ATTACHMENT 8

RSA+

PRELIMINARY DETENTION CALCULATIONS

CAPITOLA SUBDIVISION
808 CAPITOLA DRIVE
NAPA, CALIFORNIA 94559

Prepared for:

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Project #4123011.0

March 20, 2025

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INTRODUCTION

In order to satisfy the City of Napa Drainage Design Standard Section 2.10.02, which states that projects must provide detention of stormwater such that peak flows do not exceed pre-developed runoff rates, the TR-55 method was used to demonstrate the peak runoff rates of the site in both the pre- and post-developed conditions. This calculation was then used to determine the on-site storage volume necessary to limit post-development rates below the pre-developed conditions. Because the project site is in the Napa East Basin and proposes more than 4 residential units, it is required to detain up to the 10-year design storm. Based on this calculation, as summarized in the Conclusion in Appendix C, the site has adequate storage capacity in the detention facility to detain the post-development peak flows as required.

The method used for this calculation is hydrograph analysis. The unit hydrograph rainfall distribution for the City of Napa falls under Type IA-distribution. The SCS hydrograph analysis is based on the National Resources Conservation Service Technical Release 55 for Urban Hydrology for Small Watersheds (TR-55) method (refer to Appendix B for Hydrograph Calculation Parameters).

EXISTING CONDITIONS

The entire site currently drains easterly to an existing storm drain pipe that outfalls to an existing pond on the adjacent west property. This outfall will be used as the point of convergence for all time of concentration calculations. An exhibit showing the existing watershed area and time of concentration flow table can be found in Appendix A.

PROPOSED CONDITIONS

A detention facility will be provided to detain runoff and mitigate peak flows. Portions of the developed site are not feasible to be captured and detained, including the west portion of the new Capitola Drive. Therefore, the site watershed will have portions that will be detained and portions that will not be detained. Total post-development flow was calculated by summing the detained and undetained portions for comparison with pre-development conditions using the terminus at the existing outfall to the existing pond.

Refer to Appendix A for Watershed Exhibits of the proposed detained and undetained watershed areas and time of concentration flow tables. The proposed runoff for the 10-year storm is shown in the Conclusion (refer to Appendix C for Detention Calculation using Hydraflow Hydrographs Extension).

CONCLUSION

These calculations identify and describe the impacts of the proposed Capitola Subdivision on the hydrologic characteristics of the site and quantify the necessary storage requirement for the detention facility. The storm drain system of Capitola Subdivision is designed such that the proposed post-developed flow discharge from the development will not exceed pre-developed levels in accordance with the City of Napa Drainage Standards.

Summary of hydrologic analysis:

10-year Pre & Post Developed Flow Discharge

Pre-developed peak run-off =	**0.895 cfs**
Post-developed (Undetained) peak run-off =	0.131 cfs
Post-developed (Detained Routed) peak run-off =	0.744 cfs
Post-developed flow discharge =	**0.875 cfs**

Results

10-year: **0.875 cfs** (Post-developed) ≤ **0.895 cfs** (Pre-developed) √

Detention Volume Requirement

Detention volume required	=	2,036 ft^3 or 0.0467 ac-ft
Detention volume provided	=	2,230 ft^3 or 0.0512 ac-ft

Results

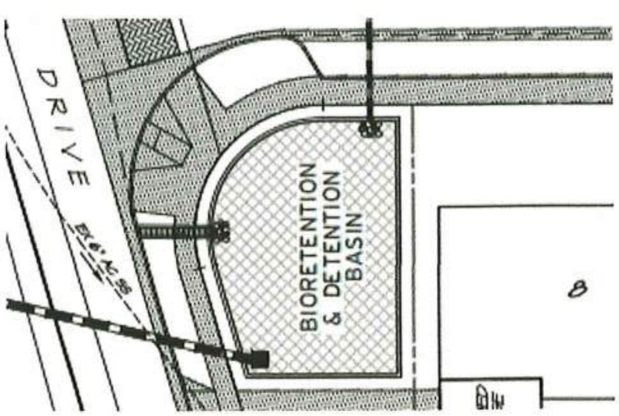
Detention: **2,036 ft^3** (required) ≤ **2,230 ft^3** (provided) √

Orifice Requirement

The routing and detention are accomplished by a broad crested orifice in the storm drain metering structure (SDMS) after the detention pipe.

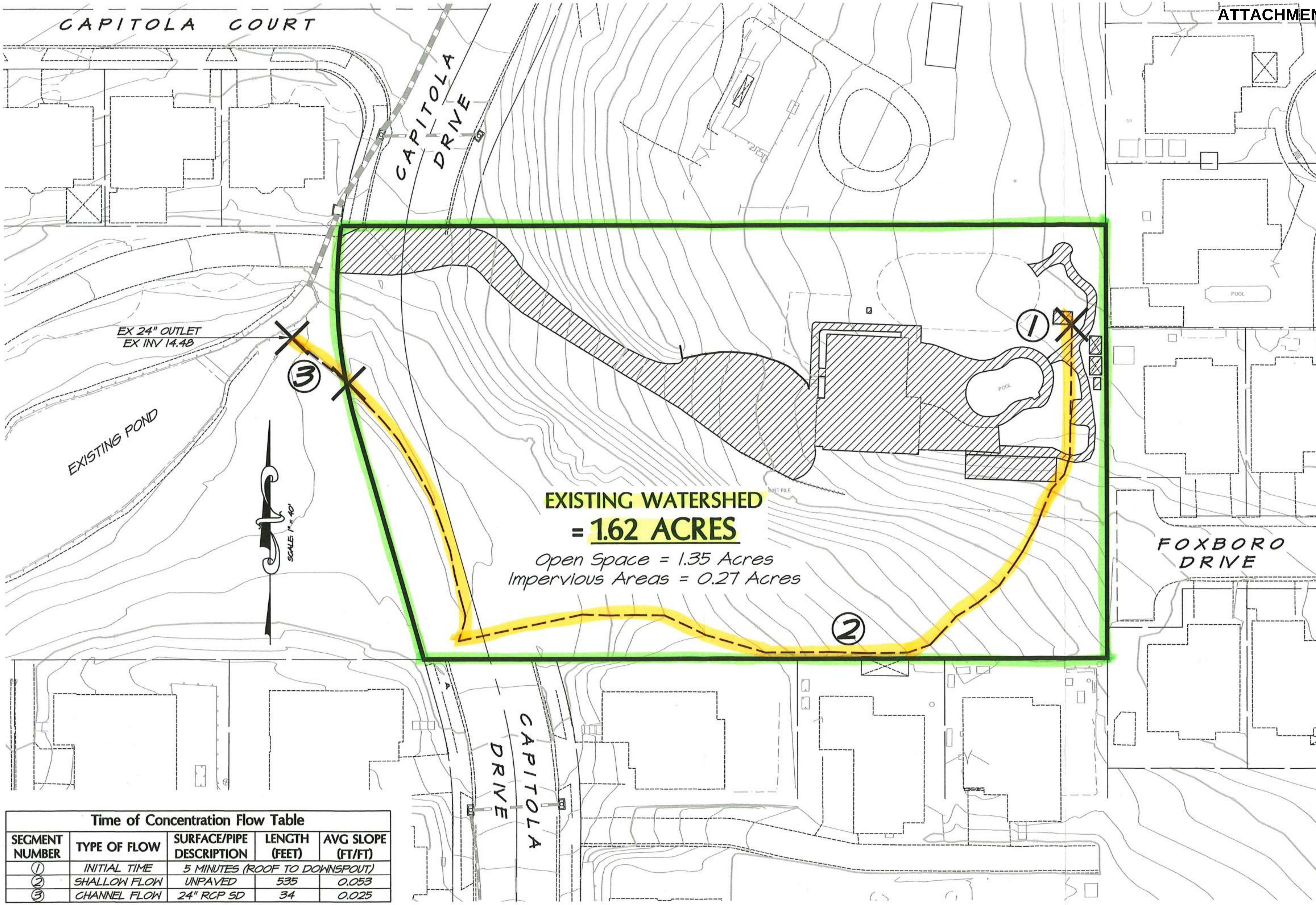
The required orifice dimensions are: 3.5 inches high & 8 inches long.

SEE BELOW FOR DETENTION POND PLAN



APPENDIX A

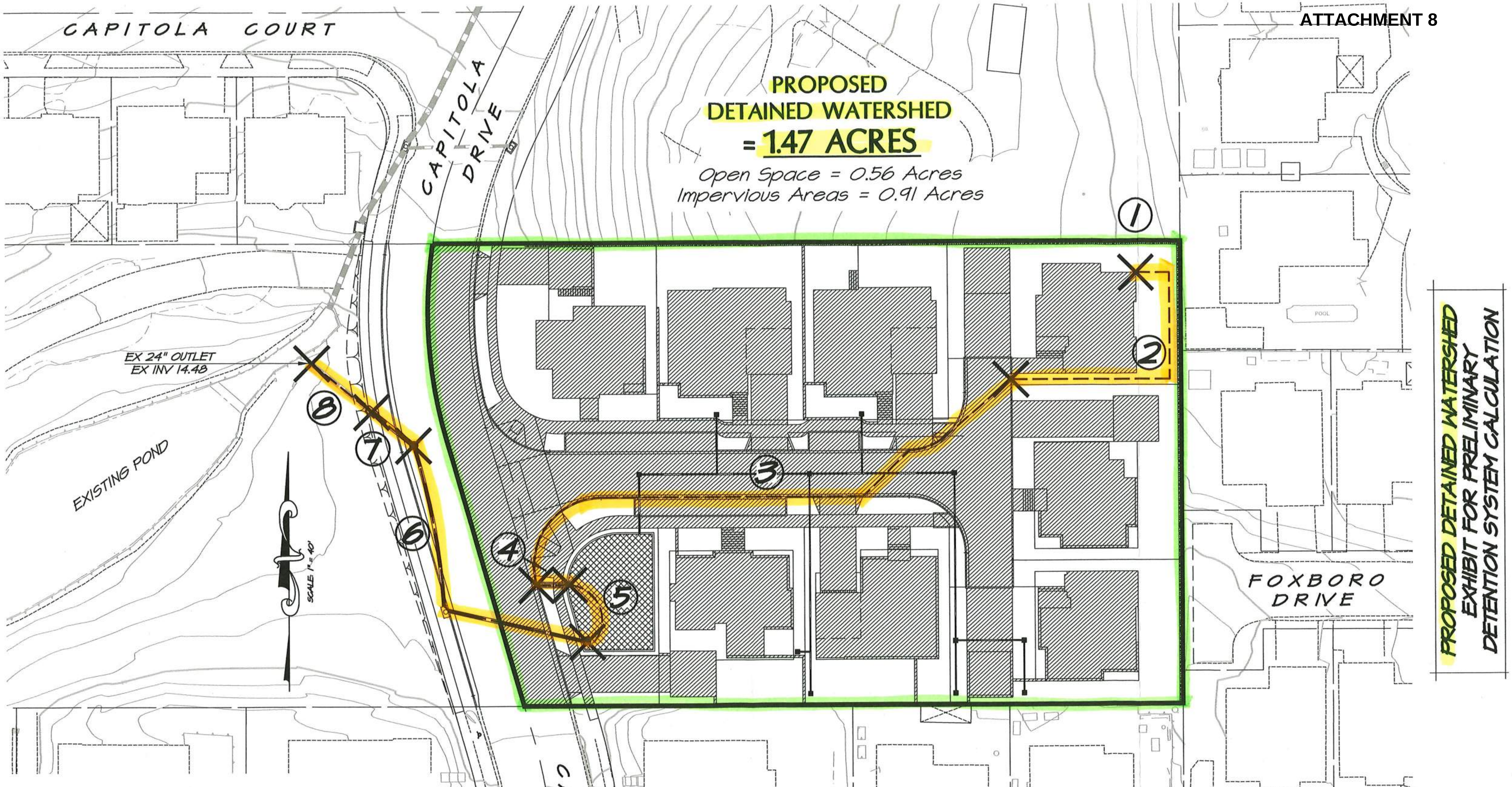
WATERSHED EXHIBITS



Time of Concentration Flow Table

SEGMENT NUMBER	TYPE OF FLOW	SURFACE/PIPE DESCRIPTION	LENGTH (FEET)	AVG SLOPE (FT/FT)
①	INITIAL TIME	5 MINUTES (ROOF TO DOWNSPOUT)		
②	SHALLOW FLOW	UNPAVED	535	0.053
③	CHANNEL FLOW	24" RCP SD	34	0.025

EXISTING WATERSHED EXHIBIT FOR PRELIMINARY DETENTION SYSTEM CALCULATION



Time of Concentration Flow Table

SEGMENT NUMBER	TYPE OF FLOW	SURFACE/PIPE DESCRIPTION	LENGTH (FEET)	AVG SLOPE (FT/FT)
①	INITIAL TIME	5 MINUTES (ROOF TO DOWNSPOUT)		
②	SHALLOW FLOW	UNPAVED	130	0.029
③	SHALLOW FLOW	PAVED	255	0.085
④	CHANNEL FLOW	18"x3" STL BOX	15	0.022
⑤	SHALLOW FLOW	UNPAVED	35	0.005
⑥	CHANNEL FLOW	14"x23" RCP SD	130	0.0027
⑦	CHANNEL FLOW	24" RCP SD	22	0.0027
⑧	CHANNEL FLOW	24" RCP SD	34	0.025

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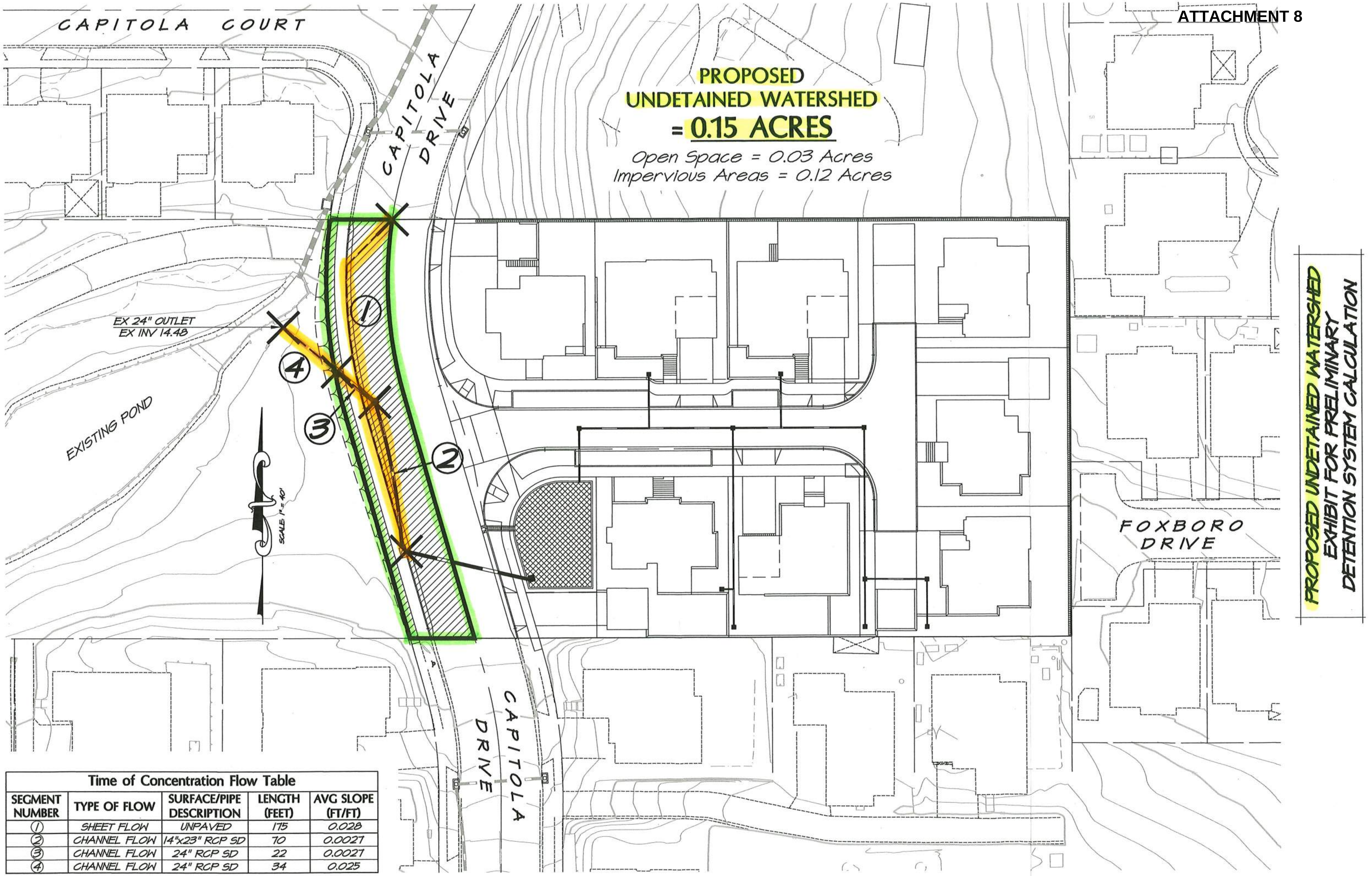

Time of Concentration Flow Table

SEGMENT NUMBER	TYPE OF FLOW	SURFACE/PIPE DESCRIPTION	LENGTH (FEET)	AVG SLOPE (FT/FT)
1	SHEET FLOW	UNPAVED	175	0.028
2	CHANNEL FLOW	14"x23" RCP SD	70	0.0027
3	CHANNEL FLOW	24" RCP SD	22	0.0027
4	CHANNEL FLOW	24" RCP SD	34	0.025

APPENDIX B

HYDROGRAPH CALCULATION PARAMETERS

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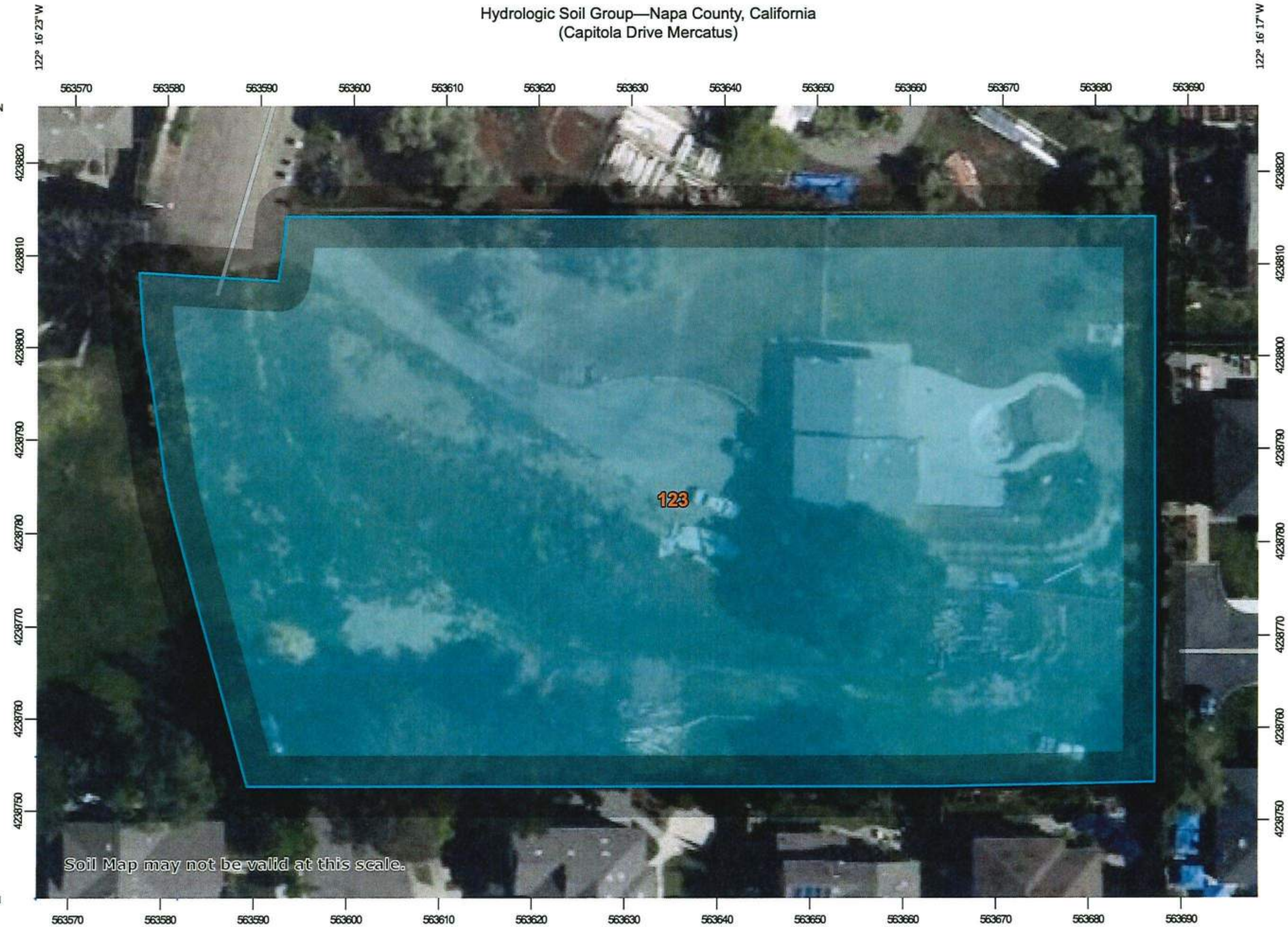
Hydrologic Soil Group—Napa County, California
(Capitola Drive Mercatus)



Map Scale: 1:602 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 5 10 20 30

Feet: 0 25 50 100 150

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

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MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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: Napa County, California
Survey Area Data: Version 15, Sep 1, 2022

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

Date(s) aerial images were photographed: Mar 26, 2022—Apr 25, 2022

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
123	Coombs gravelly loam, 2 to 5 percent slopes	C	1.6	100.0%
Totals for Area of Interest			**1.6**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

EX
NEW

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

TABLE 2-2a (TR 55)

Worksheet: Runoff Curve Number

Project: Capitola Subdivision		By: Ray	Date: 8/25/2023
Location: Napa, California		Checked:	Date:
Subshed name: Existing Watershed		Check one: ☑ Present	☐ Developed

RUNOFF CURVE NUMBER

Soil name and hydrologic group (SCS book)	Cover description (cover type, treatment and hydrogic condition; percent impervious)	CN (1) (Table 2-2)	Area ☑ acres ☐ mi2 ☐ %	Product of CN x Area
123-C	Open Space (Grass Cover, Good Condition)	79	1.35	106.65
123-C	Impervious Areas (Roofs & Pavement)	98	0.27	26.46
		TOTAL:	1.62	133.11

(1) Use only one CN source per line

$$\text{CN (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{133.11}{1.62} = 82.17$$; **USE CN** 82

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Worksheet: Runoff Curve Number

Project	Capitola Subdivision	By	Ray	Date	3/20/2025
Location	Napa, California	Checked		Date	
Subshed name	Proposed Detained Watershed	Check one:	☐ Present	☑ Developed	

RUNOFF CURVE NUMBER

Soil name and hydrologic group (SCS book)	Cover description (cover type, treatment and hydrogic condition; percent impervious)	CN (1) (Table 2-2)	Area ☑ acres ☐ mi2 ☐ %	Product of CN x Area
123-C	Open Space (Grass Cover, Good Condition)	74	0.56	41.44
123-C	Impervious Areas (Roofs & Pavement)	98	0.91	89.18
		TOTAL:	1.47	130.62

(1) Use only one CN source per line

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{130.62}{1.47} = 88.86$; USE CN **89**

2 OF 3

Worksheet: Runoff Curve Number

Project	Capitola Subdivision	By	Ray	Date	8/25/2023
Location	Napa, California	Checked		Date	
Subshed name	Proposed Undetained Watershed	Check one:	☐ Present	☑ Developed	

RUNOFF CURVE NUMBER

Soil name and hydrologic group (SCS book)	Cover description (cover type, treatment and hydrogic condition; percent impervious)	CN (1) (Table 2-2)	Area ☑ acres ☐ mi2 ☐ %	Product of CN x Area
123-C	Open Space (Grass Cover, Good Condition)	74	0.03	2.22
123-C	Impervious Areas (Roofs & Pavement)	98	0.12	11.76
		TOTAL:	0.15	13.98

(1) Use only one CN source per line

$$\text{CN (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{13.98}{0.15} = 93.20$$

; USE CN **93**

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Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

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

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \quad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

12. Pipe sizes.

As noted in Table 2.1, several options are available for use in estimating discharge for storm events. Table 2.2 provides the Design Depth Frequency (DDF) for selected storms and Table 2.3 shows Rainfall Intensity Duration.

TABLE 2.2 – RAINFALL DEPTH (DURATION)

	Rainfall Depth/Storm Duration (inches)									
DDF	5M	15M	1HR	2HR	3HR	6HR	12 HR	24 HR	2D	4D
2-Yr	0.15	0.27	0.57	0.82	1.02	1.50	1.98	2.45	3.12	4.03
5-Yr	0.20	0.38	0.80	1.16	1.42	2.12	2.79	3.44	4.51	5.77
10-Yr	0.25	0.46	0.97	1.39	1.70	2.53	3.33	4.12	5.42	6.94
25-Yr	0.30	0.56	1.16	1.66	2.04	3.03	4.00	4.95	6.63	8.38
50-Yr	0.32	0.62	1.30	1.87	2.29	3.40	4.48	5.56	7.49	9.44
100-Yr	0.36	0.69	1.44	2.07	2.54	3.76	4.96	6.14	8.33	10.45
500-Yr	0.45	0.85	1.78	2.55	3.14	4.67	6.15	7.60	10.50	13.01

Source: City of Napa 2006 Storm Drainage Master Plan Table 3-1

TABLE 2.3 – RAINFALL INTENSITY (DURATION)

	Rainfall Depth/Storm Duration (inches per hour)									
DDF	5M	15M	1HR	2HR	3HR	6HR	12 HR	24 HR	2D	4D
2-Yr	1.80	1.08	0.80	0.41	0.34	0.25	0.16	0.10	0.06	0.04
5-Yr	2.40	1.52	0.08	0.58	0.47	0.35	0.23	0.14	0.09	0.06
10-Yr	3.00	1.84	0.97	0.70	0.57	0.42	0.28	0.17	0.11	0.07
25-Yr	3.60	2.24	1.16	0.83	0.68	0.50	0.33	0.20	0.14	0.08
50-Yr	3.84	2.48	1.30	0.94	0.76	0.57	0.37	0.23	0.16	0.10
100-Yr	4.32	2.76	1.44	1.04	0.84	0.63	0.41	0.26	0.17	0.11
500-Yr	5.40	3.40	1.78	1.28	1.04	0.78	0.51	0.32	0.22	0.14

Source: City of Napa 2006 Storm Drainage Master Plan Table 3-2

A. Rational Method

The 10-and 100-year peak runoff shall be determined for each analysis point using the Rational Method. The Rational Method provides reasonable estimates of peak runoff for small watersheds. The method relates a peak discharge for the project site, a runoff coefficient (C), and rainfall intensity (i). Runoff coefficients were found to vary between 0.35 and 0.90 for land use and storm frequency.

The Rational Method equation has the form: $Q = CiA$

Where:

Q = rate of runoff, acre-inches per hour or cubic feet per second

C = runoff coefficient, which is the ratio of peak runoff to average rainfall intensity

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Worksheet: Time of Concentration (T_c) or travel time (T_t)

Project: Capitola Subdivision	By: Ray	Date: 3/20/2025	
Location: Napa, California	Checked:	Date:	
Subshed name: Existing Watershed	Check one: ☑ Present ☐ Developed		
Note: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic or description of flow segments.	Check one: ☑ Tc ☐ Tt through subarea		

SHEET FLOW (applicable to Tc only)

Segment ID	1			
1. Surface description (table 3-1)	Initial Time	5 Minutes		
2. Manning's roughness coefficient, n (table3-1)	~~0.15~~	(Roof		
3. Flow length, L (total L, 300 ft) . . . ft	~~33.65~~	to		
4. Two-year 24-hour rainfall, P_2 . . . in	~~2.45~~	Downspout)		
5. Land slope, s . . . ft/ft	~~0.017~~			
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t . . hr	0.0833	+	=	0.0833

SHALLOW CONCENTRATED FLOW

Segment ID	2			
7. Surface description (paved or unpaved)	Unpaved			
8. Flow length, L . . . ft	530			
9. Watercourse slope, s . . . ft/ft	0.053			
10. Average velocity, V (figure 3-1) . . . ft/sec	3.7144			
11. $T_t = \frac{L}{3600 V}$ Compute T_t . . hr	0.0396	+	=	0.0396

CHANNEL FLOW

Segment ID	3			
12. Cross sectional flow area, a . . . ft²	3.1416			
13. Wetted perimeter, p_w . . . ft	6.2832			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r . . ft	0.5000			
15. Channel slope, s . . . ft/ft	0.025			
16. Manning's roughness coefficient, n	0.015			
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V . ft/sec	9.8941			
18. Flow length, L . . . ft	35			
11. $T_t = \frac{L}{3600 V}$ Compute T_t . . hr	0.0010	+	=	0.0010
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19) . . . hr				0.1239

= 7.4 MINUTES

ATTACHMENT 8

Worksheet: Time of Concentration (T_c) or travel time (T_t)

Project: Capitola Subdivision	By: Ray	Date: 3/20/2025	
Location: Napa, California	Checked	Date	
Subshed name: Proposed Detained (1 of 2)	Check one: ☐ Present ☑ Developed		
Note: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic or description of flow segments.	Check one: ☑ Tc ☐ Tt through subarea		

SHEET FLOW (applicable to Tc only)

Segment ID	1			
1. Surface description (table 3-1)	Initial Time	5 Minutes		
2. Manning's roughness coefficient, n (table3-1)	~~0.15~~	(Roof		
3. Flow length, L (total L, 300 ft) ... ft	~~33.65~~	to		
4. Two-year 24-hour rainfall, P_2 ... in	~~2.45~~	Downspout)		
5. Land slope, s ... ft/ft	~~0.017~~			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t ... hr	0.0833	+	=	0.0833

SHALLOW CONCENTRATED FLOW

Segment ID	2	3		
7. Surface description (paved or unpaved)	Unpaved	Paved		
8. Flow length, L ... ft	130	255		
9. Watercourse slope, s ... ft/ft	0.029	0.085		
10. Average velocity, V (figure 3-1) ... ft/sec	2.7476	5.9266		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t ... hr	0.0131	+ 0.0120	=	0.0251

CHANNEL FLOW

Segment ID	4	6		
12. Cross sectional flow area, a ... ft^2	0.375	1.8		
13. Wetted perimeter, p_w ... ft	3.5	4.8433		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ... ft	0.1071	0.3716		
15. Channel slope, s ... ft/ft	0.022	0.003		
16. Manning's roughness coefficient, n	0.01	0.015		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V . ft/sec	4.9855	2.8124		
18. Flow length, L ... ft	15	130		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t ... hr	0.0008	+ 0.0128	=	0.0137
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19) ... hr				0.1221

2 of 5

See Next Page

ATTACHMENT 8

Worksheet: Time of Concentration (T_c) or travel time (T_t)

Project	Capitola Subdivision	By	Ray	Date	3/20/2025
Location	Napa, California	Checked		Date	
Subshed name	Proposed Detained (2 of 2)	Check one:	☐ Present	☑ Developed	
Note: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic or description of flow segments.		Check one:	☑ Tc	☐ Tt through subarea	

SHEET FLOW (applicable to Tc only)

Segment ID				
1. Surface description (table 3-1)	Time from	1 of 2		
2. Manning's roughness coefficient, n (table3-1)	~~0.15~~	(Time		
3. Flow length, L (total L, 300 ft) ... ft	~~54.25~~	from		
4. Two-year 24-hour rainfall, P_2 ... in	~~2.45~~	Page 1 of 2)		
5. Land slope, s ... ft/ft	~~0.017~~			
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t ... hr	0.1221	+	=	0.1221

SHALLOW CONCENTRATED FLOW

Segment ID	5			
7. Surface description (paved or unpaved)	Unpaved			
8. Flow length, L ... ft	35			
9. Watercourse slope, s ... ft/ft	0.005			
10. Average velocity, V (figure 3-1) ... ft/sec	1.1409			
11. $T_t = \frac{L}{3600 V}$ Compute T_t ... hr	0.0085	+	=	0.0085

CHANNEL FLOW

Segment ID	7	8		
12. Cross sectional flow area, a ... ft²	3.1416	3.1416		
13. Wetted perimeter, p_w ... ft	6.2832	6.2832		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ... ft	0.5000	0.5000		
15. Channel slope, s ... ft/ft	0.0027	0.025		
16. Manning's roughness coefficient, n	0.015	0.015		
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ... ft/sec	3.2515	9.8941		
18. Flow length, L ... ft	22	34		
11. $T_t = \frac{L}{3600 V}$ Compute T_t ... hr	0.0019	+ 0.0010	=	0.0028
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19) ... hr				0.1335

= 8.0 MINUTES

ATTACHMENT 8

Worksheet: Time of Concentration (T_c) or travel time (T_t)

Project: Capitola Subdivision	By: Ray	Date: 3/20/2025
Location: Napa, California	Checked	Date
Subshed name: Proposed Undetained (1 of 2)	Check one: ☐ Present ☑ Developed	
Note: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic or description of flow segments.	Check one: ☑ Tc ☑ Tt through subarea	

SHEET FLOW (applicable to Tc only)

Segment ID		1		
1. Surface description (table 3-1)		Short Grass		
2. Manning's roughness coefficient, n (table3-1)		0.15		
3. Flow length, L (total L, 300 ft)	ft	175		
4. Two-year 24-hour rainfall, P_2	in	2.45		
5. Land slope, s	ft/ft	0.028		
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} \; s^{0.4}}$ Compute T_t	hr	0.2552	+	= 0.2552

SHALLOW CONCENTRATED FLOW

Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/sec			
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

CHANNEL FLOW

Segment ID		2	3	
12. Cross sectional flow area, a	ft^2	1.7671	3.1416	
13. Wetted perimeter, p_w	ft	4.7124	6.2832	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	0.3750	0.5000	
15. Channel slope, s	ft/ft	0.003	0.0027	
16. Manning's roughness coefficient, n		0.015	0.015	
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V	ft/sec	2.8292	3.2515	
18. Flow length, L	ft	80	22	
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.0079	+ 0.0019	= 0.0097
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19)	hr			0.2650

4 OF 5

SEE NEXT PAGE

ATTACHMENT 8

Worksheet: Time of Concentration (T_c) or travel time (T_t)

Project: Capitola Subdivision	By: Ray	Date: 3/20/2025	
Location: Napa, California	Checked:	Date:	
Subshed name: Proposed Undetained (2 of 2)	Check one: ☐ Present ☑ Developed		
Note: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic or description of flow segments.	Check one: ☑ Tc ☑ Tt through subarea		

SHEET FLOW (applicable to Tc only)

Segment ID			
1. Surface description (table 3-1)	Time from	1 of 2	
2. Manning's roughness coefficient, n (table3-1)	0.15		
3. Flow length, L (total L, 300 ft) . . . ft	142.9		
4. Two-year 24-hour rainfall, P_2 . . . in	2.45		
5. Land slope, s . . . ft/ft	0.017		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{\,0.5}\; s^{0.4}}$ Compute T_t . . . hr	0.2650	+	= 0.2650

SHALLOW CONCENTRATED FLOW

Segment ID			
7. Surface description (paved or unpaved)			
8. Flow length, L . . . ft			
9. Watercourse slope, s . . . ft/ft			
10. Average velocity, V (figure 3-1) . . . ft/sec			
11. $T_t = \frac{L}{3600\,V}$ Compute T_t . . . hr		+	=

CHANNEL FLOW

Segment ID	4		
12. Cross sectional flow area, a . . . ft^2	3.1416		
13. Wetted perimeter, p_w . . . ft	6.2832		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r . . . ft	0.5000		
15. Channel slope, s . . . ft/ft	0.025		
16. Manning's roughness coefficient, n	0.015		
17. $V = \frac{1.49\, r^{2/3} s^{1/2}}{n}$ Compute V . ft/sec	9.8941		
18. Flow length, L . . . ft	34		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t . . . hr	0.0010	+	= 0.0010
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19) . . . hr			0.2659

5 OF 5

= 16.0 MINUTES

HYDRAFLOW CONTOUR DATA INPUT

Contours	Manual
Trapezoid	Chambers

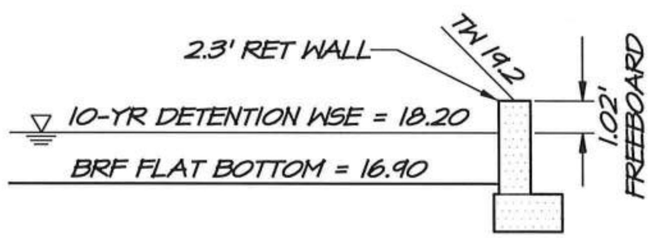
Item	Input
Storage Type =	Contours
Bottom Elev. (ft) =	16.90
Voids (%) =	100.00
Volume by =	Conic

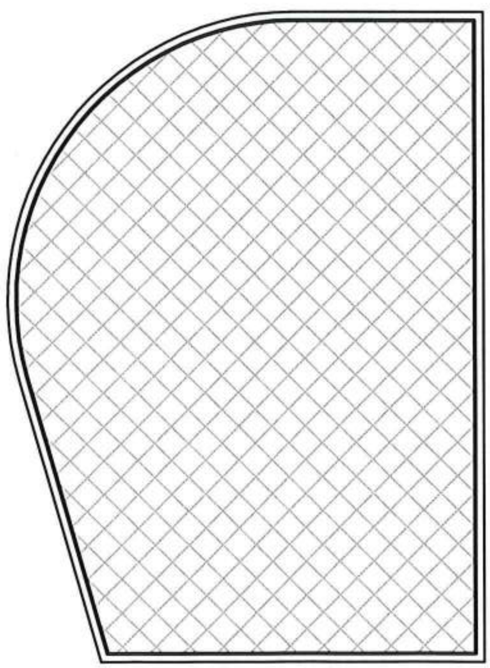
Pond Name: DETENTION BASIN

Row	Stage	Elevation	Contour Area	Incremental Storage	Total Storage
	(ft)	(ft)	(sqft)	(cuft)	(cuft)
0	0.00	16.90	1,593	0.000	0.000
1	0.50	17.40	1,593	796	796
2	1.40	18.30	1,593	1,434	2,230
3					

CONTOUR TABLE

	ELEVATION	AREA (SF)
BIORETENTION #1 FLAT BOTTOM	16.90	1,593
TAILWATER AT ORIFICE SIDE OPENING	17.40	1,593
10-YR DETENTION WATER SURFACE ELEVATION	18.20	1,593
TW (TOP OF WALL ELEVATION)	19.20	





DETENTION
BASIN
FLAT BOTTOM AT 16.90

APPENDIX C

DETENTION CALCULATIONS USING HYDRAFLOW

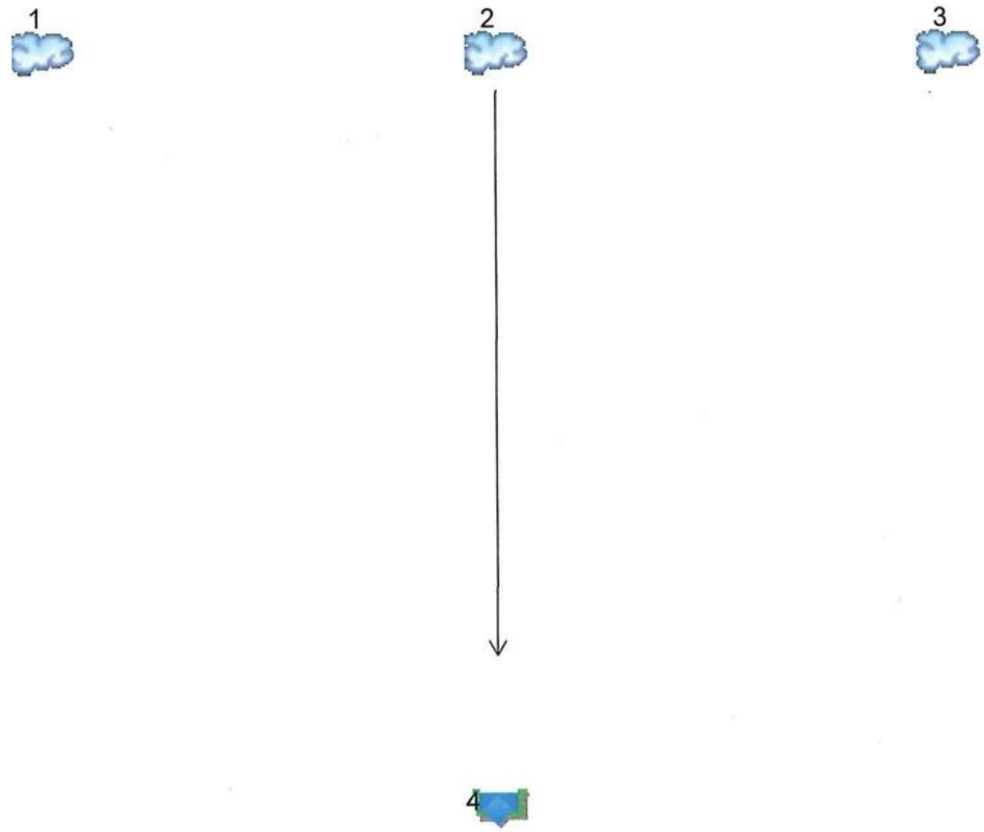
Hydraflow Table of Contents

CS-10yrDetention.gpw

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4 Thursday, 03 / 20 / 2025

Watershed Model Schematic

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4



Legend

Hyd.	Origin	Description
1	SCS Runoff	Existing 10-yr Watershed
2	SCS Runoff	Proposed Pre-Routed 10-yr Watershed
3	SCS Runoff	Proposed Undetained 10-yr Watershed
4	Reservoir	DETAINED ROUTED (10)

Project: CS-10yrDetention.gpw

Thursday, 03 / 20 / 2025

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	-------	-------	-------	-------	0.895	-------	-------	-------	Existing 10-yr Watershed
2	SCS Runoff	------	-------	-------	-------	-------	1.094	-------	-------	-------	Proposed Pre-Routed 10-yr Watersh
3	SCS Runoff	------	-------	-------	-------	-------	0.131	-------	-------	-------	Proposed Undetained 10-yr Watersh
4	Reservoir	2	-------	-------	-------	-------	0.744	-------	-------	-------	DETAINED ROUTED (10)

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.895	1	477	13,221	------	------	------	Existing 10-yr Watershed
2	SCS Runoff	1.094	1	475	15,274	------	------	------	Proposed Pre-Routed 10-yr Watersh
3	SCS Runoff	0.131	1	480	1,840	------	------	------	Proposed Undetained 10-yr Watersh
4	Reservoir	0.744	1	488	14,476	2	18.18	2,036	DETAINED ROUTED (10)

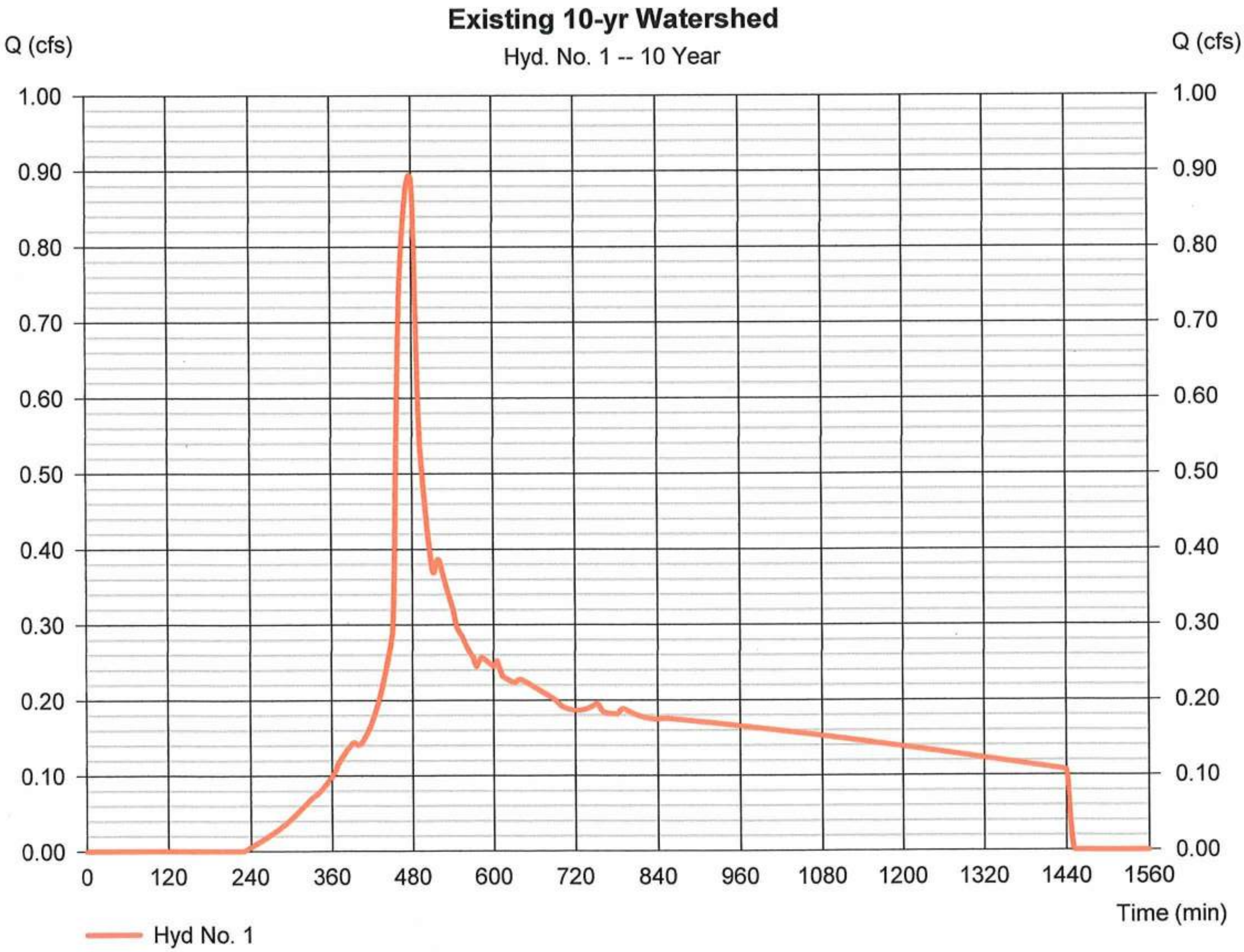
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4 — Thursday, 03 / 20 / 2025

Hyd. No. 1

Existing 10-yr Watershed

Hydrograph type	= SCS Runoff	Peak discharge	= 0.895 cfs
Storm frequency	= 10 yrs	Time to peak	= 477 min
Time interval	= 1 min	Hyd. volume	= 13,221 cuft
Drainage area	= 1.620 ac	Curve number	= 82
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 7.40 min
Total precip.	= 4.12 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= 484



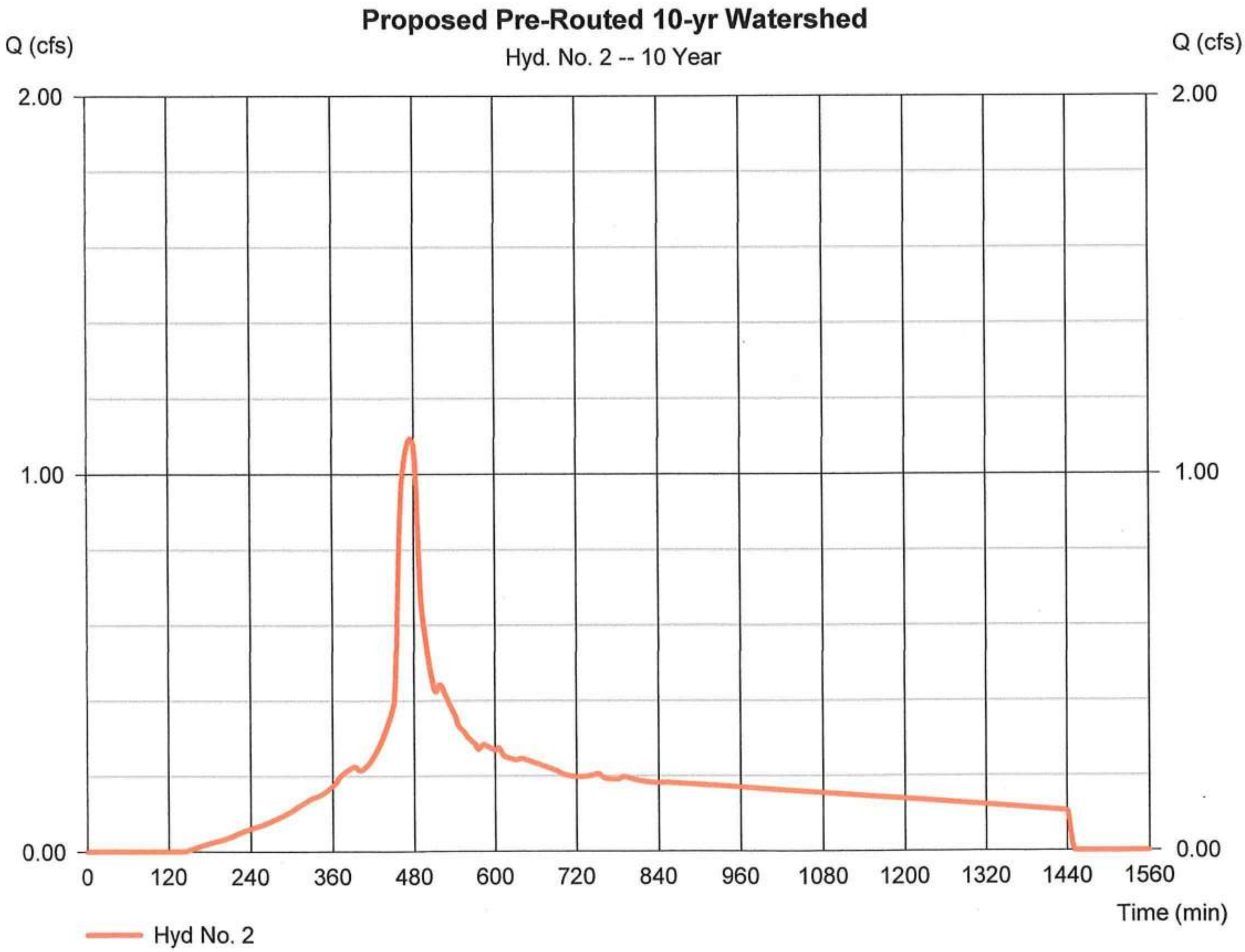
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4 Thursday, 03 / 20 / 2025

Hyd. No. 2

Proposed Pre-Routed 10-yr Watershed

Hydrograph type	= SCS Runoff	Peak discharge	= 1.094 cfs
Storm frequency	= 10 yrs	Time to peak	= 475 min
Time interval	= 1 min	Hyd. volume	= 15,274 cuft
Drainage area	= 1.470 ac	Curve number	= 89
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 8.00 min
Total precip.	= 4.12 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= 484



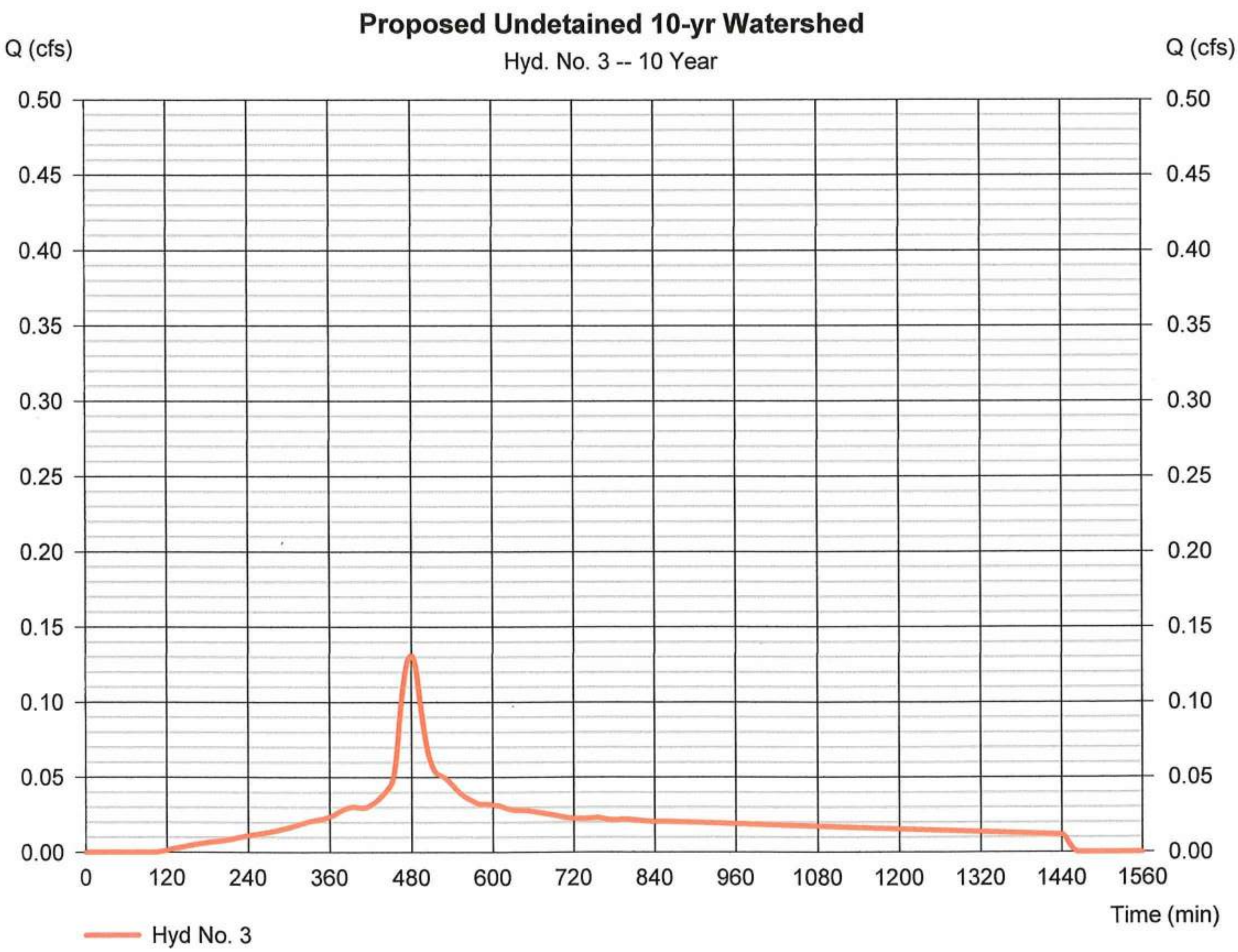
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4 Thursday, 03 / 20 / 2025

Hyd. No. 3

Proposed Undetained 10-yr Watershed

Hydrograph type	= SCS Runoff	Peak discharge	= 0.131 cfs
Storm frequency	= 10 yrs	Time to peak	= 480 min
Time interval	= 1 min	Hyd. volume	= 1,840 cuft
Drainage area	= 0.150 ac	Curve number	= 93
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 16.00 min
Total precip.	= 4.12 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4 Thursday, 03 / 20 / 2025

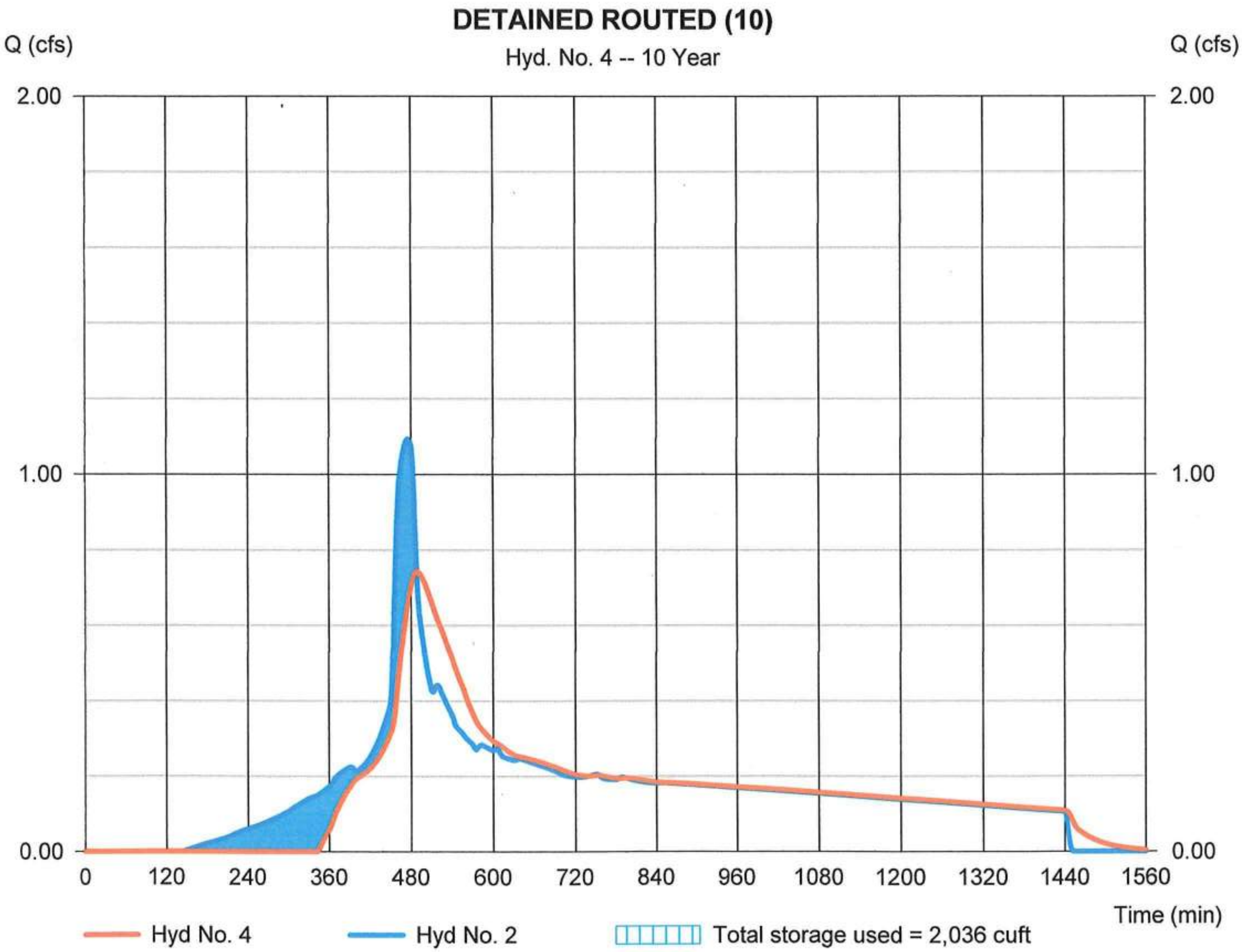
Hyd. No. 4

DETAINED ROUTED (10)

Hydrograph type	= Reservoir	Peak discharge	= 0.744 cfs
Storm frequency	= 10 yrs	Time to peak	= 488 min
Time interval	= 1 min	Hyd. volume	= 14,476 cuft
Inflow hyd. No.	= 2 - Proposed Pre-Routed 10-yr	Max. Elevation	= 18.18 ft
Reservoir name	= DETENTION BASIN	Max. Storage	= 2,036 cuft

REQ'D VOLUME

Storage Indication method used.



Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4 Thursday, 03 / 20 / 2025

Pond No. 1 - DETENTION BASIN

Pond Data

SEE APPENDIX B FOR CONTOUR INPUT

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 16.90 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	16.90	1,593	0	0
0.50	17.40	1,593	796	796
1.40	18.30	1,593	1,434	2,230

Culvert / Orifice Structures

10-YR ORIFICE

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 3.50	0.00	0.00	0.00
Span (in)	= 8.00	0.00	0.00	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 17.40	0.00	0.00	0.00
Length (ft)	= 0.00	0.00	0.00	0.00
Slope (%)	= 0.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

Weir Structures

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

Exfil.(in/hr) = 0.000 (by Contour)
TW Elev. (ft) = 17.40

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	16.90	0.00	---	---	---	---	---	---	---	---	---	0.000
0.50	796	17.40	0.00	---	---	---	---	---	---	---	---	---	0.000
1.40	2,230	18.30	0.81 ic	---	---	---	---	---	---	---	---	---	0.813

PROVIDED VOLUME

Hydraflow Rainfall Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020.4

Thursday, 03 / 20 / 2025

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	5.1978	2.3000	0.5349	--------
3	0.0000	0.0000	0.0000	--------
5	0.0000	0.0000	0.0000	--------
10	12.1604	5.1000	0.6055	--------
25	16.1806	5.9000	0.6293	--------
50	0.0000	0.0000	0.0000	--------
100	22.1077	7.4000	0.6487	--------

File name: NAPA.IDF

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1.79	1.36	1.13	0.99	0.89	0.81	0.75	0.70	0.66	0.63	0.60	0.57
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	3.00	2.35	1.98	1.73	1.55	1.41	1.30	1.21	1.14	1.07	1.02	0.97
25	3.60	2.84	2.39	2.09	1.87	1.70	1.57	1.46	1.36	1.29	1.22	1.16
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	4.32	3.47	2.94	2.58	2.32	2.11	1.94	1.81	1.70	1.60	1.51	1.44

Tc = time in minutes. Values may exceed 60.

Precip. file name: NAPA.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	0.00	2.45	0.00	3.44	4.12	4.95	5.56	6.14
SCS 6-Hr	0.00	1.50	0.00	2.12	2.53	3.03	3.40	3.76
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00