DRAINAGE STUDY
for

BEELER CANYON ROAD
SAN DIEGO, CA 92123

Project Nbr. #649669

APN: 320-030-31

Prepared By:

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San Diego, CA 92123
BWE Job #: 11900U.3.00

Date: March 2021
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TABLE OF CONTENTS

Attachments

1. Purpose

The purpose of this drainage study is to analyze the existing and proposed conditions drainage patterns, and peak flow rates for the Beeler Canyon Road project. This study will also provide recommendations to mitigate stormwater runoff in order for the project to match or decrease the pre-development peak flow rates in the proposed condition.

To determine the impacts of the proposed development on the existing drainage patterns, the pre- and post-peak flow rates are analyzed and compared for the 100-year storm event using the Rational Method. This report has been prepared in accordance with the requirements of the City of San Diego Drainage Design Manual (2017).

2. Background

The 1.7 acres project site is located in the City of San Diego, California. The site is located on the south side of the Beeler Canyon Road and approximately 500 feet west of the intersection between Beeler Canyon Road and Green Valley Court. The site is physically located at: 32.927^0 N & 117.040^0 W.

(See Attachment A for Vicinity & Imagery Maps)

The Federal Emergency Management Agency (FEMA) categorizes the site as Zone X, where Zone X is area determined to be outside of 500-year floodplain (FIRM Panel 1366 of 2375). Attachment F illustrates the FEMA floodplain mapping within the vicinity of the project site. The proposed development is located outside of the existing 100 year flood plain limits. Therefore, the redevelopment will not cause any adverse impact to the existing flood plain limits. The site is located adjacent to the Water Quality Sensitive Areas.

The site does not consist of, nor will this project disturb any Waters of the United States. Therefore, the site is not subject to or requires obtaining approval from the Regional Water Quality Control Board requirements under the Federal Clean Water Act section 401 or 404.

3. Existing Condition

The existing site is currently undeveloped and covered with vegetation. The site topography is relatively steep and slopes from the south to the north direction. The majority runoff from the site discharges towards north into a swale located adjacent to Beeler Canyon Road. The existing swale situated along northerly property line ultimately discharges to the Beeler Creek located northerly side of the Beeler Canyon Road. The remaining portion of the site (southerly area) drains to existing natural channel located along the westerly side of the site. The storm runoff originating from the site ultimately confluence at the westerly side of the site before being discharged to Beeler Creek. The Beeler Creek is a tributary to the Penasquitos Creek which ultimately discharges to the Pacific Ocean.

The runoff originating from upstream (offsite) drainage areas is discharged to Penasquitos Creek via two existing culverts located approximately 135' east to the project site. It is assumed that these culverts are sized adequately to convey the anticipated peak flow runoff from the offsite drainage area. Therefore, the hydraulic analysis of these culverts is not required.

The hydrology of the site area within the project boundary can be generally analyzed at 1 discharge point which is shown graphically in the existing conditions hydrology map.

(See Attachment B for Existing Conditions Hydrology Map)

4. Proposed Improvements

The proposed development works include construction of two new residential buildings with accessory dwelling units, access driveways, and new landscaping. The associated improvement work will also include drainage construction, and dry & wet utilities construction.

The drainage improvement work also includes construction of an 18" RCP culvert within the southerly ROW of Beeler Canyon Road where a new driveway is proposed. This culvert is designed to convey the peak runoff from 100-yr storm event.

The on-site drainage patterns will be altered slightly but discharge locations will be maintained. The hydrology of the site can be generally analyzed at one discharge point which is shown graphically in the proposed condition hydrology map.

The proposed culvert within Beeler Canyon Road is designed to convey the offsite runoff.

(See Attachment C for Proposed Conditions Hydrology Map)

5. Soil Characteristics

A conservative assumption that the project site consists of Soil Type "D" is made for the hydrologic analysis as described in the City of San Diego Drainage Design Manual (2017).

6. Methodology

Rational Method:
A rational method is utilized to perform hydrologic calculations in this study;

Rational Equation: $Q = C * I * A$

Where;
Q = Peak discharge, cfs
C = Rational method runoff coefficient
I = Rainfall intensity, inch/hour
A = Drainage area, acre

A computer model CivilD is used to automate the hydrology analysis process. This computer version of the rational method analysis allows user to develop a node-link model of the watershed. CivilD computer program has the capability of performing calculations utilizing mathematical functions. These functions are assigned code numbers, which appear in the printed results. The code numbers and their corresponding functions are described below;

Sub area Hydrologic Processes;

Code 1 - INITIAL subarea input, top of stream
Code 2 - STREET flow through subarea, includes subarea runoff
Code 3 - ADDITION of runoff from subarea to stream
Code 4 - STREET INLET + parallel street & pipe flow + area
Code 5 - PIPEFLOW travel time (program estimated pipe size)**
Code 6 - PIPEFLOW travel time (user specified pipe size)
Code 7 - IMPROVED channel travel time (open or box)**
Code 8 - IRREGULAR channel travel time**
Code 9 - USER specified entry of data at a point
Code 10 - CONFLUENCE at downstream point in current stream
Code 11 - CONFLUENCE of mainstreams
**NOTE: These options do not include subarea runoff
**NOTE: (#) - Required pipe size determined by the hydrology program

7. Calculations

7.a. Impervious and Pervious Areas

The impervious and pervious areas are calculated for both the existing and proposed site conditions. The site is designed to increase the impervious area by 8,710 square feet (=7.1% of total site area) as shown in Table 7-1. See Attachment B for pervious and impervious areas exhibit.

Table 7-1 Summary of Areas

	Area (Acres)			Percent Impervious Area	Percent Pervious Area
	Total	**Impervious (Ai)**	**Pervious (Ap)**		
Existing	1.73	0.00	1.73	0.0%`	100.0%
Proposed	1.73	0.46	1.27	26.6%	73.4%
Percentage Change	**0.0%**	**26.6%**	**-26.6%**		

7.b. Runoff Coefficient

The runoff coefficient for the site is obtained from Table A-1 of the City of San Diego Drainage Design Manual for residential type land use. The C values are estimated as 0.45 & 0.70 for the existing and proposed conditions respectively. (See Appendices B, and C for runoff coefficient calculations for existing and proposed conditions respectively). The lowest C value from Table 2 is assigned for the existing condition whereas, the C value of 0.70 is used for multi-unit residential development.

7.c. Peak Flow Rates

The rational method is used to perform the hydrologic analysis.

The peak flow rates for the 100 year storm events are calculated and summarized in Table 7-4 for comparison purpose. Tables 7-2, & 3 summarize the peak flow runoff rates at each hydrology nodes for the existing and proposed conditions respectively. Table 7-4 summarizes the peak flow rates for the hydrology nodes for the hydrology analysis for the proposed 18 inch culvert. The detailed calculations/results for existing and proposed conditions analysis are located in Appendices B and C respectively.

Table 7-2 Nodal Flow Rates for Existing Condition

Node #	Peak 100-yr Flow Rate (cfs)	Additional Subarea (Ac)	Total Area (Ac)	Drainage Area
100	0.00	0	0	
101	0.19	0.1	0.1	A-1
102	1.51	0.79	0.89	A-2
103	2.86	0.84	1.73	A-3
Total (POC 1)	**2.86**		**1.73**	

Table 7-3 Nodal Flow Rates for Proposed Condition

Node #	Ummitigated Peak 100-yr Flow Rate (cfs)	Mitigated Peak 100-yr Flow Rate (cfs)	Additional Subarea (Ac)	Total Area (Ac)	Drainage Area
100	0	-	0	0	
101	0.65	-	0.21	0.21	A-1
102	0.65	-	0	0.21	
103	1.17	-	0.18	0.39	A-2
104	1.17	-	0	0.39	
106	1.51	-	0.12	0.51	A-3
106	1.51	-	0	0.51	
107	2.62		0.4	0.91	A-4
109 (BMP 1)	2.62	1.50	0	0.91	
110	2.78	1.66	0.06	0.97	A-5,A-6
200	0.00	-	0	0	
201	0.12	-	0.04	0.04	B-1
202	0.39	-	0.09	0.13	B-2
203	0.68	-	0.1	0.23	B-3
204	0.80	-	0.04	0.27	B-4
205	0.80	-	0	0.27	
206	1.00	-	0.07	0.34	B-5
207	1.20	-	0.07	0.41	B-6
208	1.20	-	0	0.41	
209 (BMP 2)	1.83	0.80	0.23	0.64	
111	4.58	2.45	0	1.61	
112	4.89	2.76	0.12	1.73	B-7
Total (POC 1)	**4.89**	**2.76**		**1.73**	

Table 7-4 Existing and Proposed Conditions Peak Flow Rates Summary

	Drainage Area, A (acres)	Rational Coefficient, C	100-Yr Peak Flow , Q (cfs)	100-yr Velocity, V (fps)
Analysis Point 1 (POC 1) – Existing Condition	1.73	0.45	2.86	2.56
Analysis Point 1 (POC 1) – Proposed Condition (Unmitigated)	1.73	0.70	4.89	2.92
Analysis Point 1 (POC 1) – Proposed Condition (Mitigated)	1.73	0.70	2.76	2.57

Note: The peak flow rates from the offsite drainage area analyzed for the culvert analysis is not included in the comparison purpose.

Due to the proposed development of the site the runoff generated from the 100 year storm event can be expected to increase by 2.1 cfs. The increase in peak flow rate is mainly due to the increased impervious area in the proposed condition. The peak flow rate is mitigated by routing the flow through biofiltration basins and underground storage vaults. The overall peak flow reduction due to the routing is 2.2 cfs. Therefore, the peak flow rate in the mitigated condition is 2.8 cfs which is 0.1 cfs less than existing conditions. Detention calculations are provided in the hydraulics calculations in Attachment C.

Culvert Analysis: The hydrology of the tributary drainage area for the proposed culvert is also analyzed for 100-yr storm event. Majority of the drainage area tributary to this culvert lies easterly side of the subject property as shown in the proposed condition hydrology map. A portion of the Beeler Canyon road in between the cul-de-sac and the proposed culvert is also draining to the proposed culvert. For peak flow analysis, a runoff coefficient value of 0.35 was used for pervious rural land use and calculated using City of San Diego Coefficient Calculations methods to determine the runoff flow rate values. Off-site peak flow calculations and map are provided in Attachment D. The peak flow rate for the 100-yr storm event is determined to be 5.1 cfs for the approximate drainage area of 3.5 acres including the subject property. The 18” culvert with the slope of 1.1% can adequately convey the design peak 100-yr flow rate of 5.1 cfs. An energy dissipater with no. 2 backing is also proposed for the inlet and outlet protection.

Table 7-5 Nodal flow rates for Offsite Hydrology for 18 Inch Culvert

Node #	Peak 100-yr Flow Rate (cfs)	Additional Subarea (Ac)	Total Area (Ac)	Drainage Area
300	0.00	0	0	
301	0.13	0.032	0.032	C-1
302	1.62	0.8	0.832	C-2, C-3
303	3.66	1.65	2.482	C-4, C-5
108 (Offsite only)	3.84	0.06	2.542	C-6
Culvert (108 with Onsite Flow)	5.13	0.96	3.502	A-1, A-2, A-3, A-4, A-5, A-6

8. Downstream Drainage Impact Analysis

The onsite drainage patterns will change minimally due to the proposed redevelopment. The runoff will continue to flow in the same general directions, but new storm drain system is added to effectively manage the runoff in the proposed condition.

The runoff from majority site area discharges to an existing swale situated at the northerly side. The proposed condition peak flow rate from the site is maintained to an existing condition peak flow rate. Therefore, negative downstream drainage impacts are not anticipated from the redevelopment.

9. Conclusions

Storm water runoff from the site is collected and conveyed by a system of downspouts, inlets, storm drain pipes, and swales. The proposed development mitigates the water quantity impacts to the maximum extent practicable through the use of best management practices.

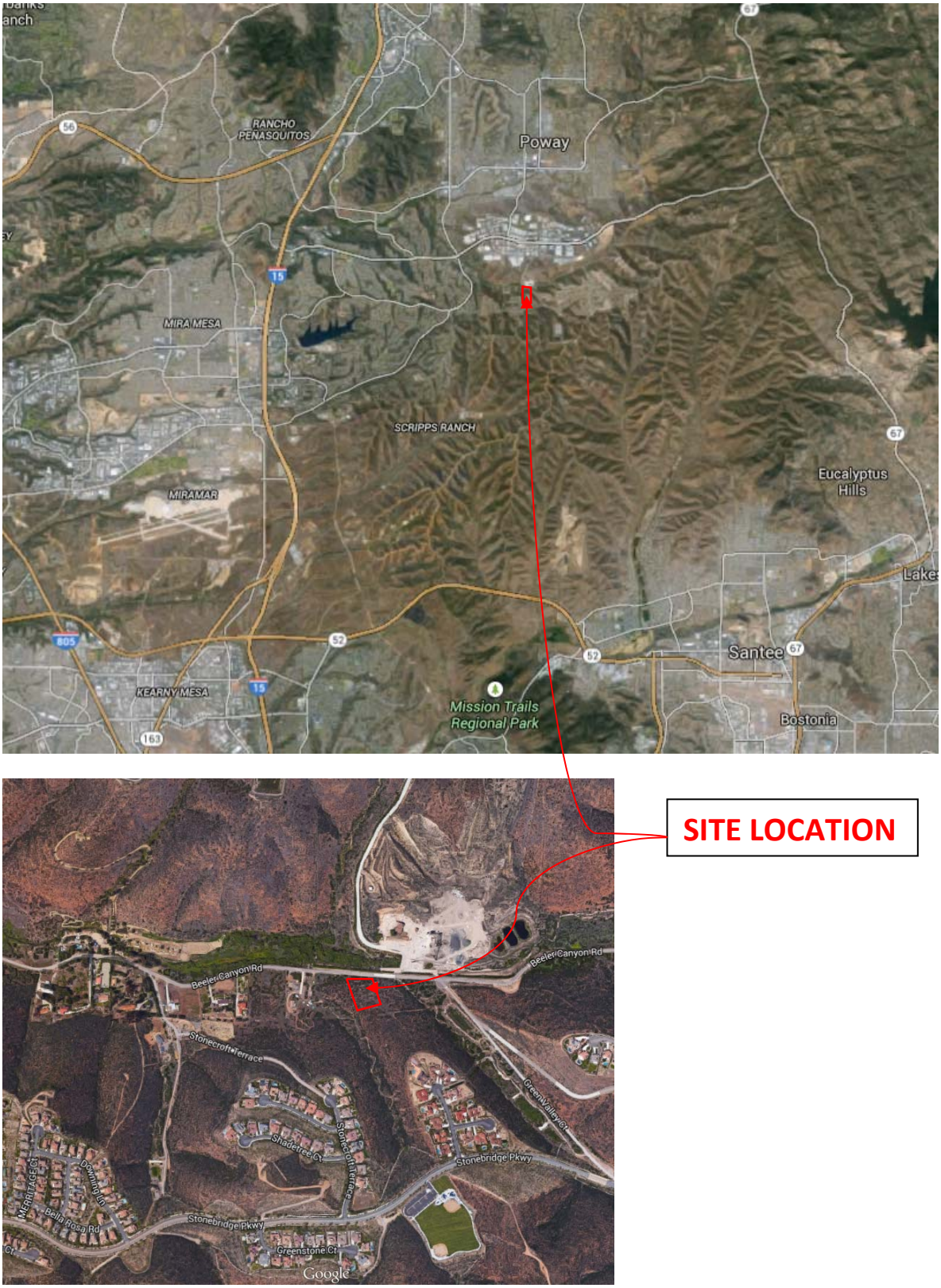
The existing drainage patterns change slightly to accommodate the proposed development. In the proposed condition, the site is expected to reduce the 100 year peak flow rates from 2.9 cfs in existing conditions to 2.8 in proposed conditions. The peak flow attenuation is achieved by routing the flow through two proposed biofiltration basins and two underground storage vaults with total storage volumes of 1,805 cubic feet and 1,824 cubic feet. Approximately 2.2 cfs is mitigated through these detention basins. As a result the proposed condition peak flow rate leaving the site does not increase from the existing condition. Therefore, the negative downstream drainage impacts are not anticipated due to this development. The proposed 18” culvert is designed to convey the peak 100-yr flow rate of 5.1 cfs.

10. References

- City of San Diego, Drainage Design Manual (January 2017).

Attachment A

Site Vicinity Map
Site Imagery Map



VICINITY MAP

IMAGERY MAP

Attachment B

Existing Conditions Runoff Coefficient Calculations
Existing Condition Hydrology Calculations
Existing Condition Hydrology Map

Composite 'C' Value Calculations

Project: Beeler Canyon Road

C-perv = 0.45 Rural - City of San Diego, Table A-1

C-imp= 0.95 (for paved areas)

Existing Conditions

Basin /Exit Point	Area (Acres)			[(Cperv*Ap + Cimp*Ai)]	C-composite
	Total Area (At)	Imp. Area (Ai)	Perv. Area (Ap)		
A/1	1.73	0.00	1.73	0.78	0.45
Overall	**1.73**	**0.00**		**0.78**	**0.45**

Existing	Total (SF)	Imp (SF)	Per (SF)
A-1	4305	0	4305
A-2	34425	0	34425
A-3	36416	0	36416
Total	75146	0	75146

Existing	Total (Ac)	Imp (Ac)	Per (Ac)	C
A-1	0.10	0.00	0.10	0.45
A-2	0.79	0.00	0.79	0.45
A-3	0.84	0.00	0.84	0.45
Total	1.73	0.00	1.73	0.45

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2005 Version 6.5

Rational method hydrology program based on
San Diego County Flood Control Division 1985 hydrology manual
        Rational Hydrology Study   Date: 08/23/21

EXISTING CONDITION
ANALYSIS POINT 1
BEELER CANYON ROAD

 *********   Hydrology Study Control Information **********

Program License Serial Number 6116

Rational hydrology study storm event year is   100.0
English (in-lb) input data Units used
English (in) rainfall data used

Standard intensity of Appendix I-B used for year and
Elevation 0 - 1500 feet
Factor (to multiply * intensity) = 1.000
Only used if inside City of San Diego
San Diego hydrology manual 'C' values used
Runoff coefficients by rational method

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Process from Point/Station   100.000 to Point/Station   101.000
**** INITIAL AREA EVALUATION ****
_____
User specified 'C' value of 0.450 given for subarea
Time of concentration computed by the
natural watersheds nomograph (App X-A)
TC = [11.9*length(Mi)^3)/(elevation change(Ft.))]^.385 *60(min/hr) + 5 min.
 (City of Oceanside)
Initial subarea flow distance = 100.000(Ft.)
Highest elevation = 636.000(Ft.)
Lowest elevation = 624.500(Ft.)
Elevation difference =   11.500(Ft.)
TC=[(11.9*0.0189^3)/(11.50)]^.385= 0.62 + 5 min. =   5.62 min.
Rainfall intensity (I) =   4.186(In/Hr) for a   100.0 year storm

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Effective runoff coefficient used for area (Q=KCIA) is C = 0.450
Subarea runoff =      0.188(CFS)
Total initial stream area =        0.100(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      101.000 to Point/Station      102.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
________________________________________________________________________
Estimated mean flow rate at midpoint of channel =      0.933(CFS)
Depth of flow =   0.091(Ft.), Average velocity =   2.261(Ft/s)
        ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
        1              0.00              0.20
        2             10.00              0.00
        3             20.00              0.20
Manning's 'N' friction factor =   0.030
------------------------------------------------------------------
Sub-Channel flow  =      0.933(CFS)
  '     '        flow top width =      9.082(Ft.)
  '     '    velocity=    2.261(Ft/s)
  '     '        area =      0.412(Sq.Ft)
  '     '        Froude number =     1.870

Upstream point elevation =   624.500(Ft.)
Downstream point elevation =   588.100(Ft.)
Flow length =   283.000(Ft.)
Travel time  =    2.09 min.
Time of concentration =    7.71 min.
Depth of flow =   0.091(Ft.)
Average velocity =   2.261(Ft/s)
Total irregular channel flow =     0.933(CFS)
Irregular channel normal depth above invert elev. =   0.091(Ft.)
Average velocity of channel(s) =   2.261(Ft/s)

Sub-Channel No. 1 Critical depth =      0.116(Ft.)
  '     '       '     Critical flow top width =     11.621(Ft.)
  '     '       '     Critical flow velocity=    1.381(Ft/s)
  '     '       '     Critical flow area =      0.675(Sq.Ft)

 Adding area flow to channel
User specified 'C' value of 0.450 given for subarea
Rainfall intensity =      3.710(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.450
Subarea runoff =      1.319(CFS) for    0.790(Ac.)
Total runoff =      1.507(CFS)  Total area =        0.89(Ac.)
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++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station      102.000 to Point/Station      103.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
________________________________________________________________________
Estimated mean flow rate at midpoint of channel =      2.219(CFS)
Depth of flow =   0.411(Ft.), Average velocity =   2.629(Ft/s)
        ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
        1              0.00              0.50
        2              2.50              0.00
        3              5.00              0.50
Manning's 'N' friction factor =   0.030
------------------------------------------------------------------
Sub-Channel flow  =      2.219(CFS)
  '     '        flow top width =      4.109(Ft.)
  '     '    velocity=    2.629(Ft/s)
  '     '        area =      0.844(Sq.Ft)
  '     '        Froude number =     1.022

Upstream point elevation =   588.100(Ft.)
Downstream point elevation =   585.000(Ft.)
Flow length =   130.000(Ft.)
Travel time  =    0.82 min.
Time of concentration =    8.53 min.
Depth of flow =   0.411(Ft.)
Average velocity =   2.629(Ft/s)
Total irregular channel flow =     2.219(CFS)
Irregular channel normal depth above invert elev. =   0.411(Ft.)
Average velocity of channel(s) =   2.629(Ft/s)

Sub-Channel No. 1 Critical depth =      0.414(Ft.)
  '     '       '     Critical flow top width =      4.141(Ft.)
  '     '       '     Critical flow velocity=    2.588(Ft/s)
  '     '       '     Critical flow area =      0.857(Sq.Ft)

 Adding area flow to channel
User specified 'C' value of 0.450 given for subarea
Rainfall intensity =      3.574(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C = 0.450
Subarea runoff =      1.351(CFS) for    0.840(Ac.)
Total runoff =      2.858(CFS)  Total area =        1.73(Ac.)
End of computations, total study area =          1.730 (Ac.)
```

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Feb 2 2022

Ditch, Proposed Mitigated

Trapezoidal

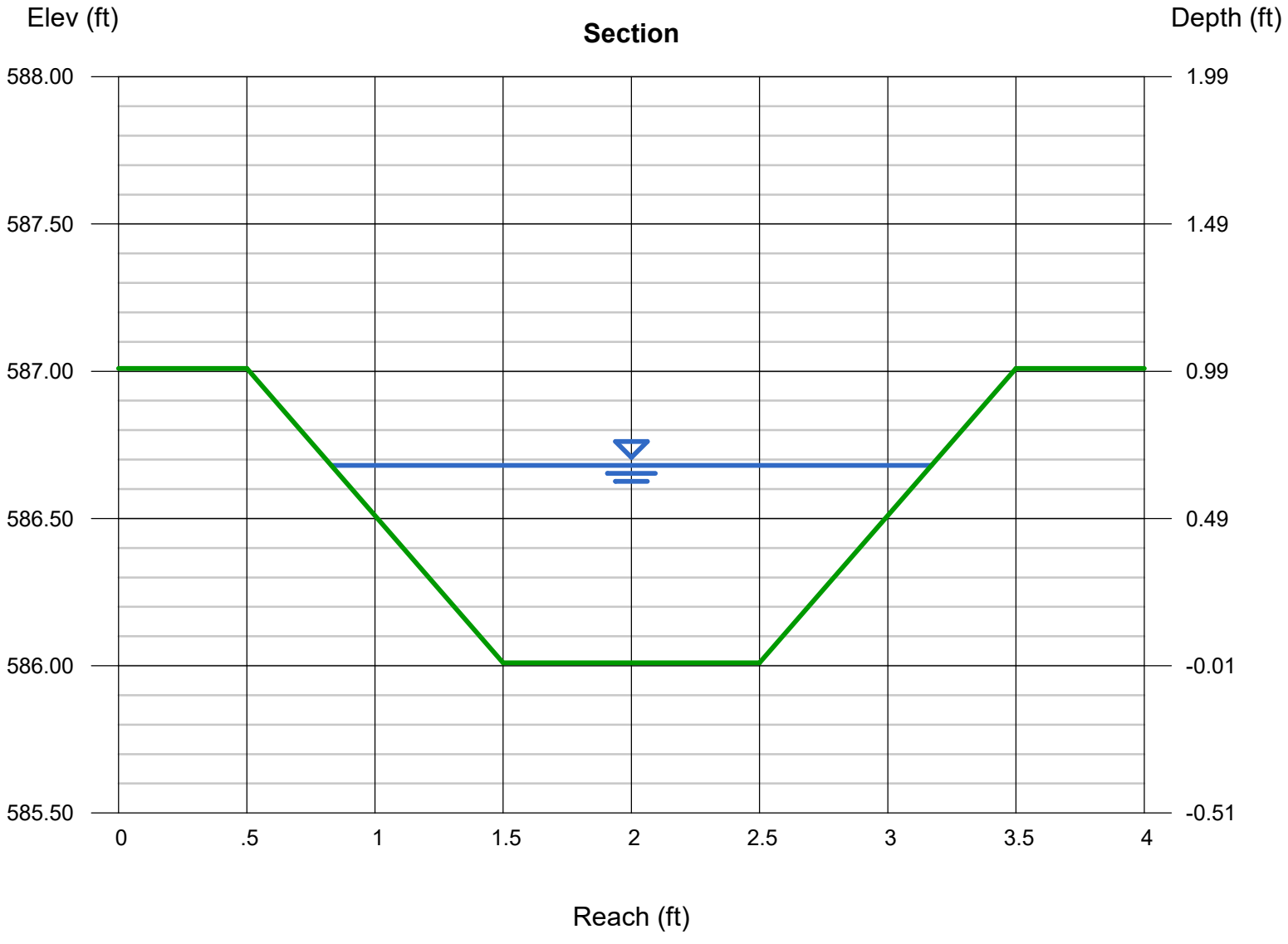
Bottom Width (ft)	= 1.00
Side Slopes (z:1)	= 1.00, 1.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 586.01
Slope (%)	= 1.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 2.86

Highlighted

Depth (ft)	= 0.67
Q (cfs)	= 2.860
Area (sqft)	= 1.12
Velocity (ft/s)	= 2.56
Wetted Perim (ft)	= 2.90
Crit Depth, Yc (ft)	= 0.53
Top Width (ft)	= 2.34
EGL (ft)	= 0.77



LEGEND

SYMBOL	
	OUTER BASIN BOUNDARY
	MAJOR BASIN BOUNDARY
	MINOR BASIN BOUNDARY
SD	EXISTING STORM DRAIN
XXX	EXISTING CONTOUR
	FLOW DIRECTION
L=XX.X'	FLOW PATH FLOW LENGTH
311.00(E) 310.00(E)	NODE ELEVATION
200	HYDROLOGY NODE
	ANALYSIS/EXIT POINT
B-X X.XX	DRAINAGE BASIN MARKER & AREA (AC)

PROJECT	SHEET TITLE	ISSUE DATE: 02/02/2022	SYM	DESCRIPTION	DATE	APPR
BEELER CANYON ROAD	HYDROLOGY EXHIBIT EXISTING CONDITION	DRAWN BY: NJW				
		CHECKED BY: MGC				
SITE ADDRESS		BWE JOB NUMBER: 11900U.3.00				
PARCEL 3 OF MAP 6554		CLIENT JOB NUMBER:				
		MUNICIPALITY PROJECT NUMBER: PTS 649669				
	SHEET 1 OF 1					

BWE
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9449 BALBOA AVE, STE 270
SAN DIEGO, CA 92123 619.299.5550

Attachment C

Proposed Conditions Runoff Coefficient Calculations
Proposed Condition Hydrology Calculations
Proposed Condition Hydrology Map

Composite 'C' Value Calculations

Project: Beeler Canyon Road

C 0.7 Multi Family Residential, City of San Diego Table A-1

Total Area At= **Ap + Ai** (sum of pervious & impervious areas)

Proposed Conditions

Basin /Exit Point	Area (Acres)			C-composite
	Total Area (At)	Imp. Area (Ai)	Perv. Area (Ap)	
A-B/1	1.73	0.46	1.27	0.70
Overall	**1.73**	**0.46**		**0.70**

Proposed

Proposed	Total (SF)	Total (Ac)
A-1	9,320	0.21
A-2	7,476	0.18
A-3	5,322	0.12
A-4	17,315	0.4
A-5	1,459	0.03
A-6	1,097	0.03
B-1	1,739	0.04
B-2	4,021	0.09
B-3	4,259	0.1
B-4	1,923	0.04
B-5	3,048	0.07
B-6	2,985	0.07
B-7	10,187	0.23
B-8	4,999	0.12
Total	75,150	1.73

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2005 Version 6.5

Rational method hydrology program based on
San Diego County Flood Control Division 1985 hydrology manual
Rational Hydrology Study Date: 02/02/22

PROPOSED CONDITION ANALYSIS
ANALYSIS POINT 1
BEELER CANYON ROAD

********* Hydrology Study Control Information **********

Program License Serial Number 6116

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used
English (in) rainfall data used

Standard intensity of Appendix I-B used for year and
Elevation 0 - 1500 feet
Factor (to multiply * intensity) = 1.000
Only used if inside City of San Diego
San Diego hydrology manual 'C' values used
Runoff coefficients by rational method

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Process from Point/Station 100.000 to Point/Station 101.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type]
Initial subarea flow distance = 30.000(Ft.)
Highest elevation = 619.750(Ft.)
Lowest elevation = 619.000(Ft.)
Elevation difference = 0.750(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) = 2.91 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.7000)*(30.000^.5)/(2.500^(1/3)]= 2.91
Setting time of concentration to 5 minutes
Rainfall intensity (I) = 4.389(In/Hr) for a 100.0 year

```
storm
      Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
      Subarea runoff =      0.645(CFS)
      Total initial stream area =        0.210(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      101.000 to Point/Station
102.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
____
      Upstream point/station elevation =   616.000(Ft.)
      Downstream point/station elevation =   615.220(Ft.)
      Pipe length  =    89.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.645(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     0.645(CFS)
      Normal flow depth in pipe =    4.05(In.)
      Flow top width inside pipe =    8.95(In.)
      Critical Depth =    4.38(In.)
      Pipe flow velocity =      3.35(Ft/s)
      Travel time through pipe =    0.44 min.
      Time of concentration (TC) =     5.44 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      102.000 to Point/Station
103.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
____
      Upstream point/station elevation =   615.220(Ft.)
      Downstream point/station elevation =   614.420(Ft.)
      Pipe length  =    75.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.645(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     0.645(CFS)
      Normal flow depth in pipe =    3.83(In.)
      Flow top width inside pipe =    8.90(In.)
      Critical Depth =    4.38(In.)
      Pipe flow velocity =      3.60(Ft/s)
      Travel time through pipe =    0.35 min.
      Time of concentration (TC) =     5.79 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      103.000 to Point/Station
103.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Time of concentration =     5.79 min.
```

```
      Rainfall intensity =      4.138(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.521(CFS) for    0.180(Ac.)
      Total runoff =      1.167(CFS)      Total area =        0.39(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      103.000 to Point/Station
104.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------
____
      Upstream point/station elevation =   614.420(Ft.)
      Downstream point/station elevation =   614.020(Ft.)
      Pipe length  =    55.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     1.167(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     1.167(CFS)
      Normal flow depth in pipe =    6.24(In.)
      Flow top width inside pipe =    8.30(In.)
      Critical Depth =    5.96(In.)
      Pipe flow velocity =      3.57(Ft/s)
      Travel time through pipe =    0.26 min.
      Time of concentration (TC) =     6.05 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      104.000 to Point/Station
106.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------
____
      Upstream point/station elevation =   614.020(Ft.)
      Downstream point/station elevation =   598.300(Ft.)
      Pipe length  =    81.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     1.167(CFS)
      Nearest computed pipe diameter  =      6.00(In.)
      Calculated individual pipe flow  =     1.167(CFS)
      Normal flow depth in pipe =    2.90(In.)
      Flow top width inside pipe =    6.00(In.)
      Critical depth could not be calculated.
      Pipe flow velocity =     12.41(Ft/s)
      Travel time through pipe =    0.11 min.
      Time of concentration (TC) =     6.16 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      106.000 to Point/Station
106.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
```

```
      Time of concentration =     6.16 min.
      Rainfall intensity =      4.040(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.339(CFS) for    0.120(Ac.)
      Total runoff =      1.506(CFS)      Total area =        0.51(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      106.000 to Point/Station
107.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
----
      Upstream point/station elevation =   598.300(Ft.)
      Downstream point/station elevation =   598.000(Ft.)
      Pipe length  =    30.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     1.506(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     1.506(CFS)
      Normal flow depth in pipe =    6.74(In.)
      Flow top width inside pipe =    7.81(In.)
      Critical Depth =    6.79(In.)
      Pipe flow velocity =      4.24(Ft/s)
      Travel time through pipe =    0.12 min.
      Time of concentration (TC) =     6.27 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      106.000 to Point/Station
107.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
----
      Upstream point/station elevation =   597.380(Ft.)
      Downstream point/station elevation =   589.000(Ft.)
      Pipe length  =    73.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     1.506(CFS)
      Nearest computed pipe diameter  =      6.00(In.)
      Calculated individual pipe flow  =     1.506(CFS)
      Normal flow depth in pipe =    4.03(In.)
      Flow top width inside pipe =    5.63(In.)
      Critical depth could not be calculated.
      Pipe flow velocity =     10.74(Ft/s)
      Travel time through pipe =    0.11 min.
      Time of concentration (TC) =     6.39 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      107.000 to Point/Station
107.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------------
----
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
```

```
      [MULTI - UNITS area type                    ]
      Time of concentration =     6.39 min.
      Rainfall intensity =      3.983(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      1.115(CFS) for    0.400(Ac.)
      Total runoff =      2.621(CFS)      Total area =        0.91(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      107.000 to Point/Station
109.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
----
      Upstream point/station elevation =   598.000(Ft.)
      Downstream point/station elevation =   590.000(Ft.)
      Pipe length  =   198.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     2.621(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     2.621(CFS)
      Normal flow depth in pipe =    6.02(In.)
      Flow top width inside pipe =    8.47(In.)
      Critical Depth =    8.41(In.)
      Pipe flow velocity =      8.34(Ft/s)
      Travel time through pipe =    0.40 min.
      Time of concentration (TC) =     6.78 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      109.000 to Point/Station
110.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
----
      Upstream point/station elevation =   590.000(Ft.)
      Downstream point/station elevation =   586.600(Ft.)
      Pipe length  =    30.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     2.621(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     2.621(CFS)
      Normal flow depth in pipe =    4.34(In.)
      Flow top width inside pipe =    8.99(In.)
      Critical Depth =    8.41(In.)
      Pipe flow velocity =     12.41(Ft/s)
      Travel time through pipe =    0.04 min.
      Time of concentration (TC) =     6.82 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      110.000 to Point/Station
110.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------------
----
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
```

```
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Time of concentration =     6.82 min.
      Rainfall intensity =      3.884(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.082(CFS) for    0.030(Ac.)
      Total runoff =      2.703(CFS)      Total area =        0.94(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      110.000 to Point/Station
110.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Time of concentration =     6.82 min.
      Rainfall intensity =      3.884(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.082(CFS) for    0.030(Ac.)
      Total runoff =      2.784(CFS)      Total area =        0.97(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      110.000 to Point/Station
111.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------
____
      Upstream point/station elevation =   586.500(Ft.)
      Downstream point/station elevation =   586.100(Ft.)
      Pipe length  =    36.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     2.784(CFS)
      Nearest computed pipe diameter  =     12.00(In.)
      Calculated individual pipe flow  =     2.784(CFS)
      Normal flow depth in pipe =    7.69(In.)
      Flow top width inside pipe =   11.52(In.)
      Critical Depth =    8.58(In.)
      Pipe flow velocity =      5.23(Ft/s)
      Travel time through pipe =    0.11 min.
      Time of concentration (TC) =     6.94 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      100.000 to Point/Station
111.000
      **** CONFLUENCE OF MAIN STREAMS ****
      ------------------------------------------------------------------
____
      The following data inside Main Stream is listed:
      In Main Stream number: 1
      Stream flow area =      0.970(Ac.)
```

```
      Runoff from this stream =      2.784(CFS)
      Time of concentration =    6.94 min.
      Rainfall intensity =     3.859(In/Hr)
      Program is now starting with Main Stream No. 2


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      200.000 to Point/Station
201.000
      **** INITIAL AREA EVALUATION ****
      ------------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Initial subarea flow distance  =   26.000(Ft.)
      Highest elevation =  609.000(Ft.)
      Lowest elevation =  608.750(Ft.)
      Elevation difference =    0.250(Ft.)
      Time of concentration calculated by the urban
      areas overland flow method (App X-C) =     3.72 min.
      TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
      TC = [1.8*(1.1-0.7000)*(  26.000^.5)/(   0.962^(1/3)]=   3.72
      Setting time of concentration to 5 minutes
      Rainfall intensity (I) =      4.389(In/Hr) for a   100.0 year
storm
      Effective runoff coefficient used for area (Q=KCIA) is C = 0.700
      Subarea runoff =      0.123(CFS)
      Total initial stream area =        0.040(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      201.000 to Point/Station
202.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
____
      Upstream point/station elevation =   605.760(Ft.)
      Downstream point/station elevation =   605.230(Ft.)
      Pipe length  =    54.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.123(CFS)
      Nearest computed pipe diameter  =      6.00(In.)
      Calculated individual pipe flow  =     0.123(CFS)
      Normal flow depth in pipe =    1.91(In.)
      Flow top width inside pipe =    5.59(In.)
      Critical Depth =    2.09(In.)
      Pipe flow velocity =      2.27(Ft/s)
      Travel time through pipe =    0.40 min.
      Time of concentration (TC) =     5.40 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      202.000 to Point/Station
202.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------------
```

```
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Time of concentration =     5.40 min.
      Rainfall intensity =      4.256(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.268(CFS) for    0.090(Ac.)
      Total runoff =      0.391(CFS)      Total area =        0.13(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      202.000 to Point/Station
203.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------
____
      Upstream point/station elevation =   605.230(Ft.)
      Downstream point/station elevation =   604.800(Ft.)
      Pipe length  =    43.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.391(CFS)
      Nearest computed pipe diameter  =      6.00(In.)
      Calculated individual pipe flow  =     0.391(CFS)
      Normal flow depth in pipe =    3.69(In.)
      Flow top width inside pipe =    5.84(In.)
      Critical Depth =    3.82(In.)
      Pipe flow velocity =      3.09(Ft/s)
      Travel time through pipe =    0.23 min.
      Time of concentration (TC) =     5.63 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      203.000 to Point/Station
203.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Time of concentration =     5.63 min.
      Rainfall intensity =      4.185(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.293(CFS) for    0.100(Ac.)
      Total runoff =      0.684(CFS)      Total area =        0.23(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      203.000 to Point/Station
204.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------
```

```
____
      Upstream point/station elevation =   604.800(Ft.)
      Downstream point/station elevation =   604.370(Ft.)
      Pipe length  =    43.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.684(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     0.684(CFS)
      Normal flow depth in pipe =    4.03(In.)
      Flow top width inside pipe =    8.95(In.)
      Critical Depth =    4.51(In.)
      Pipe flow velocity =      3.57(Ft/s)
      Travel time through pipe =    0.20 min.
      Time of concentration (TC) =     5.83 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      204.000 to Point/Station
204.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Time of concentration =     5.83 min.
      Rainfall intensity =      4.127(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.116(CFS) for    0.040(Ac.)
      Total runoff =      0.799(CFS)      Total area =        0.27(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      204.000 to Point/Station
205.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------
____
      Upstream point/station elevation =   604.370(Ft.)
      Downstream point/station elevation =   603.980(Ft.)
      Pipe length  =    38.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.799(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     0.799(CFS)
      Normal flow depth in pipe =    4.38(In.)
      Flow top width inside pipe =    9.00(In.)
      Critical Depth =    4.90(In.)
      Pipe flow velocity =      3.75(Ft/s)
      Travel time through pipe =    0.17 min.
      Time of concentration (TC) =     6.00 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      205.000 to Point/Station
206.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
```

```
------------------------------------------------------------------------
____
      Upstream point/station elevation =   603.980(Ft.)
      Downstream point/station elevation =   591.640(Ft.)
      Pipe length  =    38.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.799(CFS)
      Nearest computed pipe diameter  =      6.00(In.)
      Calculated individual pipe flow  =     0.799(CFS)
      Normal flow depth in pipe =    2.04(In.)
      Flow top width inside pipe =    5.69(In.)
      Critical Depth =    5.33(In.)
      Pipe flow velocity =     13.53(Ft/s)
      Travel time through pipe =    0.05 min.
      Time of concentration (TC) =     6.04 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      206.000 to Point/Station
206.000
      **** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                      ]
      Time of concentration =     6.04 min.
      Rainfall intensity =      4.069(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.199(CFS) for    0.070(Ac.)
      Total runoff =      0.999(CFS)      Total area =        0.34(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      206.000 to Point/Station
207.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
------------------------------------------------------------------------
____
      Upstream point/station elevation =   591.640(Ft.)
      Downstream point/station elevation =   591.160(Ft.)
      Pipe length  =    46.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.999(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     0.999(CFS)
      Normal flow depth in pipe =    4.98(In.)
      Flow top width inside pipe =    8.95(In.)
      Critical Depth =    5.51(In.)
      Pipe flow velocity =      3.98(Ft/s)
      Travel time through pipe =    0.19 min.
      Time of concentration (TC) =     6.24 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      206.000 to Point/Station
207.000
```

```
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
____
      Upstream point/station elevation =   590.590(Ft.)
      Downstream point/station elevation =   589.000(Ft.)
      Pipe length  =    22.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     0.999(CFS)
      Nearest computed pipe diameter  =      6.00(In.)
      Calculated individual pipe flow  =     0.999(CFS)
      Normal flow depth in pipe =    3.57(In.)
      Flow top width inside pipe =    5.89(In.)
      Critical Depth =    5.67(In.)
      Pipe flow velocity =      8.21(Ft/s)
      Travel time through pipe =    0.04 min.
      Time of concentration (TC) =     6.28 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      207.000 to Point/Station
207.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                    ]
      Time of concentration =     6.28 min.
      Rainfall intensity =      4.009(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.196(CFS) for    0.070(Ac.)
      Total runoff =      1.195(CFS)      Total area =        0.41(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      207.000 to Point/Station
208.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
____
      Upstream point/station elevation =   591.160(Ft.)
      Downstream point/station elevation =   590.590(Ft.)
      Pipe length  =    54.50(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     1.195(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     1.195(CFS)
      Normal flow depth in pipe =    5.58(In.)
      Flow top width inside pipe =    8.73(In.)
      Critical Depth =    6.04(In.)
      Pipe flow velocity =      4.15(Ft/s)
      Travel time through pipe =    0.22 min.
      Time of concentration (TC) =     6.50 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      208.000 to Point/Station
```

```
209.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
____
      Upstream point/station elevation =   590.590(Ft.)
      Downstream point/station elevation =   590.000(Ft.)
      Pipe length  =    22.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     1.195(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     1.195(CFS)
      Normal flow depth in pipe =    4.18(In.)
      Flow top width inside pipe =    8.98(In.)
      Critical Depth =    6.04(In.)
      Pipe flow velocity =      5.94(Ft/s)
      Travel time through pipe =    0.06 min.
      Time of concentration (TC) =     6.56 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      209.000 to Point/Station
209.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------------
____
      Decimal fraction soil group A = 0.000
      Decimal fraction soil group B = 0.000
      Decimal fraction soil group C = 0.000
      Decimal fraction soil group D = 1.000
      [MULTI - UNITS area type                      ]
      Time of concentration =     6.56 min.
      Rainfall intensity =      3.942(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
      Subarea runoff =      0.635(CFS) for    0.230(Ac.)
      Total runoff =      1.830(CFS)      Total area =        0.64(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      209.000 to Point/Station
111.000
      **** PIPEFLOW TRAVEL TIME (Program estimated size) ****
      ------------------------------------------------------------------------
____
      Upstream point/station elevation =   586.500(Ft.)
      Downstream point/station elevation =   586.010(Ft.)
      Pipe length  =    21.00(Ft.)   Manning's N = 0.013
      No. of pipes = 1  Required pipe flow  =     1.830(CFS)
      Nearest computed pipe diameter  =      9.00(In.)
      Calculated individual pipe flow  =     1.830(CFS)
      Normal flow depth in pipe =    5.68(In.)
      Flow top width inside pipe =    8.69(In.)
      Critical Depth =    7.42(In.)
      Pipe flow velocity =      6.23(Ft/s)
      Travel time through pipe =    0.06 min.
      Time of concentration (TC) =     6.62 min.


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
```

```
      Process from Point/Station      200.000 to Point/Station
111.000
      **** CONFLUENCE OF MAIN STREAMS ****
      ------------------------------------------------------------------------
____
      The following data inside Main Stream is listed:
      In Main Stream number: 2
      Stream flow area =      0.640(Ac.)
      Runoff from this stream =      1.830(CFS)
      Time of concentration =    6.62 min.
      Rainfall intensity =     3.929(In/Hr)
      Summary of stream data:

      Stream   Flow rate      TC            Rainfall Intensity
       No.       (CFS)       (min)                (In/Hr)


      1        2.784      6.94               3.859
      2        1.830      6.62               3.929
      Qmax(1) =
                1.000 *    1.000 *     2.784) +
                0.982 *    1.000 *     1.830) + =       4.582
      Qmax(2) =
                1.000 *    0.954 *     2.784) +
                1.000 *    1.000 *     1.830) + =       4.486

      Total of 2 main streams to confluence:
      Flow rates before confluence point:
             2.784       1.830
      Maximum flow rates at confluence using above data:
             4.582        4.486
      Area of streams before confluence:
             0.970        0.640


      Results of confluence:
      Total flow rate =      4.582(CFS)
      Time of concentration =     6.938 min.
      Effective stream area after confluence  =      1.610(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      111.000 to Point/Station
112.000
      **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
      ------------------------------------------------------------------------
____
      Depth of flow =   0.728(Ft.), Average velocity =   2.471(Ft/s)
            ******* Irregular Channel Data ***********
      ------------------------------------------------------------------
      Information entered for subchannel number 1 :
      Point number      'X' coordinate     'Y' coordinate
            1              0.00              1.00
            2              3.50              0.00
            3              7.00              1.00
      Manning's 'N' friction factor =   0.030
      ------------------------------------------------------------------
      Sub-Channel flow  =      4.582(CFS)
        '     '    flow top width =      5.095(Ft.)
        '     '    velocity=    2.471(Ft/s)
```

```
  '     '    area =      1.854(Sq.Ft)
  '     '    Froude number =     0.722

Upstream point elevation =   586.100(Ft.)
Downstream point elevation =   585.000(Ft.)
Flow length =   109.000(Ft.)
Travel time  =    0.74 min.
Time of concentration =    7.67 min.
Depth of flow =   0.728(Ft.)
Average velocity =   2.471(Ft/s)
Total irregular channel flow =     4.582(CFS)
Irregular channel normal depth above invert elev. =   0.728(Ft.)
Average velocity of channel(s) =   2.471(Ft/s)

Sub-Channel No. 1 Critical depth =      0.641(Ft.)
  '     '       '     Critical flow top width =      4.484(Ft.)
  '     '       '     Critical flow velocity=    3.190(Ft/s)
  '     '       '     Critical flow area =      1.436(Sq.Ft)



++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
Process from Point/Station      210.000 to Point/Station
112.000
**** SUBAREA FLOW ADDITION ****
_____________________________________________________________________
____
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[MULTI - UNITS area type                    ]
Time of concentration =     7.67 min.
Rainfall intensity =      3.716(In/Hr) for a   100.0 year storm
Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.700
Subarea runoff =      0.312(CFS) for    0.120(Ac.)
Total runoff =      4.894(CFS)      Total area =        1.73(Ac.)
End of computations, total study area =           1.730 (Ac.)
```

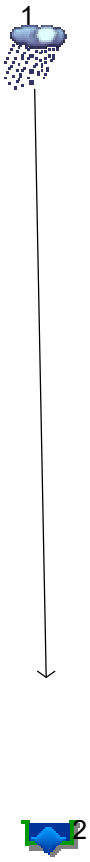
BMP 1

Storage	Incremental Storage (CF)
Permavoid (587 to 588, 1900 SF, 95% void)	1805
Media (588 to 590, 407 SF, 18" at 20% void, 6" at 40% void)	203
Biofiltration (590 to 591), 407 SF at 590, 687 at 591	547

BMP 2

Storage	Incremental Storage (CF)
Permavoid (585.5 to 587, 1280 SF,95% void)	1824
Media (587 to 589, 360 SF, 18" at 20% void, 6" at 40% void)	180
Biofiltration (589 to 590), 360 SF at 589, 906 SF at 590	633

Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	Manual	BMP1Hydrograph
2	Reservoir	BMP1

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	Manual	2.600	6	246	5,796	------	------	------	BMP1Hydrograph
2	Reservoir	1.499	6	258	5,777	1	590.11	2,412	BMP1

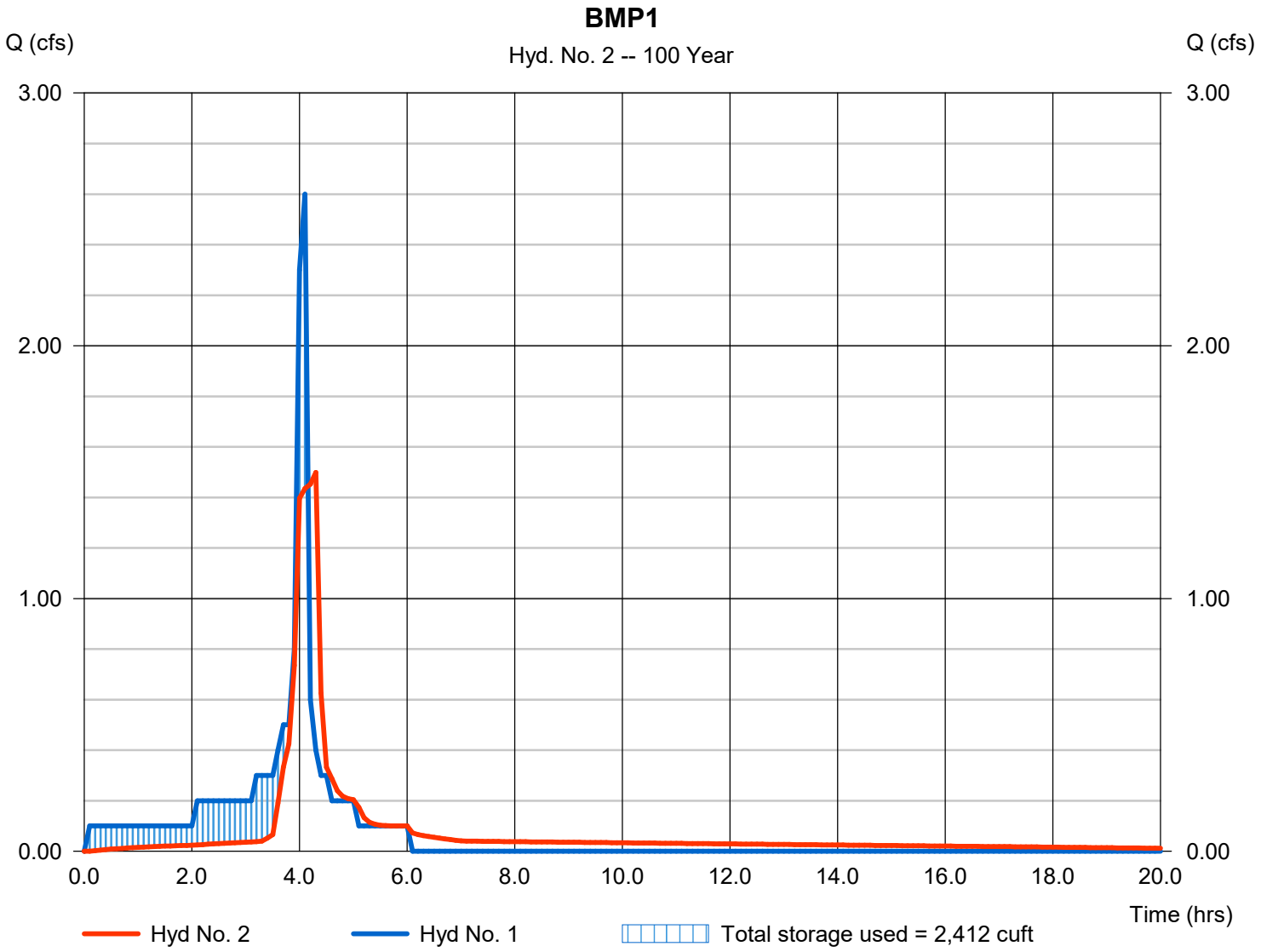
Hydrograph Report

Hyd. No. 2

BMP1

Hydrograph type	=	Reservoir	Peak discharge	=	1.499 cfs
Storm frequency	=	100 yrs	Time to peak	=	4.30 hrs
Time interval	=	6 min	Hyd. volume	=	5,777 cuft
Inflow hyd. No.	=	1 - BMP1Hydrograph	Max. Elevation	=	590.11 ft
Reservoir name	=	BMP1 Permavoid	Max. Storage	=	2,412 cuft

Storage Indication method used.



Pond No. 1 - BMP1 Permavoid

Pond Data

Pond storage is based on user-defined values.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	587.00	n/a	0	0
1.00	588.00	n/a	1,805	1,805
3.00	590.00	n/a	203	2,008
4.00	591.00	n/a	547	2,555

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 6.00	1.36	Inactive	Inactive
Span (in)	= 6.00	1.36	0.00	0.00
No. Barrels	= 1	1	0	0
Invert El. (ft)	= 587.00	587.00	0.00	0.00
Length (ft)	= 23.10	0.00	0.00	0.00
Slope (%)	= 1.73	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 3.00	3.00	Inactive	Inactive
Crest El. (ft)	= 590.50	587.88	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= 1	Rect	Broad	---
Multi-Stage	= Yes	Yes	No	No

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

TW Elev. (ft) = 0.00

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

Stage / Storage / Discharge 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	587.00	0.00	0.00	---	---	0.00	0.00	0.00	---	---	---	0.000
0.10	181	587.10	0.01 ic	0.01 ic	---	---	0.00	0.00	0.00	---	---	---	0.010
0.20	361	587.20	0.02 ic	0.02 ic	---	---	0.00	0.00	0.00	---	---	---	0.017
0.30	542	587.30	0.02 ic	0.02 ic	---	---	0.00	0.00	0.00	---	---	---	0.023
0.40	722	587.40	0.03 ic	0.03 ic	---	---	0.00	0.00	0.00	---	---	---	0.027
0.50	903	587.50	0.03 ic	0.03 ic	---	---	0.00	0.00	0.00	---	---	---	0.031
0.60	1,083	587.60	0.04 ic	0.03 ic	---	---	0.00	0.00	0.00	---	---	---	0.034
0.70	1,264	587.70	0.04 ic	0.04 ic	---	---	0.00	0.00	0.00	---	---	---	0.037
0.80	1,444	587.80	0.04 ic	0.04 ic	---	---	0.00	0.00	0.00	---	---	---	0.040
0.90	1,625	587.90	0.07 ic	0.04 ic	---	---	0.00	0.03	0.00	---	---	---	0.070
1.00	1,805	588.00	0.45 ic	0.04 ic	---	---	0.00	0.42	0.00	---	---	---	0.451
1.20	1,825	588.20	0.90 oc	0.01 ic	---	---	0.00	0.89 s	0.00	---	---	---	0.895
1.40	1,846	588.40	0.98 oc	0.01 ic	---	---	0.00	0.98 s	0.00	---	---	---	0.983
1.60	1,866	588.60	1.06 oc	0.00 ic	---	---	0.00	1.05 s	0.00	---	---	---	1.054
1.80	1,886	588.80	1.13 oc	0.00 ic	---	---	0.00	1.12 s	0.00	---	---	---	1.123
2.00	1,907	589.00	1.19 oc	0.00 ic	---	---	0.00	1.17 s	0.00	---	---	---	1.174
2.20	1,927	589.20	1.26 oc	0.00 ic	---	---	0.00	1.22 s	0.00	---	---	---	1.225
2.40	1,947	589.40	1.32 oc	0.00 ic	---	---	0.00	1.30 s	0.00	---	---	---	1.304
2.60	1,967	589.60	1.37 oc	0.00 ic	---	---	0.00	1.30 s	0.00	---	---	---	1.305
2.80	1,988	589.80	1.43 oc	0.00 ic	---	---	0.00	1.39 s	0.00	---	---	---	1.389
3.00	2,008	590.00	1.48 oc	0.00 ic	---	---	0.00	1.42 s	0.00	---	---	---	1.421
3.10	2,063	590.10	1.50 oc	0.00 ic	---	---	0.00	1.49 s	0.00	---	---	---	1.496
3.20	2,117	590.20	1.53 oc	0.00 ic	---	---	0.00	1.52 s	0.00	---	---	---	1.520
3.30	2,172	590.30	1.55 oc	0.00 ic	---	---	0.00	1.50 s	0.00	---	---	---	1.504
3.40	2,227	590.40	1.58 oc	0.00 ic	---	---	0.00	1.57 s	0.00	---	---	---	1.573
3.50	2,282	590.50	1.60 oc	0.00 ic	---	---	0.00	1.46 s	0.00	---	---	---	1.459
3.60	2,336	590.60	1.62 oc	0.00 ic	---	---	0.04 s	1.43 s	0.00	---	---	---	1.471
3.70	2,391	590.70	1.65 oc	0.00 ic	---	---	0.07 s	1.33 s	0.00	---	---	---	1.402
3.80	2,446	590.80	1.67 oc	0.00 ic	---	---	0.11 s	1.38 s	0.00	---	---	---	1.495
3.90	2,500	590.90	1.69 oc	0.00 ic	---	---	0.15 s	1.44 s	0.00	---	---	---	1.589
4.00	2,555	591.00	1.71 oc	0.00 ic	---	---	0.18 s	1.38 s	0.00	---	---	---	1.559

Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

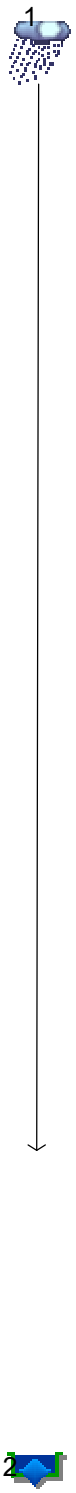
Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

Precip. file name: Sample.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	2.20	0.00	3.30	4.25	5.77	6.80	7.95
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	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	1.75	0.00	2.80	3.90	5.25	6.00	7.10

Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	Manual	BMP2Hydrograph
2	Reservoir	BMP2

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	Manual	1.910	6	246	4,288	------	------	------	BMP2Hydrograph
2	Reservoir	0.795	6	252	4,266	1	589.48	2,437	BMP2

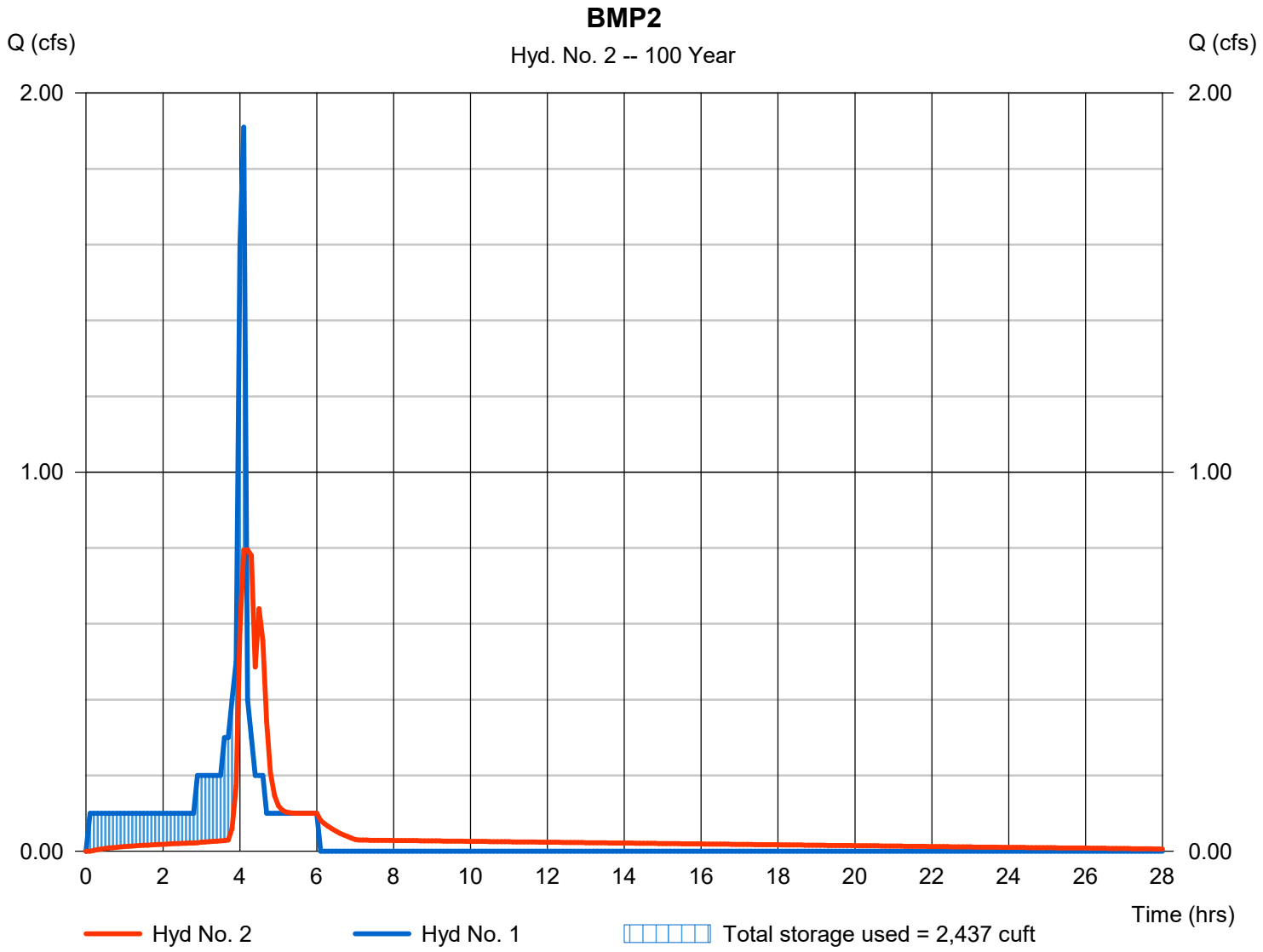
Hydrograph Report

Hyd. No. 2

BMP2

Hydrograph type	=	Reservoir	Peak discharge	=	0.795 cfs
Storm frequency	=	100 yrs	Time to peak	=	4.20 hrs
Time interval	=	6 min	Hyd. volume	=	4,266 cuft
Inflow hyd. No.	=	1 - BMP2Hydrograph	Max. Elevation	=	589.48 ft
Reservoir name	=	BMP2	Max. Storage	=	2,437 cuft

Storage Indication method used.



Pond Report

Pond No. 1 - BMP2

Pond Data

Pond storage is based on user-defined values.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	585.50	n/a	0	0
1.50	587.00	n/a	1,824	1,824
3.50	589.00	n/a	180	2,004
4.50	590.00	n/a	633	2,637

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 4.00	1.04	Inactive	Inactive
Span (in)	= 4.00	1.04	0.00	0.00
No. Barrels	= 1	1	0	0
Invert El. (ft)	= 585.50	585.50	0.00	0.00
Length (ft)	= 10.00	0.00	0.00	0.00
Slope (%)	= 4.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 3.00	3.00	Inactive	Inactive
Crest El. (ft)	= 589.50	586.82	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= 1	Rect	---	---
Multi-Stage	= Yes	Yes	No	No

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

TW Elev. (ft) = 0.00

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

Stage / Storage / Discharge 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	585.50	0.00	0.00	---	---	0.00	0.00	---	---	---	---	0.000
0.15	182	585.65	0.01 ic	0.01 ic	---	---	0.00	0.00	---	---	---	---	0.009
0.30	365	585.80	0.01 ic	0.01 ic	---	---	0.00	0.00	---	---	---	---	0.014
0.45	547	585.95	0.02 ic	0.02 ic	---	---	0.00	0.00	---	---	---	---	0.017
0.60	730	586.10	0.02 ic	0.02 ic	---	---	0.00	0.00	---	---	---	---	0.020
0.75	912	586.25	0.02 ic	0.02 ic	---	---	0.00	0.00	---	---	---	---	0.023
0.90	1,094	586.40	0.03 ic	0.03 ic	---	---	0.00	0.00	---	---	---	---	0.025
1.05	1,277	586.55	0.03 ic	0.03 ic	---	---	0.00	0.00	---	---	---	---	0.028
1.20	1,459	586.70	0.03 ic	0.03 ic	---	---	0.00	0.00	---	---	---	---	0.030
1.35	1,642	586.85	0.08 ic	0.03 ic	---	---	0.00	0.05	---	---	---	---	0.083
1.50	1,824	587.00	0.48 ic	0.01 ic	---	---	0.00	0.47 s	---	---	---	---	0.478
1.70	1,842	587.20	0.52 ic	0.00 ic	---	---	0.00	0.51 s	---	---	---	---	0.517
1.90	1,860	587.40	0.55 ic	0.00 ic	---	---	0.00	0.54 s	---	---	---	---	0.541
2.10	1,878	587.60	0.58 ic	0.00 ic	---	---	0.00	0.57 s	---	---	---	---	0.573
2.30	1,896	587.80	0.61 ic	0.00 ic	---	---	0.00	0.57 s	---	---	---	---	0.570
2.50	1,914	588.00	0.64 ic	0.00 ic	---	---	0.00	0.57 s	---	---	---	---	0.566
2.70	1,932	588.20	0.67 ic	0.00 ic	---	---	0.00	0.60 s	---	---	---	---	0.601
2.90	1,950	588.40	0.69 ic	0.00 ic	---	---	0.00	0.51 s	---	---	---	---	0.506
3.10	1,968	588.60	0.72 ic	0.00 ic	---	---	0.00	0.58 s	---	---	---	---	0.578
3.30	1,986	588.80	0.74 ic	0.00 ic	---	---	0.00	0.65 s	---	---	---	---	0.651
3.50	2,004	589.00	0.77 ic	0.00 ic	---	---	0.00	0.64 s	---	---	---	---	0.636
3.60	2,067	589.10	0.78 ic	0.00 ic	---	---	0.00	0.67 s	---	---	---	---	0.669
3.70	2,131	589.20	0.79 ic	0.00 ic	---	---	0.00	0.43 s	---	---	---	---	0.432
3.80	2,194	589.30	0.80 ic	0.00 ic	---	---	0.00	0.73 s	---	---	---	---	0.734
3.90	2,257	589.40	0.81 ic	0.00 ic	---	---	0.00	0.77 s	---	---	---	---	0.768
4.00	2,321	589.50	0.82 ic	0.00 ic	---	---	0.00	0.80 s	---	---	---	---	0.801
4.10	2,384	589.60	0.83 ic	0.00 ic	---	---	0.01 s	0.51 s	---	---	---	---	0.527
4.20	2,447	589.70	0.84 ic	0.00 ic	---	---	0.00 s	0.00 s	---	---	---	---	0.844
4.30	2,510	589.80	0.85 ic	0.00	---	---	0.00	0.00	---	---	---	---	0.854
4.40	2,574	589.90	0.86 ic	0.00	---	---	0.00	0.00	---	---	---	---	0.864
4.50	2,637	590.00	0.87 ic	0.00	---	---	0.00	0.00	---	---	---	---	0.875

Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.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	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
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	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

Precip. file name: Sample.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	2.20	0.00	3.30	4.25	5.77	6.80	7.95
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	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	1.75	0.00	2.80	3.90	5.25	6.00	7.10

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Feb 2 2022

Ditch, Proposed Mitigated

Trapezoidal

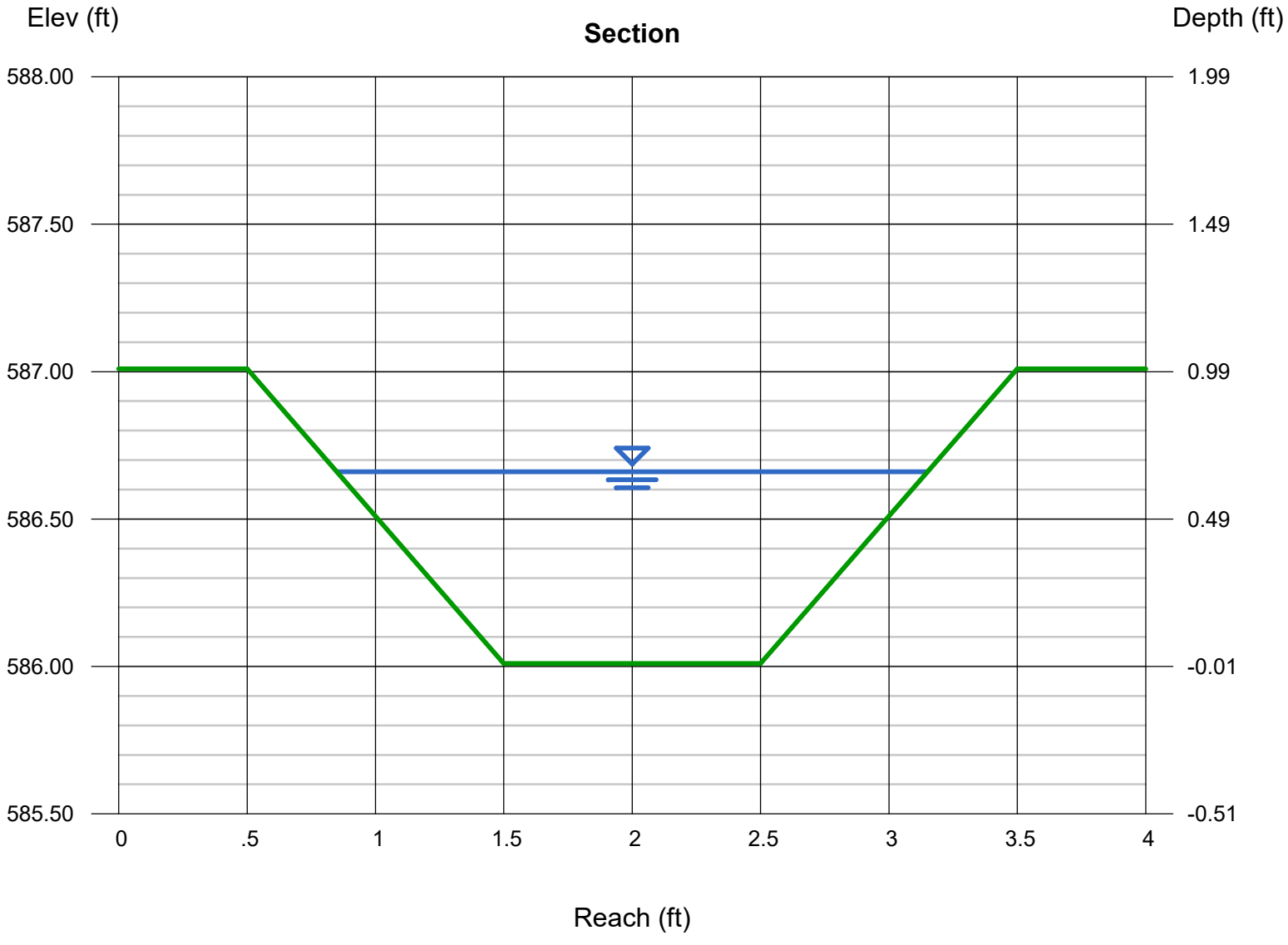
Bottom Width (ft)	= 1.00
Side Slopes (z:1)	= 1.00, 1.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 586.01
Slope (%)	= 1.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 2.76

Highlighted

Depth (ft)	= 0.65
Q (cfs)	= 2.760
Area (sqft)	= 1.07
Velocity (ft/s)	= 2.57
Wetted Perim (ft)	= 2.84
Crit Depth, Yc (ft)	= 0.52
Top Width (ft)	= 2.30
EGL (ft)	= 0.75



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Feb 2 2022

Ditch, Proposed Unmitigated

Trapezoidal

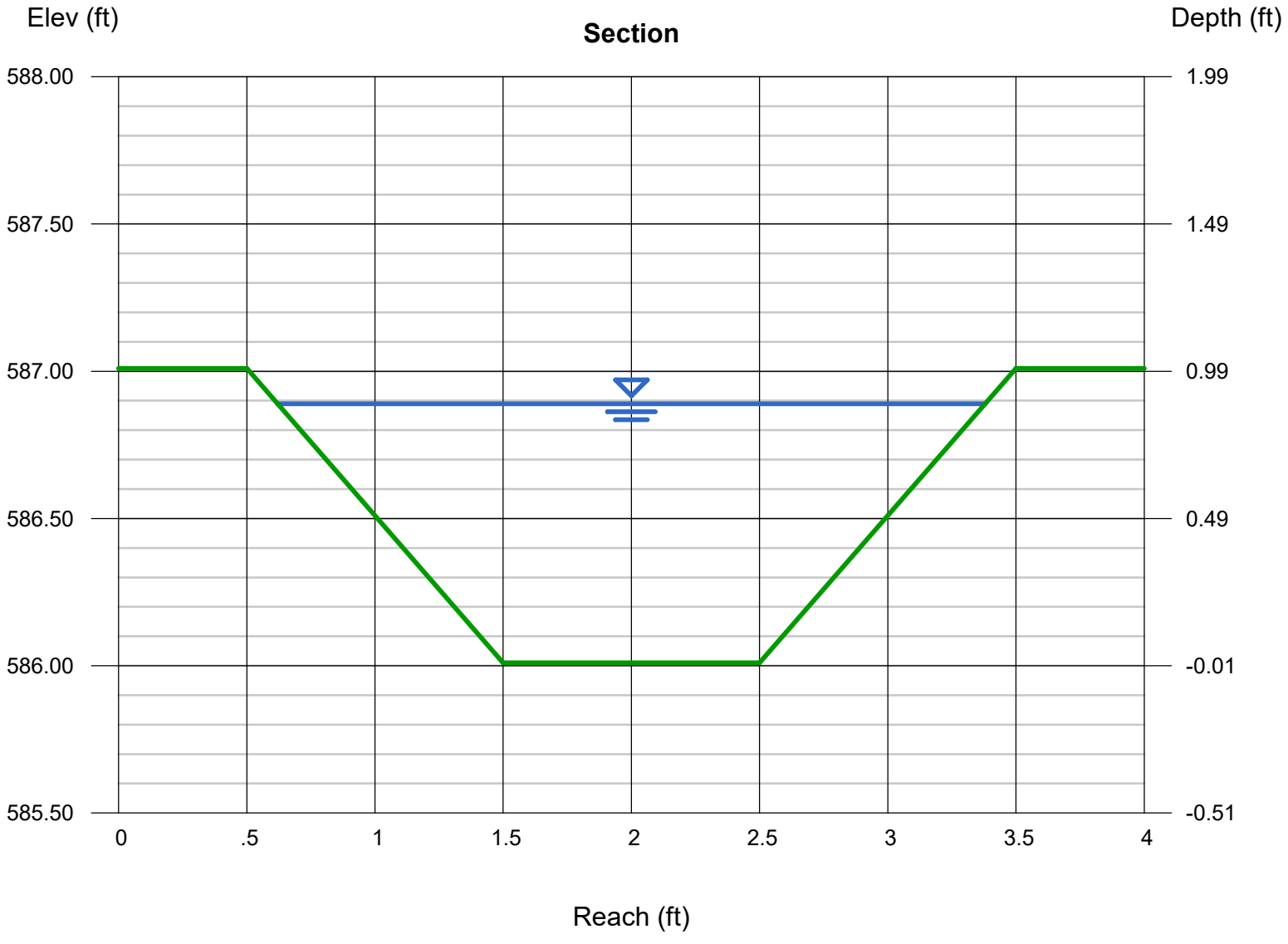
Bottom Width (ft)	= 1.00
Side Slopes (z:1)	= 1.00, 1.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 586.01
Slope (%)	= 1.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 4.89

Highlighted

Depth (ft)	= 0.88
Q (cfs)	= 4.890
Area (sqft)	= 1.65
Velocity (ft/s)	= 2.96
Wetted Perim (ft)	= 3.49
Crit Depth, Yc (ft)	= 0.72
Top Width (ft)	= 2.76
EGL (ft)	= 1.02



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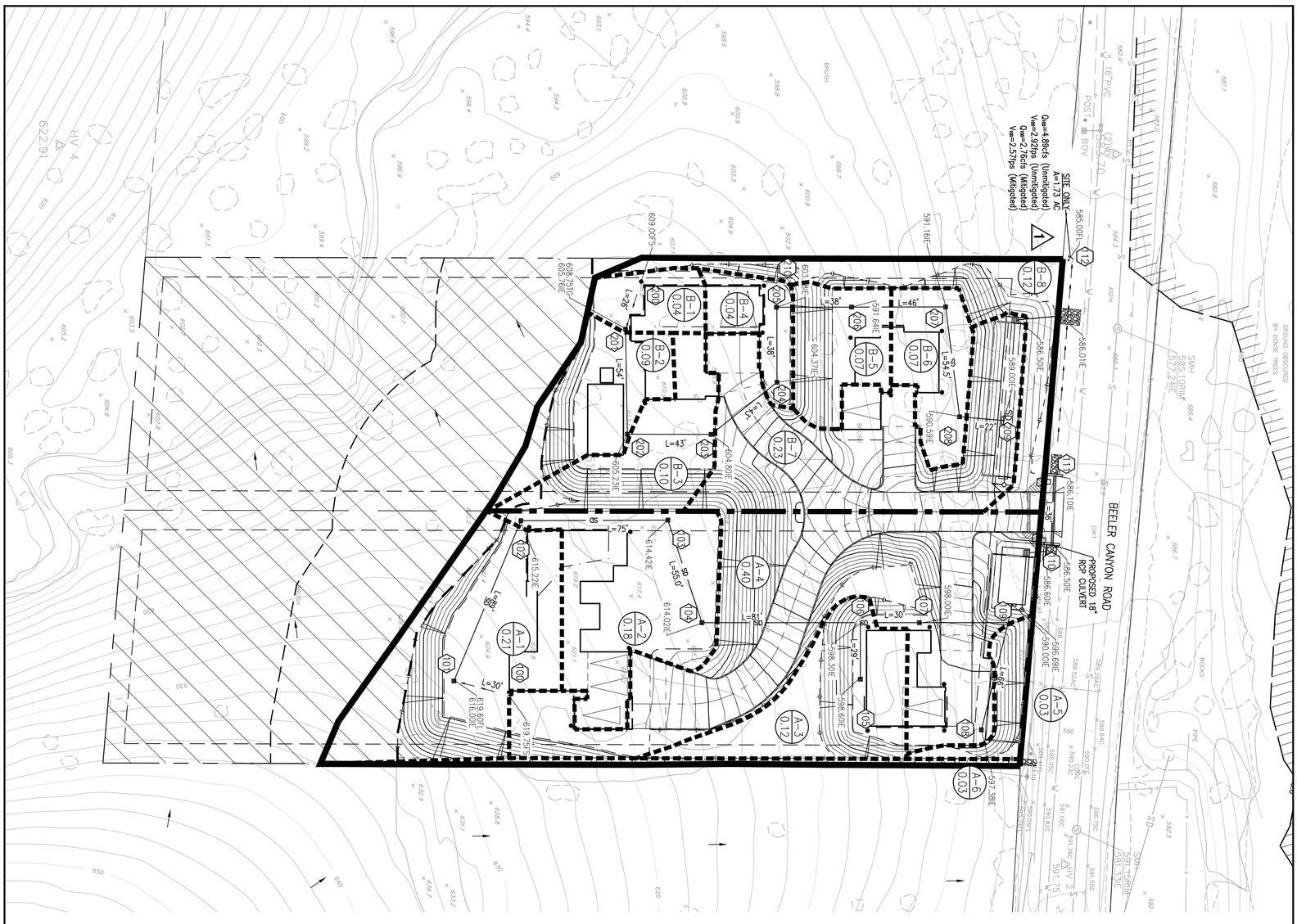

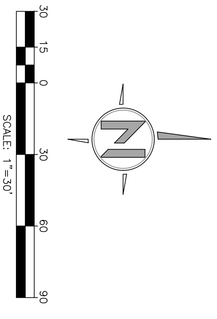

LEGEND

SYMBOL	
	OUTER BASIN BOUNDARY
	MAJOR BASIN BOUNDARY
	MINOR BASIN BOUNDARY
SD	EXISTING STORM DRAIN
SD	NEW STORM DRAIN
XXX	EXISTING CONTOUR
XXX	NEW CONTOUR
	FLOW DIRECTION
	FLOW PATH
L=XX.X'	FLOW LENGTH
327.85FL 304.35E	NODE ELEVATION
200	HYDROLOGY NODE
1	ANALYSIS/EXIT POINT
B-X X.XX	DRAINAGE BASIN MARKER & AREA (AC)

PROJECT	SHEET TITLE	ISSUE DATE: 02/02/2022	SYM	DESCRIPTION	DATE	APPR
BEELER CANYON ROAD	HYDROLOGY EXHIBIT PROPOSED CONDITION	DRAWN BY: NJW				
		CHECKED BY: MGC				
		BWE JOB NUMBER: 11900U.3.00				
		CLIENT JOB NUMBER:				
SITE ADDRESS PARCEL 3 OF MAP 6554		MUNICIPALITY PROJECT NUMBER: PTS 649669				
	SHEET 1 OF 1					

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SAN DIEGO, CA 92123 619.299.5550

Attachment D

Off-site Conditions Runoff Coefficient Calculations
Off-site Condition Hydrology Calculations
Off-site Condition Hydrology Map

Composite 'C' Value Calculations

Project: Beeler Canyon Road

C-perv = 0.35 Open Space per County of San Diego Hydrology Manual

C-imp= 0.95 (for paved areas)

C-composite= **[(Cperv*Ap + Cimp*Ai)/At]** …… (1)

Total Area At= **Ap + Ai** (sum of pervious & impervious areas)

Off-site Conditions

Basin /Exit Point	Area (Acres)			[(Cperv*Ap + Cimp*Ai)]	C-composite
	Total Area (At)	Imp. Area (Ai)	Perv. Area (Ap)		
C	2.54	0.47	2.07	1.17	0.46
Overall	**2.54**	**0.47**		**1.17**	**0.46**

Off-site

Off-site	Total (SF)	Imp (SF)	Per (SF)
C-1	1,400	1,400	0
C-2	28,320	4,730	23,590
C-3	6,470	6,470	0
C-4	66,680	0	66,680
C-5	5,310	5,310	0
C-6	2,640	2,640	0

Off-site	Total (Ac)	Imp (Ac)	Per (Ac)	Impervious Fraction	C-County
C-1	0.032	0.032	0.000	1.000	0.950
C-2	0.650	0.109	0.542	0.167	0.450
C-3	0.149	0.149	0.000	1.000	0.950
C-4	1.531	0.000	1.531	0.000	0.350
C-5	0.122	0.122	0.000	1.000	0.950
C-6	0.061	0.061	0.000	1.000	0.950
Total	2.544	0.472	2.072	0.185	0.461

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software,(c)1991-2005 Version 6.5

Rational method hydrology program based on
San Diego County Flood Control Division 1985 hydrology manual
Rational Hydrology Study Date: 08/20/21

OFFSITE HYDROLOGY ANALYSIS
PROPOSED BEELER CANYON ROAD CULVERT
BEELER CANYON ROAD

********* Hydrology Study Control Information **********

Program License Serial Number 6116

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used
English (in) rainfall data used

Standard intensity of Appendix I-B used for year and
Elevation 0 - 1500 feet
Factor (to multiply * intensity) = 1.000
Only used if inside City of San Diego
San Diego hydrology manual 'C' values used
Runoff coefficients by rational method

++

Process from Point/Station 300.000 to Point/Station 301.000
**** INITIAL AREA EVALUATION ****

User specified 'C' value of 0.950 given for subarea
Initial subarea flow distance = 65.000(Ft.)
Highest elevation = 601.500(Ft.)
Lowest elevation = 601.000(Ft.)
Elevation difference = 0.500(Ft.)
Time of concentration calculated by the urban
areas overland flow method (App X-C) = 2.38 min.
TC = [1.8*(1.1-C)*distance(Ft.)^.5)/(% slope^(1/3)]
TC = [1.8*(1.1-0.9500)*(65.000^.5)/(0.769^(1/3)]= 2.38
Setting time of concentration to 5 minutes
Rainfall intensity (I) = 4.389(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.950
Subarea runoff = 0.133(CFS)
Total initial stream area = 0.032(Ac.)

```
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      301.000 to Point/Station
302.000
      **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
      ------------------------------------------------------------------------
____
      Estimated mean flow rate at midpoint of channel =      0.444(CFS)
      Depth of flow =   0.113(Ft.), Average velocity =   1.016(Ft/s)
            ******* Irregular Channel Data ***********
      ------------------------------------------------------------------
      Information entered for subchannel number 1 :
      Point number      'X' coordinate     'Y' coordinate
            1              0.00              0.50
            2              2.00              0.00
            3             15.00              0.20
      Manning's 'N' friction factor =   0.030
      ------------------------------------------------------------------
      Sub-Channel flow  =      0.444(CFS)
        '     '    flow top width =      7.767(Ft.)
        '     '    velocity=    1.016(Ft/s)
        '     '    area =      0.437(Sq.Ft)
        '     '    Froude number =     0.755

      Upstream point elevation =   601.000(Ft.)
      Downstream point elevation =   595.000(Ft.)
      Flow length =   307.000(Ft.)
      Travel time  =    5.04 min.
      Time of concentration =   10.04 min.
      Depth of flow =   0.113(Ft.)
      Average velocity =   1.016(Ft/s)
      Total irregular channel flow =     0.444(CFS)
      Irregular channel normal depth above invert elev. =   0.113(Ft.)
      Average velocity of channel(s) =   1.016(Ft/s)

      Sub-Channel No. 1 Critical depth =      0.101(Ft.)
        '     '       '     Critical flow top width =      6.940(Ft.)
        '     '       '     Critical flow velocity=    1.272(Ft/s)
        '     '       '     Critical flow area =      0.349(Sq.Ft)

       Adding area flow to channel
      User specified 'C' value of 0.950 given for subarea
      Rainfall intensity =      3.370(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.950
      Subarea runoff =      0.477(CFS) for    0.149(Ac.)
      Total runoff =      0.610(CFS)      Total area =        0.18(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      302.000 to Point/Station
302.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------------
____
      User specified 'C' value of 0.459 given for subarea
      Time of concentration =    10.04 min.
      Rainfall intensity =      3.370(In/Hr) for a   100.0 year storm
```

```
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.459
      Subarea runoff =      1.005(CFS) for    0.650(Ac.)
      Total runoff =      1.616(CFS)      Total area =        0.83(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      302.000 to Point/Station
303.000
      **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
      ------------------------------------------------------------------
____
      Estimated mean flow rate at midpoint of channel =      1.734(CFS)
      Depth of flow =   0.209(Ft.), Average velocity =   1.674(Ft/s)
            ******* Irregular Channel Data ***********
      ------------------------------------------------------------------
      Information entered for subchannel number 1 :
      Point number      'X' coordinate     'Y' coordinate
            1              0.00              0.50
            2              2.00              0.00
            3             15.00              0.30
      Manning's 'N' friction factor =   0.030
      ------------------------------------------------------------------
      Sub-Channel flow  =      1.734(CFS)
        '     '    flow top width =      9.904(Ft.)
        '     '    velocity=    1.674(Ft/s)
        '     '    area =      1.036(Sq.Ft)
        '     '    Froude number =     0.912

      Upstream point elevation =   595.000(Ft.)
      Downstream point elevation =   590.000(Ft.)
      Flow length =   215.000(Ft.)
      Travel time  =    2.14 min.
      Time of concentration =   12.18 min.
      Depth of flow =   0.209(Ft.)
      Average velocity =   1.674(Ft/s)
      Total irregular channel flow =     1.734(CFS)
      Irregular channel normal depth above invert elev. =   0.209(Ft.)
      Average velocity of channel(s) =   1.674(Ft/s)

      Sub-Channel No. 1 Critical depth =      0.201(Ft.)
        '     '       '     Critical flow top width =      9.522(Ft.)
        '     '       '     Critical flow velocity=    1.811(Ft/s)
        '     '       '     Critical flow area =      0.958(Sq.Ft)

       Adding area flow to channel
      User specified 'C' value of 0.950 given for subarea
      Rainfall intensity =      3.141(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.950
      Subarea runoff =      0.364(CFS) for    0.122(Ac.)
      Total runoff =      1.980(CFS)      Total area =        0.95(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      303.000 to Point/Station
303.000
      **** SUBAREA FLOW ADDITION ****
      ------------------------------------------------------------------
```

```
____
      User specified 'C' value of 0.350 given for subarea
      Time of concentration =    12.18 min.
      Rainfall intensity =      3.141(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.350
      Subarea runoff =      1.683(CFS) for    1.531(Ac.)
      Total runoff =      3.663(CFS)      Total area =        2.48(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      303.000 to Point/Station
108.000
      **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
      ------------------------------------------------------------------
____
      Estimated mean flow rate at midpoint of channel =      3.708(CFS)
      Depth of flow =   0.312(Ft.), Average velocity =   2.541(Ft/s)
            ******* Irregular Channel Data ***********
      ------------------------------------------------------------------
      Information entered for subchannel number 1 :
      Point number      'X' coordinate     'Y' coordinate
            1              0.00              0.50
            2              2.50              0.00
            3             15.00              0.50
      Manning's 'N' friction factor =   0.030
      ------------------------------------------------------------------
      Sub-Channel flow  =      3.708(CFS)
        '     '    flow top width =      9.356(Ft.)
        '     '    velocity=    2.541(Ft/s)
        '     '    area =      1.459(Sq.Ft)
        '     '    Froude number =     1.134

      Upstream point elevation =   590.000(Ft.)
      Downstream point elevation =   586.500(Ft.)
      Flow length =   111.000(Ft.)
      Travel time  =    0.73 min.
      Time of concentration =   12.91 min.
      Depth of flow =   0.312(Ft.)
      Average velocity =   2.541(Ft/s)
      Total irregular channel flow =     3.708(CFS)
      Irregular channel normal depth above invert elev. =   0.312(Ft.)
      Average velocity of channel(s) =   2.541(Ft/s)

      Sub-Channel No. 1 Critical depth =      0.328(Ft.)
        '     '       '     Critical flow top width =      9.844(Ft.)
        '     '       '     Critical flow velocity=    2.296(Ft/s)
        '     '       '     Critical flow area =      1.615(Sq.Ft)

       Adding area flow to channel
      User specified 'C' value of 0.950 given for subarea
      Rainfall intensity =      3.075(In/Hr) for a   100.0 year storm
      Runoff coefficient used for sub-area, Rational method,Q=KCIA, C =
0.950
      Subarea runoff =      0.178(CFS) for    0.061(Ac.)
      Total runoff =      3.841(CFS)      Total area =        2.54(Ac.)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
```

```
      Process from Point/Station      108.000 to Point/Station
108.000
      **** CONFLUENCE OF MAIN STREAMS ****
      ------------------------------------------------------------------------
____
      The following data inside Main Stream is listed:
      In Main Stream number: 1
      Stream flow area =      2.545(Ac.)
      Runoff from this stream =      3.841(CFS)
      Time of concentration =   12.91 min.
      Rainfall intensity =     3.075(In/Hr)
      Program is now starting with Main Stream No. 2


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      107.000 to Point/Station
108.000
      **** USER DEFINED FLOW INFORMATION AT A POINT ****
      ------------------------------------------------------------------------
____
      User specified 'C' value of 0.550 given for subarea
      Rainfall intensity (I) =      3.806(In/Hr) for a   100.0 year
storm
      User specified values are as follows:
      TC =   7.20 min.  Rain intensity =       3.81(In/Hr)
      Total area =        0.960(Ac.)  Total runoff =     2.920(CFS)


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++
      Process from Point/Station      108.000 to Point/Station
108.000
      **** CONFLUENCE OF MAIN STREAMS ****
      ------------------------------------------------------------------------
____
      The following data inside Main Stream is listed:
      In Main Stream number: 2
      Stream flow area =      0.960(Ac.)
      Runoff from this stream =      2.920(CFS)
      Time of concentration =    7.20 min.
      Rainfall intensity =     3.806(In/Hr)
      Summary of stream data:

      Stream   Flow rate      TC            Rainfall Intensity
       No.       (CFS)       (min)                 (In/Hr)


      1        3.841     12.91               3.075
      2        2.920      7.20               3.806
      Qmax(1) =
                1.000 *    1.000 *     3.841) +
                0.808 *    1.000 *     2.920) + =       6.200
      Qmax(2) =
                1.000 *    0.558 *     3.841) +
                1.000 *    1.000 *     2.920) + =       5.063

      Total of 2 main streams to confluence:
      Flow rates before confluence point:
             3.841       2.920
      Maximum flow rates at confluence using above data:
```

```
        6.200        5.063
Area of streams before confluence:
        2.545        0.960


Results of confluence:
Total flow rate =      6.200(CFS)
Time of concentration =    12.906 min.
Effective stream area after confluence  =      3.505(Ac.)
End of computations, total study area =          3.505 (Ac.)
```

Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Aug 23 2021

1 x 18

Invert Elev Dn (ft)	=	586.10
Pipe Length (ft)	=	36.00
Slope (%)	=	1.11
Invert Elev Up (ft)	=	586.50
Rise (in)	=	18.0
Shape	=	Circular
Span (in)	=	18.0
No. Barrels	=	1
n-Value	=	0.012
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

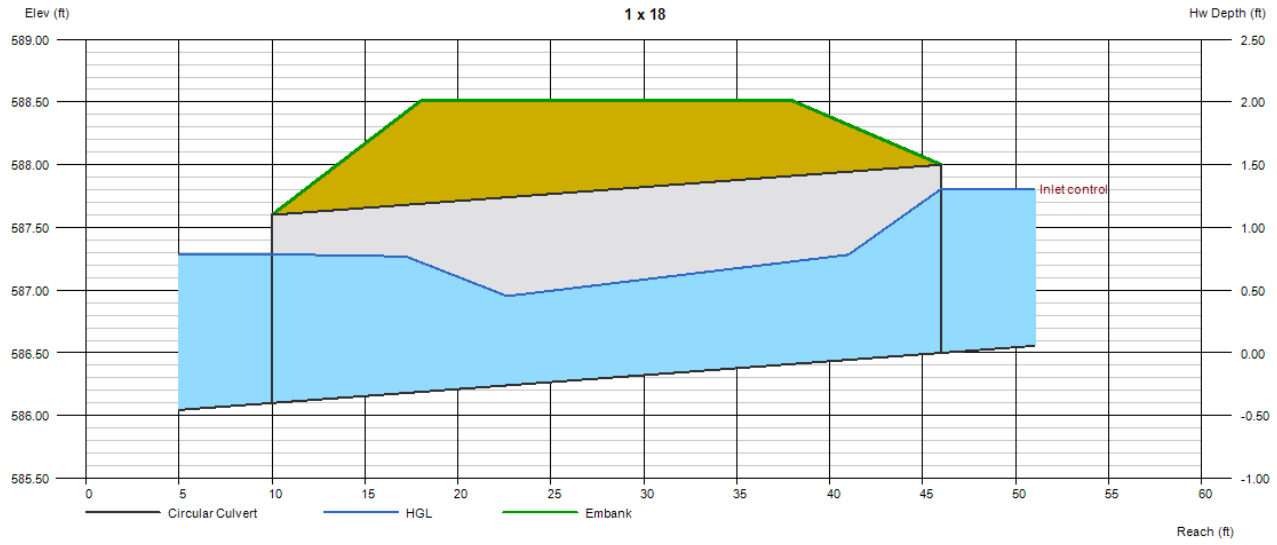
Top Elevation (ft)	=	588.51
Top Width (ft)	=	20.00
Crest Width (ft)	=	10.00

Calculations

Qmin (cfs)	=	5.14
Qmax (cfs)	=	5.14
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	5.14
Qpipe (cfs)	=	5.14
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	3.43
Veloc Up (ft/s)	=	4.82
HGL Dn (ft)	=	587.29
HGL Up (ft)	=	587.37
Hw Elev (ft)	=	587.81
Hw/D (ft)	=	0.87
Flow Regime	=	Inlet Control



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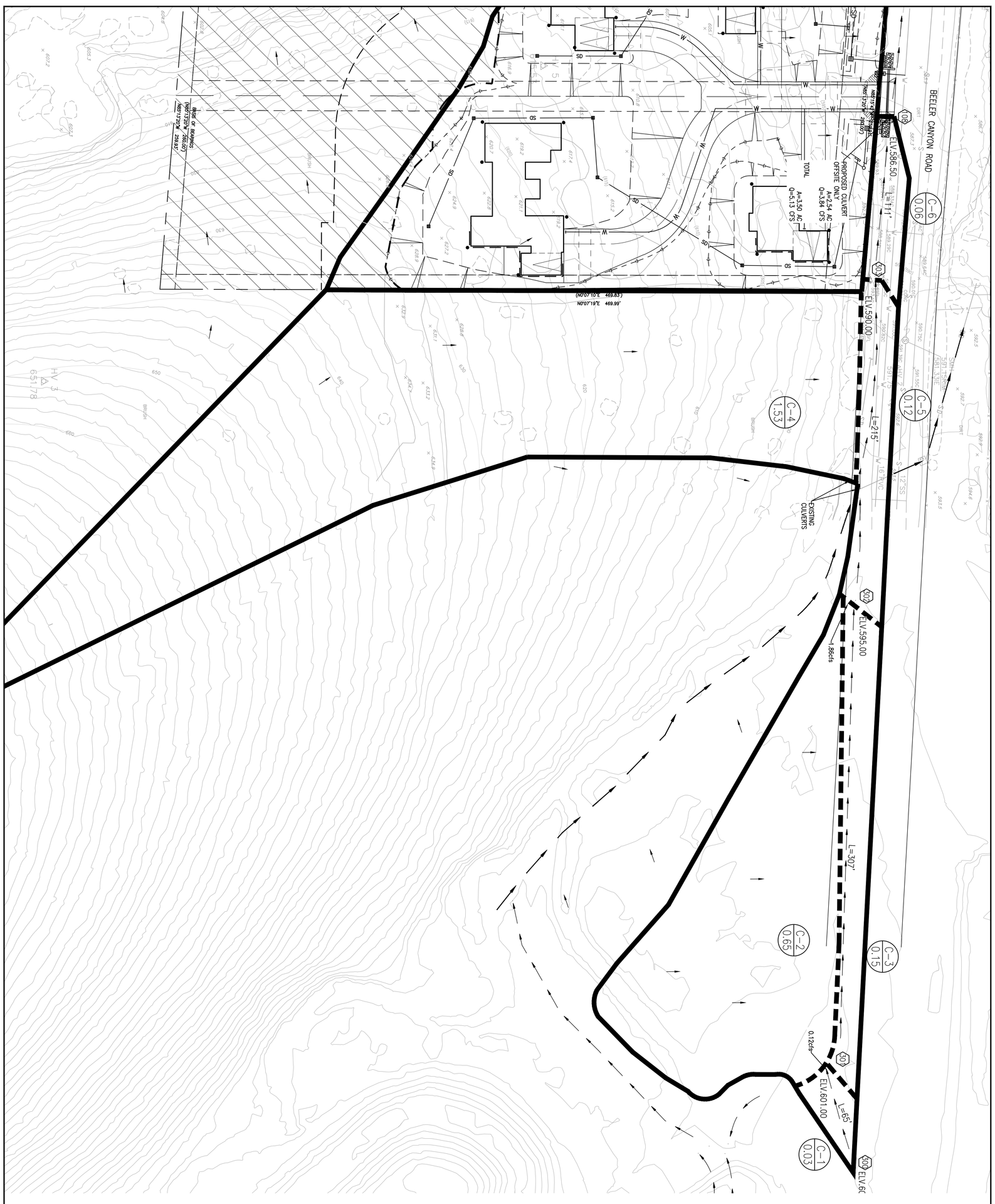

PROJECT	SHEET TITLE	ISSUE DATE:	02/05/2021	SYM	DESCRIPTION	DATE	APPR
BEELER CANYON ROAD	HYDROLOGY EXHIBIT PROPOSED CONDITION	DRAWN BY:	MDS				
		CHECKED BY:	MGC				
		BWE JOB NUMBER:	11900U.3.00				
		CLIENT JOB NUMBER:					
SITE ADDRESS PARCEL 3 OF MAP 6554		MUNICIPALITY PROJECT NUMBER:	PTS 649669				
	SHEET 1 OF 1						

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Attachment E

Excerpts from Drainage Design Manual

Chapter 2

Hydrology

The design discharge depends upon many variables. Some of the more important variables are duration and intensity of rainfall; storm frequency; ground cover; and the size, imperviousness, slope, and shape of the drainage area.

2.1. Discharge Flow Methods

The designer should check with Drainage and Flood Plain Management Section, Public Works Department, to determine if there are established storm discharge flows.

If the project involves a watershed of major size or importance, flood flows may already be established through one or more of the following activities:

1. Master Plan Developments in the City and/or County
2. Studies for Development and Road Projects near the proposed project
3. Flood Insurance Studies prepared by FEMA based on existing land use at the time the study was completed. Urbanization may have caused increased flows. FEMA maps can be viewed at the SanGIS web site (www.sangis.org).
4. Recorded flows may be available from the United States Geological Survey (USGS) or the County of San Diego

If no established storm discharge flows are available, the applicable methods are:

1. Rational Method for watersheds less than 0.5 square miles – See Appendix A
2. Modified Rational Method for watersheds between 0.5 and 1.0 square miles – See Appendix A; or,
3. Natural Resources Conservation Service (NRCS) Method (formally called Soil Conservation Service (SCS) Method) for watersheds greater than 1.0 square miles – See Appendix B; or
4. Hydrologic Engineering Center (HEC) computer method.

2.2. Design Storm Frequency

Design storm frequency shall be based upon the following criteria:

1. Within floodplain and floodplain fringe areas as defined by FEMA, the runoff criteria shall be based upon a 100-year frequency storm.

2. For all drainage channels and storm water conveyance systems, which will convey drainage from a tributary area equal to or greater than one (1) square mile, the runoff criteria, shall be based upon a 100-year frequency storm.
3. For tributary areas under one (1) square mile:
    a. The storm water conveyance system shall be designed so that the combination of storm drain system capacity and overflow (streets and gutter) will be able to carry the 100-year frequency storm without damage to or flooding of adjacent existing buildings or potential building sites.
    b. The runoff criteria for the underground storm drain system shall be based upon a 50-year frequency storm.

2.3. Soil Type

For storm drain, culverts, channels, and all associated structures, Type D soil shall be used for all areas.

2.4. Other Requirements

1. Design runoff for drainage and flood control facilities within the City shall be based upon full development of the watershed area in accordance with the land uses shown on the City of San Diego, Progress Guide and General Plan.
2. When determining criteria for floodplain management and flood proofing, design runoff within the City shall be based upon existing conditions in accordance with the City Floodplain Management Requirements and FEMA Regulations.
3. Under City requirements, the minimum elevation of the finished, first floor elevation of any building is 2 feet above the 100-year frequency flood elevation.

2.5. Water Quality Considerations

Requirements for hydrologic studies specific to the design of pollution prevention controls and hydromodification management controls are detailed in the Storm Water Standards. Where the Storm Water Standards specify modifications to the guidelines stated herein on discharge flow methods, design storm frequency, or soil type, the modifications shall supersede these but only for the purposes stated in the Storm Water Standards. Where the Storm Water Standards does not specify a modification, the guidance found here in Chapter 2 shall apply.

Appendix A

Rational Method and Modified Rational Method

A.1. Rational Method (RM)

The Rational Method (RM) is a mathematical formula used to determine the maximum runoff rate from a given rainfall. It has particular application in urban storm drainage where it is used to estimate peak runoff rates from small urban and rural watersheds for the design of storm drains and drainage structures. The RM is recommended for analyzing the runoff response from drainage areas for watersheds less than 0.5 square miles. It should not be used in instances where there is a junction of independent drainage systems or for drainage areas greater than approximately 0.5 square mile in size. In these instances, the Modified Rational Method (MRM) should be used for junctions of independent drainage systems in watersheds up to approximately 1 square mile in size (see Section A.2); or the NRCS Hydrologic Method should be used for watersheds greater than approximately 1 square mile in size (see Appendix B).

A.1.1. Rational Method Formula

The RM formula estimates the peak rate of runoff at any location in a watershed as a function of the drainage area (A), runoff coefficient (C), and rainfall intensity (I) for a duration equal to the time of concentration (T_c), which is the time required for water to flow from the most remote point of the basin to the location being analyzed. The RM formula is expressed in Equation A-1.

Equation A-1. RM Formula Expression

$$Q = C\ I\ A$$

where:

Q	=	peak discharge, in cubic feet per second (cfs)
C	=	runoff coefficient expressed as that percentage of rainfall which becomes surface runoff (no units); Refer to Appendix A.1.2
I	=	average rainfall intensity for a storm duration equal to the time of concetrnatation (T_c) of the contributing draiange area, in inches per hour; Refer to Appendix A.1.3 and Appendix A.1.4
A	=	drainage area contributing to the design location, in acres

Combining the units for the expression CIA yields:

$$\left(\frac{1\,\text{acre}\times\text{inch}}{\text{hour}}\right)\left(\frac{43{,}560\,\text{ft}^2}{\text{acre}}\right)\left(\frac{1\,\text{foot}}{12\,\text{inches}}\right)\left(\frac{1\,\text{hour}}{3{,}600\,\text{seconds}}\right)\Rightarrow 1.008\,\text{cfs}$$

For practical purposes, the unit conversion coefficient difference of 0.8% can be ignored.

The RM formula is based on the assumption that for constant rainfall intensity, the peak discharge rate at a point will occur when the raindrop that falls at the most upstream point in the tributary drainage basin arrives at the point of interest.

Unlike the MRM (discussed in Appendix A.2) or the NRCS hydrologic method (discussed in Appendix B), the RM does not create hydrographs and therefore does not add separate subarea hydrographs at collection points. Instead, the RM develops peak discharges in the main line by increasing the T_c as flow travels downstream.

Characteristics of, or assumptions inherent to, the RM are listed below:

1. The discharge resulting from any I is maximum when the I lasts as long as or longer than the T_c.
2. The storm frequency of peak discharges is the same as that of I for the given T_c.
3. The fraction of rainfall that becomes runoff (or the runoff coefficient, C) is independent of I or precipitation zone number (PZN) condition (PZN Condition is discussed in the NRCS method).
4. The peak rate of runoff is the only information produced by using the RM.

A.1.2. Runoff Coefficient

The runoff coefficients are based on land use (see Table A–1). Soil type "D" is used throughout the City of San Diego for storm drain conveyance design. An appropriate runoff coefficient (C) for each type of land use in the subarea should be selected from this table and multiplied by the percentage of the total area (A) included in that class. The sum of the products for all land uses is the weighted runoff coefficient (Σ[CA]). Good engineering judgment should be used when applying the values presented in Table A–1, as adjustments to these values may be appropriate based on site-specific characteristics.

Table A-1. Runoff Coefficients for Rational Method

Land Use	Runoff Coefficient (C)
	Soil Type [1]
Residential:	
Single Family	0.55
Multi-Units	0.70
Mobile Homes	0.65
Rural (lots greater than ½ acre)	0.45
Commercial [2]	
80% Impervious	0.85
Industrial [2]	
90% Impervious	0.95

Note:
[1] Type D soil to be used for all areas.
[2] Where actual conditions deviate significantly from the tabulated imperviousness values of 80% or 90%, the values given for coefficient C, may be revised by multiplying 80% or 90% by the ratio of actual imperviousness to the tabulated imperviousness. However, in case shall the final coefficient be less than 0.50. For example: Consider commercial property on D soil.

Actual imperviousness = 50%
Tabulated imperviousness = 80%
Revised C = (50/80) x 0.85 = 0.53

The values in Table A–1 are typical for urban areas. However, if the basin contains rural or agricultural land use, parks, golf courses, or other types of nonurban land use that are expected to be permanent, the appropriate value should be selected based upon the soil and cover and approved by the City.

A.1.3. Rainfall Intensity

The rainfall intensity (I) is the rainfall in inches per hour (in/hr.) for a duration equal to the T_C for a selected storm frequency. Once a particular storm frequency has been selected for design and a T_C calculated for the drainage area, the rainfall intensity can be determined from the Intensity-Duration-Frequency Design Chart (Figure A-1).

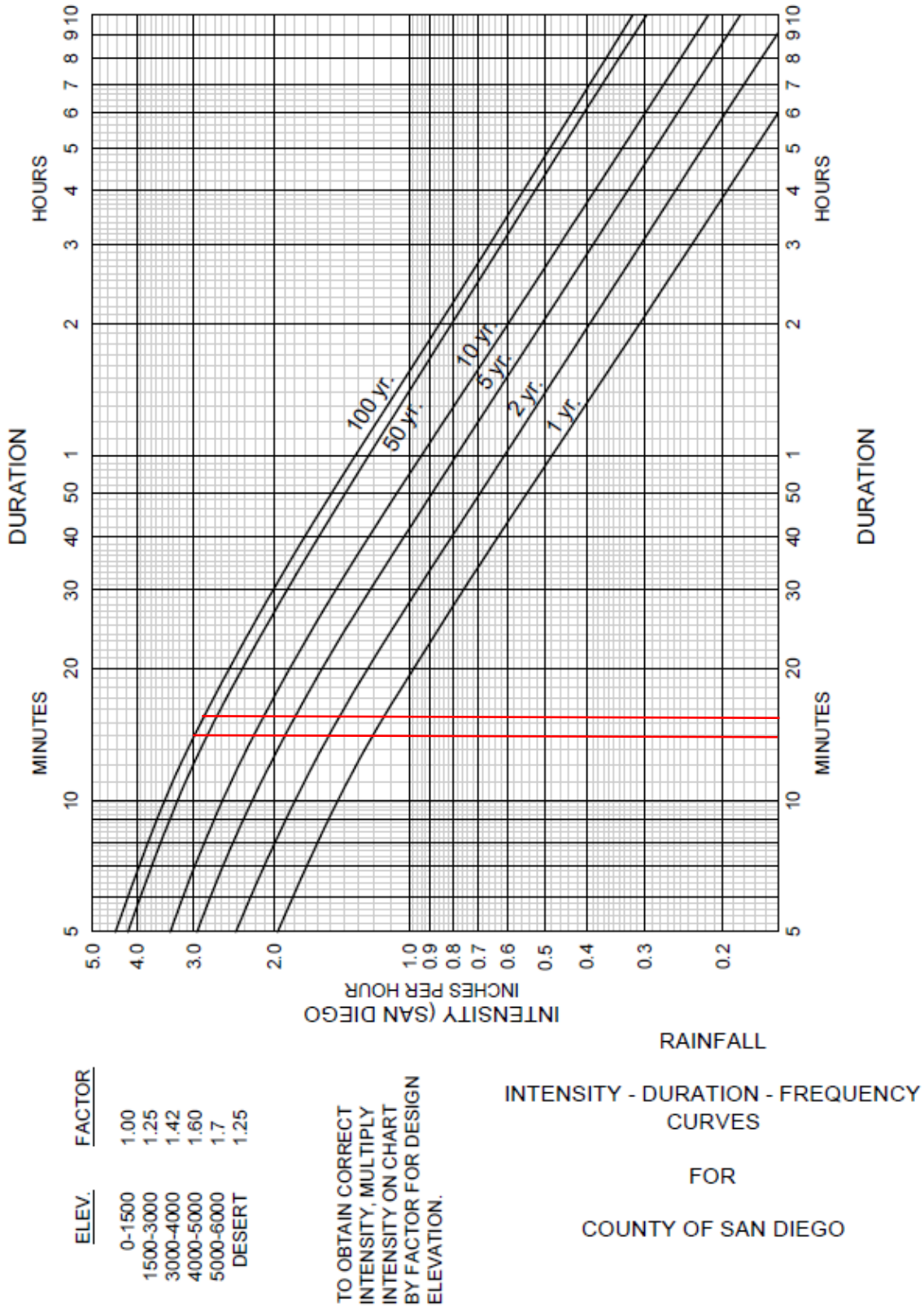


Figure A-1. Intensity-Duration-Frequency Design Chart

A.1.4. Time of Concentration

The Time of Concentration (T_c) is the time required for runoff to flow from the most remote part of the watershed to the outlet point under consideration.

Methods of calculation differ for natural watersheds (non-urbanized) and for urban drainage systems. Also, when designing storm drain systems, the designer must consider the possibility that an existing natural watershed may become urbanized during the useful life of the storm drain system. Future land uses must be used for Tc and runoff calculations, and can be determined from the Community Plans.

a. Natural watersheds: Obtain Tc from Figures A.2 and A.3

b. Urban drainage systems: In the case of urban drainage systems, the time of concentration at any point within the drainage area is given by:

   $T_c = T_i + T_t$ where

   T_i is the inlet time or the time required for the storm water to flow to the first inlet in the system. It is the sum of time in overland flow across lots and in the street gutter.

   T_t is the travel time or the time required for the storm water to flow in the storm drain from the most upstream inlet to the point in question.

   Travel Time, T_t is computed by dividing the length of storm drain by the computed flow velocity. Since the velocity normally changes at each inlet because of changes in flow rate or slope, total travel time must be computed as the sum of the travel times for each section of the storm drain.

   The overland flow component of inlet time, T_i, may be estimated by the use of the chart shown in Figure A-4. Use Figure A-5 to estimate time of travel for street gutter flow.

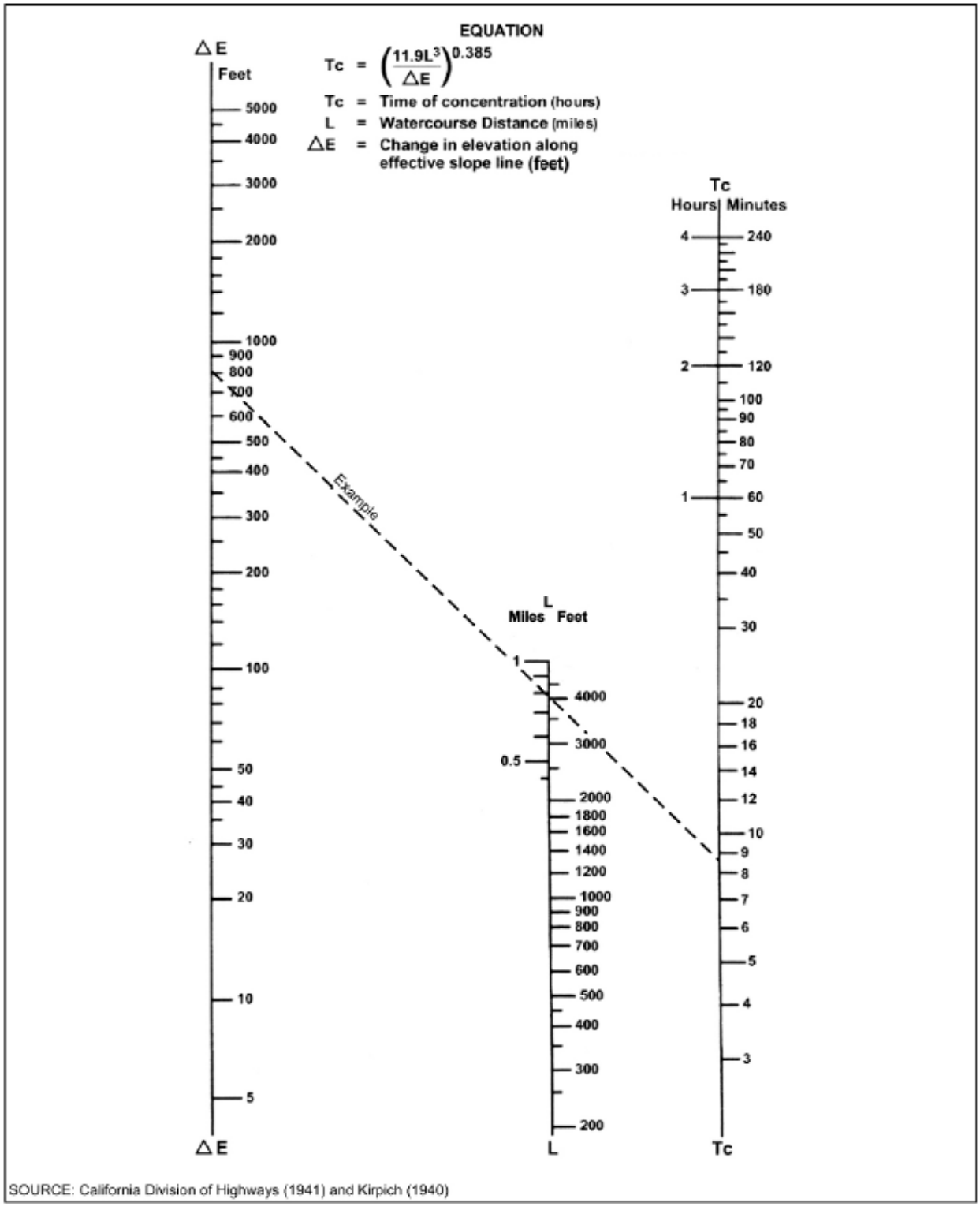


Figure A-2. Nomograph for Determination of T_c for Natural Watersheds

Note: Add ten minutes to the computed time of concentration from Figure A-2.

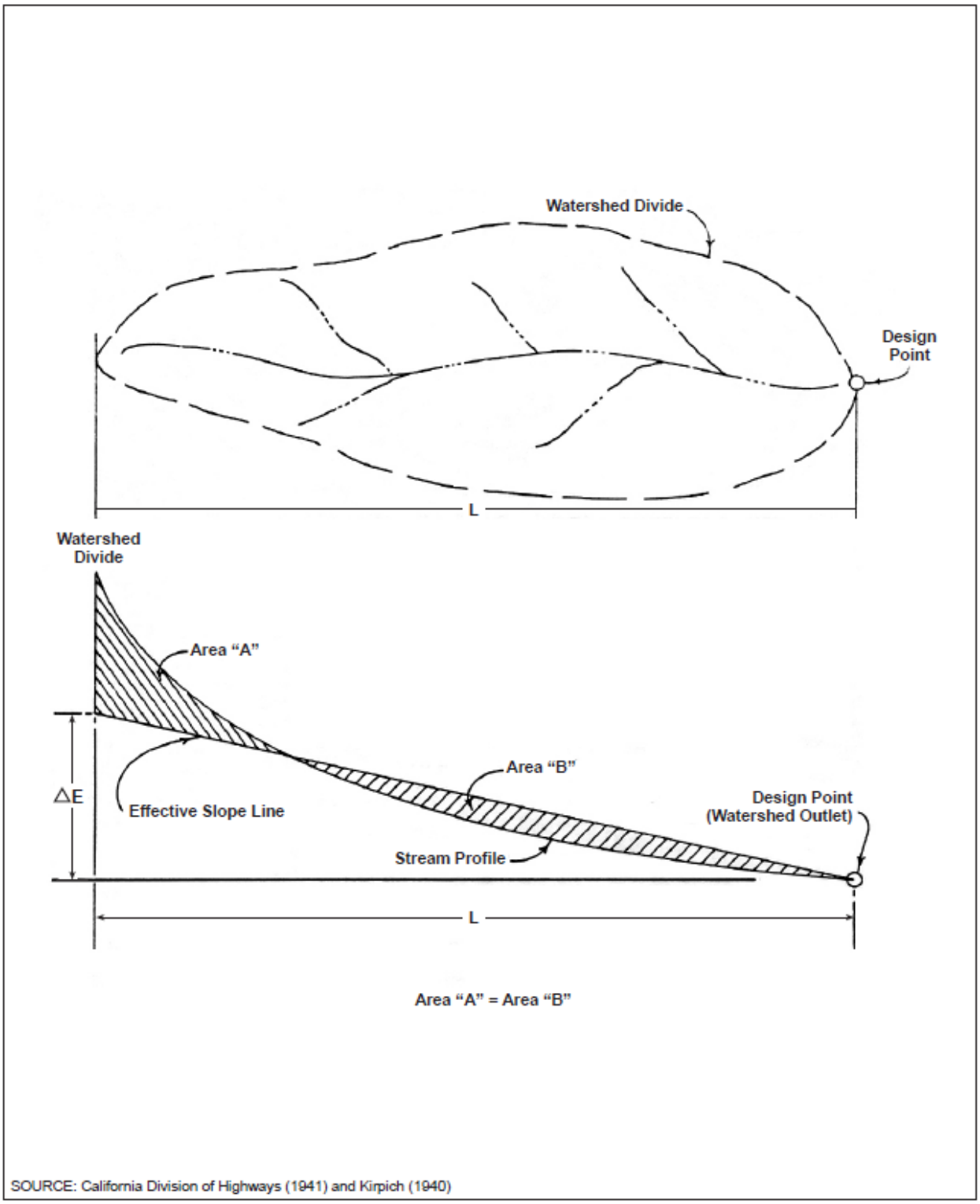


Figure A-3. Computation of Effective Slope for Natural Watersheds

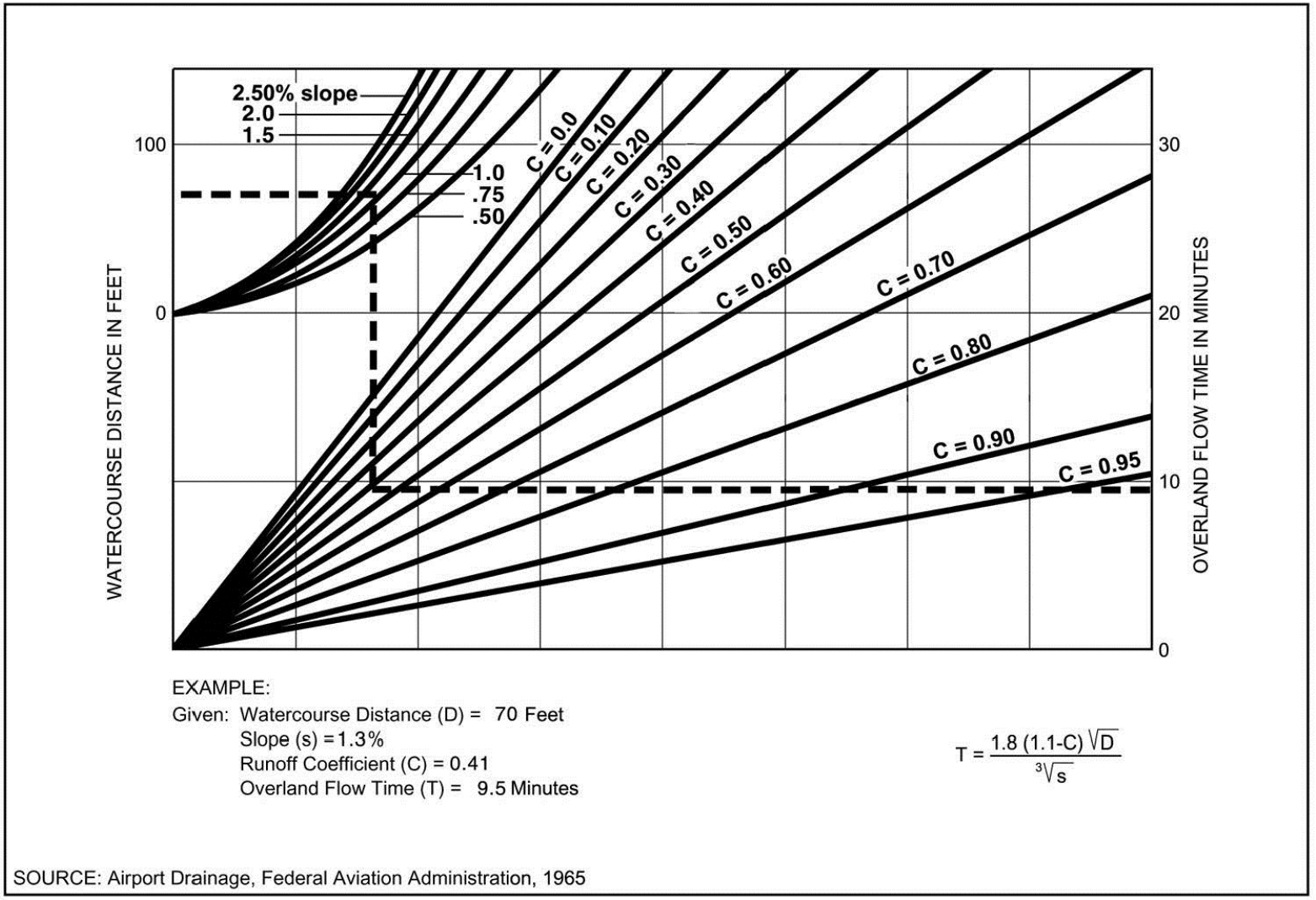
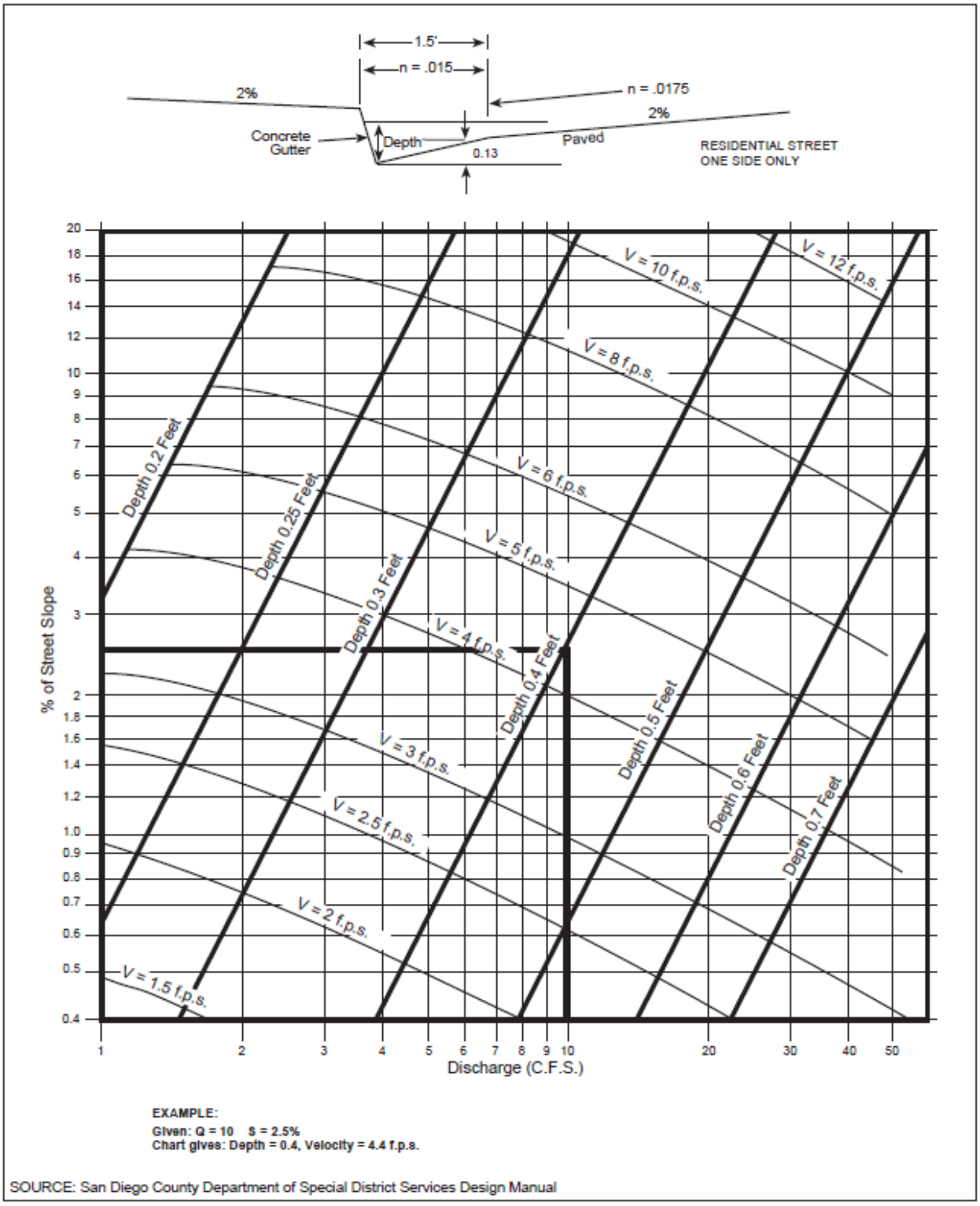


Figure A-4. Rational Formula – Overland Time of Flow Nomograph

Note: Use formula for watercourse distances in excess of 100 feet.



SOURCE: San Diego County Department of Special District Services Design Manual

Figure A-5. Gutter and Roadway Discharge – Velocity Chart

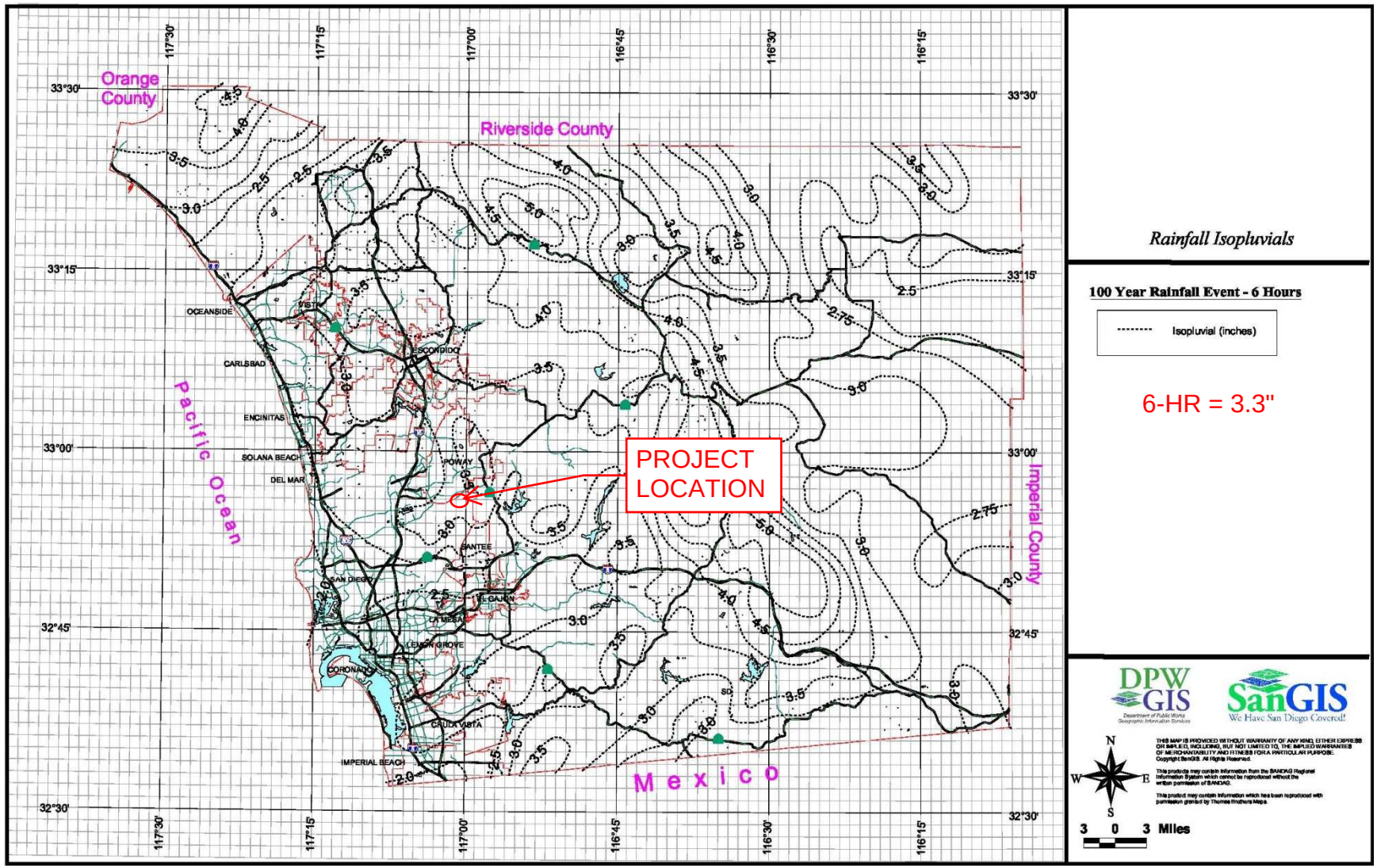


Figure B-2. 100-Year 6-Hour Isopluvials.

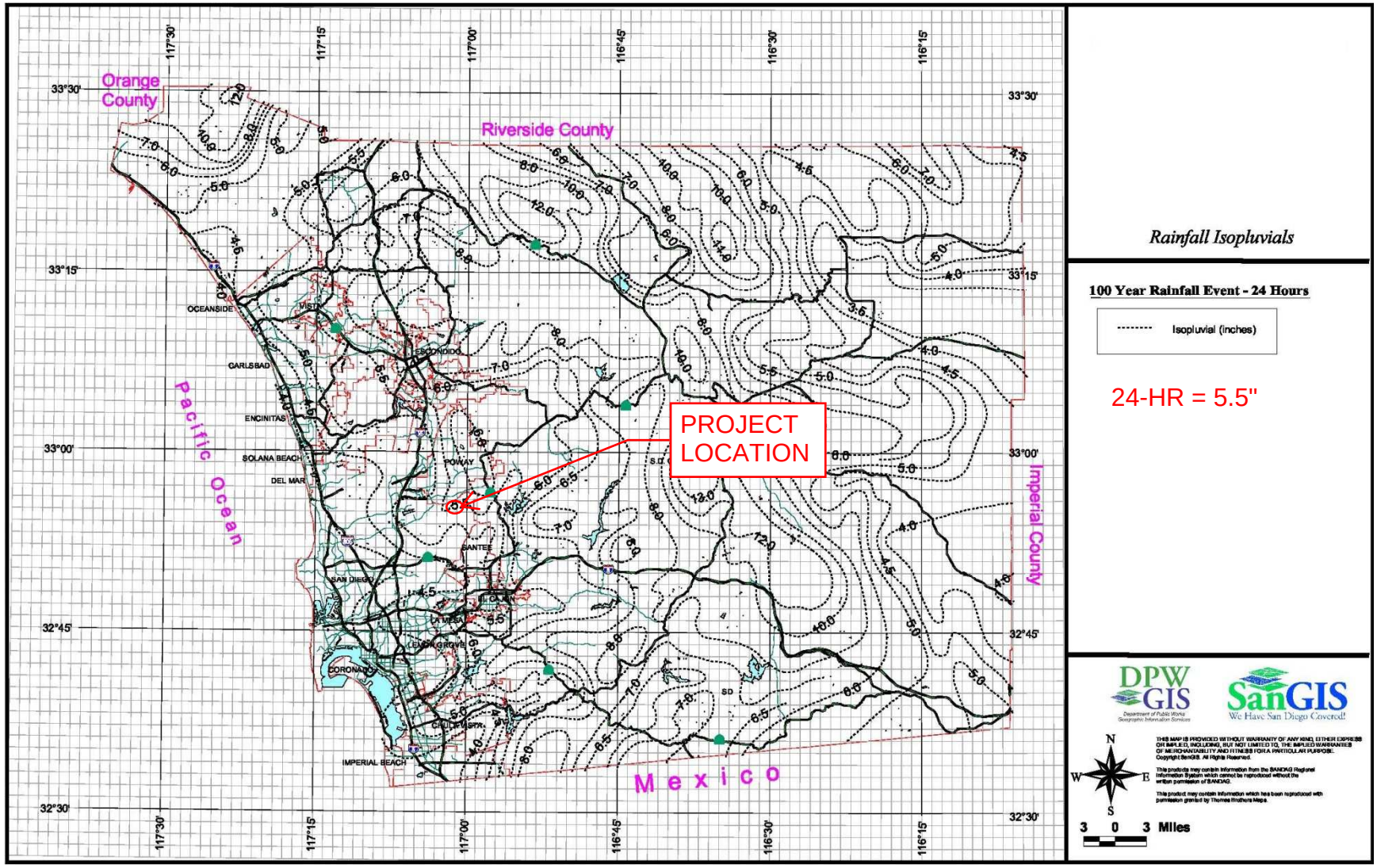
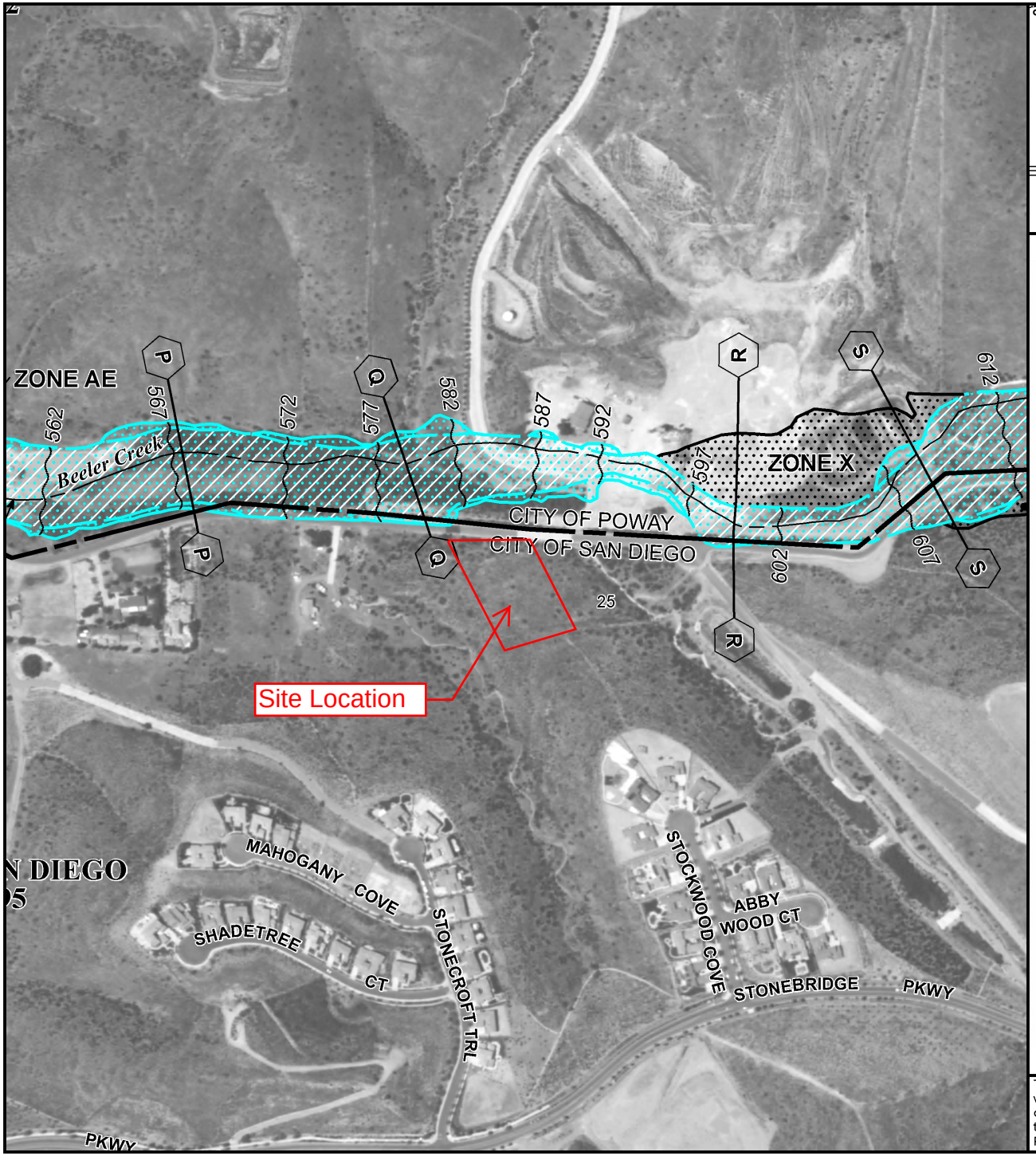


Figure B-3. 100-Year 24-Hour Isopluvials

Attachment F

FEMA Flood Plain Map



ance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

0 250 500 750 1,000 FEET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1366G

FIRM

FLOOD INSURANCE RATE MAP

SAN DIEGO COUNTY, CALIFORNIA

AND INCORPORATED AREAS

PANEL 1366 OF 2375

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
POWAY, CITY OF	060702	1366	G
SAN DIEGO, CITY OF	060295	1366	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06073C1366G

MAP REVISED
MAY 16, 2012

Federal Emergency Management Agency