APPENDIX G-1

Hydrology and Hydraulic Analysis

TECHNICAL MEMORANDUM

Date: July 3, 2022 **BKF Job Number:** 20210118

Deliver To: Jane Valerius, Environmental Consulting
Ted Winfield, Ted Winfield & Associates
Karen Massey, Burbank Housing

From: Rick Carlile, BKF Engineers

Subject: **Dry Creek Commons – Wetlands Hydrology**

Annual Precipitation

Historical records between 1931 and 2021 show that Healdsburg receives on average about 41 inches of rainfall per year. The lowest amount was 9 inches in 2013 and the highest amount was 96 inches in 1983. The average deviation within this timeframe calculates out to about 11 inches. So, for the purposes of this memo, we will use a range of values with the low value at 29 inches (average deviation below the mean) and the high value at 51 inches (average deviation above the mean).

Existing Conditions

Approximately 2.1 acres, mostly on-site, drains into the **W-1 wetland**. This is identified as drainage area 2 on the existing conditions wetland hydrology map. Using the SCS method, we estimate that this wetland receives between 4.5 to 8.3 acre-ft of runoff on an annual basis.

Approximately 15.6 acre, mostly off-site, drains from the other side of the railroad tracks, through an existing 24" culvert, through the **W-2 wetland**, then discharges into Foss Creek. This is identified as drainage area 1 on the existing conditions wetland hydrology map. Using the SCS method, we estimate that this wetland receives between 35.2 to 63.7 acre-ft of runoff on an annual basis.

In total, the project site receives between **39.7** to **72.0 acre-ft** of runoff in the **existing condition**.

Proposed Conditions

The project proposes to construct new wetlands adjacent to wetlands W-1 and W-2 resulting in one wetland basin. Approximately 14.8 acres from offsite (area 1 on the proposed condition wetland hydrology map) will continue to drain through the existing 24" culvert and into the W-2 wetland. However, for the proposed condition, the drainage will be directed into the constructed wetlands and toward wetland W-1 instead of discharging directly to Foss Creek as it does in the existing condition. Using the SCS method, we estimate that the offsite runoff is between 33.5 to 60.6 acre-ft on an annual basis.

The proposed development site is approximately 1.6 acres (area 2 on the proposed condition wetland hydrology map) and the runoff coming from this area will drain into bio-retention basins for treatment

and then discharge into the proposed wetland basin. Using the SCS method, we estimate that the proposed project runoff is between 3.8 to 6.8 acre-ft on an annual basis.

Adding in the direct runoff amounts coming from the mitigation site (1.3 acres of wetlands and adjacent uplands and identified as area 3 on the proposed condition wetland hydrology map), the wetland basin will have a total of **40.1** to **72.5 acre-ft** of runoff draining into it in the **proposed condition**.

Summary

The **0.73 acre** mitigation site (0.32 acres of existing wetlands to remain and 0.41 acres of constructed wetlands) will receive approximately **40.1** to **72.5 acre-ft** of runoff on an annual basis.

Included Exhibits:

- Existing Condition Wetland Hydrology Map
- Proposed Condition Wetland Hydrology Map
- Drainage Area and Runoff Calculations using the SCS method for the existing and proposed condition.

DRAINAGE AREAS			
Tributary Area	Impervious 98	Pervious 79	Total Area (Acre)
1	5.7	9.9	15.6
2	-	2.1	2.1
	5.7	12.0	17.6

EXISTING CONDITION

WETLAND HYDROLOGY MAP

DRY CREEK COMMONS
155 DRY CREEK RD., HEALDSBURG, CA
MAY 19, 2022

scale 1" = 60' (60 0 60 120 feet)

PREPARED BY

BKF
200 4th STREET
SUITE 300
SANTA ROSA, CA 95401
(707) 583-8500
www.bkf.com

JOB NO. 20210118

SHEET 1 OF 2 SHEETS

Plot: May 19, 2022 at 5:39pm

210118_HYDR_WETLAND.dwg

DRAINAGE AREAS			
Tributary Area	Impervious 98	Pervious 79	Total Area (Acre)
1	5.7	9.1	14.8
2	1.4	0.2	1.6
3	-	1.3	1.3
	7.0	10.7	17.7

PROPOSED CONDITION

WETLAND HYDROLOGY MAP

DRY CREEK COMMONS
155 DRY CREEK RD., HEALDSBURG, CA
JULY 3, 2022

PREPARED BY

60 0 60 120
scale 1" = 60' feet

BKF
200 4th STREET
SUITE 300
SANTA ROSA, CA 95401
(707) 583-8500
www.bkf.com

JOB NO. 20210118

SHEET 2 OF 2 SHEETS

Plot Jul 03, 2022 at 4:14pm

210118_HYDR_WETLAND.dwg

Dry Creek Commons

Wetland Hydrology

EXISTING CONDITION

DRAINAGE AREAS

Tributary Area	Impervious 98	Pervious 79	Total Area (Acre)
1	5.7	9.9	15.6
2	-	2.1	2.1
	5.7	12.0	17.6

TOTAL ANNUAL RUNOFF

			LOW RANGE			HIGH RANGE		
CN x Area	Composite CN	S (inch)	P_{LOW}[1] (inch)	Q_{LOW} (ft)	V_{LOW} (Acre-Ft)	P_{HIGH}[1] (inch)	Q_{HIGH} (ft)	V_{HIGH} (Acre-Ft)
1,337	85.9	1.641	29.00	2.260	35.2	51.00	4.090	63.7
165	79.0	2.658	29.00	2.170	4.5	51.00	3.995	8.3
					39.7			72.0

PROPOSED CONDITION

DRAINAGE AREAS

Tributary Area	Impervious 98	Pervious 79	Total Area (Acre)
1	5.7	9.1	14.8
2	1.4	0.2	1.6
3	-	1.3	1.3
	7.0	10.7	17.7

TOTAL ANNUAL RUNOFF

			LOW RANGE			HIGH RANGE		
CN x Area	Composite CN	S (inch)	P_{LOW}[1] (inch)	Q_{LOW} (ft)	V_{LOW} (Acre-Ft)	P_{HIGH}[1] (inch)	Q_{HIGH} (ft)	V_{HIGH} (Acre-Ft)
1,277	86.3	1.593	29.00	2.264	33.5	51.00	4.095	60.6
154	95.2	0.503	29.00	2.367	3.8	51.00	4.200	6.8
101	79.0	2.658	29.00	2.170	2.8	51.00	3.995	5.1
					40.1			72.5

[1]Average mean historical annual preciptiation (1931-2021) = 40.8 inches. P_{LOW} is average standard deviation (11.3) below the mean and P_{HIGH} is average standard deviation above the mean

$S = (1000 / CN_{POST}) - 10$

S = Potential maximum retention after runoff (in)

CN = Curve Number for the developed condition associated with the tributary area (A)

$Q = ((P) - (0.2*S))^2/((P) + (0.8*S)) * 1ft/12in$

Q = Runoff depth (ft)

P = Precipitation (in)

V = (Q)(A)

V = Volume of storm water runoff (Acre-Ft)

A = Tributary Area (Acre)

JOB NO. 20210118

HYDROLOGY AND HYDRAULIC ANALYSIS

DRY CREEK COMMONS

155 Dry Creek Road, Healdsburg
Sonoma County, CA

APN 089-071-002

April 12, 2022

Prepared by BKF Engineers
FOR
City of Healdsburg
Public Works Department
401 Grove St
Healdsburg, Ca 95448

RICHARD CARLILE PE
NO. C-57885

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HYDROLOGY AND HYDRAULIC ANALYSIS

This study was performed under the guidelines established by the Healdsburg Engineering Design Standards Section 4 dated 8/4/2008 and the Sonoma County Water Agency (SCWA) in their publication Flood Management Design Manual (2020).

GENERAL

The 155 Dry Creek Road project includes the development of multi-family housing on an existing undeveloped site along Foss Creek. The site is located along the north side of Dry Creek Rd in the narrow parcel between Foss Creek and the Sonoma Marina Area Rail Transit (SMART) train tracks. The existing parcel (APN 089-071-002) is 3.52 acres and is currently undeveloped and currently covered in dense low vegetation. A large area of the existing site has been determined to be wetlands. The intent for the development is to construct two multi-family residential buildings totaling approximately 18,500sf and all associated asphalt parking and walkways. This will overlap with the existing wetlands so the removed area shall be replaced at a 2:1 ratio on site. Between the site development and the wetland mitigation efforts the goal is to maintain existing drainage patterns and develop a healthy functional wetland to replace the portion removed.

The immediate project development includes the clearing and grubbing of the existing site and the course grading required for the installation of the proposed parking, sidewalks and the proposed buildings. Both construction and final vehicle access to the project will be provided along Dry Creek Rd. No additional access shall be required.

FEMA maps were observed to help determine whether the area being developed is subject to routine flooding. The project area is split between 2 F.I.R.M. Panels Numbered 344 and 363 of 1150 (Map Number 06097C0344E and 06097C363E Respectively). The published F.I.R.M. indicates the majority of the site is designated within Zone A which is area determined to be within the 1% Special Flood Hazard Areas. This corresponds with the 100-year storm event. More current and unpublished information available on the FEMA FIRMette website. This indicate the areas within the site designated as Regulatory Floodways and channel sections where the Base Flood Elevation (BFE) has been determined. The FEMA established approximate flood surface elevation for the site ranges from 129.4ft to 133.8ft along the channel. Excerpts from the F.I.R.M. have been included in the body of this report for reference.

PRE-DEVELOPMENT

These calculations are performed under the guidelines established by the Sonoma County Water Agency (SCWA) in their publication Flood Management Design Manual (2020).

The rainfall intensities were determined using the NOAA precipitation data and the method outlined in the SCWA Flood Management Design Manual. C values for the post-development condition were determined using composite C calculations in the SCWA Flood Management Design Manual and can be found on Exhibits #1.

Summaries of the pre-development values used are as follows:

Runoff Coefficient (C-Factor)	0.5	Exhibits #1
Time of Concentration (Tc)	7 minutes	SCWA for Commercial Properties
Time of Concentration (Tc)	10 minutes	SCWA for lots <1/2 acre
10-Yr Intensity at Initial Tc=7 minutes	3.08” /hr	
25-Yr Intensity at Initial Tc=7 minutes	3.67” /hr	

The existing site has multiple small areas which sheet flow and collect to discharge areas along Foss Creek. One of these areas has a culvert coming from an off-site source located along the east side of the SMART railway tracks. This larger tributary area sheet flows similar to the project site but includes multiple cover types including asphalt paving, gravel, a sports field, etc and is approximately 15.5 acres with an average slope of 1.5%. The 24" culvert discharges to the site and flows through the wetland into Foss Creek. A small area along the south edge including minor site area and public street collects in an area drain which is connected into the city storm drainage system. It discharged further downstream into Foss Creek under the nearby bridge.

POST-DEVELOPMENT

This study was performed under the guidelines established by the Sonoma County Water Agency (SCWA) in their publication Flood Management Design Manual (2020).

The rainfall intensities were determined using the NOAA precipitation data and the method outlined in the SCWA Flood Management Design Manual. C-Factor values for the post-development condition were determined using composite C calculations in the SCWA Flood Management Design Manual and can be found on Exhibit 3.

Summaries of the post-development values used are as follows:

Runoff Coefficient (C-Factor)	Varies	Multi-Residential Properties
Time of Concentration (Tc)	7 minutes	SCWA for multi-Residential Properties
Time of Concentration (Tc)	10 minutes	SCWA for lots <1/2 acre
10-Yr Intensity at Initial Tc=7 minutes	3.08" /hr	
25-Yr Intensity at Initial Tc=7 minutes	3.69" /hr	

NOAA Precipitation intensities and Bentley StormCAD used to determine 10-year and 100-yrear rainfall intensities for the site. NOAA precipitation data can be found in the appendices.

Area C-factors are given on the drainage exhibit. Conservative estimates were given for each of the developed tributary areas.

The proposed site shall have drainage similar to the existing site. The site hardscape improvement will be along the east side of the site nearest the train tracks. The reconstructed wetland will be developed in between the new hardscapes and the existing creek. Hardscape drainage collected in drain inlets and discharged to the site bioretention BMP's first in accordance with the MS4 permit and the Stormwater Low Impact Development design manual. Once the BMP's reach their saturation capacity, excess flow will convey into the existing and proposed wetlands area. The wetland areas are designed to retain a certain flow/volume level from high frequency storm events in order to maintain an approximate continuous saturation of the native and design soils. Simply, to maintain a continuous "wetness level". The wetlands will be graded in a manner which promote saturation and infiltration. In high flow storm events a discharge location will be included at the southwest end of the site. An overflow drain inlet there will be connected into the existing storm drain system and discharge into Foss Creek. In the event the inlet becomes clogged or overburdened the area provides overland release directly into Foss Creek similar to the existing condition.

The existing 24" drainage culvert shall be extended under the site. The east end shall be extended to a 90 degree sharp edge culvert inlet built into a retaining wall and the west discharge will include a flared end concrete structure. Calculations for the capacity of the culvert from existing off-site drainage is included in the appendices.

The public improvements of the project include widening Dry creek road and installing curb and gutter along the length of the site. The curb and gutter shall convey the street runoff and minor site runoff to a street-side bioretention BMP near the west side of the improvements. Similarly, to the other BMP's, once the media is fully saturated the runoff discharges to a street catch basin which is connected to the existing storm drain system and discharges to Foss Creek.

Additional Drainage calculations for the site are intended to do two things.

1. Prove the drainage system intended for the site provides sufficient capacity in accordance with the design criteria of Sonoma County Water Agency's Flood Management Design Manual (2020).
2. Provide supporting calculation showing the designed wetlands retain/saturate a similar volume of water to the existing condition. Also, determine a 30-60 day storm frequency flow necessary to maintain the desired saturation and "wetness".

Since the development is a combination of hardscapes and large vegetated areas there is a composite estimated runoff coefficient (C-Factor) for the site in accordance with the SCWA Flood Control Design Manual. The composite C-Factor calculation can be found in the appendices.

A Post-Development Hydrology Exhibit and supporting calculations have been included in the body of this report for reference. The hydrologics of the drainage system were analyzed using the Rational Method and pipe capacity calculations shall be done using Hydraflow Express Extension by Autodesk which utilizes the Manning's equation. All inlets, catch basins, and pipes have been designed to convey 25-year storm event flows in accordance with the City of Healdsburg Engineering Design Standards Section 4.

Support documentation and channel is provided in the appendices.

Drainage Inlet Capacities

The proposed grated drop inlets for this project will be 24" square inline drains (or drain basins) for the bioretention basins. Catch basins shall be per city standard. Capacity calculations for the inlets, basins, and curb and gutters are in the appendices. Therefore, they are anticipated to easily pass their respective tributary flows.

100-Year Storm Water Route

The site has been designed having positive gradients away from structures with overland relief and the storm drain system proposed with this development is being installed as a matter of convenience to route stormwater from rooftop and paved surfaces to the proposed storm drain system. If the storm drain system becomes plugged with debris or is overburdened during larger storm events, the site has been designed with overland relief and will drain toward Foss Creek similar to the existing condition.

Conclusion Statement

BKF Engineers has conservatively assessed the hydrology and hydraulics of the proposed site, and we are confident that the design will adequately carry design flows and allow for larger storms without risking inundation of buildings or other damage. The overall surface coverage and drainage patterns of the final buildout condition are very similar to the pre-developed and current condition. The drainage system is designed to improve the previous damaged storm drain system and infrastructure where possible. The project development is not anticipated to exceed the capacity of the existing system and in the event of overburdening of storm drain inlets shall use the over land release Foss Creek similar to the existing condition.

APPENDIX "A"

County Assessor's Parcel Map

NOAA Precipitation Data

Site Rainfall Intensity Graph

COUNTY ASSESSOR'S PARCEL MAP

Parcel Map No. 3511
REC. 12-28-72 IN BK. 183, MAPS, PGS. 21-00

Parcel Map No. 5247
REC. 06-08-76 IN BK. 234, MAPS, PGS. 07-08

Parcel Map No. 77
REC. 04-15-81 IN BK. 320, MAPS, PGS. 16-00

Parcel Map No. 8324
REC. 08-08-85 IN BK. 374, MAPS, PGS. 05-06

Parcel Map No. 88-451
REC. 10-12-88 IN BK. 425, MAPS, PGS. 35-37

Parcel Map No. 89-201
REC. 10-27-89 IN BK. 445, MAPS, PGS. 28-30

Parcel Map No. 87-908
REC. 11-30-90 IN BK. 467, MAPS, PGS. 27-29

Parcel Map No. 142
REC. 08-29-97 IN BK. 569, MAPS, PGS. 10-11

Parcel Map No. 143
REC. 11-19-97 IN BK. 572, MAPS, PGS. 31-33

Parcel Map No. 176
REC. 12-18-2009 IN BK. 736, MAPS, PGS. 36-40

Parcel Map No. 193
REC. 10-13-2016 IN BK. 781, MAPS, PGS. 23-24

SAUERS INDUSTRIAL PARK UNIT I
REC. 02-17-89 IN BK. 432, MAPS, PGS. 07-11

AMENDED
SAUERS INDUSTRIAL PARK UNIT I
REC. 11-04-97 IN BK. 571, MAPS, PGS. 24-27

SAUERS INDUSTRIAL PARK UNIT II
REC. 07-20-95 IN BK. 540, MAPS, PGS. 01-04

SAUERS INDUSTRIAL PARK UNIT III
REC. 03-29-99 IN BK. 592, MAPS, PGS. 09-11

AMENDED
SAUERS INDUSTRIAL PARK UNIT IV
REC. 06-11-02 IN BK. 635, MAPS, PGS. 02-03

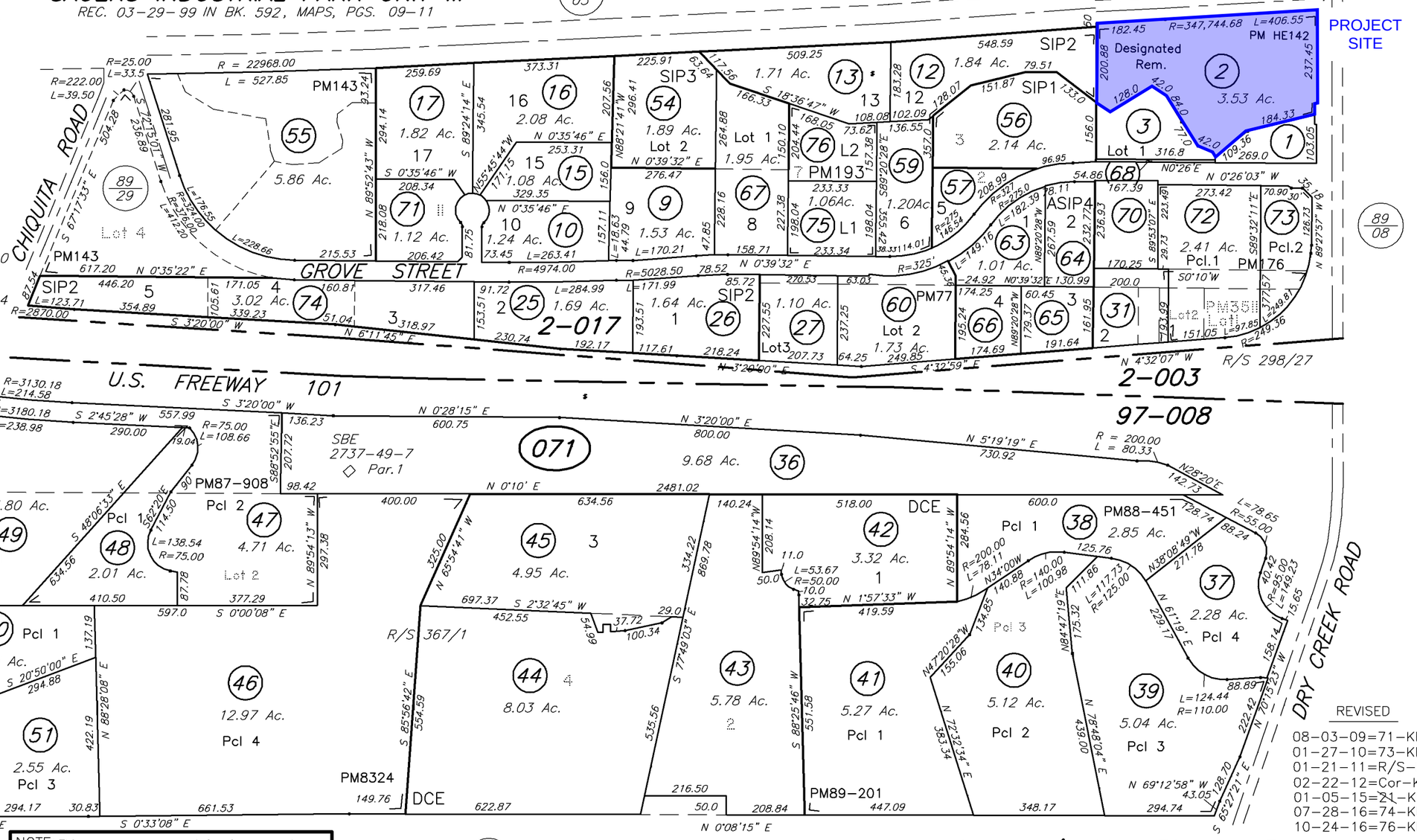
DRY CREEK ESTATES
REC. 02-26-91 IN BK. 472, MAPS, PGS. 16-20

TAX RATE AREA
002-003
002-017
097-008

089-07

SCALE: 1"=300'

PROJECT SITE



NOTE: Assessor's parcels do not necessarily constitute legal lots. To verify legal parcel status, check with the appropriate city or county community development or planning division.

NOTE: This map was prepared for Assessment purposes only and does not indicate either parcel legality or a valid building site. No liability is assumed for the accuracy of the data delineated. The acreages are based on the information supplied to the Assessor (i.e. recorded survey maps recorded deeds, prior assessment maps, etc.)

0 150 300 600

REVISED
08-03-09=71-KB
01-27-10=73-KB
01-21-11=R/S-KB
02-22-12=Cor-KB
01-05-15=21-KB
07-28-16=74-KB
10-24-16=76-KB

Assessor's Map Bk. 089, Pg. 07
Sonoma County, Calif. (ACAD)

KEY 2-25-09 KB

NOAA Atlas 14, Volume 6, Version 2
Location name: Healdsburg, California, USA*
Latitude: 38.627°, Longitude: -122.8748°
Elevation: 129.69 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	1.91 (1.69-2.16)	2.46 (2.18-2.80)	3.14 (2.78-3.59)	3.68 (3.23-4.25)	4.37 (3.68-5.24)	4.87 (4.01-5.99)	5.36 (4.28-6.78)	5.84 (4.51-7.64)	6.47 (4.76-8.87)	6.92 (4.90-9.89)
10-min	1.37 (1.22-1.55)	1.76 (1.57-2.00)	2.26 (2.00-2.57)	2.64 (2.32-3.04)	3.13 (2.64-3.76)	3.49 (2.87-4.30)	3.85 (3.07-4.87)	4.19 (3.24-5.48)	4.63 (3.41-6.35)	4.96 (3.51-7.09)
15-min	1.10 (0.980-1.25)	1.42 (1.26-1.62)	1.82 (1.61-2.08)	2.13 (1.86-2.45)	2.53 (2.13-3.03)	2.82 (2.32-3.46)	3.10 (2.48-3.92)	3.38 (2.61-4.42)	3.74 (2.75-5.12)	4.00 (2.83-5.71)
30-min	0.764 (0.680-0.868)	0.986 (0.874-1.12)	1.26 (1.12-1.44)	1.48 (1.29-1.70)	1.75 (1.48-2.10)	1.95 (1.60-2.40)	2.15 (1.72-2.72)	2.34 (1.81-3.06)	2.59 (1.91-3.55)	2.77 (1.96-3.96)
60-min	0.537 (0.478-0.610)	0.693 (0.616-0.789)	0.888 (0.786-1.01)	1.04 (0.910-1.20)	1.23 (1.04-1.48)	1.37 (1.13-1.69)	1.51 (1.21-1.91)	1.65 (1.27-2.15)	1.82 (1.34-2.50)	1.95 (1.38-2.79)
2-hr	0.422 (0.375-0.480)	0.533 (0.473-0.606)	0.670 (0.593-0.765)	0.776 (0.680-0.895)	0.913 (0.769-1.09)	1.01 (0.832-1.24)	1.11 (0.885-1.40)	1.20 (0.930-1.57)	1.32 (0.974-1.82)	1.41 (1.00-2.02)
3-hr	0.367 (0.326-0.416)	0.458 (0.407-0.521)	0.571 (0.505-0.652)	0.658 (0.577-0.758)	0.769 (0.648-0.922)	0.850 (0.699-1.05)	0.928 (0.741-1.17)	1.00 (0.776-1.31)	1.10 (0.811-1.51)	1.17 (0.829-1.67)
6-hr	0.285 (0.254-0.324)	0.353 (0.314-0.402)	0.436 (0.386-0.498)	0.499 (0.438-0.575)	0.579 (0.488-0.695)	0.637 (0.523-0.783)	0.692 (0.552-0.875)	0.745 (0.575-0.973)	0.812 (0.598-1.11)	0.860 (0.609-1.23)
12-hr	0.209 (0.186-0.237)	0.261 (0.232-0.297)	0.323 (0.286-0.369)	0.370 (0.324-0.426)	0.428 (0.360-0.513)	0.469 (0.385-0.576)	0.507 (0.405-0.642)	0.544 (0.420-0.711)	0.590 (0.434-0.809)	0.622 (0.440-0.888)
24-hr	0.149 (0.134-0.169)	0.189 (0.170-0.215)	0.236 (0.211-0.269)	0.271 (0.241-0.311)	0.314 (0.271-0.371)	0.344 (0.291-0.414)	0.371 (0.308-0.457)	0.397 (0.321-0.501)	0.429 (0.334-0.562)	0.452 (0.341-0.610)
2-day	0.099 (0.089-0.112)	0.127 (0.114-0.144)	0.160 (0.144-0.183)	0.185 (0.164-0.212)	0.215 (0.185-0.254)	0.235 (0.199-0.283)	0.254 (0.210-0.312)	0.271 (0.219-0.342)	0.293 (0.228-0.383)	0.307 (0.232-0.415)
3-day	0.076 (0.068-0.086)	0.099 (0.089-0.112)	0.125 (0.112-0.143)	0.145 (0.129-0.166)	0.168 (0.145-0.199)	0.185 (0.156-0.222)	0.199 (0.165-0.245)	0.213 (0.172-0.269)	0.230 (0.179-0.301)	0.242 (0.182-0.326)
4-day	0.063 (0.057-0.072)	0.082 (0.074-0.094)	0.105 (0.094-0.119)	0.121 (0.108-0.139)	0.141 (0.122-0.167)	0.154 (0.131-0.186)	0.167 (0.138-0.205)	0.179 (0.144-0.225)	0.193 (0.150-0.252)	0.203 (0.153-0.274)
7-day	0.045 (0.041-0.051)	0.058 (0.052-0.066)	0.074 (0.066-0.084)	0.085 (0.076-0.098)	0.099 (0.085-0.117)	0.109 (0.092-0.131)	0.118 (0.098-0.145)	0.126 (0.102-0.160)	0.137 (0.107-0.179)	0.144 (0.109-0.195)
10-day	0.036 (0.033-0.041)	0.047 (0.042-0.053)	0.059 (0.053-0.067)	0.068 (0.060-0.078)	0.079 (0.068-0.093)	0.087 (0.074-0.105)	0.094 (0.078-0.116)	0.101 (0.082-0.128)	0.110 (0.086-0.144)	0.116 (0.088-0.157)
20-day	0.024 (0.021-0.027)	0.031 (0.027-0.035)	0.039 (0.035-0.044)	0.045 (0.040-0.051)	0.052 (0.045-0.062)	0.057 (0.049-0.069)	0.062 (0.052-0.077)	0.067 (0.054-0.085)	0.073 (0.057-0.096)	0.077 (0.058-0.104)
30-day	0.019 (0.017-0.022)	0.024 (0.022-0.028)	0.031 (0.028-0.035)	0.036 (0.032-0.041)	0.042 (0.036-0.049)	0.046 (0.039-0.055)	0.050 (0.041-0.061)	0.054 (0.043-0.068)	0.058 (0.045-0.076)	0.061 (0.046-0.083)
45-day	0.016 (0.014-0.018)	0.020 (0.018-0.023)	0.025 (0.023-0.029)	0.029 (0.026-0.033)	0.034 (0.029-0.040)	0.037 (0.031-0.045)	0.040 (0.033-0.049)	0.043 (0.035-0.054)	0.047 (0.036-0.061)	0.049 (0.037-0.067)
60-day	0.014 (0.012-0.016)	0.018 (0.016-0.020)	0.022 (0.020-0.025)	0.025 (0.023-0.029)	0.030 (0.026-0.035)	0.032 (0.027-0.039)	0.035 (0.029-0.043)	0.038 (0.030-0.047)	0.041 (0.032-0.053)	0.043 (0.032-0.058)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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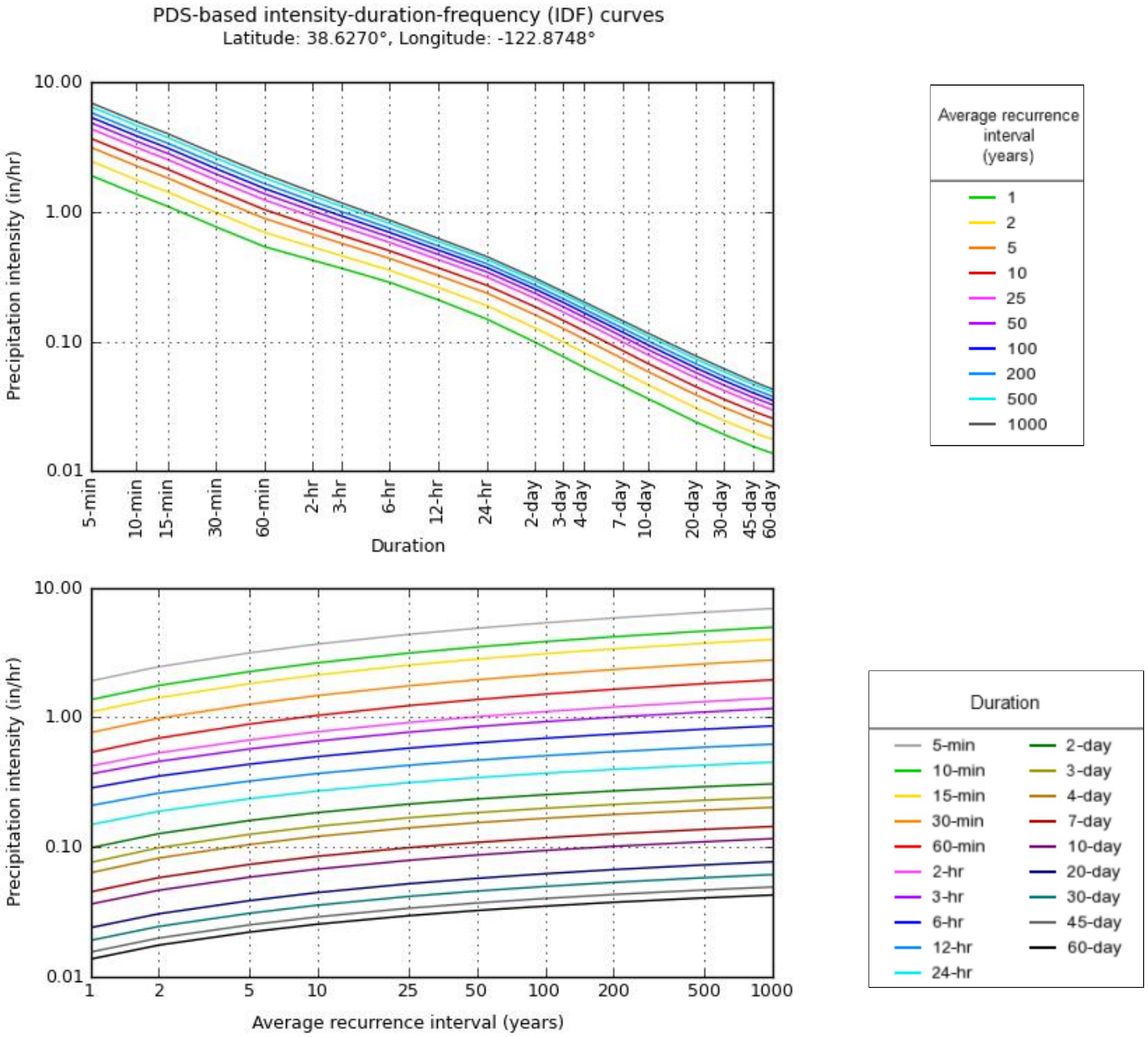
PF graphical



NOAA Atlas 14, Volume 6, Version 2

Created (GMT): Thu Sep 16 18:52:36 2021

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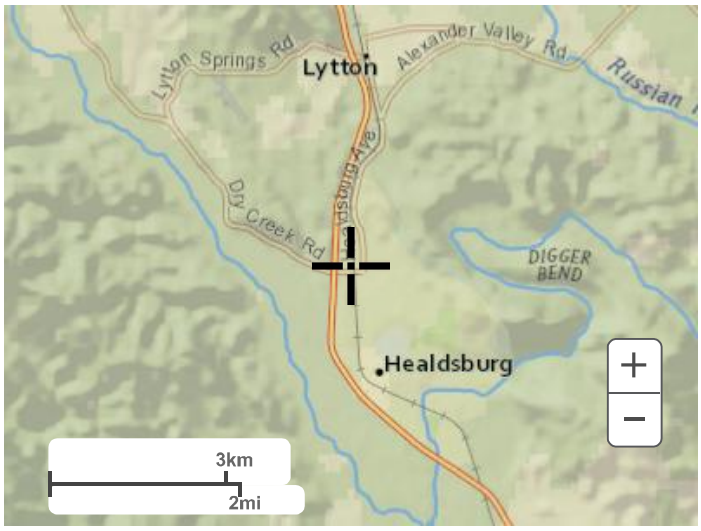
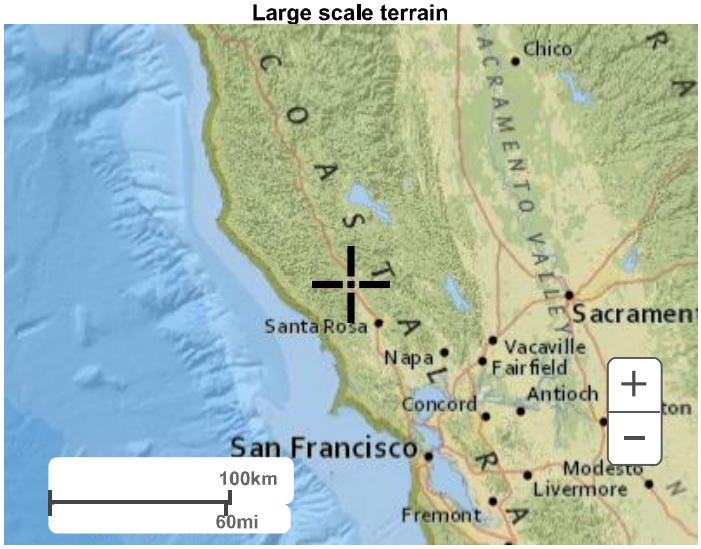
Maps & aerials

Small scale terrain

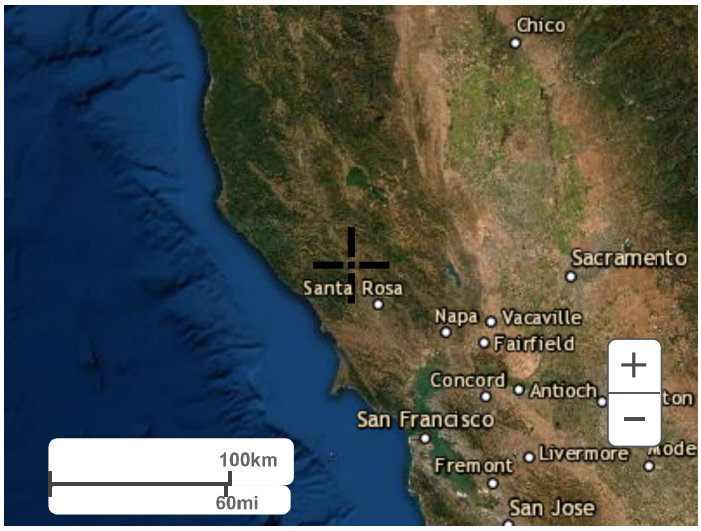


Large scale terrain



Large scale map

Large scale aerial



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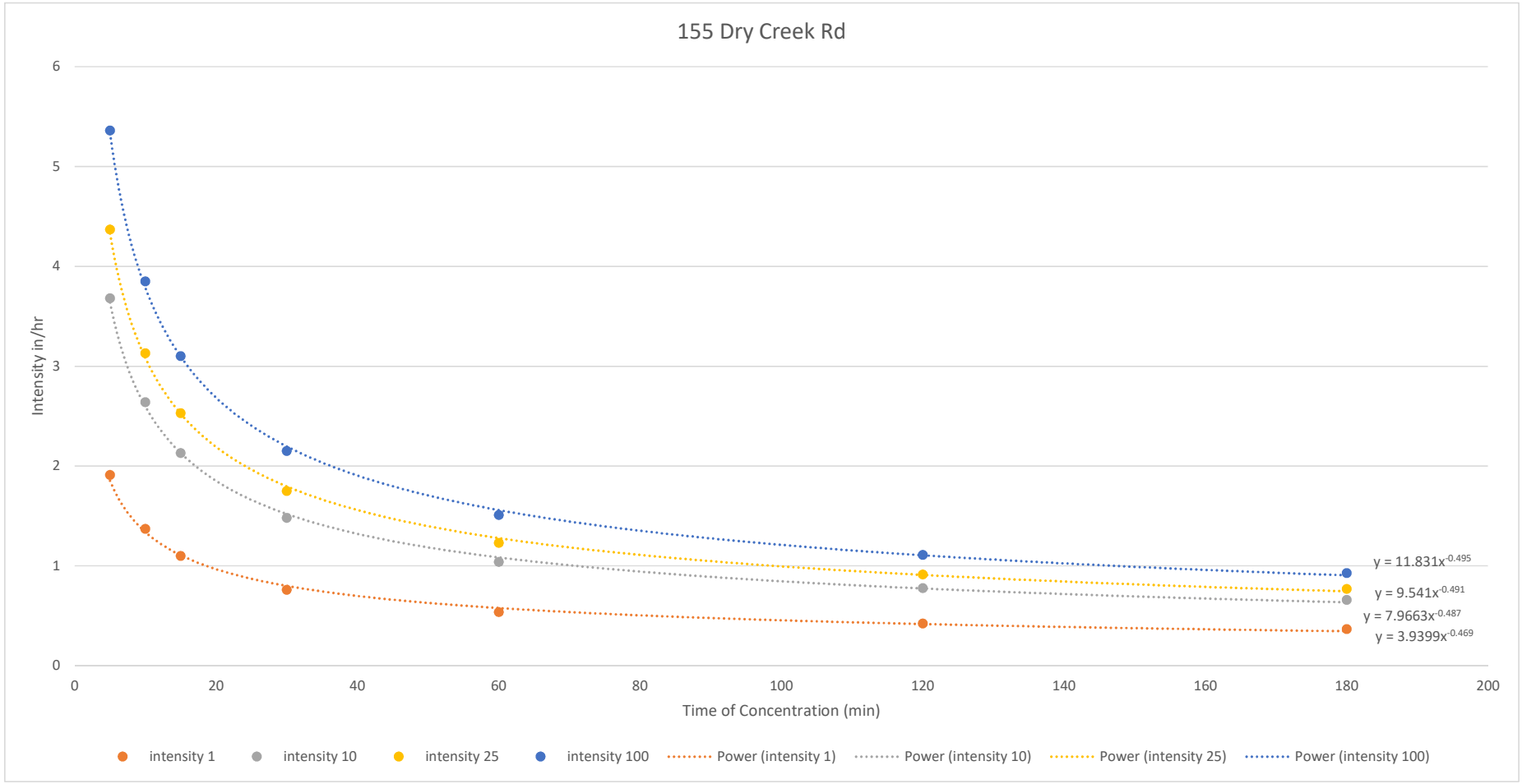
US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer


155 Dry Creek Rd
Intensity in/hr
Time of Concentration (min)
0
1
2
3
4
5
6
0
20
40
60
80
100
120
140
160
180
200
y = 11.831x-0.495
y = 9.541x-0.491
y = 7.9663x-0.487
y = 3.9399x-0.469
intensity 1
intensity 10
intensity 25
intensity 100
Power (intensity 1)
Power (intensity 10)
Power (intensity 25)
Power (intensity 100)

APPENDIX “B”

Pre-Development Exhibit

EXISTING WETLAND TO REMAIN (0.17 ACRES)

EXISTING WETLAND TO BE REMOVED (0.40 ACRES)

EXISTING CONDITION TRIBUTARY AREA SUMMARY		
AREA #	SIZE (ACRES)	C-FACTOR
1	14.49	0.4
2	0.67	0.3
3	0.80	0.3
4	2.37	0.3
5	0.50	0.7

60 0 60 120
scale 1" = 60' feet

EXISTING CONDITION HYDROLOGY MAP

155 DRY CREEK ROAD
CITY OF HEALDSBURG, CALIFORNIA
APRIL 12, 2022

PREPARED BY

BKF
ENGINEERS / SURVEYORS / PLANNERS
200 4TH ST, STE. 300 SANTA ROSA, CA 95401
(707) 583-8500 FAX: (707) 583-8539

Plot Apr 12, 2022 at 7:21pm

JOB NO. 210118-10

APPENDIX "C"

Post-Development Exhibit

Sonoma County Runoff Coefficients for Rational Formula

Post-Development Composite C-Factor Calculations

Post-Development 25-Year Site Flow Calculations

PROPOSED BIO-RETENTION BASIN

EXISTING WETLAND TO REMAIN (0.17 ACRES)

PROPOSED WETLAND (0.58 ACRES)

PROPOSED WETLAND WITHIN RIPARIAN SETBACK (0.36 ACRES)

PROPOSED CONDITION TRIBUTARY AREA SUMMARY		
AREA #	SIZE (ACRES)	C-FACTOR
1	14.49	0.4
2	0.59	0.3
3	3.98	

PROPOSED DEVELOPMENT HYDROLOGY MAP

155 DRY CREEK ROAD
CITY OF HEALDSBURG, CALIFORNIA
SEPTEMBER 17, 2021

PREPARED BY

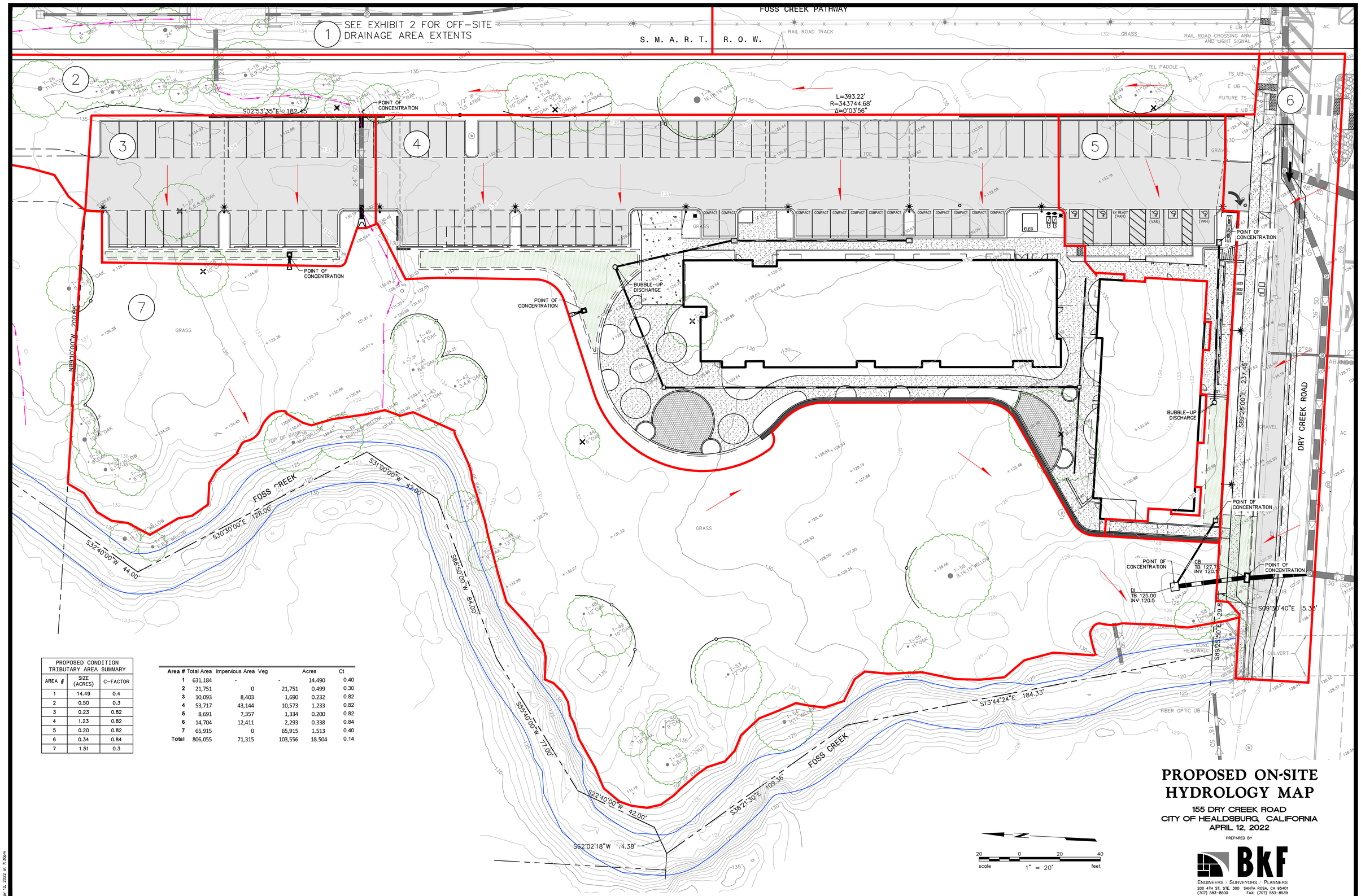
BKF
ENGINEERS / SURVEYORS / PLANNERS
200 4TH ST, STE. 300 SANTA ROSA, CA 95401
(707) 583-8500 FAX: (707) 583-8539

JOB NO. 210118-10

SHEET 2 OF 2 SHEETS

Plot Apr 12, 2022 at 7:28am

210118_HYDR.dwg



PROPOSED CONDITION TRIBUTARY AREA SUMMARY		
AREA #	SIZE (ACRES)	C-FACTOR
1	14.49	0.4
2	0.50	0.3
3	0.23	0.82
4	1.23	0.82
5	0.20	0.82
6	0.34	0.84
7	1.51	0.3

Area #	Total Area	Impervious Area	Veg	Acres	Ct
1	631,184	-	-	14.490	0.40
2	21,751	0	21,751	0.499	0.30
3	10,093	8,403	1,690	0.232	0.82
4	53,717	43,144	10,573	1.233	0.82
5	8,691	7,357	1,334	0.200	0.82
6	14,704	12,411	2,293	0.338	0.84
7	65,915	0	65,915	1.513	0.40
Total	806,055	71,315	103,556	18.504	0.14

scale 1" = 20' feet (20 0 20 40)

PROPOSED ON-SITE HYDROLOGY MAP

155 DRY CREEK ROAD
CITY OF HEALDSBURG, CALIFORNIA
APRIL 12, 2022

PREPARED BY

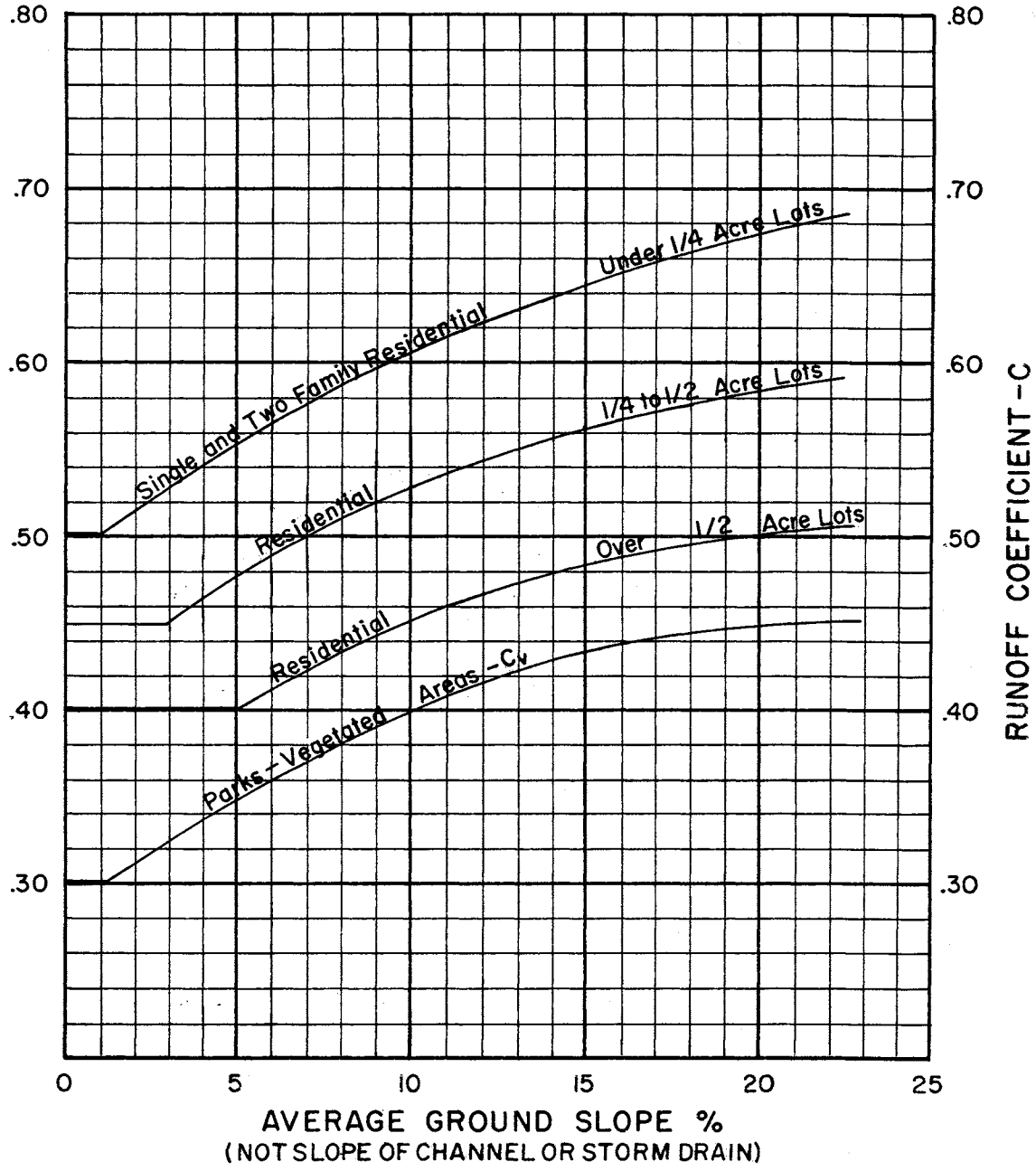
BKF
ENGINEERS / SURVEYORS / PLANNERS
200 4TH ST, STE. 300 SANTA ROSA, CA 95401
(707) 583-8500 FAX: (707) 583-8539

Plot Apr 12, 2022 at 7:30pm

JOB NO. 210118-10

SHEET 2 OF 2 SHEETS

RUNOFF COEFFICIENTS FOR RATIONAL FORMULA



NOTE: Commercial, Industrial & Multiple Residential Areas

$C_P = 0.9$ (Based on paving, roofs, etc.)

When vegetated area exceeds 20% of total, C_V from vegetated curve may be used to reduce above C_P as follows:

$$C_T = C_V \frac{A_V}{A_T} + C_P \frac{A_P}{A_T}$$

SONOMA COUNTY WATER AGENCY

118-2
7/64

PLATE No. B-1

BkF
ENGINEERS / SURVEYORS / PLANNERS

155 Dry Creek Rd
Job No. 20210188
Date: 4/12/2022
Prepared By : SPT

POST DEVELOPMENT COMPOSITE RUNOFF COEFFICIENT CALCULATION

Area #	Total Area	Impervious Area	Veg	Acres	Ct
1	631,184	-	-	14.490	0.40
2	21,751	0	21,751	0.499	0.30
3	10,093	8,403	1,690	0.232	0.82
4	53,717	43,144	10,573	1.233	0.82
5	8,691	7,357	1,334	0.200	0.82
6	14,704	12,411	2,293	0.338	0.84
7	65,915	0	65,915	1.513	0.40
Total	806,055	71,315	103,556	18.504	0.14

Ai	71,315	SF	Ci	0.9
Av	103,556	SF	Cv	0.5
At	174,871		Ct	0.663

over 80% impervious, use Cp

Legend:

Ai	Impervious Area	Cr	Runoff Coefficient for Impervious Area
Av	Lot Development	Cp	Runoff Coefficient for Vegetated Area
At	Total Area	Ct	Composite Runoff Coefficient
K	Rainfall Distribution Factor		

Ct=(Ai/At)*Ci+(Av/At)*Cv

Notes: Runoff cooeficient for family residential based of SCWA "Runoff Coefficients For Rational Method", lots under 1/4 acre, and individual lot grading at or below 2% slopes.

ENGINEERS / SURVEYORS / PLANNERS

Proj# 20210188
155 Dry Creek Rd

Calculation of Storm flow for 25 and 100 year storm event based on SCWA Flood Management Design Manual (2020) criteria

Post-Development 25-year hydraulics

Area 4 On-site Drainage to Bioretention Area and Drop Inlet

USE:

Tc= 35 min $i_{25}=(9.541)*(Tc^{-0.491})=$ 1.67 in/hr

C= 0.82

A= 53717 ft^2 $Q_{25}=C*i_{25}*A=$ 1.684 cfs

1.2332 acres

ENGINEERS / SURVEYORS / PLANNERS

Proj# 20210188
155 Dry Creek Rd

Calculation of Storm flow for 25 and 100 year storm event based on SCWA Flood Management Design Manual (2020) criteria

Post-Development 25-year hydraulics

Area 6 Public Street Improvements to Catch Basin

USE:

Tc= 7 min $i_{25}=(9.541)*(Tc^{-0.491})=$ 3.67 in/hr

C= 0.84

A= 14704 ft^2 $Q_{25}=C*i_{25}*A=$ 1.041 cfs

0.3376 acres

ENGINEERS / SURVEYORS / PLANNERS

Proj# 20210188
155 Dry Creek Rd

Calculation of Storm flow for 25 and 100 year storm event based on SCWA Flood Management Design Manual (2020) criteria

Total Estimated Flow Connection into Existing SD Manhole

Post-Development 25-year hydraulics

Area 4 On-site Drainage to Bioretention Area and Drop Inlet
USE:

Tc= 35 min $i_{25}=(9.541)*(Tc^{-0.491})=$ 1.67 in/hr
C= 0.82
A= 53717 ft^2 $Q_{25}=C*i_{25}*A=$ 1.684 cfs
1.2332 acres

Area 5 On-site Drainage to Bioretention Area and Drop Inlet
USE:

Tc= 21 min $i_{25}=(9.541)*(Tc^{-0.491})=$ 2.14 in/hr
C= 0.82
A= 8691 ft^2 $Q_{25}=C*i_{25}*A=$ 0.35 cfs
0.1995 acres

Area 6 On-site Drainage to Bioretention Area and Drop Inlet
USE:

Tc= 7 min $i_{25}=(9.541)*(Tc^{-0.491})=$ 3.67 in/hr
C= 0.84
A= 14704 ft^2 $Q_{25}=C*i_{25}*A=$ 1.041 cfs
0.3376 acres

Area 7 On-site Drainage to Bioretention Area and Drop Inlet
USE:

Tc= 32 min $i_{25}=(9.541)*(Tc^{-0.491})=$ 1.74 in/hr
C= 0.3
A= 65915 ft^2 $Q_{25}=C*i_{25}*A=$ 0.79 cfs
1.5132 acres

Total Drainage to Ex Manhole
1.68cfs+0.35cfs+1.04cfs+0.79cfs= 3.86cfs

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Apr 12 2022

Pipe Connection to Ex SD

Circular

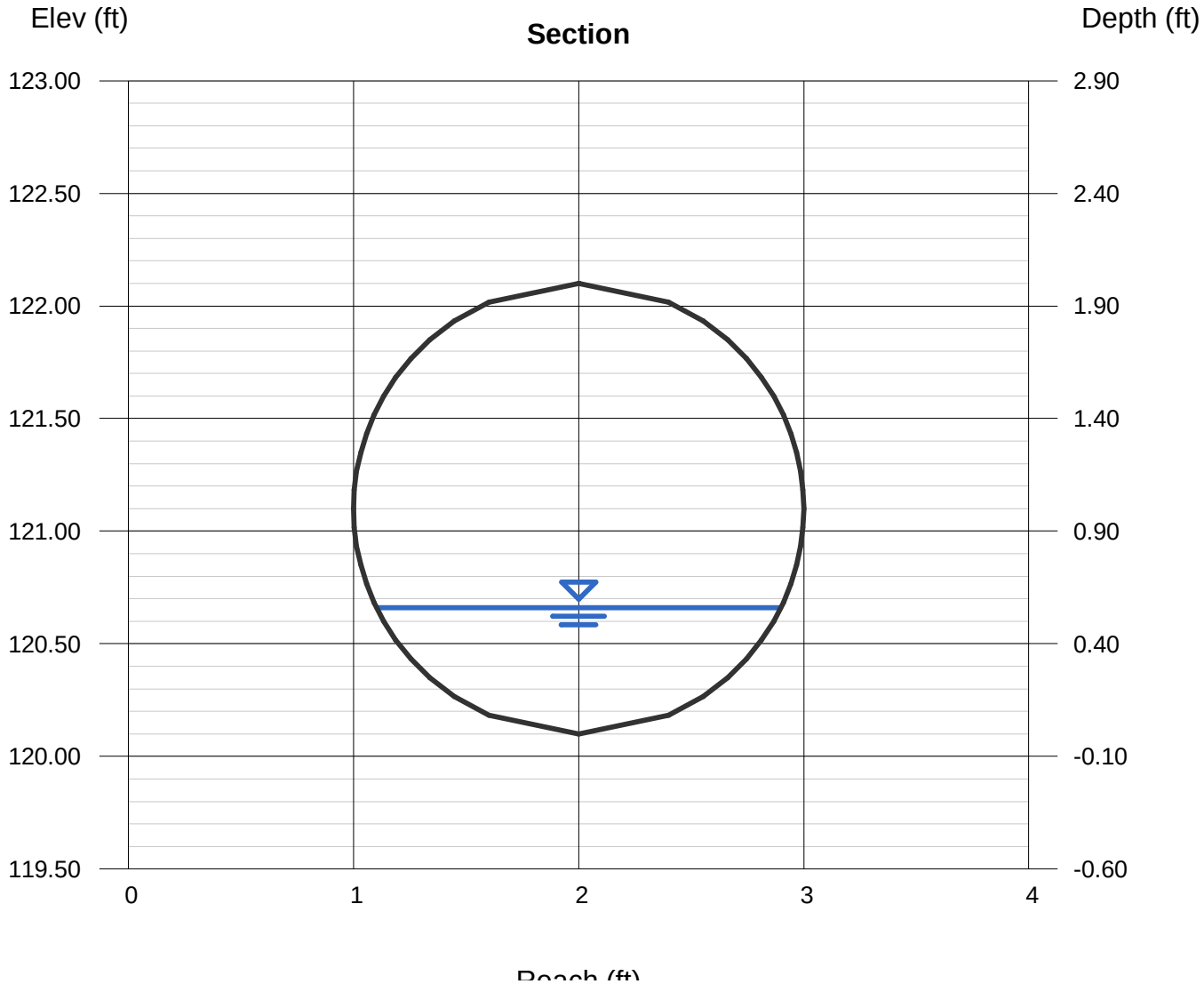
Diameter (ft)	= 2.00
Invert Elev (ft)	= 120.10
Slope (%)	= 1.00
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 3.86

Highlighted

Depth (ft)	= 0.56
Q (cfs)	= 3.860
Area (sqft)	= 0.73
Velocity (ft/s)	= 5.30
Wetted Perim (ft)	= 2.24
Crit Depth, Yc (ft)	= 0.69
Top Width (ft)	= 1.80
EGL (ft)	= 1.00



ENGINEERS / SURVEYORS / PLANNERS

Proj# 20210188
155 Dry Creek Rd

Calculation of Storm flow for 25 and 100 year storm event based on SCWA Flood Management Design Manual (2020) criteria

Post-Development 25-year hydraulics
Flow to Improved Site Culvert

Area 1 Estimated surface drainage from off-site areas east of tracks
USE:

Tc=	65	min	$i_{25}=(9.541)*(Tc^{-0.491})=$	1.23	in/hr
C=	0.4				
A=	631184	ft^2	$Q_{25}=C*i_{25}*A=$	7.12	cfs
	14.49	acres			

Post-Development 25-year hydraulics
Area 2 Portion of existing area on west side of tracks to culvert
USE:

Tc=	10	min	$i_{25}=(9.541)*(Tc^{-0.491})=$	3.08	in/hr
C=	0.3				
A=	21751	ft^2	$Q_{25}=C*i_{25}*A=$	0.46	cfs
	0.4993	acres			

Total Drainage to Improved Culvert
7.12cfs+0.46cfs= 7.58cfs

Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Apr 12 2022

Improved Site Culvert

Invert Elev Dn (ft)	=	129.10
Pipe Length (ft)	=	51.00
Slope (%)	=	2.00
Invert Elev Up (ft)	=	130.12
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	1
n-Value	=	0.015
Culvert Type	=	Circular Culvert
Culvert Entrance	=	Smooth tapered inlet throat
Coeff. K,M,c,Y,k	=	0.534, 0.555, 0.0196, 0.9, 0.2

Embankment

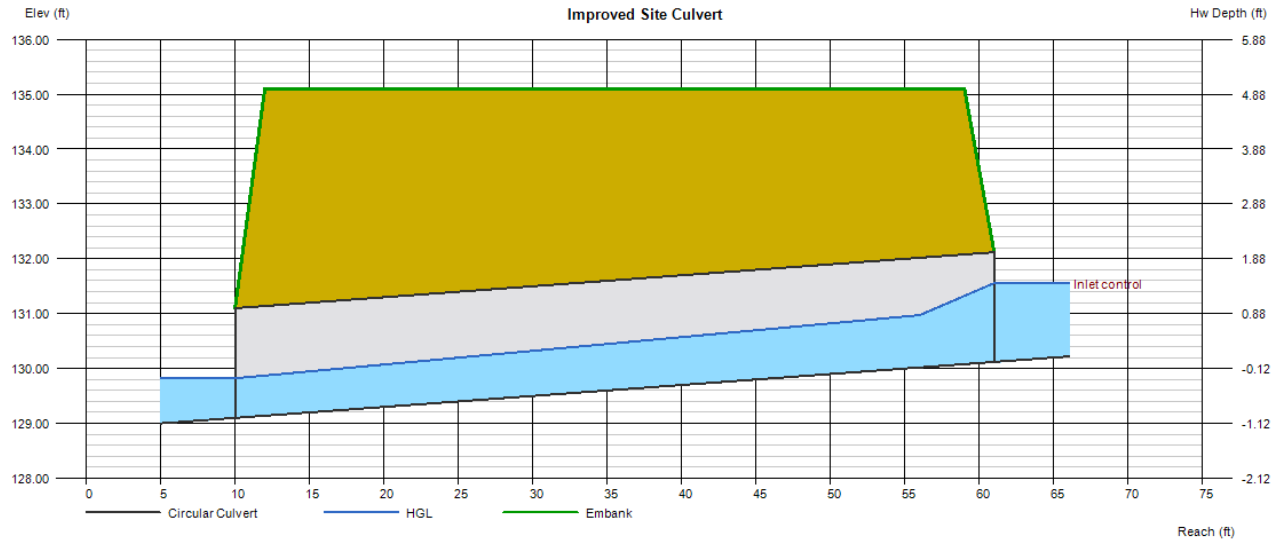
Top Elevation (ft)	=	135.10
Top Width (ft)	=	47.00
Crest Width (ft)	=	10.00

Calculations

Qmin (cfs)	=	7.58
Qmax (cfs)	=	8.00
Tailwater Elev (ft)	=	0.00

Highlighted

Qtotal (cfs)	=	7.58
Qpipe (cfs)	=	7.58
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	7.40
Veloc Up (ft/s)	=	4.97
HGL Dn (ft)	=	129.82
HGL Up (ft)	=	131.10
Hw Elev (ft)	=	131.56
Hw/D (ft)	=	0.72
Flow Regime	=	Inlet Control



APPENDIX "D"

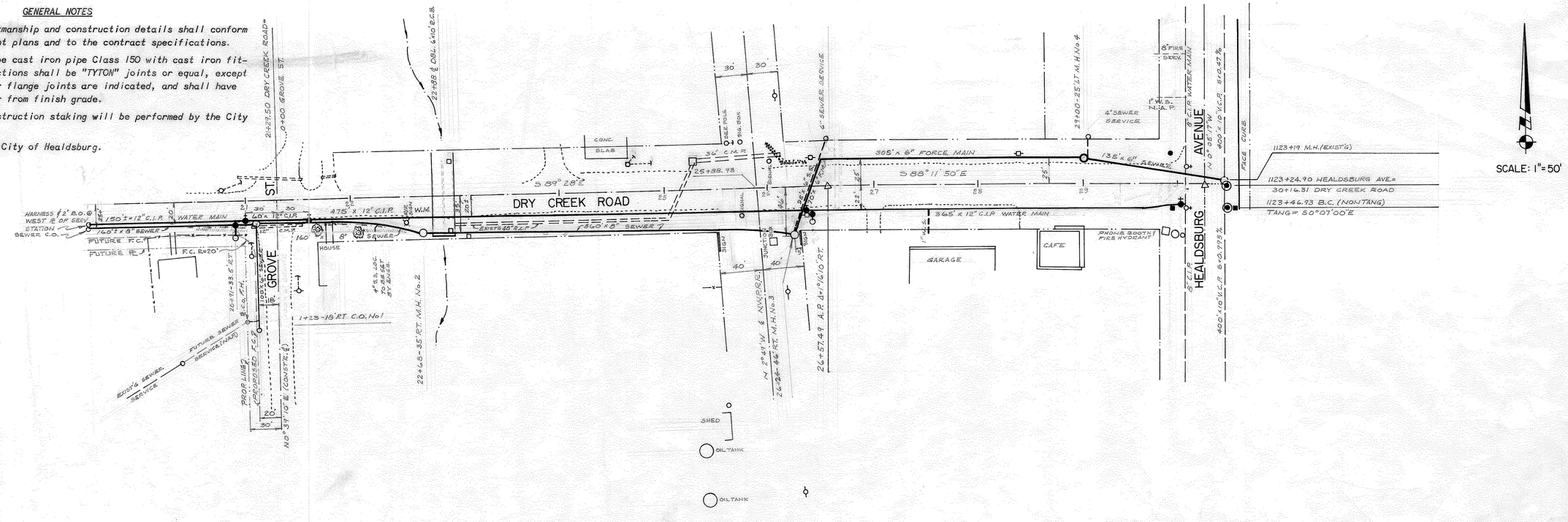
Excerpts from City Of Healdsburg Dry Creek Road – Water & Sewer Plan 1964

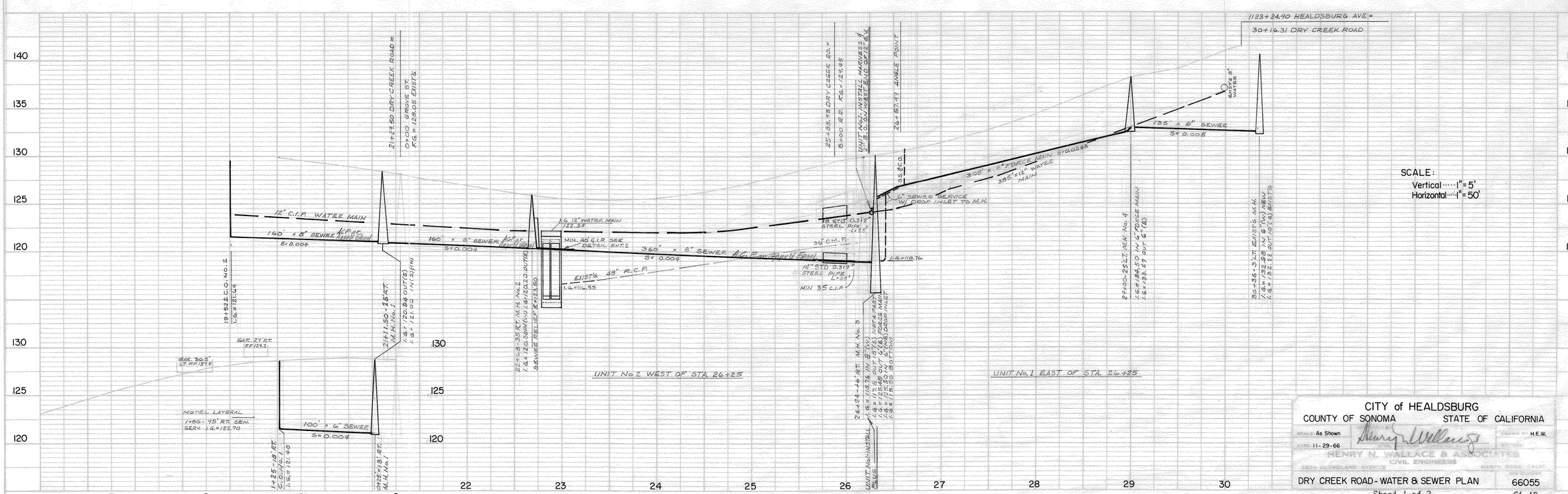
Excerpts from City Of Healdsburg North Trunk Sewer Improvement Plan 1995

National Flood Hazard Layer FIRMette, FEMA

GENERAL NOTES

1. All materials, workmanship and construction details shall conform to these improvement plans and to the contract specifications.
2. Water Mains shall be cast iron pipe Class 150 with cast iron fittings. Pipe connections shall be "TYTON" joints or equal, except where mechanical or flange joints are indicated, and shall have 44" to 50" of cover from finish grade.
3. Inspection and construction staking will be performed by the City of Healdsburg.
4. Elevations Datum: City of Healdsburg.

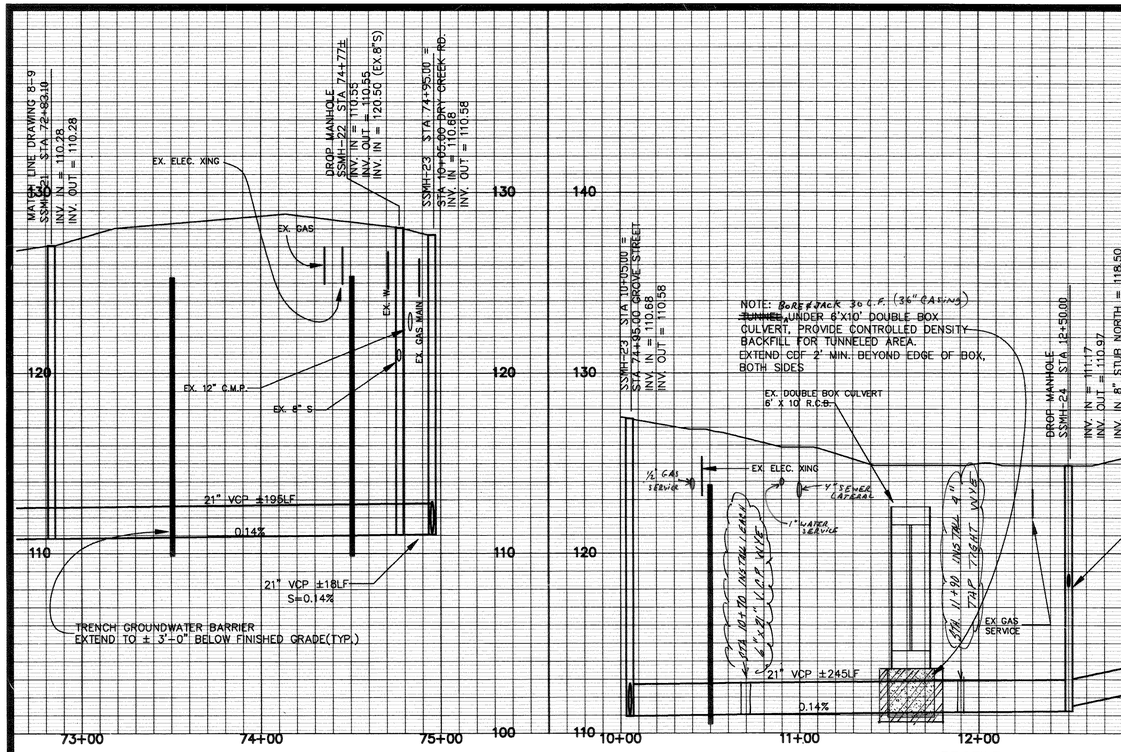




CITY of HEALDSBURG
COUNTY OF SONOMA STATE OF CALIFORNIA
SCALE: As Shown DRAWN BY: H.E.W.
DATE: 11-29-66
HENRY N. WALLACE & ASSOCIATES
CIVIL ENGINEERS
DRY CREEK ROAD - WATER & SEWER PLAN 66055
Sheet 1 of 2 64-18

File No. CIP1966.03

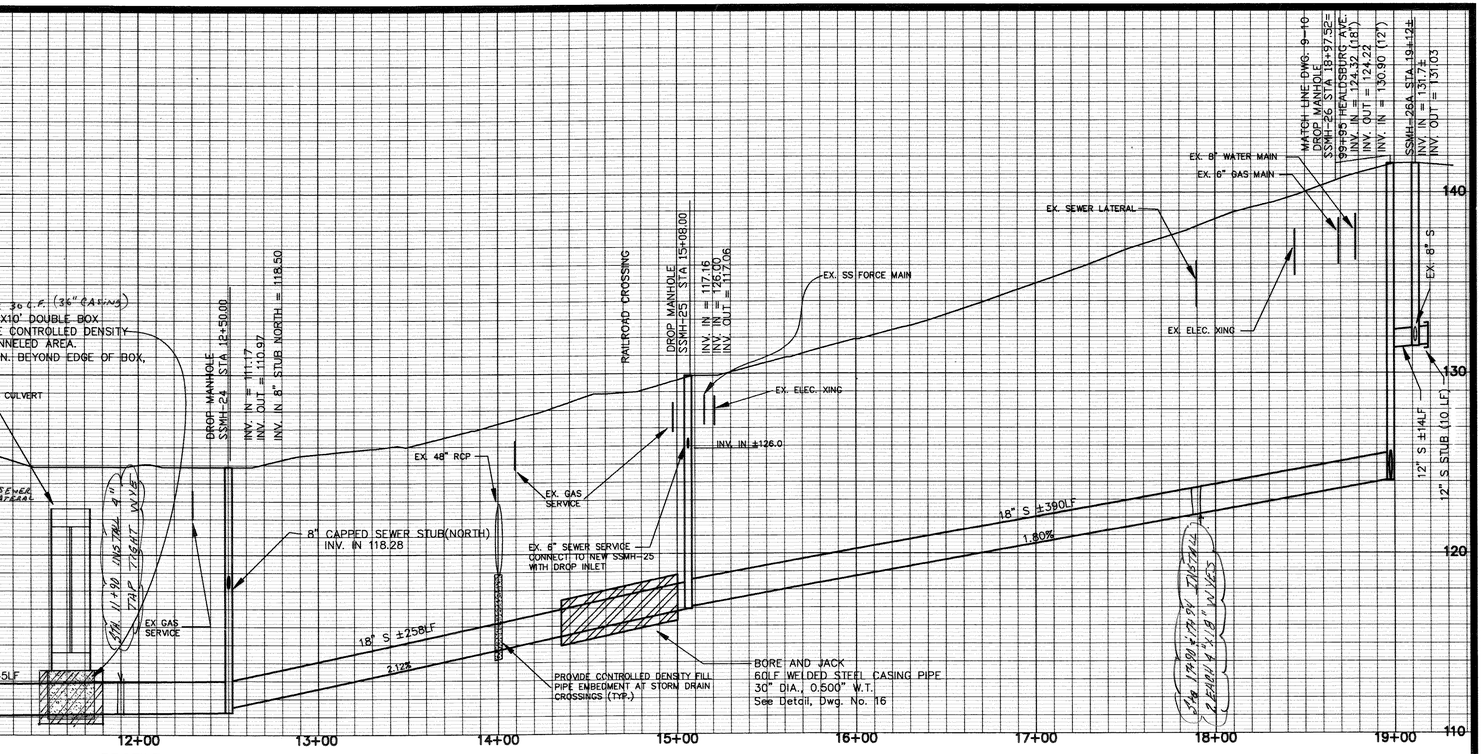
GROVE STREET SEWER PROFILE



PROFILE

HORIZONTAL SCALE: 1"=40'
VERTICAL SCALE: 1"=4'

DRY CREEK ROAD SEWER PROFILE



NOTES

~~No Sewer at This Location~~

9.1 ~~Contractor~~ shall locate ~~ex. 6" SS~~ and place SSMH-21 in proper alignment to extend and connect ex. 6" SS to SSMH-21.

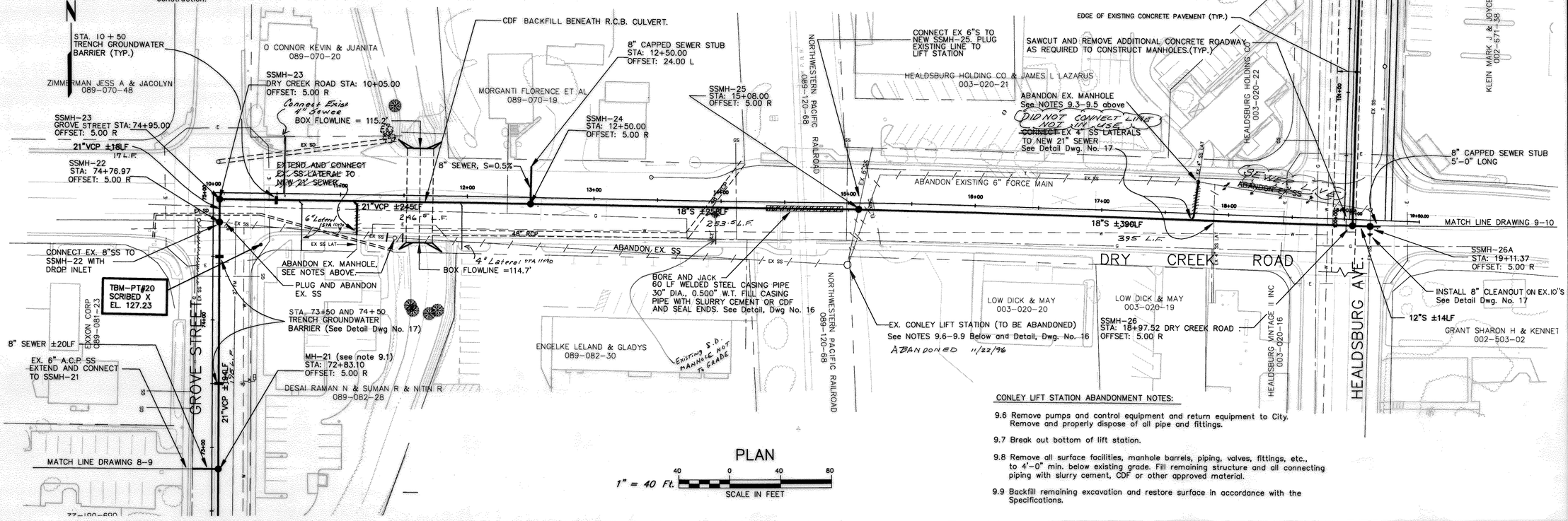
9.2 Contractor shall replace traffic signal detector loops damaged or removed during sewer main construction.

MANHOLE ABANDONMENT NOTES:

9.3 Remove cover, grade rings, top cone, and first barrel section.

9.4 Break out manhole bottom

9.5 Backfill remaining sections and all connecting piping with slurry cement, CDF, or other approved material.



PLAN

1" = 40 Ft.

SCALE IN FEET 40 0 40 80

CONLEY LIFT STATION ABANDONMENT NOTES:

9.6 Remove pumps and control equipment and return equipment to City. Remove and properly dispose of all pipe and fittings.

9.7 Break out bottom of lift station.

9.8 Remove all surface facilities, manhole barrels, piping, valves, fittings, etc., to 4'-0" min. below existing grade. Fill remaining structure and all connecting piping with slurry cement, CDF or other approved material.

9.9 Backfill remaining excavation and restore surface in accordance with the Specifications.

PROFESSIONAL ENGINEER * WILFRED WILHELM DOIDA * No. 29875 Exp. 3-31-98 * REGISTERED * CIVIL * STATE OF CALIFORNIA

Wilhelm Doida R.C.E. 29875

John S. Lacey R.C.E. 31909

BRELJE & RACE
CONSULTING CIVIL ENGINEERS
3970 SKYLANE BLVD. P.O. BOX 1895 SANTA ROSA CA 95402 707/576-1322

CITY OF HEALDSBURG
NORTH TRUNK SEWER
SONOMA COUNTY CALIFORNIA

GROVE ST. PLAN AND PROFILE
DRY CREEK ROAD PLAN AND PROFILE

DATE FEB. 1995
REVISIONS

DRAWN BY RD | CHECKED

JOB NO. 1608

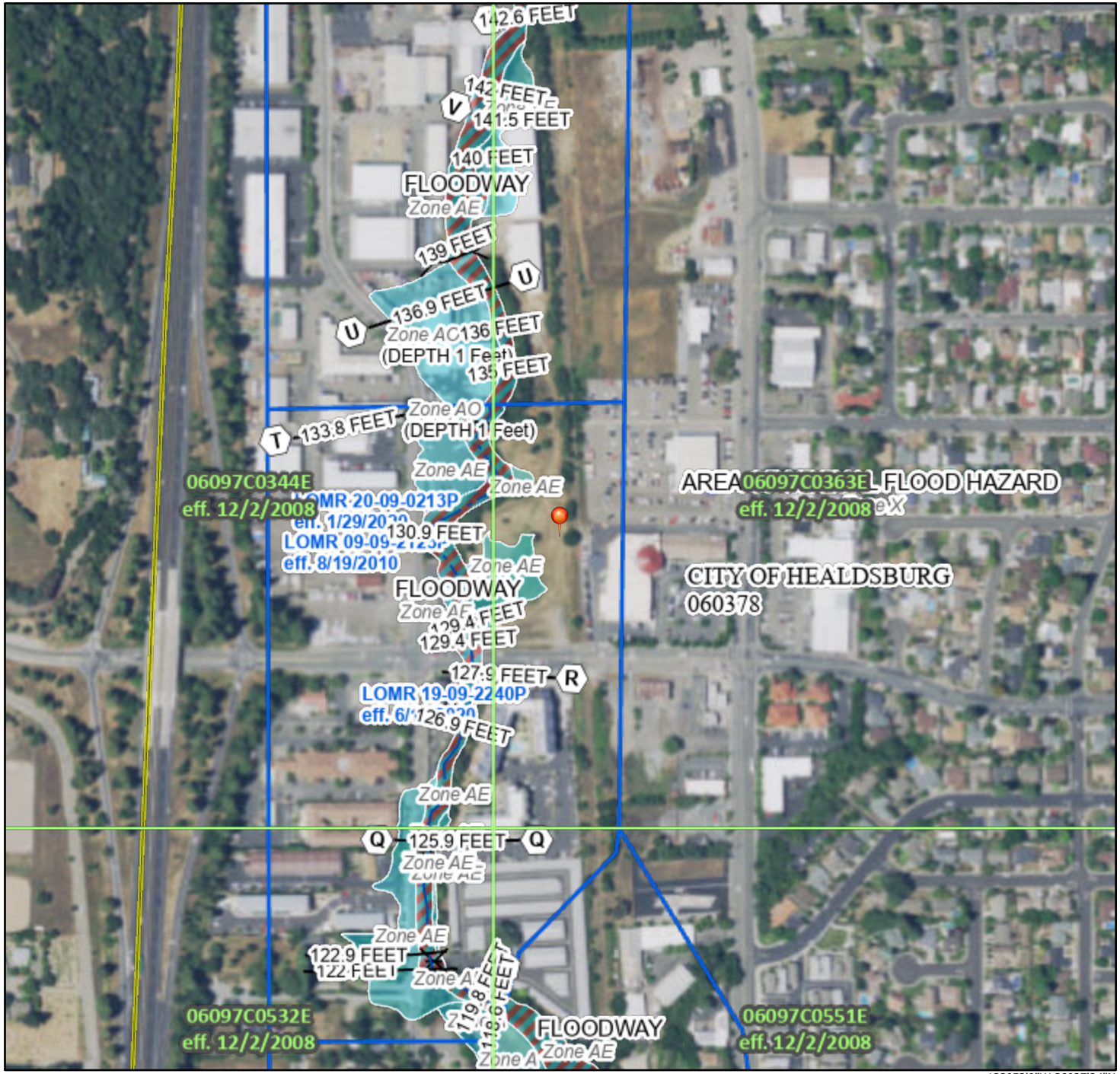
DRAWING NUMBER 9 OF 17

File No. CIP1995.01

National Flood Hazard Layer FIRMette

FEMA

122°52'47"W 38°37'52"N



122°52'9"W 38°37'24"N

Feet

0 250 500 1,000 1,500 2,000

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

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

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

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

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

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 4/12/2022 at 1:33 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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


Zone AO
(DEPTH 1)
Zone
AE
133.8
T
Zone AE
LOMR 20-09-0213P
eff. 1/29/2020
CITY OF
HEALDSBURG
060378
Zone AE
S
130.9
06097C0344E
eff. 12/2/2008
LOMR 19-09-2240P
eff. 6/19/2020
LOMR 09-09-2125P
eff. 8/19/2010
06097C0363E
eff. 12/2/2008
Zone AE
Foss Creek
129.4
129.4
Selected Flood Map Boundary
Digital Data Available
No Digital Data Available
Unmapped
Streets
Esri, USDA Farm Service Agency
POWERED BY
esri

APPENDIX “E”

Inlet Capacity Exhibits and Checks

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Apr 12 2022

Area 4 Discharge Pipe Capacity

Circular

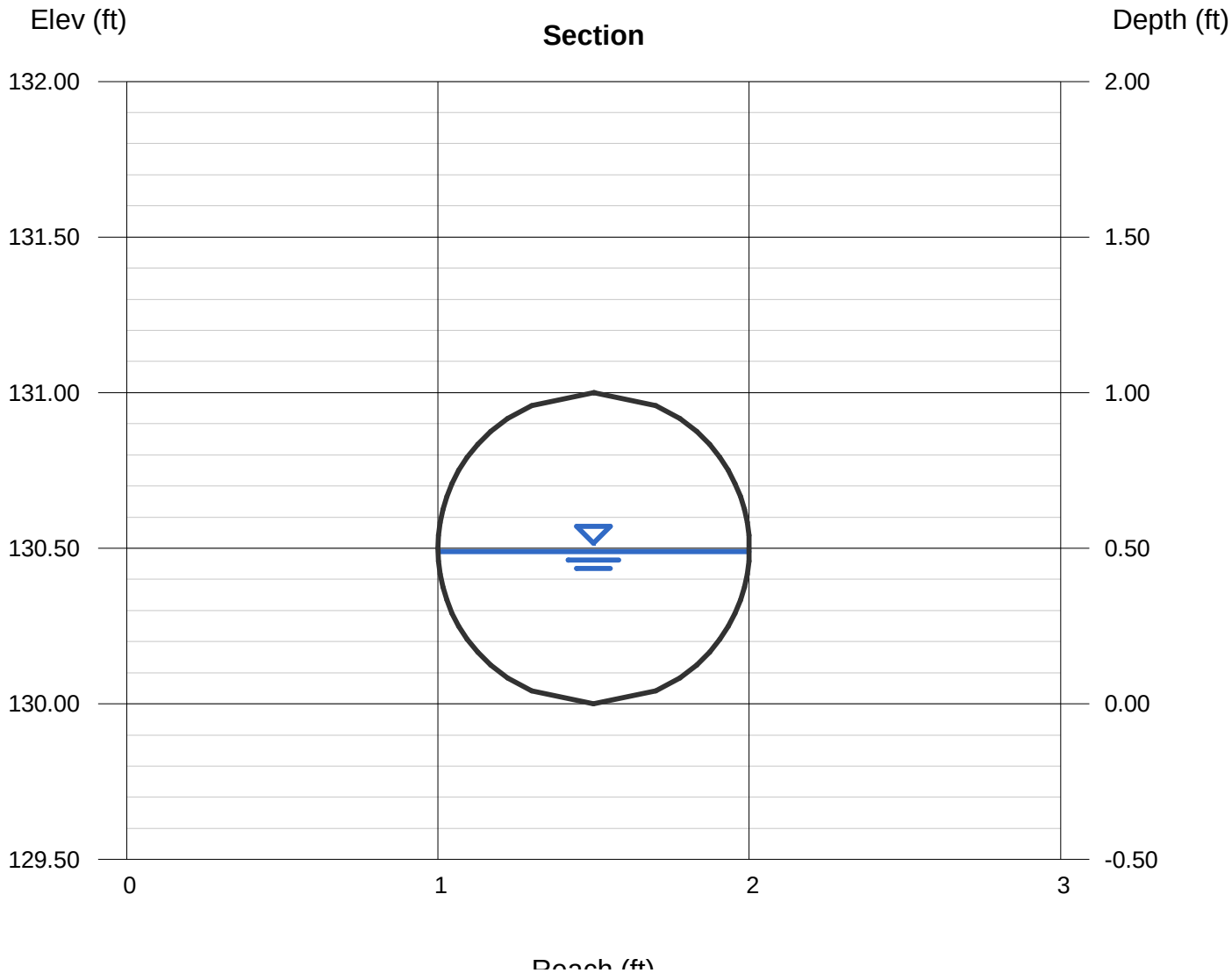
Diameter (ft)	= 1.00
Invert Elev (ft)	= 130.00
Slope (%)	= 1.00
N-Value	= 0.013

Calculations

Compute by:	Known Q
Known Q (cfs)	= 1.68

Highlighted

Depth (ft)	= 0.49
Q (cfs)	= 1.680
Area (sqft)	= 0.38
Velocity (ft/s)	= 4.37
Wetted Perim (ft)	= 1.55
Crit Depth, Yc (ft)	= 0.55
Top Width (ft)	= 1.00
EGL (ft)	= 0.79



Weir Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Apr 12 2022

Area 4 Inlet Weir Capacity

Trapezoidal Weir

Crest	= Sharp
Bottom Length (ft)	= 1.67
Total Depth (ft)	= 0.75
Side Slope (z:1)	= 0.08

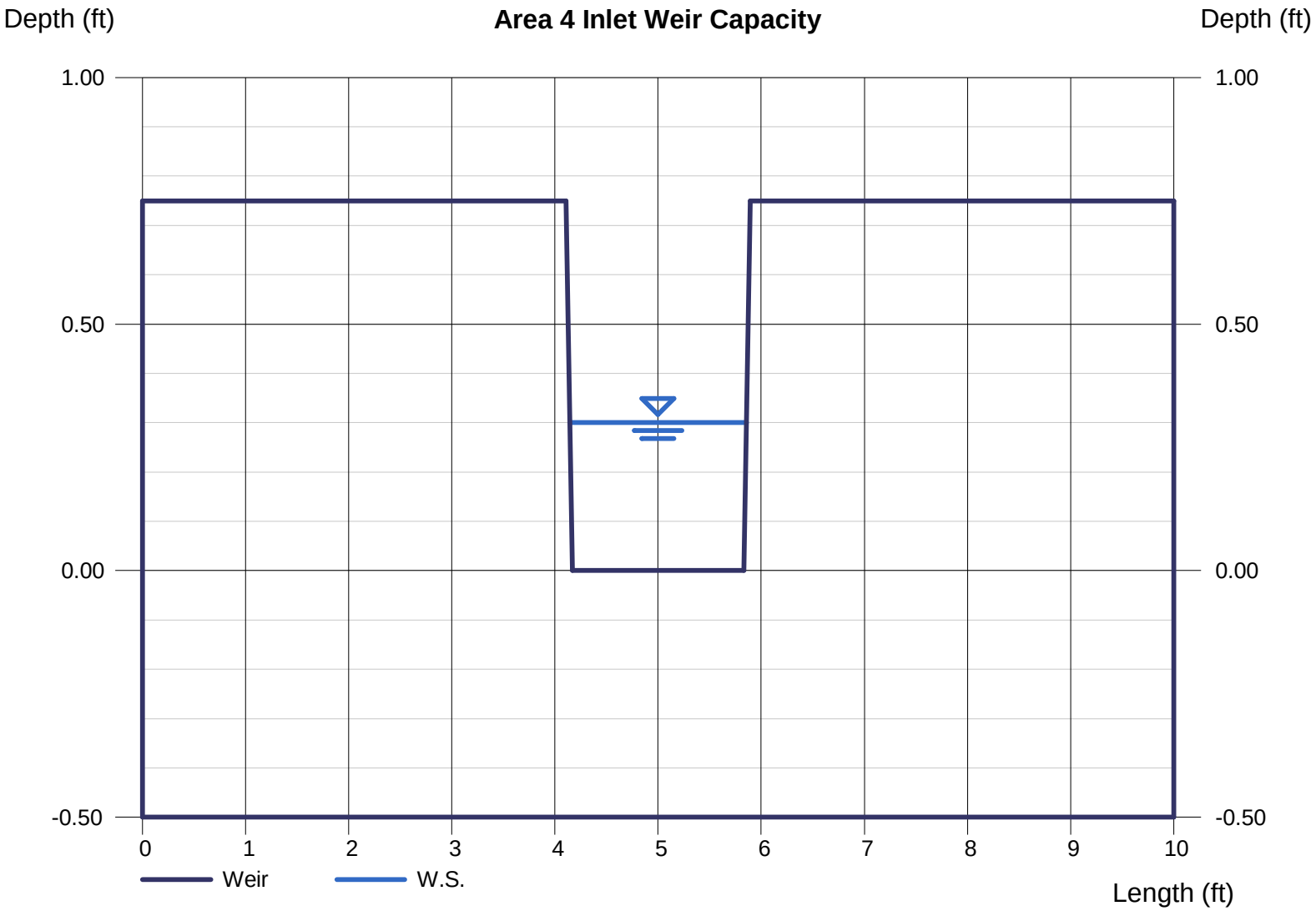
Calculations

Weir Coeff. Cw	= 3.10
Compute by:	Known Q
Known Q (cfs)	= 0.84

Highlighted

Depth (ft)	= 0.30
Q (cfs)	= 0.840
Area (sqft)	= 0.51
Velocity (ft/s)	= 1.66
Top Width (ft)	= 1.71

Split with 2 weirs
1.68cfs/2= 0.84cfs



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Apr 12 2022

Area 6 Gutter Capacity

Gutter

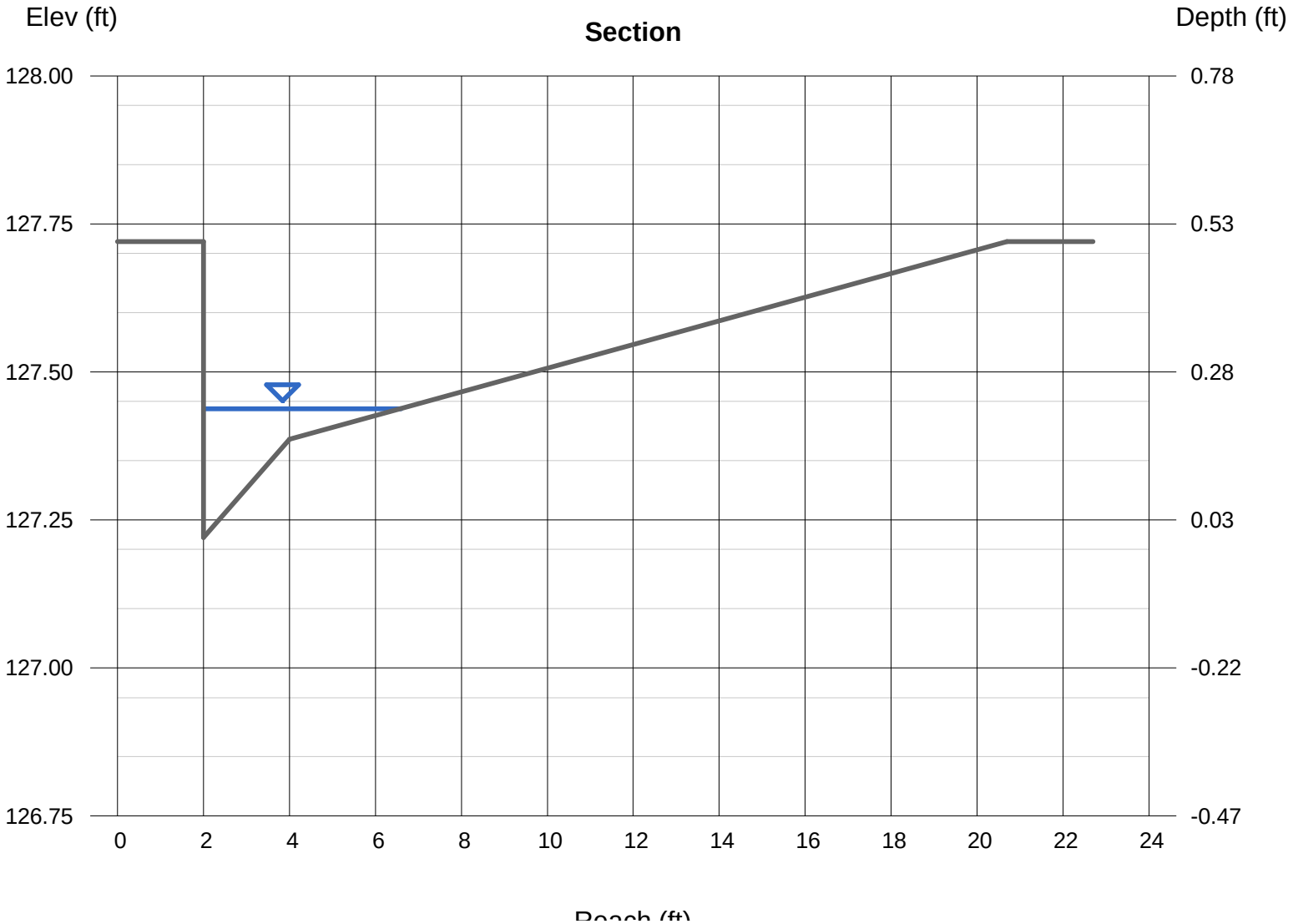
Cross Sl, Sx (ft/ft)	= 0.020
Cross Sl, Sw (ft/ft)	= 0.083
Gutter Width (ft)	= 2.00
Invert Elev (ft)	= 127.22
Slope (%)	= 1.60
N-Value	= 0.015

Calculations

Compute by:	Known Q
Known Q (cfs)	= 1.04

Highlighted

Depth (ft)	= 0.22
Q (cfs)	= 1.040
Area (sqft)	= 0.34
Velocity (ft/s)	= 3.08
Wetted Perim (ft)	= 4.83
Crit Depth, Yc (ft)	= 0.27
Spread Width (ft)	= 4.60
EGL (ft)	= 0.37



Inlet Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Tuesday, Apr 12 2022

Area 6 Curb Inlet Capacity

Curb Inlet

Location	= On grade
Curb Length (ft)	= 4.00
Throat Height (in)	= 4.50
Grate Area (sqft)	= -0-
Grate Width (ft)	= -0-
Grate Length (ft)	= -0-

Gutter

Slope, Sw (ft/ft)	= 0.083
Slope, Sx (ft/ft)	= 0.020
Local Depr (in)	= 2.00
Gutter Width (ft)	= 2.00
Gutter Slope (%)	= 1.60
Gutter n-value	= 0.015

Calculations

Compute by:	Known Q
Q (cfs)	= 1.04

Highlighted

Q Total (cfs)	= 1.04
Q Capt (cfs)	= 0.83
Q Bypass (cfs)	= 0.21
Depth at Inlet (in)	= 4.61
Efficiency (%)	= 80
Gutter Spread (ft)	= 4.58
Gutter Vel (ft/s)	= 3.10
Bypass Spread (ft)	= 1.46
Bypass Depth (in)	= 1.46