

**(AS-BUILT)**  
**MACRO STORM WATER DRAINAGE STUDY**

**NAPA VALLEY 2ND PLAT**  
**SITE ACREAGE: 48.11 ACRES**

**Lee's Summit, MO**

***PREPARED ON:***  
***July 8, 2020***

***PREPARED BY:***



**Revision**

Date	Comment	By
7-28-20	Revised Per City Comments Dated 7-22-20	AEP
3-12-21	As-Built Study	AEP
5-20-21	Rev. As-Built Study	AEP

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Matthew J. Schlicht, PE

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### **3. GENERAL INFORMATION**

Napa Valley is an existing single family residential subdivision comprised of multiple phases, either planned or constructed. The development is located east of SW Pryor Road approximately 1,400 feet south of 150 Highway. The 4<sup>th</sup> phase is the latest in the development and is under construction. The Developer would like to convert the existing detention basin to a retention basin to provide an additional site amenity for the residents. The purpose of this report is to analyze both existing and proposed conditions for the site and determine the improvements necessary to convert the existing detention basin into a retention basin under current regulations. For clarity the originally approved storm drainage report is being rewritten in its entirety to accommodate the current regulatory framework helping ensure compliance. The original approved report may be found in Exhibit A for reference. The original report was approved prior to construction of the 2<sup>nd</sup> phase and included all developable property for the master development excluding the existing 1<sup>st</sup> phase. This report includes the same property scope as the original. The site is located in Section 36, Township 48N, Range 22W, Lee's Summit, Jackson County, Missouri.

See Exhibit B for an aerial image of the proposed project site along with an aerial image of the surrounding area. As shown in the aerial photos Napa Valley has developed significantly since initial approval.

#### **3.1 FEMA FLOODPLAIN DETERMINATION**

The property is located in an Area of Minimal Flood Hazard, Zone X, according to FEMA Firm Map Number 29095C0531G, effective January 20, 2017.

See Exhibit C for a FIRMette which includes the proposed project site.

#### **3.2 NRCS SOIL CLASSIFICATION**

Soil classifications published by the United States Department of Agriculture/National Resources Conservation Service (USDA/NRCS) website for Jackson County, Missouri, Version 20, September 16, 2019. The existing site contains three major soil types:

10000	Arisburg Silt Loam, 1 to 5 Percent Slopes Hydrologic Soils Group (HSG): Type C
10116	Sampsel Silty Clay Loam, 2 to 5 Percent Slopes (HSG): Type C/D
10117	Sampsel Silty Clay Loam, 5 to 9 Percent Slopes (HSG): Type C/D

See Exhibit D for a detailed soils report of the proposed project site.

### **4. METHODOLOGY**

This Macro Storm Drainage Study has been prepared to evaluate potential hydrologic impacts from the proposed development and recommend improvements to eliminate potential negative impacts. The study utilized existing city contours to create the Pre-Development Drainage Area Map. The study conforms to the requirements of the City of Lee's Summit, Missouri "Design and Construction Manual" and all applicable codes and criteria referred to therein.



Using the above criteria, the proposed site was evaluated using the Soil Conservation Service, SCS TR-55 method to calculate storm runoff volumes, peak rates of discharge, pre and post developed hydrographs and required storage volumes for detention facilities. TR-55 was first introduced in 1975 by the SCS particularly for small urbanizing watersheds. The analysis contains results for the 1, 2, 10 and 100-year design storms. The 1-year storm is equal to 1.37" which equates to the water quality storm event per the MARC BMP Manual.

Hydraflow Hydrographs Extension for AutoCAD Civil 3D was utilized to model the various SCS TR-55 stormwater rainfall runoff events. The following SCS TR-55 Unit Hydrograph variables were utilized;

- AMC II Soil Moisture Conditions
- 24-Hour SCS Type II Rainfall Distribution (Shape Factor 484)
- SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a to 2-2c)

Time of Concentration has been calculated using the following formulas:

- Sheet Flow (Max. 100 LF): SCS TR-55 Travel Time,  $T_t = 0.007 \times (n * L)^{0.8} / (P_2^{0.5} * S^{0.4} * 60)$
- Shallow Concentrated Flow: SCS TR-55 Appendix F:
 

Unpaved	$V = 16.1345(S)^{0.5}$
Paved	$V = 20.3282(S)^{0.5}$

Shallow Concentrated Travel Time (min): SCS TR-55 Eq-3-1,  $T_t = L / V \times 60$

- Channel Flow Improved: Manning's Equation (Full Flow)
- Channel Flow Unimproved: APWA 5602.7.A. Travel Time, Table 5602-6

<u>Avg. Channel Slope (%)</u>	<u>Velocity (fps)</u>
< 2	7
2 to 5	10
>5	15

## 5. EXISTING CONDITIONS ANALYSIS

The pre-developed site consisted entirely of grass and wooded areas. Based on the site cover and the hydrologic soil group of the soils the more restrictive Group D soil was used to determine the appropriate curve numbers for both pre and post development. An existing condition curve number of 82 was selected from the MARC BMP Manual for grass and wooded areas fair condition. The property of interest contains three sub-basins referred to as NW, SW and E for the purposes of this report. Each Sub-basin drains to a Point of Interest which corresponds to its given sub-basin name, i.e., Sub-basin NW drains to Point of Interest NW. The NW sub-basin is oblong in geometry and drains via both sheet and shallow concentrated flow to the north where it is intercepted by an existing street for further conveyance downstream. The runoff is conveyed to the east via a creek identified as Tributary G2 to Raintree Lake. The property is located in the Middle Big Creek watershed. All runoff from the property is tributary to Raintree Lake. The Pre-Development Drainage Area Map is located in Exhibit E. Following is a brief description of each existing sub-basin.

**Sub-basin NW** is generally located in the northwest corner of the property and drains to the north via both sheet and shallow concentrated flow. The sub-basin is oblong in geometry and runoff generated from it is intercepted by an existing east/west street constructed in Phase I. POI NW consists of its northern boundary due to its flow characteristics, not a singular point. It is then collected by an enclosed storm sewer system and released to the creek which flows through the northwest portion of the Phase I development. The runoff is conveyed to the east via a creek identified as Tributary G2 to Raintree Lake. Runoff from this sub-basin combines with runoff from the East Sub-basin on the east side of the property for further conveyance downstream. The sub-basin consists of 4.08 acres.

**Sub-basin SW** is generally located in the southwest corner of the property and drains to an unnamed creek which is tributary to the neighboring pond to the south. The discharge point is labeled as Point SW. The sub-basin consists of 7.55 acres. Excess runoff from this sub-basin eventually drains to Raintree Lake.

**Sub-basin E** is by far the largest sub-basin on the property consisting of 36.49 acres. The sub-basin is generally located in the central and eastern portions of the property and discharges to the east via sheet, shallow concentrated and channel flow to Tributary G2 to Raintree Lake. The discharge point is located on the eastern property boundary and has been labeled as Point E.

The following tables summarize the results of the Existing Conditions analysis. A complete breakdown of TR-55 unit hydrographs may be found in Exhibit F.

Table 5-1 Existing Conditions Sub-basin Data

Sub-basin	Area (ac.)	Composite CN	Tc (min.)
NW	4.08	82	8.7
SW	7.55	82	12.1
E	36.49	82	19.2

Table 5-2 Existing Conditions Sub-basin/Point of Interest Peak Discharge Rates

Sub-basin	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
NW	11.67	21.04	35.12
SW	19.04	34.45	57.64
E	75.52	137.68	231.61

Per APWA 5608.4 and City of Lee's Summit criteria, post development peak discharge rates from the site shall not exceed those indicated below:

- 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

Allowable release rates are comprised of a combination of allowable onsite post development peak flows and onsite undeveloped peak flows at each point of interest. The area ratio method will be used to determine allowable release rates as applicable.

Allowable Release Example Calculation Sub-basin E (2-Yr):  $(8.56 / 36.49) \times 75.52 + (36.49 - 8.56) \times 0.5 = 31.68 \text{ cfs}$

Table 5-3 Existing Conditions APWA Allowable Peak Discharge Release Rates

Sub-basin	Total Onsite Area (ac.)	Undeveloped Onsite Area (ac.)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
NW	4.08	0	2.04	8.16	12.24
SW	7.55	0	3.78	15.10	22.65
E	36.49	8.56	31.68	88.16	138.12

Undeveloped onsite area consists of 7.64 acres adjacent to Tributary G1 to Raintree Lake located on the east side of the property that will not be developed in addition to 0.92 acres tributary to the retention system from Phase I totaling 8.56 acres that may be released per the existing conditions analysis.

## 6. PROPOSED CONDITIONS ANALYSIS

The proposed conditions analysis consists of three sub-basins which are the same as the existing NW, SW and E. All three sub-basins will either be fully or partially developed with single family residential lots. Based upon the MARC BMP Manual ¼ acre residential lots in a Group D soil should utilize a curve number of 87 for analysis. All three sub-basins have been modified based upon the proposed development layout. The NW sub-basin contains 4.33 acres and will be fully developed. Runoff from the NW sub-basin will be collected by an enclosed storm sewer system and conveyed downstream via Tributary G1 to Raintree Lake. These improvements were approved with the 4<sup>th</sup> Plat of the development. The improvements have been constructed and no issues have been reported to date. The SW sub-basin contains 2.35 acres and will be fully developed. Runoff will be conveyed by sheet flow to POI SW. The E sub-basin is the largest containing 40.47 acres of which 0.92 acres contribute from Phase I. The E sub-basin currently contains the existing detention basin. The E sub-basin will be partially developed. The retention basin will be located in a 4.89 acre green space and 7.64 acres adjacent to the creek on the eastern boundary of the property will not be developed. A 4.09 acre tract on the east side of the development will not be detained. The main objective of the report is to determine the necessary improvements to convert the existing detention basin into a retention pond while ensuring regulatory compliance. If regulatory compliance is achieved it is anticipated that no negative impacts will be realized downstream.

The Post-Development Drainage Area Map is located in Exhibit I. Select as-builts from both the 2<sup>nd</sup> and 3<sup>rd</sup> plats may also be found in Exhibit I for reference.

Table 6-1 Proposed Conditions Sub-basin Data

Sub-basin	Area (ac.)	Composite CN	Tc (min.)
NW	4.33	87	9.80
SW	2.35	87	6.90
E Detained	30.61	88	14.70
E Undetained	4.09	87	7.80
E Undeveloped	7.64	82	19.20

Table 6-2 Proposed Conditions Sub-basin/Point of Interest Peak Discharge Rates

Sub-basin	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
NW	14.96	25.12	39.99
SW	8.44	14.14	22.48
E Detained	92.73	154.22	244.07
E Undetained	14.69	24.61	39.13
E Undeveloped	15.81	28.83	48.49

Sub-basin E will require detention/retention to attenuate peak discharge rates below allowable.

### 6.1 RETENTION

The existing detention system shall be converted into a new retention system. Following are a list of design parameters for the proposed retention system.

Designation: E

Type: Earthen Retention Basin

Side Slopes: 3:1 Max. Bottom Slope: N/A

Basin Bottom Elevation: 977.98

Basin Top Berm Elevation: 988.50

Basin Volume: 593,800 cf (983.00 – 987.00)

Control Structure: 5' x 6'

Baffle Wall Orifices: (1) 10" Diameter, FL=981.86

Baffle Wall Crest Elevation: 983.93

Control Structure Top Elevation: 987.93

Overflow Weir Openings: 986.43 All Sides (1.00' High Openings)

Control Structure Influent Pipe: 36" HDPE, FL (In) = 982.43, FL (Out) = 981.54, L=58.44', S= 1.52%

Control Structure Effluent Pipe: 36" HDPE, FL (In) = 981.66, FL (Out) = 980.60, L=102.73', S=1.03%

Emergency Overflow is comprised of the Earthen Broad Crested Weir and the Control Structure Weirs

Earthen Broad Crested Weir, Crest Elevation=986.26, Crest Length=74'

Consecutive 100-Yr Q=244.07 cfs, Emergency Spillway HGL=987.28, Freeboard=1.22', Assumed Top=988.50

Sediment Storage Required: 5-Year Accumulated per APWA Figure 5608-1 = 100 cf \* 30.61 ac \* 5 = 15,305 cf

Sediment Storage Provided: 43,560 cf @ EI=978.42 Excess Storage is Available

The permanent pool shall be 4.44' deep with a 0.44' sedimentation allowance. The pond will not support fish which requires a minimum 10' depth plus sedimentation allowance. The Retention Basin Plan may be found in Exhibit H. Emergency spillway calculations may be found in Exhibit I. See Table 6-3 for a summary of retention basin data.

Table 6-3 Retention Basin Data

	Peak Q In (cfs)	Tp In (min.)	Peak Q Out (cfs)	Tp Out (min)	Peak W.S.E.	Max. Storage Vol. (cf)
(Sub-basin E Detained)						
2-Year	92.73	722	3.02	897	983.74	159,815
10-Year	154.22	722	10.23	782	984.49	252,616
100-Year	244.07	722	34.31	744	985.48	381,676

As shown in the table above all Sub-basin E peak flowrates have been attenuated. See Table 6-4 below for a summary of proposed peak discharge rates at Point of Interest E. Hydrographs tributary to each point of interest have been combined to determine subsequent peak discharge rates.

Table 6-4 Proposed Conditions Post Detention Point of Interest Peak Discharge Rates

Point of Interest	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
E	29.19	50.69	88.15

As can be seen in the above table all peak discharge rates attributable to Sub-basin E improvements have been attenuated below both existing and allowable release rates as outlined in Tables 5-2 and 5-3 respectively. Table 6-5 below provides a comparison of runoff data at each POI.

Table 6-5 Point of Interest Discharge Comparison

POI	Condition	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
E	Proposed	29.19	50.69	88.15
	Existing	75.52	137.68	231.61
	Difference	-46.33	-86.99	-143.46
	Allowable	31.68	88.16	138.12
	Difference	-2.49	-37.47	-49.97

Point E peak discharge rates will be reduced below both Existing and Allowable peak discharge rates.

## **7. 40 HOUR EXTENDED DETENTION**

In addition to mitigation of peak flow rates, APWA Section 5608.4 also requires 40 hour extended detention of runoff from the local 90% mean annual event (1.37"/24-hour rainfall). The proposed retention facility will release the water quality event over a period of 40-72 hours. See Exhibit F for water quality extended detention hydrographs. The 1-year storm represents the 1.37" water quality storm event. The stage storage discharge relationship of the retention basin provides extended detention without the need for a specialized control structure.

## **8. CONCLUSIONS & RECOMMENDATIONS**

This macro storm water drainage study reveals that the Napa Valley 2<sup>nd</sup> Plat detention system may be converted to a single cell earthen retention basin without generating any negative hydrologic nor hydraulic impacts downstream.

In conclusion, proposed peak discharge rates for Sub-basin E are calculated to be well below both Existing and Allowable peak discharge rates with the employ of the proposed retention basin. The proposed SW sub-basin peak discharge rates are significantly below Existing. The proposed NW sub-basin peak discharge rates are slightly above Existing however the enclosed storm sewer system which conveys the runoff has been designed to meet and exceed the projected 100-year peak discharge rates. The NW storm sewer conveys runoff directly to Tributary G1 to Raintree Lake. The overall post development peak discharge contributing to Tributary G1 to Raintree Lake from the combined NW and E sub-basins has been significantly reduced from Existing. Due to the large reduction in peak discharge rates no negative downstream impacts are anticipated with the development of Napa Valley 2<sup>nd</sup> Plat. The study is in conformance with all applicable City of Lee's Summit standards and criteria.

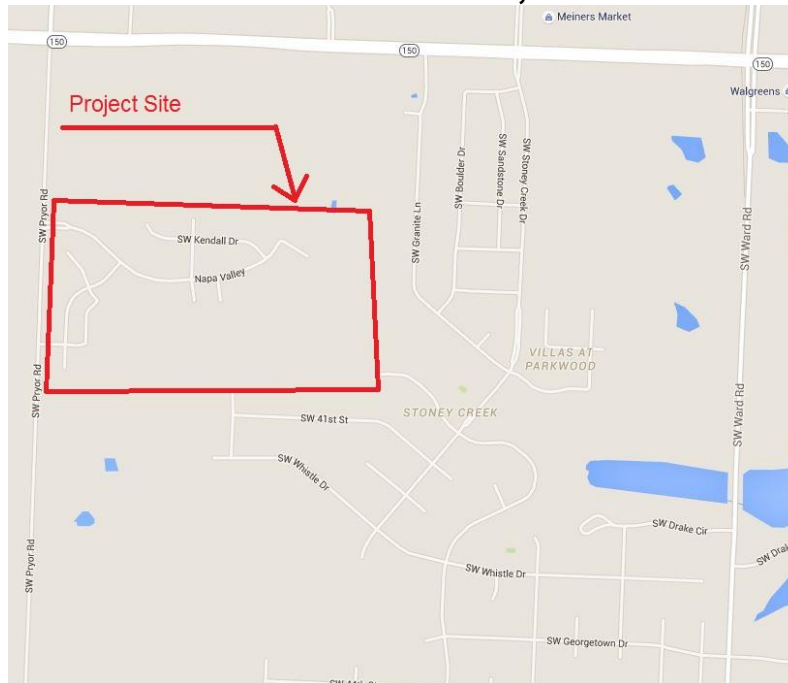
Waivers: N/A

# **Exhibit A**

## **Napa Valley 2<sup>nd</sup> Plat Storm Report** **By** **Warger & Associates**

# MACRO-STORMWATER DRAINAGE STUDY NAPA VALLEY MIDDLE BIG CREEK WATERSHED

**Plat Name: Napa Valley 2<sup>nd</sup> Plat**  
**SE of Napa Valley St. and SW Pryor Road**  
**Lee's Summit, Missouri**  
**Section 36, Township 48, Range 22**  
**September 3, 2015**  
**Revised October 5, 2015**



Prepared for:  
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WA No. 401-01

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## **BIBLIOGRAPHY**

### **APWA 5600 SPECIFICATIONS -**

<http://kcmetro.apwa.net/content/chapters/kcmetro.apwa.net/file/Specifications/APWA5600.pdf>, Latest Revision.

### **APWA 5600 SUPPLEMENT(S) -**

SECTION 5600 - STORM DRAINAGE SYSTEMS & FACILITIES CITY OF LEE'S SUMMIT, MISSOURI DESIGN CRITERIA - <http://cityofls.net/Development/Development-Regulations/Design-and-Construction-Manual.aspx>

**BMP – MANUAL OF BEST MANAGEMENT PRACTICES FOR STORMWATER QUALITY, MARCH 2012, MARC**

### **GEOTECHNICAL REPORT –**

Report of Geotechnical Exploration, Napa Valley, Latest Edition.

### **GOOGLE MAP –**

<https://maps.google.com/maps?hl=en>

### **FEMA MAP SERVICE CENTER -**

<https://msc.fema.gov/webapp/wcs/stores/servlet/CategoryDisplay?catalogId=10001&storeId=10001&categoryId=12001&langId=-1&userType=G&type=1&dfirmCatId=12009&future=false>

### **UNITED STATES OF AGRICULTURE – NATURAL RESOURCES CONSERVATION SERVICE -**

<http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>

### **SOFTWARE PACKAGE**

Bentley Systems, Inc. Haestad Methods Solution Center, Bentley PondPack V8i

## **GENERAL INFORMATION**

This storm drainage study is being submitted on behalf of Wehmeir Development, LLC for the construction of public infrastructure for Napa Valley, a single family residential development located southwest of the intersection of Napa Valley St. and SW Pryor Road in Section 36, Township 48, Range 22, Lee's Summit Jackson County, Missouri, which is in the Middle Big Creek Watershed, (See Figure 1 of Appendix A for site plan). The purpose of this study is to provide recommendations to ensure that storm water runoff from the proposed development will not have an adverse impact on existing downstream developments. This storm drainage study will examine the existing and proposed conditions at the above referenced site and determine if the proposed improvement adheres to all local, state, and federal requirements including but not limited to the City of Lee's Summit Storm Water and Best Management Practices (BMP's).

The proposed development consists of approximately 40.23 acres of land disturbance for Phases 1, 2, 3, and 4 on the 80.00 +/- acre site. The site is bordered by single family residential to the north, and east, public right of way for SW Pryor Road to the west, and a park to the south. The area being studied is currently undeveloped. The project is scheduled to consist of public infrastructure for future single family residential with associated utilities and landscaping. The remainder of the site will remain undisturbed.

The project site has four (4) major soil types according to the Natural Conservation Service (NRCS) Web Soil Survey and is listed below. The full soils report is attached in Appendix B.

- Arisburg silt loam, 1 to 5 percent slopes
- Arisburg-Urban land complex, 1 to 5 percent slopes
- Sampsel silty clay loam, 2 to 5 percent slopes
- Sampsel silty clay loam, 5 to 9 percent slopes

## **METHODOLOGY**

This report was prepared in accordance with the provisions of the City of Lee's Summit Design and Construction Manual includes the General Provisions; the City's adopted additions, deletions and revisions to the Kansas City Metropolitan Chapter of the American Public Works Association specifications; and certain of the KC Metro APWA specifications. The analytical and design criteria used in the study conform to those of "Division V - Section 5600 – Storm Drainage Systems and Facilities" of the Kansas City Metropolitan Chapter of the American Public Works Association's "Standard Specifications and Design Criteria" dated February 16, 2011 and all supplements to the APWA Section 5600. Based on these criteria, allowable discharge from the development is based on limiting 100-year (1%), 10-year (10%), and 2-year (50%) post development discharges to 3 cfs/acre, 2 cfs/acre, and 0.50 cfs/acre respectively.

Stormwater discharges from the site for the existing and proposed watersheds were evaluated using the SCS Technical Release No. 55 per KCMO APWA Section 5602.2. Existing times of concentration were determined using Inlet Time and Travel Time equations found in section 5602.7 of APWA Section 5600. A minimum inlet time of five minutes was used when calculated times were under five minutes. Proposed times of concentration were calculated in the same manner.

## **FEMA FLOOD CLASSIFICATION**

The existing site is located outside of the 100-year flood plain. This area being developed lies in Zone X according to the Flood Insurance Rate Map, FIRM 29095C0406F, Effective Date September 29, 2006 for Jackson County, Missouri and Incorporated Areas. The FIRM identifies

Zone X as “Areas determined to be outside the 0.2% annual chance floodplain.” The FEMA map is attached in Appendix C. The proposed development lies adjacent to Zone AE. The FIRM identifies Zone AE as “Base Flood Elevations Determined.” See Appendix C for base flood elevations.

#### EXISTING CONDITIONS

The site is comprised of woods and grass. The site routes runoff east to tributary G2 to Raintree Lake which is in the Middle Big Creek watershed. Existing drainage boundaries can be found in Figure 1 of Appendix A. A brief summary of allowable release rates can be found in Table 1. All calculated flow rates are in cubic feet per second (cfs).

**Table 1: Allowable Release Rate**

Napa Valley	Area, Acres	Q-2 Year, cfs	Q-10 Year, cfs	Q-100 Year, cfs
East Basin	40.23	20.12	80.46	120.69

#### PROPOSED CONDITIONS

The proposed project will include the construction of public infrastructure, public and private utilities, and associated landscaping. The property will convey the 100-year design runoff within a private storm sewer system to a detention basin. The proposed drainage patterns will not vary from the existing drainage boundaries. A curve number was based upon BMP – MANUAL OF BEST MANAGEMENT PRACTICES FOR STORMWATER QUALITY, MARCH 2012, MARC 2012 MARC for ¼ acre residential lots in HSG D. The proposed development results in an overall curve number of 90, see Appendix E. Hydrographs for all sub-basins and storm events can be found in Appendix D. Proposed drainage boundaries can be found in Figure 2 of Appendix A. A brief summary of proposed runoff can be found in Table 2. All calculated flow rates are in cubic feet per second (cfs).

**Table 2: Proposed Drainage Calculations**

Napa Valley	Area, Acres	HSG	CN	Q-2 Year, cfs	Q-10 Year, cfs	Q-100 Year, cfs
East Basin	40.23	D	90	129.46	214.19	325.79

#### DETENTION ANALYSIS

The proposed project does increase the runoff from the site and the subject site lies adjacent to Tributary G2 of Rain Tree Lake flood boundaries. Therefore it is our recommendation that detention should be provided on the site for the 90% Mean Storm for 40 hours, 2-year, and the 10-year storm events. We are requesting a waiver from the 100-year storm event detention requirement. This is due to the 100-year flood elevations adjacent to the site. In order to detain the 100-year event, we would need to place fill within the floodplain to elevate the site above the 100-year water surface elevation. We are proposing that runoff for Phases 1, 2, 3, and 4 to the proposed detention basin. Upon development of Phases 1 and 2, the design should route the 100-year event to the proposed detention basin. Runoff will be routed to the basin within a public storm sewer system for the 100 year event. The proposed basin will act as a regional basin for Phases 1, 2, 3, and 4. A brief summary of the proposed detention can be found in Table 3.

**Table 3: Summary of East Detention Basin Design**

Napa Valley	Q-2 Year	Q-10 Year	Q-100 Year
Drainage Area	40.23 ac		
Curve Number	90		
Detained Discharge	19.88 cfs	59.97 cfs	82.29 cfs
Detained Peak Hours	12.40 hrs.	12.20 hrs.	12.25 hrs.
Storage Volume	3.357 ac-ft	5.352 ac-ft	8.311 ac-ft
Storage Elevation	984.24	985.01	985.95
Basin Flowline Outflow Elevation	889.00		
Outlet Structure	1 – 4.4" Culvert @ 980.00 1 – 2.50'x1' Orifice @ 981.70 1 – 6'x6' Riser/Weir @ 984.25		
100-Year Emergency Weir Elevation	986.25		
Basin Top Elevation	988.25		

Table 4 below summarizes the comparison between the allowable total runoff and proposed total runoff for each sub-basin for the 2-year and 10-year storm events. All flow rates are in cubic feet per second (cfs).

**Table 4: Comparison of Allowable and Proposed Peak Flow Release Rate from Each Basin**

Napa Valley	Q-2 Year, cfs	Q-10 Year, cfs	Q-100 Year, cfs
Allowable Release Rate	20.12	80.46	120.69
Proposed Release Rate	19.88	59.97	82.29

### **BMP ANALYSIS**

We are meeting the BMP requirements for the City of Lee's Summit by detaining the 90% Mean Storm for 40 hours. We will be installing a 4.4" diameter release orifice at 980.00 that will be protected from clogging by trash and debris. See Appendix E for the design calculations.

### **CONCLUSIONS AND RECOMMENDATIONS**

The proposed project will cause an increase of runoff after the improvements are made to the site. We are proposing to reduce the 2-year and 10-Year runoff rates to meet the City of Lee's Summit discharge requirements in the east basin. We are requesting a waiver from meeting the 100-year storm due to the location of the proposed development. The site is adjacent to the 100-year storm water surface elevation. The proposed project does require BMP's. To meet the BMP requirements, we are proposing an extended dry detention be designed to detain the 90% Mean Storm for 40 hours. Based upon the information provided herein, we request your approval of the storm drainage study for Wehmeir Development, LLC. If you have any questions, please do not hesitate to contact us.



United States  
Department of  
Agriculture

NRCS

Natural  
Resources  
Conservation  
Service

A product of the National  
Cooperative Soil Survey,  
a joint effort of the United  
States Department of  
Agriculture and other  
Federal agencies, State  
agencies including the  
Agricultural Experiment  
Stations, and local  
participants

# Custom Soil Resource Report for **Jackson County, Missouri**

**Napa Valley**



August 18, 2015

# Preface

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Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<http://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist ([http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2\\_053951](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951)).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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# How Soil Surveys Are Made

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Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

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The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.


# Custom Soil Resource Report Soil Map



# Custom Soil Resource Report


## MAP LEGEND

### Area of Interest (AOI)

 Area of Interest (AOI)


### Soils


 Soil Map Unit Polygons


 Soil Map Unit Lines


 Soil Map Unit Points

### Special Point Features

 Blowout

 Borrow Pit

 Clay Spot

 Closed Depression

 Gravel Pit

 Gravelly Spot


 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry


 Miscellaneous Water


 Perennial Water

 Rock Outcrop


 Saline Spot

 Sandy Spot

 Severely Eroded Spot


 Sinkhole


 Slide or Slip

 Sodic Spot

 Spoil Area

 Stony Spot


 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

### Water Features

 Streams and Canals


### Transportation

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

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

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

Source of Map: Natural Resources Conservation Service  
Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>  
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Jackson County, Missouri  
Survey Area Data: Version 13, Aug 4, 2014

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

Date(s) aerial images were photographed: Feb 19, 2012—Mar 25, 2012

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

## Map Unit Legend

Jackson County, Missouri (MO095)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10000	Arisburg silt loam, 1 to 5 percent slopes	30.4	41.1%
10082	Arisburg-Urban land complex, 1 to 5 percent slopes	0.3	0.4%
10116	Sampsel silty clay loam, 2 to 5 percent slopes	21.1	28.6%
10117	Sampsel silty clay loam, 5 to 9 percent slopes	22.2	30.0%
<b>Totals for Area of Interest</b>		<b>73.9</b>	<b>100.0%</b>

## Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic

classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.



## Jackson County, Missouri

### 10000—Arisburg silt loam, 1 to 5 percent slopes

#### Map Unit Setting

*National map unit symbol:* 2qkxq  
*Elevation:* 650 to 1,350 feet  
*Mean annual precipitation:* 33 to 41 inches  
*Mean annual air temperature:* 50 to 55 degrees F  
*Frost-free period:* 177 to 220 days  
*Farmland classification:* All areas are prime farmland

#### Map Unit Composition

*Arisburg and similar soils:* 90 percent  
*Minor components:* 3 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Arisburg

##### Setting

*Landform:* Interfluves  
*Landform position (two-dimensional):* Summit  
*Landform position (three-dimensional):* Interfluve  
*Down-slope shape:* Convex  
*Across-slope shape:* Convex  
*Parent material:* Loess

##### Typical profile

*A - 0 to 13 inches:* silt loam  
*AB - 13 to 19 inches:* silty clay loam  
*Btg - 19 to 56 inches:* silty clay loam  
*Cg - 56 to 80 inches:* silty clay loam

##### Properties and qualities

*Slope:* 1 to 5 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Somewhat poorly drained  
*Runoff class:* High  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* About 18 to 30 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)  
*Available water storage in profile:* High (about 11.9 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 2e  
*Hydrologic Soil Group:* D  
*Ecological site:* Loess Upland Prairie (R107BY007MO)  
*Other vegetative classification:* Grass/Prairie (Herbaceous Vegetation)



## Minor Components

### Haig

*Percent of map unit:* 3 percent  
*Landform:* Interfluves  
*Landform position (two-dimensional):* Summit  
*Landform position (three-dimensional):* Interfluve  
*Down-slope shape:* Convex  
*Across-slope shape:* Linear  
*Other vegetative classification:* Grass/Prairie (Herbaceous Vegetation)

## 10082—Arisburg-Urban land complex, 1 to 5 percent slopes

### Map Unit Setting

*National map unit symbol:* 2qkz8  
*Elevation:* 700 to 1,390 feet  
*Mean annual precipitation:* 33 to 41 inches  
*Mean annual air temperature:* 50 to 55 degrees F  
*Frost-free period:* 177 to 220 days  
*Farmland classification:* All areas are prime farmland

### Map Unit Composition

*Arisburg and similar soils:* 63 percent  
*Urban land:* 33 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

## Description of Arisburg

### Setting

*Landform:* Interfluves  
*Landform position (two-dimensional):* Summit  
*Landform position (three-dimensional):* Interfluve  
*Down-slope shape:* Concave, convex  
*Across-slope shape:* Concave, convex  
*Parent material:* Loess

### Typical profile

*A - 0 to 13 inches:* silt loam  
*AB - 13 to 19 inches:* silty clay loam  
*Btg - 19 to 56 inches:* silty clay loam  
*Cg - 56 to 80 inches:* silty clay loam

### Properties and qualities

*Slope:* 1 to 5 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Somewhat poorly drained  
*Runoff class:* High  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* About 18 to 30 inches

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*Frequency of flooding:* None

*Frequency of ponding:* None

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

*Available water storage in profile:* High (about 11.9 inches)

### **Interpretive groups**

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 2e

*Hydrologic Soil Group:* D

*Ecological site:* Loess Upland Prairie (R107BY007MO)

*Other vegetative classification:* Grass/Prairie (Herbaceous Vegetation)

### **Description of Urban Land**

#### **Setting**

*Landform:* Interfluves

*Landform position (two-dimensional):* Summit

*Landform position (three-dimensional):* Interfluve

#### **Interpretive groups**

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 8

## **10116—Sampsel silty clay loam, 2 to 5 percent slopes**

### **Map Unit Setting**

*National map unit symbol:* 2qkzy

*Elevation:* 600 to 900 feet

*Mean annual precipitation:* 33 to 41 inches

*Mean annual air temperature:* 50 to 55 degrees F

*Frost-free period:* 177 to 220 days

*Farmland classification:* Prime farmland if drained

### **Map Unit Composition**

*Sampsel and similar soils:* 95 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

### **Description of Sampsel**

#### **Setting**

*Landform:* Hillslopes

*Landform position (two-dimensional):* Footslope

*Landform position (three-dimensional):* Base slope

*Down-slope shape:* Concave

*Across-slope shape:* Convex, concave

*Parent material:* Residuum weathered from shale

#### **Typical profile**

*Ap - 0 to 11 inches:* silty clay loam

*Bt - 11 to 80 inches:* silty clay

**Properties and qualities**

*Slope:* 2 to 5 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Poorly drained  
*Runoff class:* Very high  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* About 0 to 18 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)  
*Available water storage in profile:* Moderate (about 8.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 2e  
*Hydrologic Soil Group:* C/D  
*Ecological site:* Wet Footslope Prairie (R112XY041MO)  
*Other vegetative classification:* Grass/Prairie (Herbaceous Vegetation)

**10117—Sampsel silty clay loam, 5 to 9 percent slopes**

**Map Unit Setting**

*National map unit symbol:* 2qkzz  
*Elevation:* 600 to 900 feet  
*Mean annual precipitation:* 33 to 41 inches  
*Mean annual air temperature:* 50 to 55 degrees F  
*Frost-free period:* 177 to 220 days  
*Farmland classification:* Prime farmland if drained

**Map Unit Composition**

*Sampsel and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Sampsel**

**Setting**

*Landform:* Hillslopes  
*Landform position (two-dimensional):* Shoulder  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Concave  
*Across-slope shape:* Convex, concave  
*Parent material:* Residuum weathered from shale

**Typical profile**

*Ap - 0 to 13 inches:* silty clay loam  
*Bt - 13 to 80 inches:* silty clay

**Properties and qualities**

*Slope:* 5 to 9 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Somewhat poorly drained

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*Runoff class:* Very high

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)

*Depth to water table:* About 0 to 18 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

*Available water storage in profile:* Moderate (about 8.6 inches)

### **Interpretive groups**

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 3e

*Hydrologic Soil Group:* C/D

*Ecological site:* Shale Upland Prairie (R112XY021MO)

*Other vegetative classification:* Grass/Prairie (Herbaceous Vegetation)

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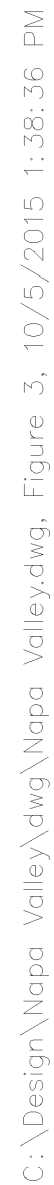








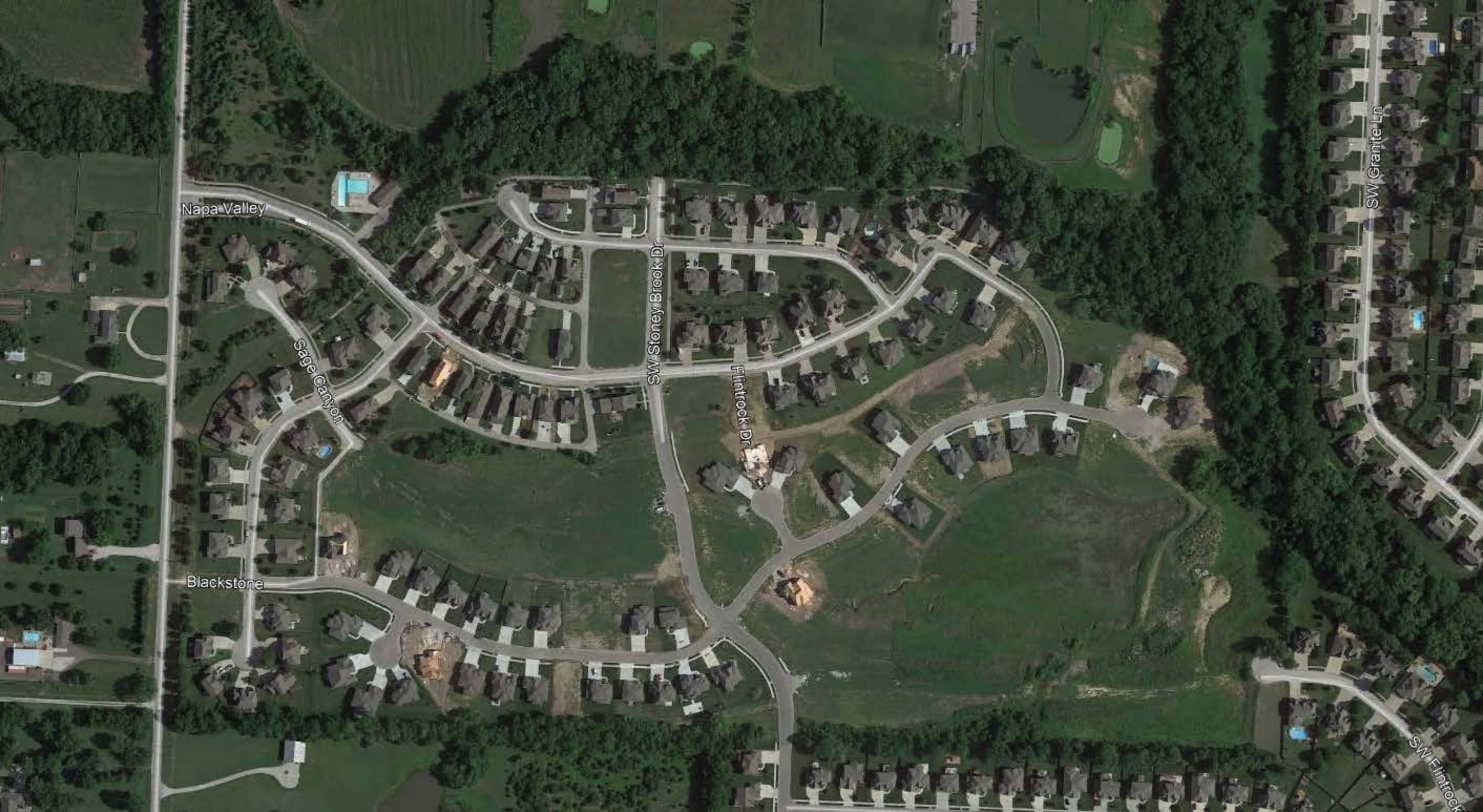




# **Exhibit B**

## **Aerial Image & Aerial Image of Surrounding Area**





Napa Valley

Sage Canyon

Blackstone

SW Stoney Brook Dr

Flintrock Dr

SW Granite Ln

SW Flintrock

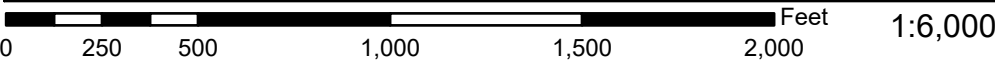
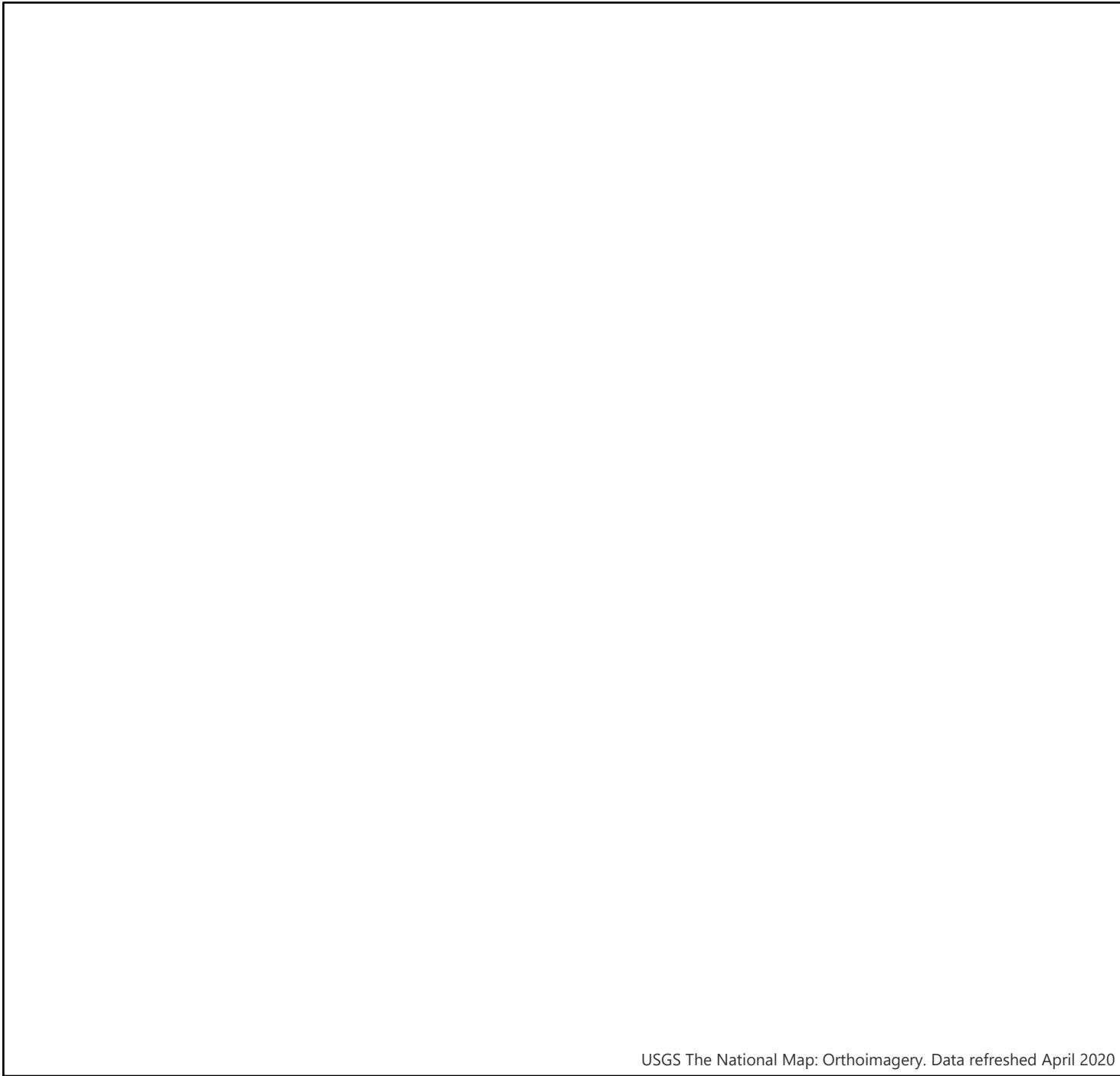


# **Exhibit C**

## **FEMA FIRMette**

# National Flood Hazard Layer FIRMette

94°25'5"W 38°51'5"N





























USGS The National Map: Orthoimagery. Data refreshed April 2020

94°24'28"W 38°50'37"N

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) <i>Zone A, V, A99</i>
		With BFE or Depth <i>Zone AE, AO, AH, VE, AR</i>
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile <i>Zone X</i>
		Future Conditions 1% Annual Chance Flood Hazard <i>Zone X</i>
		Area with Reduced Flood Risk due to Levee. See Notes. <i>Zone X</i>
		Area with Flood Risk due to Levee <i>Zone D</i>
		NO SCREEN Area of Minimal Flood Hazard <i>Zone X</i>
OTHER AREAS		Effective LOMRs
		Area of Undetermined Flood Hazard <i>Zone D</i>
		
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
		
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 6/18/2020 at 11:25 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

# **Exhibit D**

## **NRCS Soil Classification Report**



United States  
Department of  
Agriculture

**NRCS**

Natural  
Resources  
Conservation  
Service

A product of the National  
Cooperative Soil Survey,  
a joint effort of the United  
States Department of  
Agriculture and other  
Federal agencies, State  
agencies including the  
Agricultural Experiment  
Stations, and local  
participants

# Custom Soil Resource Report for **Jackson County, Missouri**



June 18, 2020



# Preface

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Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist ([http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2\\_053951](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951)).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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# How Soil Surveys Are Made

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Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

## Custom Soil Resource Report

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

---

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.



# Custom Soil Resource Report Soil Map





## MAP LEGEND

### Area of Interest (AOI)

 Area of Interest (AOI)

### Soils


 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

### Special Point Features

 Blowout

 Borrow Pit


 Clay Spot


 Closed Depression

 Gravel Pit

 Gravelly Spot

 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water

 Perennial Water

 Rock Outcrop

 Saline Spot

 Sandy Spot

 Severely Eroded Spot


 Sinkhole


 Slide or Slip


 Sodic Spot


 Spoil Area

 Stony Spot


 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

### Water Features

 Streams and Canals

### Transportation

 Rails


 Interstate Highways

 US Routes

 Major Roads

 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

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

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

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

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

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

Soil Survey Area: Jackson County, Missouri  
Survey Area Data: Version 20, Sep 16, 2019

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

Date(s) aerial images were photographed: Sep 6, 2019—Nov 16, 2019

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

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10000	Arisburg silt loam, 1 to 5 percent slopes	22.4	52.0%
10116	Sampsel silty clay loam, 2 to 5 percent slopes	0.6	1.3%
10117	Sampsel silty clay loam, 5 to 9 percent slopes	20.1	46.7%
<b>Totals for Area of Interest</b>		<b>43.0</b>	<b>100.0%</b>

## Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or

landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

## Jackson County, Missouri

### 10000—Arisburg silt loam, 1 to 5 percent slopes

#### Map Unit Setting

*National map unit symbol:* 2w22b

*Elevation:* 610 to 1,130 feet

*Mean annual precipitation:* 39 to 43 inches

*Mean annual air temperature:* 50 to 55 degrees F

*Frost-free period:* 177 to 220 days

*Farmland classification:* All areas are prime farmland

#### Map Unit Composition

*Arisburg and similar soils:* 87 percent

*Minor components:* 13 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Arisburg

##### Setting

*Landform:* Interfluves

*Landform position (two-dimensional):* Summit

*Landform position (three-dimensional):* Interfluve

*Down-slope shape:* Convex

*Across-slope shape:* Convex

*Parent material:* Loess

##### Typical profile

*Ap - 0 to 6 inches:* silt loam

*A - 6 to 13 inches:* silt loam

*Bt - 13 to 19 inches:* silty clay loam

*Btg - 19 to 56 inches:* silty clay loam

*BCg - 56 to 79 inches:* silty clay loam

##### Properties and qualities

*Slope:* 1 to 5 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Somewhat poorly drained

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)

*Depth to water table:* About 18 to 30 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

*Available water storage in profile:* High (about 11.5 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 2e

*Hydrologic Soil Group:* C

*Ecological site:* Loess Upland Prairie (R107BY007MO)

*Hydric soil rating:* No

## Minor Components

### Greenton

*Percent of map unit:* 5 percent  
*Landform:* Hillslopes  
*Landform position (two-dimensional):* Shoulder  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Convex  
*Across-slope shape:* Convex  
*Ecological site:* Loess Upland Prairie (R109XY002MO)  
*Hydric soil rating:* No

### Sharpsburg

*Percent of map unit:* 5 percent  
*Landform:* Ridges  
*Landform position (two-dimensional):* Summit  
*Landform position (three-dimensional):* Interfluve  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Ecological site:* Loess Upland Prairie (R109XY002MO)  
*Hydric soil rating:* No

### Haig

*Percent of map unit:* 3 percent  
*Landform:* Flats  
*Landform position (two-dimensional):* Summit  
*Landform position (three-dimensional):* Talf  
*Down-slope shape:* Linear  
*Across-slope shape:* Convex  
*Ecological site:* Claypan Summit Prairie (R109XY001MO)  
*Hydric soil rating:* Yes

## 10116—Sampsel silty clay loam, 2 to 5 percent slopes

### Map Unit Setting

*National map unit symbol:* 2qkzy  
*Elevation:* 600 to 900 feet  
*Mean annual precipitation:* 33 to 41 inches  
*Mean annual air temperature:* 50 to 55 degrees F  
*Frost-free period:* 177 to 220 days  
*Farmland classification:* Prime farmland if drained

### Map Unit Composition

*Sampsel and similar soils:* 95 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Sampsel

#### Setting

*Landform:* Hillslopes

## Custom Soil Resource Report

*Landform position (two-dimensional):* Footslope  
*Landform position (three-dimensional):* Base slope  
*Down-slope shape:* Concave  
*Across-slope shape:* Convex, concave  
*Parent material:* Residuum weathered from shale

### Typical profile

*Ap - 0 to 11 inches:* silty clay loam  
*Bt - 11 to 80 inches:* silty clay

### Properties and qualities

*Slope:* 2 to 5 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Poorly drained  
*Runoff class:* Very high  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* About 0 to 18 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)  
*Available water storage in profile:* Moderate (about 8.4 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 2e  
*Hydrologic Soil Group:* C/D  
*Ecological site:* Wet Footslope Prairie (R112XY041MO)  
*Other vegetative classification:* Grass/Prairie (Herbaceous Vegetation)  
*Hydric soil rating:* No

## 10117—Sampsel silty clay loam, 5 to 9 percent slopes

### Map Unit Setting

*National map unit symbol:* 2qkzz  
*Elevation:* 600 to 900 feet  
*Mean annual precipitation:* 33 to 41 inches  
*Mean annual air temperature:* 50 to 55 degrees F  
*Frost-free period:* 177 to 220 days  
*Farmland classification:* Prime farmland if drained

### Map Unit Composition

*Sampsel and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Sampsel

#### Setting

*Landform:* Hillslopes  
*Landform position (two-dimensional):* Shoulder  
*Landform position (three-dimensional):* Side slope

## Custom Soil Resource Report

*Down-slope shape:* Concave  
*Across-slope shape:* Convex, concave  
*Parent material:* Residuum weathered from shale

### Typical profile

*Ap - 0 to 13 inches:* silty clay loam  
*Bt - 13 to 80 inches:* silty clay

### Properties and qualities

*Slope:* 5 to 9 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Somewhat poorly drained  
*Runoff class:* Very high  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* About 0 to 18 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)  
*Available water storage in profile:* Moderate (about 8.6 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 3e  
*Hydrologic Soil Group:* C/D  
*Ecological site:* Interbedded Sedimentary Upland Savanna (R109XY010MO)  
*Other vegetative classification:* Grass/Prairie (Herbaceous Vegetation)  
*Hydric soil rating:* No

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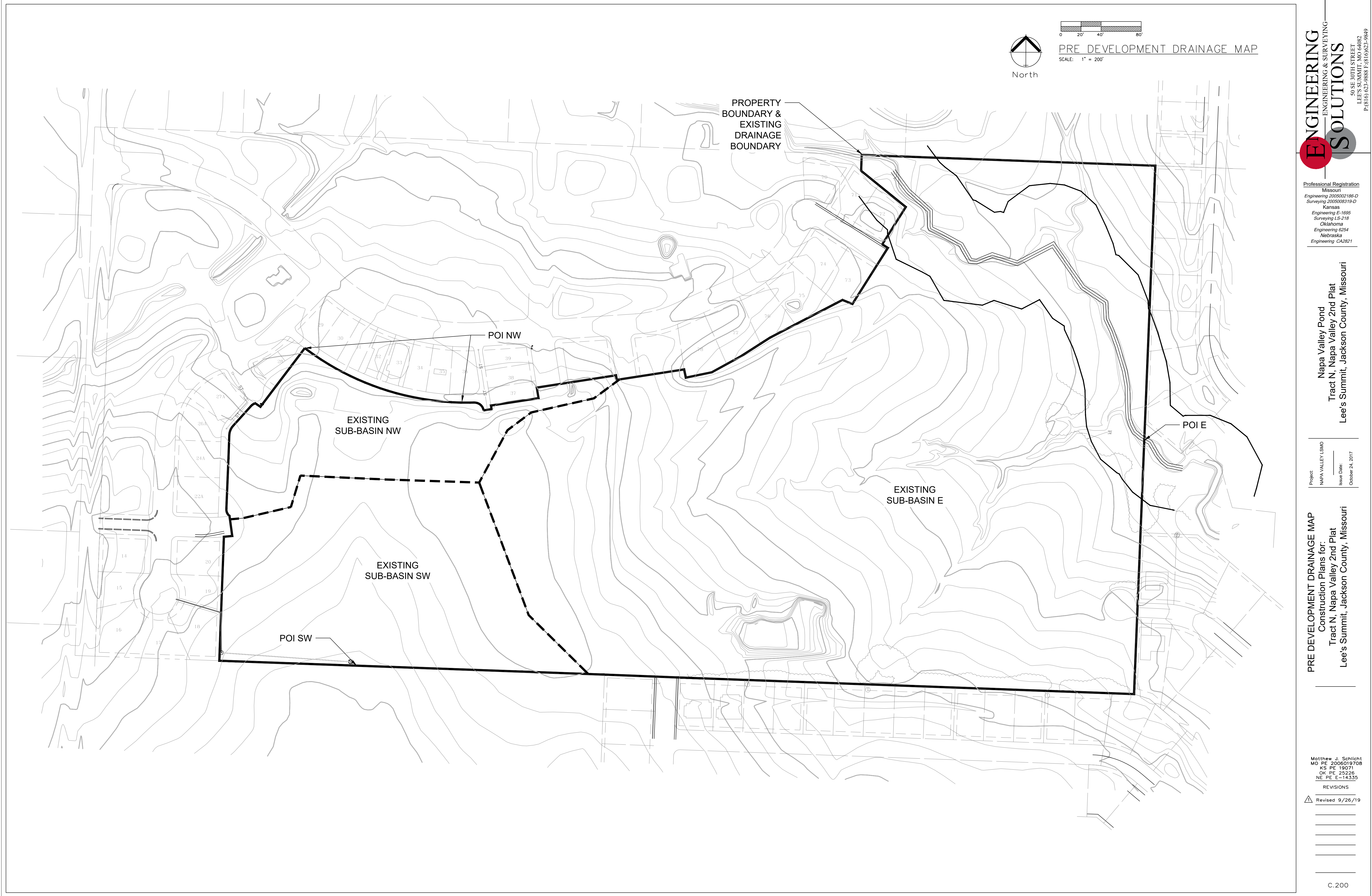
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United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. [http://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs142p2\\_052290.pdf](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf)

# **Exhibit E**

## **Pre-Development Drainage Map**





Professional Registration  
Missouri  
Engineering 2005002186-D  
Surveying 2005008319-D  
Kansas  
Engineering E-1695  
Surveying LS-218  
Oklahoma  
Engineering 6254  
Nebraska  
Engineering CA2821

**PRE DEVELOPMENT DRAINAGE MAP**  
Construction Plans for:  
Tract N, Napa Valley 2nd Plat  
Lee's Summit, Jackson County, Missouri

Project:  
NAPA VALLEY LSNO  
Issue Date:  
October 24, 2017

**PRE DEVELOPMENT DRAINAGE MAP**  
Construction Plans for:  
Tract N, Napa Valley 2nd Plat  
Lee's Summit, Jackson County, Missouri

Matthew J. Schlicht  
MO PE 2006019708  
KS PE 19071  
OK PE 25226  
NE PE E-14335

REVISIONS	
Revised 9/26/19	

# **Exhibit F**

## **Complete Hydraflow Report**



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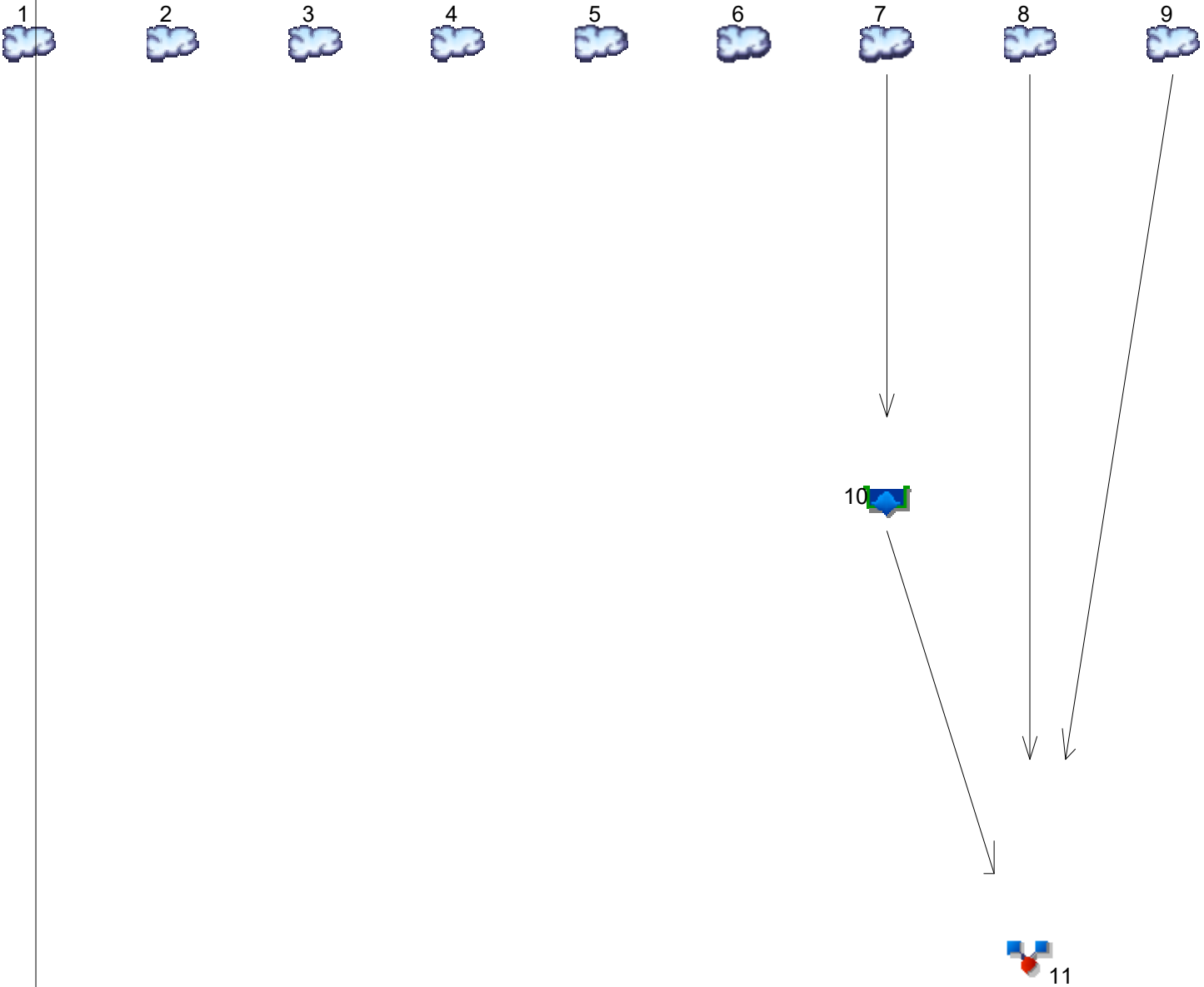
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# Watershed Model Schematic

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021



## Legend

Hyd.	Origin	Description
1	SCS Runoff	EX NW
2	SCS Runoff	EX SW
3	SCS Runoff	EX E
4	SCS Runoff	PROP NW
5	SCS Runoff	PROP SW
6	SCS Runoff	PROP E
7	SCS Runoff	PROP E DETAINED
8	SCS Runoff	PROP E UNDETAINED
9	SCS Runoff	PROP E UNDEVELOPED
10	Reservoir	PROP E DETAINED ROUTED
11	Combine	COMBINED PROP E

# Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

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	-----	1.619	11.67	-----	-----	21.04	-----	-----	35.12	EX NW
2	SCS Runoff	-----	2.562	19.04	-----	-----	34.45	-----	-----	57.64	EX SW
3	SCS Runoff	-----	9.667	75.52	-----	-----	137.68	-----	-----	231.61	EX E
4	SCS Runoff	-----	3.061	14.96	-----	-----	25.12	-----	-----	39.99	PROP NW
5	SCS Runoff	-----	1.747	8.439	-----	-----	14.14	-----	-----	22.48	PROP SW
6	SCS Runoff	-----	17.60	110.64	-----	-----	194.69	-----	-----	319.79	PROP E
7	SCS Runoff	-----	19.75	92.73	-----	-----	154.22	-----	-----	244.07	PROP E DETAINED
8	SCS Runoff	-----	3.040	14.69	-----	-----	24.61	-----	-----	39.13	PROP E UNDETAINED
9	SCS Runoff	-----	2.024	15.81	-----	-----	28.83	-----	-----	48.49	PROP E UNDEVELOPED
10	Reservoir	7	1.224	3.020	-----	-----	10.23	-----	-----	34.31	PROP E DETAINED ROUTED
11	Combine	8, 9, 10	4.909	29.19	-----	-----	50.69	-----	-----	88.15	COMBINED PROP E
Proj. file: NAPA VALLEY 2ND AS-BUILT 210312.gpw										Thursday, 03 / 11 / 2021	



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

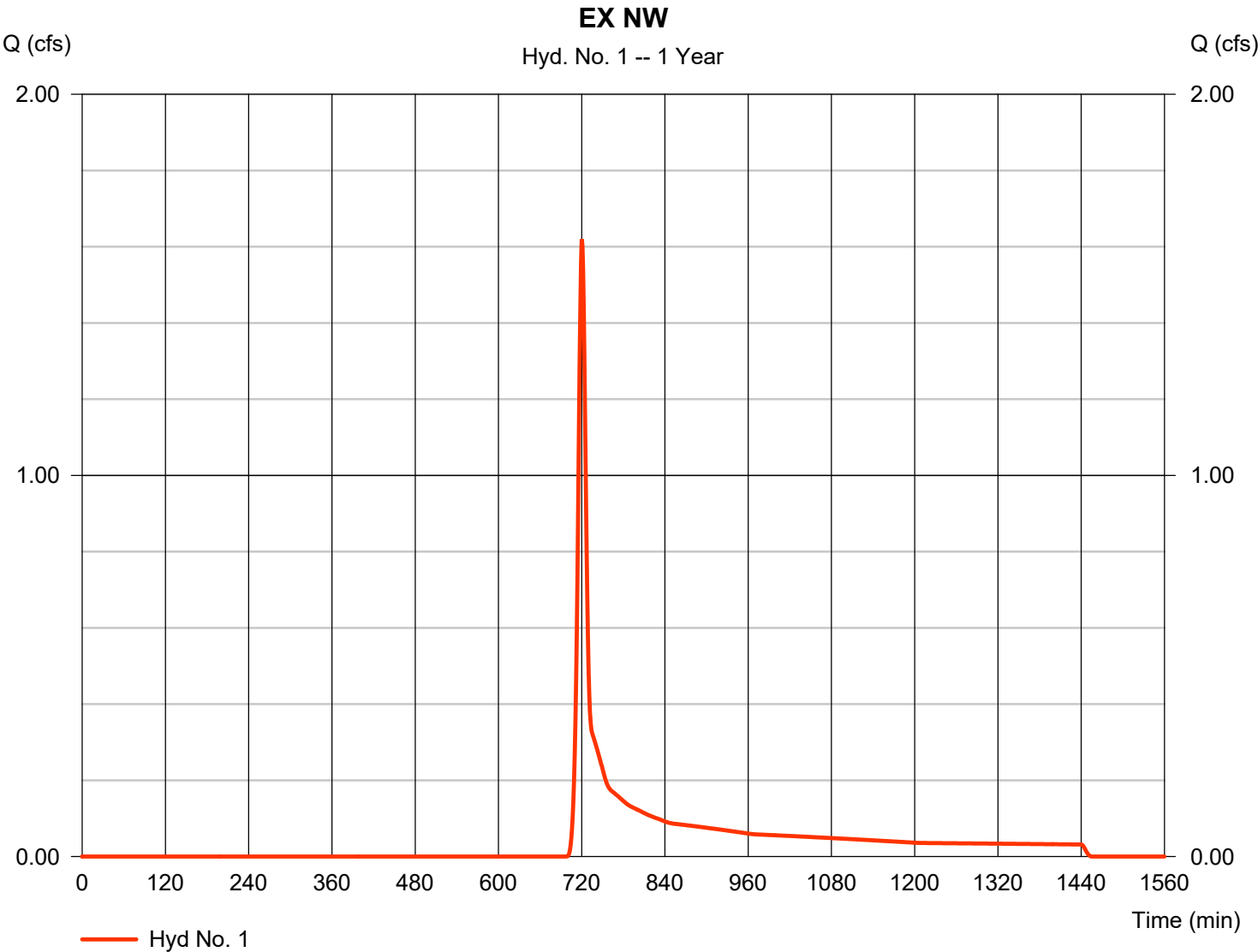
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	1.619	1	720	4,106	-----	-----	-----	EX NW
2	SCS Runoff	2.562	1	722	7,480	-----	-----	-----	EX SW
3	SCS Runoff	9.667	1	727	36,724	-----	-----	-----	EX E
4	SCS Runoff	3.061	1	720	7,030	-----	-----	-----	PROP NW
5	SCS Runoff	1.747	1	719	3,720	-----	-----	-----	PROP SW
6	SCS Runoff	17.60	1	723	51,954	-----	-----	-----	PROP E
7	SCS Runoff	19.75	1	723	54,363	-----	-----	-----	PROP E DETAINED
8	SCS Runoff	3.040	1	719	6,474	-----	-----	-----	PROP E UNDETAINED
9	SCS Runoff	2.024	1	727	7,689	-----	-----	-----	PROP E UNDEVELOPED
10	Reservoir	1.224	1	820	54,342	7	982.65	27,071	PROP E DETAINED ROUTED
11	Combine	4.909	1	720	68,505	8, 9, 10	-----	-----	COMBINED PROP E
NAPA VALLEY 2ND AS-BUILT 210312.gpw					Return Period: 1 Year			Thursday, 03 / 11 / 2021	

# Hydrograph Report

## Hyd. No. 1

EX NW

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.619 cfs
Storm frequency	=	1 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	4,106 cuft
Drainage area	=	4.080 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	8.70 min
Total precip.	=	1.37 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

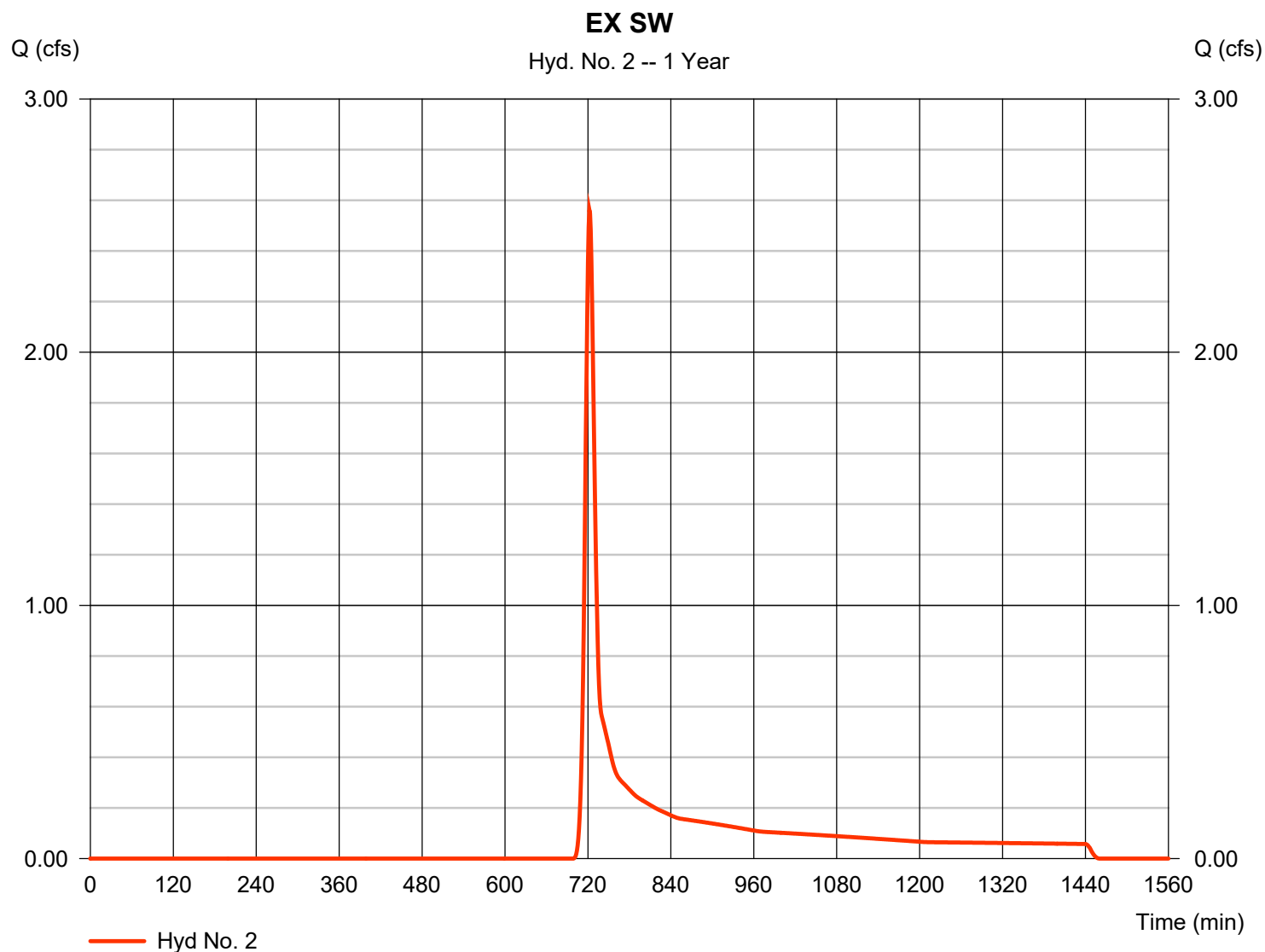
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 2

EX SW

Hydrograph type	= SCS Runoff	Peak discharge	= 2.562 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 7,480 cuft
Drainage area	= 7.550 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 12.10 min
Total precip.	= 1.37 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

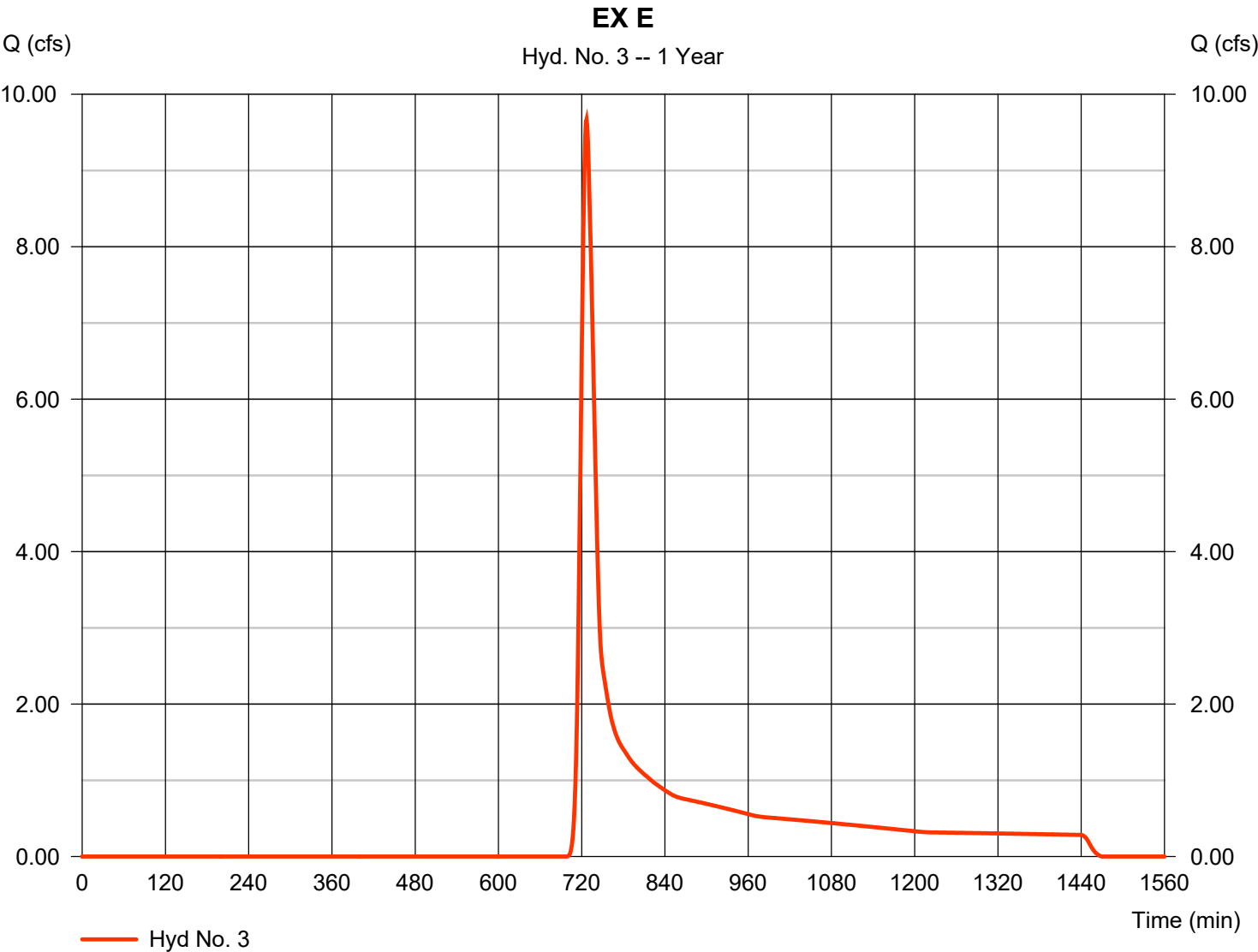


# Hydrograph Report

## Hyd. No. 3

EX E

Hydrograph type	= SCS Runoff	Peak discharge	= 9.667 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 36,724 cuft
Drainage area	= 36.490 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 19.20 min
Total precip.	= 1.37 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

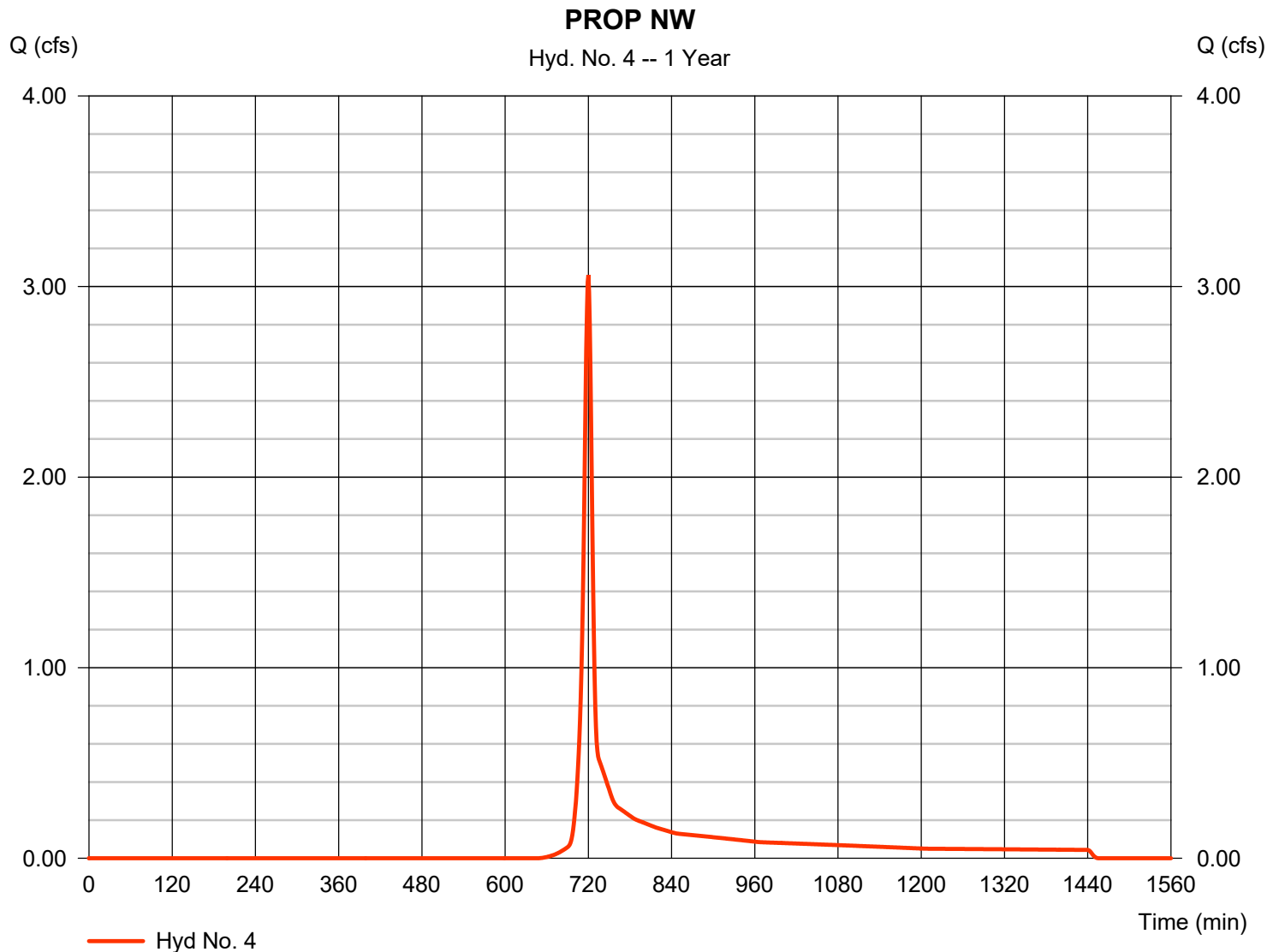
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Thursday, 03 / 11 / 2021

## Hyd. No. 4

PROP NW

Hydrograph type	= SCS Runoff	Peak discharge	= 3.061 cfs
Storm frequency	= 1 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 7,030 cuft
Drainage area	= 4.330 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 9.80 min
Total precip.	= 1.37 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

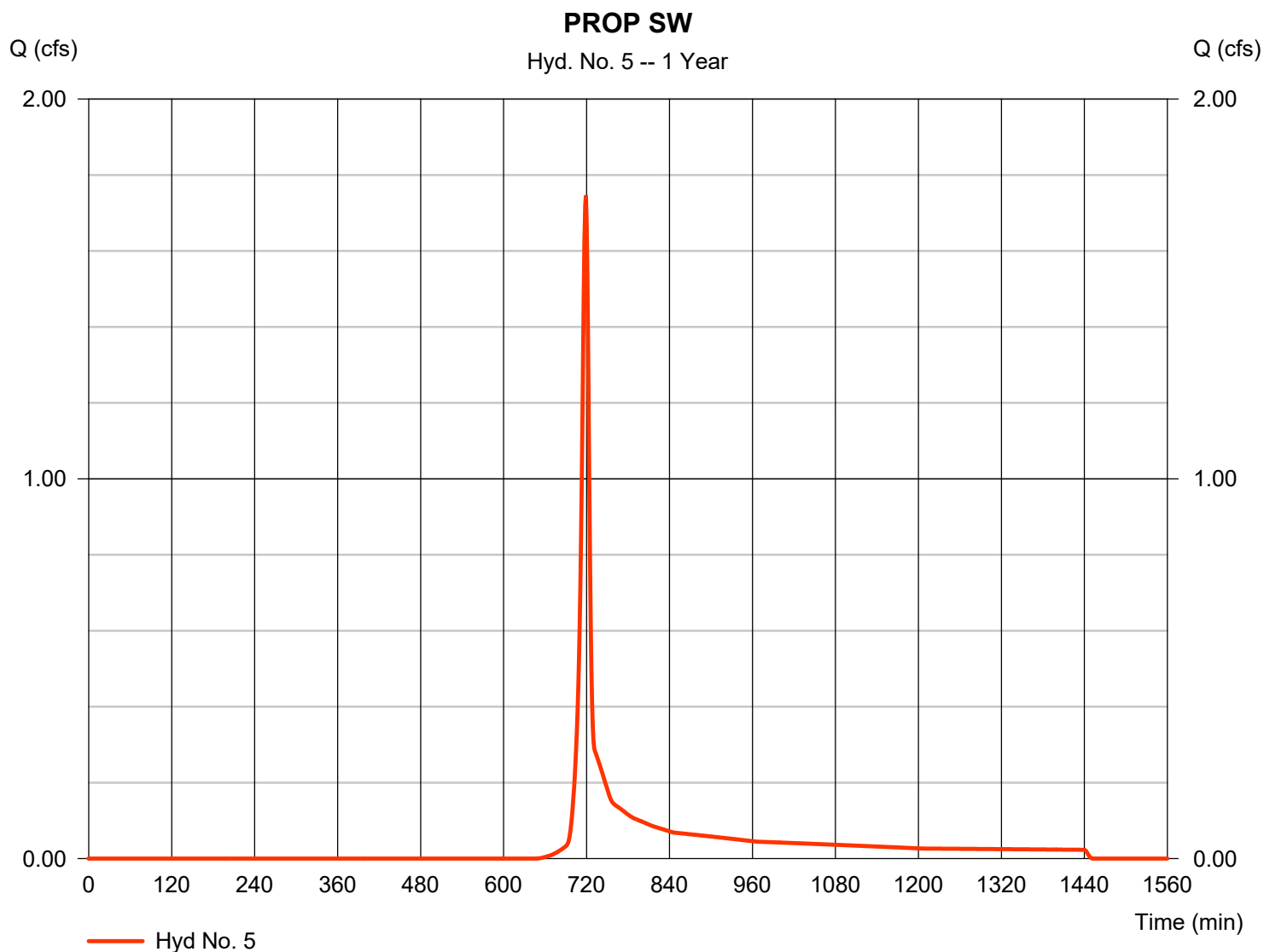
Thursday, 03 / 11 / 2021

## Hyd. No. 5

PROP SW

Hydrograph type = SCS Runoff  
 Storm frequency = 1 yrs  
 Time interval = 1 min  
 Drainage area = 2.350 ac  
 Basin Slope = 0.0 %  
 Tc method = User  
 Total precip. = 1.37 in  
 Storm duration = 24 hrs

Peak discharge = 1.747 cfs  
 Time to peak = 719 min  
 Hyd. volume = 3,720 cuft  
 Curve number = 87  
 Hydraulic length = 0 ft  
 Time of conc. (Tc) = 6.90 min  
 Distribution = Type II  
 Shape factor = 484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

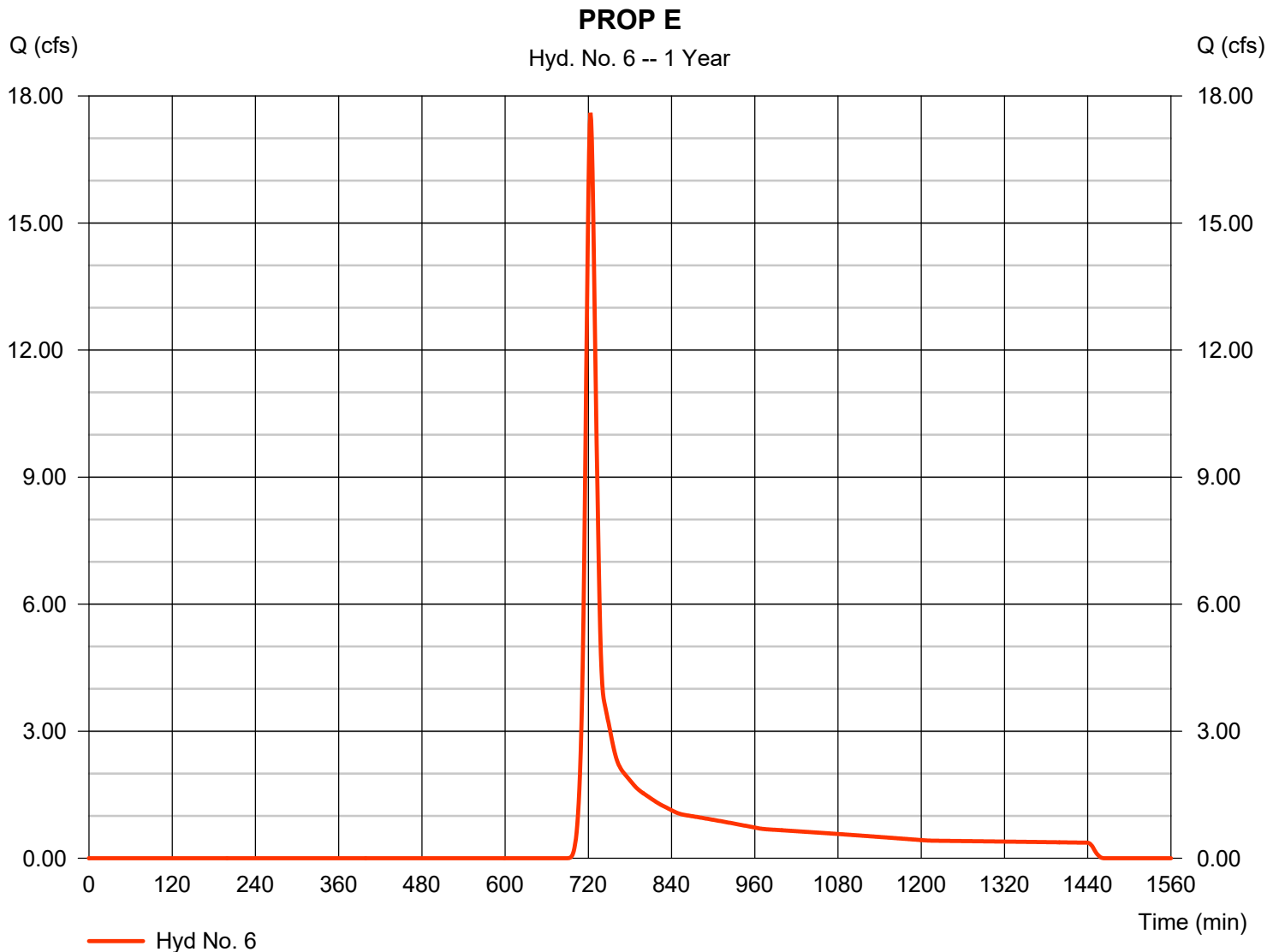
Thursday, 03 / 11 / 2021

## Hyd. No. 6

PROP E

Hydrograph type = SCS Runoff  
 Storm frequency = 1 yrs  
 Time interval = 1 min  
 Drainage area = 42.340 ac  
 Basin Slope = 0.0 %  
 Tc method = User  
 Total precip. = 1.37 in  
 Storm duration = 24 hrs

Peak discharge = 17.60 cfs  
 Time to peak = 723 min  
 Hyd. volume = 51,954 cuft  
 Curve number = 84  
 Hydraulic length = 0 ft  
 Time of conc. (Tc) = 14.70 min  
 Distribution = Type II  
 Shape factor = 484



# Hydrograph Report

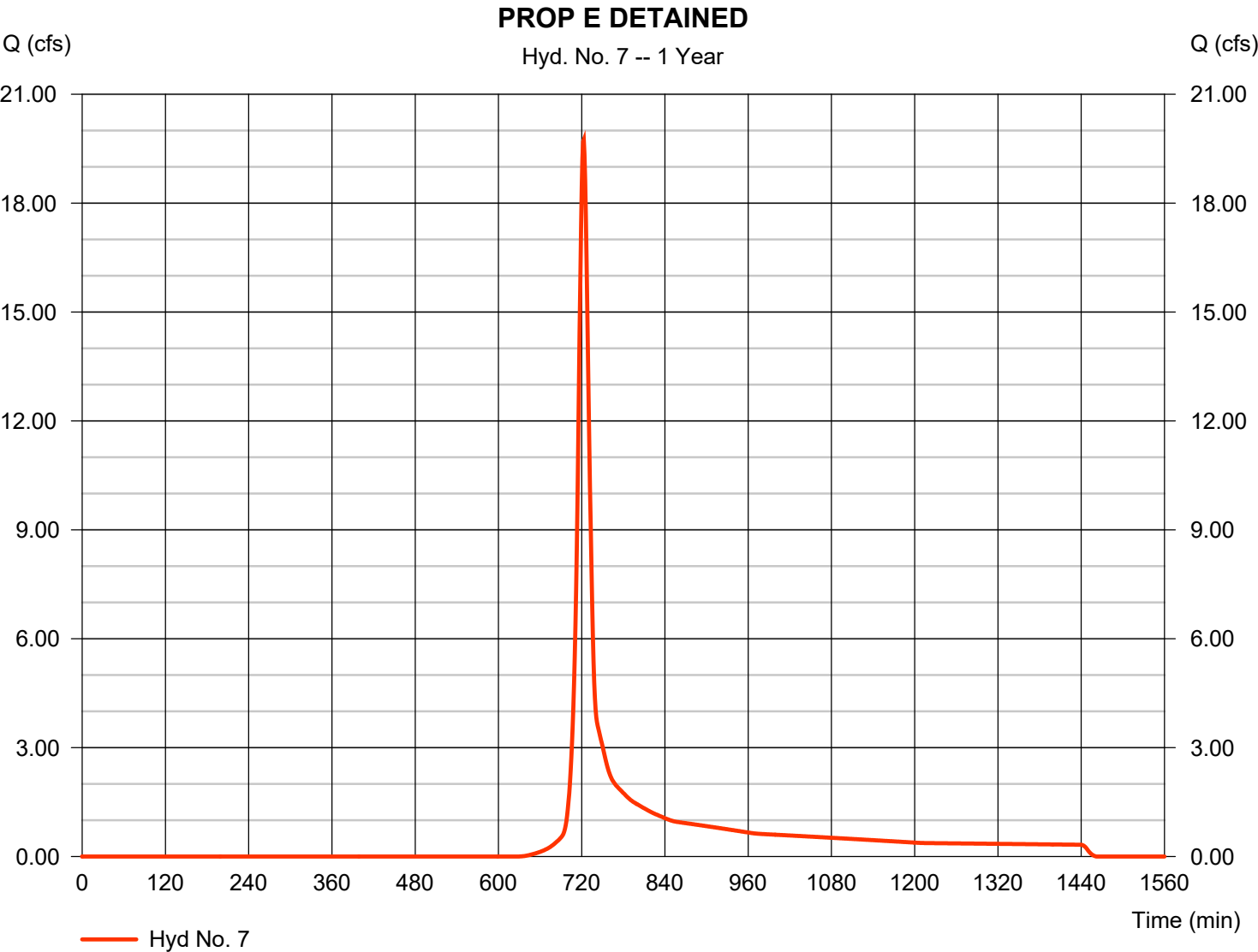
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Thursday, 03 / 11 / 2021

## Hyd. No. 7

### PROP E DETAINED

Hydrograph type	=	SCS Runoff	Peak discharge	=	19.75 cfs
Storm frequency	=	1 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	54,363 cuft
Drainage area	=	30.610 ac	Curve number	=	88
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	14.70 min
Total precip.	=	1.37 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



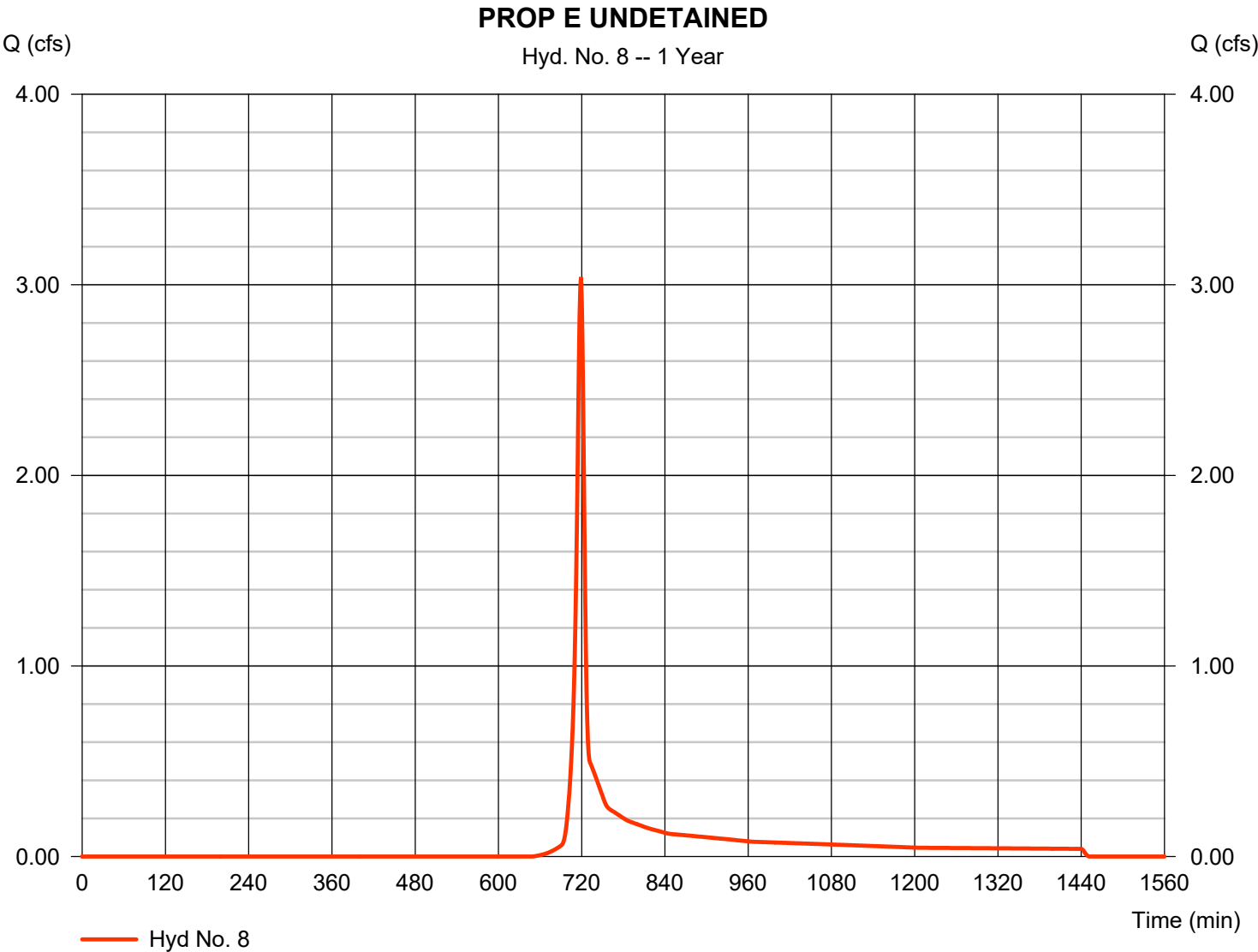


# Hydrograph Report

## Hyd. No. 8

PROP E UNDETAINED

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.040 cfs
Storm frequency	=	1 yrs	Time to peak	=	719 min
Time interval	=	1 min	Hyd. volume	=	6,474 cuft
Drainage area	=	4.090 ac	Curve number	=	87
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	7.80 min
Total precip.	=	1.37 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

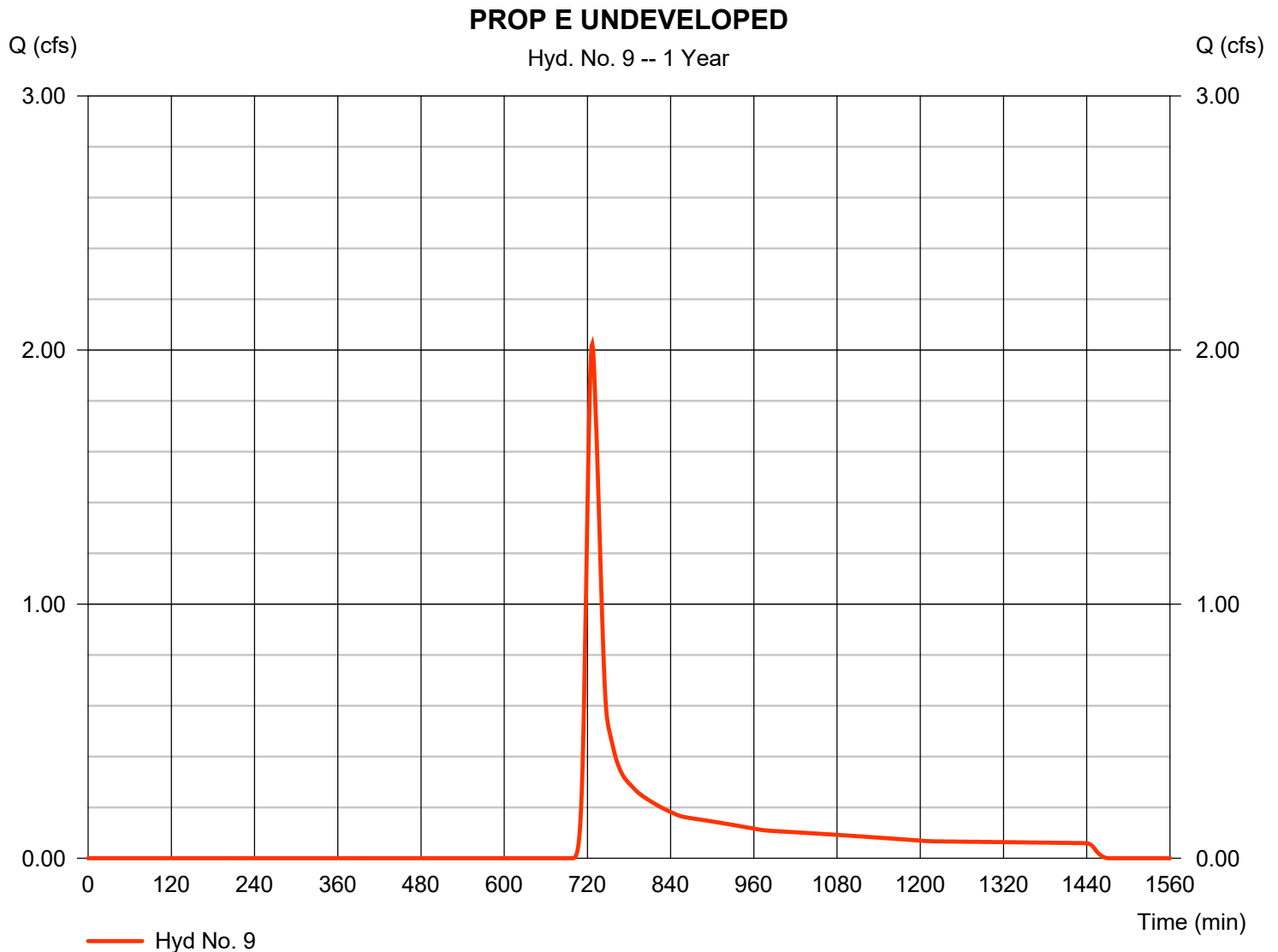
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 9

### PROP E UNDEVELOPED

Hydrograph type	= SCS Runoff	Peak discharge	= 2.024 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 7,689 cuft
Drainage area	= 7.640 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 19.20 min
Total precip.	= 1.37 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

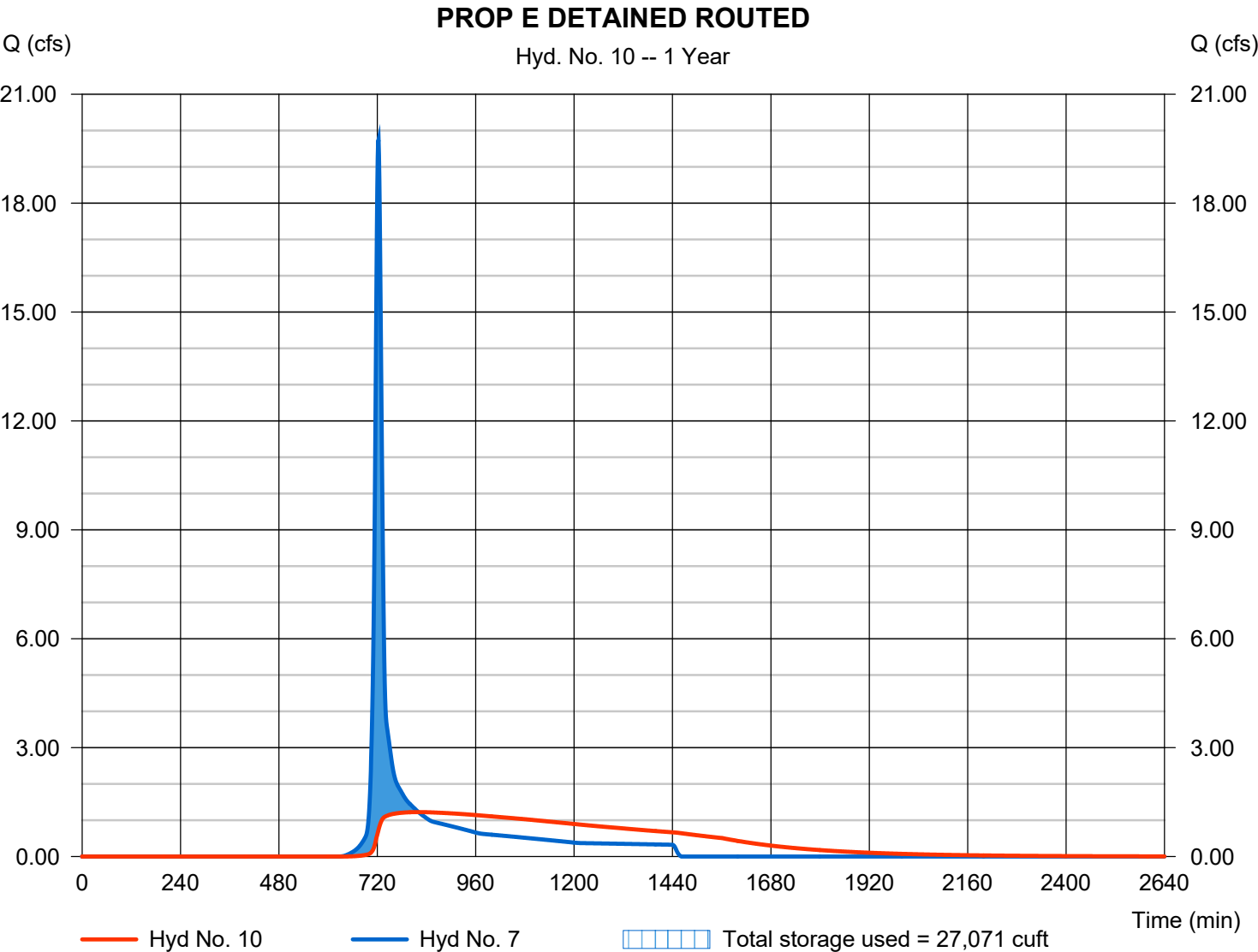
Thursday, 03 / 11 / 2021

## Hyd. No. 10

PROP E DETAINED ROUTED

Hydrograph type	= Reservoir	Peak discharge	= 1.224 cfs
Storm frequency	= 1 yrs	Time to peak	= 820 min
Time interval	= 1 min	Hyd. volume	= 54,342 cuft
Inflow hyd. No.	= 7 - PROP E DETAINED	Max. Elevation	= 982.65 ft
Reservoir name	= RP 2 AS-BUILT	Max. Storage	= 27,071 cuft

Storage Indication method used.



## Pond No. 2 - RP 2 AS-BUILT

### Pond Data

**Contours** -User-defined contour areas. Conic method used for volume calculation. Beginning Elevation = 982.42 ft

### Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	982.42	118,503	0	0
0.58	983.00	119,949	69,144	69,144
1.58	984.00	124,036	121,975	191,118
2.58	985.00	129,319	126,656	317,774
3.58	986.00	136,950	133,103	450,877
4.58	987.00	149,010	142,923	593,800

### Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 36.00	10.00	0.00	0.00
Span (in)	= 36.00	10.00	0.00	0.00
No. Barrels	= 1	1	0	0
Invert El. (ft)	= 981.66	981.86	0.00	0.00
Length (ft)	= 102.73	0.00	0.00	0.00
Slope (%)	= 1.62	0.00	0.00	n/a
N-Value	= .012	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

### Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 5.00	74.00	15.50	0.00
Crest El. (ft)	= 983.93	986.26	986.43	0.00
Weir Coeff.	= 3.33	2.60	3.33	3.33
Weir Type	= Rect	Broad	Rect	---
Multi-Stage	= Yes	No	Yes	No
Exfil.(in/hr)	= 0.000 (by Wet area)			
TW Elev. (ft)	= 0.00			

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

### Stage / Storage / Discharge Table

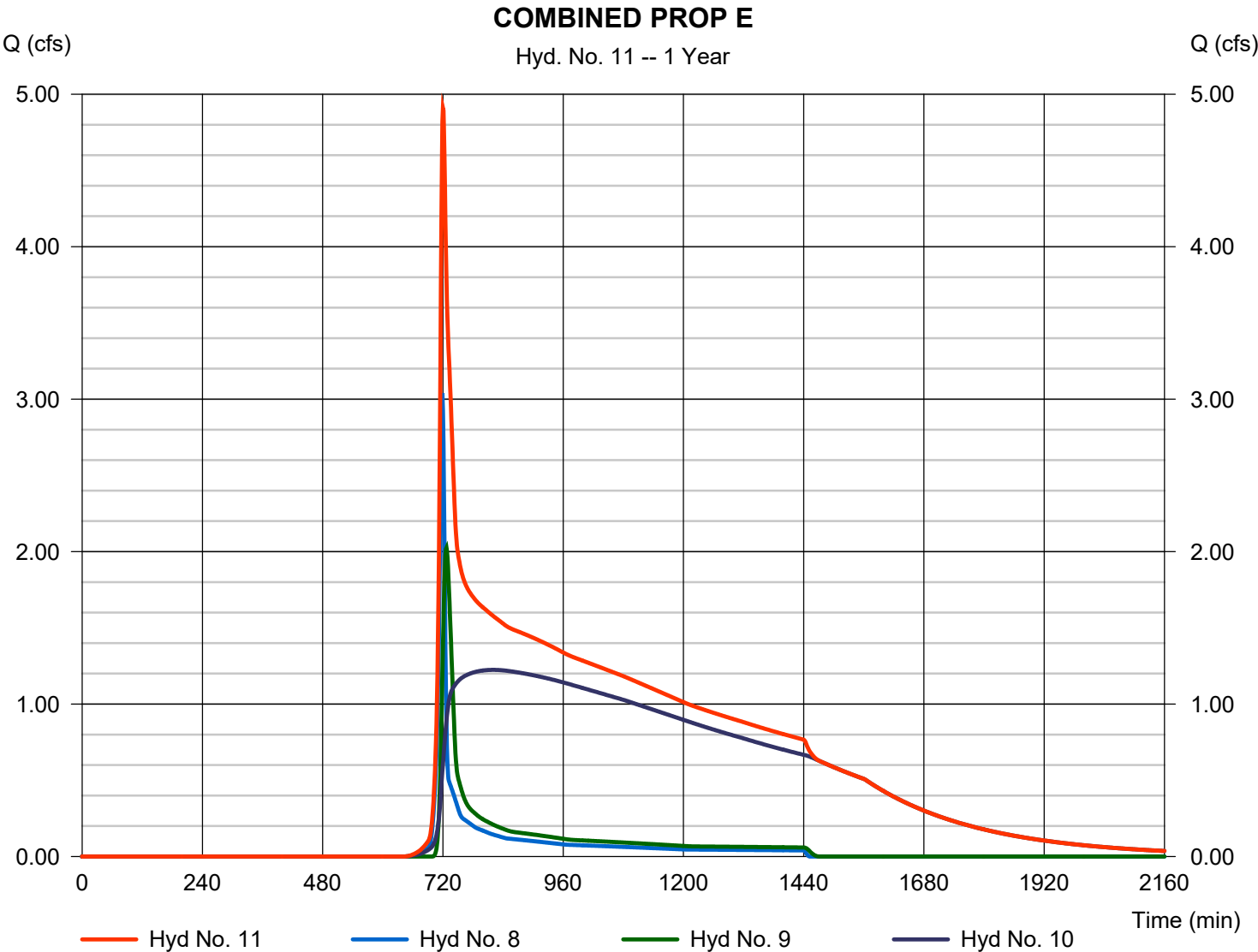
Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	982.42	0.00	0.00	---	---	0.00	0.00	0.00	---	---	---	0.000
0.58	69,144	983.00	4.31 ic	2.00 ic	---	---	0.00	0.00	0.00	---	---	---	2.000
1.58	191,118	984.00	4.31 ic	3.30 ic	---	---	0.31	0.00	0.00	---	---	---	3.609
2.58	317,774	985.00	21.61 ic	3.18 ic	---	---	18.43	0.00	0.00	---	---	---	21.61
3.58	450,877	986.00	45.18 ic	2.73 ic	---	---	42.45 s	0.00	0.00	---	---	---	45.18
4.58	593,800	987.00	63.90 ic	1.47 ic	---	---	43.08 s	122.47	19.35 s	---	---	---	186.37

# Hydrograph Report

## Hyd. No. 11

### COMBINED PROP E

Hydrograph type	= Combine	Peak discharge	= 4.909 cfs
Storm frequency	= 1 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 68,505 cuft
Inflow hyds.	= 8, 9, 10	Contrib. drain. area	= 11.730 ac



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

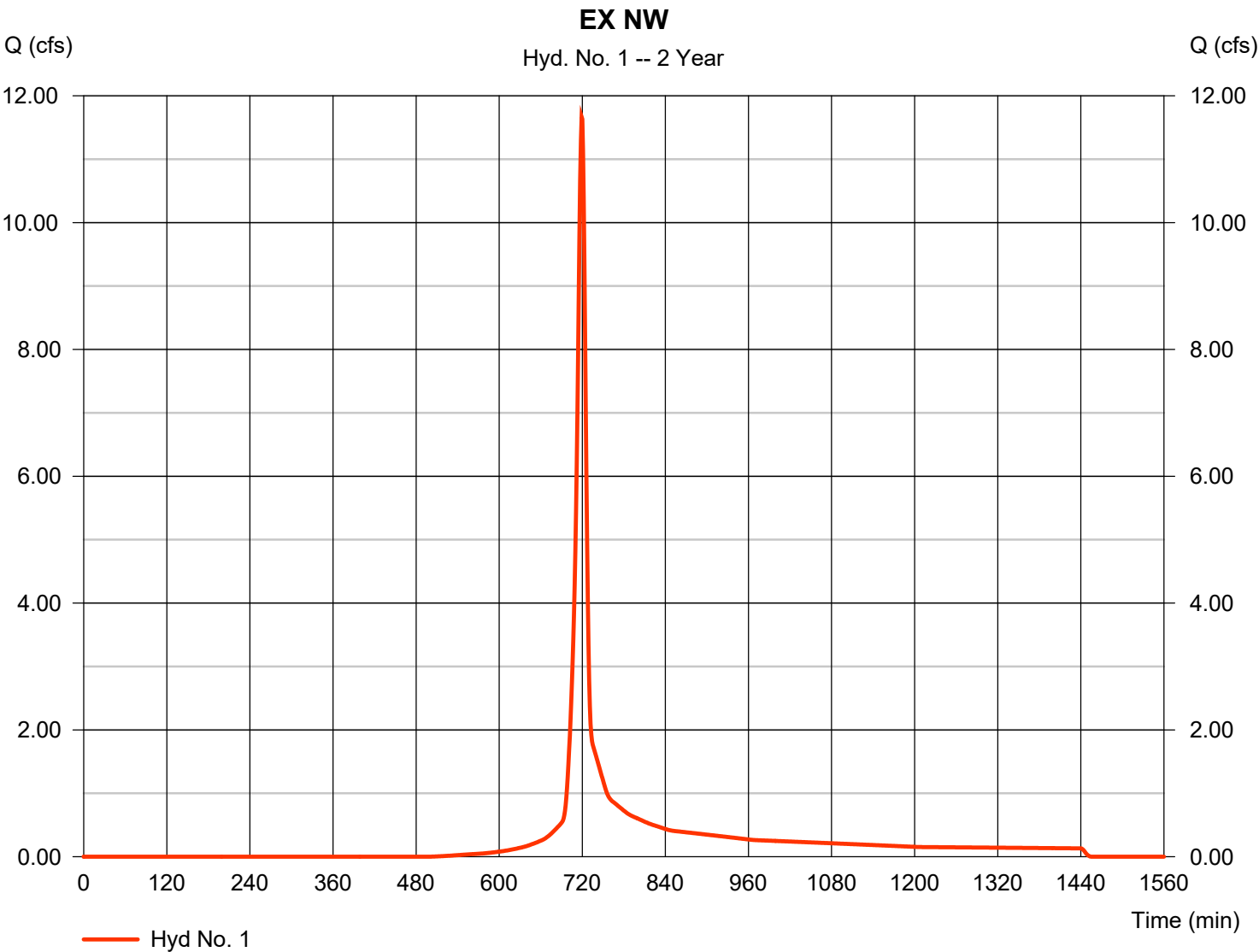
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	11.67	1	719	26,401	-----	-----	-----	EX NW
2	SCS Runoff	19.04	1	721	48,092	-----	-----	-----	EX SW
3	SCS Runoff	75.52	1	725	236,122	-----	-----	-----	EX E
4	SCS Runoff	14.96	1	719	34,303	-----	-----	-----	PROP NW
5	SCS Runoff	8.439	1	718	18,152	-----	-----	-----	PROP SW
6	SCS Runoff	110.64	1	722	297,624	-----	-----	-----	PROP E
7	SCS Runoff	92.73	1	722	252,082	-----	-----	-----	PROP E DETAINED
8	SCS Runoff	14.69	1	718	31,592	-----	-----	-----	PROP E UNDETAINED
9	SCS Runoff	15.81	1	725	49,438	-----	-----	-----	PROP E UNDEVELOPED
10	Reservoir	3.020	1	897	249,610	7	983.74	159,815	PROP E DETAINED ROUTED
11	Combine	29.19	1	720	330,639	8, 9, 10	-----	-----	COMBINED PROP E
NAPA VALLEY 2ND AS-BUILT 210312.gpw					Return Period: 2 Year			Thursday, 03 / 11 / 2021	

# Hydrograph Report

## Hyd. No. 1

EX NW

Hydrograph type	=	SCS Runoff	Peak discharge	=	11.67 cfs
Storm frequency	=	2 yrs	Time to peak	=	719 min
Time interval	=	1 min	Hyd. volume	=	26,401 cuft
Drainage area	=	4.080 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	8.70 min
Total precip.	=	3.50 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

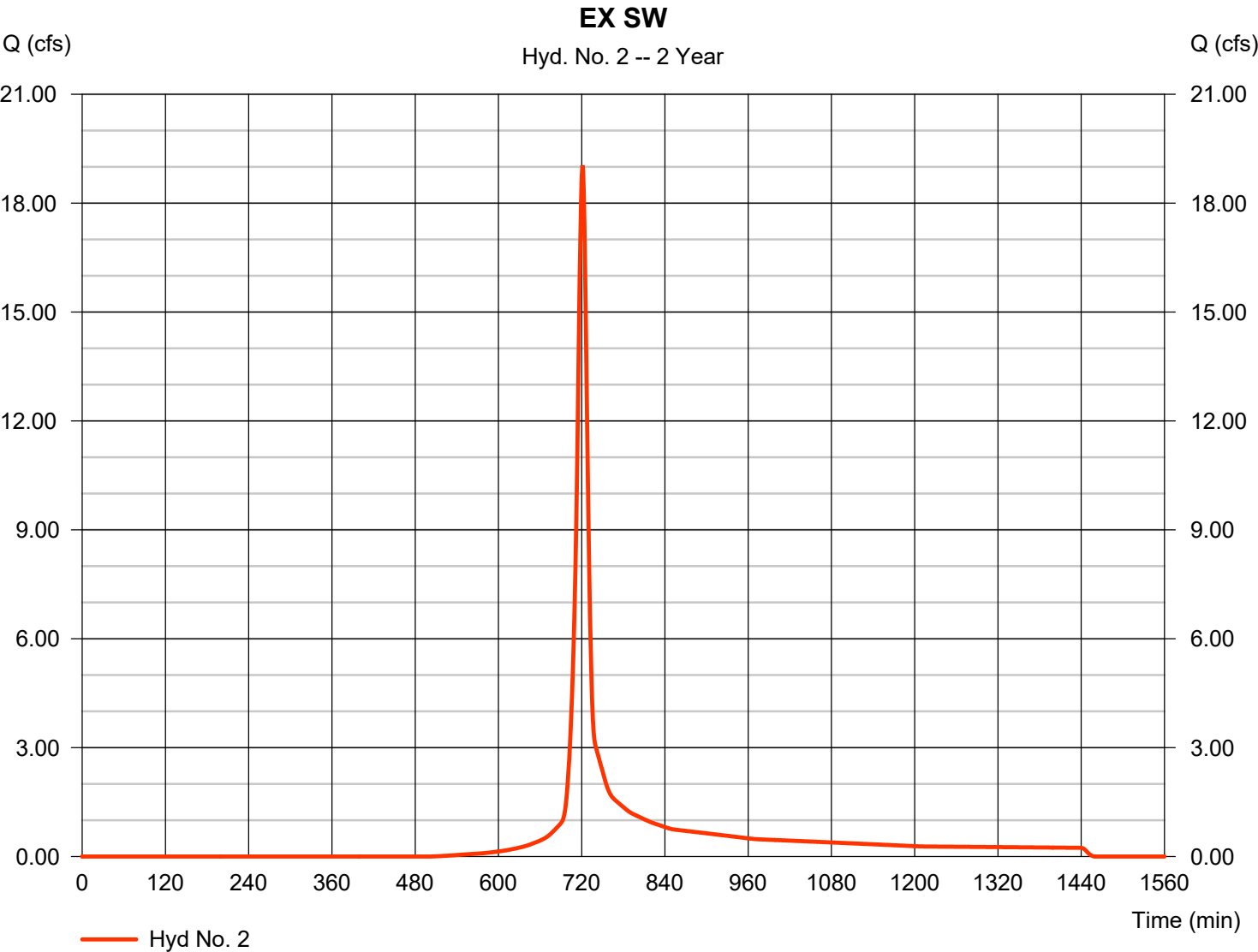
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 2

EX SW

Hydrograph type	=	SCS Runoff	Peak discharge	=	19.04 cfs
Storm frequency	=	2 yrs	Time to peak	=	721 min
Time interval	=	1 min	Hyd. volume	=	48,092 cuft
Drainage area	=	7.550 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	12.10 min
Total precip.	=	3.50 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484





# Hydrograph Report

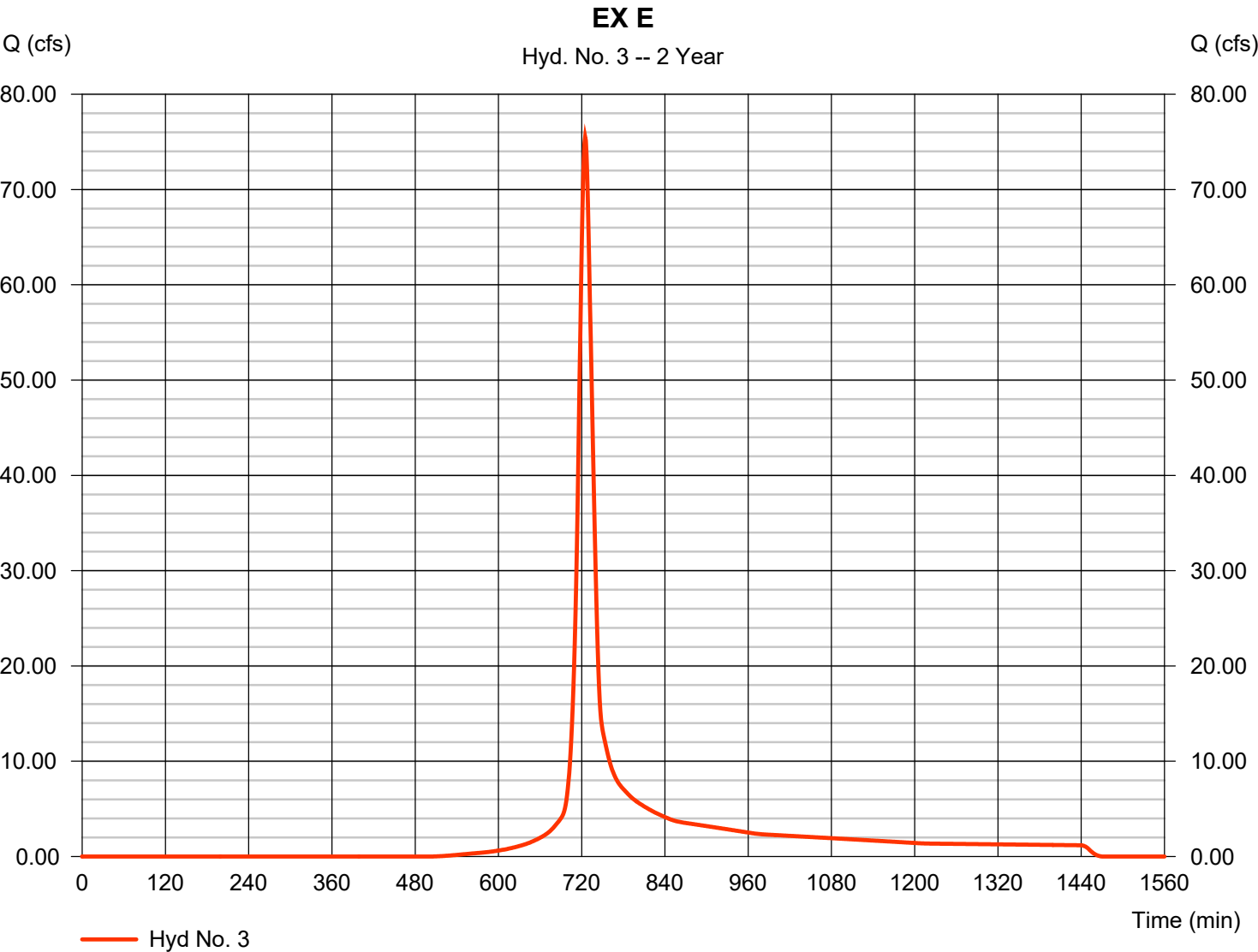
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 3

EX E

Hydrograph type	= SCS Runoff	Peak discharge	= 75.52 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 236,122 cuft
Drainage area	= 36.490 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 19.20 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

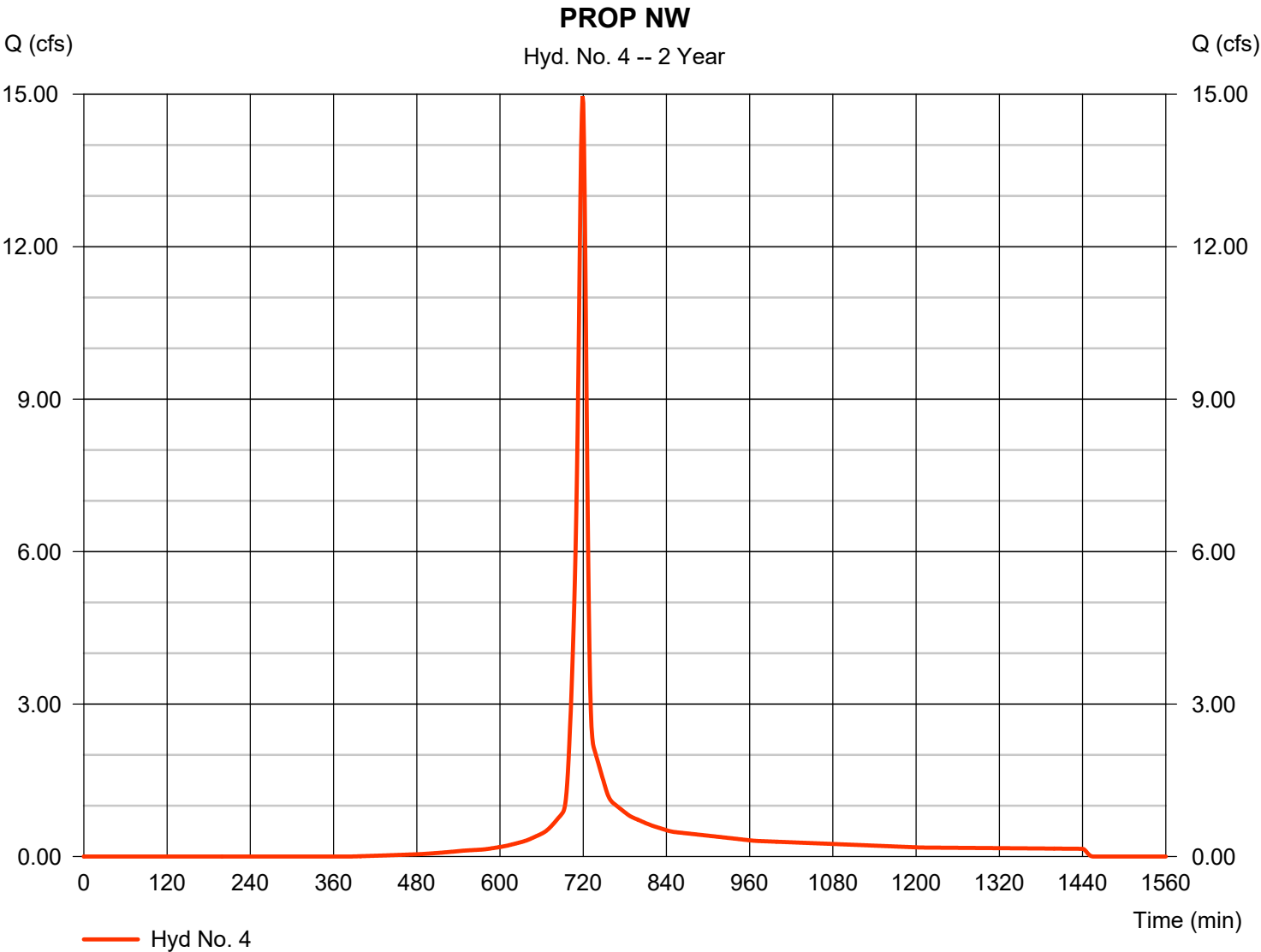
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 4

PROP NW

Hydrograph type	=	SCS Runoff	Peak discharge	=	14.96 cfs
Storm frequency	=	2 yrs	Time to peak	=	719 min
Time interval	=	1 min	Hyd. volume	=	34,303 cuft
Drainage area	=	4.330 ac	Curve number	=	87
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	9.80 min
Total precip.	=	3.50 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

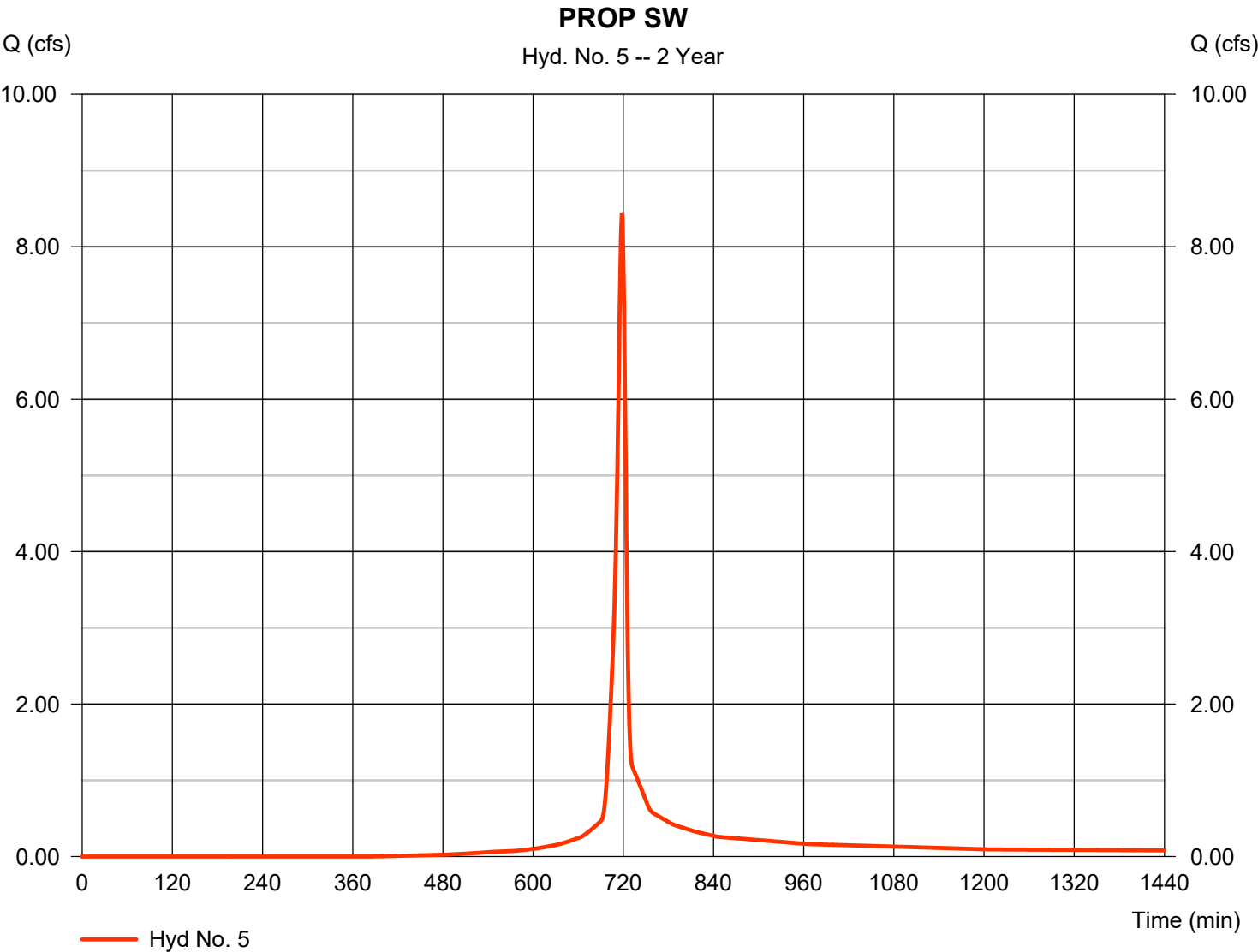
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 5

PROP SW

Hydrograph type	= SCS Runoff	Peak discharge	= 8.439 cfs
Storm frequency	= 2 yrs	Time to peak	= 718 min
Time interval	= 1 min	Hyd. volume	= 18,152 cuft
Drainage area	= 2.350 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.90 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

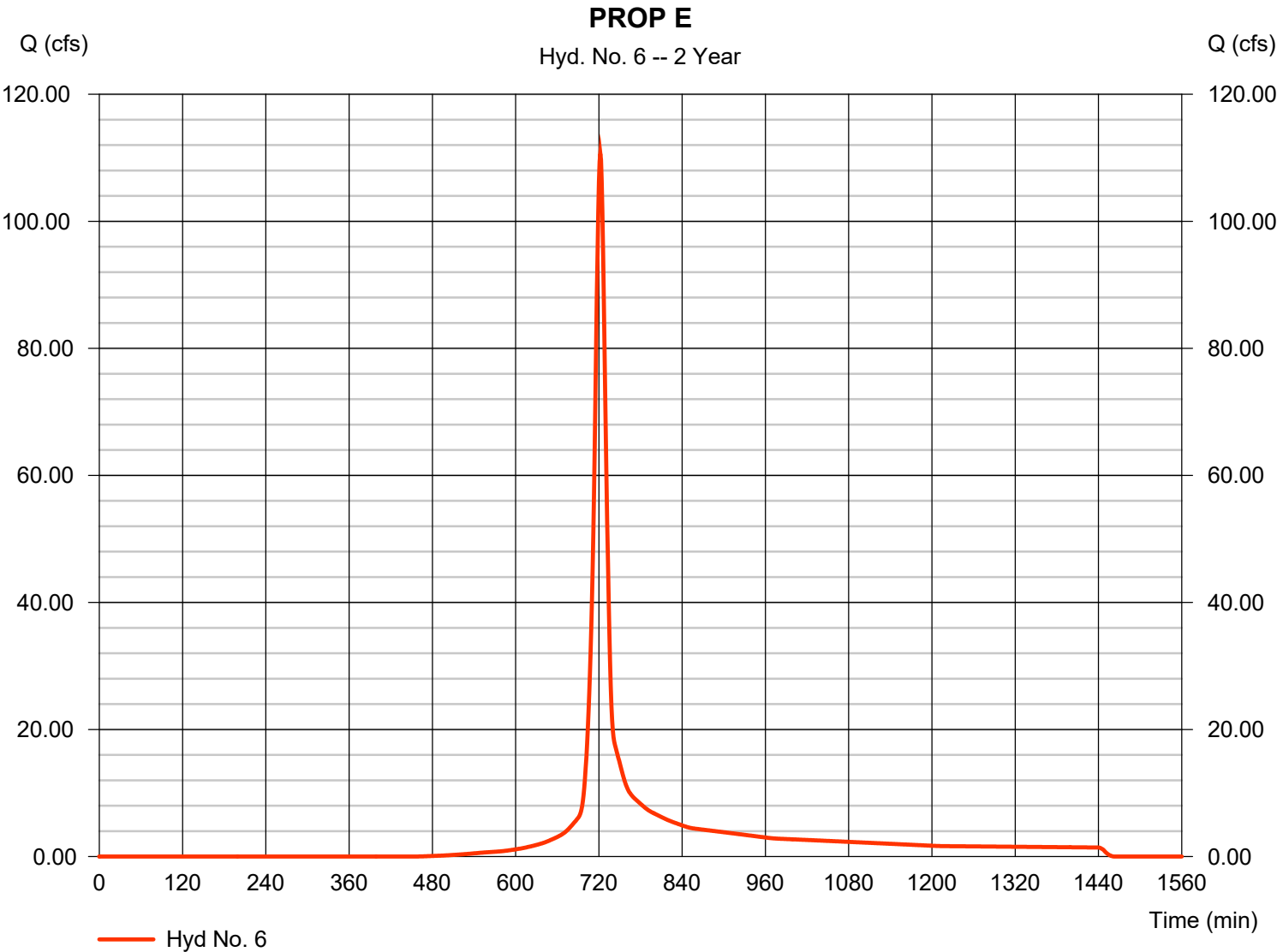
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 6

PROP E

Hydrograph type	= SCS Runoff	Peak discharge	= 110.64 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 297,624 cuft
Drainage area	= 42.340 ac	Curve number	= 84
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 14.70 min
Total precip.	= 3.50 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

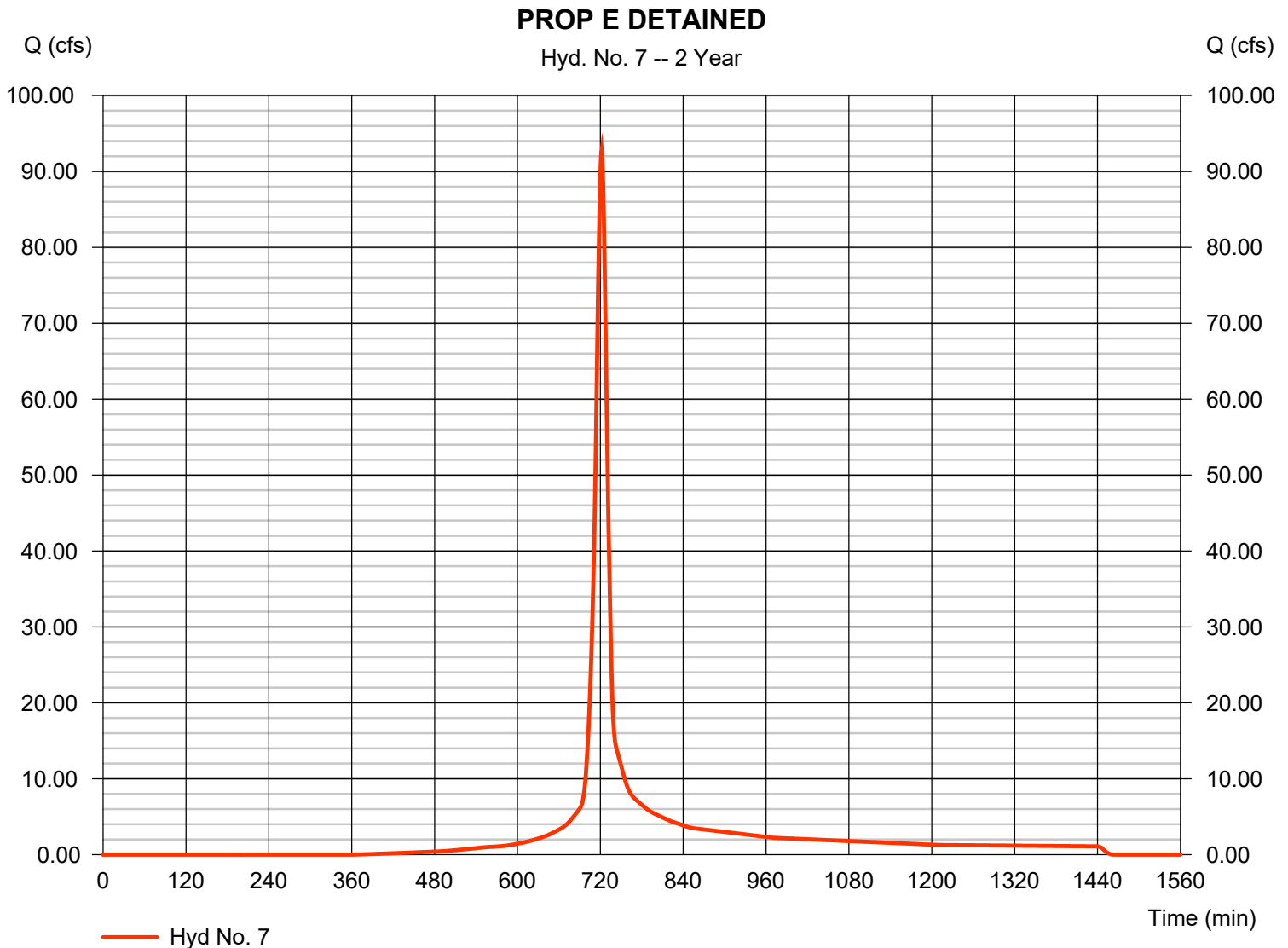
Thursday, 03 / 11 / 2021

## Hyd. No. 7

### PROP E DETAINED

Hydrograph type = SCS Runoff  
 Storm frequency = 2 yrs  
 Time interval = 1 min  
 Drainage area = 30.610 ac  
 Basin Slope = 0.0 %  
 Tc method = User  
 Total precip. = 3.50 in  
 Storm duration = 24 hrs

Peak discharge = 92.73 cfs  
 Time to peak = 722 min  
 Hyd. volume = 252,082 cuft  
 Curve number = 88  
 Hydraulic length = 0 ft  
 Time of conc. (Tc) = 14.70 min  
 Distribution = Type II  
 Shape factor = 484



# Hydrograph Report

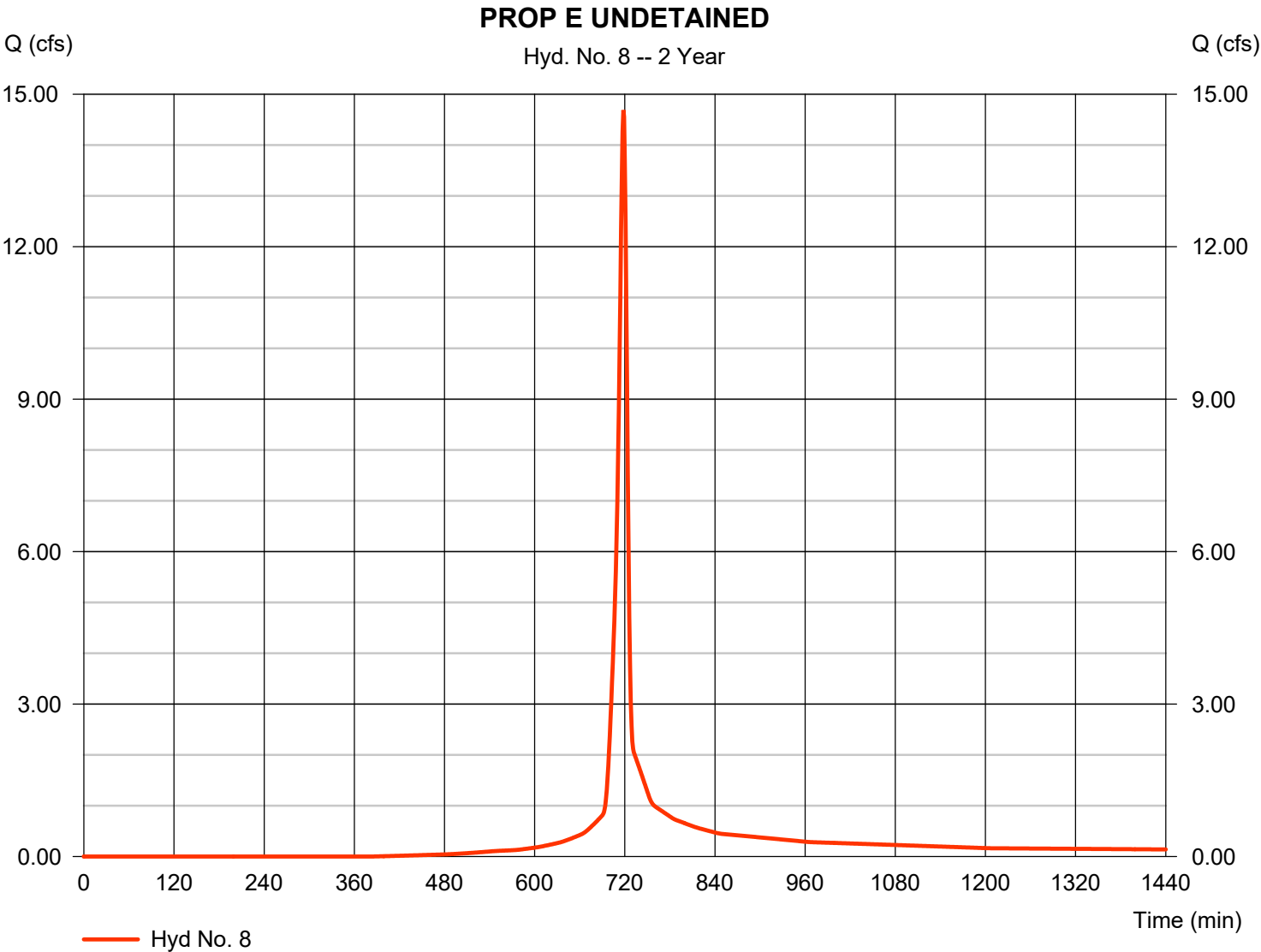
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 8

PROP E UNDETAINED

Hydrograph type	=	SCS Runoff	Peak discharge	=	14.69 cfs
Storm frequency	=	2 yrs	Time to peak	=	718 min
Time interval	=	1 min	Hyd. volume	=	31,592 cuft
Drainage area	=	4.090 ac	Curve number	=	87
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	7.80 min
Total precip.	=	3.50 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

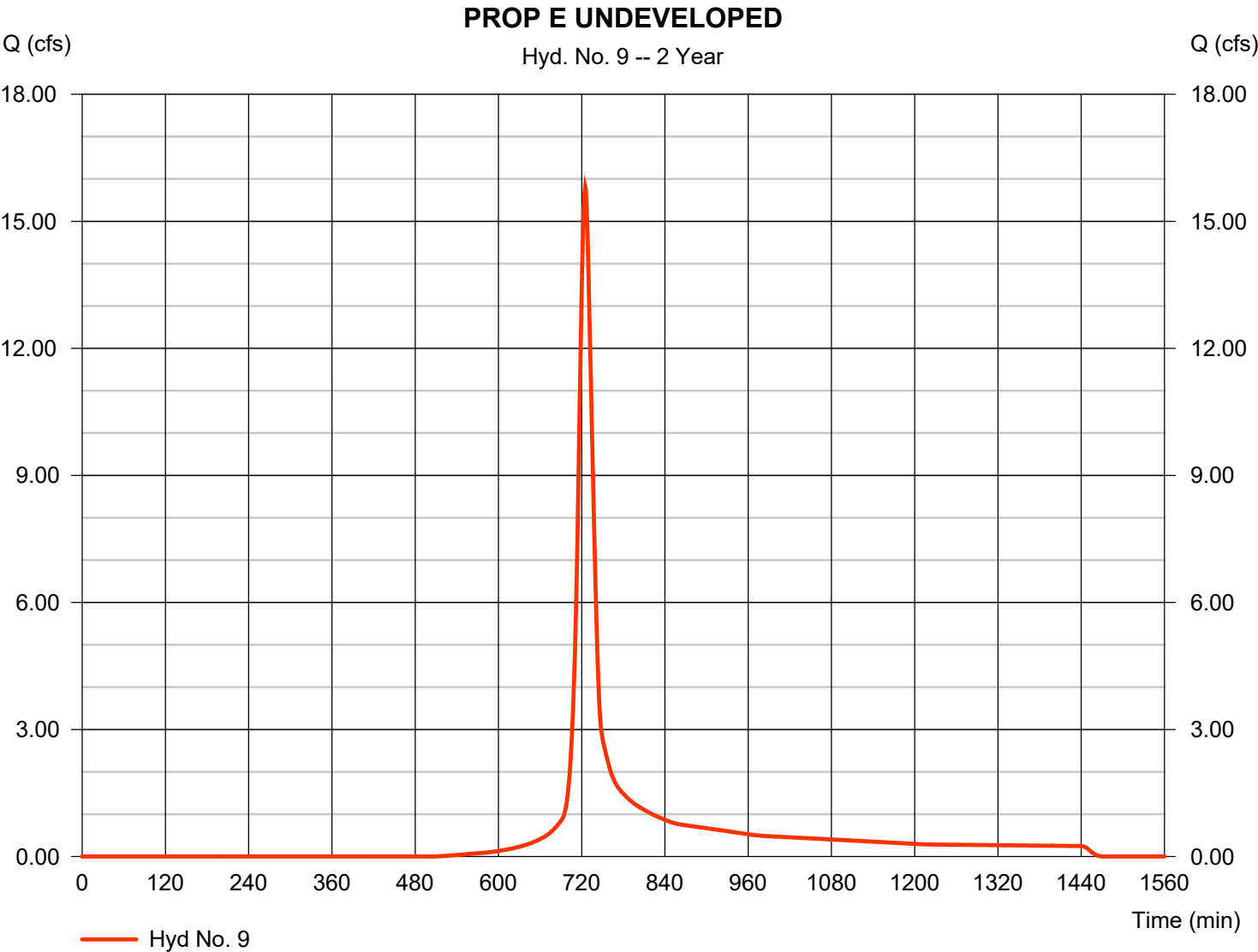
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 9

PROP E UNDEVELOPED

Hydrograph type	=	SCS Runoff	Peak discharge	=	15.81 cfs
Storm frequency	=	2 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	49,438 cuft
Drainage area	=	7.640 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	19.20 min
Total precip.	=	3.50 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

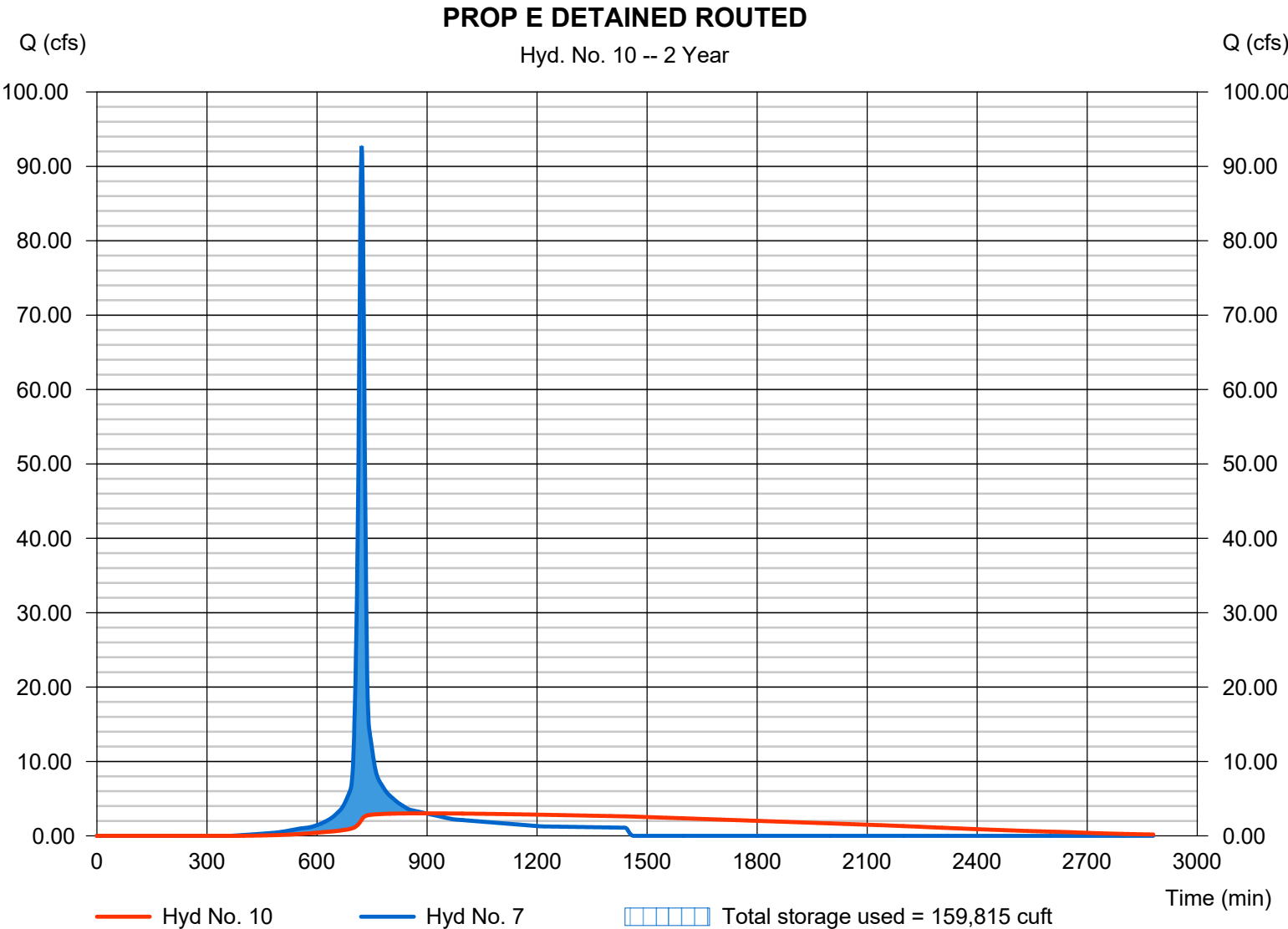
Thursday, 03 / 11 / 2021

## Hyd. No. 10

### PROP E DETAINED ROUTED

Hydrograph type	= Reservoir	Peak discharge	= 3.020 cfs
Storm frequency	= 2 yrs	Time to peak	= 897 min
Time interval	= 1 min	Hyd. volume	= 249,610 cuft
Inflow hyd. No.	= 7 - PROP E DETAINED	Max. Elevation	= 983.74 ft
Reservoir name	= RP 2 AS-BUILT	Max. Storage	= 159,815 cuft

Storage Indication method used.





# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

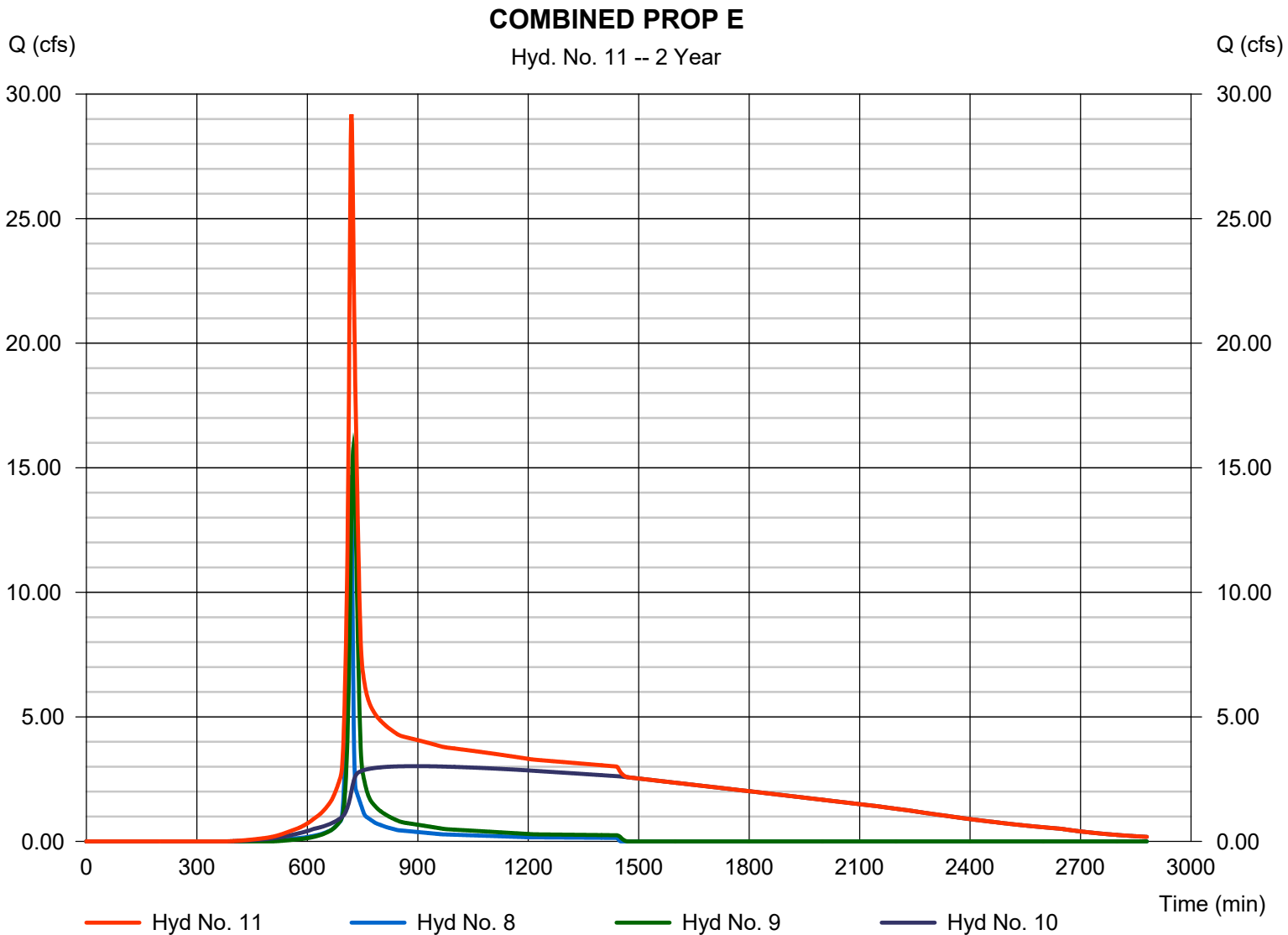
Thursday, 03 / 11 / 2021

## Hyd. No. 11

### COMBINED PROP E

Hydrograph type = Combine  
 Storm frequency = 2 yrs  
 Time interval = 1 min  
 Inflow hyds. = 8, 9, 10

Peak discharge = 29.19 cfs  
 Time to peak = 720 min  
 Hyd. volume = 330,639 cuft  
 Contrib. drain. area = 11.730 ac



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

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	21.04	1	719	48,261	-----	-----	-----	EX NW
2	SCS Runoff	34.45	1	721	87,910	-----	-----	-----	EX SW
3	SCS Runoff	137.68	1	725	431,625	-----	-----	-----	EX E
4	SCS Runoff	25.12	1	719	59,037	-----	-----	-----	PROP NW
5	SCS Runoff	14.14	1	718	31,240	-----	-----	-----	PROP SW
6	SCS Runoff	194.69	1	722	530,841	-----	-----	-----	PROP E
7	SCS Runoff	154.22	1	722	428,815	-----	-----	-----	PROP E DETAINED
8	SCS Runoff	24.61	1	718	54,370	-----	-----	-----	PROP E UNDETAINED
9	SCS Runoff	28.83	1	725	90,370	-----	-----	-----	PROP E UNDEVELOPED
10	Reservoir	10.23	1	782	419,608	7	984.49	252,616	PROP E DETAINED ROUTED
11	Combine	50.69	1	720	564,349	8, 9, 10	-----	-----	COMBINED PROP E
NAPA VALLEY 2ND AS-BUILT 210312.gpw					Return Period: 10 Year			Thursday, 03 / 11 / 2021	

# Hydrograph Report

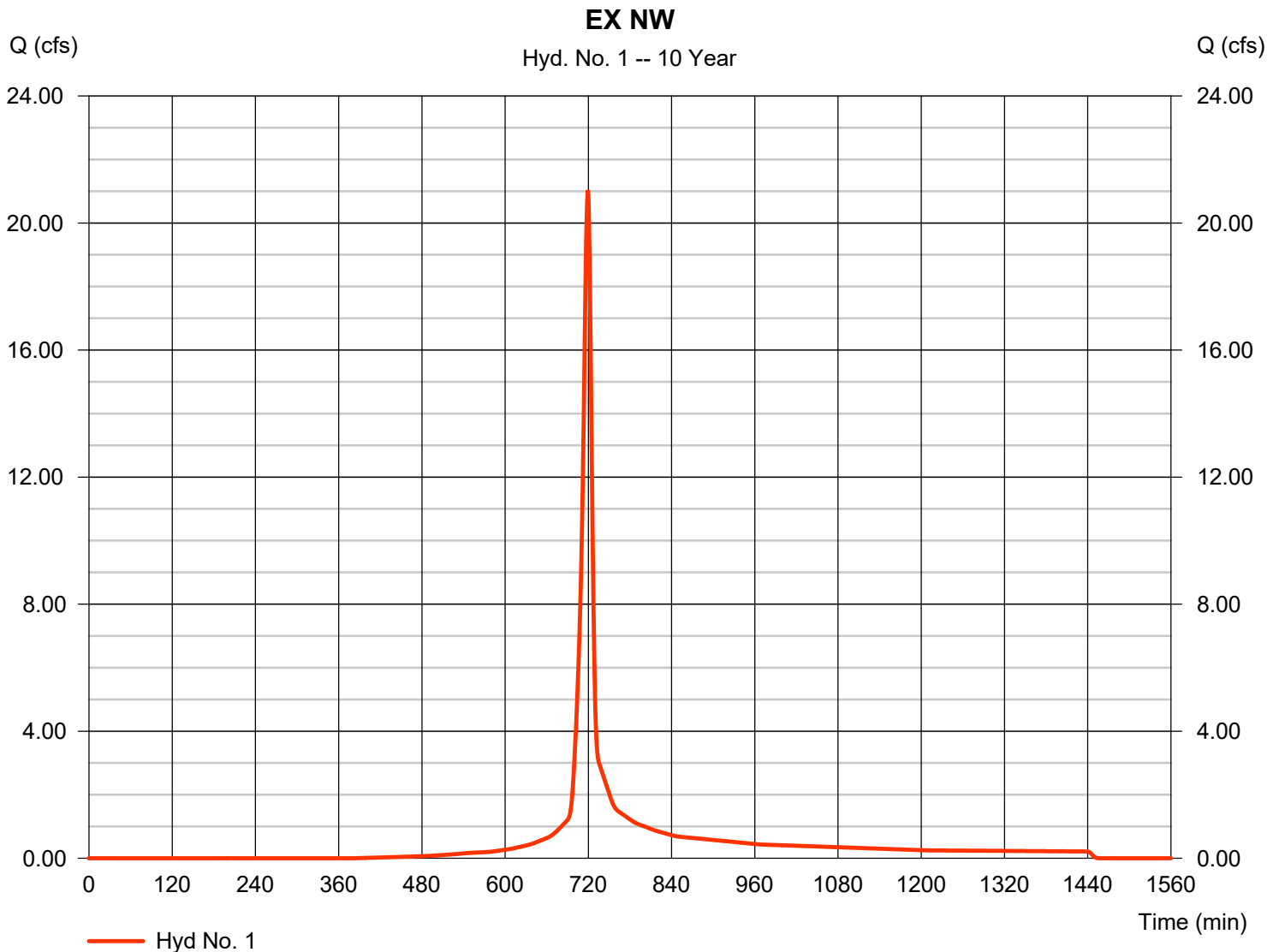
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 1

EX NW

Hydrograph type	= SCS Runoff	Peak discharge	= 21.04 cfs
Storm frequency	= 10 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 48,261 cuft
Drainage area	= 4.080 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 8.70 min
Total precip.	= 5.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

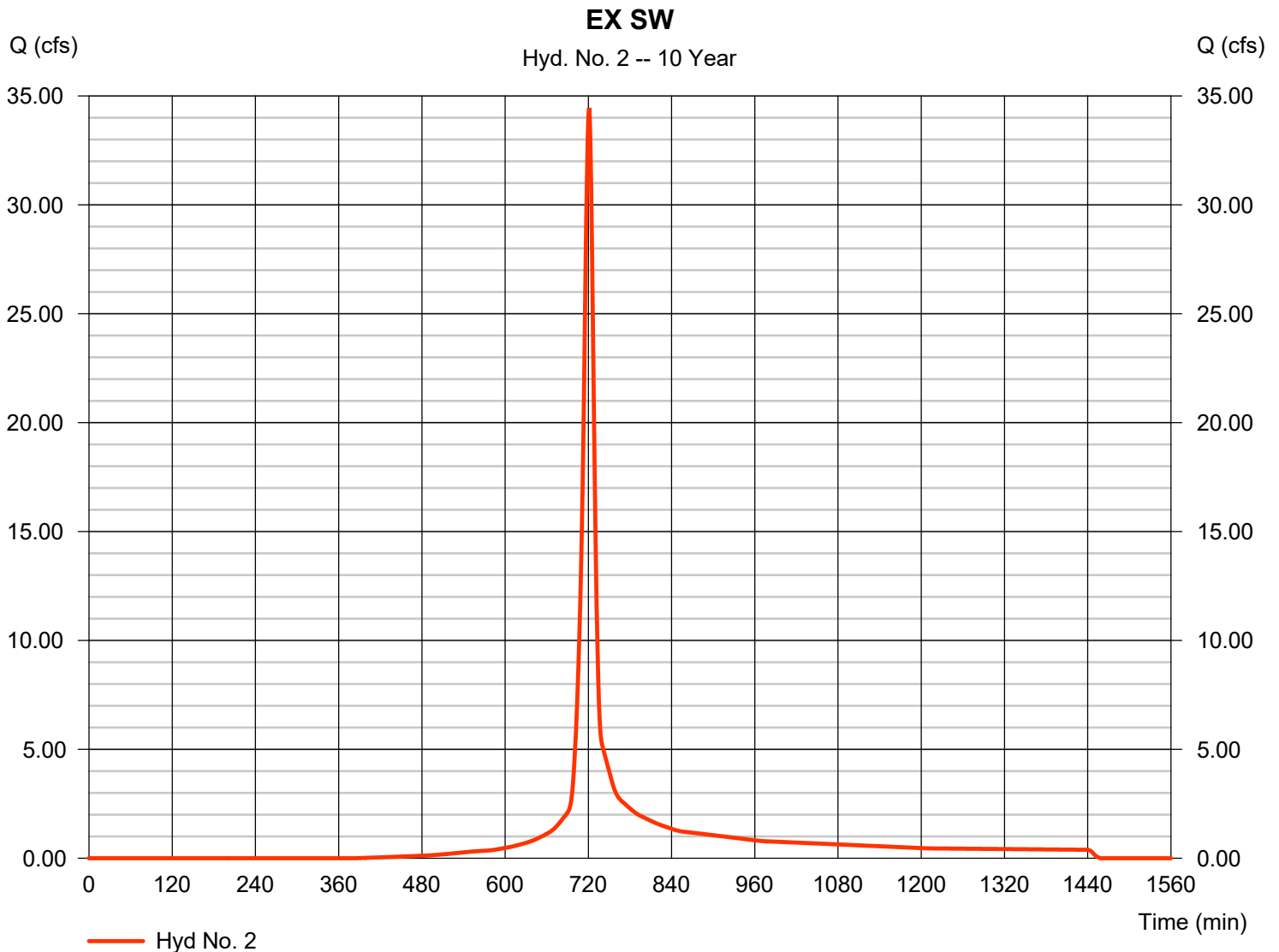
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 2

EX SW

Hydrograph type	= SCS Runoff	Peak discharge	= 34.45 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 87,910 cuft
Drainage area	= 7.550 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 12.10 min
Total precip.	= 5.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

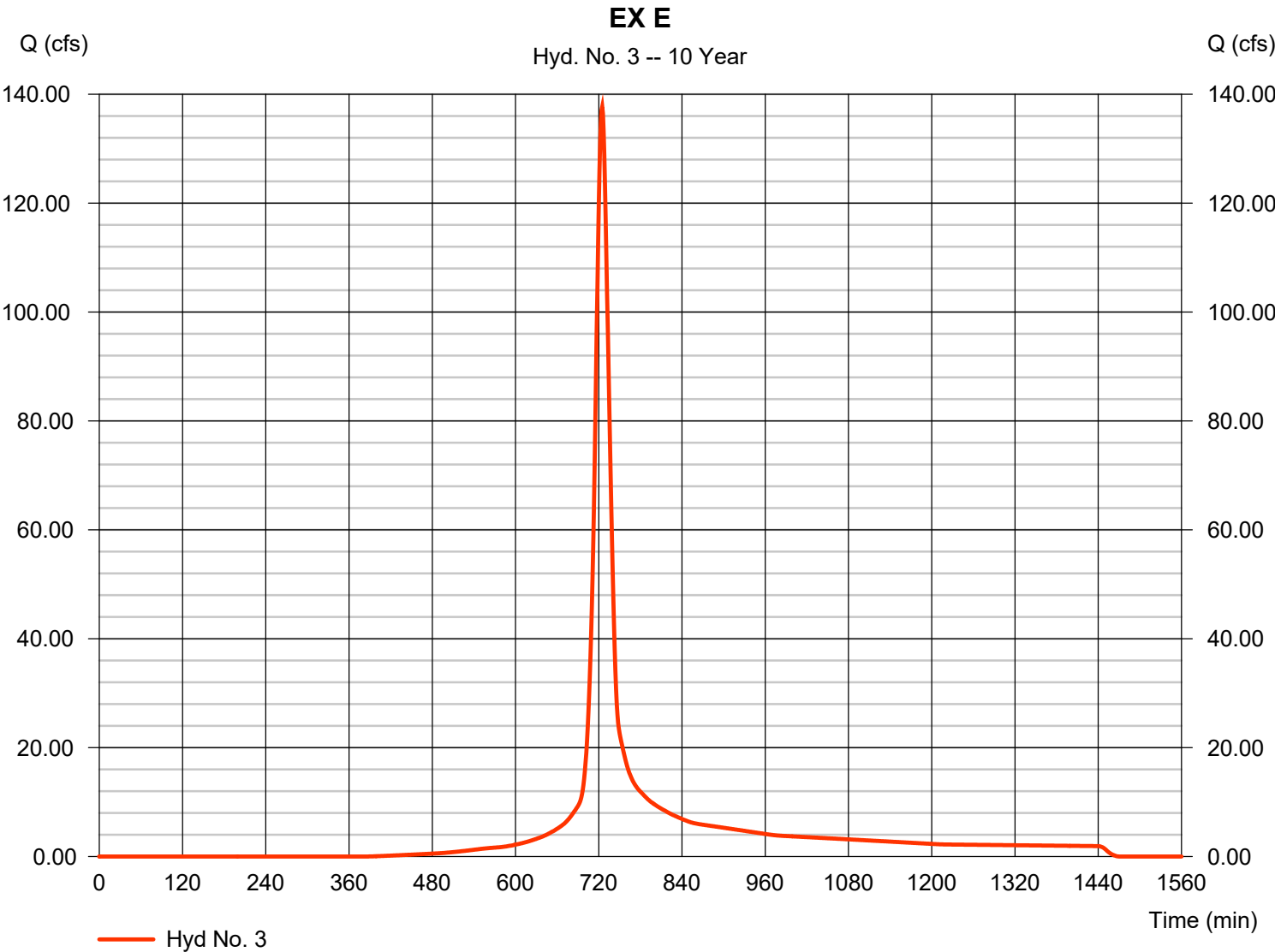
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 3

EX E

Hydrograph type	= SCS Runoff	Peak discharge	= 137.68 cfs
Storm frequency	= 10 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 431,625 cuft
Drainage area	= 36.490 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 19.20 min
Total precip.	= 5.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

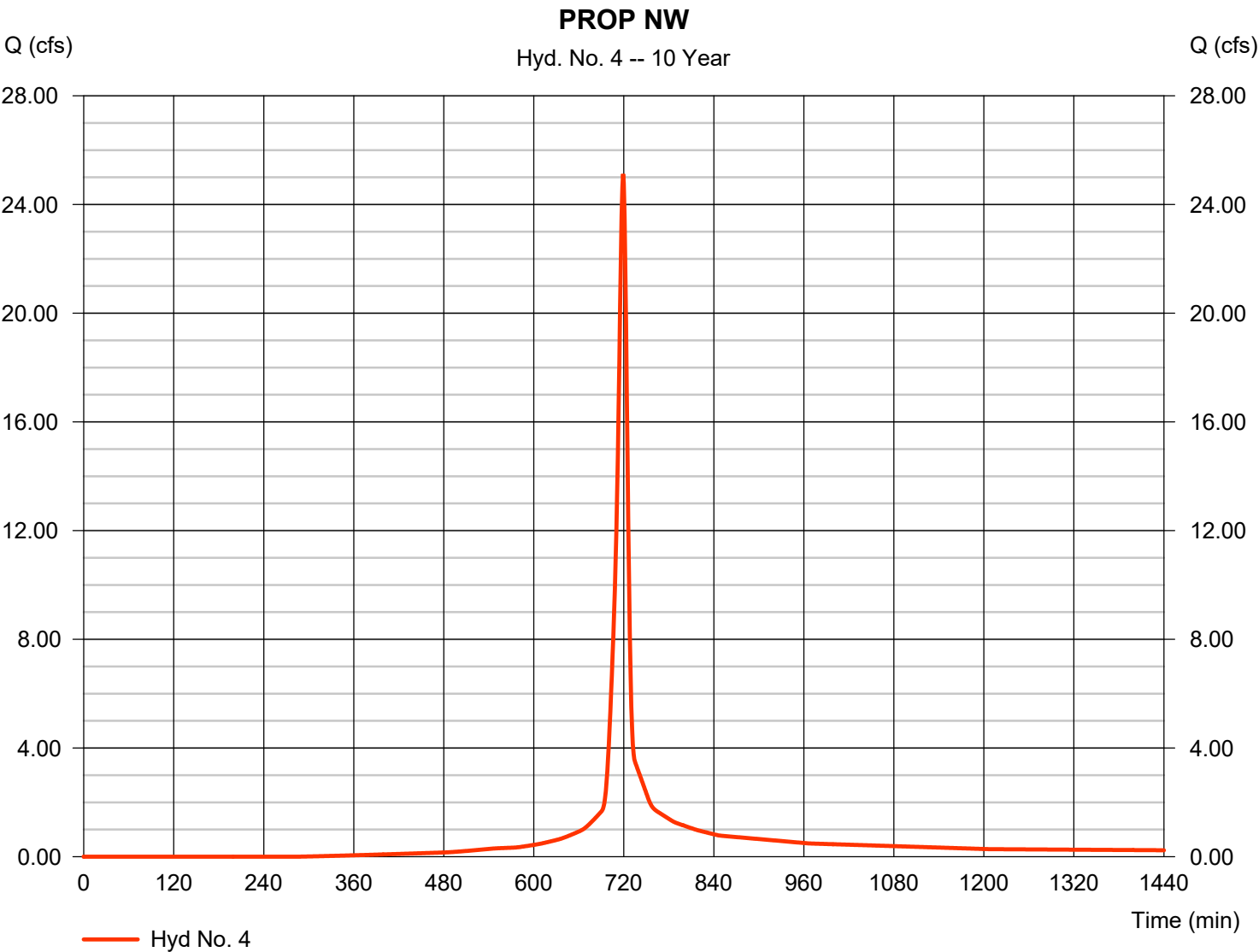
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 4

PROP NW

Hydrograph type	= SCS Runoff	Peak discharge	= 25.12 cfs
Storm frequency	= 10 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 59,037 cuft
Drainage area	= 4.330 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 9.80 min
Total precip.	= 5.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

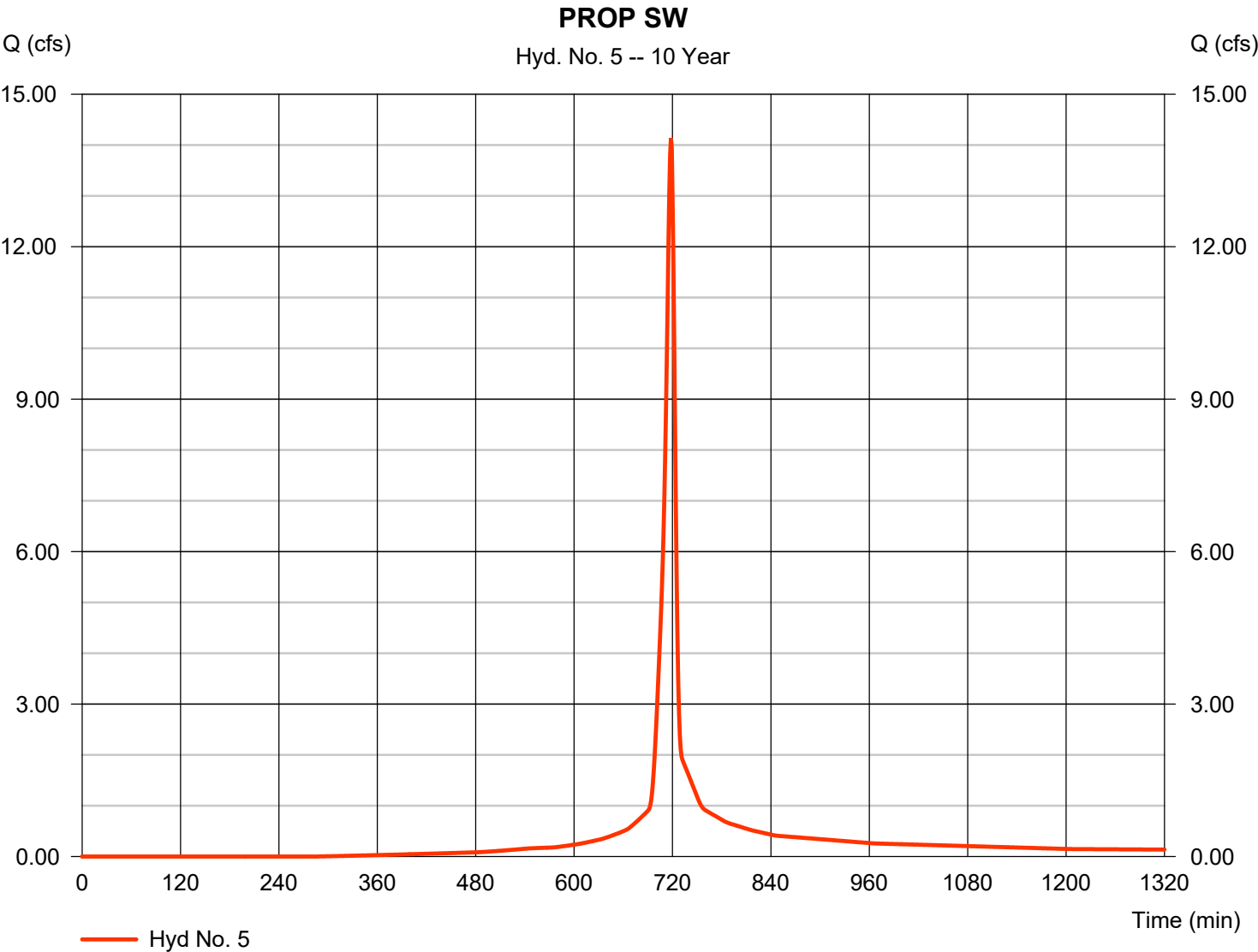
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 5

PROP SW

Hydrograph type	= SCS Runoff	Peak discharge	= 14.14 cfs
Storm frequency	= 10 yrs	Time to peak	= 718 min
Time interval	= 1 min	Hyd. volume	= 31,240 cuft
Drainage area	= 2.350 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.90 min
Total precip.	= 5.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

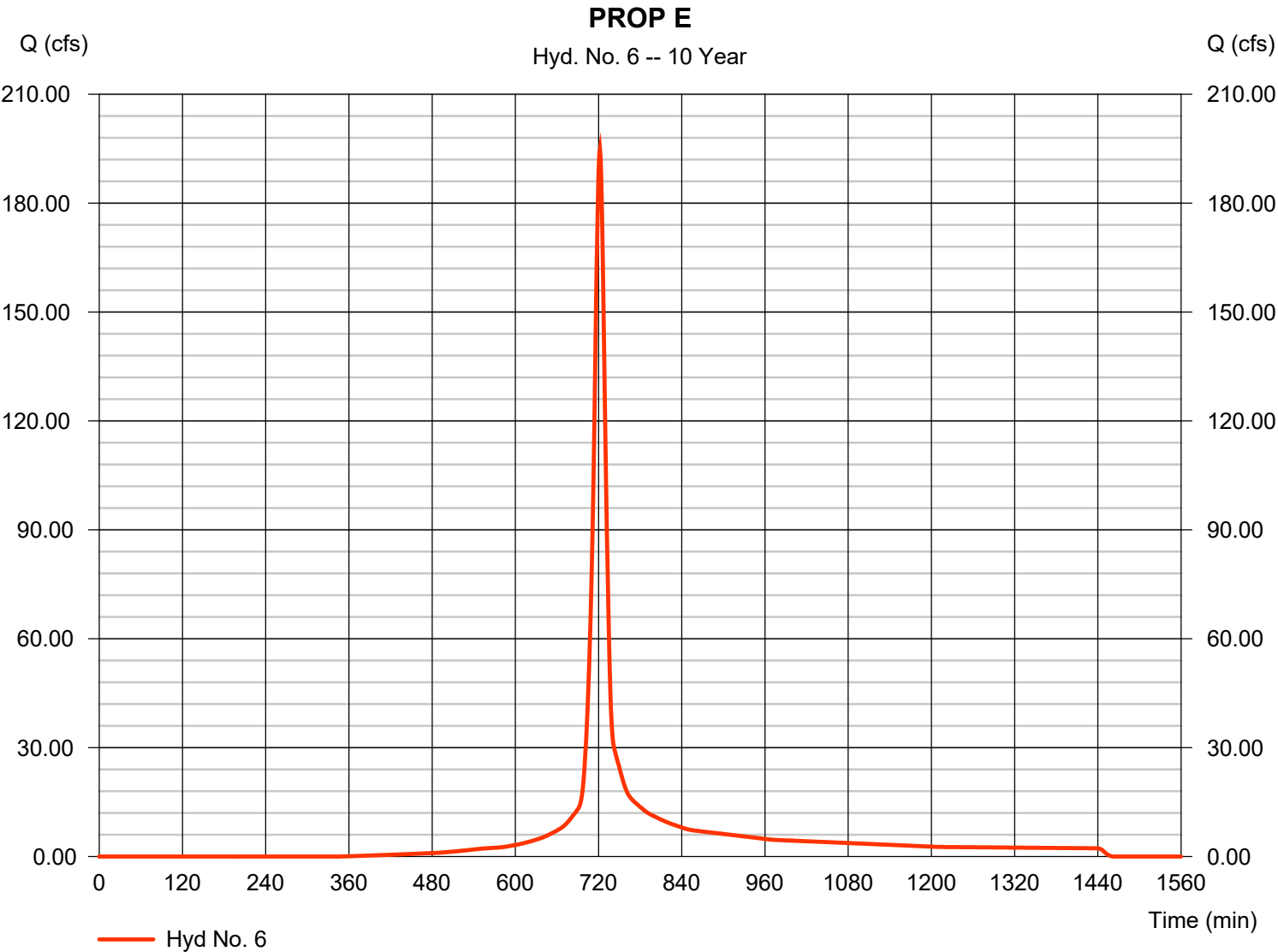
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 6

PROP E

Hydrograph type	= SCS Runoff	Peak discharge	= 194.69 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 530,841 cuft
Drainage area	= 42.340 ac	Curve number	= 84
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 14.70 min
Total precip.	= 5.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484





# Hydrograph Report

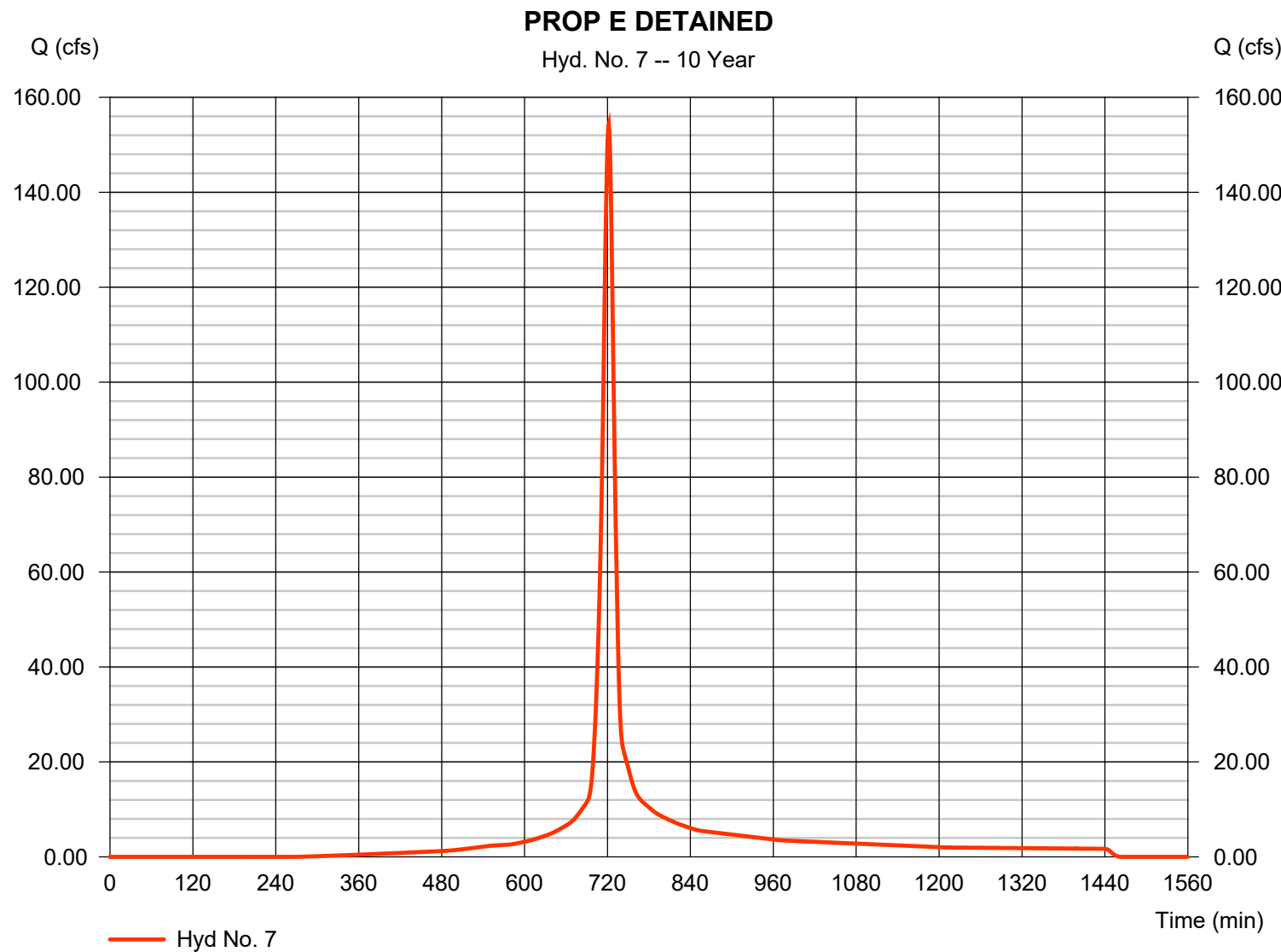
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 7

### PROP E DETAINED

Hydrograph type	= SCS Runoff	Peak discharge	= 154.22 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 428,815 cuft
Drainage area	= 30.610 ac	Curve number	= 88
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 14.70 min
Total precip.	= 5.20 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

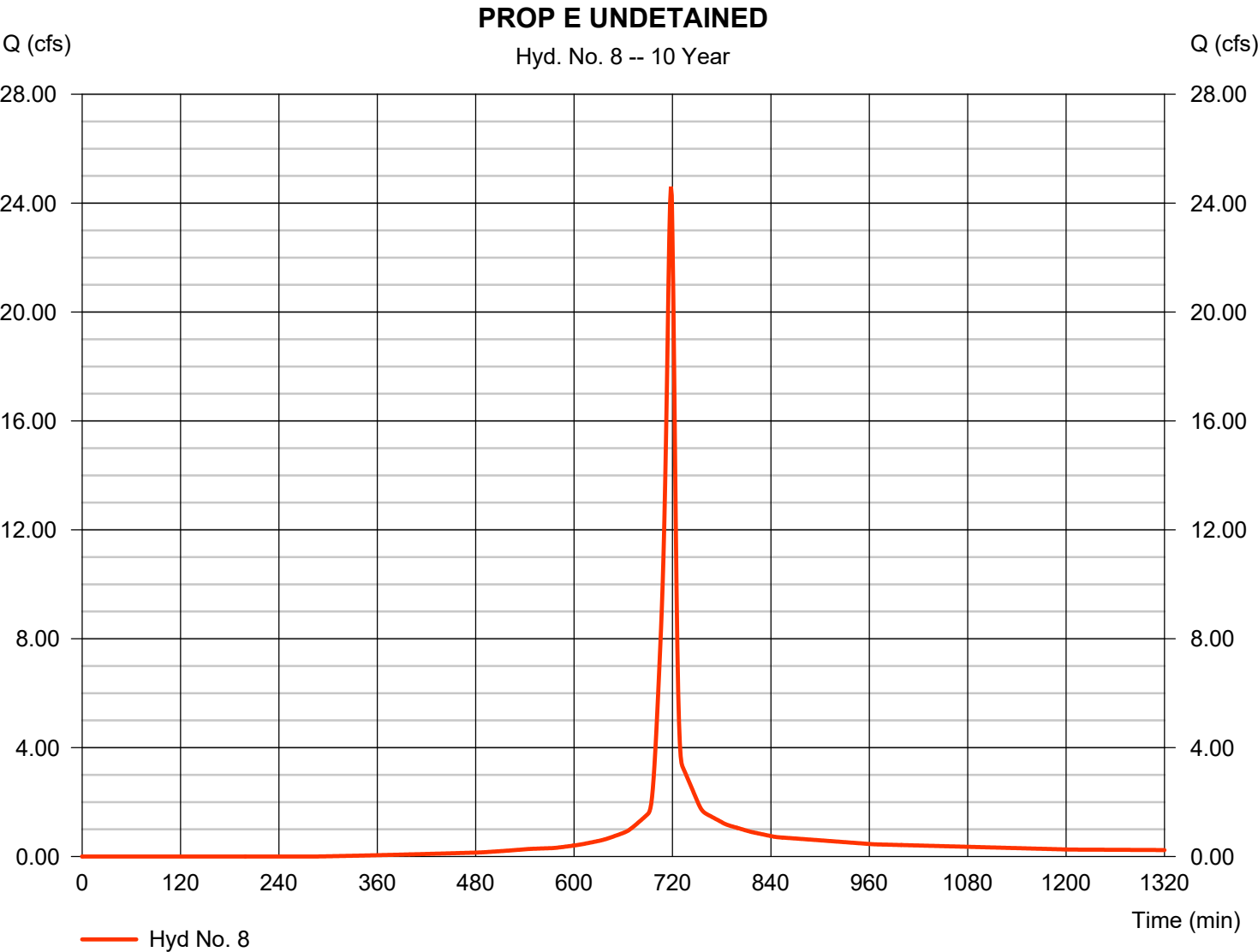
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 8

PROP E UNDETAINED

Hydrograph type	=	SCS Runoff	Peak discharge	=	24.61 cfs
Storm frequency	=	10 yrs	Time to peak	=	718 min
Time interval	=	1 min	Hyd. volume	=	54,370 cuft
Drainage area	=	4.090 ac	Curve number	=	87
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	7.80 min
Total precip.	=	5.20 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

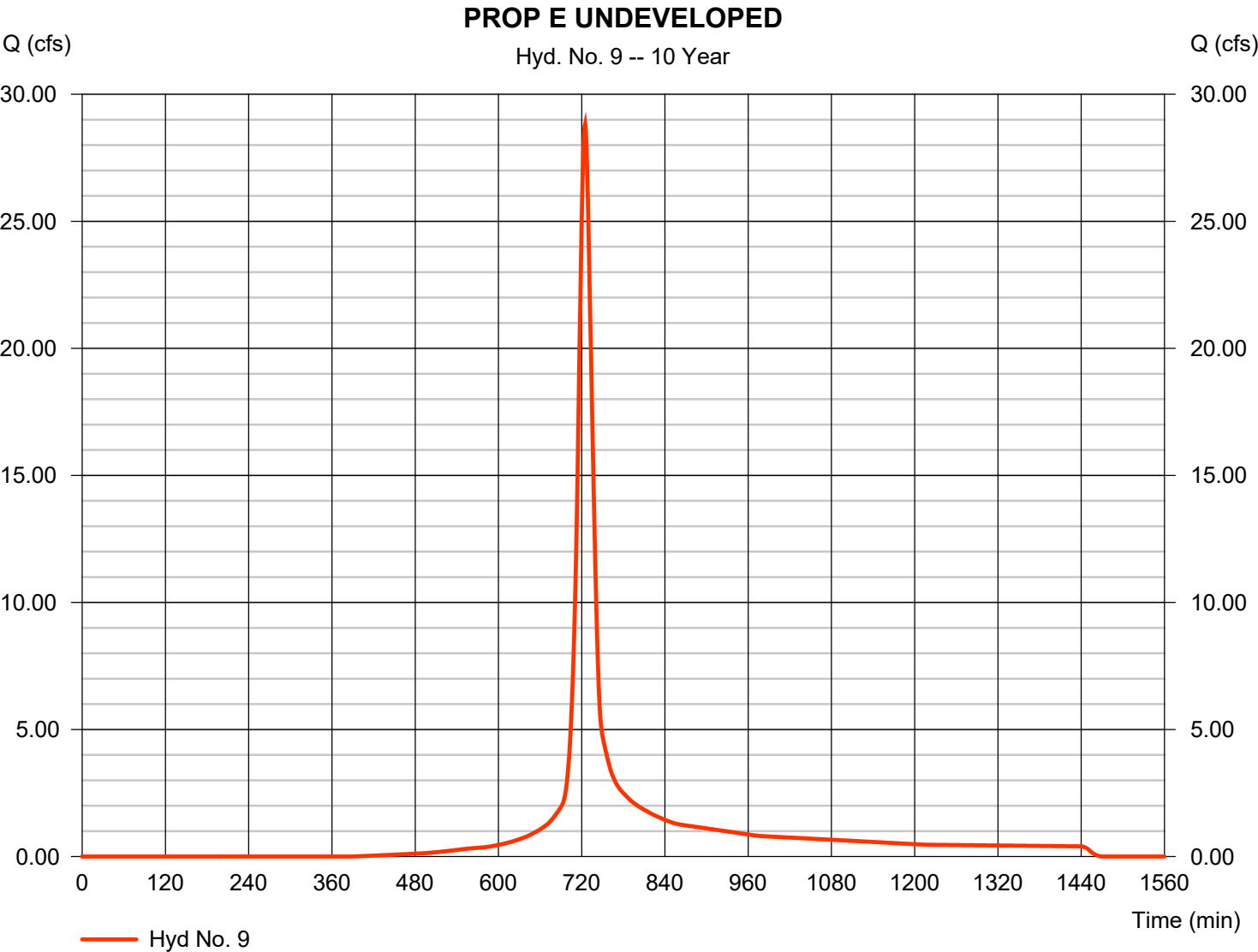
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 9

PROP E UNDEVELOPED

Hydrograph type	=	SCS Runoff	Peak discharge	=	28.83 cfs
Storm frequency	=	10 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	90,370 cuft
Drainage area	=	7.640 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	19.20 min
Total precip.	=	5.20 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 10

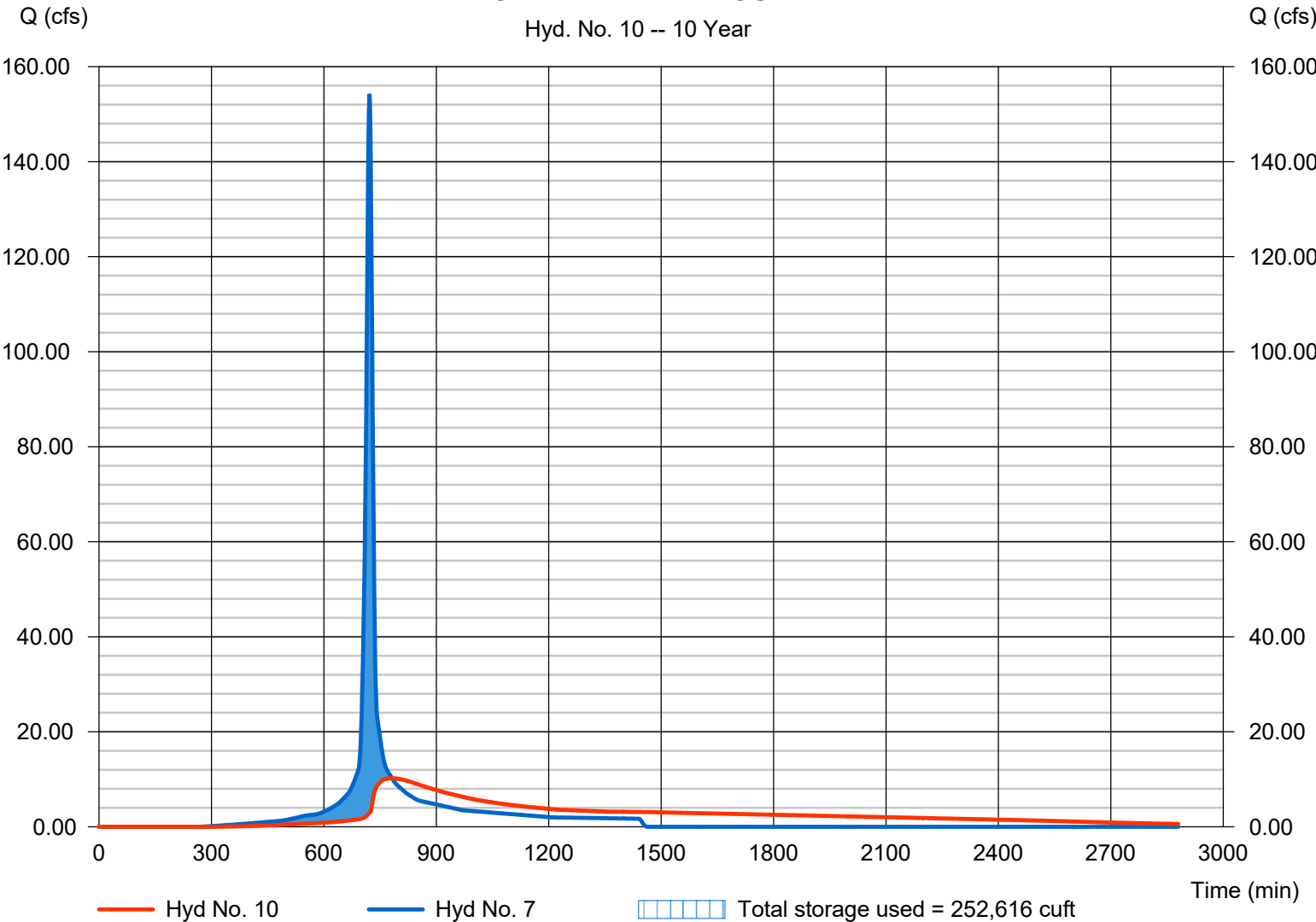
PROP E DETAINED ROUTED

Hydrograph type	= Reservoir	Peak discharge	= 10.23 cfs
Storm frequency	= 10 yrs	Time to peak	= 782 min
Time interval	= 1 min	Hyd. volume	= 419,608 cuft
Inflow hyd. No.	= 7 - PROP E DETAINED	Max. Elevation	= 984.49 ft
Reservoir name	= RP 2 AS-BUILT	Max. Storage	= 252,616 cuft

Storage Indication method used.

### PROP E DETAINED ROUTED

Hyd. No. 10 -- 10 Year

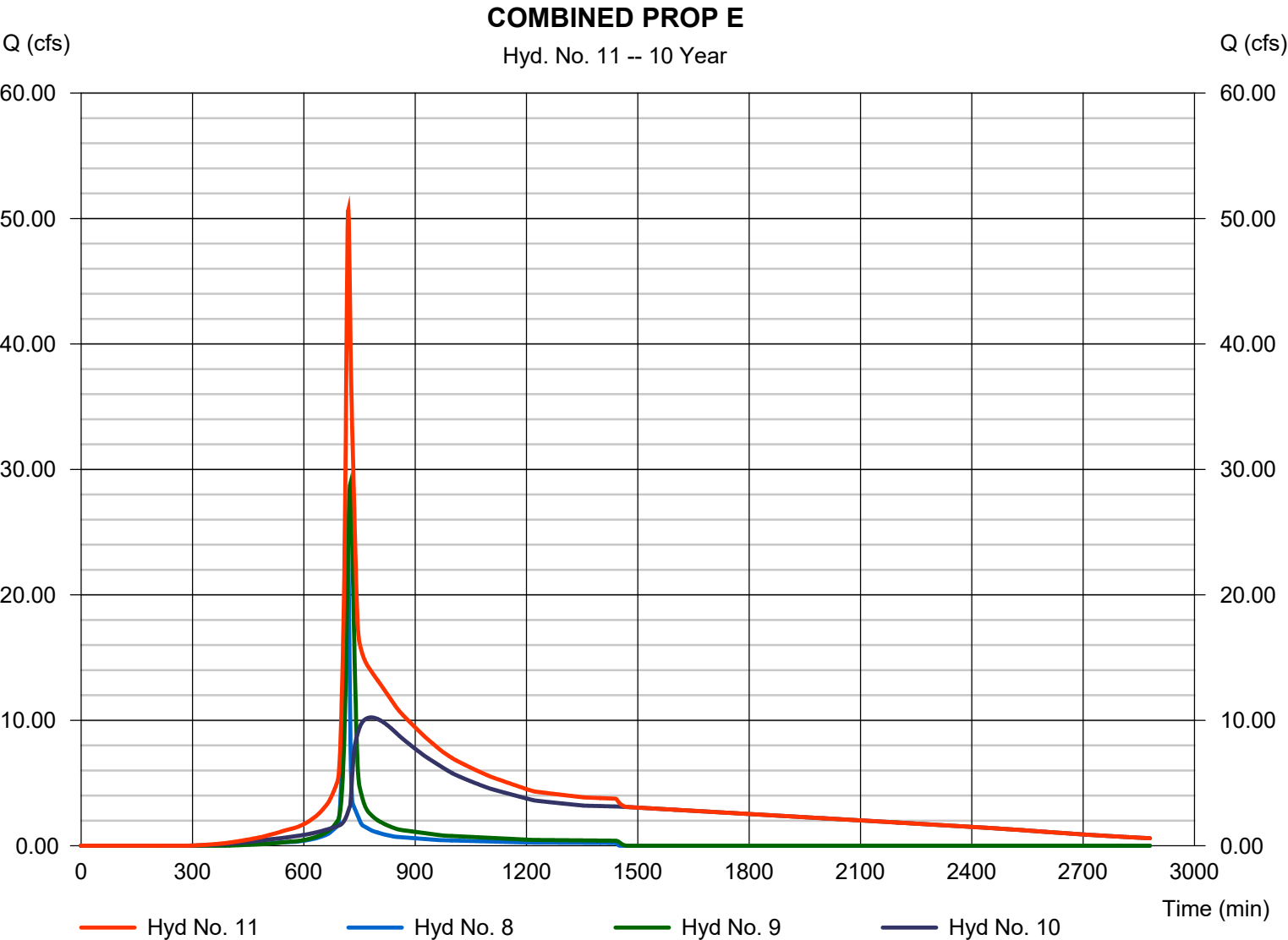


# Hydrograph Report

## Hyd. No. 11

### COMBINED PROP E

Hydrograph type	= Combine	Peak discharge	= 50.69 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 564,349 cuft
Inflow hyds.	= 8, 9, 10	Contrib. drain. area	= 11.730 ac



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

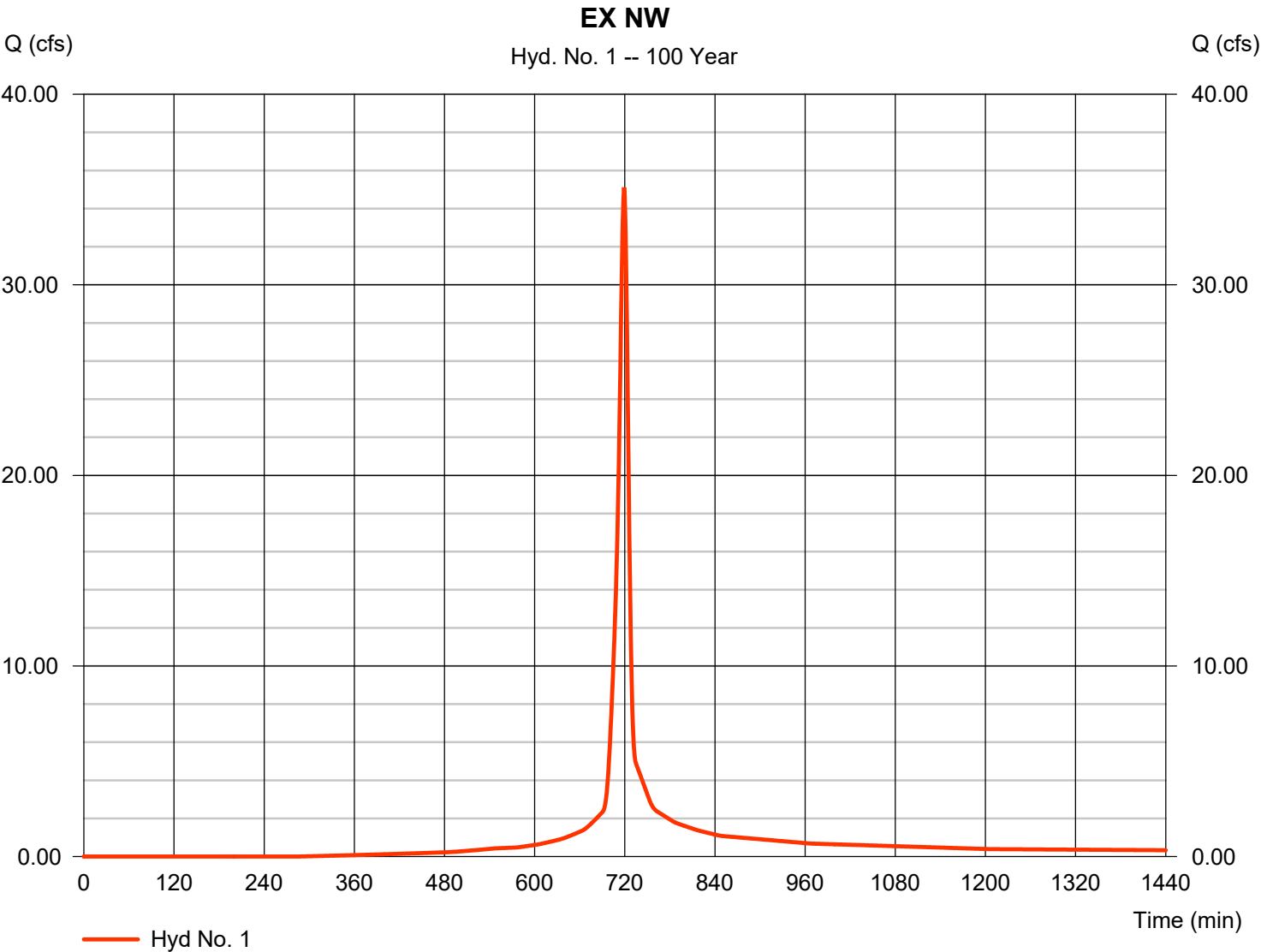
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	35.12	1	719	82,574	-----	-----	-----	EX NW
2	SCS Runoff	57.64	1	721	150,415	-----	-----	-----	EX SW
3	SCS Runoff	231.61	1	725	738,514	-----	-----	-----	EX E
4	SCS Runoff	39.99	1	719	96,789	-----	-----	-----	PROP NW
5	SCS Runoff	22.48	1	718	51,217	-----	-----	-----	PROP SW
6	SCS Runoff	319.79	1	722	892,599	-----	-----	-----	PROP E
7	SCS Runoff	244.07	1	722	697,260	-----	-----	-----	PROP E DETAINED
8	SCS Runoff	39.13	1	718	89,139	-----	-----	-----	PROP E UNDETAINED
9	SCS Runoff	48.49	1	725	154,625	-----	-----	-----	PROP E UNDEVELOPED
10	Reservoir	34.31	1	744	684,160	7	985.48	381,676	PROP E DETAINED ROUTED
11	Combine	88.15	1	721	927,923	8, 9, 10	-----	-----	COMBINED PROP E
NAPA VALLEY 2ND AS-BUILT 210312.gpw					Return Period: 100 Year			Thursday, 03 / 11 / 2021	

# Hydrograph Report

## Hyd. No. 1

EX NW

Hydrograph type	= SCS Runoff	Peak discharge	= 35.12 cfs
Storm frequency	= 100 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 82,574 cuft
Drainage area	= 4.080 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 8.70 min
Total precip.	= 7.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

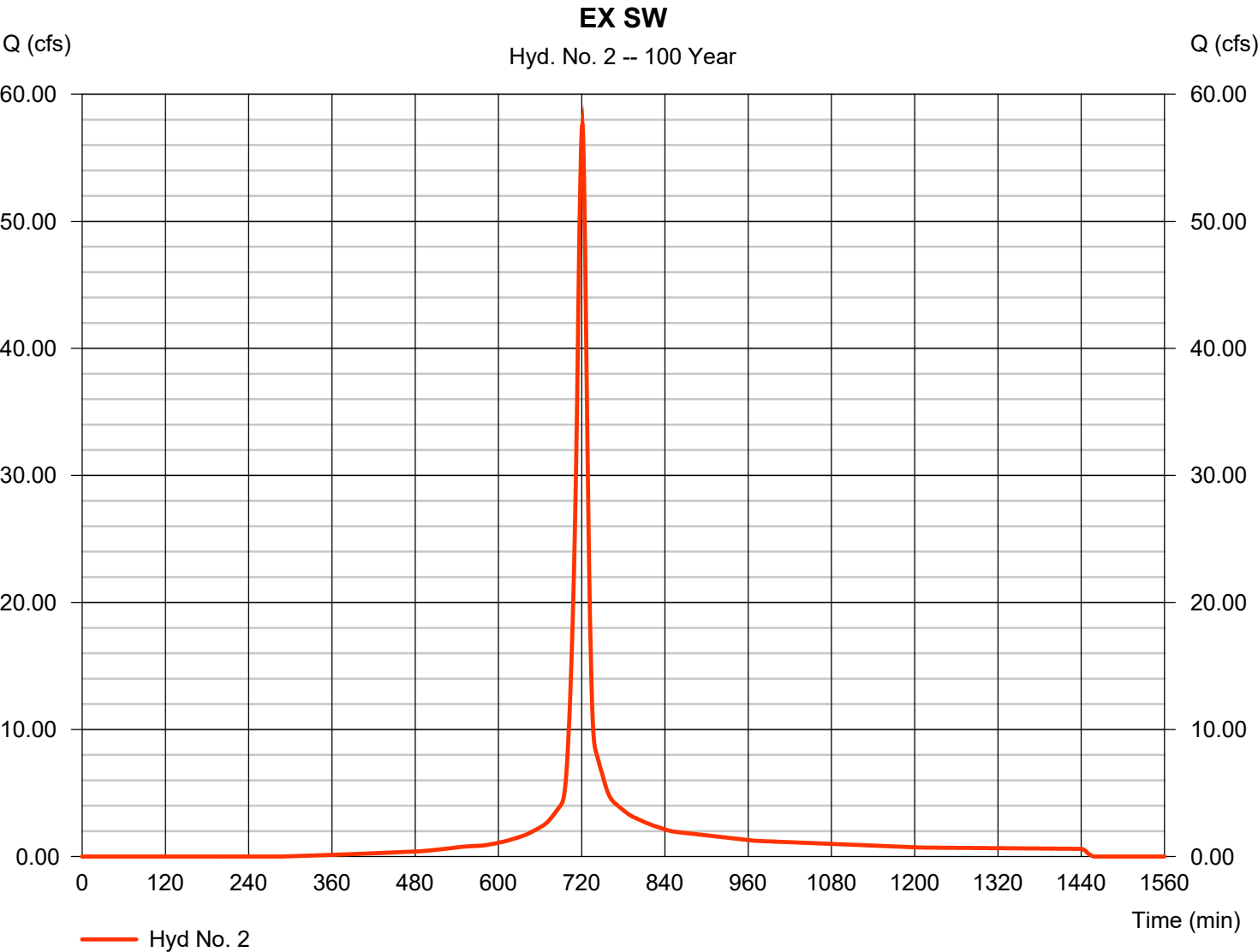


# Hydrograph Report

## Hyd. No. 2

EX SW

Hydrograph type	= SCS Runoff	Peak discharge	= 57.64 cfs
Storm frequency	= 100 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 150,415 cuft
Drainage area	= 7.550 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 12.10 min
Total precip.	= 7.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484





# Hydrograph Report

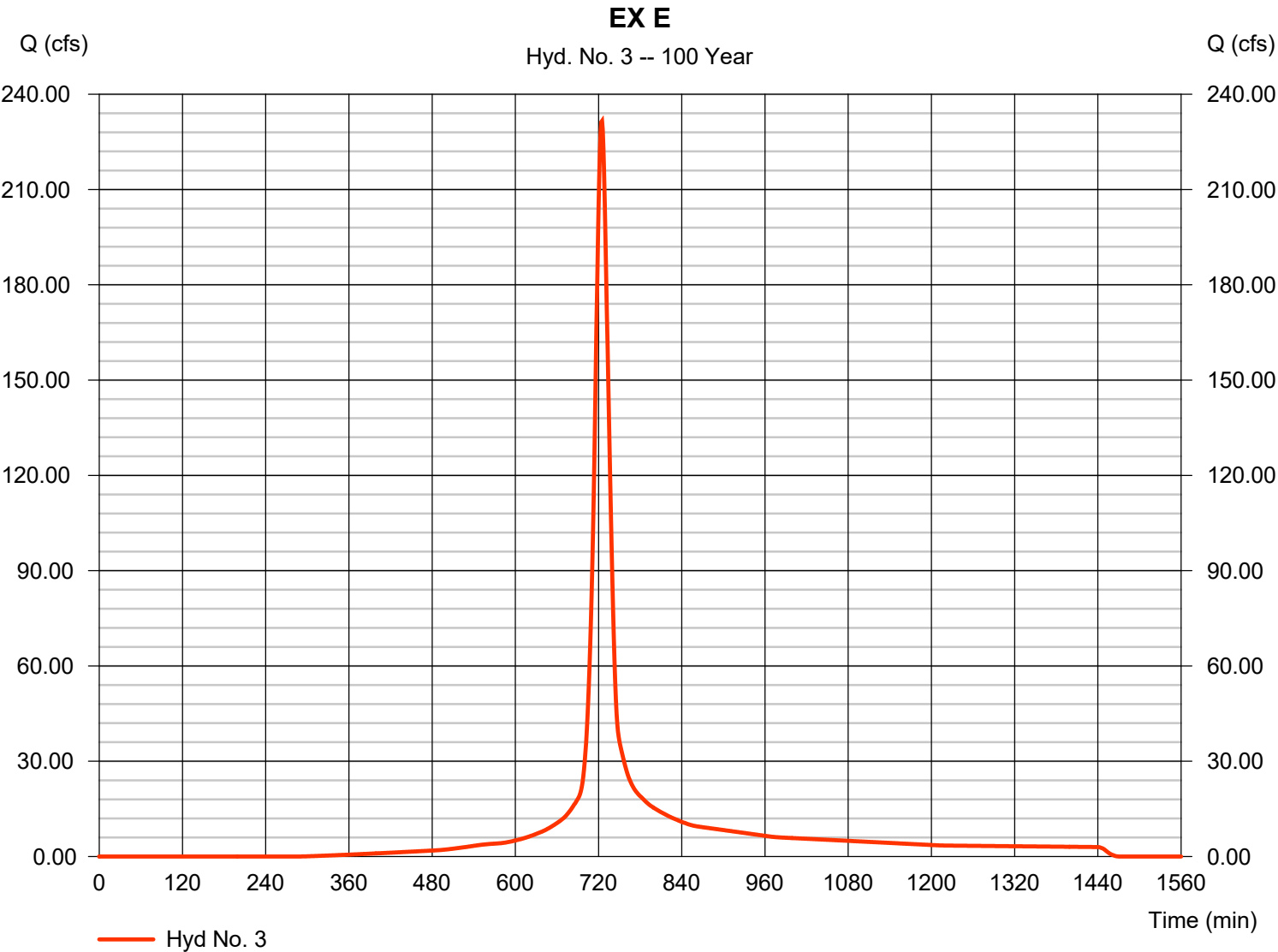
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 3

EX E

Hydrograph type	= SCS Runoff	Peak discharge	= 231.61 cfs
Storm frequency	= 100 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 738,514 cuft
Drainage area	= 36.490 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 19.20 min
Total precip.	= 7.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

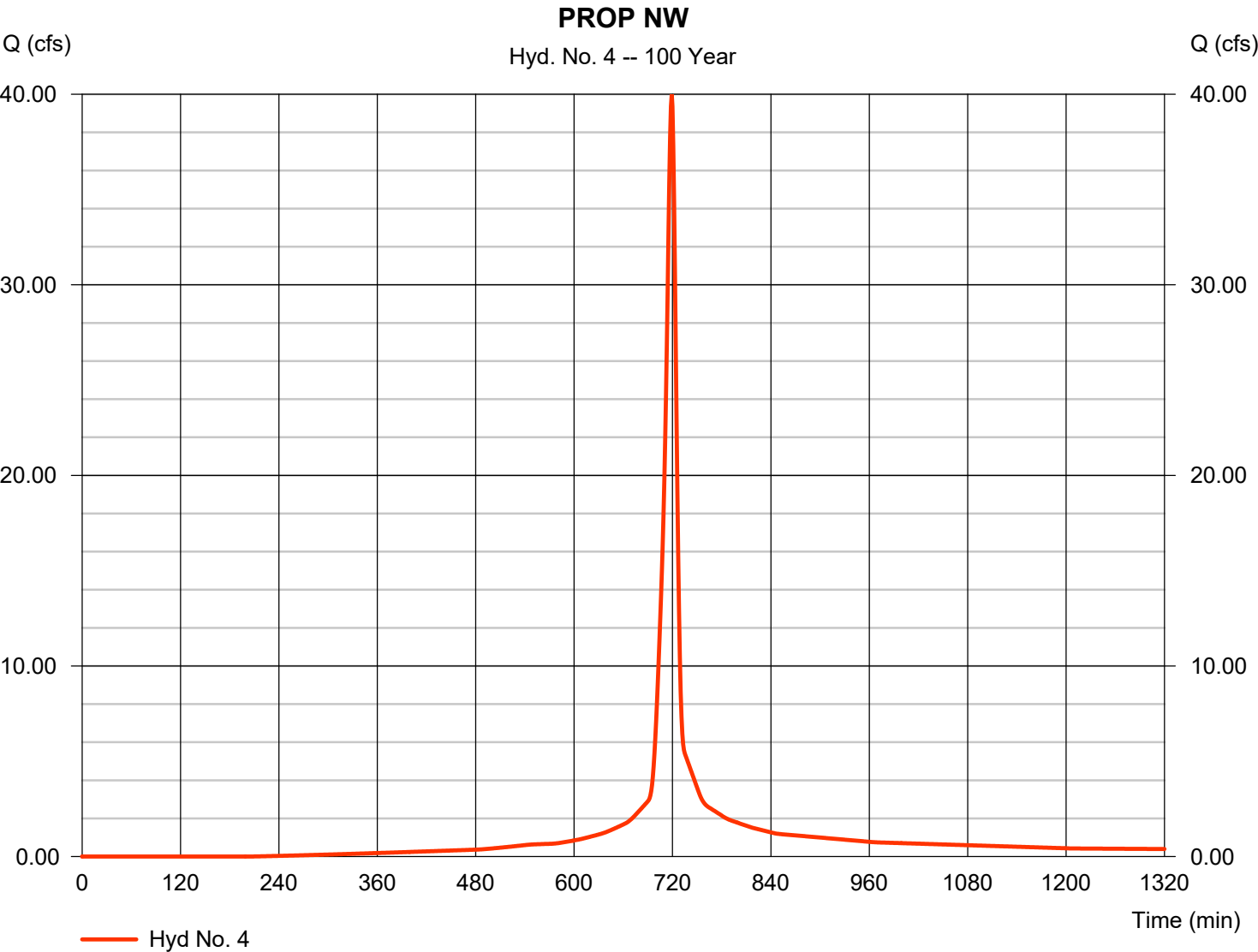
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 4

PROP NW

Hydrograph type	= SCS Runoff	Peak discharge	= 39.99 cfs
Storm frequency	= 100 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 96,789 cuft
Drainage area	= 4.330 ac	Curve number	= 87
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 9.80 min
Total precip.	= 7.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 5

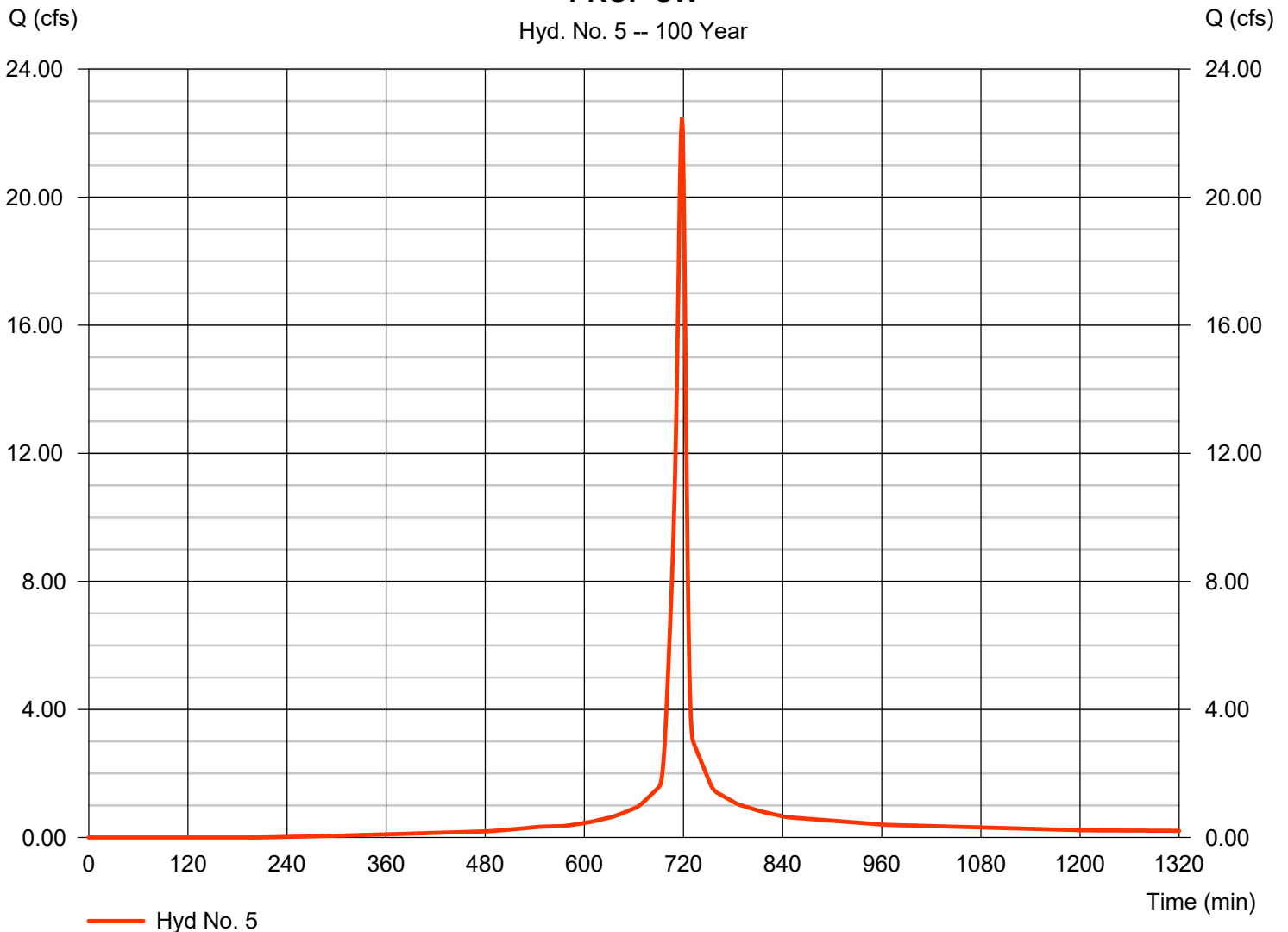
PROP SW

Hydrograph type = SCS Runoff  
 Storm frequency = 100 yrs  
 Time interval = 1 min  
 Drainage area = 2.350 ac  
 Basin Slope = 0.0 %  
 Tc method = User  
 Total precip. = 7.70 in  
 Storm duration = 24 hrs

Peak discharge = 22.48 cfs  
 Time to peak = 718 min  
 Hyd. volume = 51,217 cuft  
 Curve number = 87  
 Hydraulic length = 0 ft  
 Time of conc. (Tc) = 6.90 min  
 Distribution = Type II  
 Shape factor = 484

### PROP SW

Hyd. No. 5 -- 100 Year



# Hydrograph Report

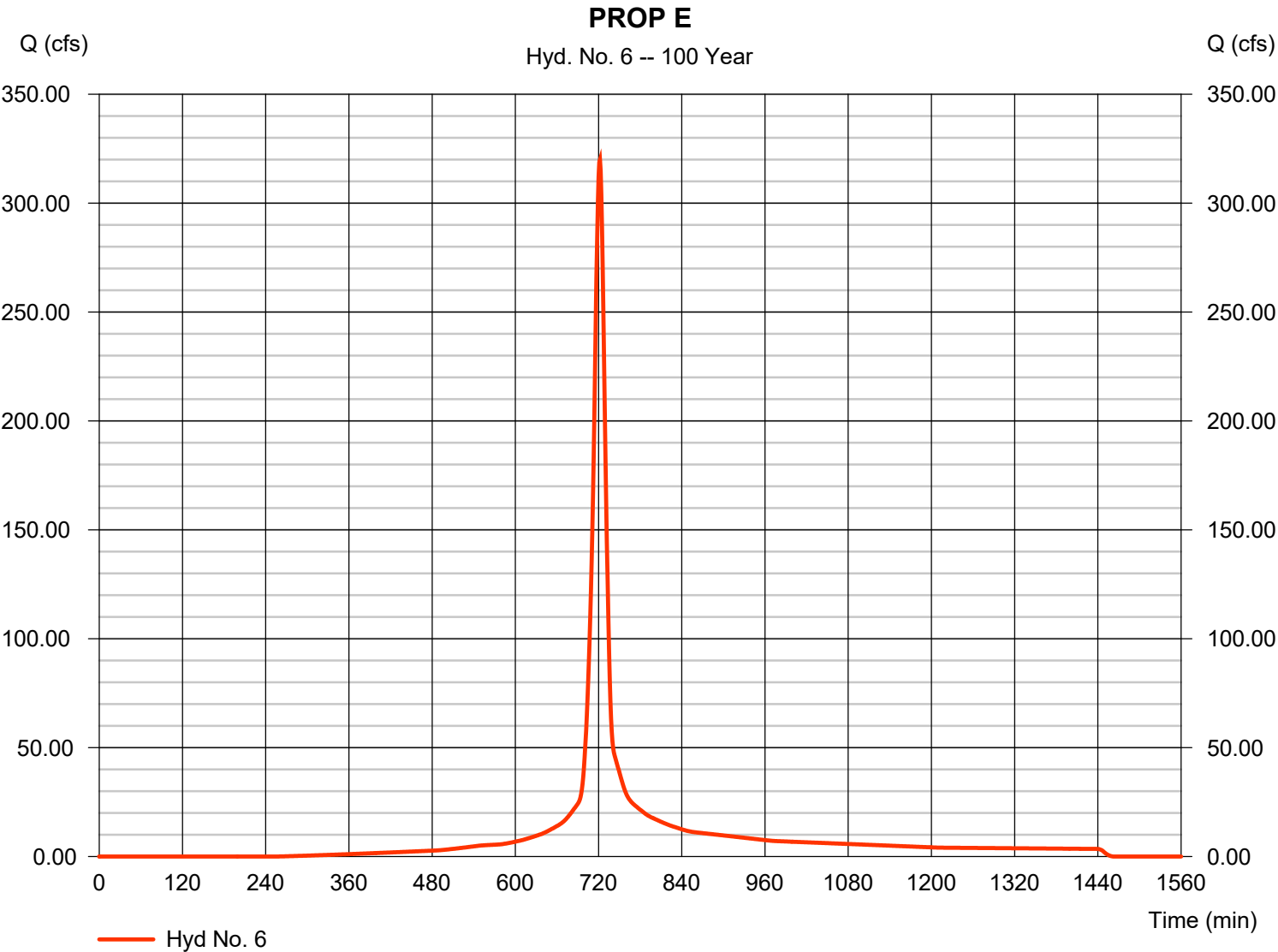
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 6

PROP E

Hydrograph type	= SCS Runoff	Peak discharge	= 319.79 cfs
Storm frequency	= 100 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 892,599 cuft
Drainage area	= 42.340 ac	Curve number	= 84
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 14.70 min
Total precip.	= 7.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

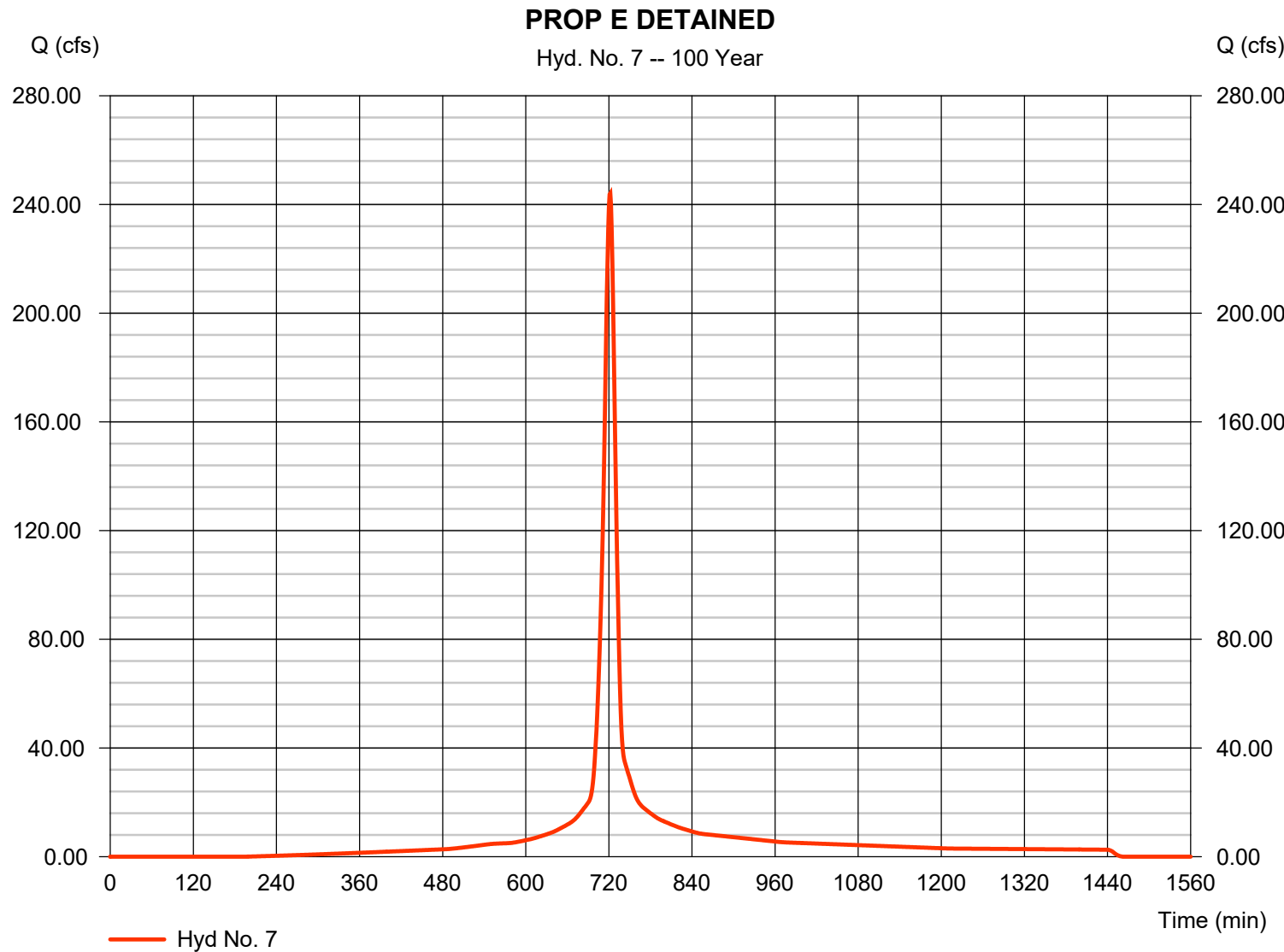
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 7

PROP E DETAINED

Hydrograph type	=	SCS Runoff	Peak discharge	=	244.07 cfs
Storm frequency	=	100 yrs	Time to peak	=	722 min
Time interval	=	1 min	Hyd. volume	=	697,260 cuft
Drainage area	=	30.610 ac	Curve number	=	88
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	14.70 min
Total precip.	=	7.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

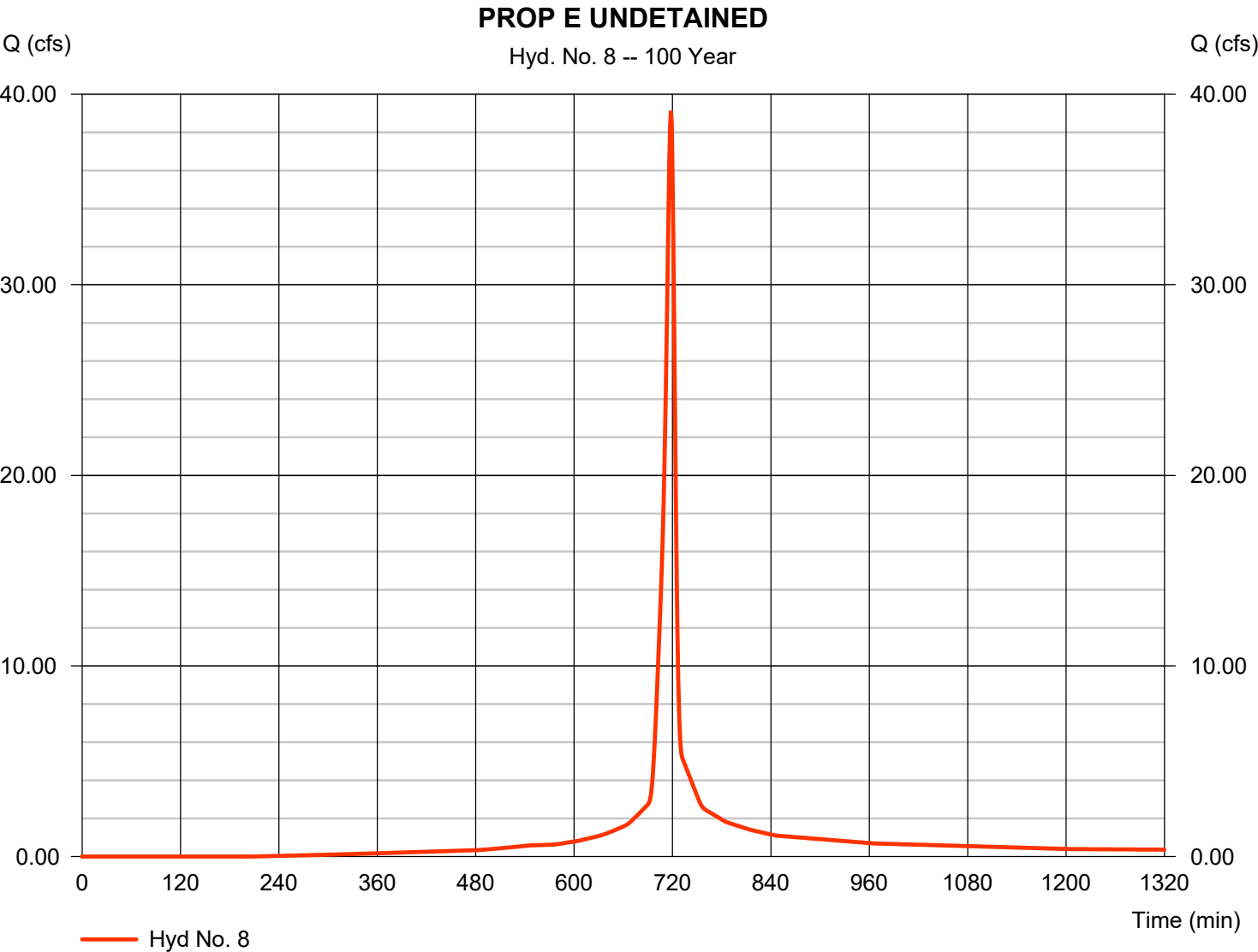


# Hydrograph Report

## Hyd. No. 8

### PROP E UNDETAINED

Hydrograph type	=	SCS Runoff	Peak discharge	=	39.13 cfs
Storm frequency	=	100 yrs	Time to peak	=	718 min
Time interval	=	1 min	Hyd. volume	=	89,139 cuft
Drainage area	=	4.090 ac	Curve number	=	87
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	7.80 min
Total precip.	=	7.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

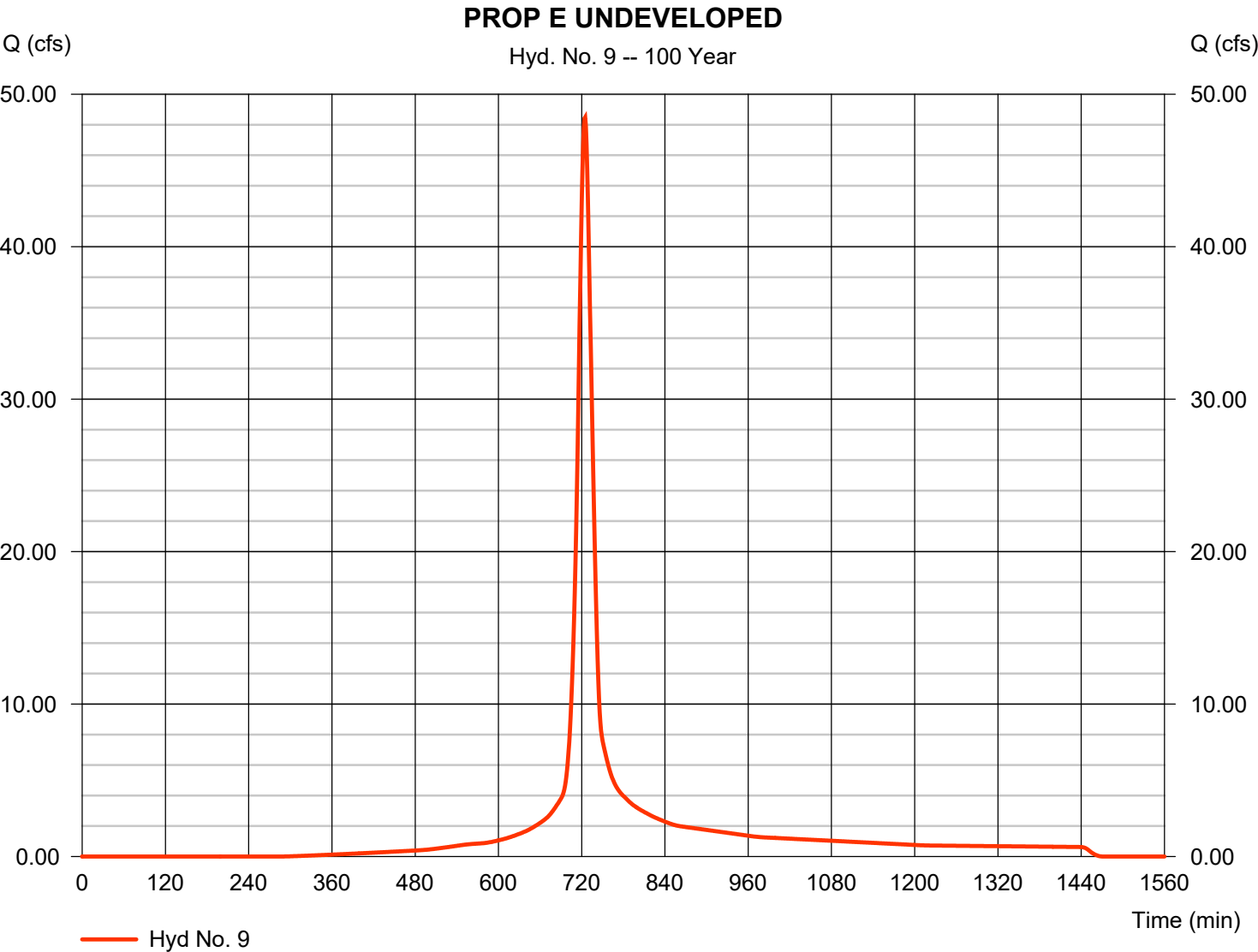
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

## Hyd. No. 9

PROP E UNDEVELOPED

Hydrograph type	=	SCS Runoff	Peak discharge	=	48.49 cfs
Storm frequency	=	100 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	154,625 cuft
Drainage area	=	7.640 ac	Curve number	=	82
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	19.20 min
Total precip.	=	7.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

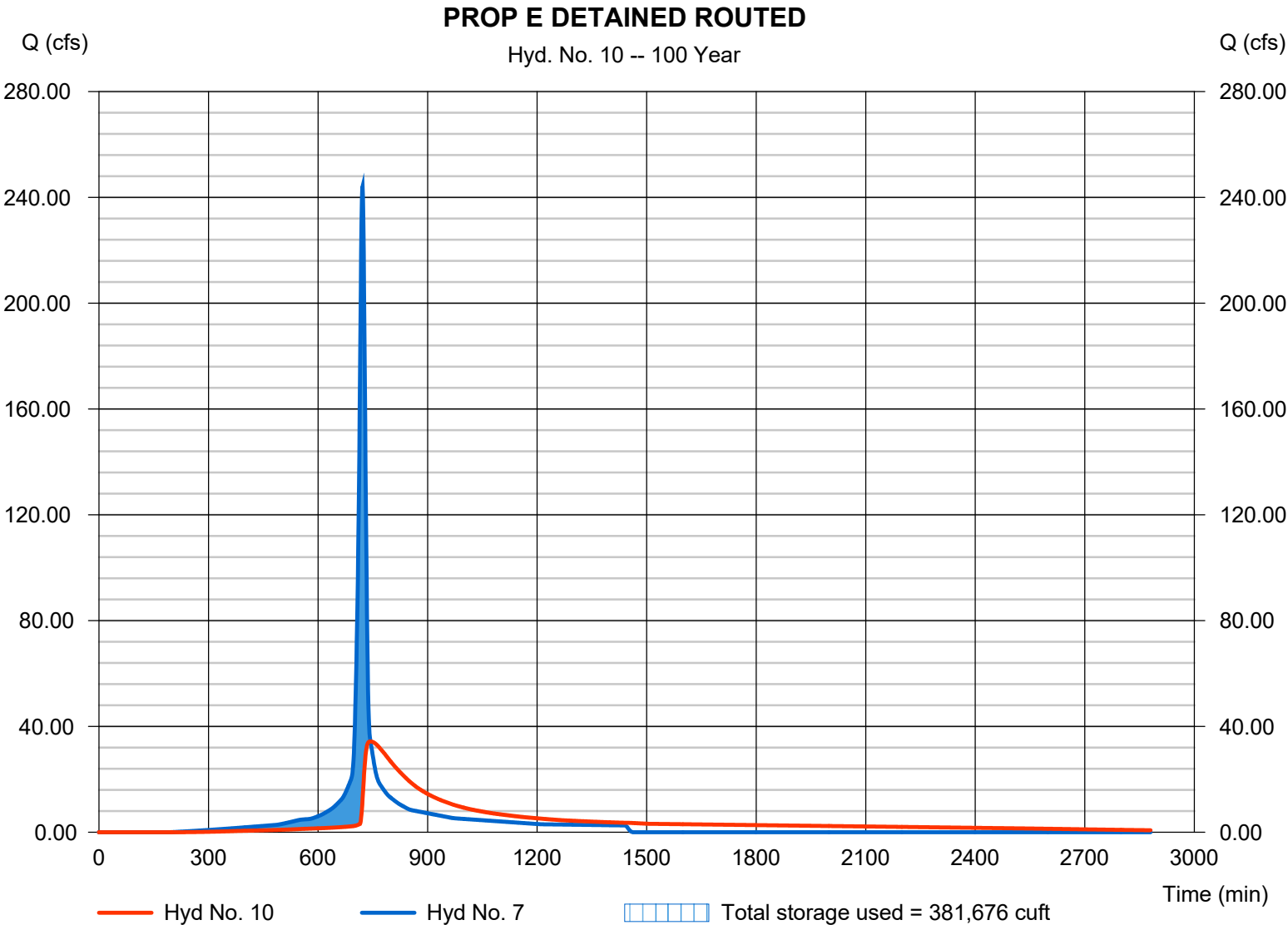
Thursday, 03 / 11 / 2021

## Hyd. No. 10

### PROP E DETAINED ROUTED

Hydrograph type	= Reservoir	Peak discharge	= 34.31 cfs
Storm frequency	= 100 yrs	Time to peak	= 744 min
Time interval	= 1 min	Hyd. volume	= 684,160 cuft
Inflow hyd. No.	= 7 - PROP E DETAINED	Max. Elevation	= 985.48 ft
Reservoir name	= RP 2 AS-BUILT	Max. Storage	= 381,676 cuft

Storage Indication method used.





# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

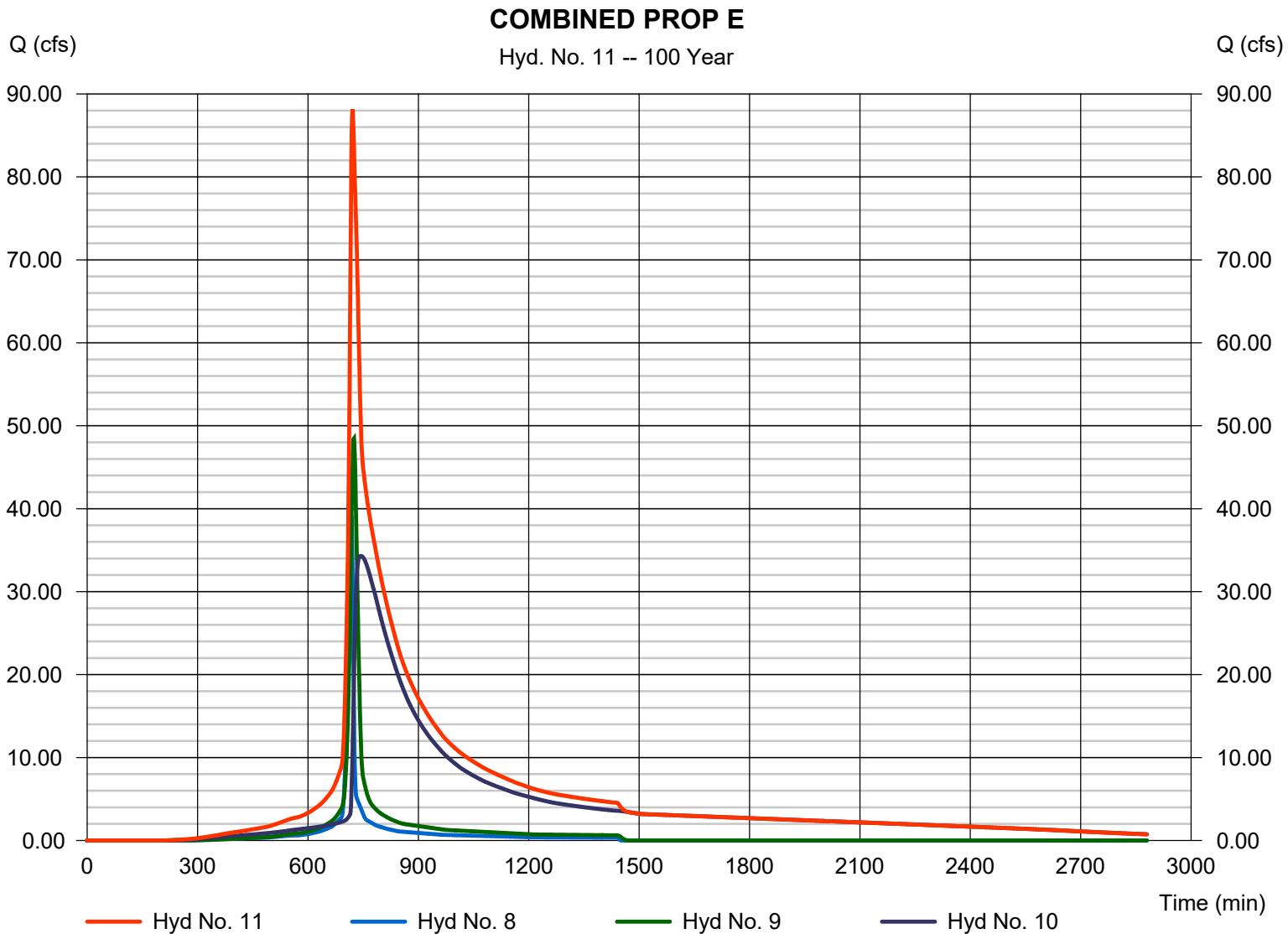
Thursday, 03 / 11 / 2021

## Hyd. No. 11

### COMBINED PROP E

Hydrograph type = Combine  
 Storm frequency = 100 yrs  
 Time interval = 1 min  
 Inflow hyds. = 8, 9, 10

Peak discharge = 88.15 cfs  
 Time to peak = 721 min  
 Hyd. volume = 927,923 cuft  
 Contrib. drain. area = 11.730 ac



# Hydraflow Rainfall Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021

Thursday, 03 / 11 / 2021

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	64.1474	17.7000	0.8922	-----
2	95.7859	19.2000	0.9317	-----
3	0.0000	0.0000	0.0000	-----
5	118.7799	19.1000	0.9266	-----
10	125.1300	18.2000	0.9051	-----
25	158.9867	18.7000	0.9180	-----
50	171.2459	18.3000	0.9078	-----
100	187.3624	18.1000	0.9031	-----

File name: KCMO.IDF

$$\text{Intensity} = B / (T_c + D)^E$$

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	3.96	3.31	2.86	2.52	2.25	2.04	1.87	1.72	1.60	1.49	1.40	1.32
2	4.92	4.13	3.56	3.14	2.81	2.54	2.32	2.14	1.98	1.85	1.73	1.63
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.23	5.23	4.51	3.98	3.56	3.22	2.94	2.71	2.52	2.35	2.20	2.07
10	7.27	6.09	5.26	4.63	4.14	3.75	3.43	3.16	2.93	2.74	2.57	2.42
25	8.70	7.30	6.30	5.54	4.96	4.49	4.10	3.78	3.51	3.27	3.07	2.89
50	9.83	8.24	7.11	6.26	5.60	5.07	4.64	4.27	3.97	3.70	3.47	3.27
100	11.00	9.21	7.95	7.00	6.26	5.67	5.19	4.78	4.44	4.14	3.89	3.66

Tc = time in minutes. Values may exceed 60.

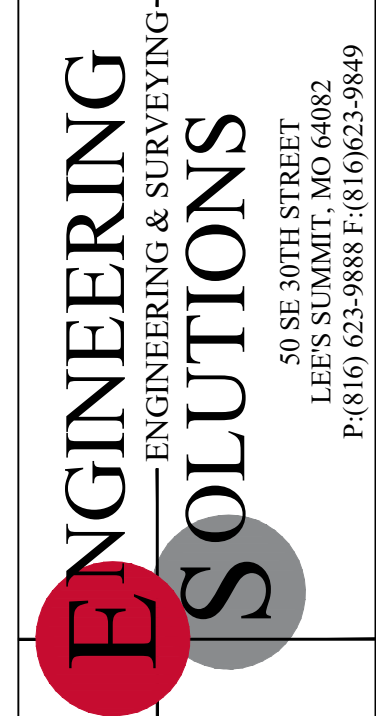
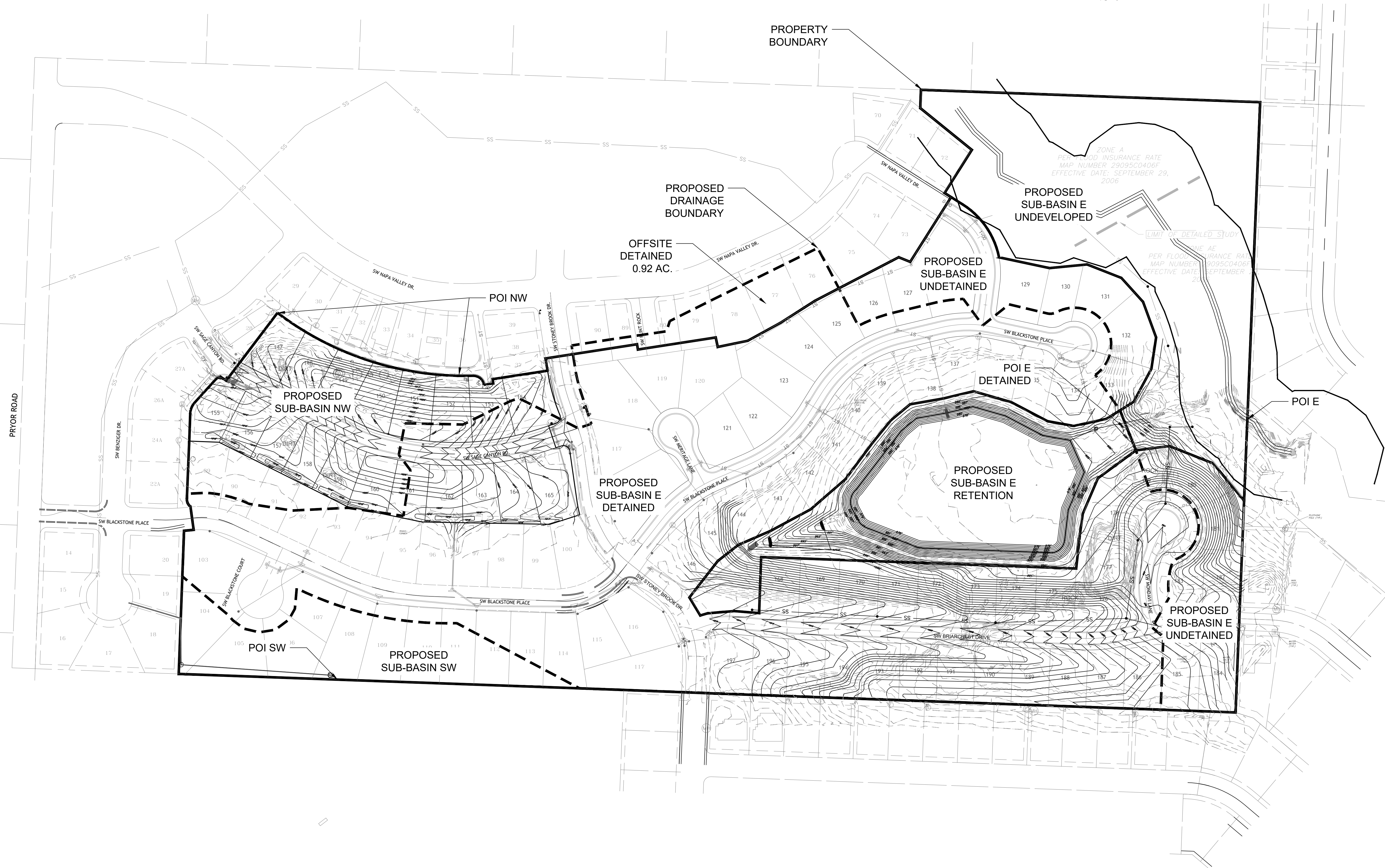
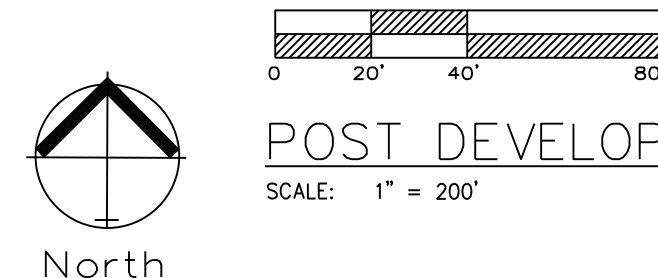
Precip. file name: Z:\acad\KCMO.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	1.37	3.50	0.00	3.30	5.20	6.00	6.80	7.70
SCS 6-Hr	0.00	1.80	0.00	0.00	2.60	0.00	0.00	4.00
Huff-1st	0.00	1.55	0.00	2.75	4.00	5.38	6.50	8.00
Huff-2nd	2.49	3.10	0.00	4.01	4.64	5.52	6.21	6.90
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	1.55	0.00	2.75	4.00	5.38	6.50	8.00
Custom	0.00	1.75	0.00	2.80	3.90	5.25	6.00	7.10

# **Exhibit G**

## **Post-Development Drainage Area Map**





Professional Registration  
Missouri  
Engineering 2005002186-D  
Surveying 2005008319-D  
Kansas  
Engineering E-1695  
Surveying LS-218  
Oklahoma  
Engineering 6254  
Nebraska  
Engineering CA2821

Napa Valley Pond  
Tract N, Napa Valley 2nd Plat  
Lee's Summit, Jackson County, Missouri

Project:  
NAPA VALLEY LSMO  
Issue Date:  
October 24, 2017

POST DEVELOPMENT DRAINAGE MAP  
Construction Plans for:  
Tract N, Napa Valley 2nd Plat  
Lee's Summit, Jackson County, Missouri

Matthew J. Schlicht  
MO PE 2006019708  
KS PE 19071  
OK PE 25226  
NE PE E-14335

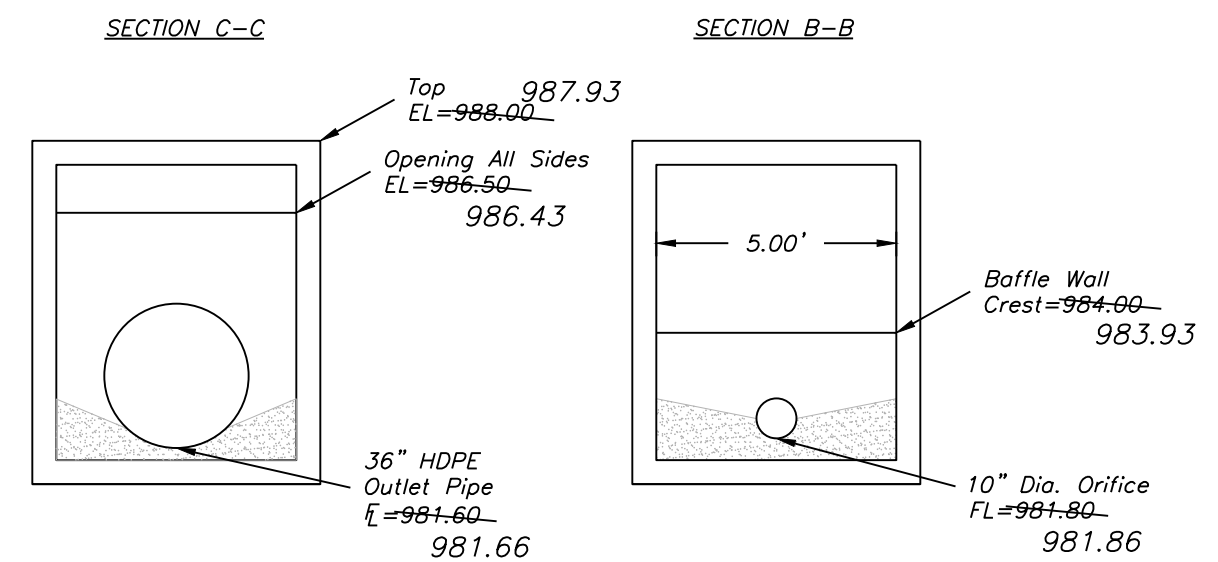
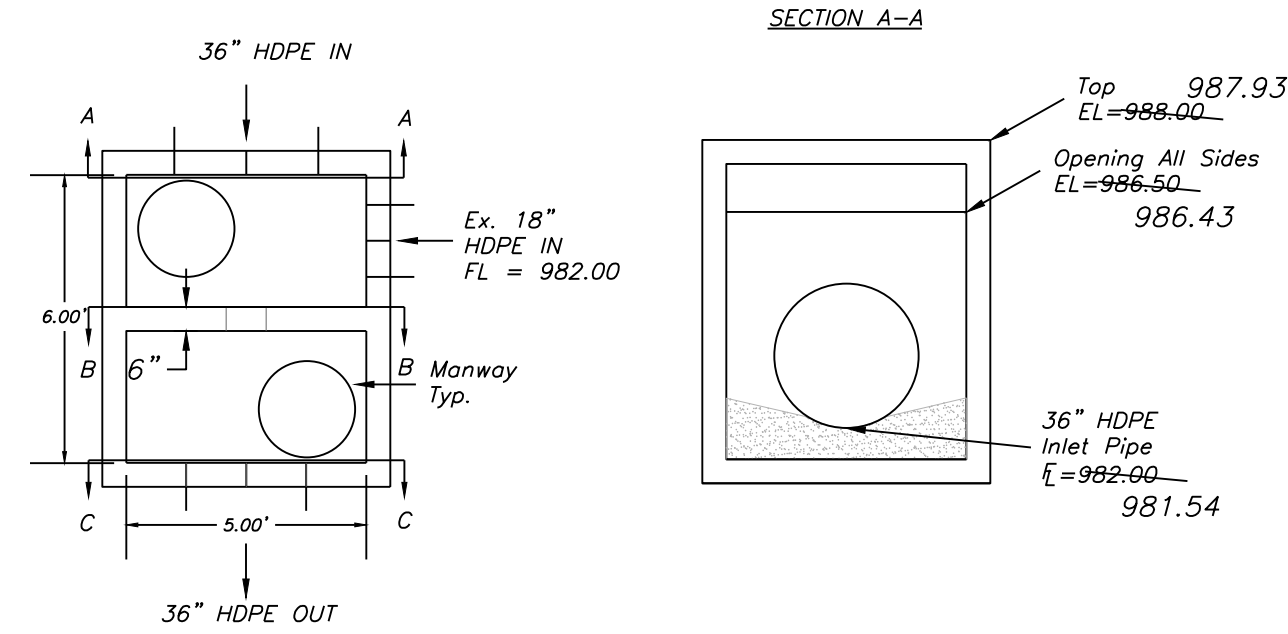
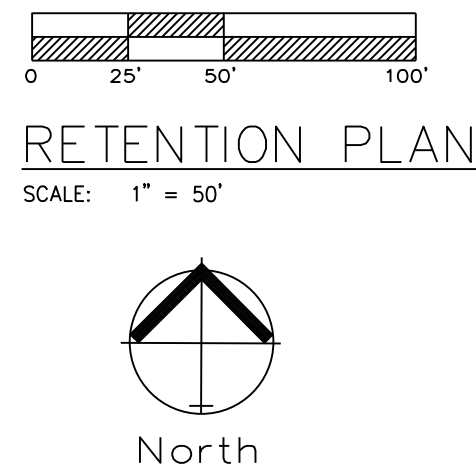
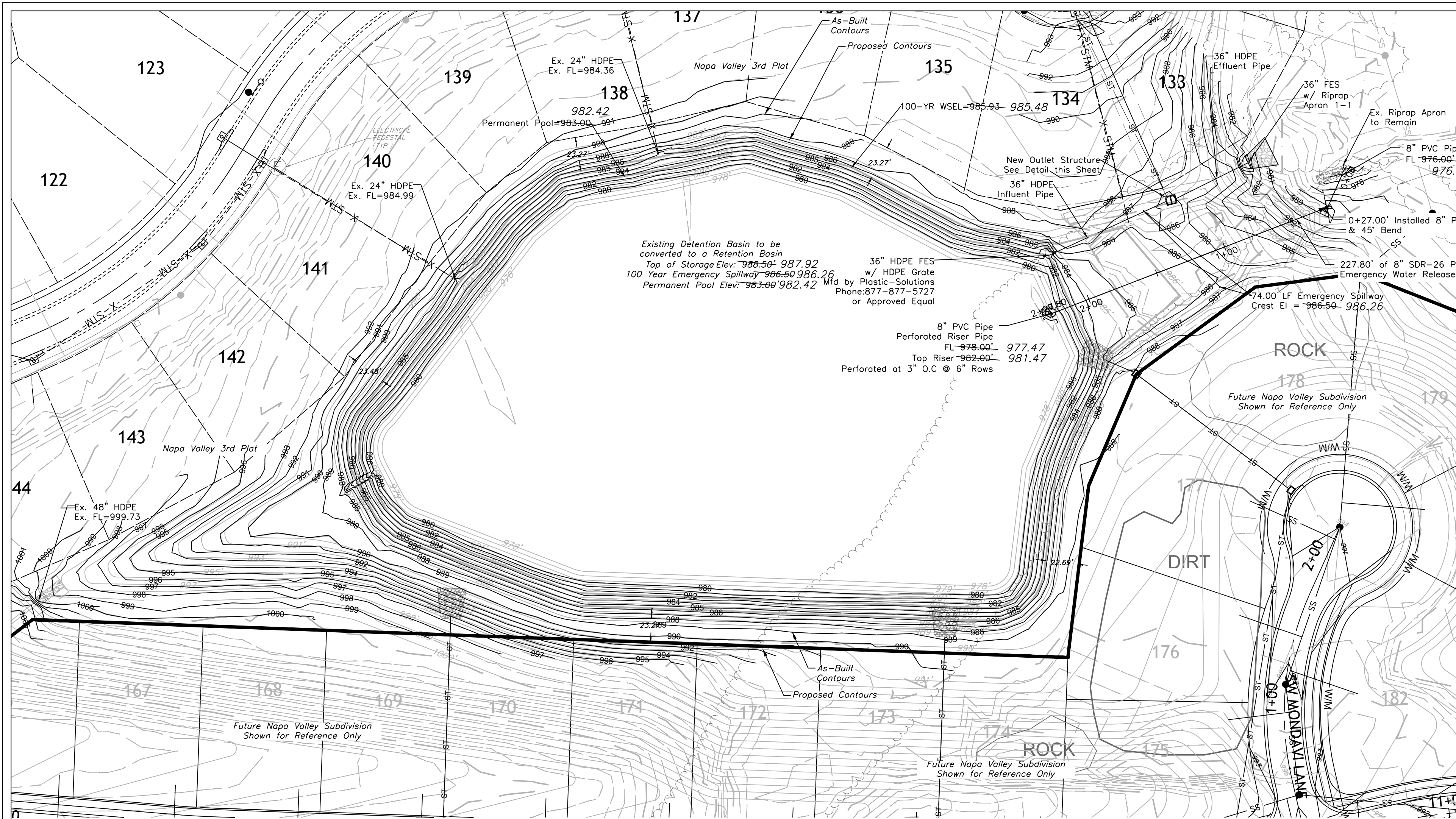
REVISIONS	
Revised 9/26/19	



# **Exhibit H**

## **Retention Basin Plan**





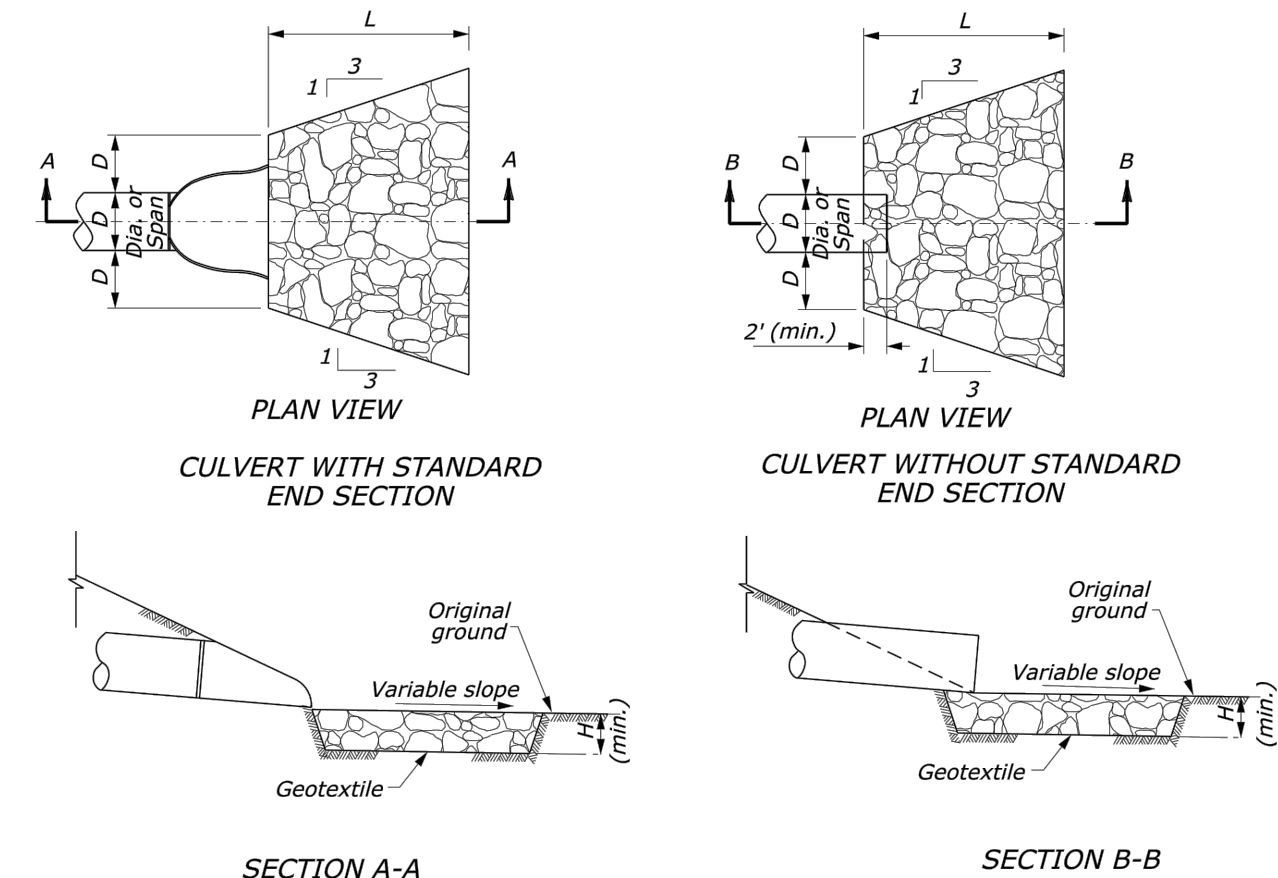
OUTLET STRUCTURE - BASIN E  
1" = 1'-0"

Field End Section #	1-1
Q =	50.57 cfs
D =	3 ft
Tw =	1.2 ft
g =	32.2 ft/s <sup>2</sup>
D <sub>50</sub> =	8.54 inches
S =	0.0156 ft/ft
n =	0.01
Q <sub>cap</sub> =	108.14 ft <sup>3</sup> /s
Q/Q <sub>cap</sub> =	0.47
d/D =	0.48
d =	1.44 ft
Central <	87.71 deg
A <sub>seg</sub> =	2.63 ft <sup>2</sup>
V =	19.21 ft/s
Fr =	2.82
Flow =	Supercritical
D' =	2.22 ft
y <sub>n</sub> =	1.44 ft
D <sub>50</sub> =	12.76 inches

D<sub>50</sub> = riprap size, m(ft)  
Q = design discharge, m<sup>3</sup>/s (ft<sup>3</sup>/s)  
D = culvert diameter (circular), m(ft)  
Tw = tailwater depth, m(ft), if unknown use 0.4\*D  
g = acceleration due to gravity, 9.81 m/s<sup>2</sup> (32.2 ft/s<sup>2</sup>)  
Subcritical Flow  
S = pipe slope, m/(ft/ft)  
n = manning's roughness coefficient, unitless  
Q<sub>cap</sub> = full pipe capacity, m<sup>3</sup>/s (ft<sup>3</sup>/s)  
Q/Q<sub>cap</sub> = design discharge/full pipe capacity, unitless  
d/D = water depth/pipe diameter, unitless  
d = depth of flow, m(ft)  
lookup, degrees  
lookup \* pipe area, m<sup>2</sup>(ft<sup>2</sup>)  
V = velocity of flow segment, m<sup>2</sup>/s(ft<sup>2</sup>/s)  
Fr > 1 Supercritical, Fr = 1 Critical, Fr < 1 Subcritical  
If flow is Supercritical adjust culvert diameter  
D' = culvert diameter adjustment, m(ft)  
y<sub>n</sub> = normal (supercritical) depth in culvert, m(ft)  
See Riprap Apron Schedule for Size

RipRap Apron Area (ac.)		Q100 (cfs)		Dia. (ft)		RipRap Apron			
1-1	30.61	46.78	3	4	14	18	31	21	1.56

#### STANDARD RIPRAP APRON DETAIL

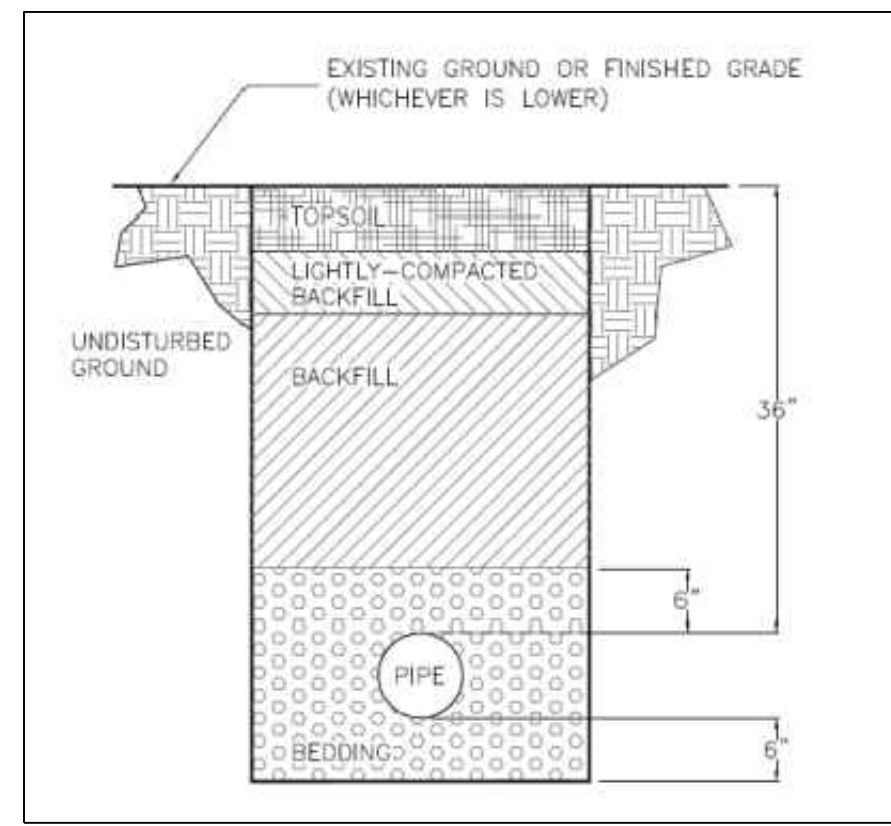
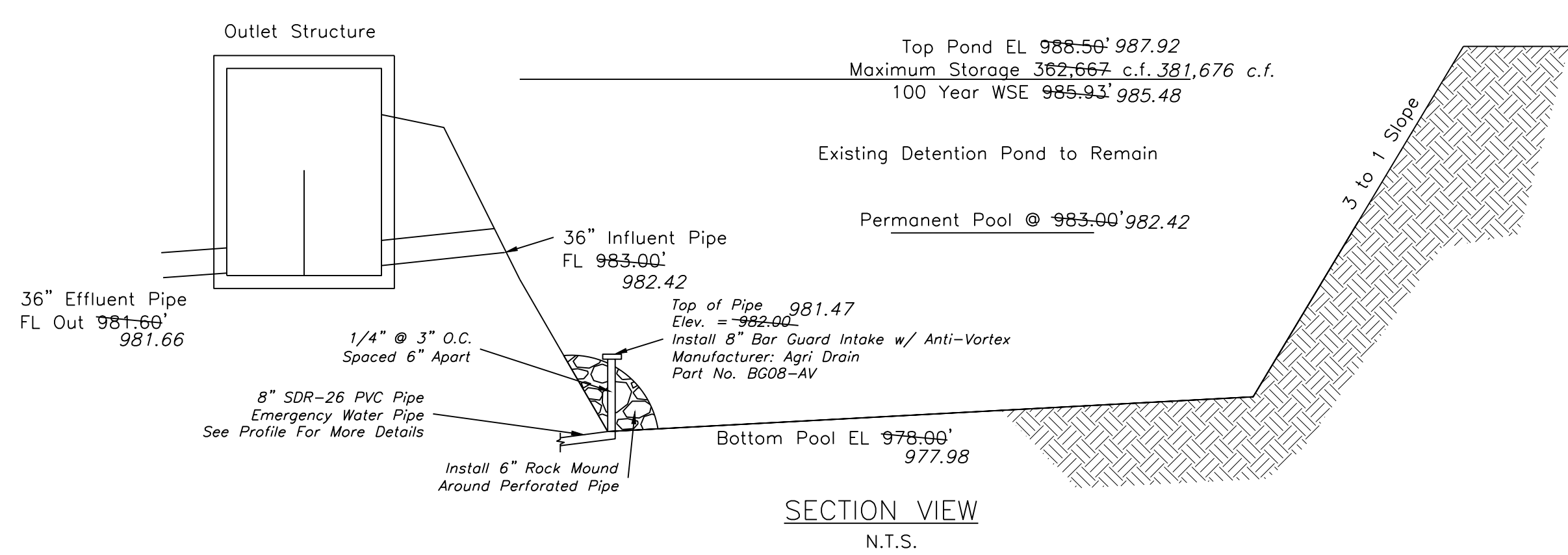
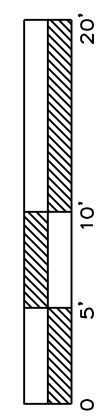
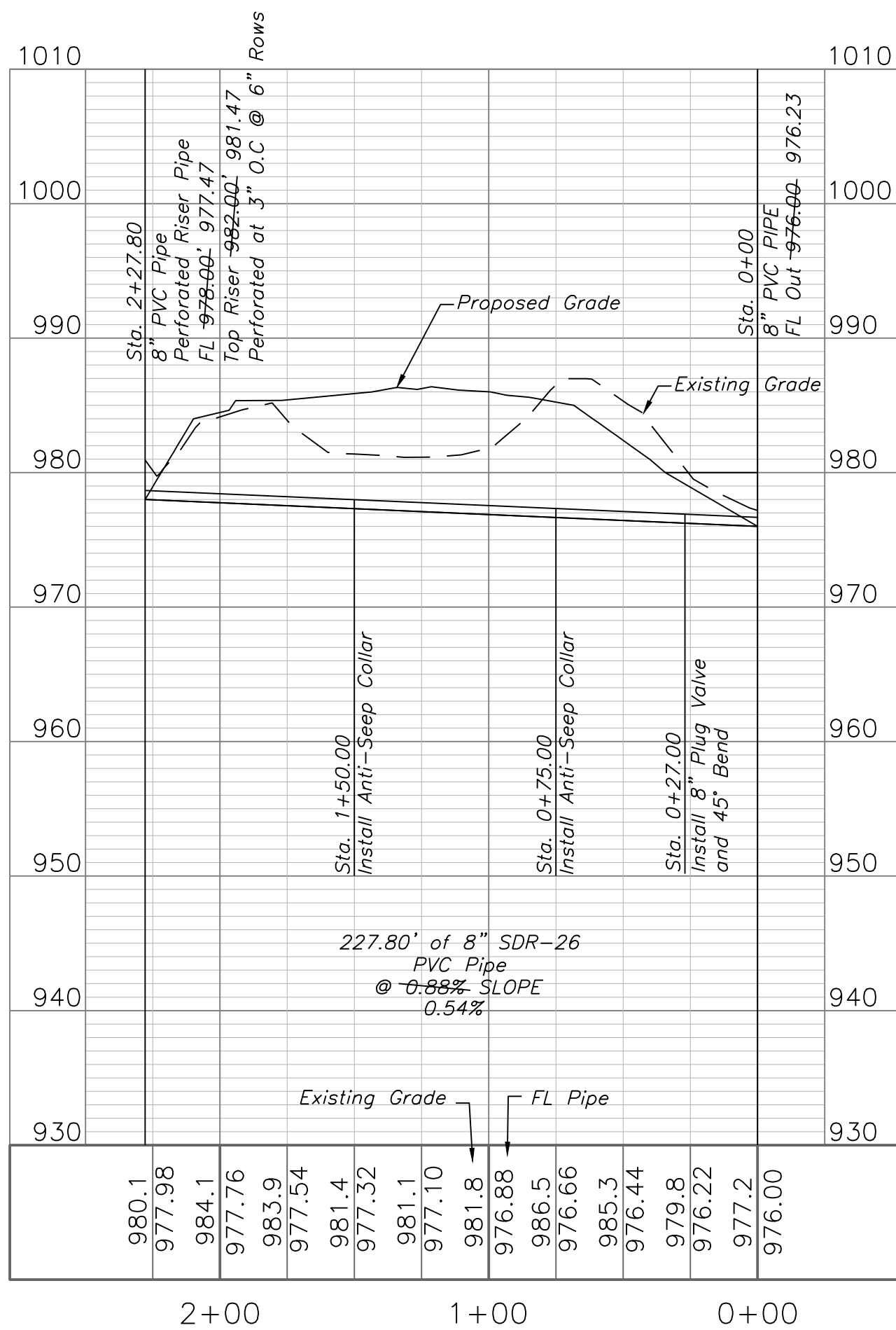


- NOTES:
1. ALL RIPRAP APRONS SHALL CONFORM TO THE STANDARD CONFIGURATION SHOWN IN THE STANDARD DETAIL ABOVE UNLESS OTHERWISE NOTED. PLAN VIEW DIMENSIONS SHOWN SHALL BE MET OR EXCEEDED INCLUDING AREAS OF LONGITUDINAL AND/OR TRANSVERSE SLOPE.
  2. DIMENSIONS FOR EACH RIPRAP APRON AND ASSOCIATED RIPRAP ARE DETAILED IN THE TABLE ABOVE.
  3. WIDTH REFERS TO DIMENSION OPPOSITE PIPE AND DEPTH IS DIMENSION H.
  4. GEOTEXTILE SHALL BE "ONE WORKS 4 OUNCE" NON-WOVEN FILTER FABRIC DESIGNED FOR FILTRATION, STABILIZATION AND SEPARATION WRAPPED CONTINUOUSLY ALONG THE SIDEWALLS AND BOTTOM OF THE PREPARED AREA OR SLOPE.
- WATER FLOW = 120 GPM/SF
  - GRAB STRENGTH (MIN) = 400 N
  - PUNCTURE STRENGTH (MIN) = 178 N
  - TRAPEZOIDAL TEAR (MIN) = 133 N
  - ELONGATION (MIN) = 15%

#### "AS-BUILT"

900.10  
~~900.00~~ Indicates data replaced with "As-Built" information. All other data is as designed and has not been field verified.

## EMERGENCY WATER PIPE



TRENCHING NOTES: (8" EMERGENCY WATER PIPE & 36" HDPE INFLUENT PIPE)  
LOW PERMEABILITY BEDDING AND BACKFILL SHALL BE PLACED ALONG PIPE. TWO ANTI-SEEP COLLARS SHALL BE PLACED ALONG THE PIPE AT 1/3RD POINTS. ANTI-SEEP COLLARS SHALL BE CONCRETE, 6" THICK FORMED AROUND THE PIPE WITH #3 REBAR SPACED 15" HORIZONTALLY AND VERTICALLY. OVERALL SQUARE COLLAR DIMENSION SHALL BE 36" + PIPE DIA. EXAMPLE A 12" PIPE SHALL HAVE COLLAR DIMENSIONS OF 48" SQUARE. A MINIMUM 12" OF EARTHEN BACKFILL SHALL BE PROVIDED ABOVE COLLARS REGARDLESS OF COLLAR DIMENSION, MODIFY COLLAR AS REQUIRED.



# **Exhibit I**

## **Emergency Spillway Calculations**

Total Q (cfs)	244.07
---------------	--------

**Broad Crested Weir Capacity**

Capacity, Q (cfs)	203.5
-------------------	-------

Crest Length, L (ft)	74.00
----------------------	-------

Weir Coefficient, C	2.67
---------------------	------

Required Head, H (ft)	1.02
-----------------------	------

Crest Elev.	986.26
-------------	--------

HGL	<b>987.28</b>
-----	---------------

**Rectangular Weir Capacity**

Capacity, Q (cfs)	40.57
-------------------	-------

Crest Length, L (ft)	15.50
----------------------	-------

Weir Coefficient, C	3.33
---------------------	------

Required Head, H (ft)	0.85
-----------------------	------

Crest Elev.	986.43
-------------	--------

HGL	<b>987.28</b>
-----	---------------

$$Q = C \times L \times H^{3/2}$$