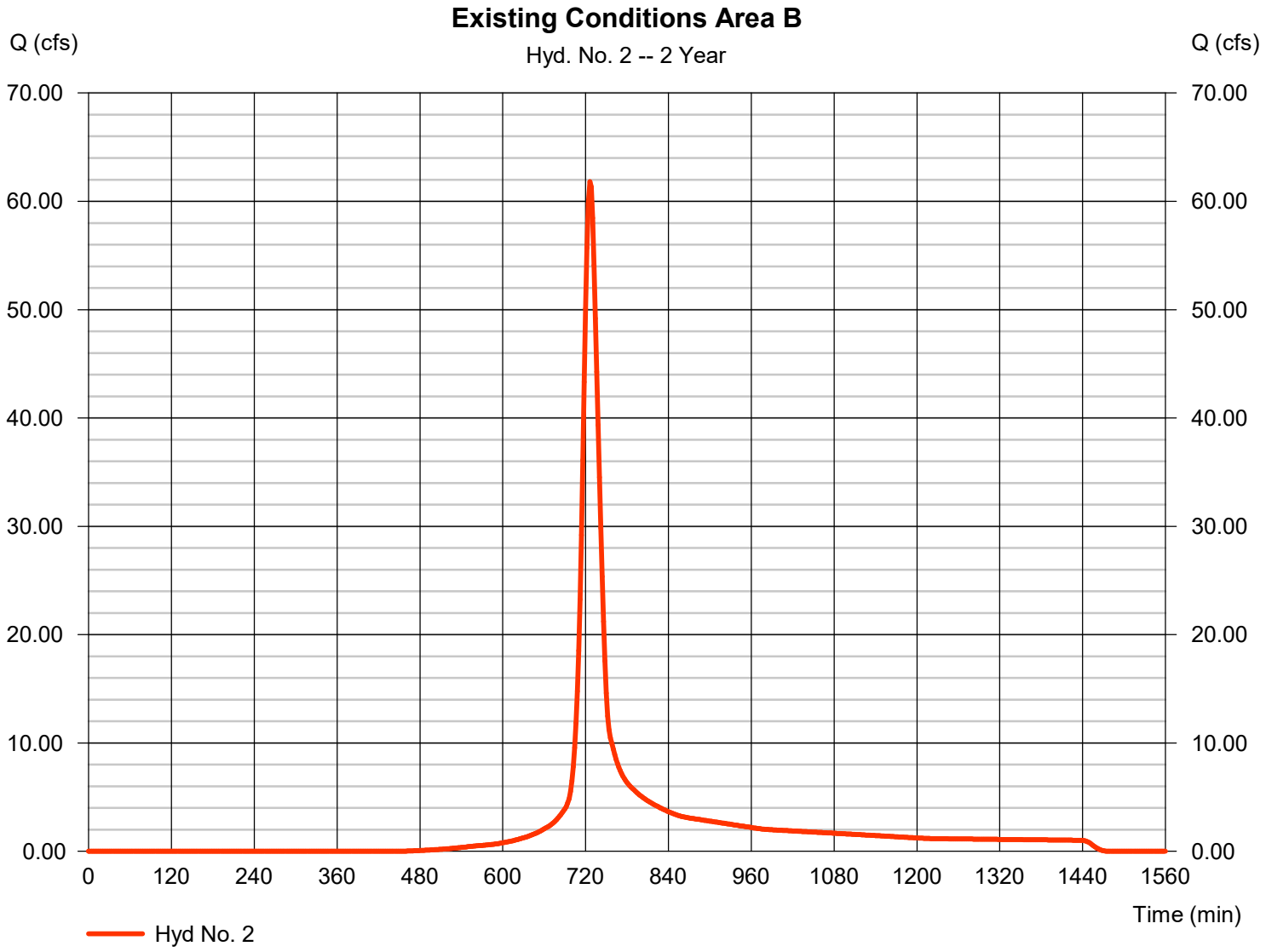


Hydrograph Report

Hyd. No. 2

Existing Conditions Area B

Hydrograph type	= SCS Runoff	Peak discharge	= 61.82 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 213,484 cuft
Drainage area	= 28.570 ac	Curve number	= 84
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 22.00 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

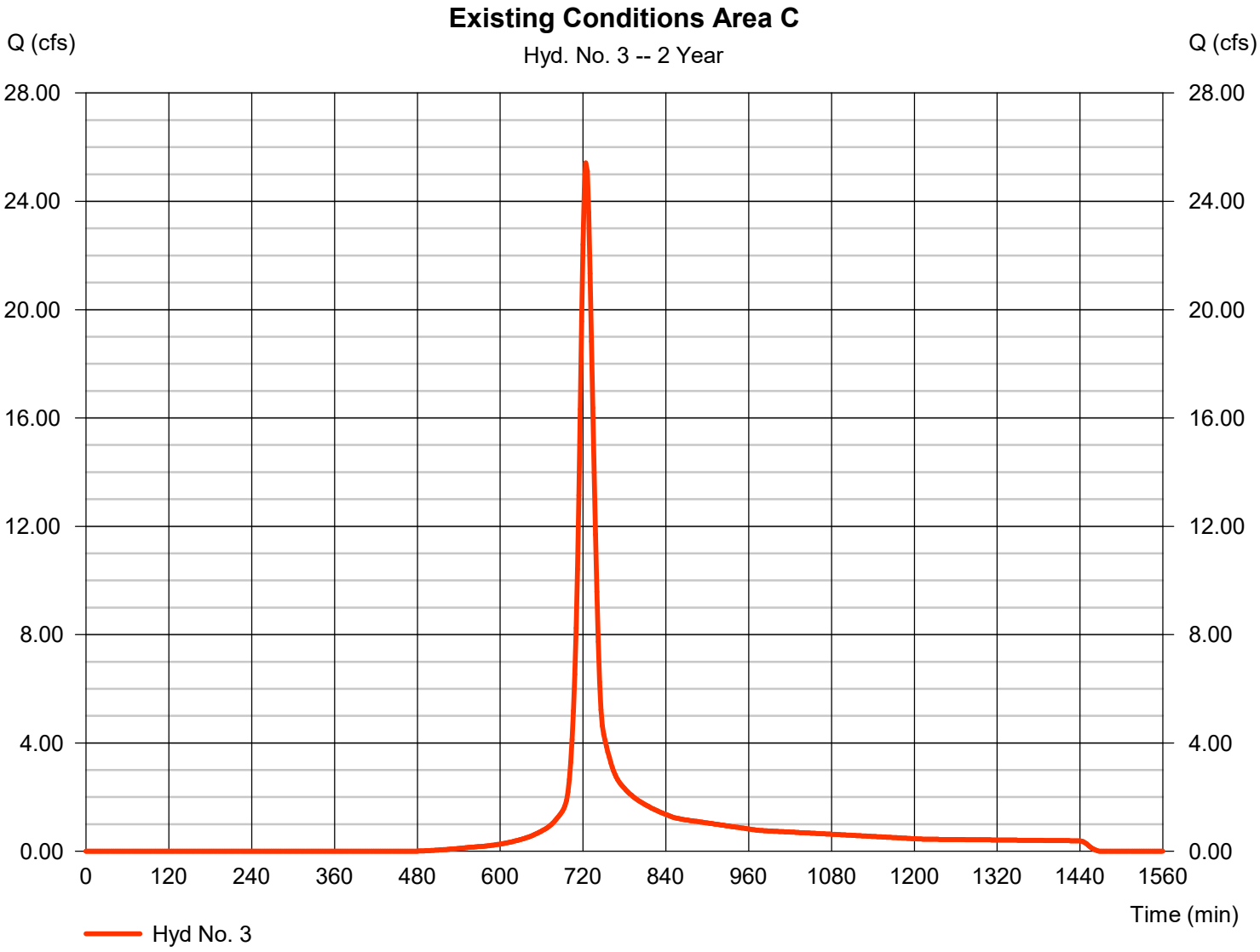


Hydrograph Report

Hyd. No. 3

Existing Conditions Area C

Hydrograph type	= SCS Runoff	Peak discharge	= 25.41 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 79,488 cuft
Drainage area	= 11.270 ac	Curve number	= 83
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 20.00 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

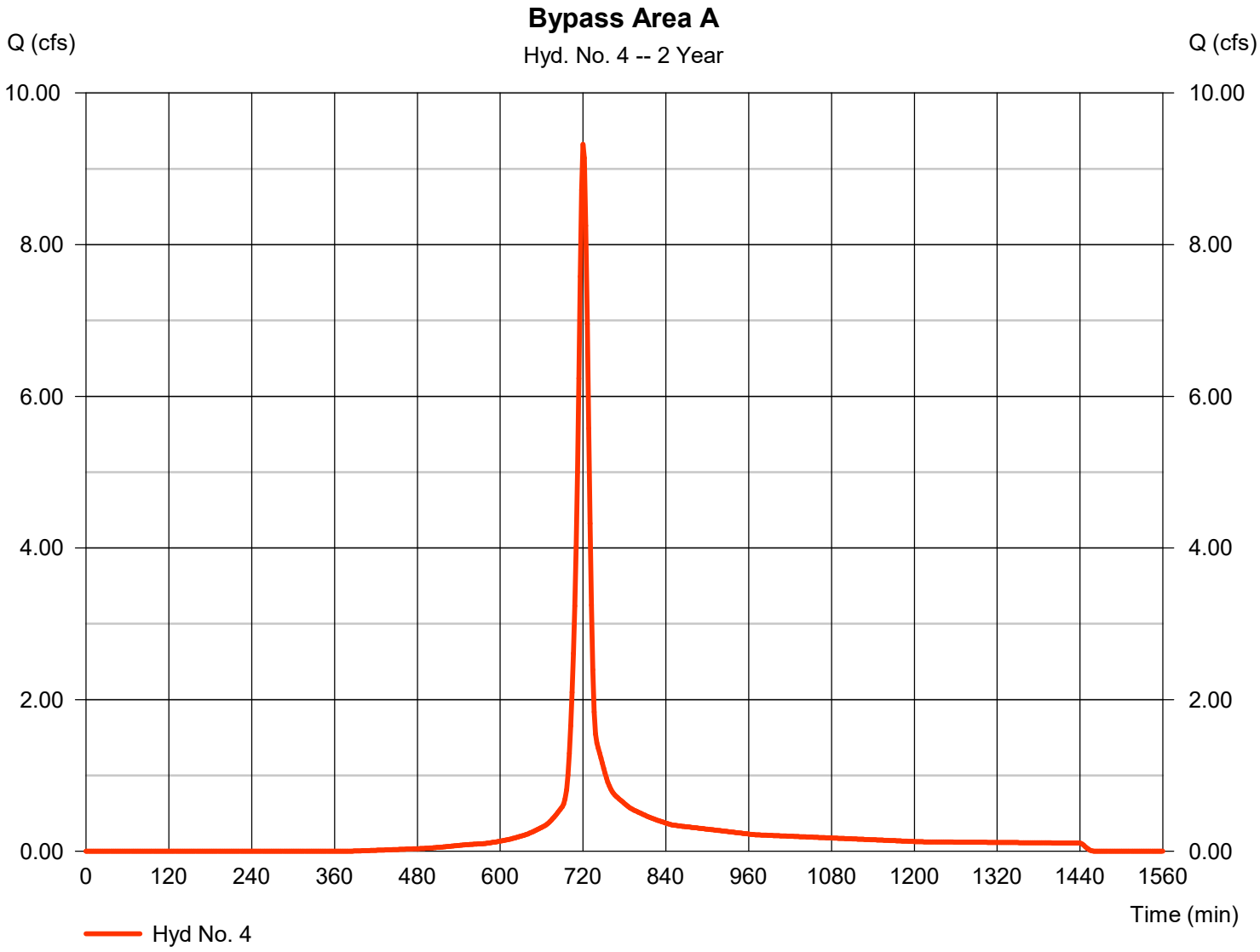


Hydrograph Report

Hyd. No. 4

Bypass Area A

Hydrograph type	= SCS Runoff	Peak discharge	= 9.322 cfs
Storm frequency	= 2 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 24,330 cuft
Drainage area	= 2.860 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 10.60 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

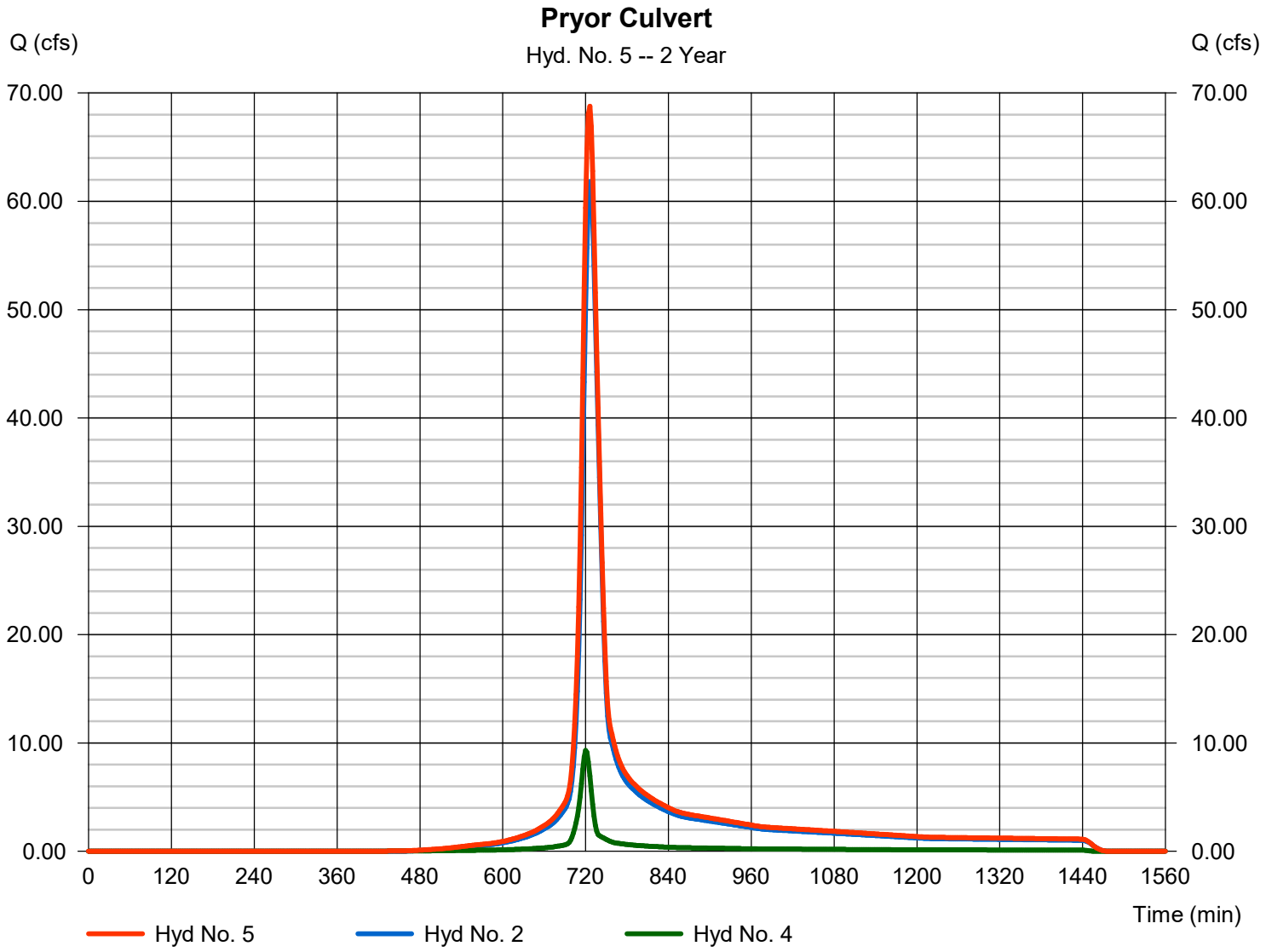


Hydrograph Report

Hyd. No. 5

Pryor Culvert

Hydrograph type	= Combine	Peak discharge	= 68.77 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 237,814 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 31.430 ac



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

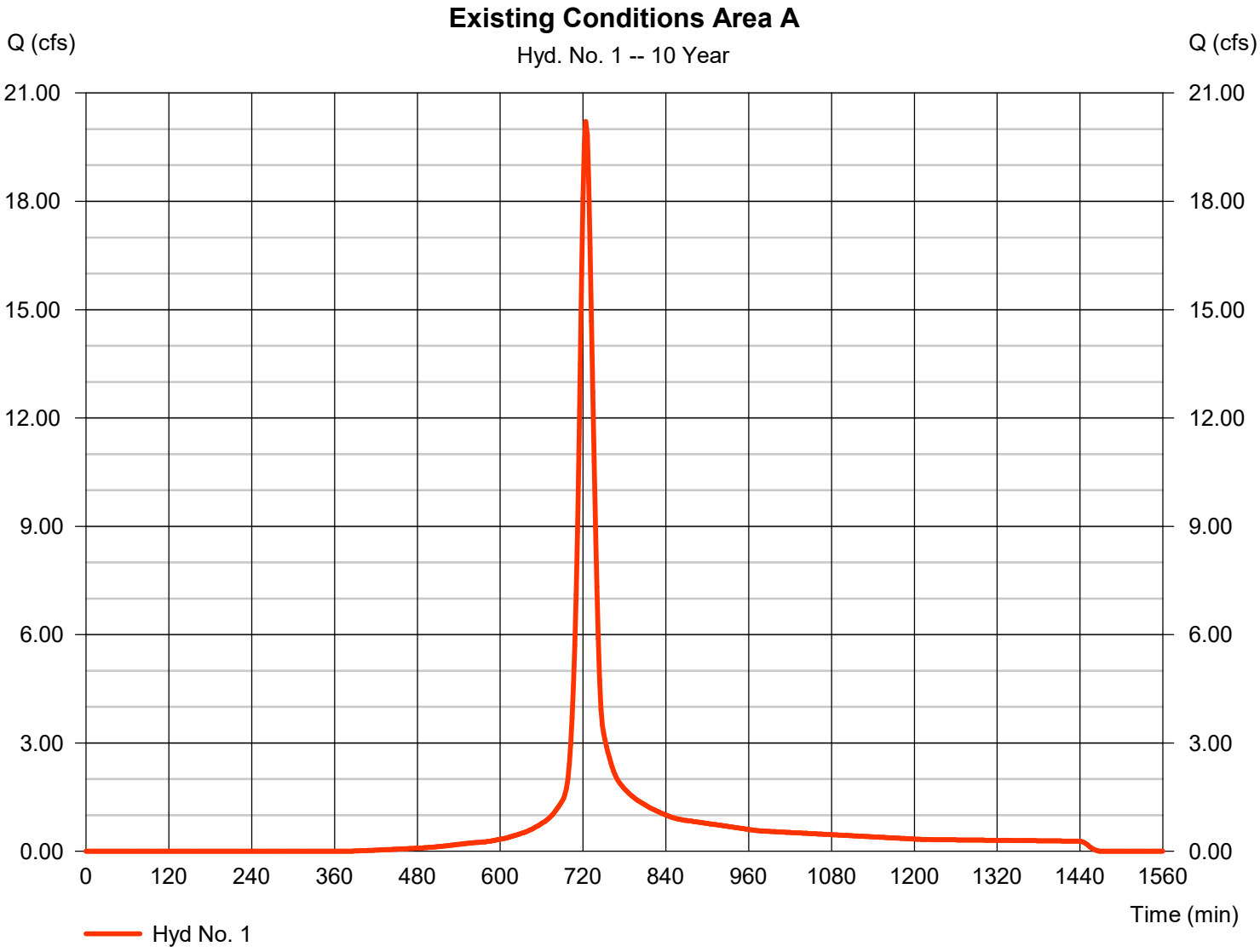
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	20.21	2	724	63,402	------	------	------	Existing Conditions Area A
2	SCS Runoff	108.92	2	726	378,212	------	------	------	Existing Conditions Area B
3	SCS Runoff	45.33	2	724	142,503	------	------	------	Existing Conditions Area C
4	SCS Runoff	15.64	2	720	41,632	------	------	------	Bypass Area A
5	Combine	120.39	2	726	419,844	2, 4	------	------	Pryor Culvert

Hydrograph Report

Hyd. No. 1

Existing Conditions Area A

Hydrograph type	=	SCS Runoff	Peak discharge	=	20.21 cfs
Storm frequency	=	10 yrs	Time to peak	=	724 min
Time interval	=	2 min	Hyd. volume	=	63,402 cuft
Drainage area	=	5.160 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	20.00 min
Total precip.	=	5.34 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

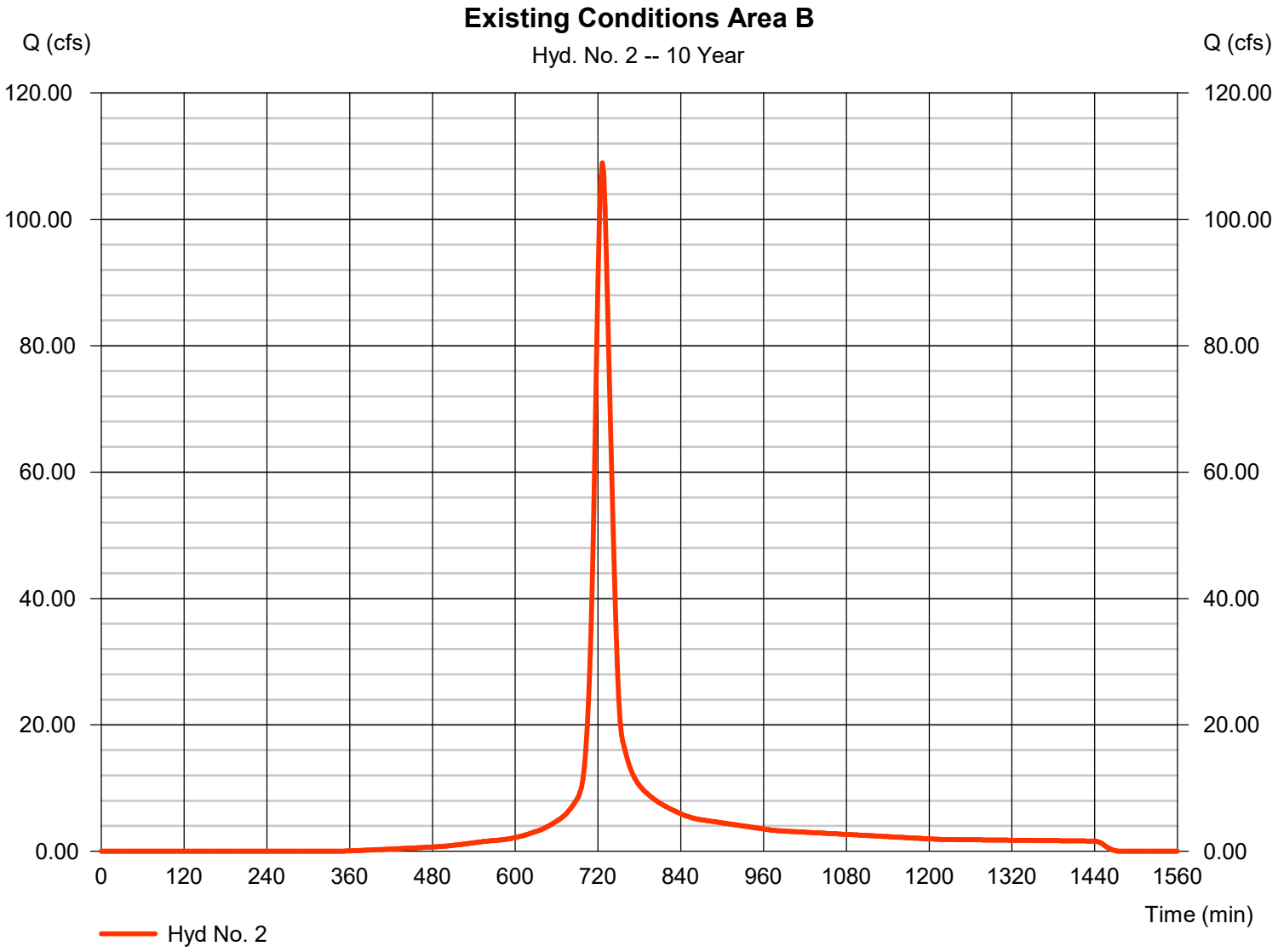


Hydrograph Report

Hyd. No. 2

Existing Conditions Area B

Hydrograph type	=	SCS Runoff	Peak discharge	=	108.92 cfs
Storm frequency	=	10 yrs	Time to peak	=	726 min
Time interval	=	2 min	Hyd. volume	=	378,212 cuft
Drainage area	=	28.570 ac	Curve number	=	84
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	22.00 min
Total precip.	=	5.34 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

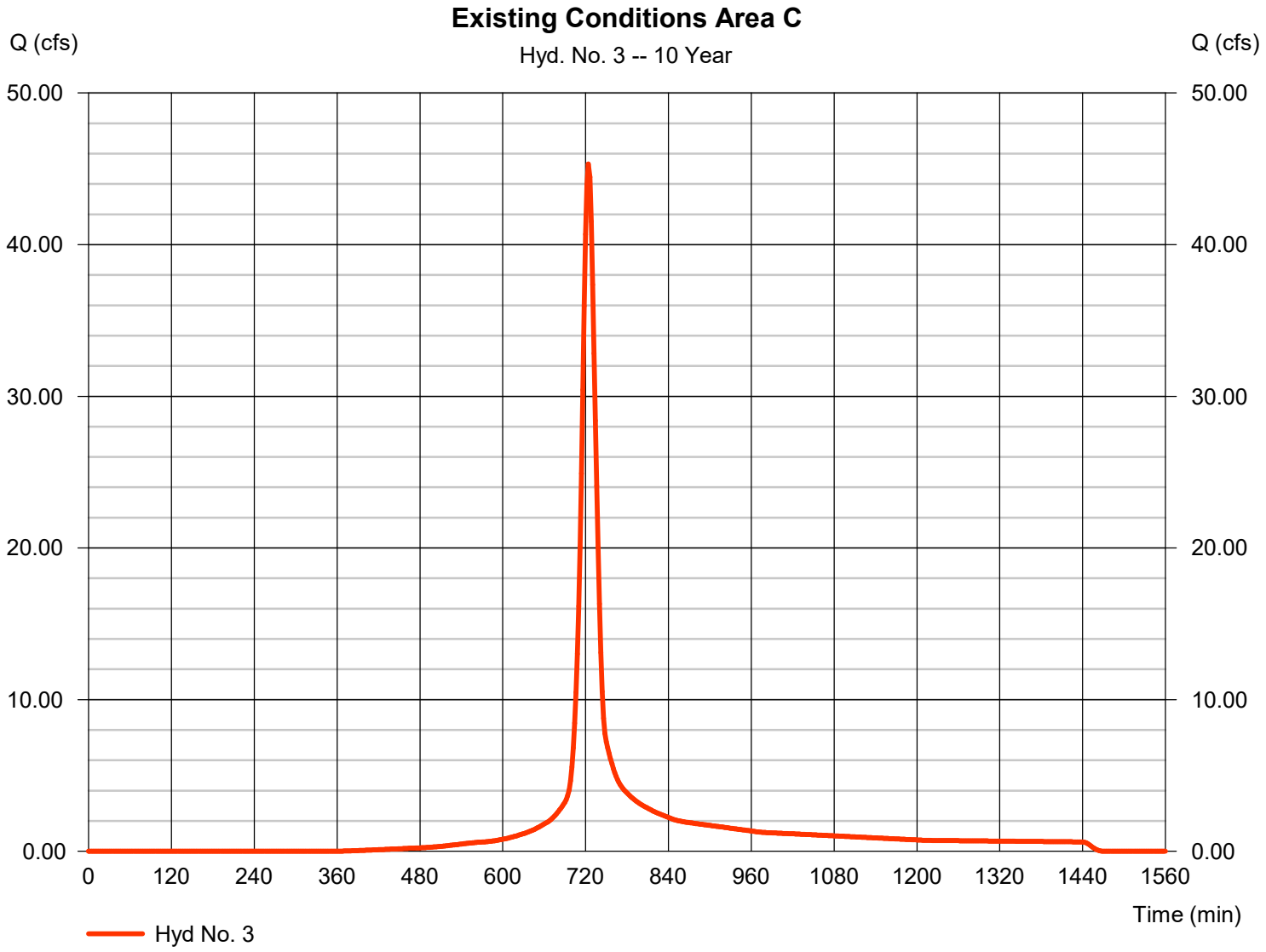


Hydrograph Report

Hyd. No. 3

Existing Conditions Area C

Hydrograph type	= SCS Runoff	Peak discharge	= 45.33 cfs
Storm frequency	= 10 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 142,503 cuft
Drainage area	= 11.270 ac	Curve number	= 83
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 20.00 min
Total precip.	= 5.34 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

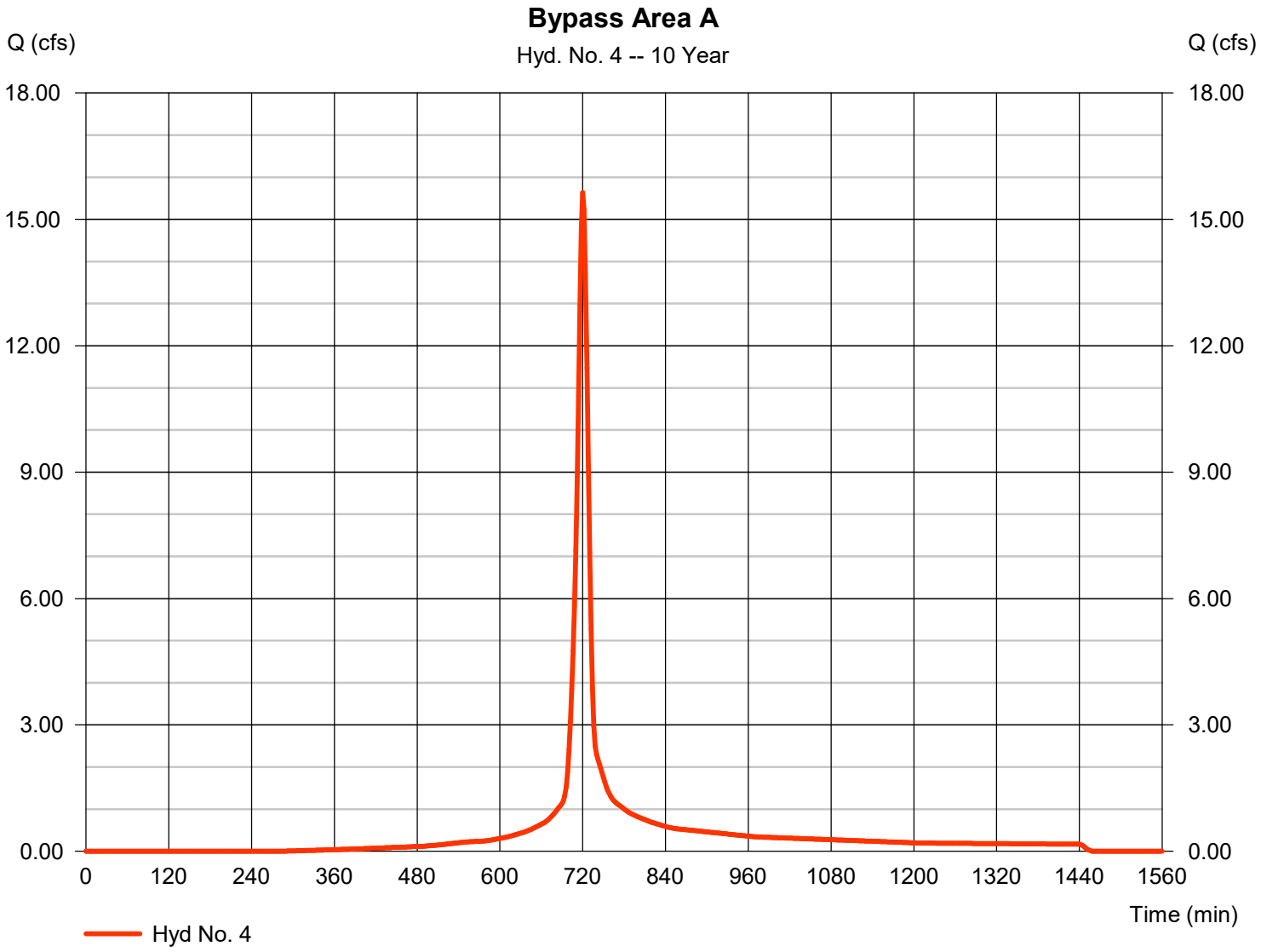


Hydrograph Report

Hyd. No. 4

Bypass Area A

Hydrograph type	= SCS Runoff	Peak discharge	= 15.64 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 41,632 cuft
Drainage area	= 2.860 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 10.60 min
Total precip.	= 5.34 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

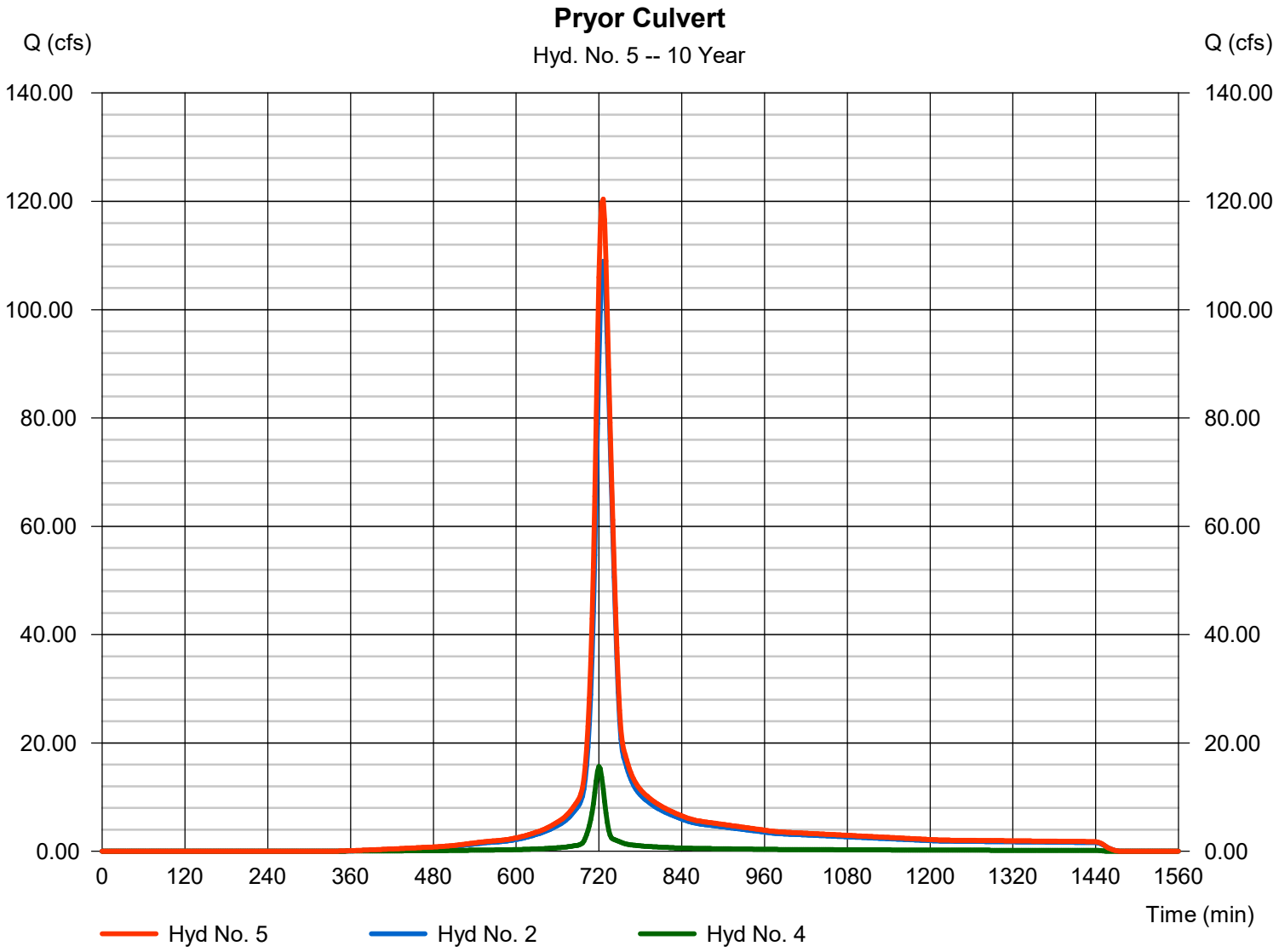


Hydrograph Report

Hyd. No. 5

Pryor Culvert

Hydrograph type	= Combine	Peak discharge	= 120.39 cfs
Storm frequency	= 10 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 419,844 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 31.430 ac



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

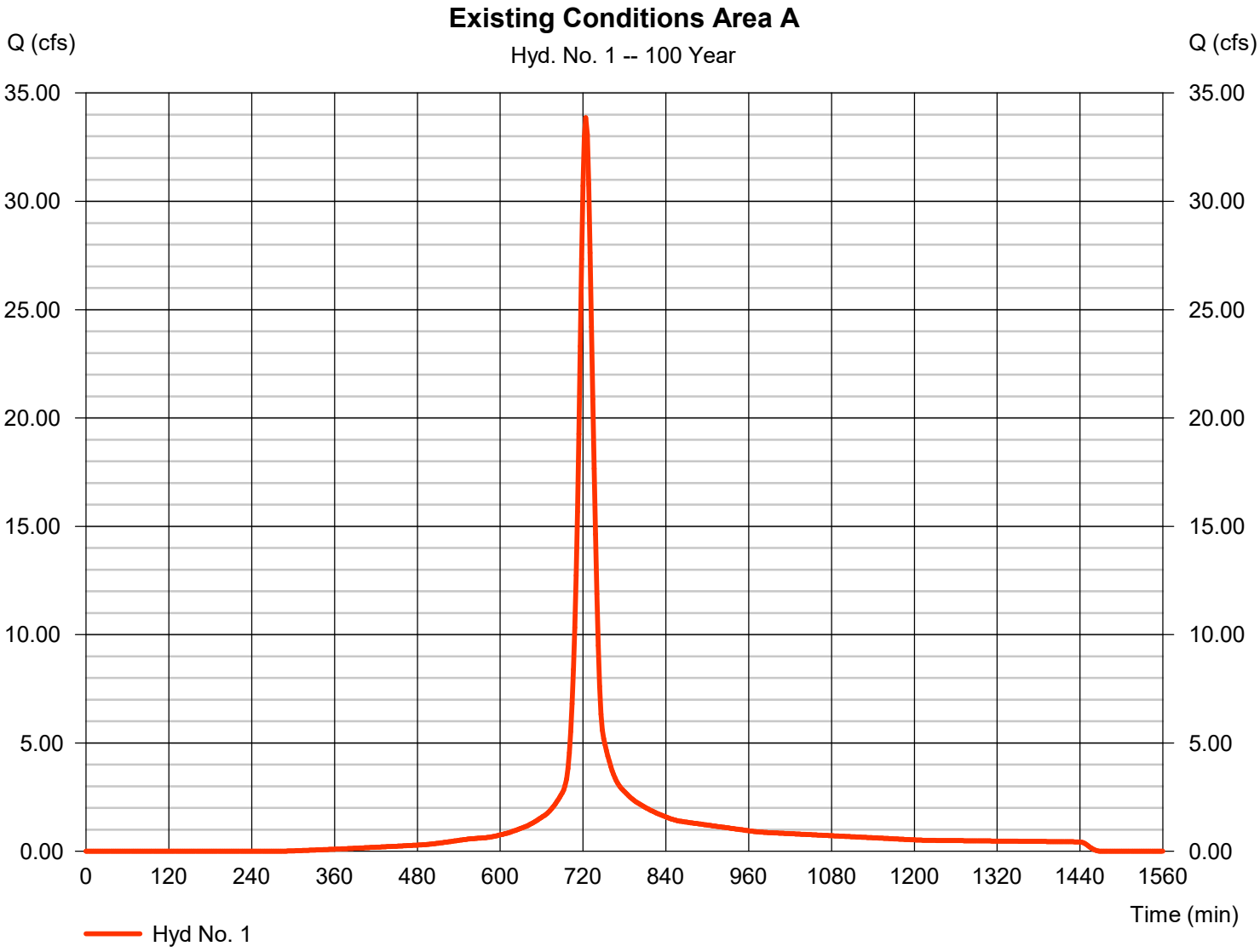
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	33.87	2	724	107,981	------	------	------	Existing Conditions Area A
2	SCS Runoff	179.23	2	726	633,290	------	------	------	Existing Conditions Area B
3	SCS Runoff	75.19	2	724	240,632	------	------	------	Existing Conditions Area C
4	SCS Runoff	24.90	2	720	68,010	------	------	------	Bypass Area A
5	Combine	197.29	2	726	701,300	2, 4	------	------	Pryor Culvert

Hydrograph Report

Hyd. No. 1

Existing Conditions Area A

Hydrograph type	=	SCS Runoff	Peak discharge	=	33.87 cfs
Storm frequency	=	100 yrs	Time to peak	=	724 min
Time interval	=	2 min	Hyd. volume	=	107,981 cuft
Drainage area	=	5.160 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	20.00 min
Total precip.	=	7.90 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

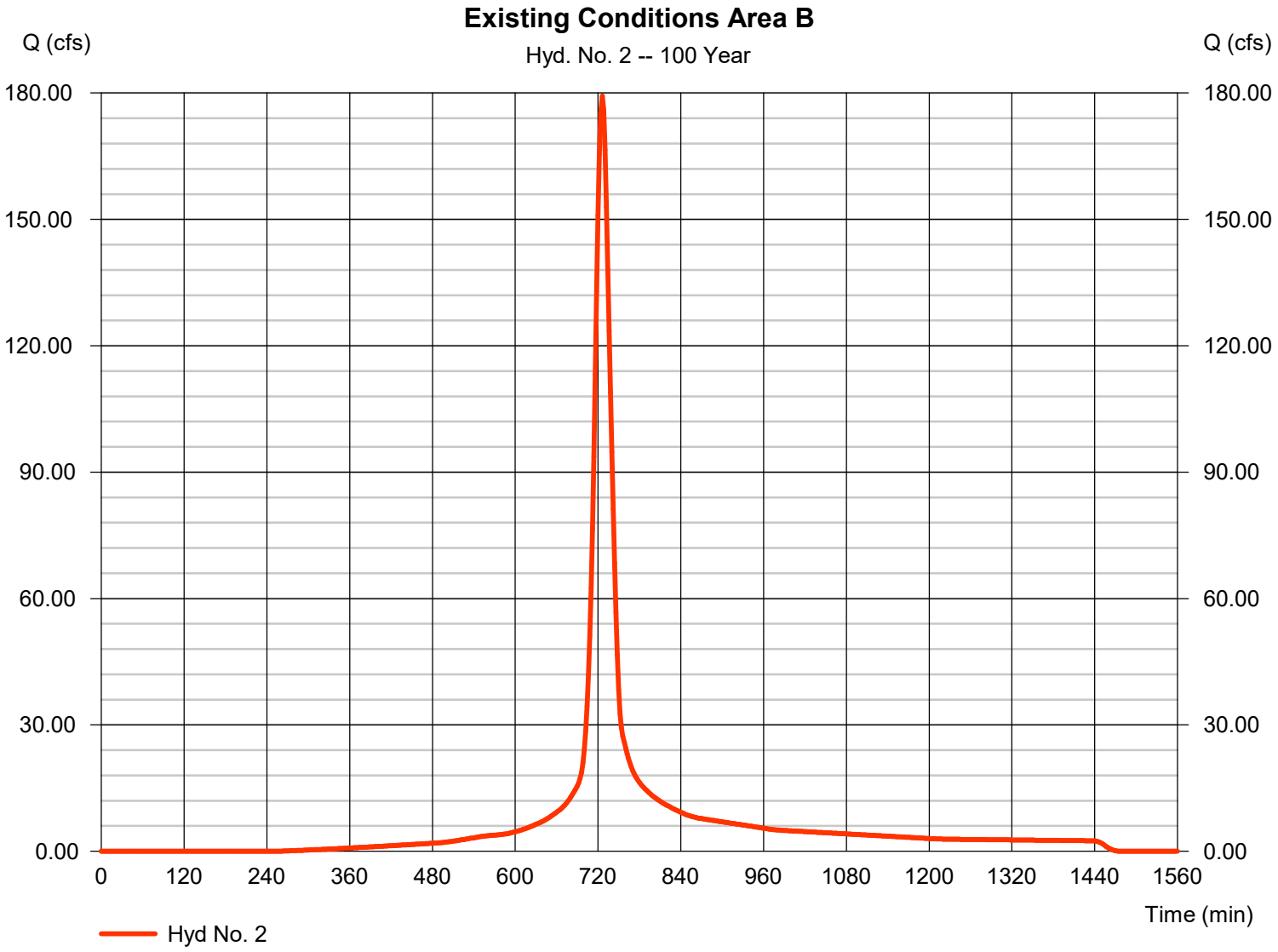


Hydrograph Report

Hyd. No. 2

Existing Conditions Area B

Hydrograph type	=	SCS Runoff	Peak discharge	=	179.23 cfs
Storm frequency	=	100 yrs	Time to peak	=	726 min
Time interval	=	2 min	Hyd. volume	=	633,290 cuft
Drainage area	=	28.570 ac	Curve number	=	84
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	22.00 min
Total precip.	=	7.90 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

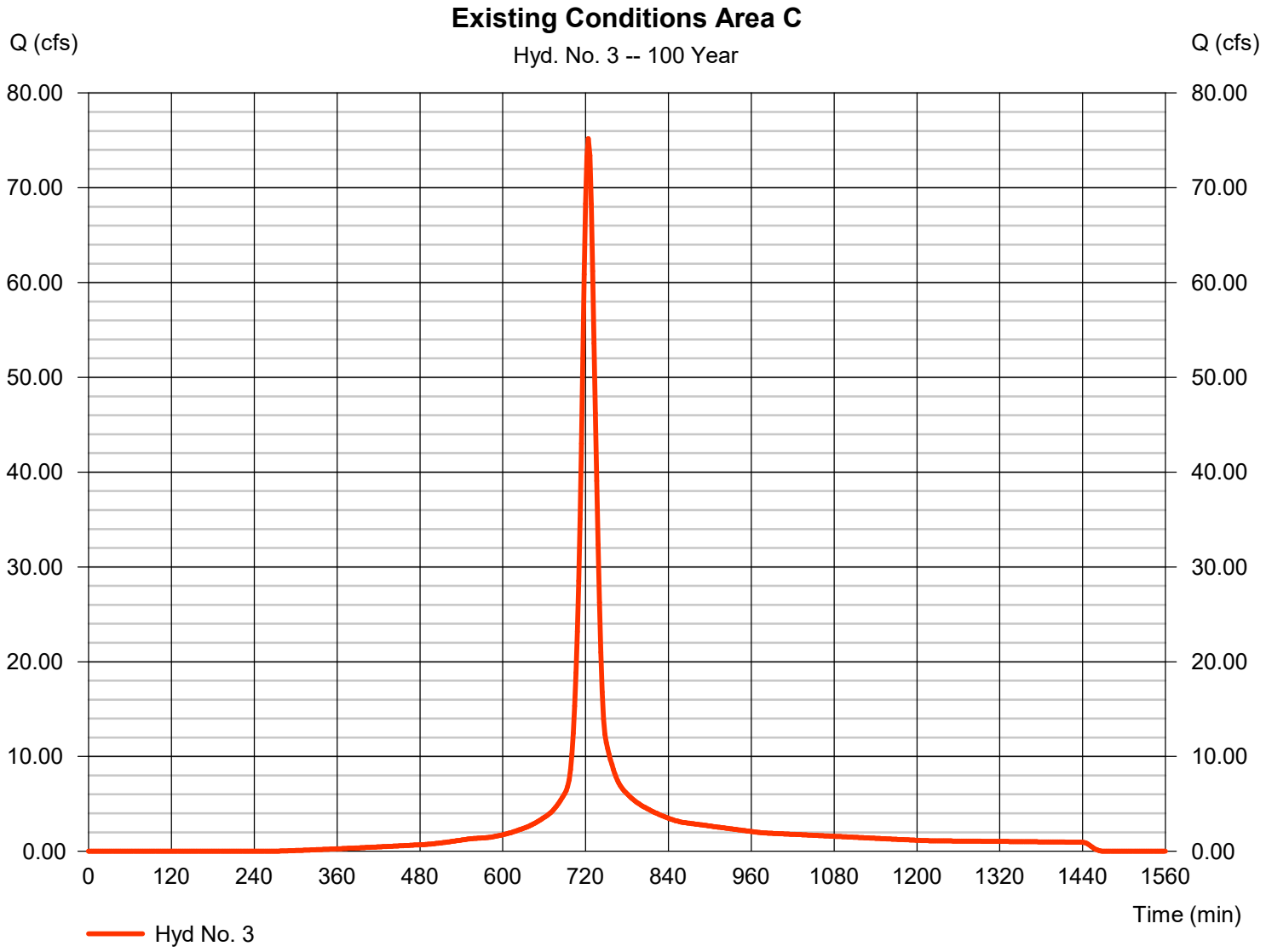


Hydrograph Report

Hyd. No. 3

Existing Conditions Area C

Hydrograph type	= SCS Runoff	Peak discharge	= 75.19 cfs
Storm frequency	= 100 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 240,632 cuft
Drainage area	= 11.270 ac	Curve number	= 83
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 20.00 min
Total precip.	= 7.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

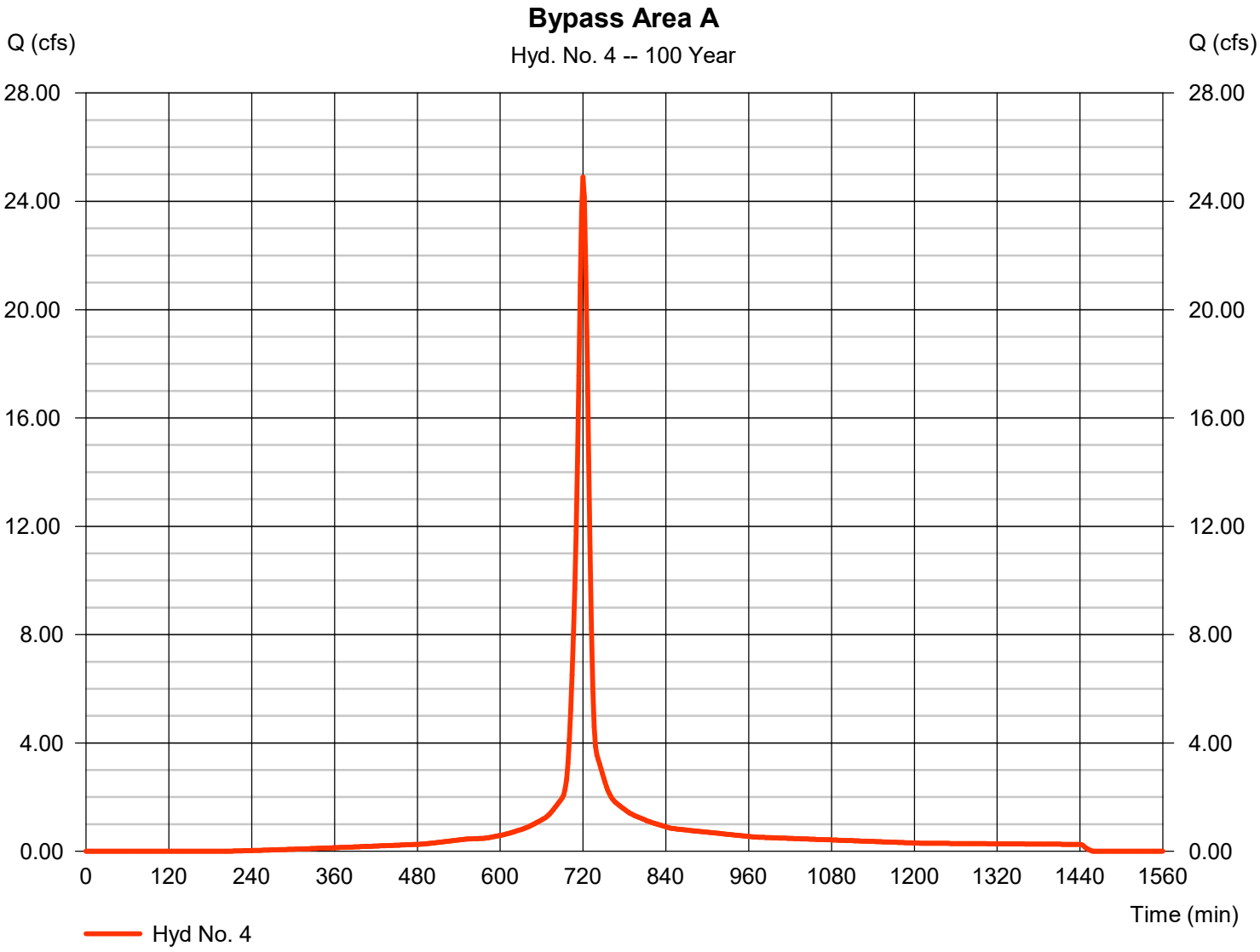


Hydrograph Report

Hyd. No. 4

Bypass Area A

Hydrograph type	= SCS Runoff	Peak discharge	= 24.90 cfs
Storm frequency	= 100 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 68,010 cuft
Drainage area	= 2.860 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 10.60 min
Total precip.	= 7.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

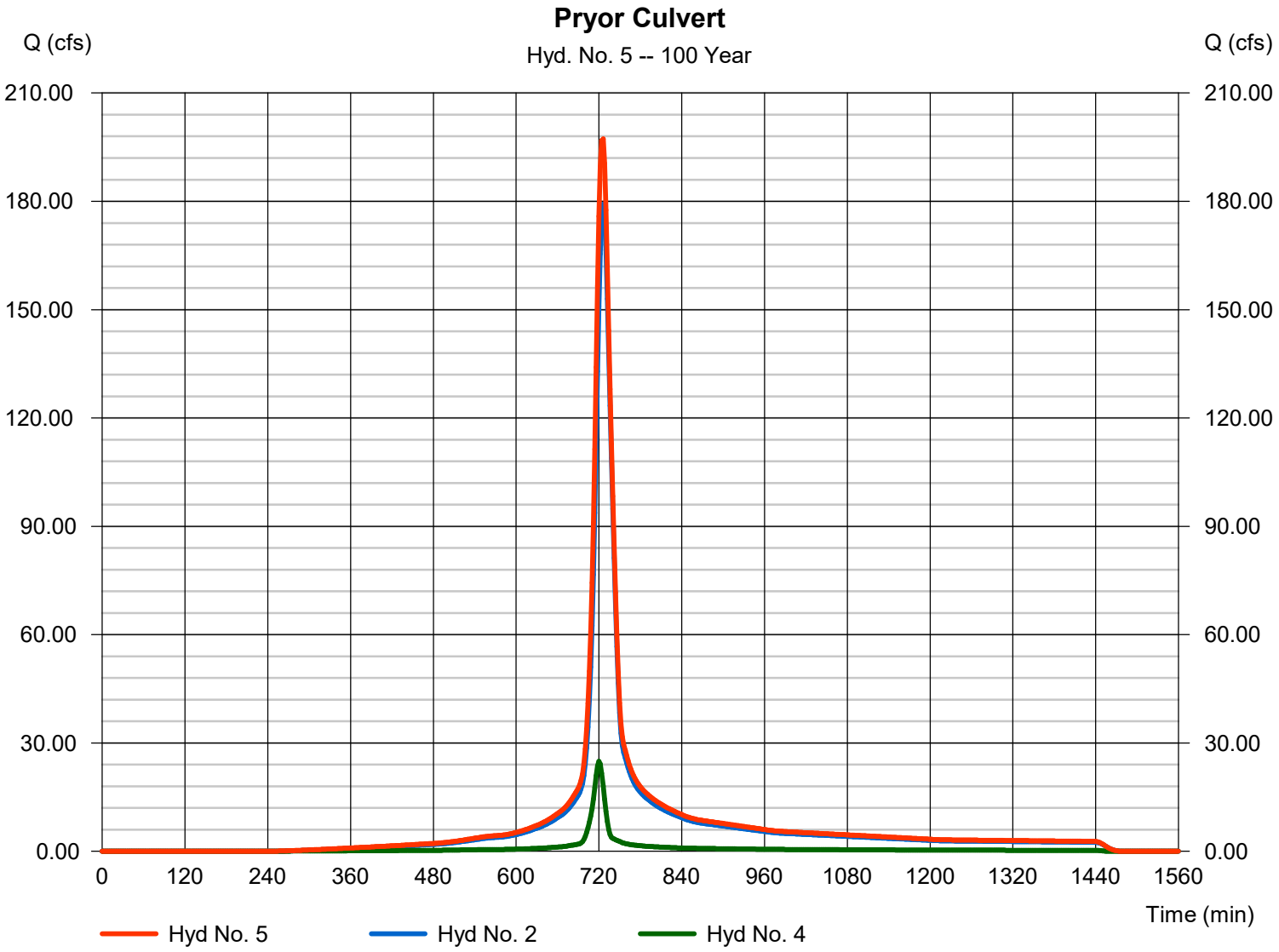


Hydrograph Report

Hyd. No. 5

Pryor Culvert

Hydrograph type	= Combine	Peak discharge	= 197.29 cfs
Storm frequency	= 100 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 701,300 cuft
Inflow hyds.	= 2, 4	Contrib. drain. area	= 31.430 ac



APPENDIX C

Proposed Conditions Hydraflow Hydrographs Model Input and Results

Subarea A

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.005	Grass-Range, Short (0.15)		0.272
Shallow Concentrated	778	0.052	Unpaved		0.059
Channel					
Total	878				0.331

Subarea B1

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.005	Grass-Range, Short (0.15)		0.272
Shallow Concentrated	646	0.0503	Unpaved		0.05
Channel	1,771			15	0.033
Total	2,517				0.355

Subarea B2

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.0420	Grass-Range, Short (0.15)		0.116
Shallow Concentrated	469	.0336	Unpaved		0.044
Channel	539			7	0.021
Total	1,108				0.181

Subarea C

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.005	Grass-Range, Short (0.15)		0.272
Shallow Concentrated	451	0.057	Unpaved		0.033
Channel	746			10	0.021
Total	1,297				0.326

Bypass Area A

	Length (ft)	Slope (ft/ft)	Surface (Manning's n)	Velocity (ft/s)	Time (hr)
Sheet	100	0.030	Grass-Range, Short (0.15)		0.133
Shallow Concentrated	472	0.035	Unpaved		0.044
Channel					
Total	572				0.177

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.000	11.16	-------	-------	20.21	-------	27.99	33.87	Proposed Area A
2	SCS Runoff	------	0.000	69.97	-------	-------	118.08	-------	158.49	188.79	Proposed Area B1
3	SCS Runoff	------	0.000	20.15	-------	-------	34.89	-------	47.36	56.74	Proposed Area C
4	SCS Runoff	------	0.000	9.813	-------	-------	15.83	-------	20.84	24.59	Proposed Area B2
5	SCS Runoff	------	0.000	9.322	-------	-------	15.64	-------	20.93	24.90	Bypass Area A
6	Reservoir	2	0.000	4.275	-------	-------	28.05	-------	46.49	56.31	Detention Pond
7	Combine	4, 6	0.000	9.813	-------	-------	29.88	-------	49.02	59.28	Point of Interest
8	Combine	5, 7	0.000	19.14	-------	-------	43.85	-------	66.58	99.07	Point of Interest w/ Bypass Area

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

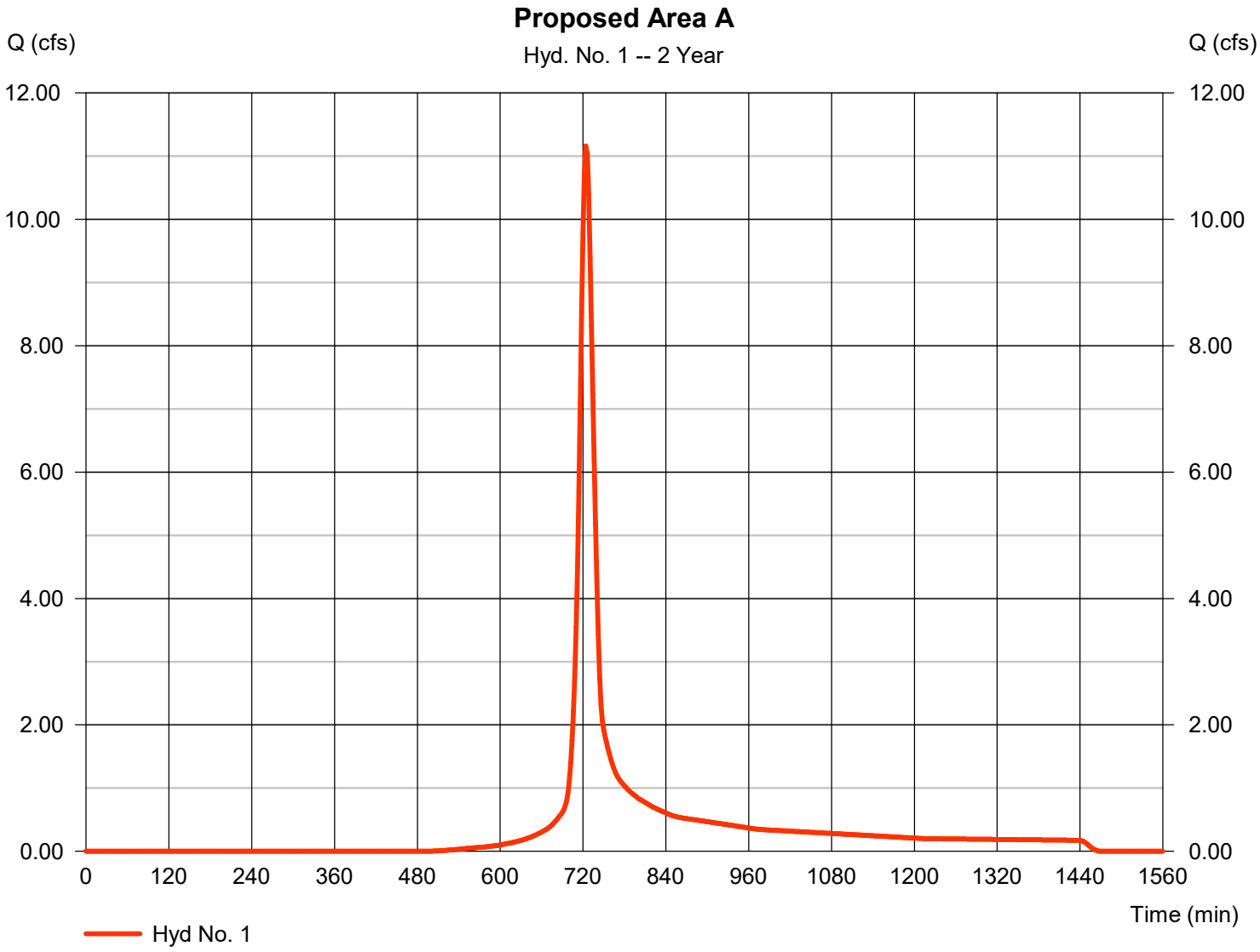
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	11.16	2	724	34,942	------	------	------	Proposed Area A
2	SCS Runoff	69.97	2	726	241,987	------	------	------	Proposed Area B1
3	SCS Runoff	20.15	2	724	63,001	------	------	------	Proposed Area C
4	SCS Runoff	9.813	2	720	25,975	------	------	------	Proposed Area B2
5	SCS Runoff	9.322	2	720	24,330	------	------	------	Bypass Area A
6	Reservoir	4.275	2	830	155,233	2	1013.53	152,744	Detention Pond
7	Combine	9.813	2	720	181,208	4, 6	------	------	Point of Interest
8	Combine	19.14	2	720	256,012	5, 7	------	------	Point of Interest w/ Bypass Area

Hydrograph Report

Hyd. No. 1

Proposed Area A

Hydrograph type	=	SCS Runoff	Peak discharge	=	11.16 cfs
Storm frequency	=	2 yrs	Time to peak	=	724 min
Time interval	=	2 min	Hyd. volume	=	34,942 cuft
Drainage area	=	5.160 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	20.00 min
Total precip.	=	3.60 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

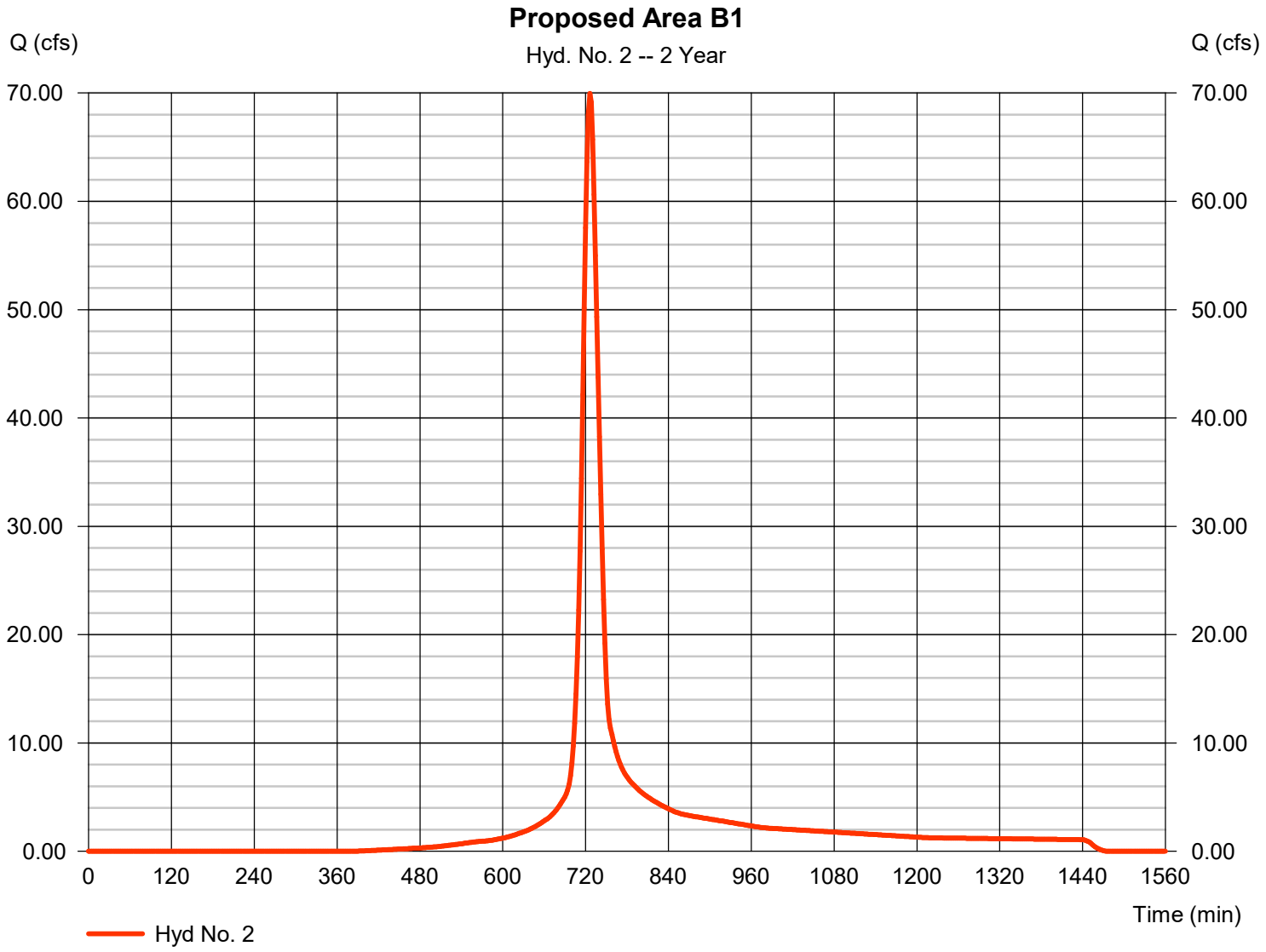


Hydrograph Report

Hyd. No. 2

Proposed Area B1

Hydrograph type	= SCS Runoff	Peak discharge	= 69.97 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 241,987 cuft
Drainage area	= 28.820 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 21.30 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

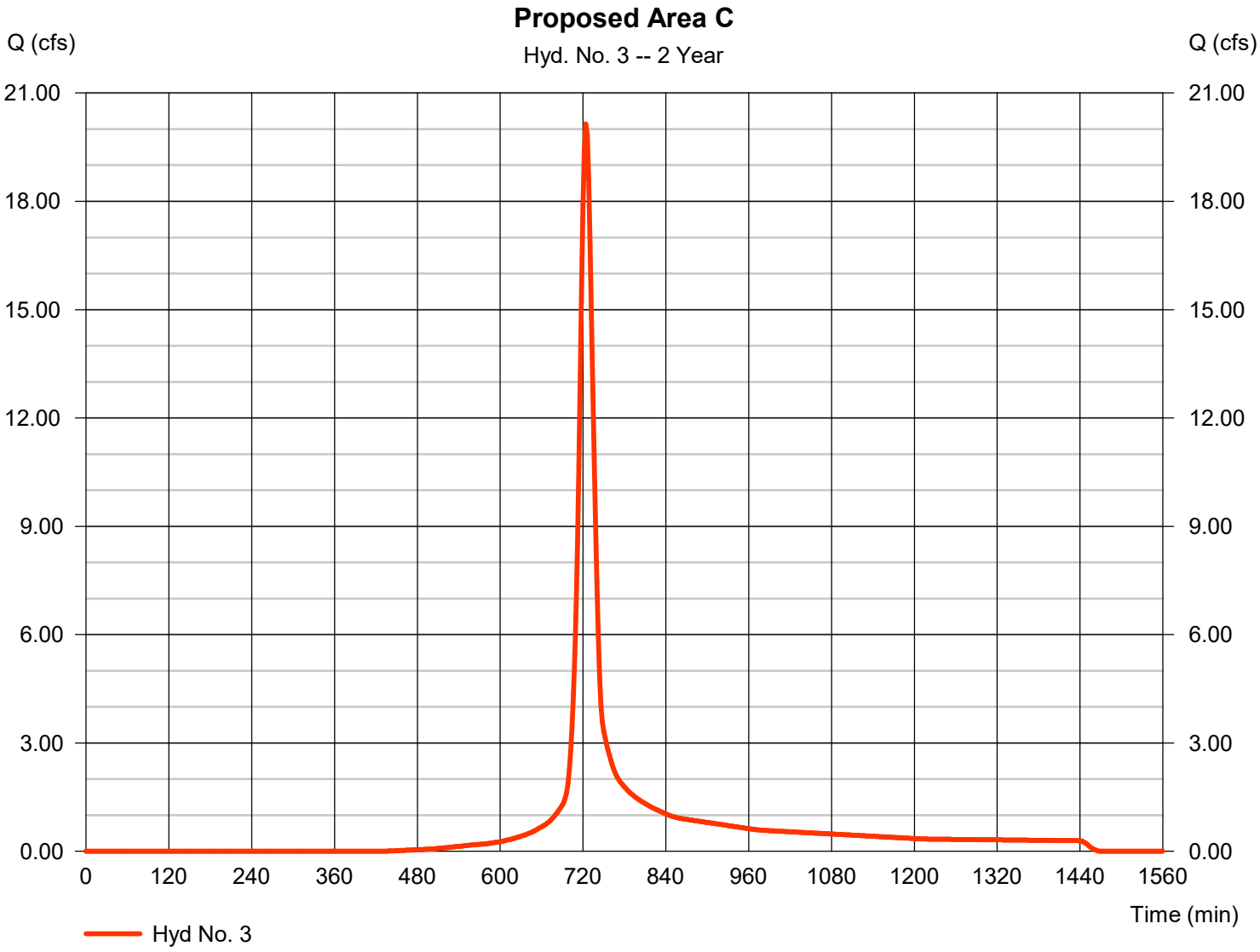


Hydrograph Report

Hyd. No. 3

Proposed Area C

Hydrograph type	= SCS Runoff	Peak discharge	= 20.15 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 63,001 cuft
Drainage area	= 8.250 ac	Curve number	= 85
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 19.60 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

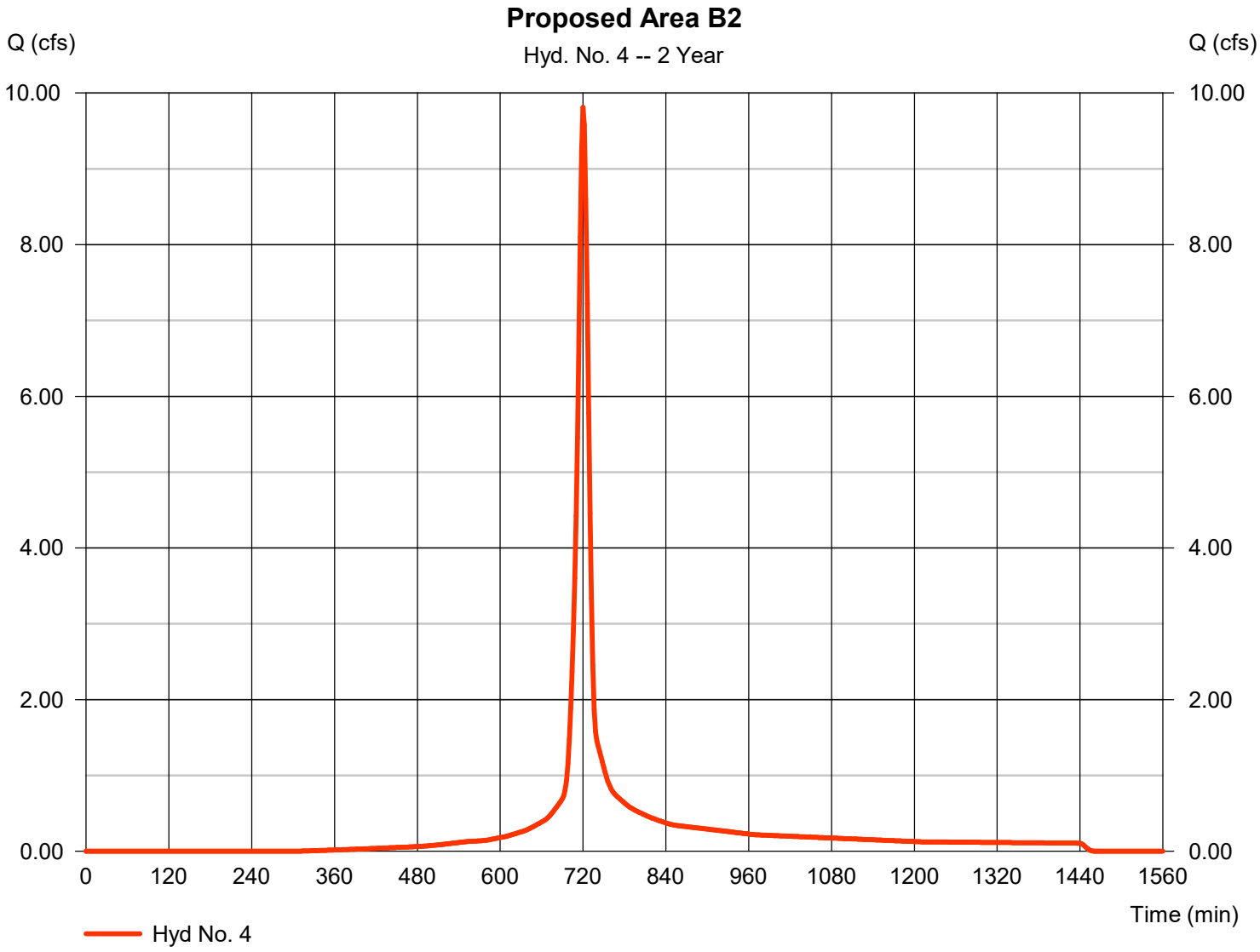


Hydrograph Report

Hyd. No. 4

Proposed Area B2

Hydrograph type	= SCS Runoff	Peak discharge	= 9.813 cfs
Storm frequency	= 2 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 25,975 cuft
Drainage area	= 2.730 ac	Curve number	= 90
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 10.90 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

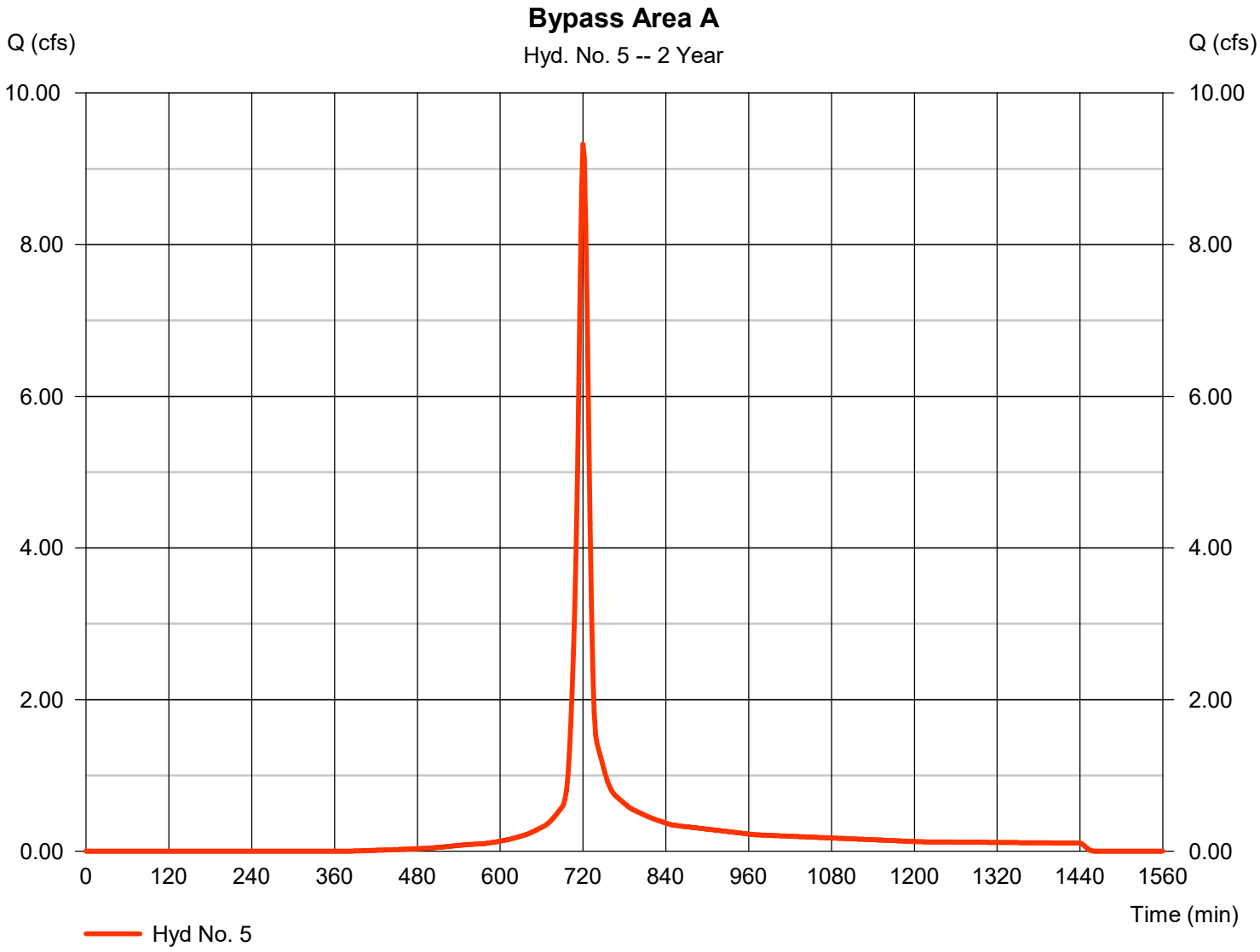


Hydrograph Report

Hyd. No. 5

Bypass Area A

Hydrograph type	= SCS Runoff	Peak discharge	= 9.322 cfs
Storm frequency	= 2 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 24,330 cuft
Drainage area	= 2.860 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 10.60 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



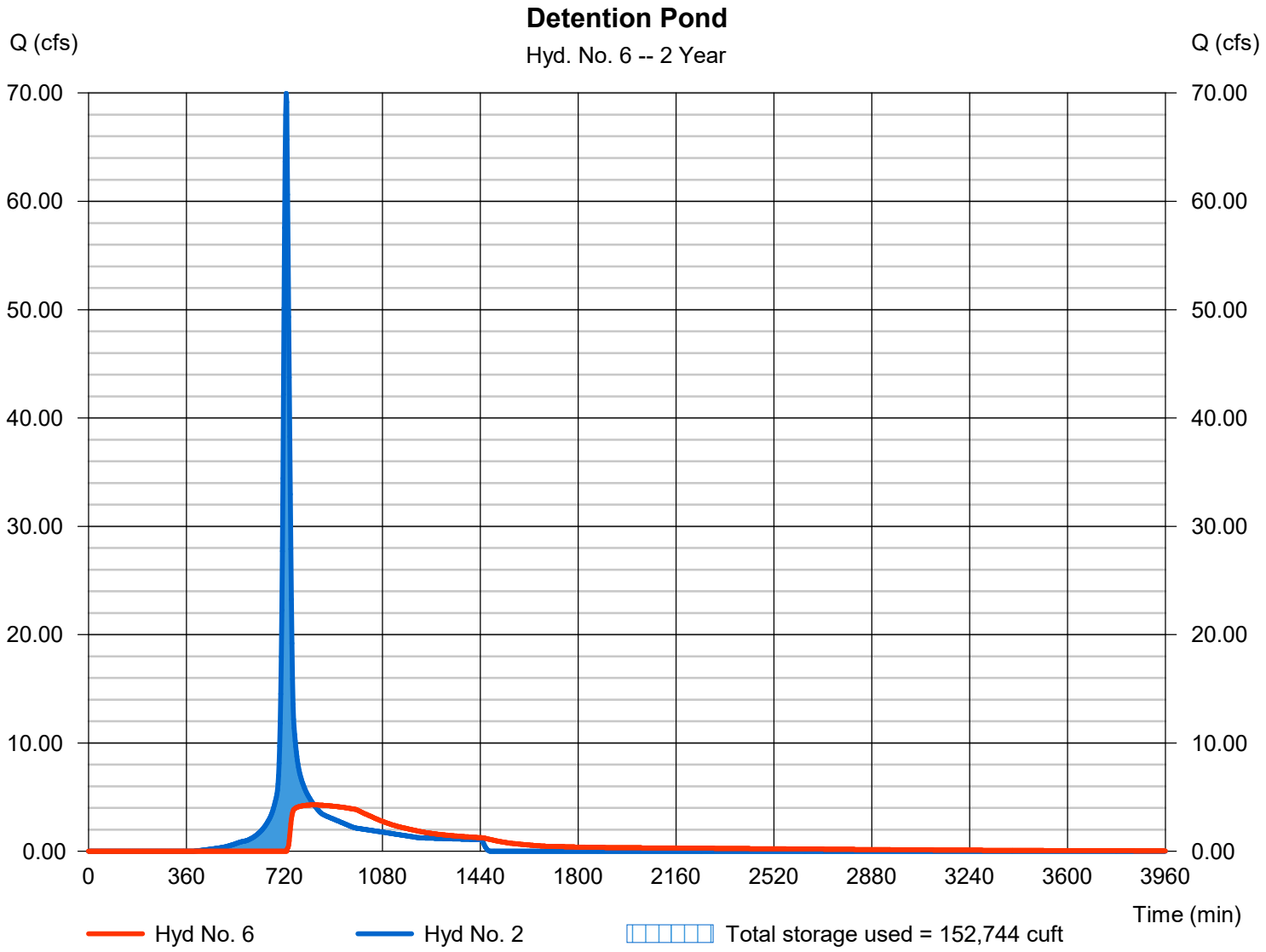
Hydrograph Report

Hyd. No. 6

Detention Pond

Hydrograph type	=	Reservoir	Peak discharge	=	4.275 cfs
Storm frequency	=	2 yrs	Time to peak	=	830 min
Time interval	=	2 min	Hyd. volume	=	155,233 cuft
Inflow hyd. No.	=	2 - Proposed Area B1	Max. Elevation	=	1013.53 ft
Reservoir name	=	Detention	Max. Storage	=	152,744 cuft

Storage Indication method used.

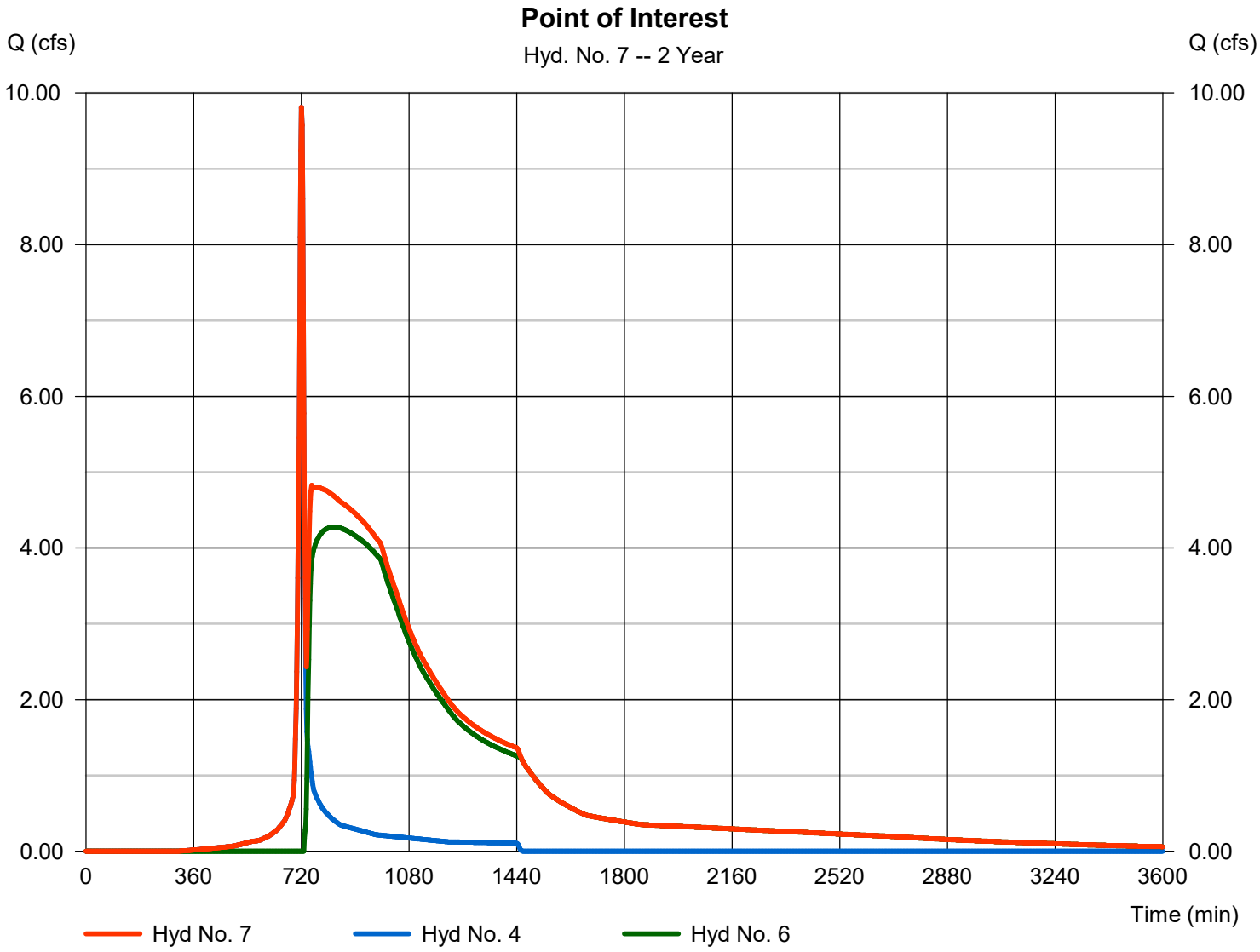


Hydrograph Report

Hyd. No. 7

Point of Interest

Hydrograph type	= Combine	Peak discharge	= 9.813 cfs
Storm frequency	= 2 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 181,208 cuft
Inflow hyds.	= 4, 6	Contrib. drain. area	= 2.730 ac

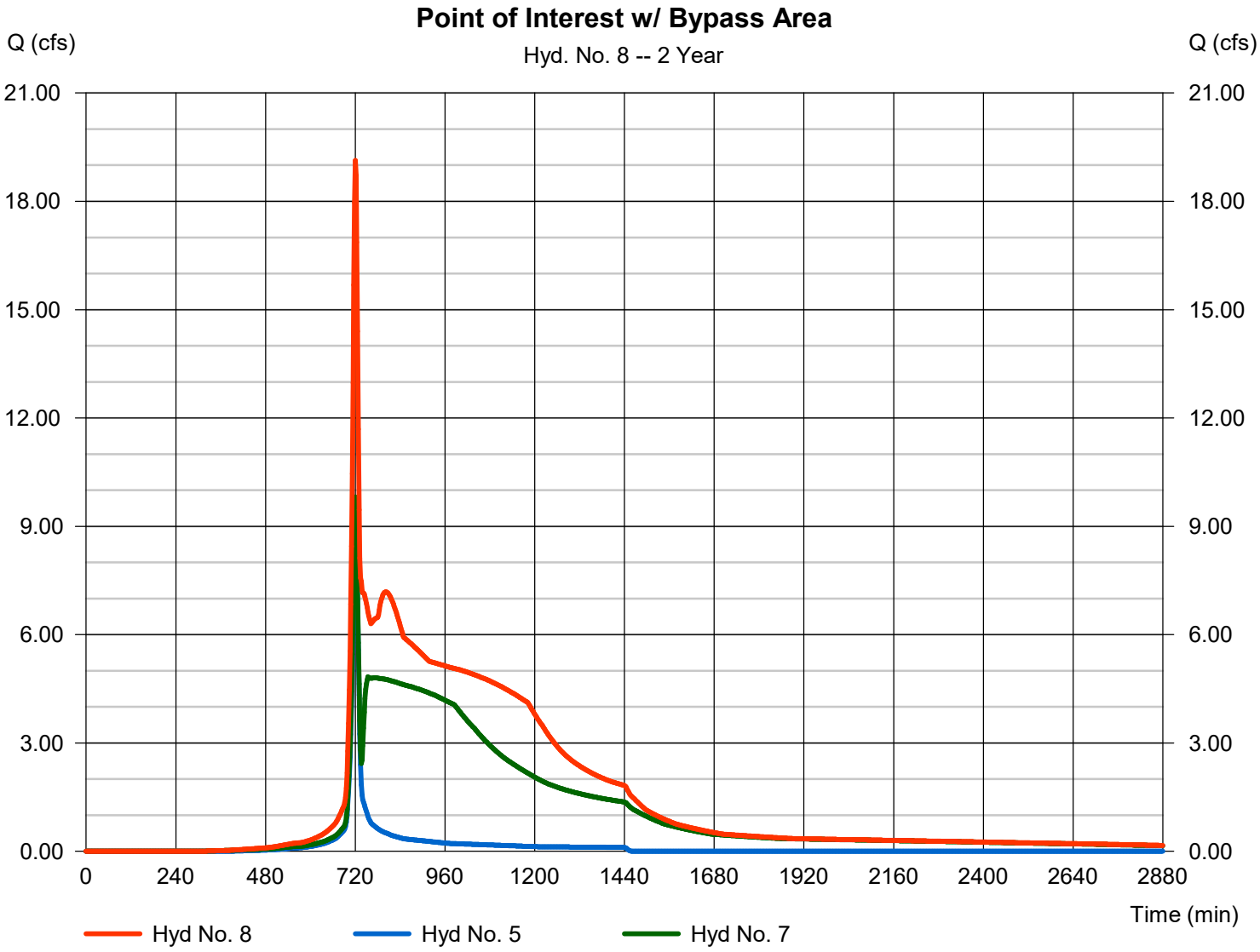


Hydrograph Report

Hyd. No. 8

Point of Interest w/ Bypass Area

Hydrograph type	= Combine	Peak discharge	= 19.14 cfs
Storm frequency	= 2 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 256,012 cuft
Inflow hyds.	= 5, 7	Contrib. drain. area	= 2.860 ac



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

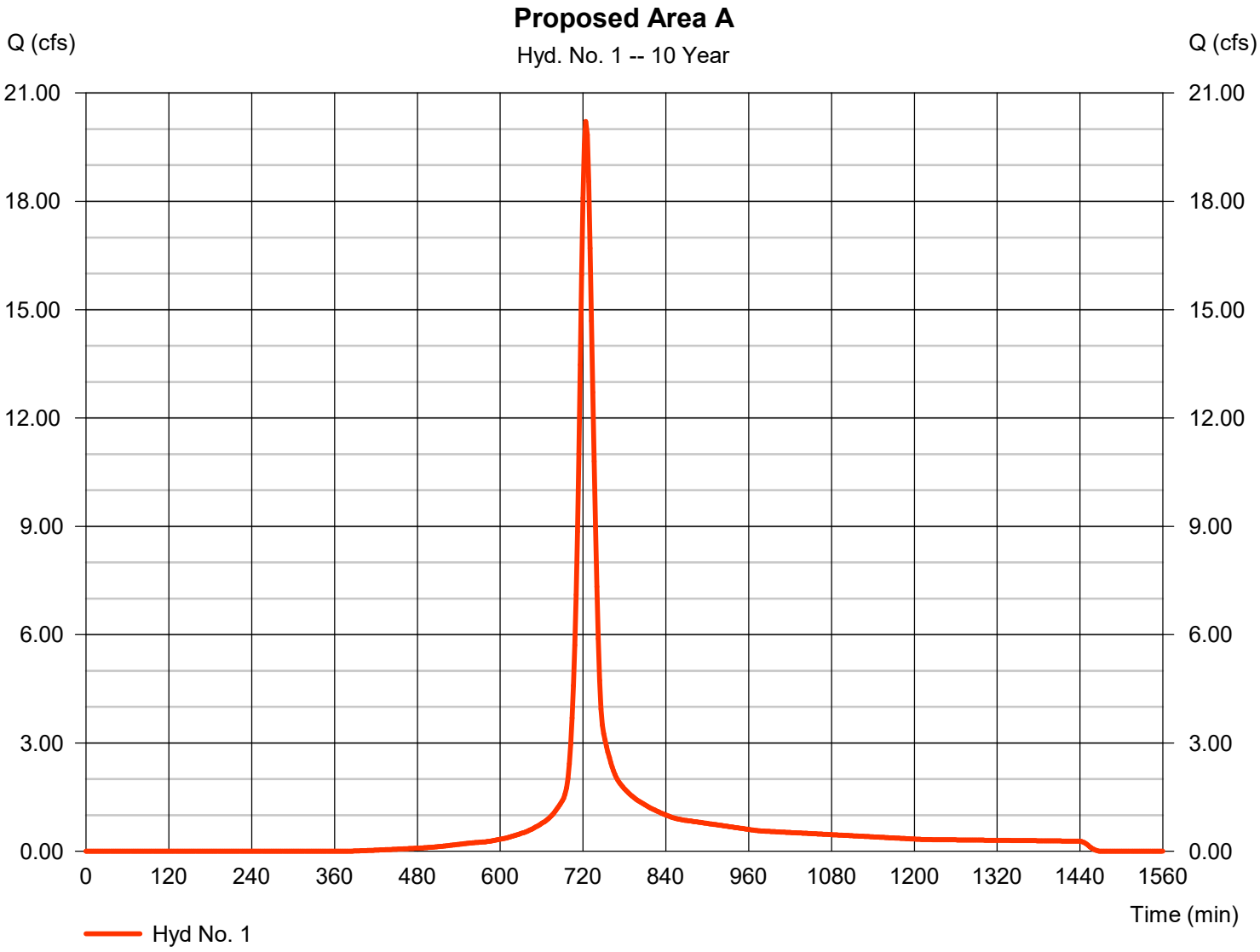
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	20.21	2	724	63,402	------	------	------	Proposed Area A
2	SCS Runoff	118.08	2	726	414,070	------	------	------	Proposed Area B1
3	SCS Runoff	34.89	2	724	110,315	------	------	------	Proposed Area C
4	SCS Runoff	15.83	2	720	42,972	------	------	------	Proposed Area B2
5	SCS Runoff	15.64	2	720	41,632	------	------	------	Bypass Area A
6	Reservoir	28.05	2	750	327,304	2	1015.03	228,021	Detention Pond
7	Combine	29.88	2	748	370,276	4, 6	------	------	Point of Interest
8	Combine	43.85	2	746	492,636	5, 7	------	------	Point of Interest w/ Bypass Area

Hydrograph Report

Hyd. No. 1

Proposed Area A

Hydrograph type	= SCS Runoff	Peak discharge	= 20.21 cfs
Storm frequency	= 10 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 63,402 cuft
Drainage area	= 5.160 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 20.00 min
Total precip.	= 5.34 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

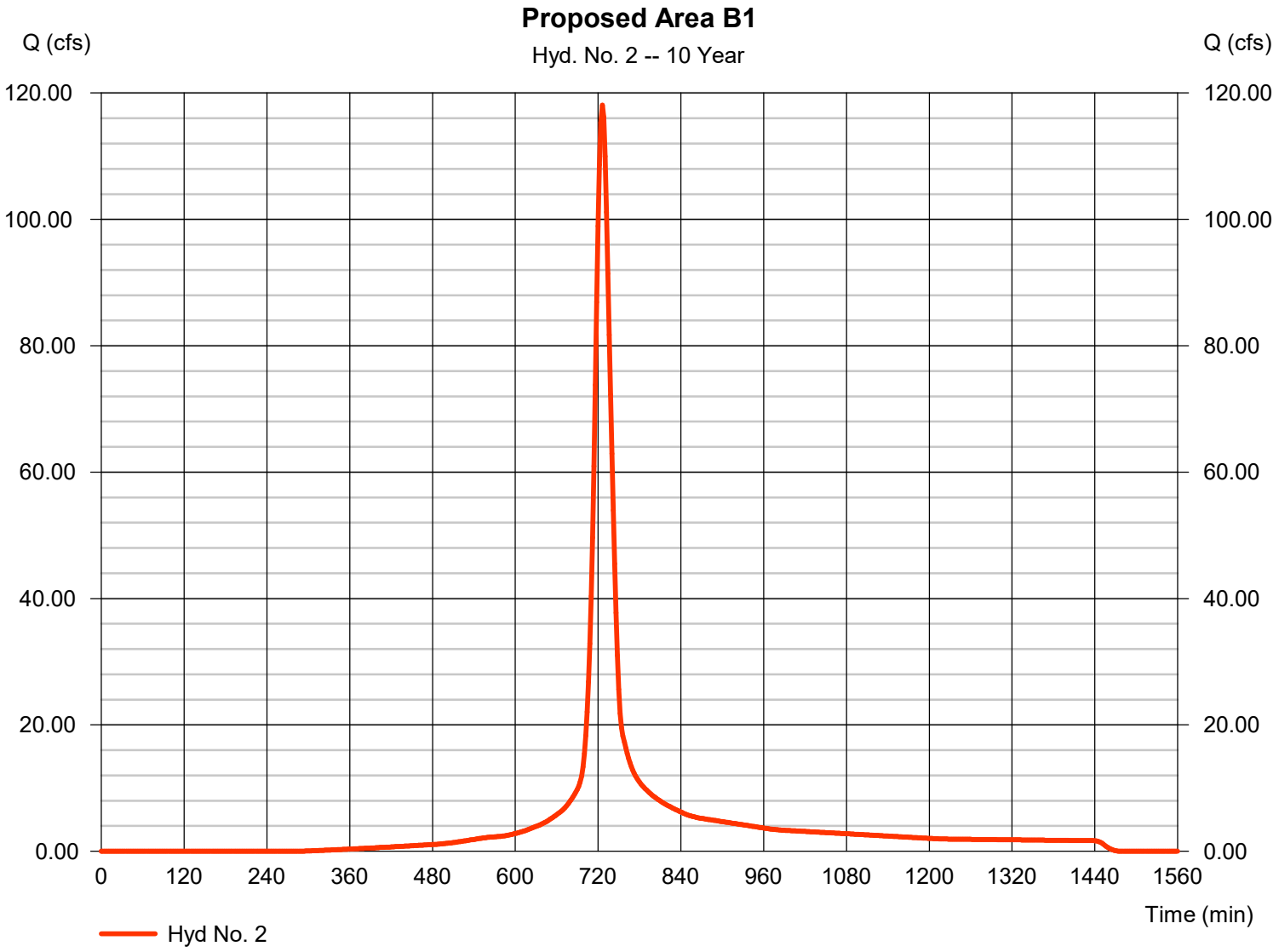


Hydrograph Report

Hyd. No. 2

Proposed Area B1

Hydrograph type	= SCS Runoff	Peak discharge	= 118.08 cfs
Storm frequency	= 10 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 414,070 cuft
Drainage area	= 28.820 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 21.30 min
Total precip.	= 5.34 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

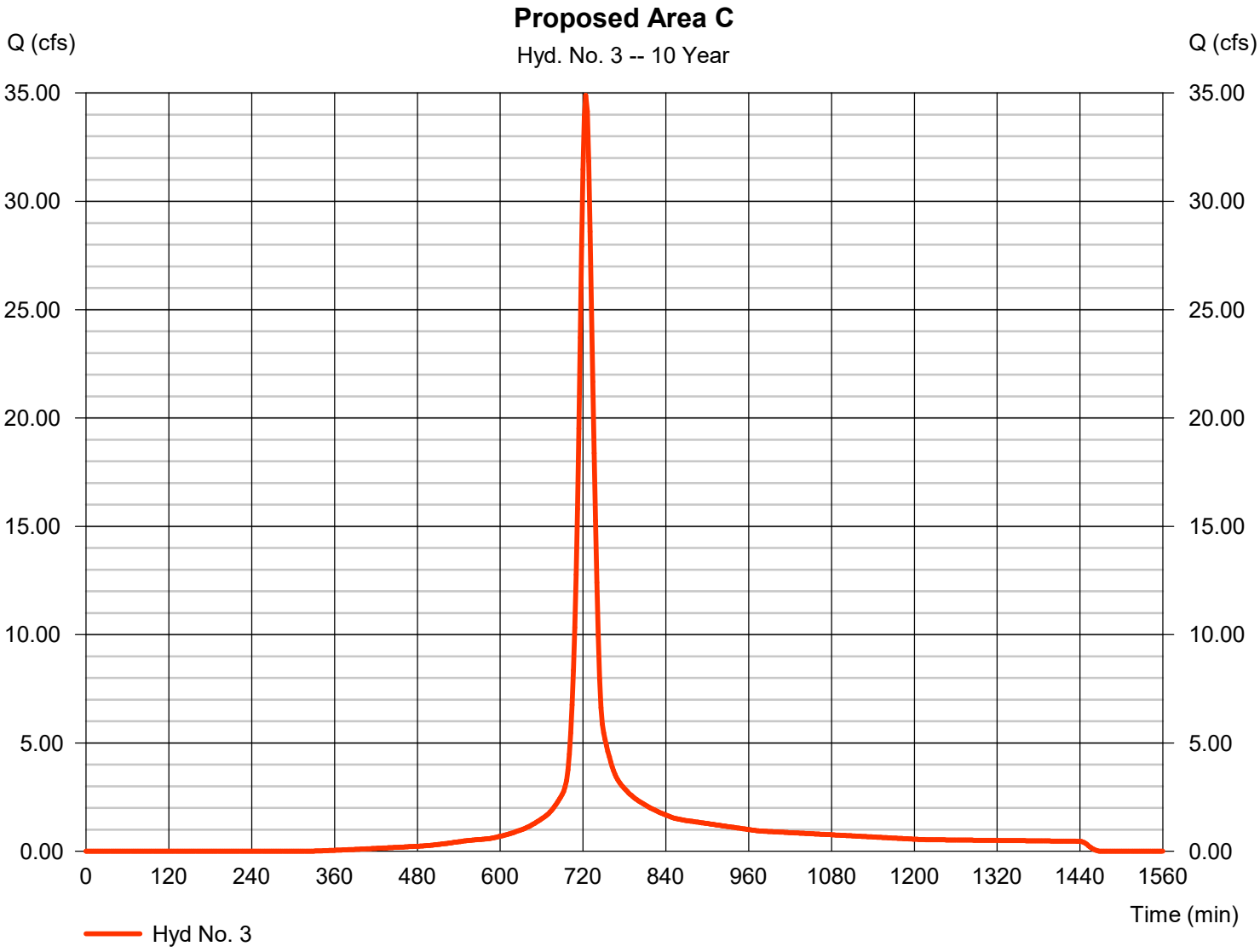


Hydrograph Report

Hyd. No. 3

Proposed Area C

Hydrograph type	=	SCS Runoff	Peak discharge	=	34.89 cfs
Storm frequency	=	10 yrs	Time to peak	=	724 min
Time interval	=	2 min	Hyd. volume	=	110,315 cuft
Drainage area	=	8.250 ac	Curve number	=	85
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	19.60 min
Total precip.	=	5.34 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

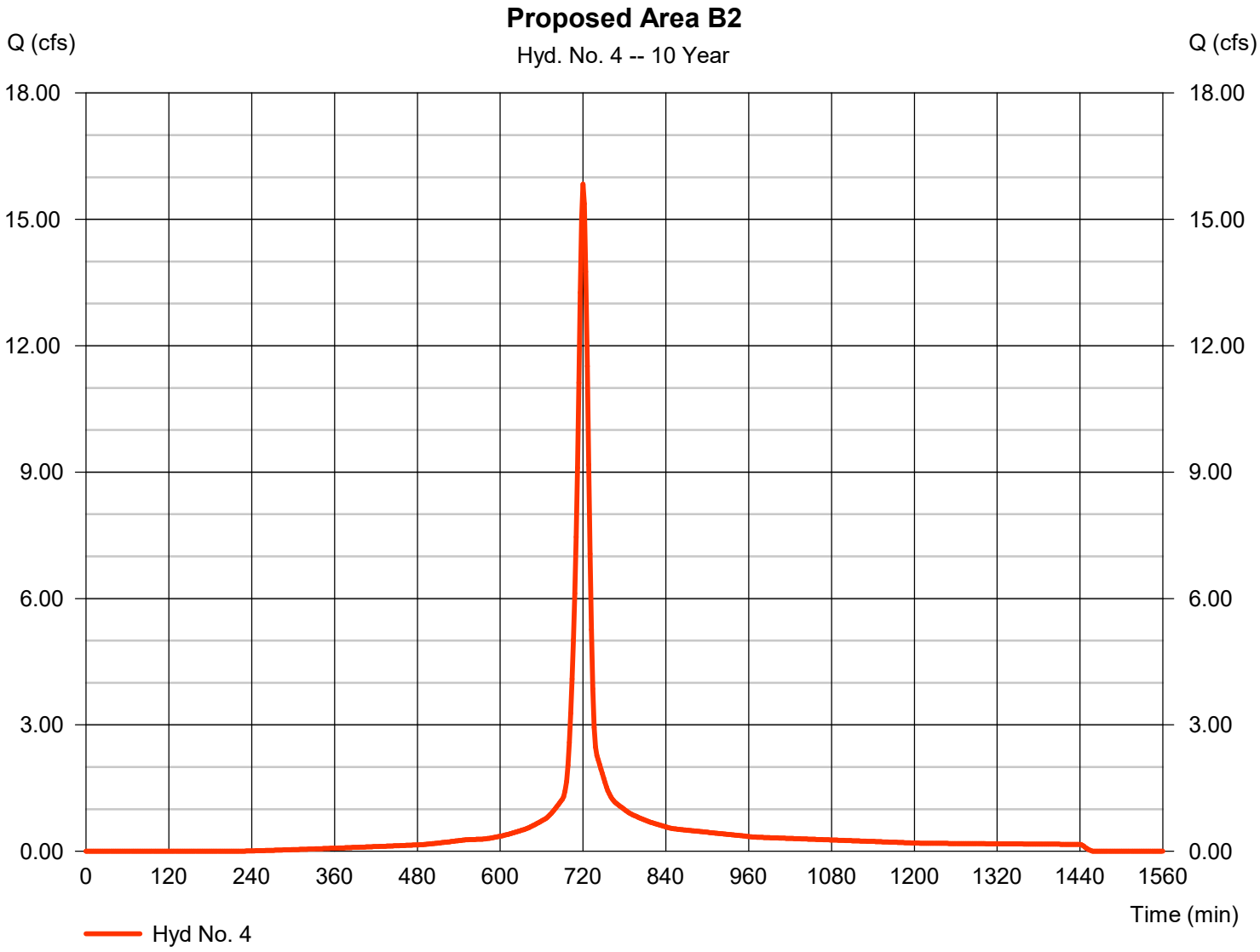


Hydrograph Report

Hyd. No. 4

Proposed Area B2

Hydrograph type	=	SCS Runoff	Peak discharge	=	15.83 cfs
Storm frequency	=	10 yrs	Time to peak	=	720 min
Time interval	=	2 min	Hyd. volume	=	42,972 cuft
Drainage area	=	2.730 ac	Curve number	=	90
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	10.90 min
Total precip.	=	5.34 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

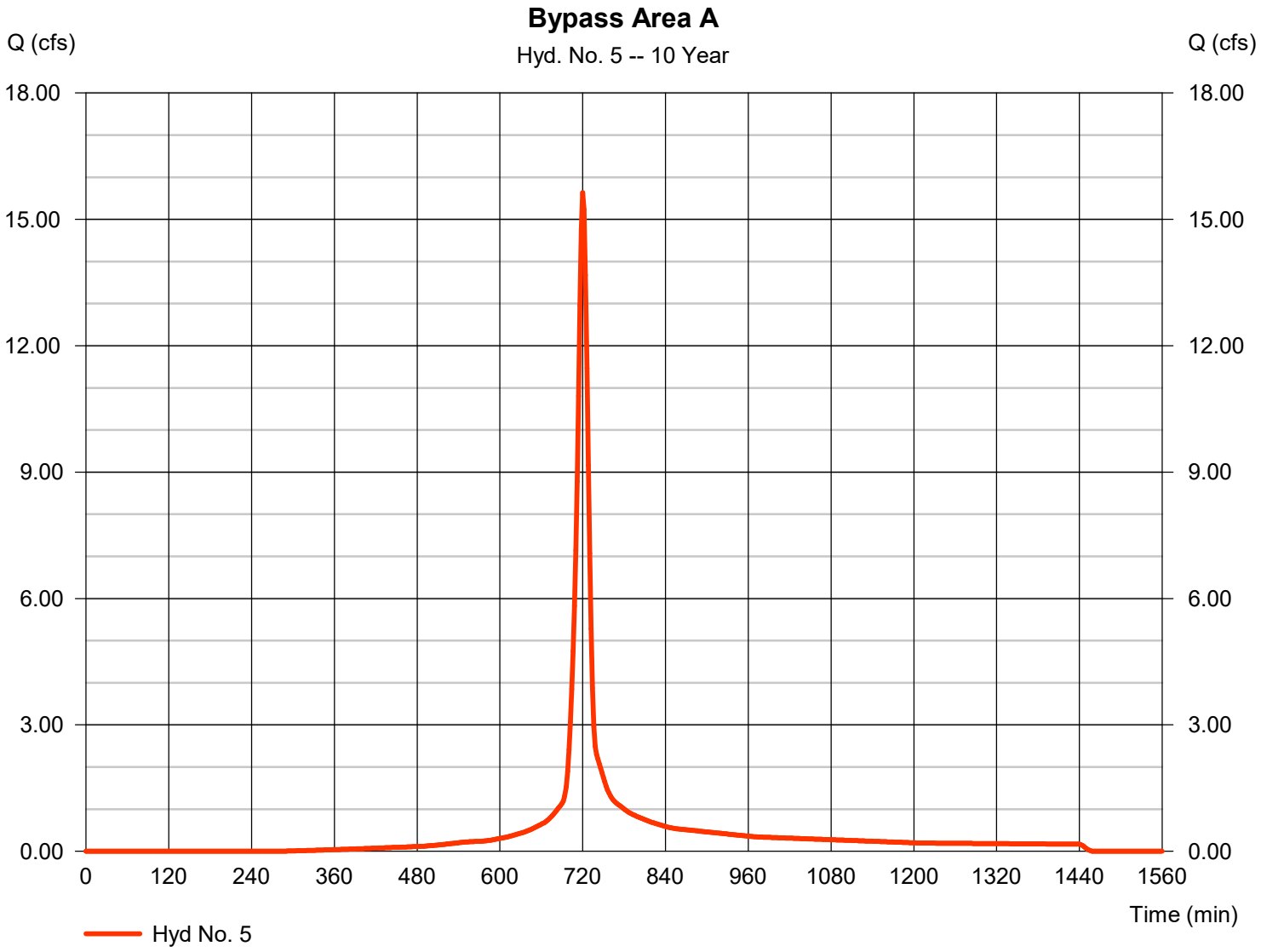


Hydrograph Report

Hyd. No. 5

Bypass Area A

Hydrograph type	= SCS Runoff	Peak discharge	= 15.64 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 41,632 cuft
Drainage area	= 2.860 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 10.60 min
Total precip.	= 5.34 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



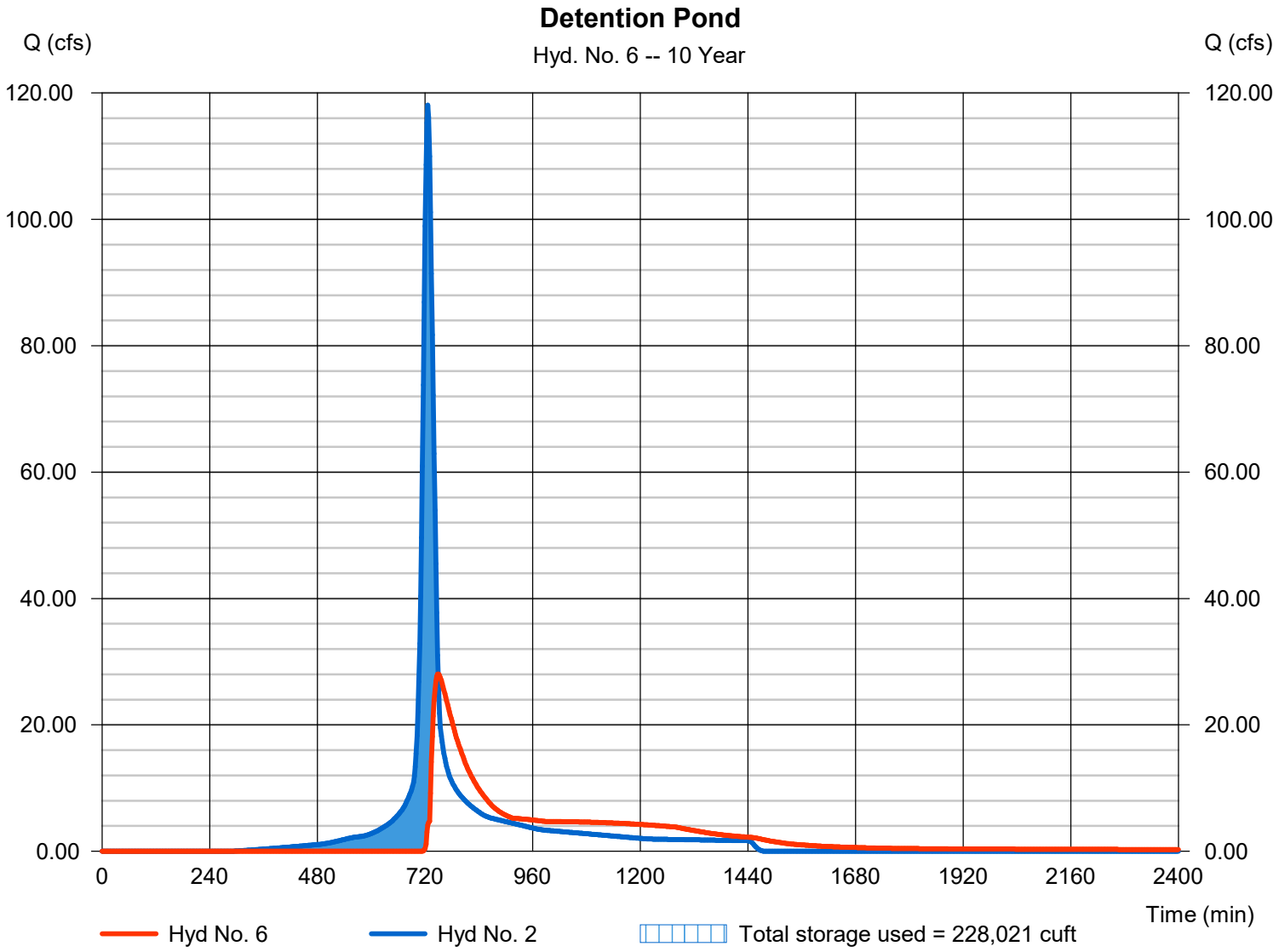
Hydrograph Report

Hyd. No. 6

Detention Pond

Hydrograph type	=	Reservoir	Peak discharge	=	28.05 cfs
Storm frequency	=	10 yrs	Time to peak	=	750 min
Time interval	=	2 min	Hyd. volume	=	327,304 cuft
Inflow hyd. No.	=	2 - Proposed Area B1	Max. Elevation	=	1015.03 ft
Reservoir name	=	Detention	Max. Storage	=	228,021 cuft

Storage Indication method used.

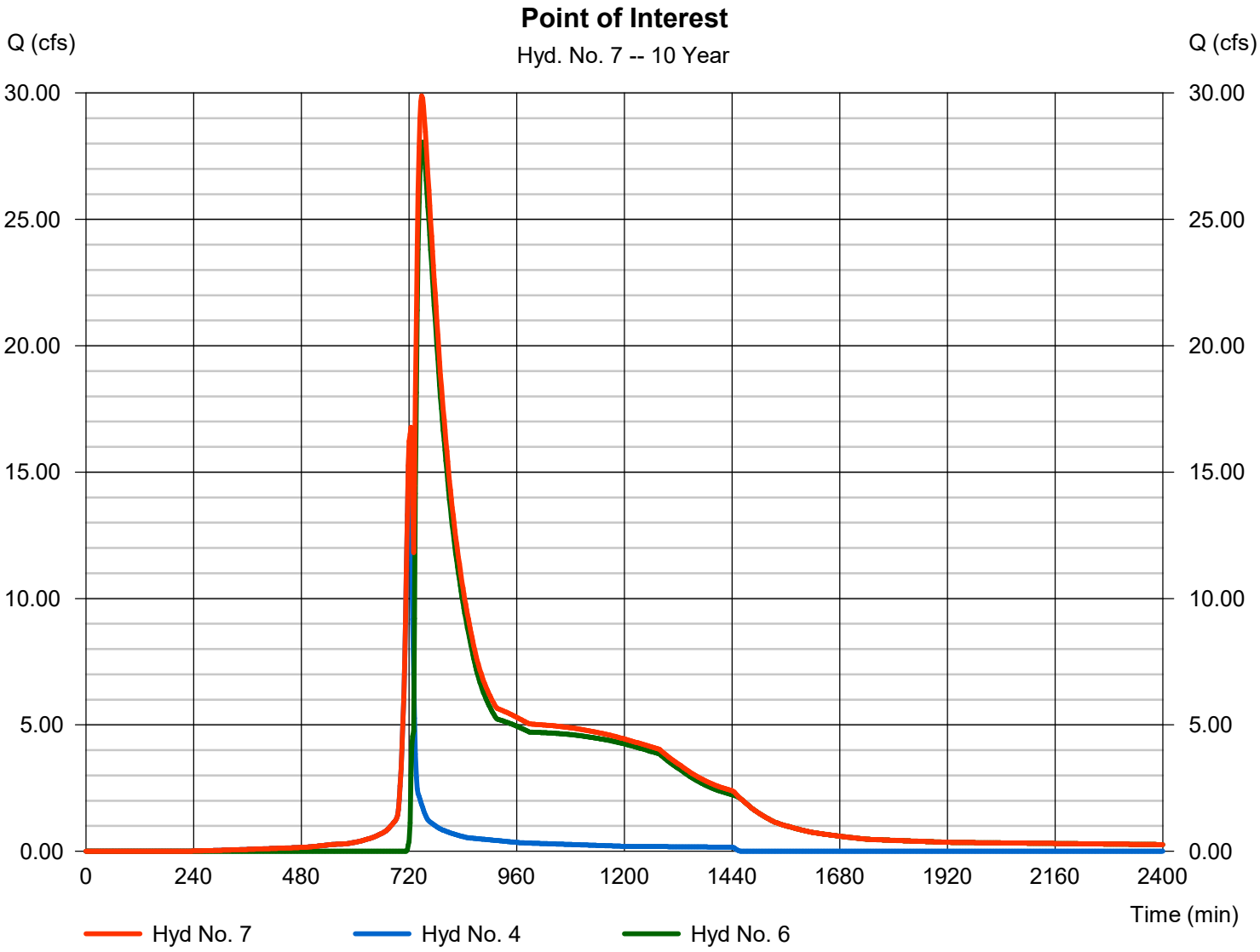


Hydrograph Report

Hyd. No. 7

Point of Interest

Hydrograph type	= Combine	Peak discharge	= 29.88 cfs
Storm frequency	= 10 yrs	Time to peak	= 748 min
Time interval	= 2 min	Hyd. volume	= 370,276 cuft
Inflow hyds.	= 4, 6	Contrib. drain. area	= 2.730 ac

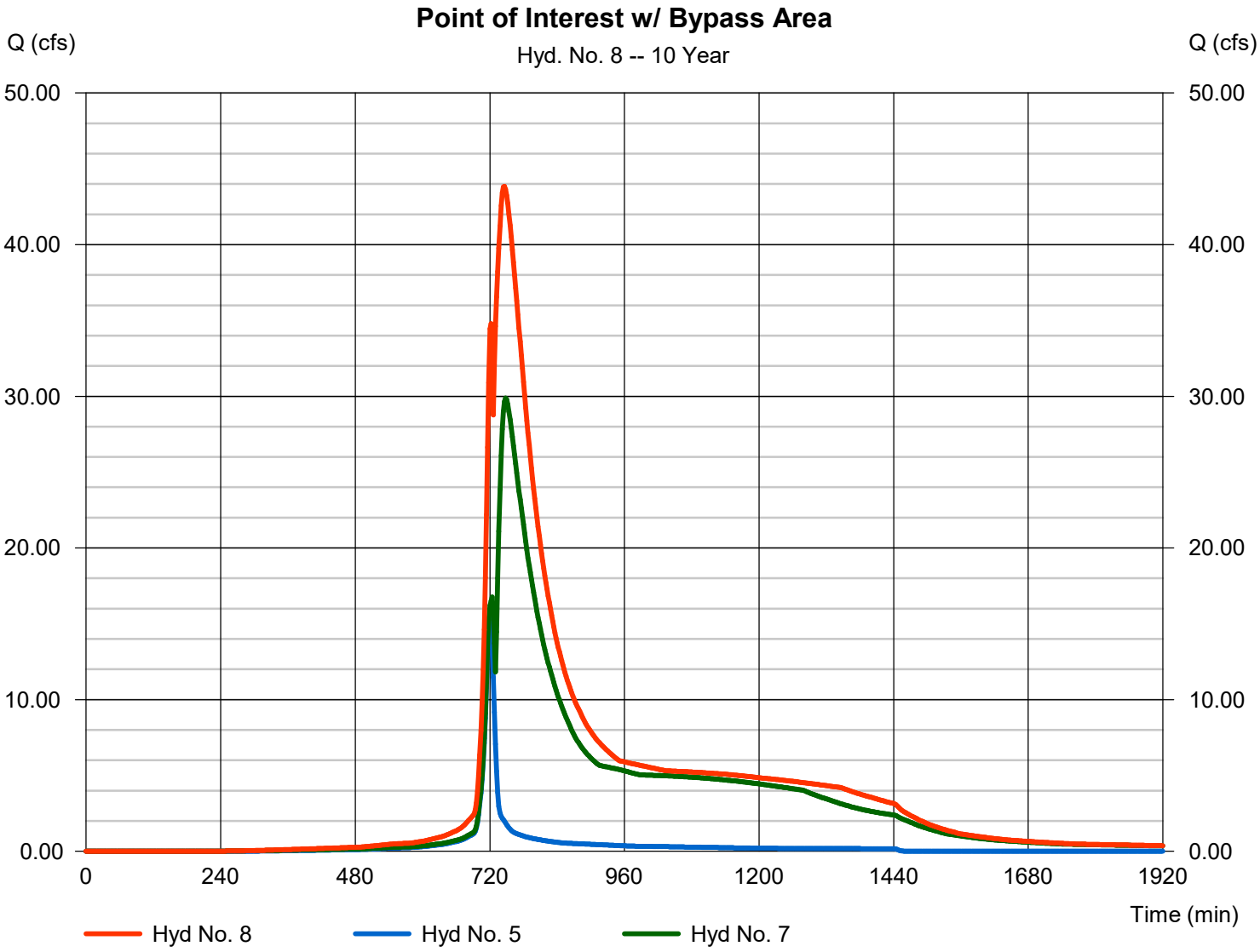


Hydrograph Report

Hyd. No. 8

Point of Interest w/ Bypass Area

Hydrograph type	= Combine	Peak discharge	= 43.85 cfs
Storm frequency	= 10 yrs	Time to peak	= 746 min
Time interval	= 2 min	Hyd. volume	= 492,636 cuft
Inflow hyds.	= 5, 7	Contrib. drain. area	= 2.860 ac



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

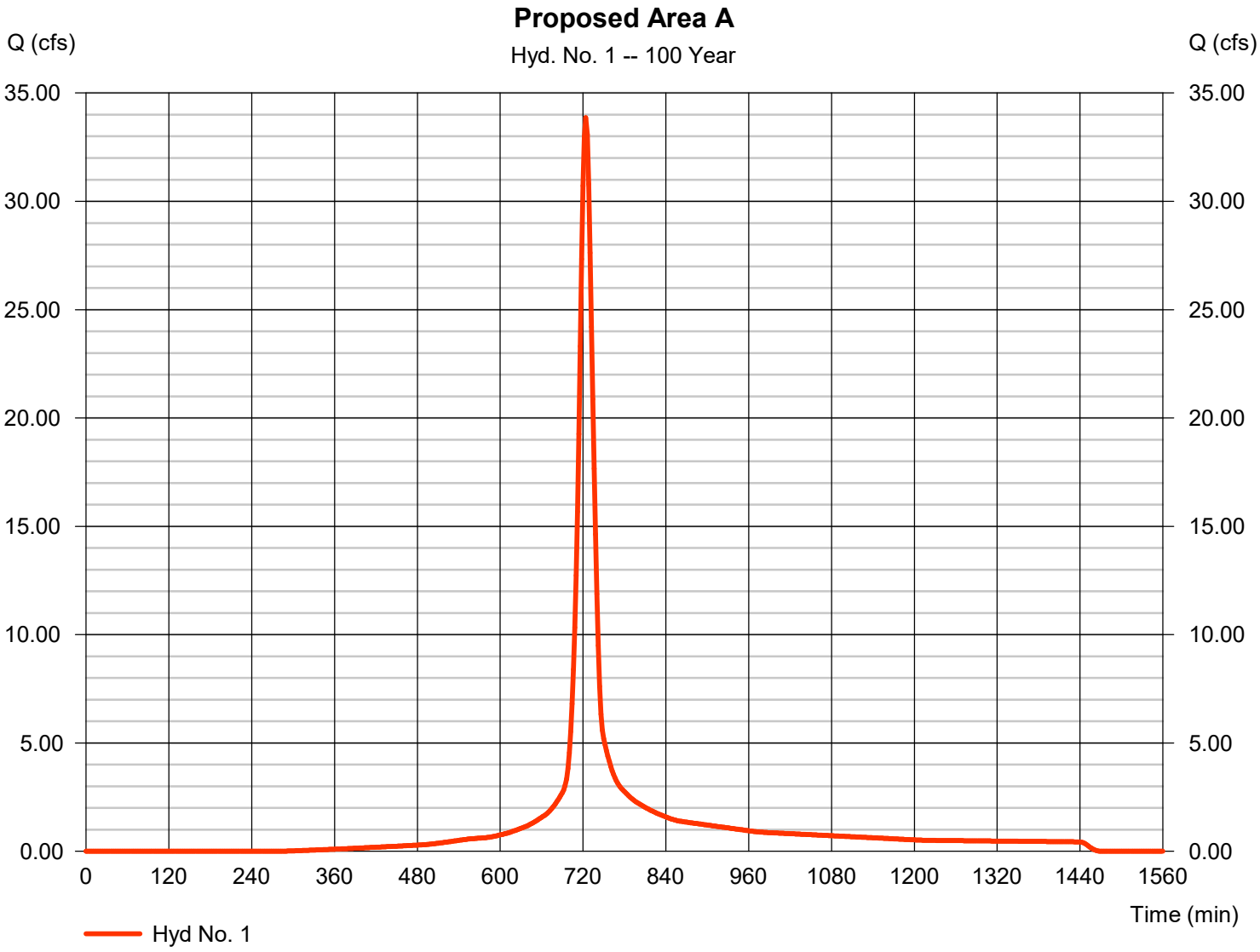
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	33.87	2	724	107,981	------	------	------	Proposed Area A
2	SCS Runoff	188.79	2	726	676,432	------	------	------	Proposed Area B1
3	SCS Runoff	56.74	2	724	183,183	------	------	------	Proposed Area C
4	SCS Runoff	24.59	2	720	68,544	------	------	------	Proposed Area B2
5	SCS Runoff	24.90	2	720	68,010	------	------	------	Bypass Area A
6	Reservoir	56.31	2	746	589,649	2	1017.16	347,372	Detention Pond
7	Combine	59.28	2	746	658,193	4, 6	------	------	Point of Interest
8	Combine	99.07	2	742	851,611	5, 7	------	------	Point of Interest w/ Bypass Area

Hydrograph Report

Hyd. No. 1

Proposed Area A

Hydrograph type	=	SCS Runoff	Peak discharge	=	33.87 cfs
Storm frequency	=	100 yrs	Time to peak	=	724 min
Time interval	=	2 min	Hyd. volume	=	107,981 cuft
Drainage area	=	5.160 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	20.00 min
Total precip.	=	7.90 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

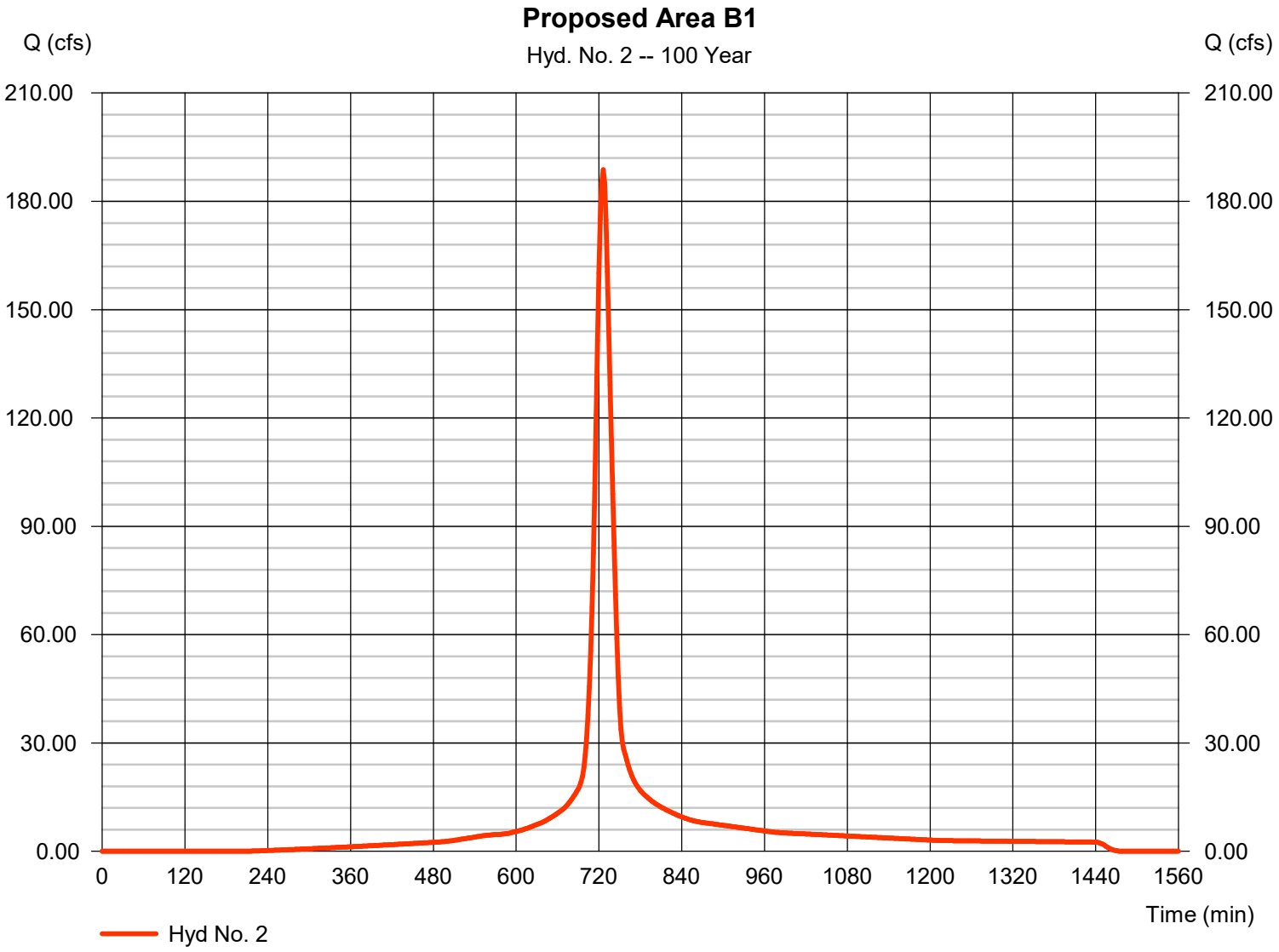


Hydrograph Report

Hyd. No. 2

Proposed Area B1

Hydrograph type	=	SCS Runoff	Peak discharge	=	188.79 cfs
Storm frequency	=	100 yrs	Time to peak	=	726 min
Time interval	=	2 min	Hyd. volume	=	676,432 cuft
Drainage area	=	28.820 ac	Curve number	=	87
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	21.30 min
Total precip.	=	7.90 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

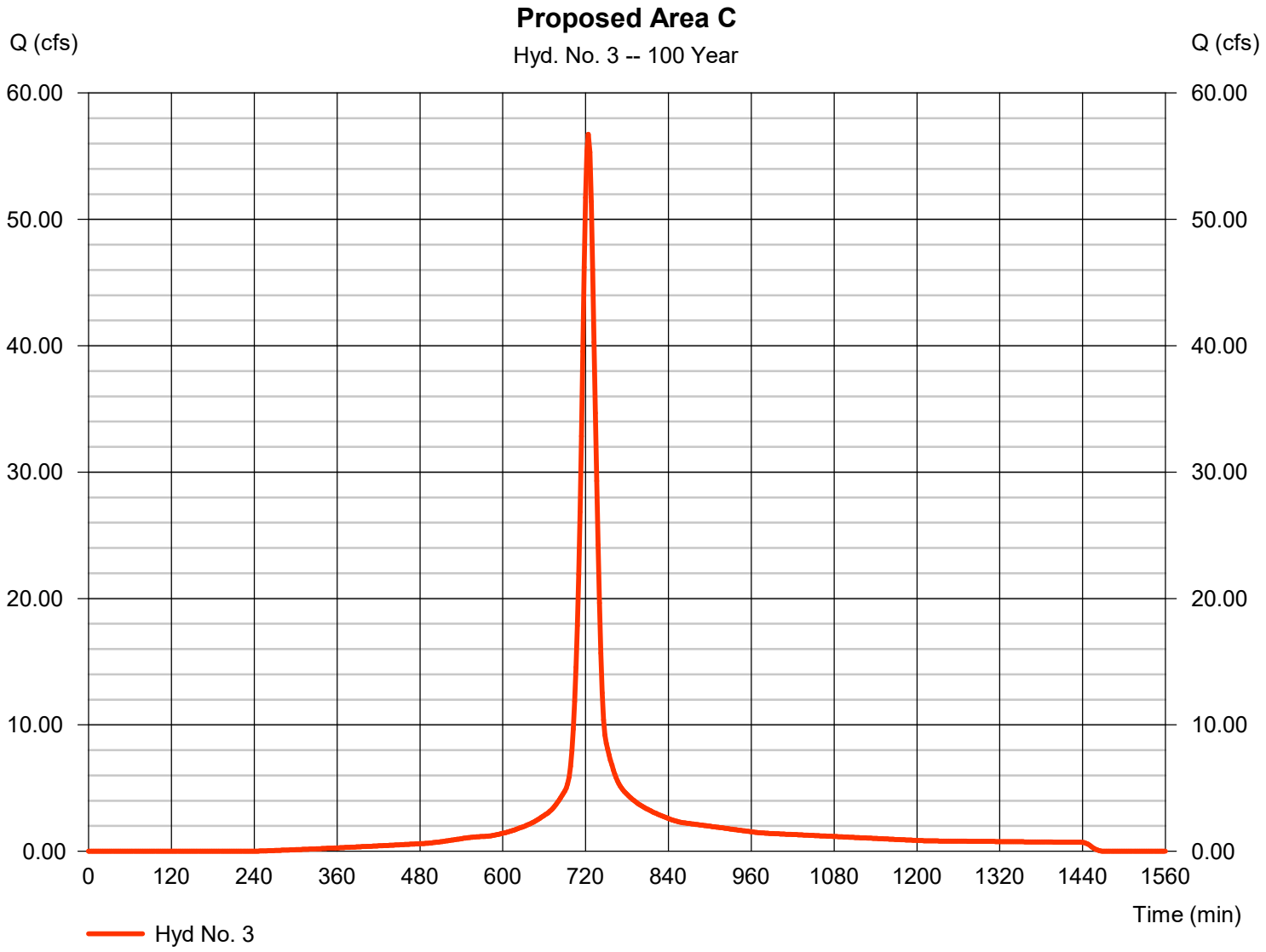


Hydrograph Report

Hyd. No. 3

Proposed Area C

Hydrograph type	=	SCS Runoff	Peak discharge	=	56.74 cfs
Storm frequency	=	100 yrs	Time to peak	=	724 min
Time interval	=	2 min	Hyd. volume	=	183,183 cuft
Drainage area	=	8.250 ac	Curve number	=	85
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	19.60 min
Total precip.	=	7.90 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

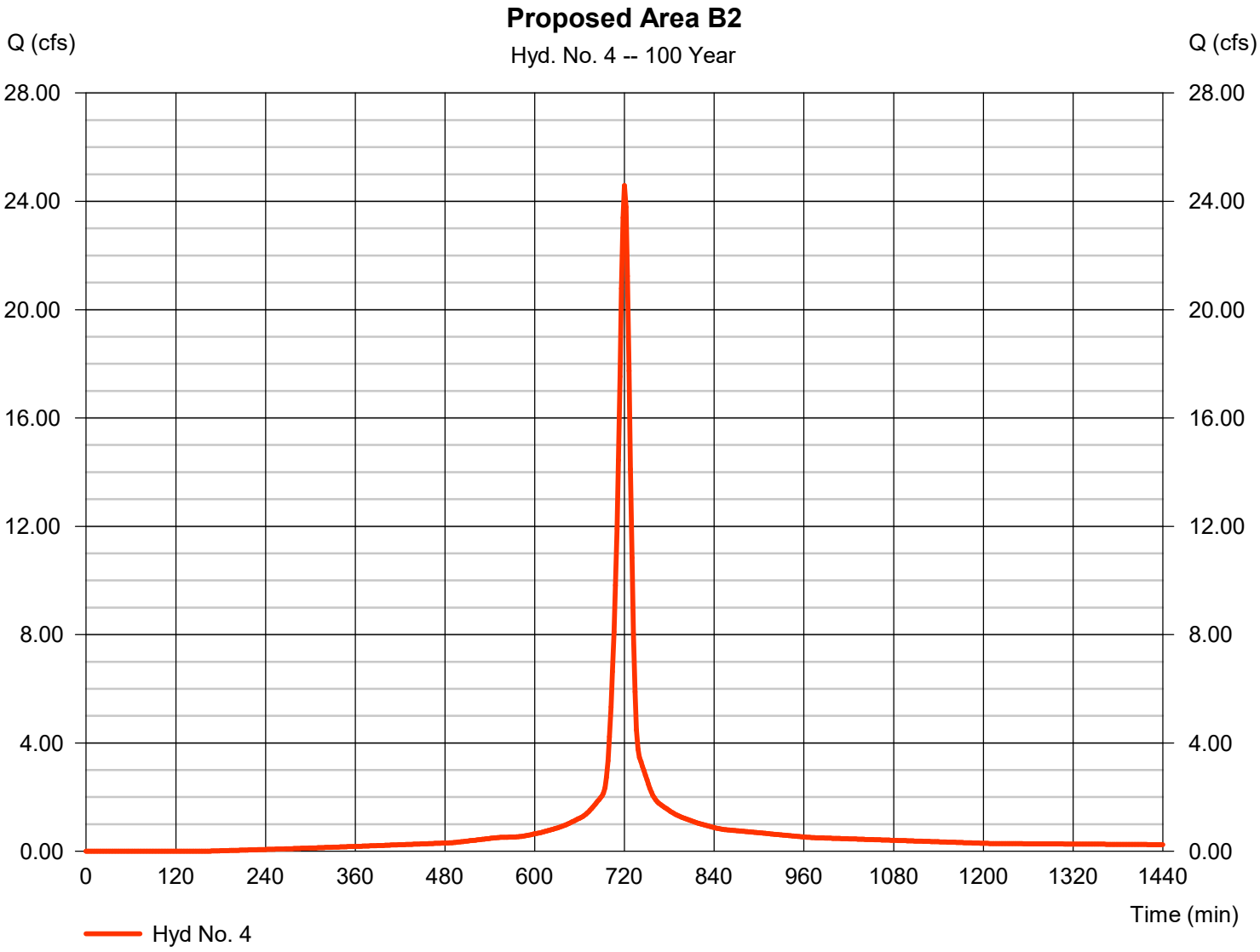


Hydrograph Report

Hyd. No. 4

Proposed Area B2

Hydrograph type	= SCS Runoff	Peak discharge	= 24.59 cfs
Storm frequency	= 100 yrs	Time to peak	= 720 min
Time interval	= 2 min	Hyd. volume	= 68,544 cuft
Drainage area	= 2.730 ac	Curve number	= 90
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 10.90 min
Total precip.	= 7.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

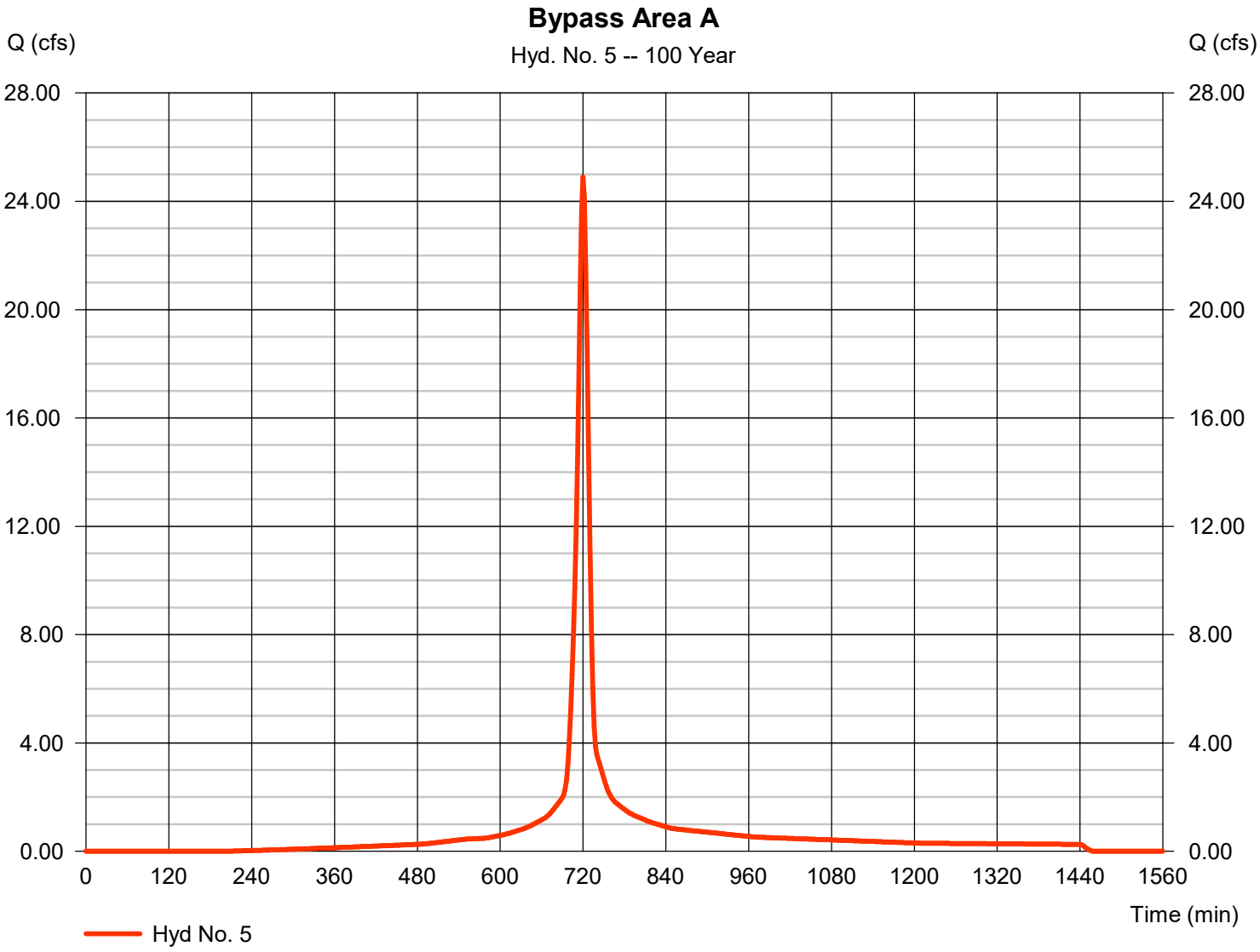


Hydrograph Report

Hyd. No. 5

Bypass Area A

Hydrograph type	=	SCS Runoff	Peak discharge	=	24.90 cfs
Storm frequency	=	100 yrs	Time to peak	=	720 min
Time interval	=	2 min	Hyd. volume	=	68,010 cuft
Drainage area	=	2.860 ac	Curve number	=	87
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	10.60 min
Total precip.	=	7.90 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



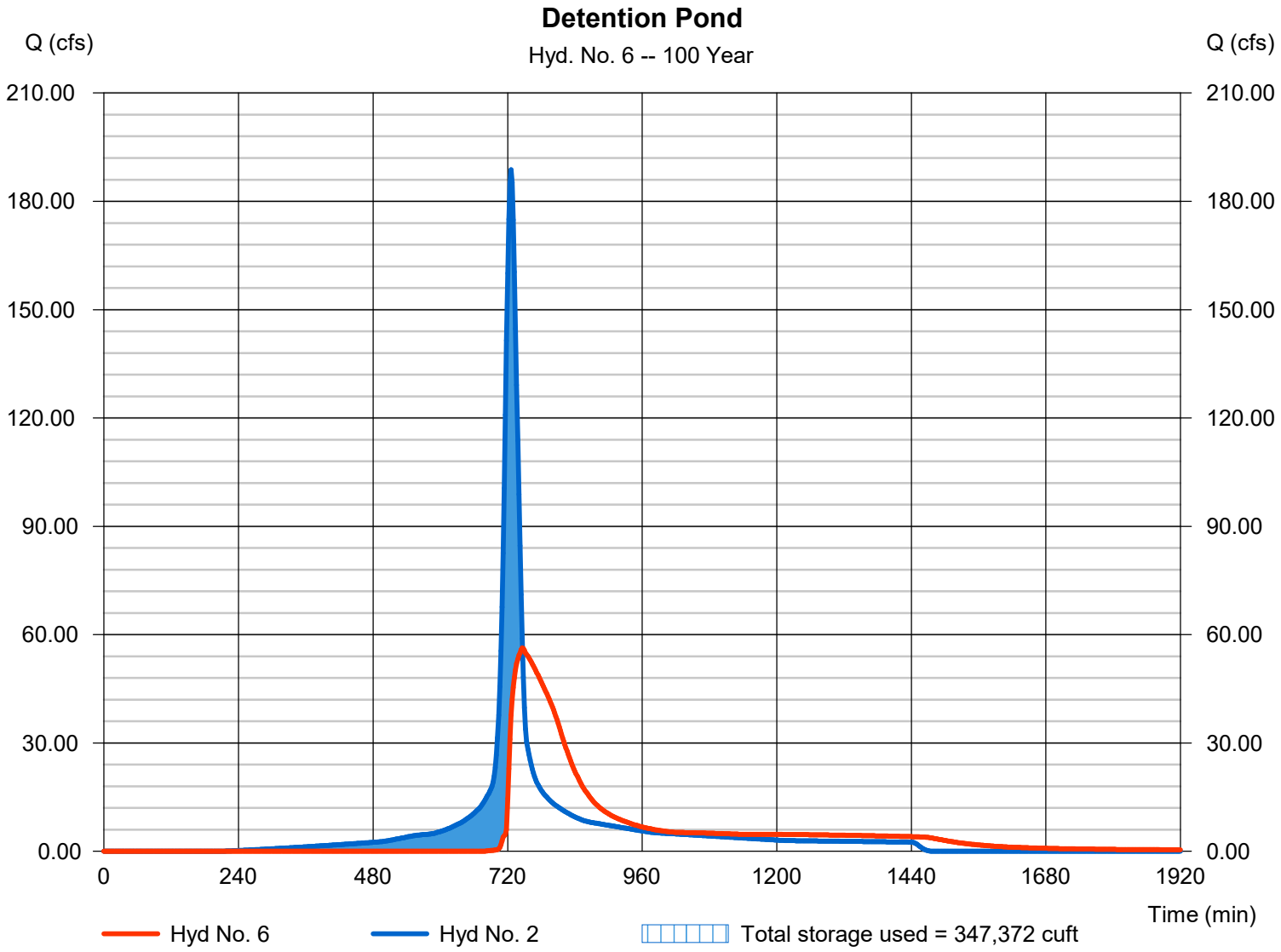
Hydrograph Report

Hyd. No. 6

Detention Pond

Hydrograph type	=	Reservoir	Peak discharge	=	56.31 cfs
Storm frequency	=	100 yrs	Time to peak	=	746 min
Time interval	=	2 min	Hyd. volume	=	589,649 cuft
Inflow hyd. No.	=	2 - Proposed Area B1	Max. Elevation	=	1017.16 ft
Reservoir name	=	Detention	Max. Storage	=	347,372 cuft

Storage Indication method used.

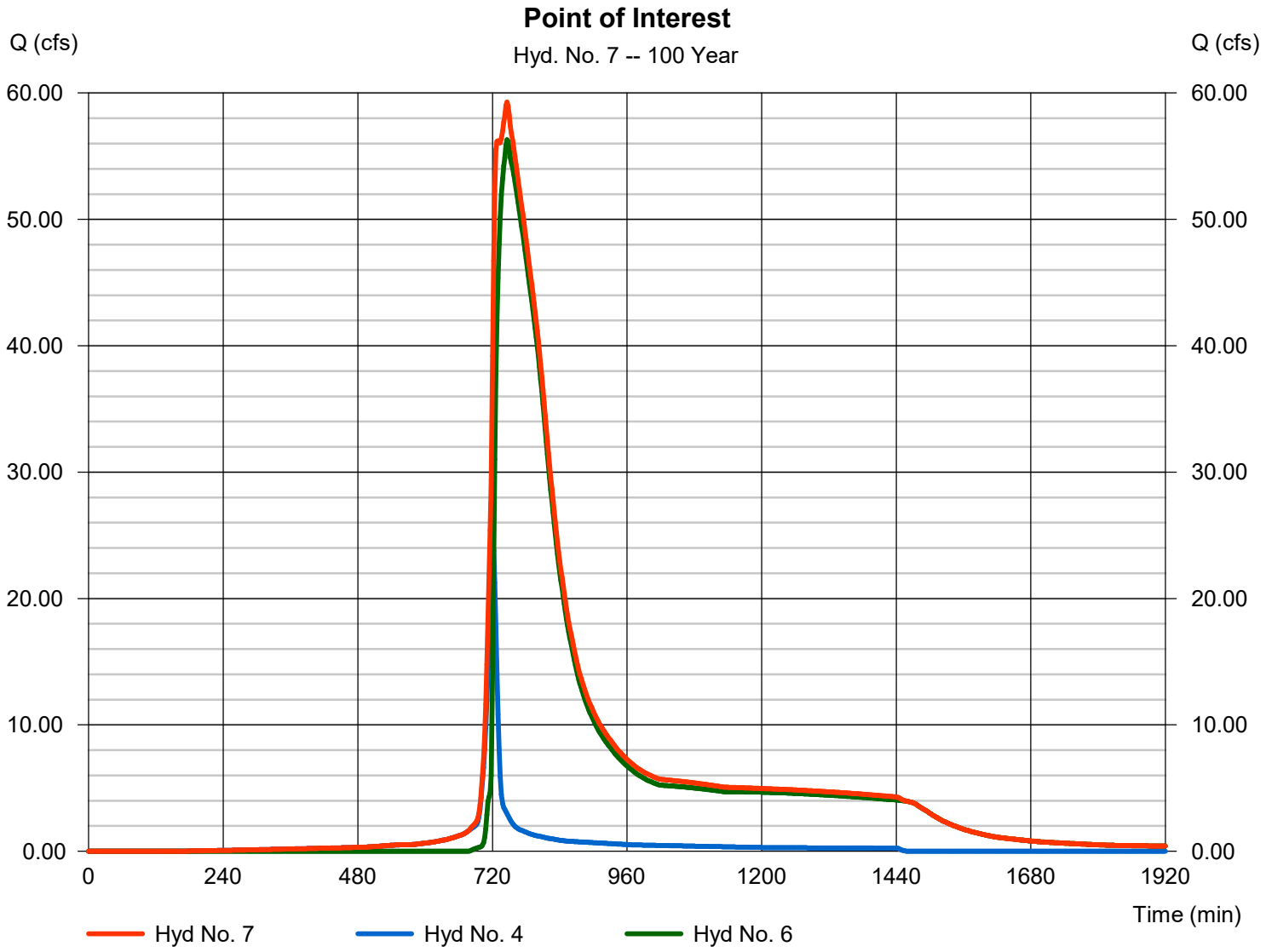


Hydrograph Report

Hyd. No. 7

Point of Interest

Hydrograph type	= Combine	Peak discharge	= 59.28 cfs
Storm frequency	= 100 yrs	Time to peak	= 746 min
Time interval	= 2 min	Hyd. volume	= 658,193 cuft
Inflow hyds.	= 4, 6	Contrib. drain. area	= 2.730 ac

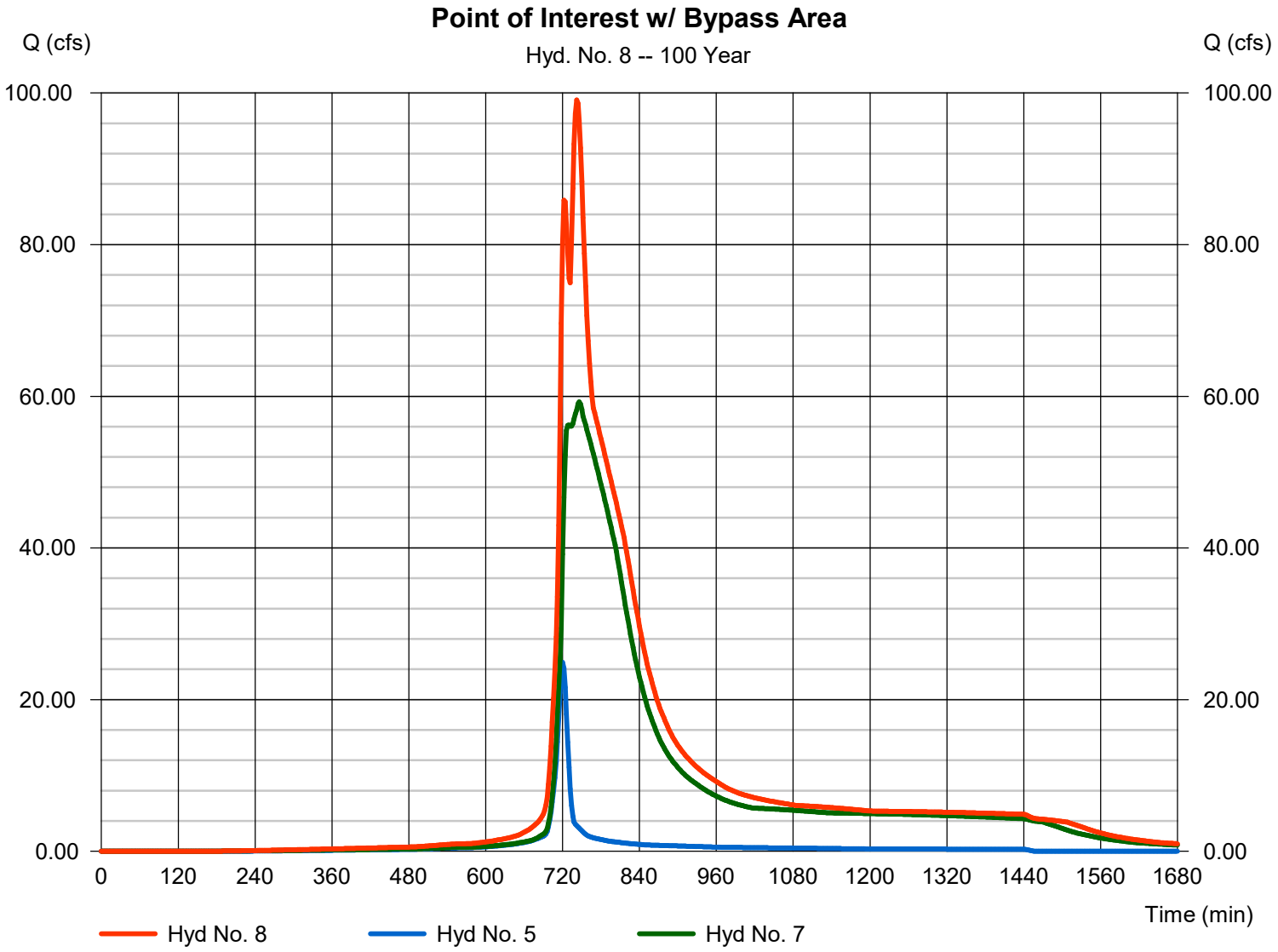


Hydrograph Report

Hyd. No. 8

Point of Interest w/ Bypass Area

Hydrograph type	= Combine	Peak discharge	= 99.07 cfs
Storm frequency	= 100 yrs	Time to peak	= 742 min
Time interval	= 2 min	Hyd. volume	= 851,611 cuft
Inflow hyds.	= 5, 7	Contrib. drain. area	= 2.860 ac



APPENDIX D

Hy-8 Input and Results

Table 1 - Summary of Culvert Flows at Crossing: Pryor Road

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Pryor Road Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1009.66	2 year Proposed	20.00	20.00	0.00	1
1010.25	10 year Proposed	40.00	40.00	0.00	1
1011.07	2 year Existing	69.00	69.00	0.00	1
1012.16	100 year Proposed	97.00	97.00	0.00	1
1012.47	10 year Existing	120.00	103.50	16.35	9
1012.76	100 year Existing	197.00	109.31	87.43	4
1012.32	Overtopping	100.49	100.49	0.00	Overtopping

Table 2 - Culvert Summary Table: Pryor Road

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
2 year Proposed	20.00	20.00	1009.66	1.253	0.0*	1-S2n	0.778	0.850	0.778	0.565	4.937
10 year Proposed	40.00	40.00	1010.25	1.844	0.851	1-S2n	1.134	1.228	1.134	0.836	5.957
2 year Existing	69.00	69.00	1011.07	2.656	1.911	5-S2n	1.593	1.629	1.593	1.127	6.764
100 year Proposed	97.00	97.00	1012.16	3.747	3.519	7-M2c	2.500	1.934	1.934	1.353	7.936
10 year Existing	120.00	103.50	1012.47	4.055	3.725	7-M2c	2.500	1.994	1.994	1.514	8.220
100 year Existing	197.00	109.31	1012.76	4.348	3.995	7-M2c	2.500	2.044	2.044	1.955	8.481

* Full Flow Headwater elevation is below inlet invert.

****

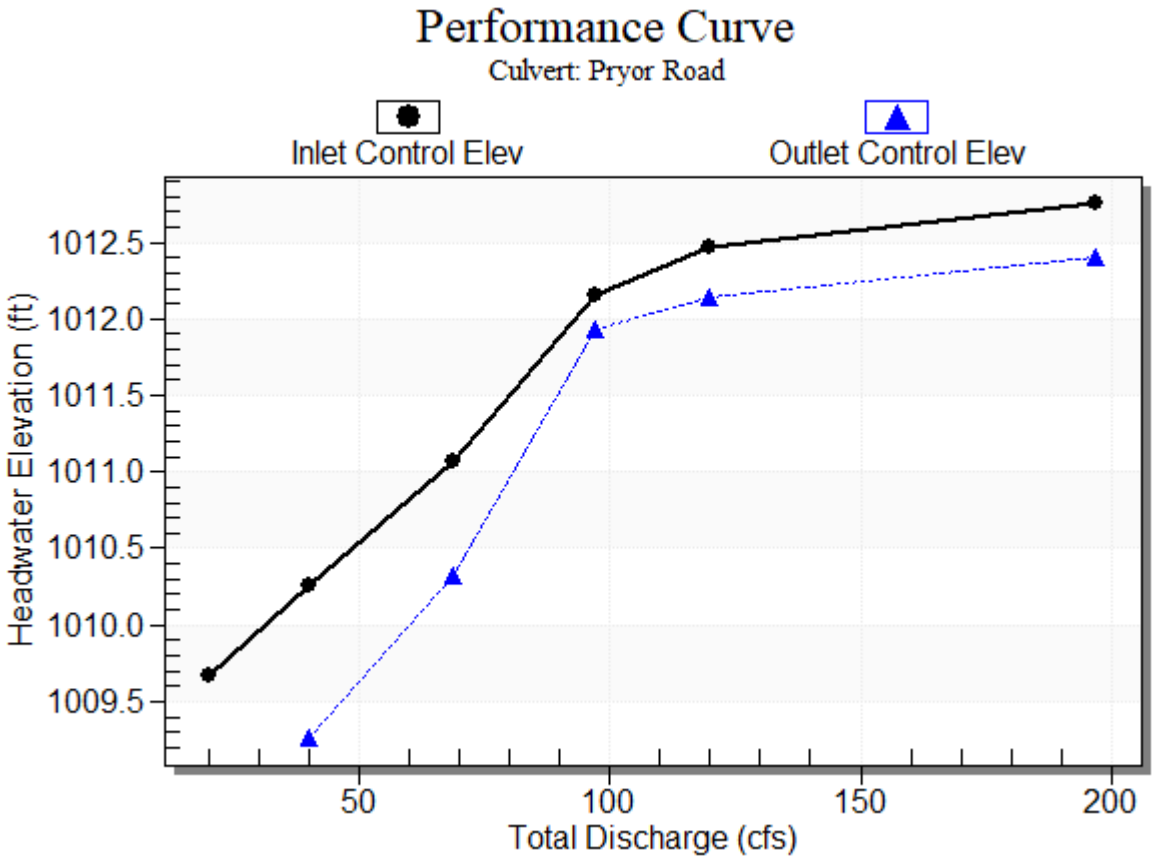
Straight Culvert

Inlet Elevation (invert): 1008.41 ft, Outlet Elevation (invert): 1007.70 ft

Culvert Length: 38.71 ft, Culvert Slope: 0.0183

****

Culvert Performance Curve Plot: Pryor Road



Water Surface Profile Plot for Culvert: Pryor Road

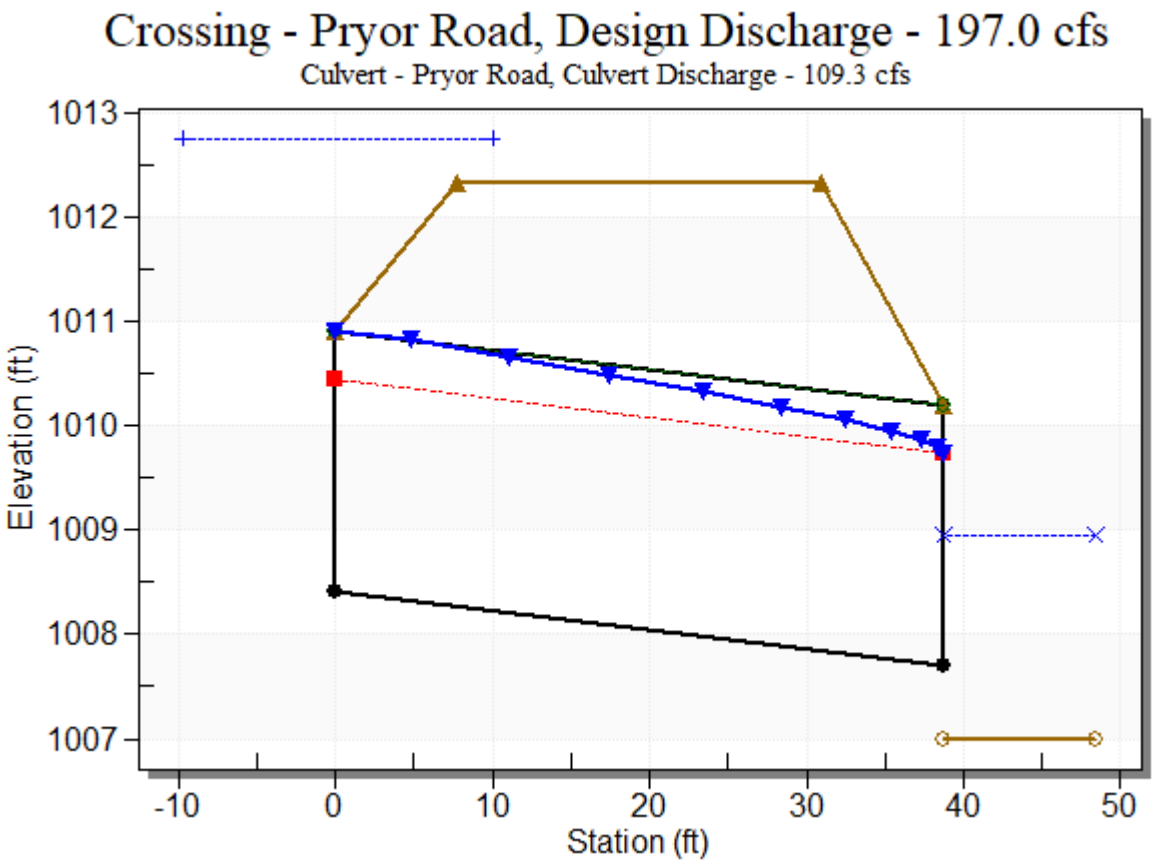


Table 3 - Downstream Channel Rating Curve (Crossing: Pryor Road)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
20.00	1007.57	0.57	3.65	0.71	0.93
40.00	1007.84	0.84	4.56	1.04	0.98
69.00	1008.13	1.13	5.38	1.41	1.02
97.00	1008.35	1.35	5.95	1.69	1.04
120.00	1008.51	1.51	6.32	1.89	1.06
197.00	1008.96	1.96	7.27	2.44	1.09

APPENDIX E

Additional Future Conditions Calculations

Curve Number Calculations

Curve Number Calculations

Existing Conditions

Area A

Area (ac)	Soil_Type	Land_Use	CN	Weight	CN x Weight
2.906	C	Pasture	79	0.56	44.46
0.243485726	C	Pasture	79	0.05	3.73
0.613818779	D	Straight Row Crop	89	0.12	10.58
1.400523294	C	Straight Row Crop	85	0.27	23.05
5.163827799	**=Total Area**			**Weighted CN=**	81.8
				Rounded CN=	**82**

Area B

Area (ac)	Soil_Type	Land_Use	CN	Weight	CN x Weight
1.312066014	D	Straight Row Crop	89	0.05	4.09
0.017100042	D	Pasture	84	0.00	0.05
0.529108307	C	Straight Row Crop	85	0.02	1.57
0.849328427	C	Pasture	79	0.03	2.35
3.30E-01	C	Pasture	79	0.01	0.91
23.41341854	C	Straight Row Crop	85	0.82	69.67
2.114782111	C	Pasture	79	0.07	5.85
28.56593904	**=Total Area**			**Weighted CN=**	84.49
				Rounded CN=	**84**

Area C

Area (ac)	Soil_Type	Land_Use	CN	Weight	CN x Weight
0.79150623	C	Pasture	79	0.07	5.55
7.030021517	C	Straight Row Crop	85	0.62	53.02
2.474000902	C	Pasture	79	0.22	17.34
0.266295138	C	Pasture	79	0.02	1.87
0.708077602	C	Straight Row Crop	85	0.06	5.34
11.26990139	**=Total Area**			**Weighted CN=**	83.12
				Rounded CN=	**83**

Bypass Area

Bypass Area A

Area (ac)	Soil_Type	Land_Use	CN	Weight	CN x Weight
0.722	C	Pasture	79	0.25	19.92
0.722	D	Pasture	84	0.25	21.18
0.71	C	Paved Open Ditches	92	0.25	22.81
0.71	D	Paved Open Ditches	93	0.25	23.06
2.864	**=Total Area**			**Weighted CN**	86.95
				Rounded CN=	87

Proposed Conditions

Area A

Area (ac)	Soil_Type	Land_Use	CN	Weight	CN x Weight
0.128	D	Multifamily Residentia	92	0.30	27.39
0.302	C	Multifamily Residentia	90	0.70	63.21
0.43	**=Total Area**			**Weighted CN=**	90.60
				Rounded CN=	**91**

Area B1

Area (ac)	Soil_Type	Land_Use	CN	Weight	CN x Weight
0.823052	D	Multifamily Residentia	92	0.02	2.26
0.017108	D	Pasture	84	0.00	0.04
0.248037	C	Pasture	79	0.01	0.58
2.25E+00	C	Multifamily Residentia	90	0.07	6.04
1.391016	C	Straight Row Crop	85	0.04	3.53
2.192	C	Pasture	79	0.07	5.16
0.839925	C	Pasture	79	0.03	1.98
23.19	C	Multifamily Residentia	90	0.69	62.23
0.471729	C	Straight Row Crop	85	0.01	1.20
2.114399	C	Pasture	79	0.06	4.98
33.53989				**Weighted CN=**	88.00
				Rounded CN=	**88**

Area C

Area (ac)	Soil_Type	Land_Use	CN	Weight	CN x Weight
0.543476	C	Pasture	79	0.07	5.20
1.487245	C	Pasture	79	0.18	14.24
4.327	C	Multifamily Residentia	90	0.52	47.19
1.89E+00	C	Straight Row Crop	85	0.23	19.51
8.252144	**=Total Area**			**Weighted CN=**	86.15
				Rounded CN=	**86**

Area (ac)

Area	Soil_Type	Land_Use	CN	Weight	CN x Weight
0.468749	D	Multifamily Residentia	92	0.17	15.80
2.261	C	Multifamily Residentia	90	0.83	74.55
2.729749	**=Total Area**			**Weighted CN=**	90.34
				Rounded CN=	**90**

Inflow Hydrographs

Hydrograph Report

Inflow Hydrograph - 2 Year Storm

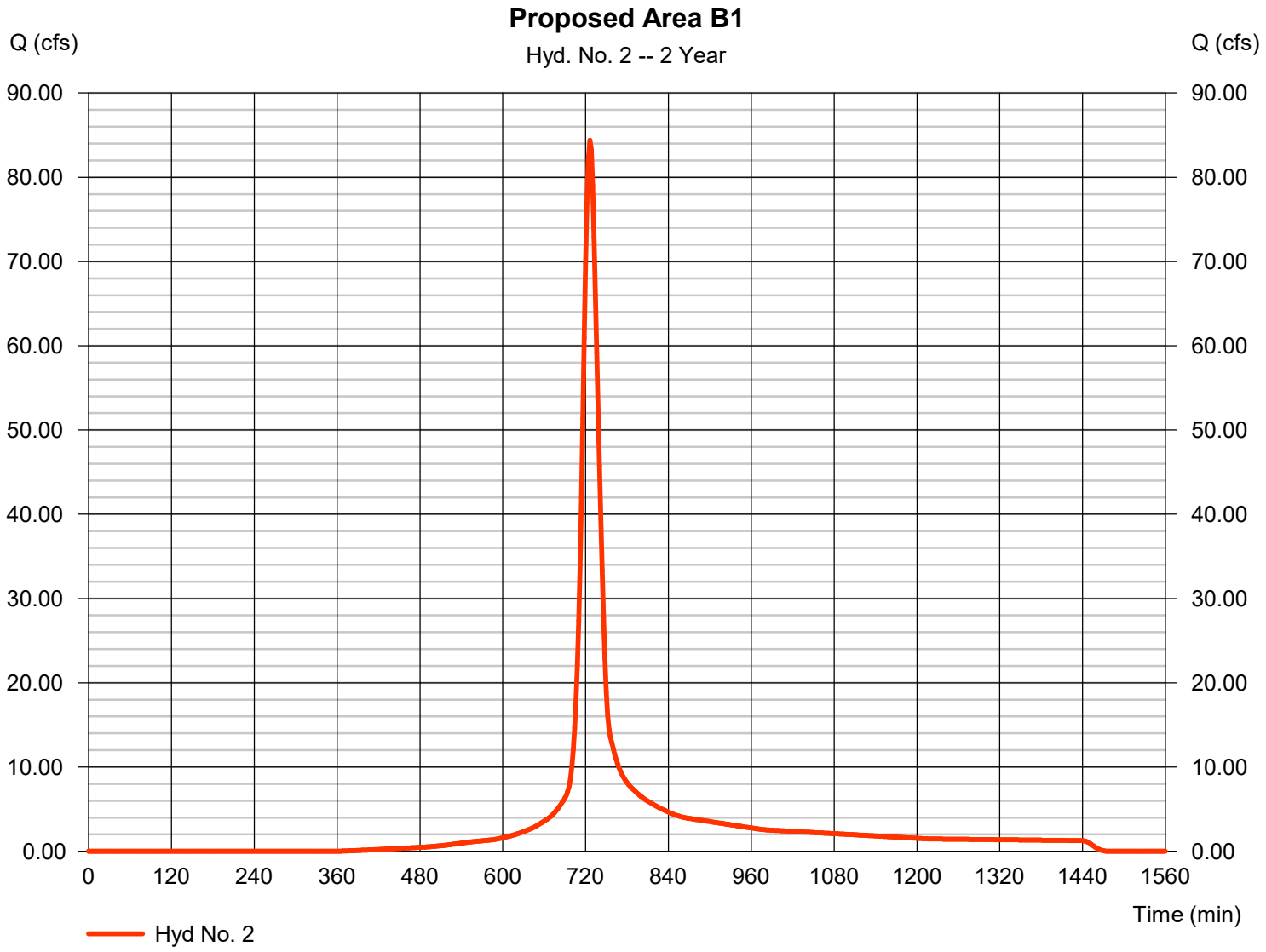
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

Monday, 03 / 2 / 2020

Hyd. No. 2

Proposed Area B1

Hydrograph type	= SCS Runoff	Peak discharge	= 84.38 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 292,466 cuft
Drainage area	= 33.540 ac	Curve number	= 88
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 21.30 min
Total precip.	= 3.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

Inflow Hydrograph - 10 Year Storm

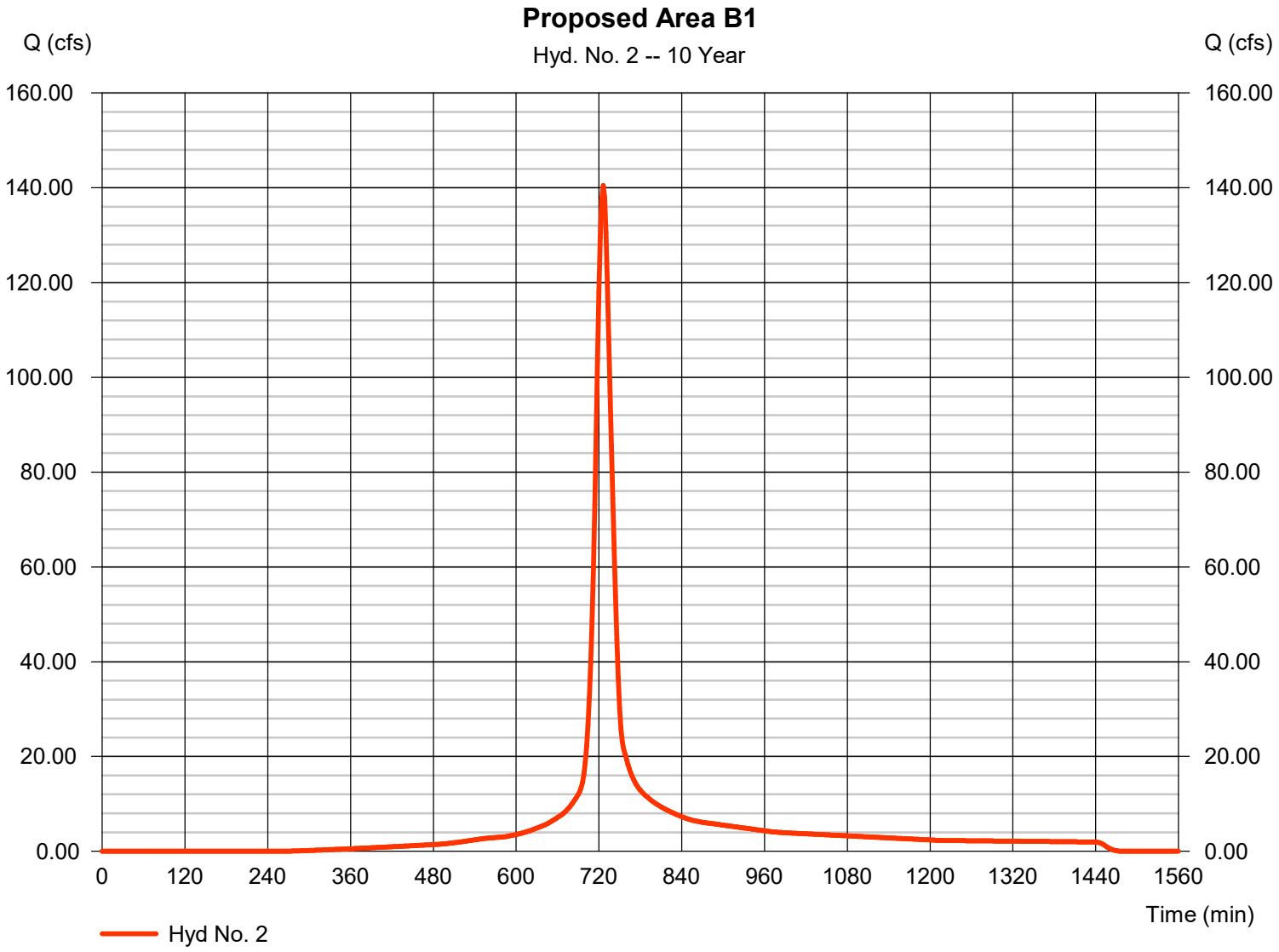
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

Monday, 03 / 2 / 2020

Hyd. No. 2

Proposed Area B1

Hydrograph type	= SCS Runoff	Peak discharge	= 140.46 cfs
Storm frequency	= 10 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 494,803 cuft
Drainage area	= 33.540 ac	Curve number	= 88
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 21.30 min
Total precip.	= 5.34 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

Inflow Hydrograph - 100 Year Storm

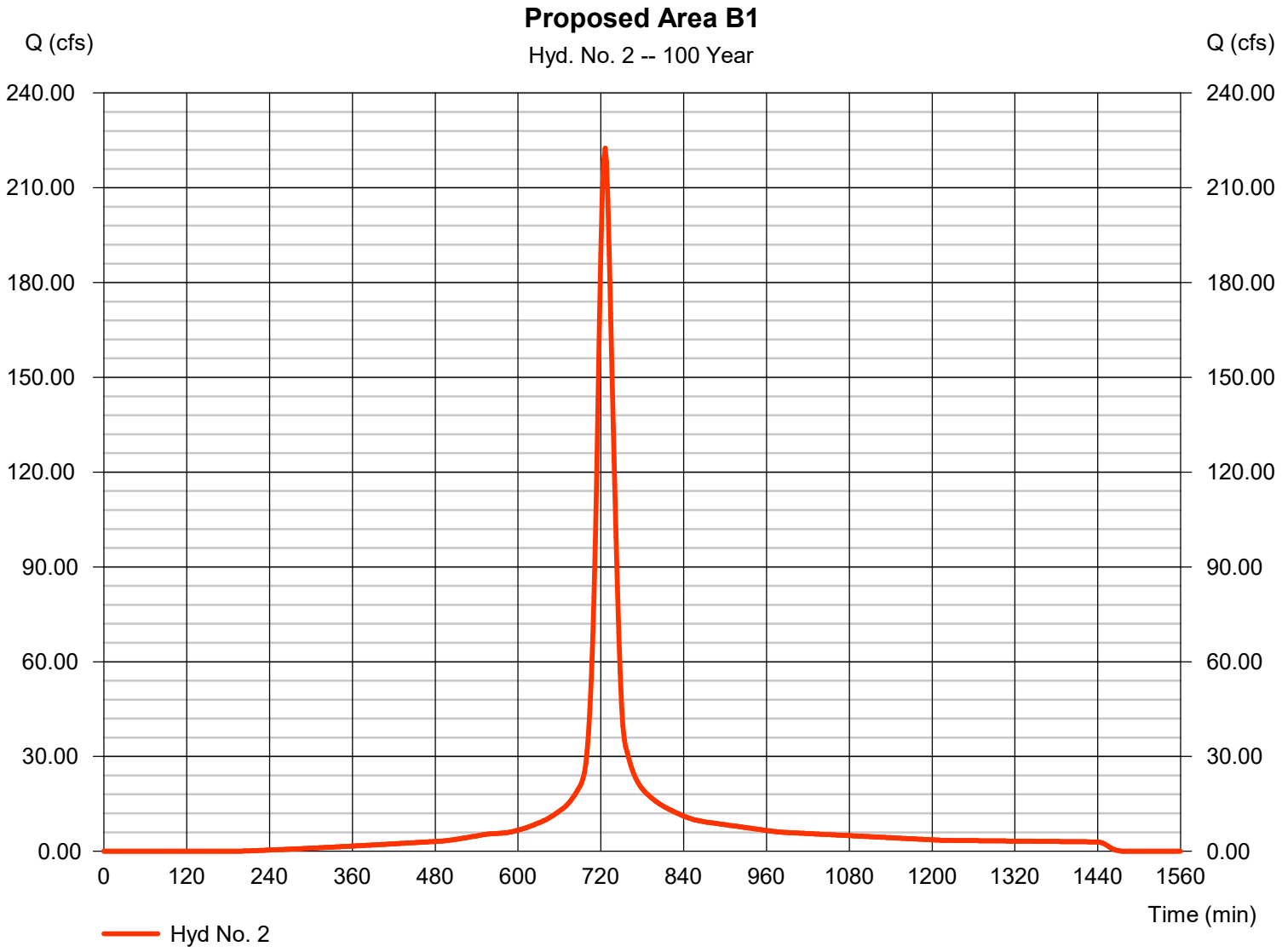
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

Monday, 03 / 2 / 2020

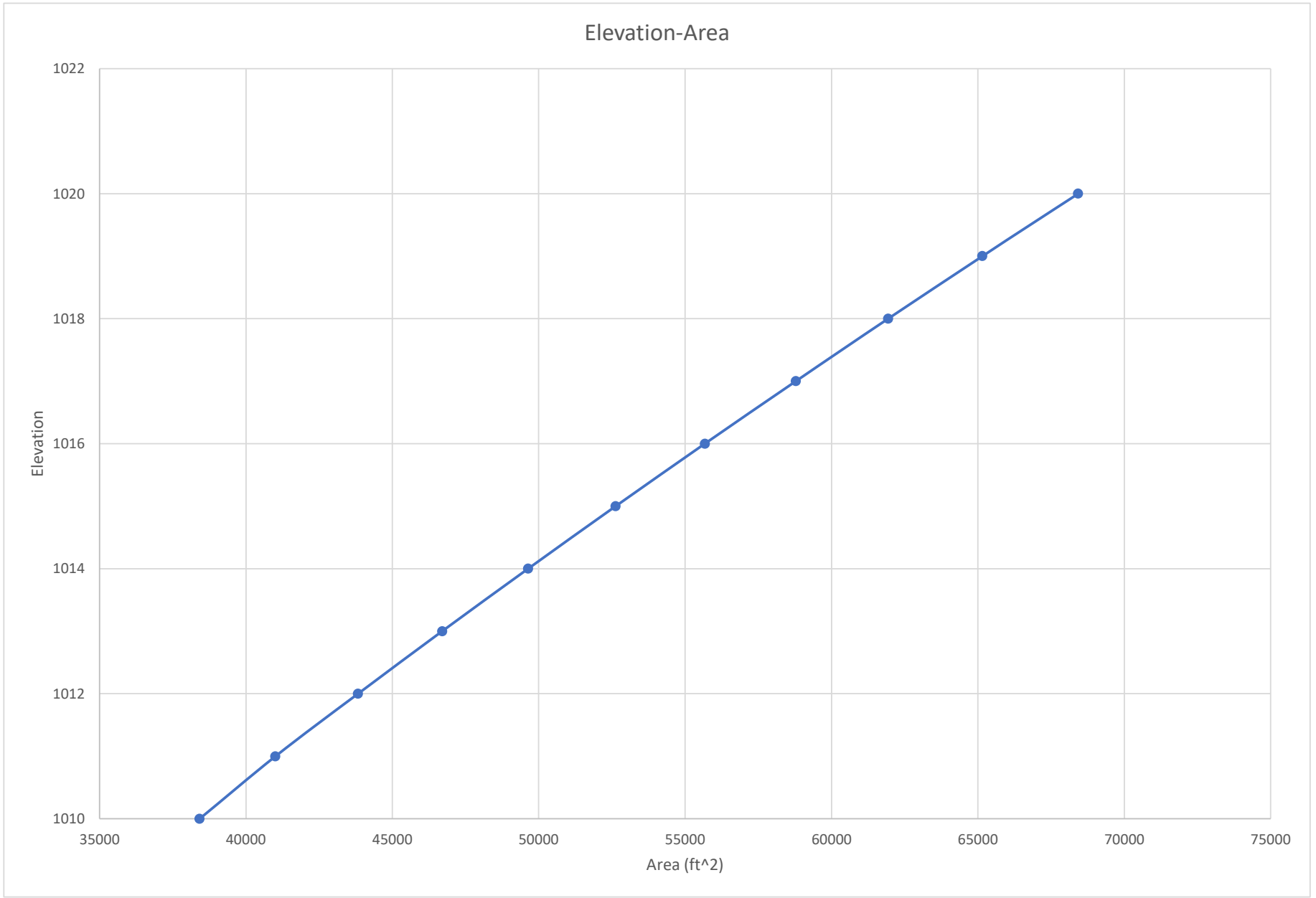
Hyd. No. 2

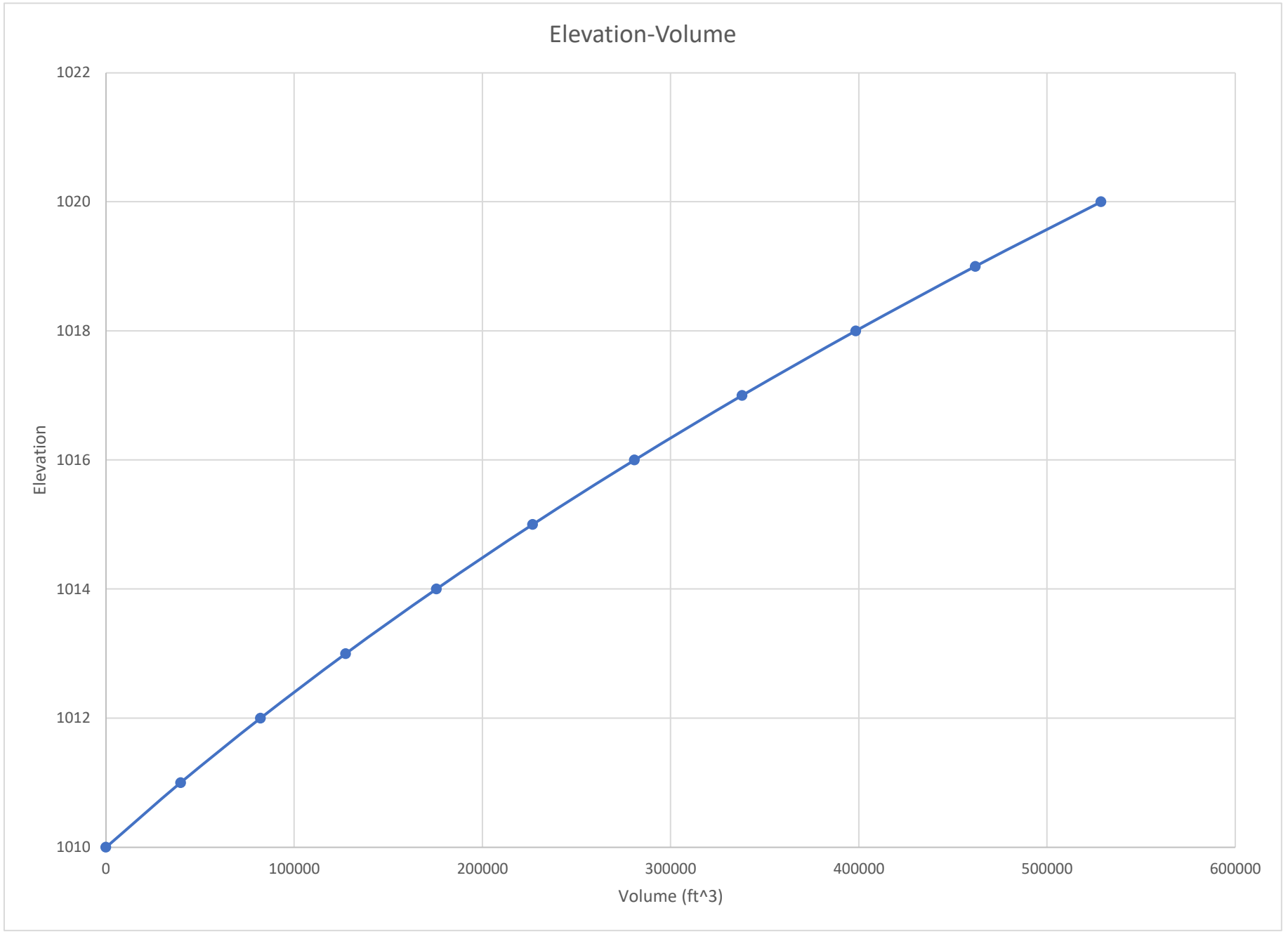
Proposed Area B1

Hydrograph type	= SCS Runoff	Peak discharge	= 222.56 cfs
Storm frequency	= 100 yrs	Time to peak	= 726 min
Time interval	= 2 min	Hyd. volume	= 801,846 cuft
Drainage area	= 33.540 ac	Curve number	= 88
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 21.30 min
Total precip.	= 7.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Detention Storage Information


Elevation-Area
1022
1020
1018
1016
1014
1012
1010
Elevation
35000
40000
45000
50000
55000
60000
65000
70000
75000
Area (ft^2)


Elevation-Volume
1022
1020
1018
1016
1014
1012
1010
Elevation
0
100000
200000
300000
400000
500000
600000
Volume (ft^3)

Outlet Structures Information

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Pond No. 1 - Detention

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	1010.00	38,421	0	0
1.00	1011.00	41,007	39,703	39,703
2.00	1012.00	43,827	42,405	82,108
3.00	1013.00	46,706	45,254	127,362
4.00	1014.00	49,638	48,160	175,522
5.00	1015.00	52,631	51,122	226,644
6.00	1016.00	55,675	54,141	280,785
7.00	1017.00	58,781	57,215	338,000
8.00	1018.00	61,937	60,346	398,346
9.00	1019.00	65,152	63,531	461,877
10.00	1020.00	68,424	66,775	528,652

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.00	36.00	4.50	Inactive
Span (in)	= 48.00	36.00	4.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 1010.01	1012.60	1010.02	0.00
Length (ft)	= 82.00	0.00	0.00	0.00
Slope (%)	= 0.00	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	Yes	Yes	No

Weir Structures

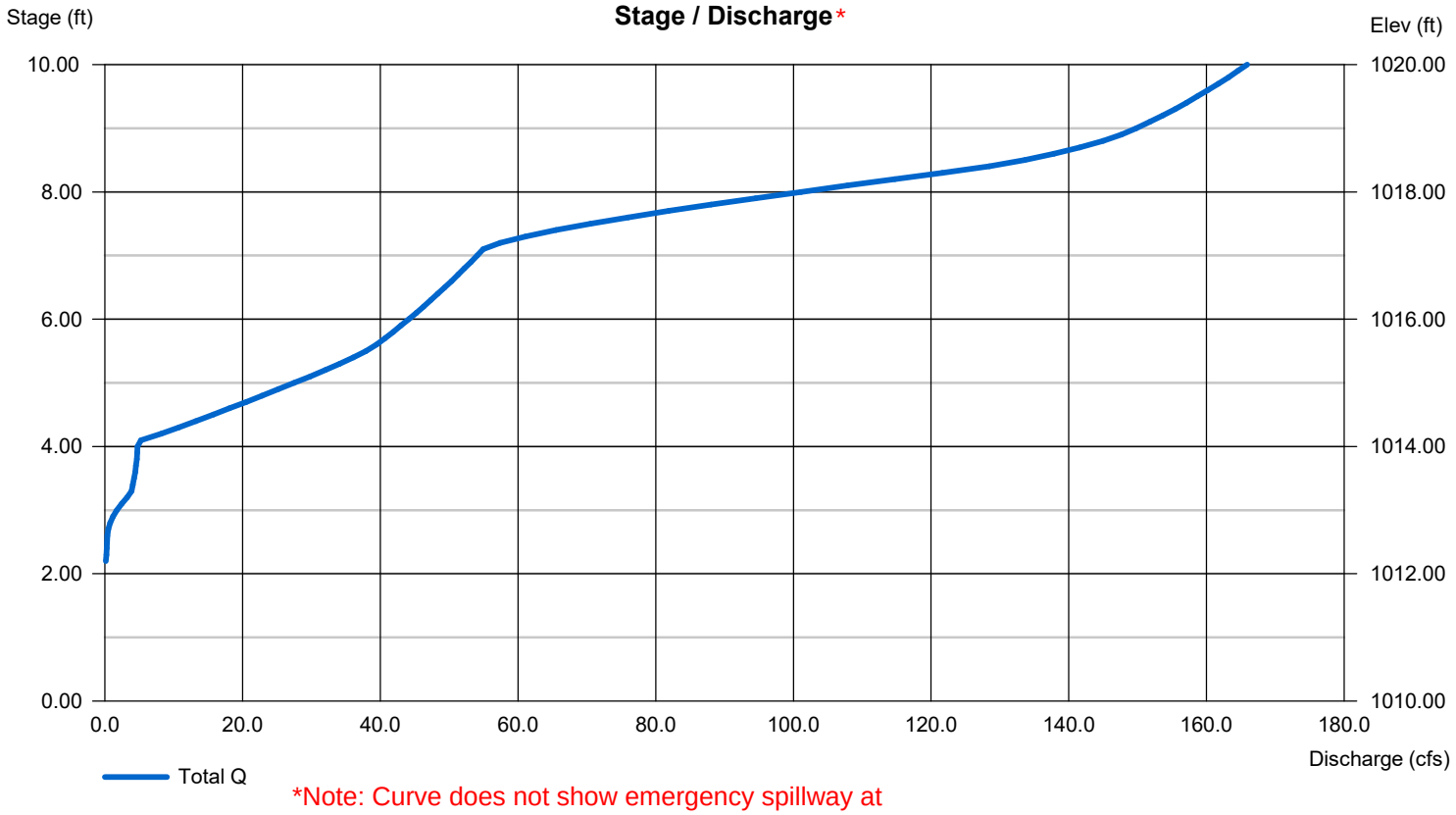
	[A]	[B]	[C]	[D]
Crest Len (ft)	= 20.00	Inactive	Inactive	Inactive
Crest El. (ft)	= 1017.10	0.00	0.00	0.00
Weir Coeff.	= 3.00	3.33	3.33	3.33
Weir Type	= Rect	Rect	Rect	---
Multi-Stage	= Yes	Yes	Yes	No

Exfil.(in/hr) = 0.000 (by Contour)

TW Elev. (ft) = 1012.16

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

Combined Outlet Structure (All Openings)



*Note: Curve does not show emergency spillway at 1018.4. Separate output attached.

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Pond No. 1 - Detention

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	1010.00	38,421	0	0
1.00	1011.00	41,007	39,703	39,703
2.00	1012.00	43,827	42,405	82,108
3.00	1013.00	46,706	45,254	127,362
4.00	1014.00	49,638	48,160	175,522
5.00	1015.00	52,631	51,122	226,644
6.00	1016.00	55,675	54,141	280,785
7.00	1017.00	58,781	57,215	338,000
8.00	1018.00	61,937	60,346	398,346
9.00	1019.00	65,152	63,531	461,877
10.00	1020.00	68,424	66,775	528,652

Culvert / Orifice Structures

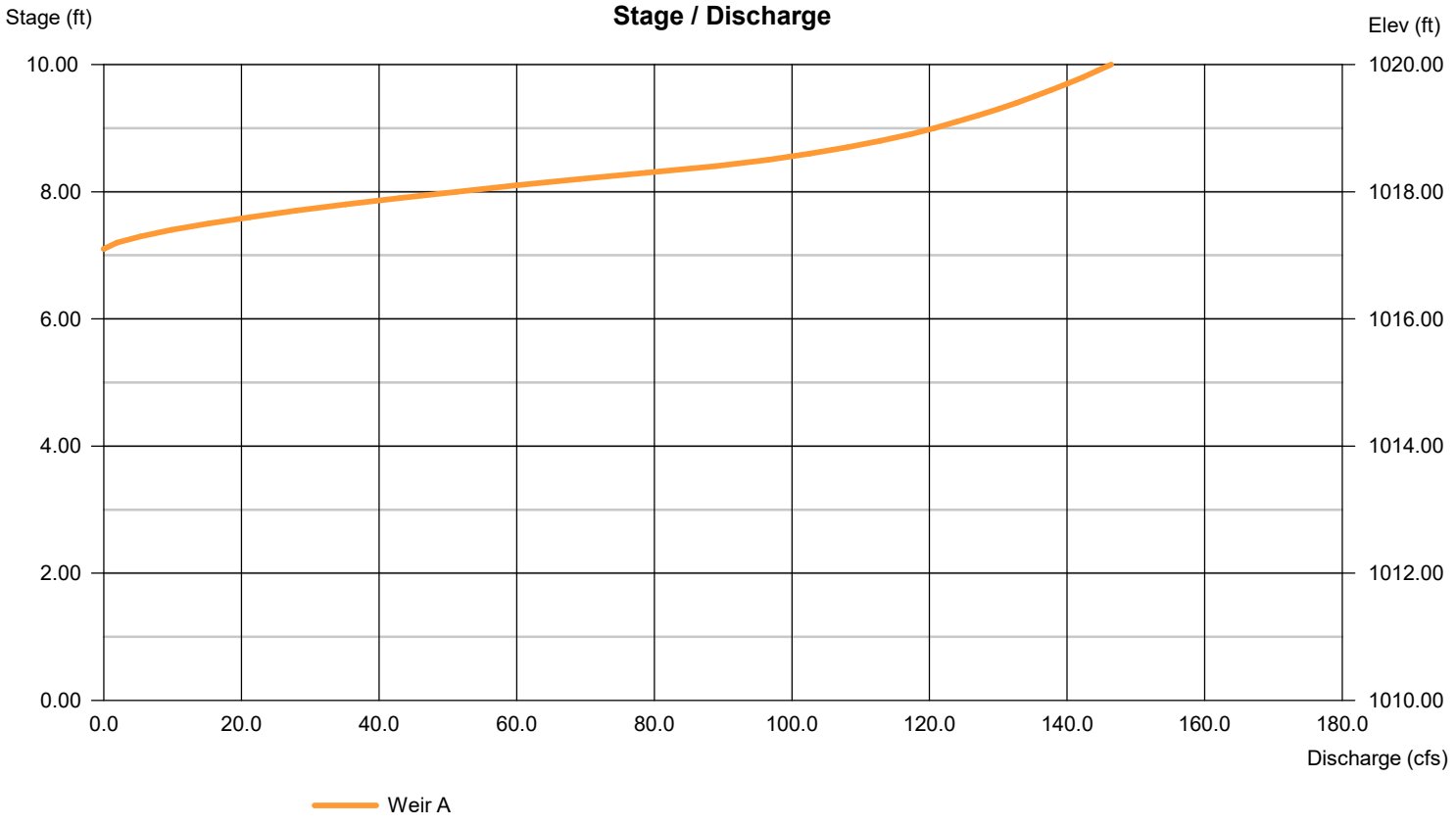
	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.00	36.00	4.50	Inactive
Span (in)	= 48.00	36.00	4.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 1010.01	1012.60	1010.02	0.00
Length (ft)	= 82.00	0.00	0.00	0.00
Slope (%)	= 0.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	Yes	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 20.00	Inactive	Inactive	Inactive
Crest El. (ft)	= 1017.10	0.00	0.00	0.00
Weir Coeff.	= 3.00	3.33	3.33	3.33
Weir Type	= Rect	Rect	Rect	---
Multi-Stage	= Yes	Yes	Yes	No
Exfil.(in/hr)	= 0.000 (by Contour)			
TW Elev. (ft)	= 1012.16			

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

5'x5' Open Top Concrete Box With Top Elevation 1017.1



Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Pond No. 1 - Detention

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	1010.00	38,421	0	0
1.00	1011.00	41,007	39,703	39,703
2.00	1012.00	43,827	42,405	82,108
3.00	1013.00	46,706	45,254	127,362
4.00	1014.00	49,638	48,160	175,522
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6.00	1016.00	55,675	54,141	280,785
7.00	1017.00	58,781	57,215	338,000
8.00	1018.00	61,937	60,346	398,346
9.00	1019.00	65,152	63,531	461,877
10.00	1020.00	68,424	66,775	528,652

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.00	36.00	4.50	Inactive
Span (in)	= 48.00	36.00	4.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 1010.01	1012.60	1010.02	0.00
Length (ft)	= 82.00	0.00	0.00	0.00
Slope (%)	= 0.00	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	Yes	Yes	No

Weir Structures

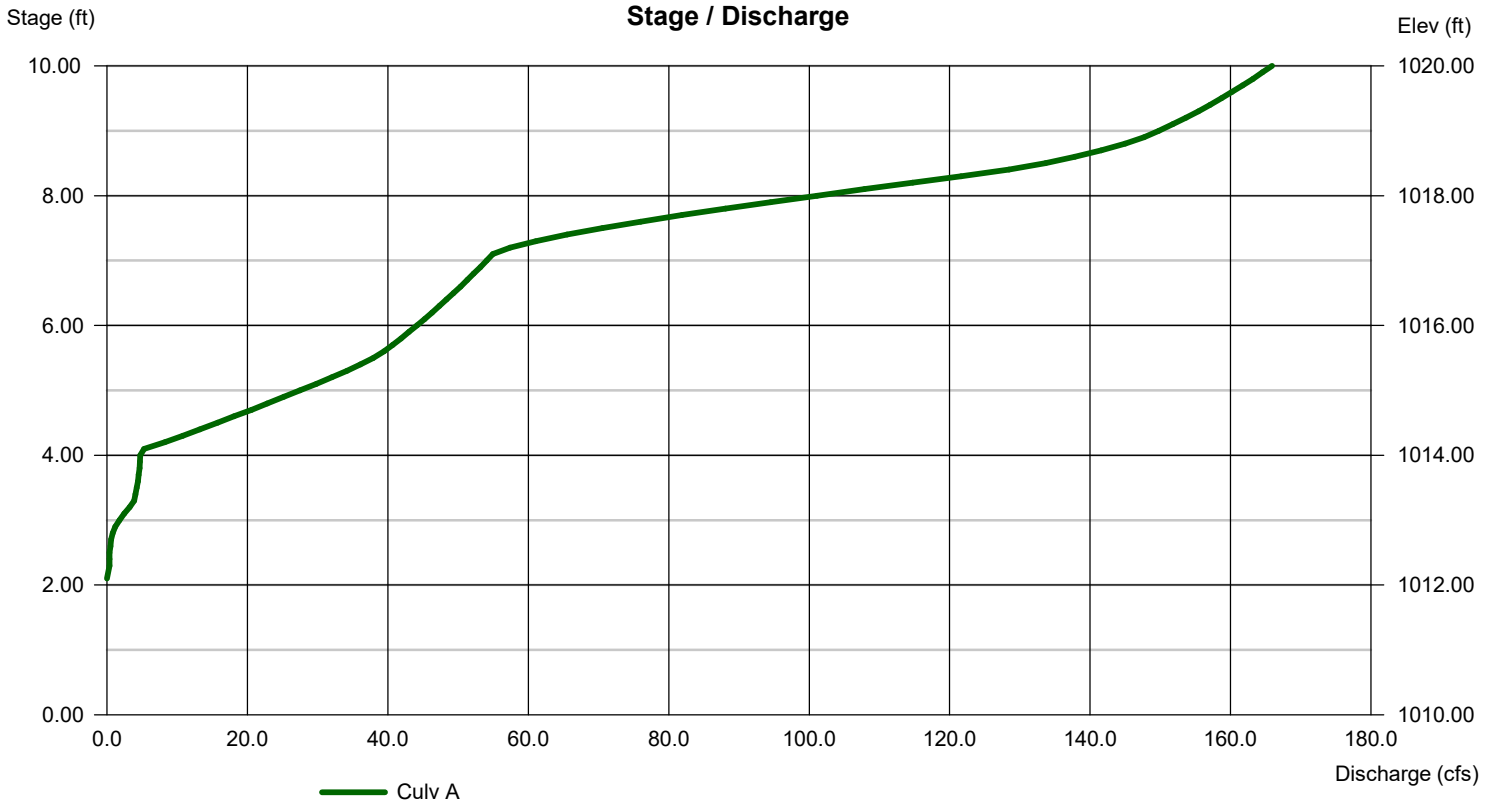
	[A]	[B]	[C]	[D]
Crest Len (ft)	= 20.00	Inactive	Inactive	Inactive
Crest El. (ft)	= 1017.10	0.00	0.00	0.00
Weir Coeff.	= 3.00	3.33	3.33	3.33
Weir Type	= Rect	Rect	Rect	---
Multi-Stage	= Yes	Yes	Yes	No

Exfil.(in/hr) = 0.000 (by Contour)

TW Elev. (ft) = 1012.16

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

48" RCP- Primary Outlet



Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Pond No. 1 - Detention

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	1010.00	38,421	0	0
1.00	1011.00	41,007	39,703	39,703
2.00	1012.00	43,827	42,405	82,108
3.00	1013.00	46,706	45,254	127,362
4.00	1014.00	49,638	48,160	175,522
5.00	1015.00	52,631	51,122	226,644
6.00	1016.00	55,675	54,141	280,785
7.00	1017.00	58,781	57,215	338,000
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9.00	1019.00	65,152	63,531	461,877
10.00	1020.00	68,424	66,775	528,652

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 48.00	36.00	4.50	Inactive
Span (in)	= 48.00	36.00	4.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 1010.01	1012.60	1010.02	0.00
Length (ft)	= 82.00	0.00	0.00	0.00
Slope (%)	= 0.00	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	Yes	Yes	No

Weir Structures

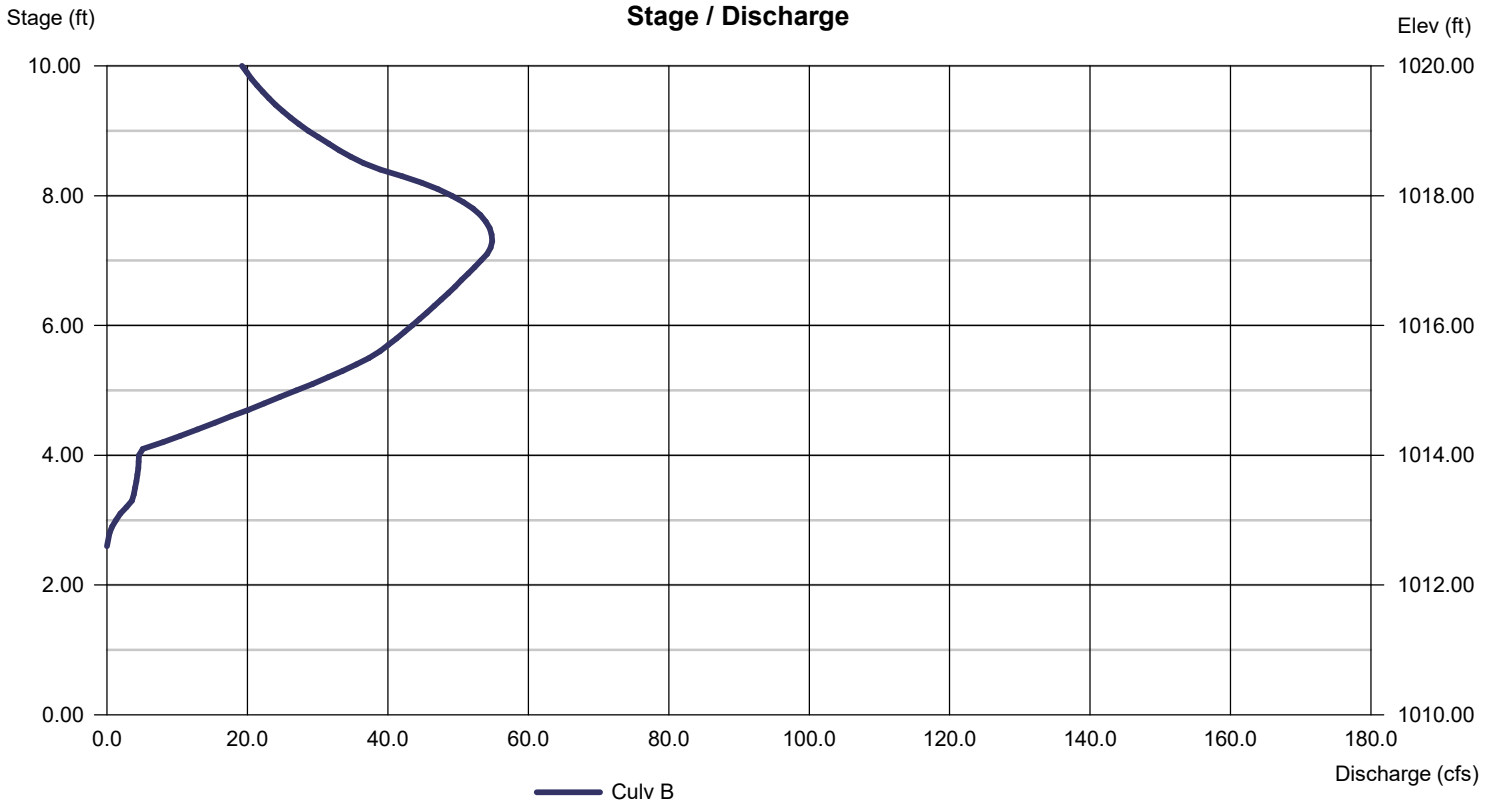
	[A]	[B]	[C]	[D]
Crest Len (ft)	= 20.00	Inactive	Inactive	Inactive
Crest El. (ft)	= 1017.10	0.00	0.00	0.00
Weir Coeff.	= 3.00	3.33	3.33	3.33
Weir Type	= Rect	Rect	Rect	---
Multi-Stage	= Yes	Yes	Yes	No

Exfil.(in/hr) = 0.000 (by Contour)

TW Elev. (ft) = 1012.16

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

36" Opening in Box at Elevation 1012.6



Weir Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Mar 2 2020

Osage Emergency Spillway

Rectangular Weir

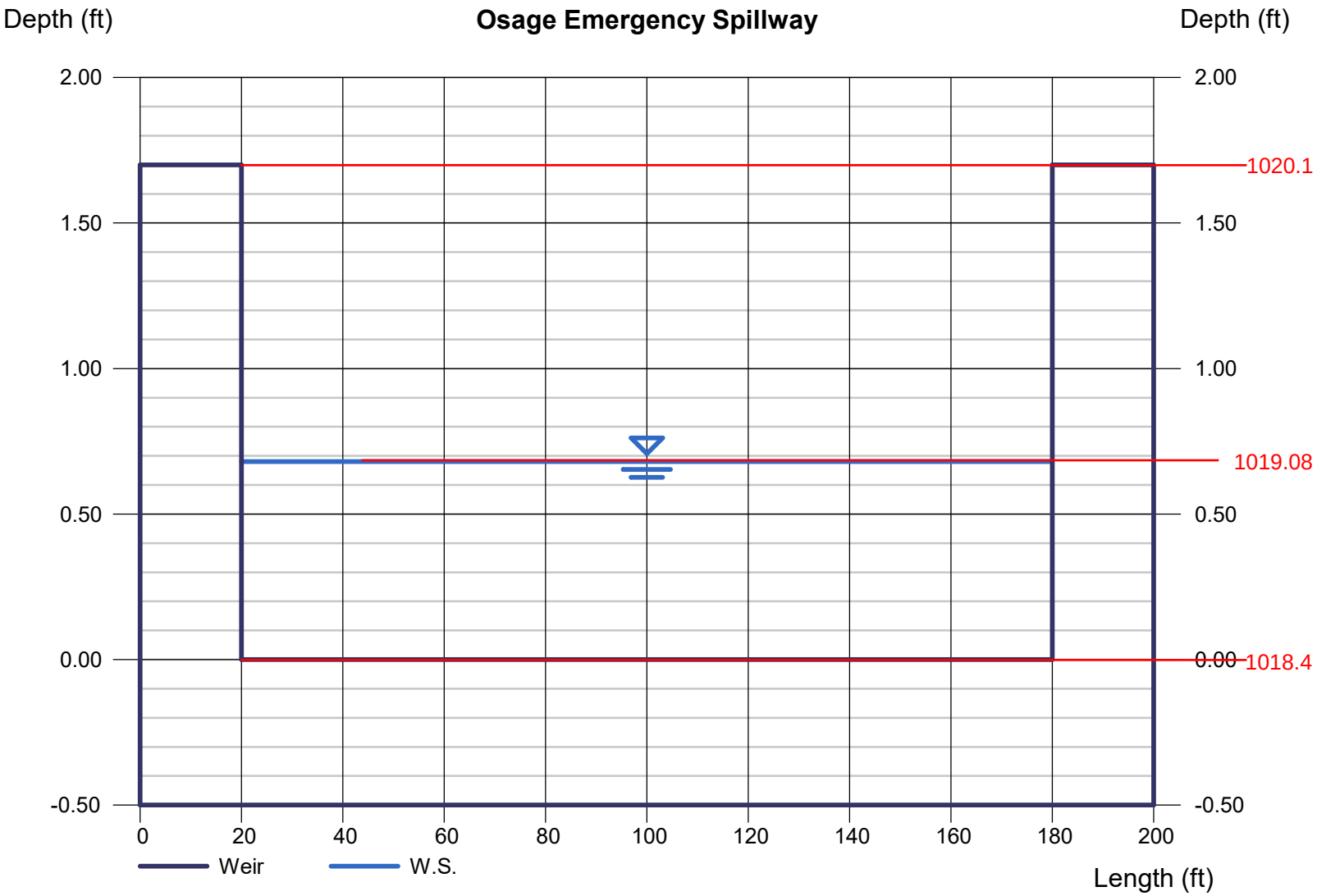
Crest	= Broad
Bottom Length (ft)	= 160.00
Total Depth (ft)	= 1.70

Calculations

Weir Coeff. Cw	= 2.60
Compute by:	Q vs Depth
No. Increments	= 50

Highlighted

Depth (ft)	= 0.68
Q (cfs)	= 233.27
Area (sqft)	= 108.80
Velocity (ft/s)	= 2.14
Top Width (ft)	= 160.00



Detention Discharge/Storage vs Time

Hydrograph Report

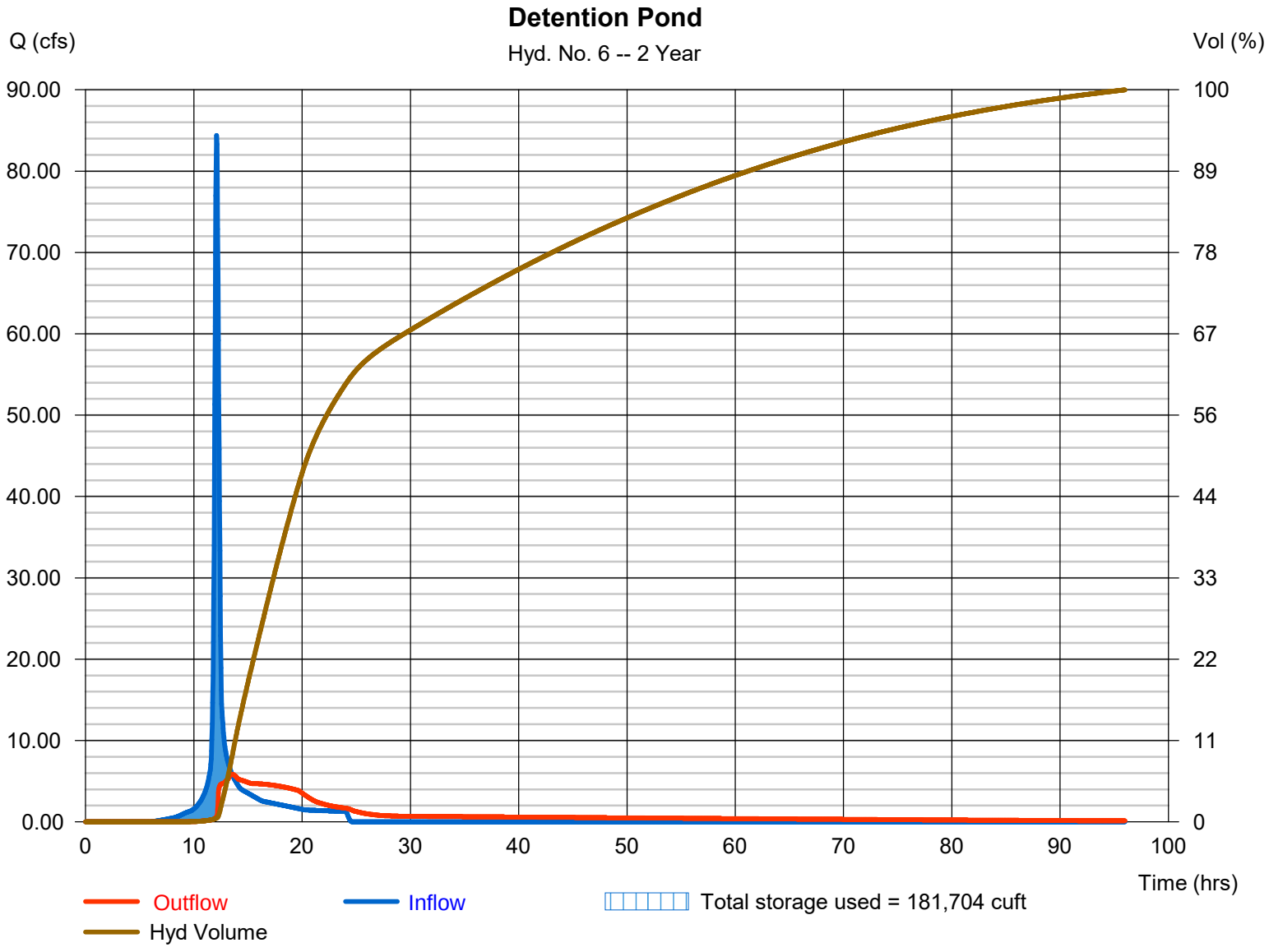
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Hyd. No. 6

Detention Pond

Hydrograph type	= Reservoir	Peak discharge	= 5.853 cfs
Storm frequency	= 2 yrs	Time to peak	= 13.53 hrs
Time interval	= 2 min	Hyd. volume	= 276,519 cuft
Inflow hyd. No.	= 2 - Proposed Area B1	Max. Elevation	= 1014.12 ft
Reservoir name	= Detention	Max. Storage	= 181,704 cuft

Storage Indication method used.



Hydrograph Report

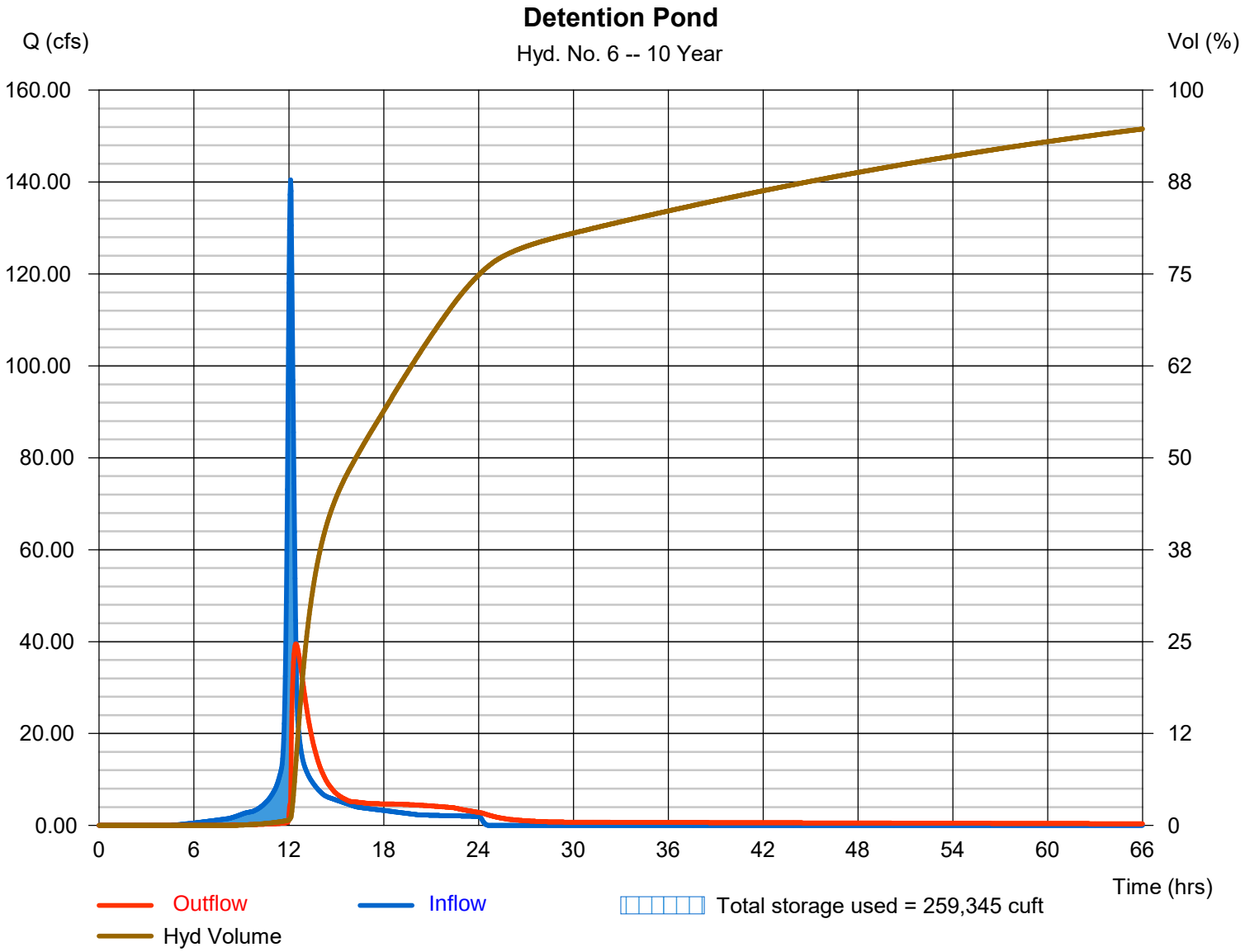
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Hyd. No. 6

Detention Pond

Hydrograph type	= Reservoir	Peak discharge	= 39.50 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.47 hrs
Time interval	= 2 min	Hyd. volume	= 478,332 cuft
Inflow hyd. No.	= 2 - Proposed Area B1	Max. Elevation	= 1015.60 ft
Reservoir name	= Detention	Max. Storage	= 259,345 cuft

Storage Indication method used.



Hydrograph Report

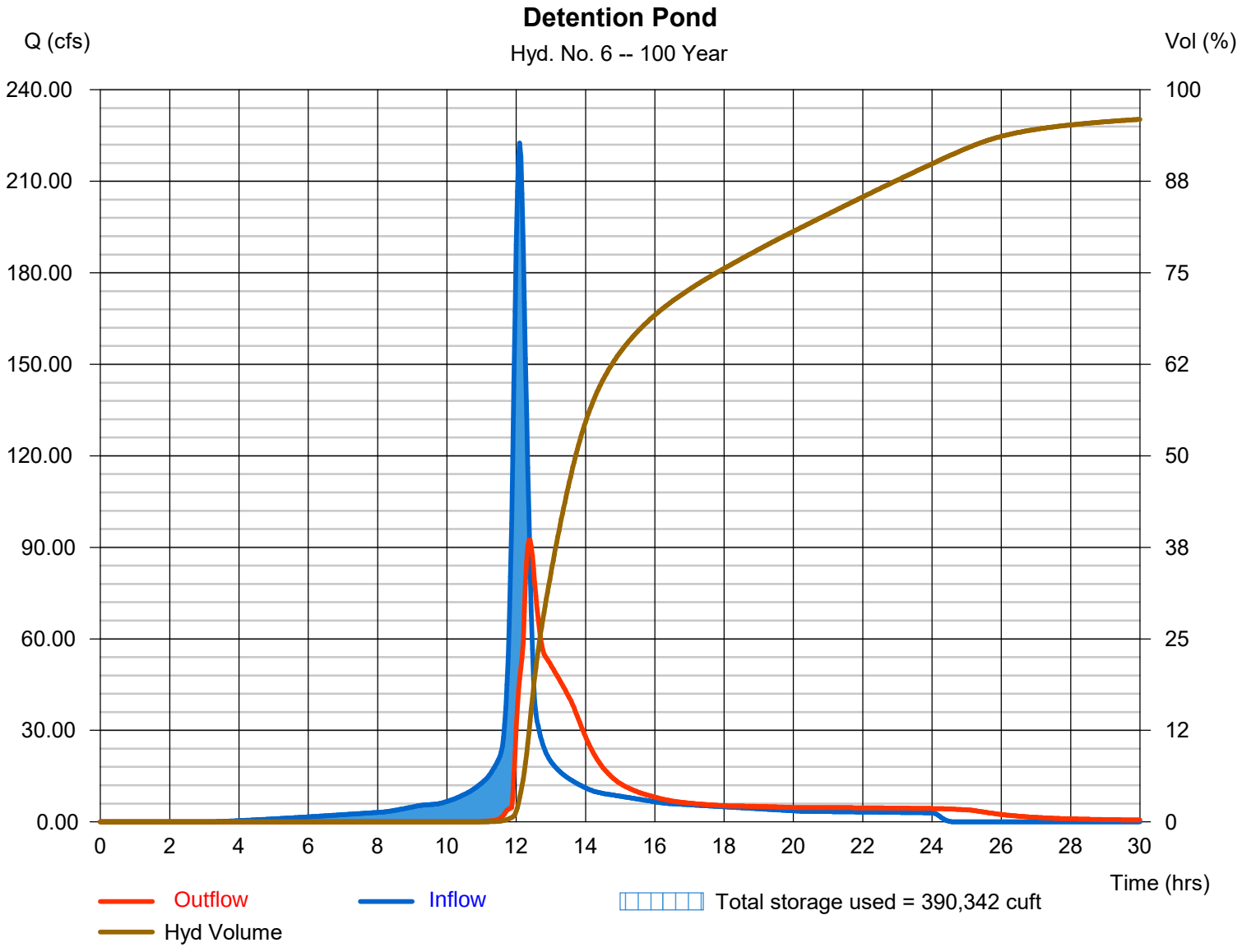
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Hyd. No. 6

Detention Pond

Hydrograph type	= Reservoir	Peak discharge	= 92.38 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.37 hrs
Time interval	= 2 min	Hyd. volume	= 715,056 cuft
Inflow hyd. No.	= 2 - Proposed Area B1	Max. Elevation	= 1017.87 ft
Reservoir name	= Detention	Max. Storage	= 390,342 cuft

Storage Indication method used.



Hydrograph Report

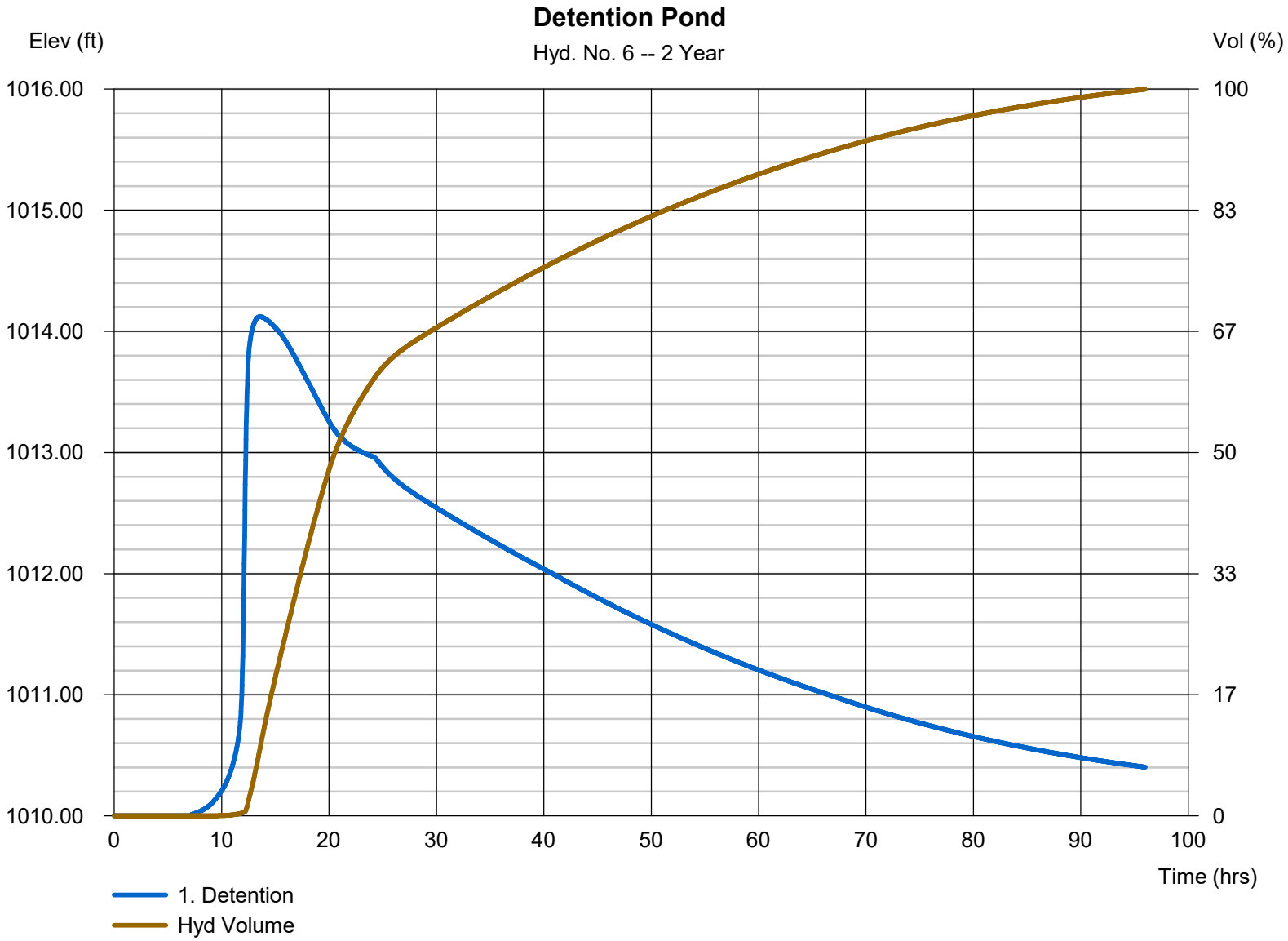
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Hyd. No. 6

Detention Pond

Hydrograph type	= Reservoir	Peak discharge	= 5.853 cfs
Storm frequency	= 2 yrs	Time to peak	= 13.53 hrs
Time interval	= 2 min	Hyd. volume	= 276,519 cuft
Inflow hyd. No.	= 2 - Proposed Area B1	Max. Elevation	= 1014.12 ft
Reservoir name	= Detention	Max. Storage	= 181,704 cuft

Storage Indication method used.



Hydrograph Report

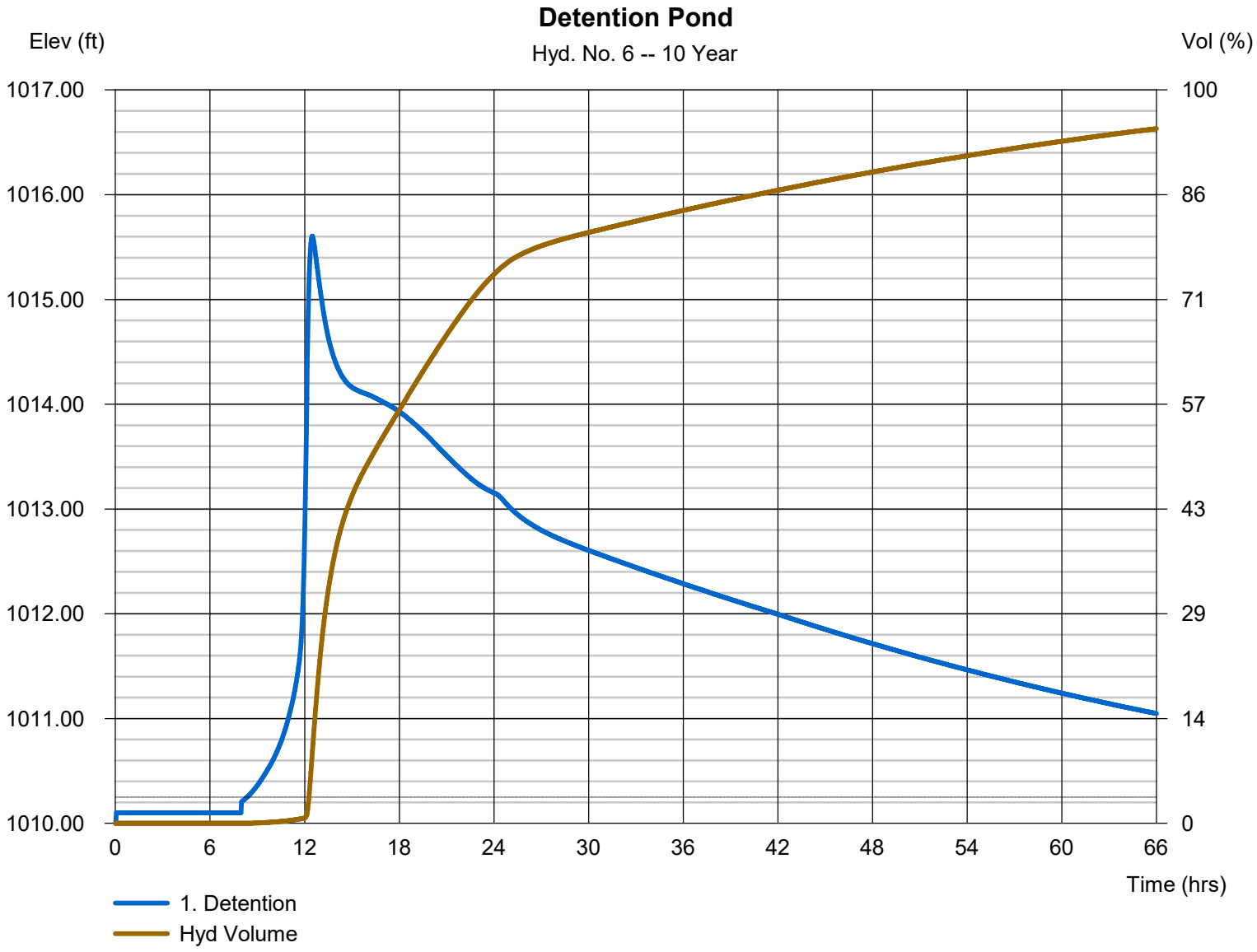
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Hyd. No. 6

Detention Pond

Hydrograph type	= Reservoir	Peak discharge	= 39.50 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.47 hrs
Time interval	= 2 min	Hyd. volume	= 478,332 cuft
Inflow hyd. No.	= 2 - Proposed Area B1	Max. Elevation	= 1015.60 ft
Reservoir name	= Detention	Max. Storage	= 259,345 cuft

Storage Indication method used.



Hydrograph Report

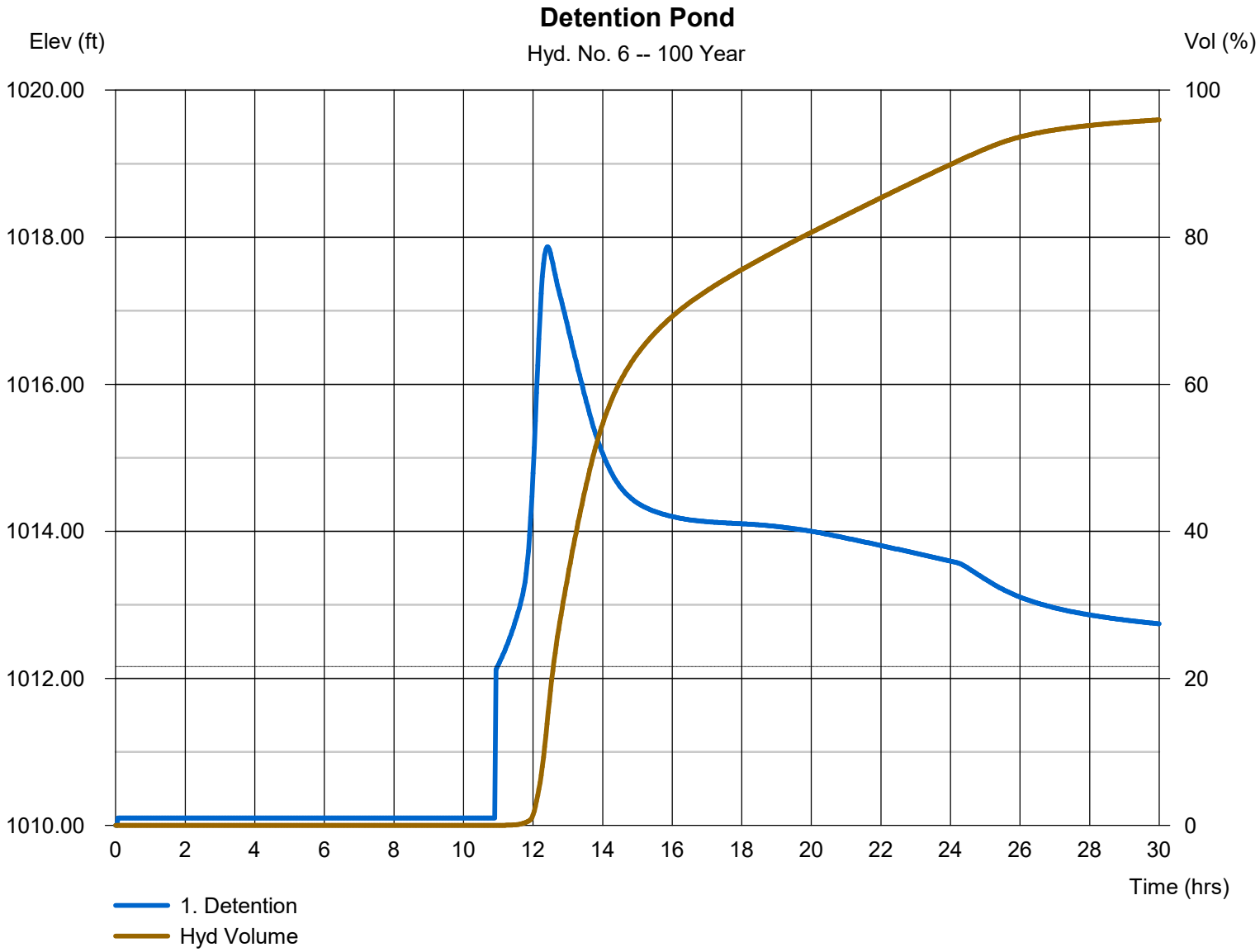
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

Hyd. No. 6

Detention Pond

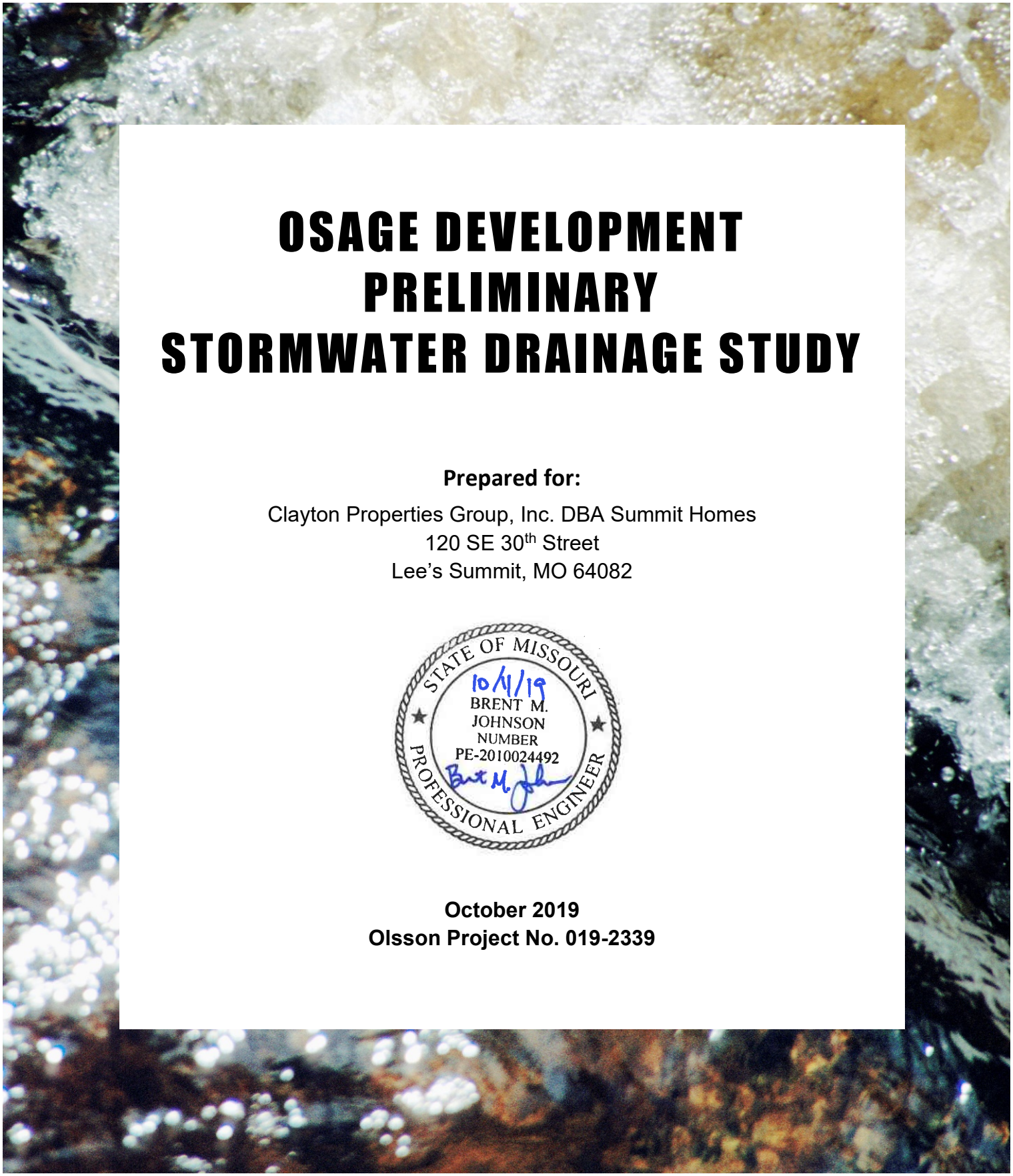
Hydrograph type	= Reservoir	Peak discharge	= 92.38 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.37 hrs
Time interval	= 2 min	Hyd. volume	= 715,056 cuft
Inflow hyd. No.	= 2 - Proposed Area B1	Max. Elevation	= 1017.87 ft
Reservoir name	= Detention	Max. Storage	= 390,342 cuft

Storage Indication method used.



APPENDIX F

Preliminary Stormwater Drainage Study



OSAGE DEVELOPMENT PRELIMINARY STORMWATER DRAINAGE STUDY

Prepared for:

Clayton Properties Group, Inc. DBA Summit Homes
120 SE 30th Street
Lee's Summit, MO 64082

STATE OF MISSOURI
10/1/19
BRENT M. JOHNSON
NUMBER
PE-2010024492
PROFESSIONAL ENGINEER

October 2019
Olsson Project No. 019-2339

olsson

TABLE OF CONTENTS

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APPENDICES

1.0 GENERAL INFORMATION

Osage is a proposed single-family residential development on approximately 36 acres, including a pool, amenity tract reserved for open space, and stormwater detention basin. This project is located in the southwest of the intersection of NW Pryor Road and Highway 150 in Lee's Summit, Missouri

Figure 1. Location Map

1.1 FEMA Floodplain Classification

FEMA Flood Boundary and Floodway Map Community Panel Number 29095C0531G classifies the Osage property as unshaded "Zone X" Area, which FEMA defines as an area of minimal flood hazard, usually above the 500-year flood level. See Exhibit 1—Floodplain Map in Appendix A for location of site in relation to FEMA flood boundaries.

1.2 Soil Classifications

Soil Maps published on the NRCS Web Soil Survey categorize soils on the Osage property as shown in Table 1. See Exhibit 2 in Appendix A for a map of soils on the property.

Table 1. Soil Classifications

Symbol	Name	Slopes	HSG
10082	Arisburg-Urban Land Complex	1-5%	C
10116	Sampsel Silty Clay Loam	2-5%	C/D
10117	Sampsel Silty Clay Loam	5-9%	C/D
10122	Sharpsburg Silt Loam	5-9%	C

2.0 METHODOLOGY

This drainage study has been prepared to evaluate the hydrologic impact generated by development of Osage. The base data for the models prepared for this report has been obtained from available online maps and aerial imagery. Stormwater management is based upon methods and objectives defined in “Kansas City Metropolitan Chapter American Public Works Association (KC-APWA) Section 5600 Storm Drainage Systems & Facilities” (2011).

The following methods were used in this study to model Existing and Proposed Conditions for stormwater runoff:

Hydraflow Hydrographs Extension Version 12

- SCS Unit Hydrograph Method
  - 2-year, 10-year and 100-year Return Frequency Storms
  - AMC II Soil Moisture Conditions
  - 24-Hour SCS Type II Rainfall Distribution
  - SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a – 2-2c)
  - SCS TR-55 methods for determination of Time of Concentration and Travel Time. Where specific data pertaining to channel geometry is not available, “Length & Velocity” estimates for channel flow Travel Time is utilized per Section 5600, KC-APWA Standard Specifications and Design Criteria.

Stormwater runoff models were created for the 2-, 10- and 100-year design storm events. The precipitation depths used in the analysis have been interpolated from the “Technical Paper No. 40 Rainfall Frequency Atlas of the United States” (TP-40) isopluvial maps (May 1961). The following table summarizes the rainfall depths used in this analysis:

Table 2. Precipitation Depths

Return Period	24-Hour Precipitation Depth (in.)
2-Year (50% Storm)	3.60
10-year (10% Storm)	5.34
100-Year (1% Storm)	7.90

3.0 EXISTING CONDITIONS

To quantify the effects of development of this project, the following areas and points of interest have been used for existing and proposed conditions analysis. See Exhibit 3—Existing Conditions Drainage Map in Appendix A.

Drainage Area A represents the area in the southwest corner of the site, which bypasses the proposed detention location. In existing conditions, drainage area A has an area of 5.16 acres.

Drainage Area B represents the majority of the site in both the existing and proposed conditions models, which drains to the southeast corner of the site. In existing conditions, drainage area B has an area of 28.57 acres.

Drainage Area C is located in the northwest corner of the site and drains north to Highway 150. In existing conditions, drainage area C has an area of 11.27 acres.

Three points of interest were chosen for comparison between existing and proposed conditions based on the three points of discharge from the site. These points can be found in both Exhibits 3 and 4 in Appendix A.

Point of Interest A1 represents the southwest corner of the site and compares drainage area A for both models.

Point of Interest B1 represents a point near the southeast corner of the site, just upstream of the triple 30-inch CMP culverts crossing NW Pryor Road. Discharge to this point was compared between drainage area B in the existing conditions model and drainage areas B1 and B2 in the proposed conditions model at the outlet of the detention basin. Drainage area B2 bypasses the basin; flows from drainage areas B1 and B2 were combined before comparison with Existing Conditions. See Exhibit—4 Proposed Conditions Drainage Map and Section 4.0 of this report for a more detailed discussion of the Proposed Conditions drainage areas.

Point of Interest C1 represents the northwest corner of the site and compares drainage area C for existing and proposed conditions.

Bypass Area A was included in the model to account for area that that does not pass through the site but drains to the culvert under NW Pryor Road near the southeast corner of the development. This area was included in the model to calculate tailwater elevations for the proposed detention basin.

The following tables summarize the results of the Existing Conditions analysis. The proposed conditions data is compared to these results in Sections 4 of this report. Refer to Appendix B for output and a schematic for the existing conditions model and detailed calculations for the time of concentration.

Curve Numbers were determined for existing and proposed conditions as shown in Table 3.

Table 3. Curve Numbers

Land Use	HSG*	CN
Straight Row Crop	C	85
Straight Row Crop	D	89
Multi-Family Residential	C	90
Multi-Family Residential	D	92
Pasture	C	79
Pasture	D	84
Paved Open Ditches with ROW	C	92
Paved Open Ditched with ROW	D	93

***Hydrologic Soil Group**

Table 4. Existing Conditions Area Data

Area Name	Onsite Area (ac.)	Offsite Area (ac.)	Total Area (ac.)	T_C (hr.)	Weighted CN
A	2.10	3.06	5.16	0.33	82
B	25.26	3.31	28.57	0.36	84
C	4.02	7.25	11.27	0.33	83
Bypass A	0	2.86	2.86	0.18	87

Table 5. Existing Conditions Point of Interest Peak Flow Rates

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	11.1	20.2	33.9
B1	61.8	109	179
C1	25.4	45.3	75.2

Per APWA Section 5608.4 and the City of Lee's Summit criteria, the performance criteria for comprehensive control is to provide detention to limit peak flow rates at downstream points of interest to maximum release rates:

- 50% storm peak rate less than or equal to 0.5 cfs per site acre
- 10% storm peak rate less than or equal to 2.0 cfs per site acre
- 1% storm peak rate less than or equal to 3.0 cfs per site acre

Extended detention of the 90% mean annual event is also required for comprehensive control per APWA Section 5608.4.

Allowable release rates were calculated for the points of interest, allowing that offsite peak discharges would be permitted to bypass the detention. Offsite bypass peak flow rates were calculated as a percentage of the existing conditions, relating to the percentage of offsite area flowing to each point. The release rates for the proposed development on the development site were calculated based on the detention criteria. The development release rates were added to the bypass peak flow rates to calculate an allowable peak flow rate for each point of interest as follows.

Table 6. Point of Interest Onsite Area

Point of Interest	Total Area (ac)	Onsite Area (ac)	Percent Onsite
A1	5.16	2.10	40.7%
B1	28.57	25.26	88.4%
C1	11.27	4.02	35.7%

Table 7. Allowable Peak Flow Rates

Point of Interest	Allowable 2-Year Q (cfs)	Allowable 10-Year Q (cfs)	Allowable 100-Year Q (cfs)
A1	7.6	16.0	26.1
B1	19.8	63.2	96.5
C1	18.3	37.1	60.3

4.0 PROPOSED CONDITIONS

4.1 Effects of Development

The proposed conditions analysis assumes completion of the entire Osage development. The modeled subareas and points of interest are similar to the existing conditions model. However, throughout the site, some shifting of ridgelines will occur accommodating proposed detention facilities and anticipated grading activities, which will change the relative areas draining to each point of interest. The following is a summary of the proposed conditions drainage areas, see Exhibit 4—Proposed Conditions Drainage Map in Appendix A.

Drainage Area A in proposed conditions has an area of 0.43 acres. Proposed grading shifts 4.72 acres from drainage area A to drainage area B1.

Drainage Area B1 in proposed conditions has an area is 33.54 acres and will drain to the proposed detention basin. Drainage area from existing conditions is shifted from drainage areas A and C to area B1.

Drainage Area B2 was previously part of drainage area B in existing conditions. This area was separated in the proposed conditions model because it bypasses the detention basin. For

consistency, the sum of drainage areas B1 and B2 were compared at the same point of interest as drainage area B in existing conditions. Drainage Area B2 has an area of 2.73 acres.

Drainage Area C in proposed conditions has a drainage area of 8.30 acres. Proposed grading shifts area from drainage area C to drainage area B1.

The analysis provided in Section 3 established existing conditions of the development's drainage areas and analysis in this section will provide guidance for configuration of detention basin to meet the objectives established in Section 3.

The following tables summarize the results of the proposed conditions analysis. Tables 9 and 10 assume no detention is provided, to demonstrate the effects of development for each drainage area. Refer to Appendix C for output from and a schematic of the proposed conditions Hydraflow Hydrographs model.

Table 8. Proposed Conditions Area Data

Area Name	Area (ac.)	T_C (hr.)	Weighted CN
A	0.43	0.10	91
B1	33.54	0.35	88
B2	2.73	0.10	90
C	8.30	0.32	86
Bypass A	2.86	0.18	87

Table 9. Proposed (No Detention) Conditions Point of Interest Peak Flow Rates

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	1.7	2.8	4.3
B1	91.6	152.0	240.0
C1	21.0	35.9	57.9

The following table compares the results of the proposed conditions analysis to the existing conditions from Section 3 at the points of interest. Negative values indicate a reduction in peak flow rate, while positive values indicate an increase. Without detention, flow rates will increase at point B1, but decrease for A1 and C1. The decrease in flow rates at A1 and C1 is due to the proposed changes in grading, which shifts parts of each of these areas to drainage area B1.

Table 10. Proposed (No Detention) vs. Existing Conditions

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	-9.4	-17.4	-29.6
B1	29.8	43.0	61.0
C1	-4.4	-9.4	-17.3

4.2 Proposed Detention Facilities

To mitigate the increases in peak flows shown in the previous table and where possible, decrease further to the allowable release rates established in Section 3, detention will be provided for drainage area B1.

The detention facility was placed to capture most of the site runoff and to mitigate increases in peak discharge from the site. The detention facility will be located near the southeast corner of the site and will meet of the requirements outlined in Section 3. It will contain a multistage outlet structure and an independent 160-ft long broad crested weir graded into the east side of the berm. The following points summarize the multistage outlet structure and the emergency spillway:

- The structure itself will be a 5'x5' open-top concrete box with a top elevation of 1017.1, which generally controls the 100-year discharge.
- A 36'' opening is present in the box at an elevation of 1012.6, which generally controls the 10-year and 100-year discharge.
- A 4.5'' orifice is present in the box at the bottom elevation of the pond- 1010.0. This helps control the 90% mean annual storm event. The 2-year discharge is controlled by a combination of the 4.5'' orifice and the 36'' opening.
- The entire structure outlets to a 48'' RCP, which carries the water to Pryor Road.
- The emergency spillway will consist of a 160-ft long broad crested weir set at an elevation of 1018.4.

A 4.5-inch orifice will be set at the bottom of the multi-stage outlet structure to comply with the KC-APWA requirement for 40-hour release of the 90% mean annual event. The total inflow volume from this event is 2.09 acre-feet for this site. This will be released over 40 hours at a rate of 0.63 cfs.

Table 11 includes a summary of the Proposed Detention Facility

Due to constrictions in lot grading, site size limitations, and the relatively small drainage area detention is not planned for drainage area C. The drainage area to this point is reduced from existing conditions with proposed grading. As a result, the peak discharge rates for the 2-, 10-, and 100-year storms are below the existing values shown in Table 5. Table 10 illustrates these reductions. For point C1, the peak discharge values meet the allowable release rates for the 10-year and 100-year storm but exceed the KC-APWA 5600 allowable release rates of 0.5 cfs per

acre for the 2-year storm. A comparison with allowable release rates can be seen in Table 13. To achieve these release rates at point C-1, a small detention facility would need to be placed in the northwest corner of the site. The benefit of installing this detention facility in order to reduce the 2-year peak discharge value by 3.0 cfs is outweighed by the impact the facility would have on the feasibility of the development, especially considering the substantial reduction in peak discharge values already achieved when compared to existing conditions. As such, a waiver is requested for the 2-year storm for point C-1.

Table 11. Proposed Conditions Detention Flow and Volume Data

	Peak Q In (cfs)	TP In (hr)	Peak Q Out (cfs)	TP Out (hr)	Peak W.S.E. (ft)	Stored Volume (ac-ft)
2-Year	84.4	12.10	5.9	13.53	1014.12	4.2
10-Year	141.0	12.10	39.5	12.47	1015.61	6.0
100-Year	223.0	12.10	92.4	12.37	1017.87	9.0

4.3 Effects of Proposed Detention

The following tables compares the results of the proposed conditions analysis with the detention described above to the existing conditions from Section 3 at the points of interest. In Table 13, negative values indicate a reduction in peak flows, while positive values indicate an increase.

Table 12. Proposed (with Detention) Point of Interest Peak Flow Rates

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	1.7	2.8	4.3
B1	10.3	41.4	95.7
C1	21.3	35.9	57.9

Table 13. Proposed (with Detention) vs. Allowable Release Rates

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	-5.9	-13.2	-21.8
B1	-9.5	-21.8	-0.9
C1	3.0	-1.2	-2.4

Table 14. Proposed (with Detention) vs. Existing Conditions

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	-9.4	-17.4	-29.6
B1	-51.5	-67.6	-83.3
C1	-4.1	-9.4	-17.3

5.0 SUMMARY

This stormwater drainage study was prepared to evaluate the hydrologic impact generated by the development of Osage and to provide recommendations for a comprehensive stormwater management plan. The project is a single-family residential development on approximately 36 acres, including a pool and amenity tract and open space which will be reserved for detention.

Increases in peak flow rates caused by development will be mitigated for all points of discharge through the site through a combination of dry detention and drainage area changes.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This proposed stormwater management plan was designed to achieve compliance with current design criteria in effect for the City of Lee's Summit, Missouri; however, a waiver is requested at point of interest C1 for the 2-year storm. A final macro and first plat micro stormwater drainage study will be required with submittal of the first plat of this development.

The results of the analysis demonstrate that the proposed stormwater management plan for the project achieves compliance with design criteria, including extended detention of the 90% mean annual event, along with the requested waiver for drainage area C. We therefore request approval of this Osage Stormwater Drainage Study. This approval is conditional and should be substantiated with each future plat of Osage.

Osage Development Final/First Plat Micro Stormwater Drainage Study

Lee's Summit, Missouri - 2020

March 2020

Olsson Project No. A19--2339