City of Calistoga

Staff Report

TO: Honorable Mayor and City Council

FROM: Derek Rayner, Senior Civil Engineer

VIA: Michael Kirn, Public Works Director/City Engineer

DATE: October 21, 2014

SUBJECT: Presentation by Napa County on the Greenwood Ave. Culvert Replacement Project over the Napa River

APPROVAL FOR FORWARDING:

Richard D. Spitler, City Manager

ISSUE: Discussion on possible downstream impacts to the City of Calistoga associated with to the replacement of the existing Greenwood Ave. culvert with a full span bridge over the Napa River.

RECOMMENDATION: Receive presentation from Napa County and provide direction as necessary

BACKGROUND: The project is located on Greenwood Avenue (south side of Grant), in Napa County, where the road crosses over the Napa River. Napa County currently has an existing 15-ft diameter culvert that has deteriorated and needs to be replaced. Calistoga City limits begin about 10-feet, downstream of this culvert.

Staff has expressed our concern to the County that there can be no negative downstream impacts to Calistoga's flood plain. Initially the County proposed to replace the culvert with a similar sized culvert, but after consultation with various wildlife agencies they were advised that they would be required to replace the existing culvert with a new, larger spanning bridge.

Staff has raised concerns with County representatives that opening up the culvert with a larger spanning bridge may lead to increased downstream peak flows and potentially have negative downstream impacts. We have requested that that the County present their findings of the recent hydrology study documenting no adverse impacts.

FISCAL IMPACT: This is a Napa County Improvement Project that will not require funding from Calistoga for the construction of this project.

ATTACHMENTS

1. Technical Memorandum from Napa County's Consultants
2. Flood Map

Schaaf & Wheeler
Consulting Civil Engineers

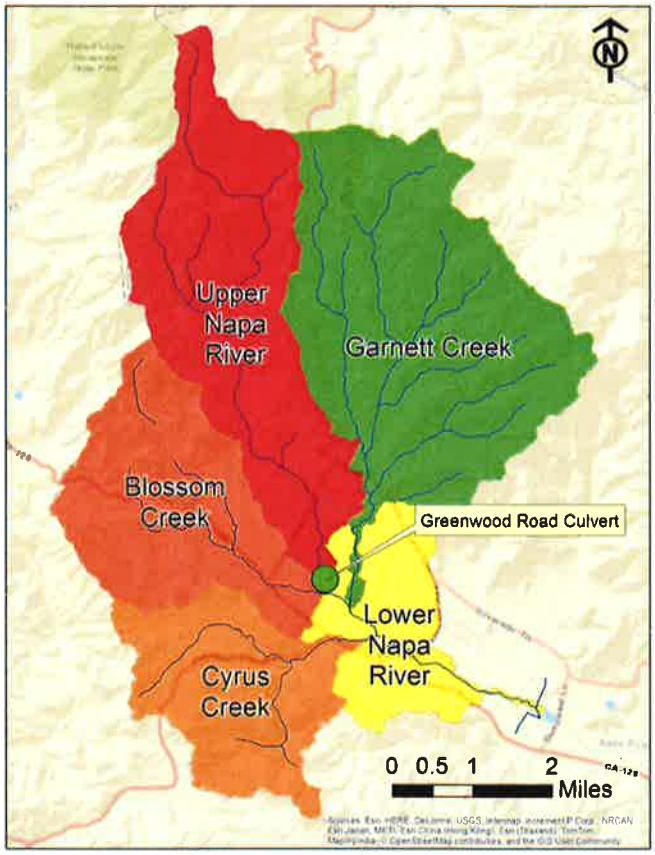
870 Market Street, Suite 1278
San Francisco, CA 94102
(415) 433-4848
FAX (415) 433-1029

TO:	Napa County	DATE:	September 25, 2014
FROM:	Dan Schaaf, PE	JOB #:	CONA.01.14
SUBJECT:	**Greenwood Road Impact Analysis**		

Introduction and Purpose

The proposed Napa River crossing at Greenwood Road may have hydrologic impacts on downstream communities. Schaaf & Wheeler has been contracted by Napa County to determine the possible impacts from replacing the existing 15-foot diameter culvert with a structure ranging from a 30-foot arch culvert to a free span bridge. Effective FEMA hydrologic models are not available; therefore, new HEC-HMS models of the region (Figure 1) were developed.

Figure 1: Watershed



Available Data

There are several published studies of the Napa River watershed. Many of these studies included hydrologic analyses and modeling. Schaaf & Wheeler worked with the County to determine the appropriate precipitation pattern and loss methods to apply to this study. The unit hydrographs published in the 1963 Review Report for Flood Control and Allied Purposes, Napa River Basin were utilized along with the 1964 Laytonville storm pattern. Basin characteristics including length, length to centroid, average channel slope and drainage area were developed from the County's GIS data. FEMA effective peak discharges were used to calibrate the hydrologic models. The discharges and corresponding drainage areas are shown in Table 1. The first area figure listed is from FEMA's Flood Insurance Study and the second is from an application of the most recent County GIS. With the exception of Blossom Creek the drainage areas are within 10 percent of each other. For Blossom Creek they are within 15 percent of one another. Either drainage area could be used for model purposes as model will be calibrated to the effective FEMA discharges.

Table 1: FEMA Flow Rates

Basin	Area (square miles)	100-yr Discharge (cfs)
Napa River at Corp Limits	5.4/5.7	3,500*
Garnett Creek	6.9/7.5	3,200
Blossom Creek	3.4/3.9	1,700
Cyrus Creek	2.9/3.1	1,500

**Published value (5,100cfs) includes Blossom Creek flows.*

Rainfall Intensity

Rainfall statistics from NOAA Atlas 14 Point Precipitation Frequency Estimates for California (http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca) were used to develop rainfall depths and balance the Laytonville storm pattern. These statistics were completed in 2011. The NOAA website allows the user to pin-point a place on a map or to enter latitude and longitude coordinates. NOAA statistics are then readily produced. These are reportedly based on 11 nearby daily stations. This NOAA web site does provide a statistical analysis it does not show the raw data and does not show computed Mean Annual Precipitation (MAP) values for any site selected.

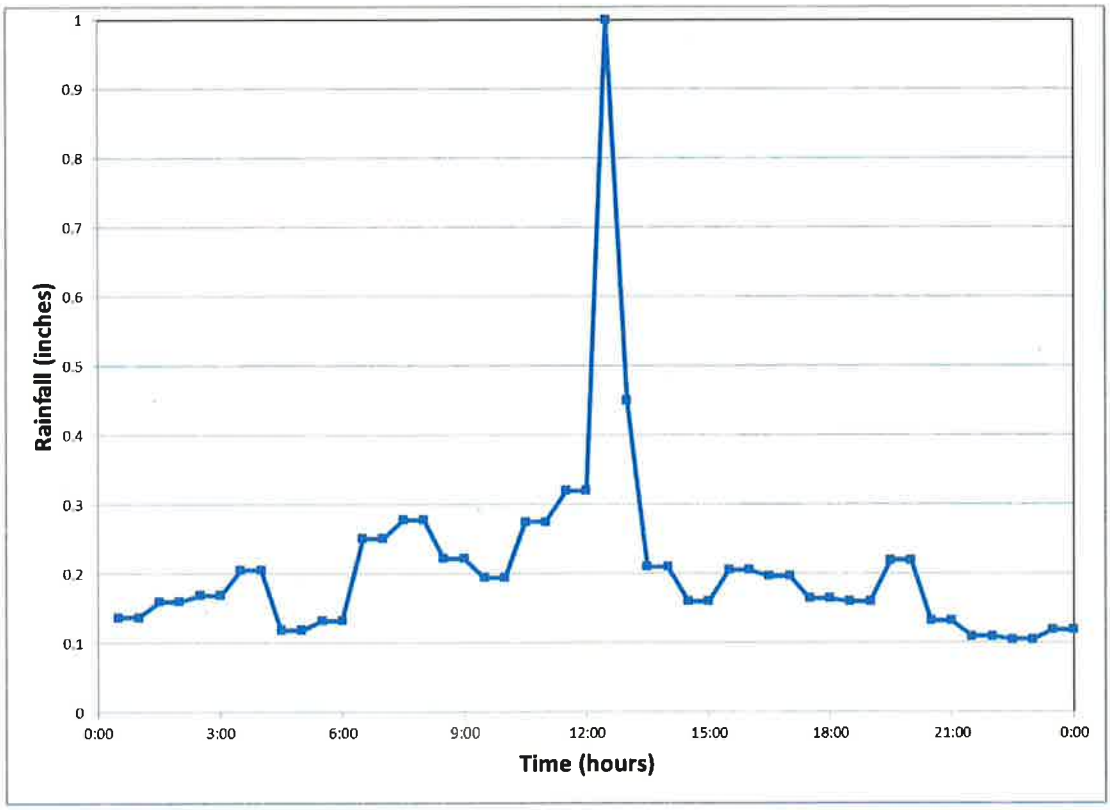
Balanced Rainfall Pattern

A 96-hr Laytonville storm pattern was selected for this study. This pattern was shortened to a 24-hour duration by extracting hours 34 through 57, which is roughly the storm peak. 100-year rainfall depths at the centroid of the study area from NOAA Atlas 14 where utilized to balance the 24-hour storm. Table 2 lists the balancing depths. The resulting balanced storm is shown in Figure 2.

Table 2: 100-year Rainfall Depths

Duration	Depth (inches)
30-min	1.0
60-min	1.45
2-hour	2.1
3-hour	2.6
6-hour	4.0
12-hour	6.4
24-hour	9.9

Figure 2: 24-hour Rainfall Pattern



Unit Hydrographs

A unit hydrograph for each basin was developed using the S-Graph from the published unit hydrograph of Napa River at Bale Dam. This S-Graph was applied based on basin lag and drainage area. Basin hydrologic parameters are listed in Table 3 and 30-minute unit hydrographs for each basin area shown in Table 4.

Table 3: Basin Characteristics

Catchment	L (mi)	Lc (mi)	Slope (ft/mi)	Basin N	Lag (hrs)
Blossom	3.72	1.79	311.5	0.15	2.49
Cyrus	3.10	1.26	286.2	0.15	2.06
Garnett	5.40	2.83	433.4	0.15	3.20
Lower Napa	1.60	0.68	391.2	0.15	1.20
Upper Napa	6.75	3.34	528.8	0.15	3.57

Table 4: Unit Hydrographs

Time	Blossom Creek	Garnett Creek	Cyrus Creek	Napa River at Corp Limits
0:30	0	0	0	0
1:00	64	81	80	56
1:30	214	235	269	143
2:00	536	474	779	264
2:30	965	989	795	428
3:00	755	1449	450	1019
3:30	469	1307	329	953
4:00	357	782	240	775
4:30	277	626	186	529
5:00	221	512	150	417
5:30	184	423	123	348
6:00	151	355	104	297
6:30	129	303	86	255
7:00	114	264	72	213
7:30	95	220	61	189
8:00	82	198	50	167
8:30	72	180	41	148
9:00	62	162	32	132
9:30	53	141	27	121
10:00	45	126	22	109
10:30	37	111	17	98
11:00	32	101	13	87
11:30	26	89	10	78
12:00	22	78	5	72
12:30	18	70	3	66
13:00	14	61	2	57
13:30	12	51	0	51
14:00	8	46	0	46
14:30	5	40	0	41
15:00	4	35	0	35
15:30	3	30	0	32
16:00	2	26	0	28
16:30	0	22	0	25
17:00	0	19	0	22
17:30	0	14	0	19
18:00	0	10	0	16
18:30	0	7	0	14
19:00	0	5	0	13
19:30	0	5	0	9
20:00	0	3	0	7
20:30	0	0	0	0
21:00	0	0	0	0

Hydrologic Routing

Routing in the HEC-HMS models is based on the Muskingum method. X is set at 0.2 to represent flow generally contained within the channel. The K values are approximated using 2/3 of the 100-year channel velocities from the HEC-2 models by Nolte and Associates. Table 5 lists routing parameters.

Table 5: Routing Parameters

Reach	HEC2 XS	Vch (fps)	Length (ft)	K (hrs)	X
Greenwood Rd to Blossom Ck	12790	6.5	770	0.05	0.2
Blossom Ck to Garnett Ck	12780	5.8	1,360	0.10	0.2
Garnett Ck to Cyrus Ck	12750 12760	8.0	2,140	0.11	0.2

Model Calibration

The HEC-HMS model was developed with previously listed data. The model was calibrated to published FEMA 100-year flows by adjusting the constant loss value. No initial loss was applied. Rainfall depth was based on NOAA Atlas 14 and adjusted as needed. Table 7 lists the constant loss and rainfall depths for the 24-hour 100-year,10-year and Frequent events. The Frequent event is the 2-year rainfall with the 10-year loss rates.

Table 7: Rainfall and Losses

Catchment	Frequent Storm Rainfall (in)	10-year Rainfall (in)	100-year Rainfall (in)	Frequent Storm Constant Loss (in/hr)	10-year Constant Loss (in/hr)	100-year Constant Loss (in/hr)
Blossom	4.5	6.79	9.78	0.18	0.18	0.15
Cyrus	4.5	6.76	9.72	0.15	0.15	0.11
Garnett	4.5	7.3	10.50	0.17	0.17	0.14
Lower Napa	4.5	6.63	9.56	0.16	0.16	0.14
Upper Napa	4.5	8.53	12.98	0.00	0.00	0.00

Existing Culvert and Proposed Arch Hydraulics

The HEC-RAS models of the current Greenwood Road culvert (Figure 3), a proposed arch culvert (Figure 4), and free span bridge (Figure 5) were utilized to create rating curves (Figure 6) of hydraulic performance. County LiDAR topography (Figure 8) was used to create elevation vs. storage curves (Figure 7). These curves were utilized to route the Upper Napa flows through the floodplain and culvert at Greenwood Road in HEC-HMS. The proposed crossing improvements lower the 100-year water surface 6.5-feet, significantly reducing the floodplain upstream of Greenwood Road.

Figure 3: Existing Culvert Section at Greenwood Road

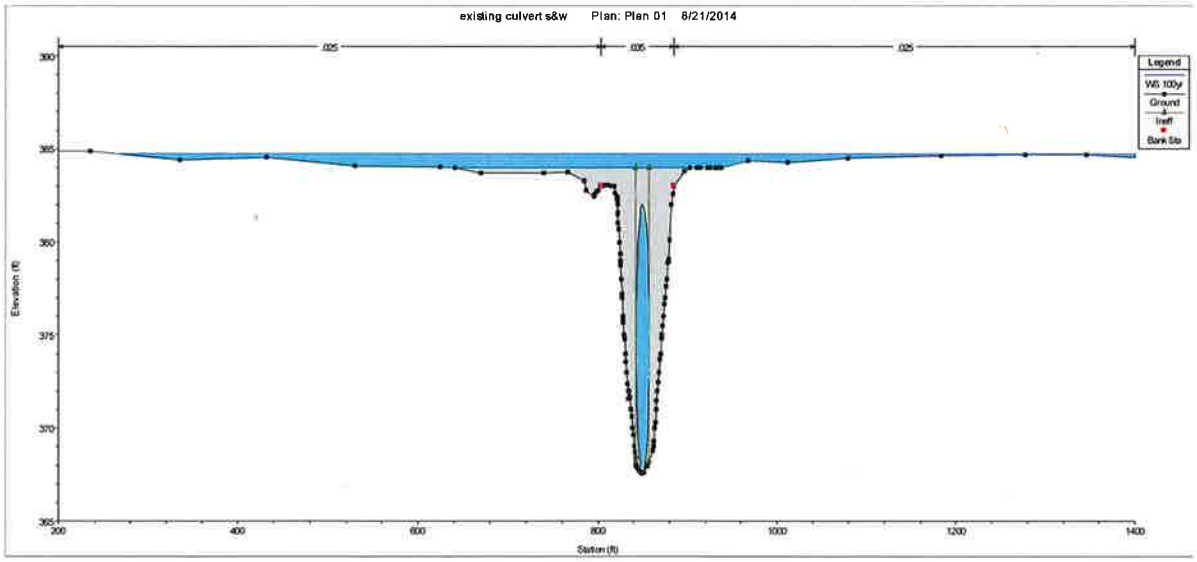


Figure 4: Proposed Arch Culvert Section at Greenwood Road

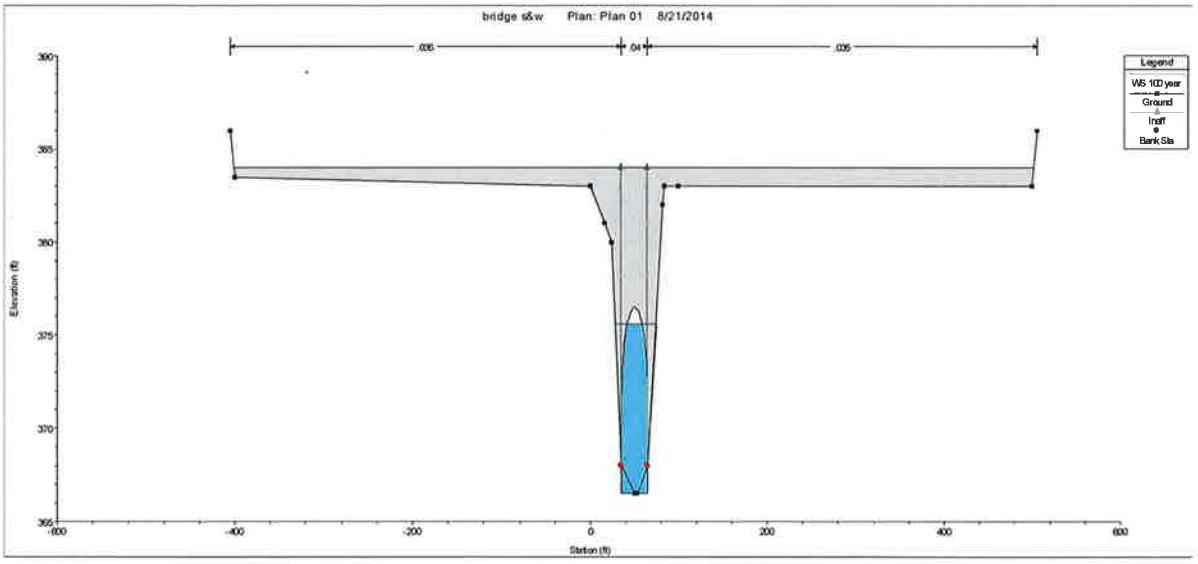


Figure 5: Free Span Bridge Section at Greenwood Road

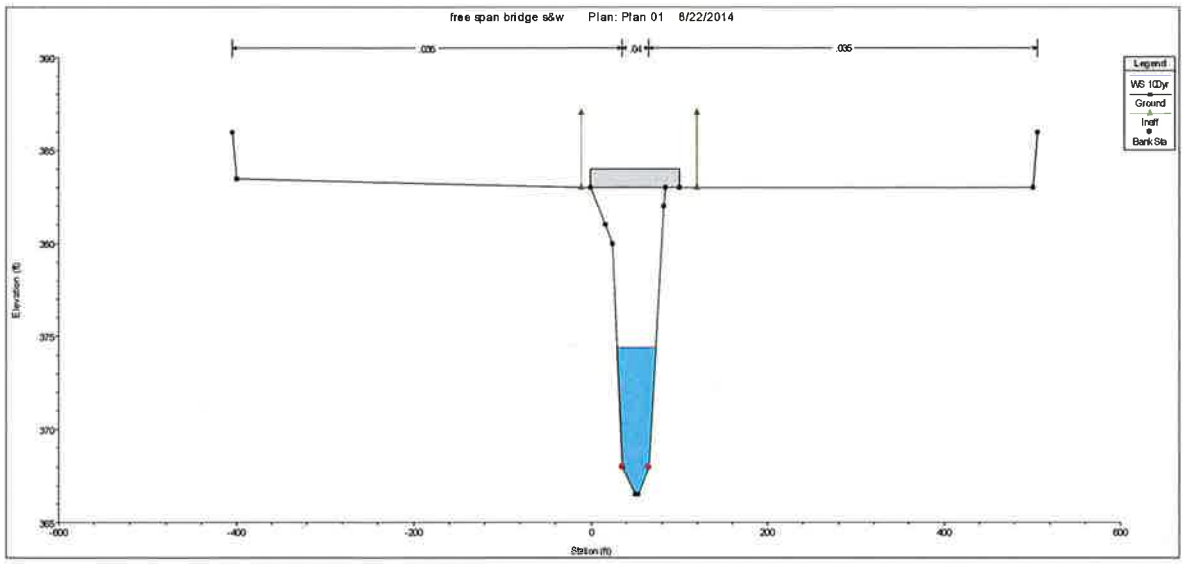


Figure 6: Greenwood Road Arch and Culvert Curves

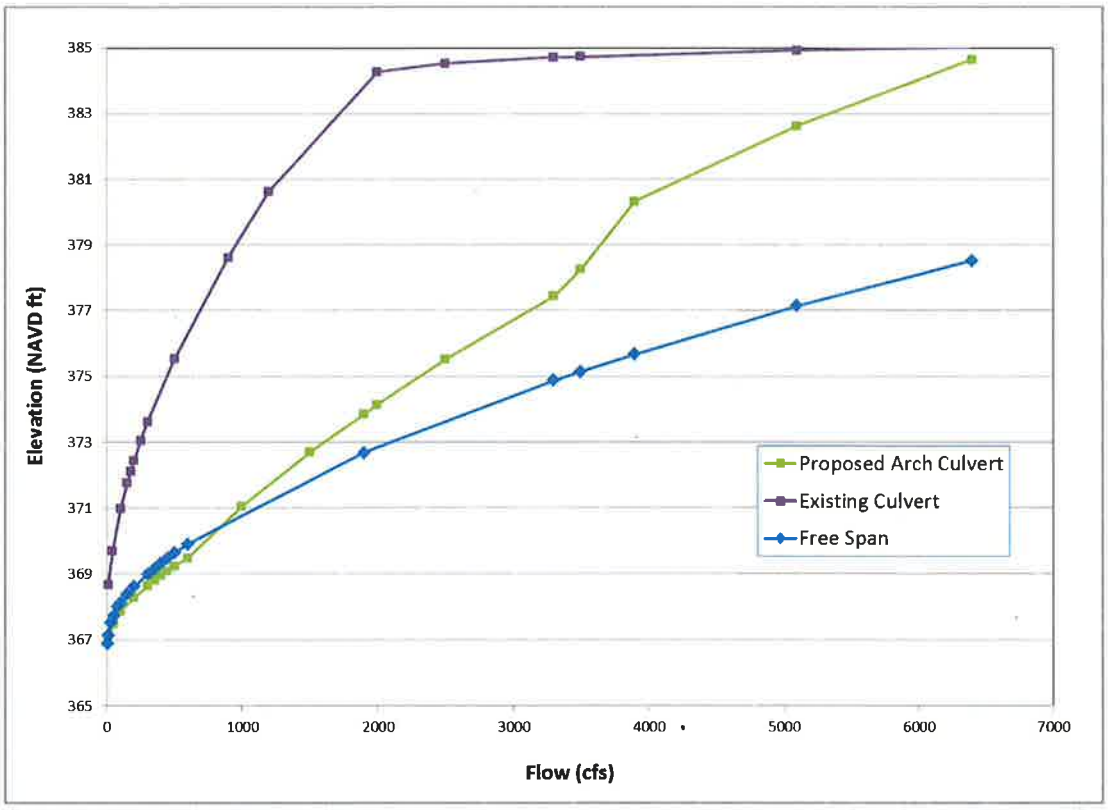


Figure 7: Greenwood Road Elevation-Area Curve

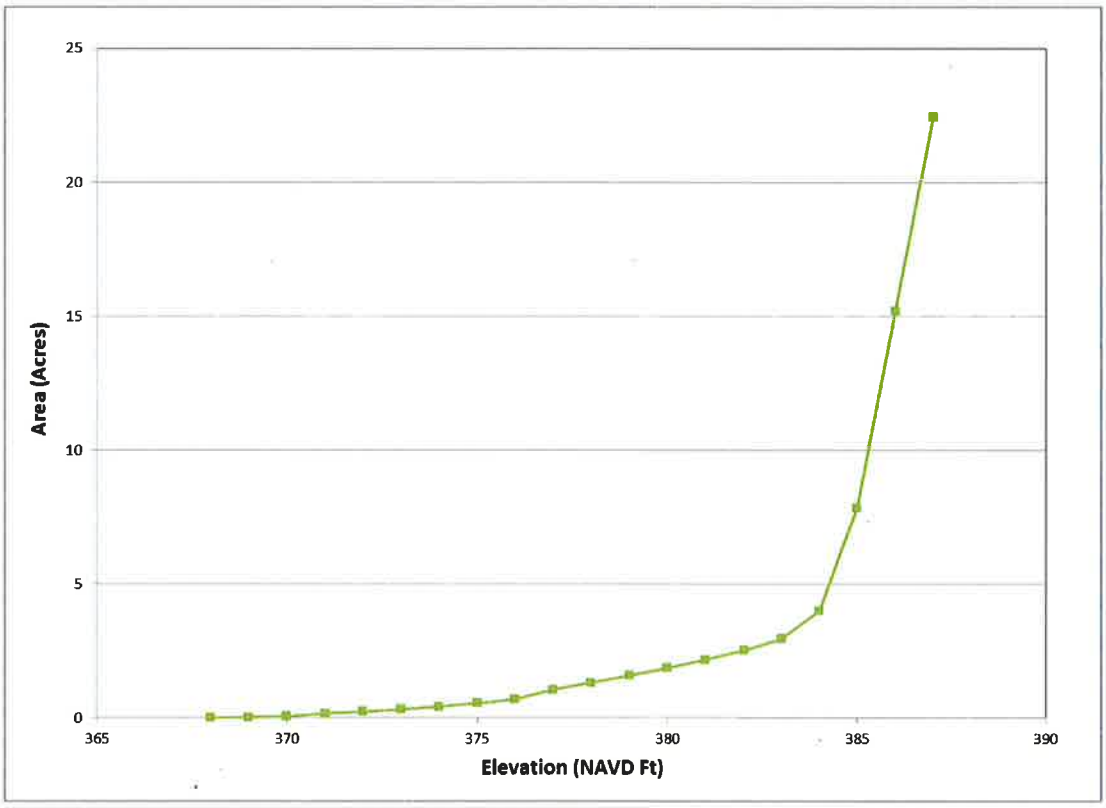
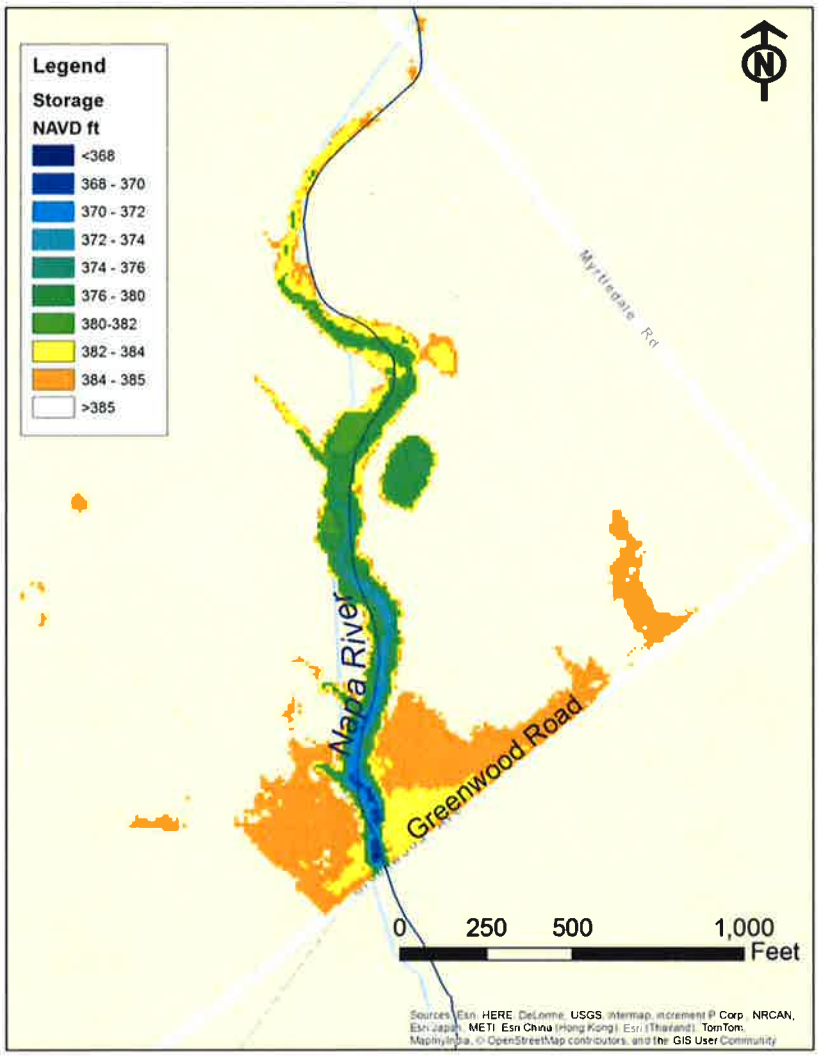

25
20
15
10
5
0
Area (Acres)
365
370
375
380
385
390
Elevation (NAVD Ft)

Figure 8: Floodplain Storage Area



Hydrologic Model Results

The HEC-HMS models show no significant impacts on downstream flows for the Frequent, 10-year and the 100-year 24-hour events. Figure 9 shows the Frequent, 10-year and 100-year hydrographs on the Napa River at the confluence with Cyrus Creek. Table 8 lists the peak discharges at key locations within the Napa River system for both the existing and proposed culvert system.

Figure 9: Napa River Flow Hydrographs at Confluence with Cyrus Creek

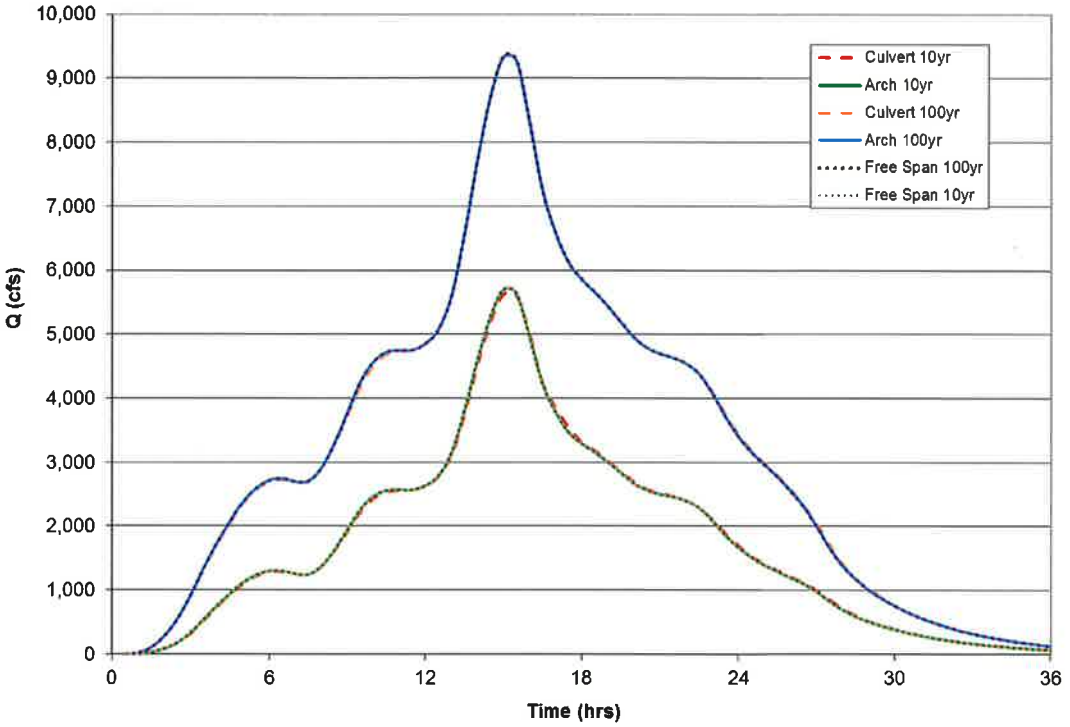


Table 8: Model Peak Discharges

Location	Existing Frequent (cfs)	Arch Culvert Frequent (cfs)	Free Span Frequent (cfs)	Existing 10-year (cfs)	Arch Culvert 10-year (cfs)	Free Span 10-year (cfs)	Existing 100-year (cfs)	Arch Culvert 100-year (cfs)	Free Span 100-year (cfs)
Napa River at Greenwood Culvert	1,120	1,120	1,220	2,380	2,320	2,310	3,540	3,520	3,520
Napa River at Blossom Creek	1,570	1,630	1,630	3,080	3,120	3,130	4,940	4,900	4,940
Napa River at Garnett Creek	2,450	2,500	2,510	4,920	4,980	4,990	8,080	8,060	8,080
Napa River at Cyrus Creek	2,870	2,870	2,870	5,630	5,700	5,700	9,350	9,330	9,350

Historic Storm Pattern Model Results

Schaaf & Wheeler also modeled the full 96-hour 1964 Laytonville Standard Project (SP) storm pattern with HEC-HMS. Rainfall depths were based on US Army Corps of Engineers reports. 38.4 inches was used for the 100-year event throughout the watershed, while 25 inches was used for the 10-year event, and 15 inches was used for the Frequent event. Constant loss rates were adjusted to calibrate the SP peak flows to the published FEMA flows. Table 9 lists the 96-hour hydrologic parameters. Proposed arch and existing culvert hydrographs are shown in Figure 10. Peak flows are shown in Table 10. Again there is no significant impact on downstream flows from the proposed arch project.

Table 9: 96-hour Rainfall and Losses

Catchment	Frequent Storm Rainfall (in)	10-year Rainfall (in)	100-year Rainfall (in)	Frequent Storm Constant Loss (in/hr)	10-year Constant Loss (in/hr)	100-year Constant Loss (in/hr)
Blossom	15	25	38.4	0.35	0.35	0.45
Cyrus	15	25	38.4	0.30	0.30	0.40
Garnett	15	25	38.4	0.31	0.31	0.42
Lower Napa	15	25	38.4	0.30	0.30	0.40
Upper Napa	15	25	38.4	0.08	0.08	0.10

Figure 10: 96-hour Napa River Flow Hydrographs at Confluence with Cyrus Creek

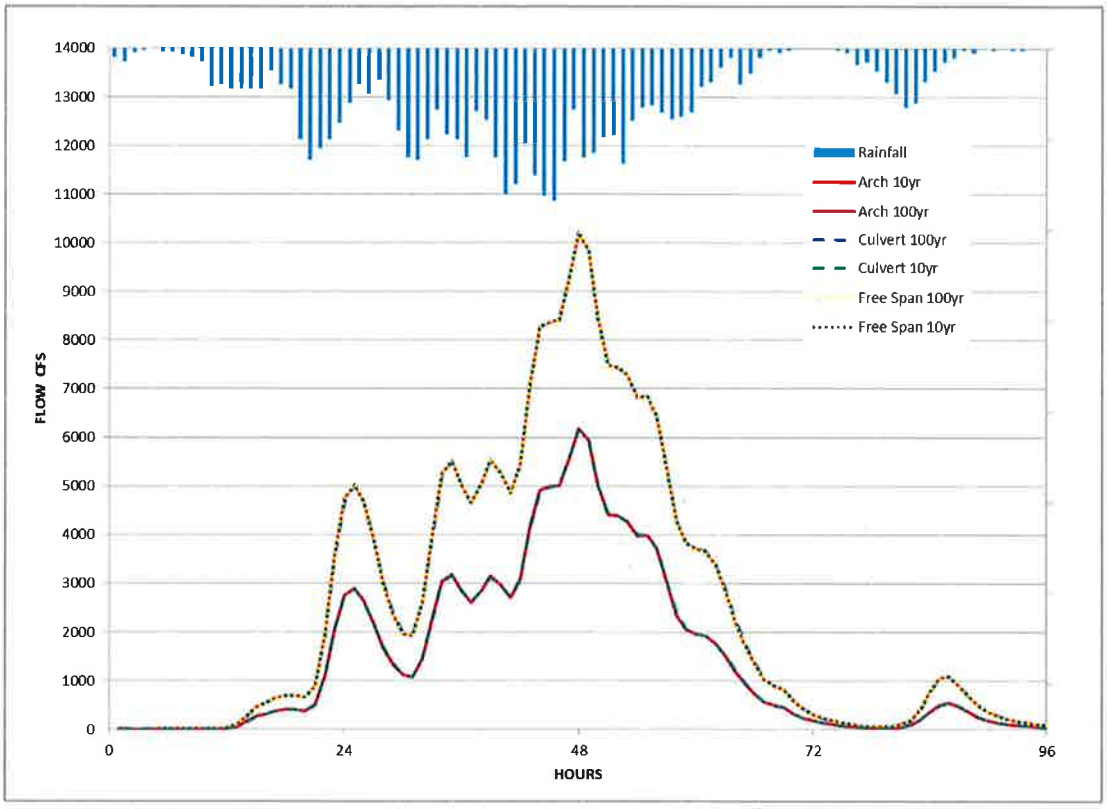


Table 10: 96-hour Model Peak Discharges

Location	Existing Frequent (cfs)	Arch Culvert Frequent (cfs)	Free Span Frequent (cfs)	Existing 10-year (cfs)	Arch Culvert 10-year (cfs)	Free Span 10-year (cfs)	Existing 100-year (cfs)	Arch Culvert 100-year (cfs)	Free Span 100-year (cfs)
Napa River at Greenwood Culvert	1,250	1,250	1,260	2,270	2,290	2,290	3,600	3,600	3,600
Napa River at Blossom Creek	1,470	1,480	1,480	3,230	3,210	3,310	5,250	5,220	5,230
Napa River at Garnett Creek	2,030	2,050	2,050	5,100	5,100	5,110	8,420	8,400	8,420
Napa River at Cyrus Creek	2,380	2,400	2,400	6,160	6,180	6,180	10,210	10,200	10,220

Hydraulic Analysis

Utilizing the 24-hour and 96-hour hydrology, Schaaf & Wheeler performed a hydraulic analysis on the Napa River using HEC-RAS. The models were developed to determine the potential downstream impacts of modifying the Greenwood Avenue crossing.

The HEC-RAS models utilize cross sections and bridge information from the HEC-2 models developed for the effective FEMA mapping performed by Nolte and Associates. HEC-RAS models of both the existing and proposed conditions for the Greenwood Avenue crossing were created. All HEC-RAS models are on the NAVD-88 datum.

The impact analysis was broken into two primary categories: a steady state analysis and an unsteady state analysis. The unsteady models account for channel attenuation while the steady state models match the FEMA methodology. Each of the analyses compares the water surface elevation (WSEL) at Berry Street as the control point. A frequent, 10-year and 100-year event were analyzed with the existing culvert and the proposed freespan bridge at Greenwood Avenue. The analysis was further subdivided to compare varying tailwater conditions (i.e. normal depth, critical depth and the FEMA WSEL) for each of the three selected return intervals. The analysis was performed for both of the 24-hour storm and 96-hour storm hydrology. The results of the hydraulic analyses are summarized in Tables 11 to 14.

Table 11: 24-Hour Steady State Hydraulic Analysis

	STEADY STATE 24 Hr Peak Discharges					
	Max WSEL at U/S face of Berry Street (NAVD)					
	Frequent Storm Event		10 Yr		100 Yr	
Tailwater Condition	Existing	Freespan	Existing	Freespan	Existing	Freespan
Normal Depth	348.09	348.23	352.89	352.89	355.99	355.79
Critical Depth	347.79	347.9	352.89	352.89	355.99	355.79
FEMA	NA	NA	352.89	352.89	355.99	355.79

Table 12: 96-Hour Steady State Hydraulic Analysis

	STEADY STATE 96 Hr Peak Discharges Max WSEL at U/S face of Berry Street (NAVD)					
	Frequent Storm Event		10 Yr		100 Yr	
Tailwater Condition	Existing	Freespan	Existing	Freespan	Existing	Freespan
Normal Depth	346.97	347.02	353.47	353.5	356.26	355.99
Critical Depth	346.76	346.81	353.48	353.5	356.26	355.99
FEMA	NA	NA	353.48	353.5	356.26	355.99

Table 13: 24-Hour Unsteady State Hydraulic Analysis

Unsteady State: 24 Hr Peak Discharges Max WSEL at U/S face of Berry Street (NAVD)					
Frequent Storm Event		10 Yr		100 Yr	
Existing	Freespan	Existing	Freespan	Existing	Freespan
348.11	348.14	352.87	352.91	355.18	355.23

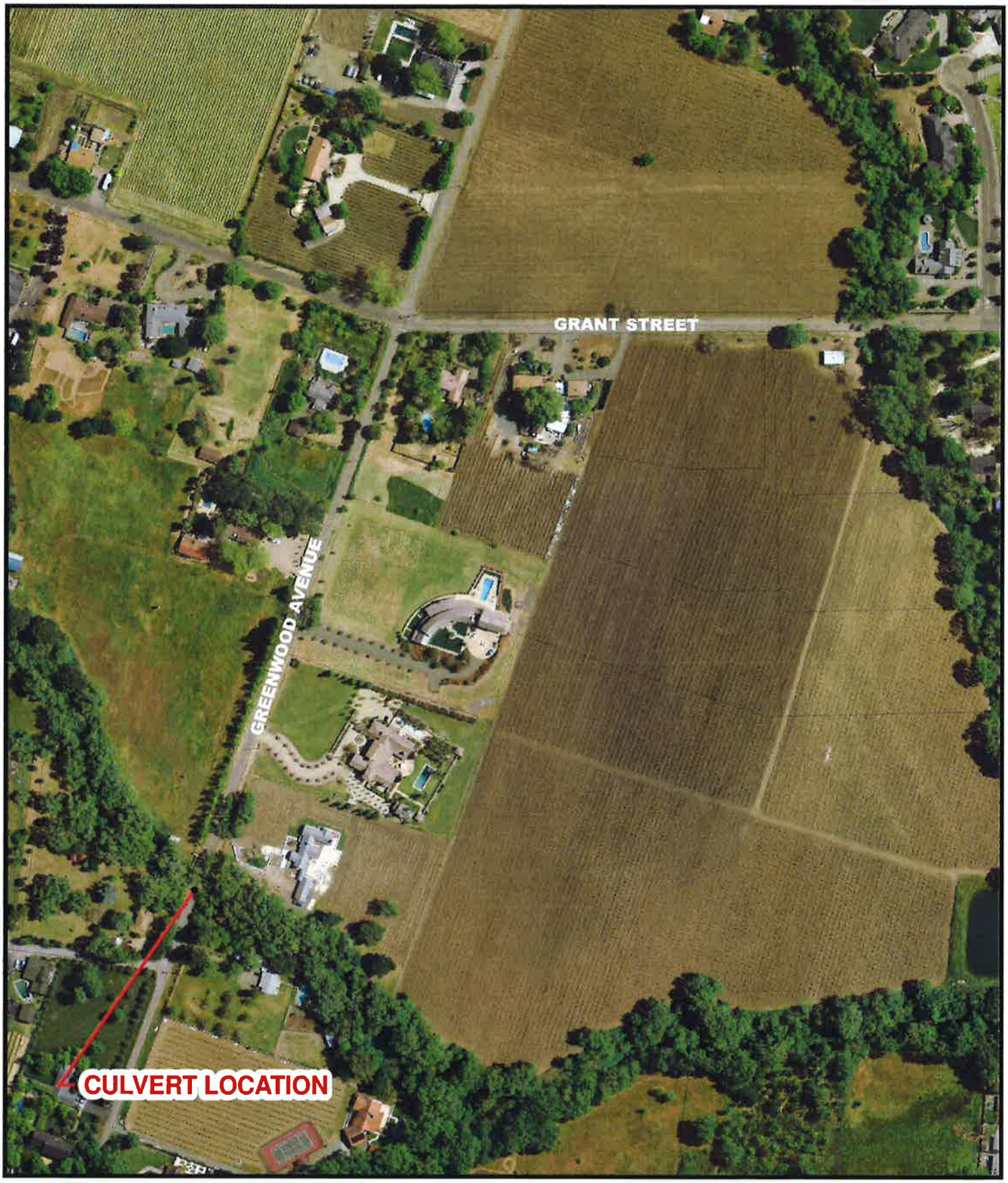
Table 14: 96-Hour Unsteady State Hydraulic Analysis

Unsteady State: 96 Hr Peak Discharges Max WSEL at U/S face of Berry Street (NAVD)					
Frequent Storm Event		10 Yr		100 Yr	
Existing	Freespan	Existing	Freespan	Existing	Freespan
347.04	347.04	353.48	353.49	355.23	355.27

Conclusion

Schaaf & Wheeler has found no significant hydrologic impacts on the Napa River from proposed projects at Greenwood Road that have a rating curve ranging between the existing culvert and a free span bridge as shown on Figure 4. The floodplain storage loss at the 100-year level is roughly 20 acre-feet. This volume is insignificant compared to the 2,600 acre-feet of runoff above Greenwood Road during a 24-hour 10-year event or the 20,000 acre-feet of runoff during the 96-hour 100-year event in the City of Calistoga.

Based on hydraulic analyses the City of Calistoga can expect slightly higher water surface elevations during the frequent storm events: however, these events are contained in channel and do not pose additional flood risks. There is no indication the proposed Greenwood Road bridge would increase flood risk in the City of Calistoga during a 100-year event.



VICINITY MAP

GREENWOOD AVENUE CULVERT AT NAPA RIVER

CITY OF CALISTOGA

2011