FINAL DESIGN HYDRAULIC STUDY

HYDROLOGY AND HYDRAULIC ANALYSIS FOR THE REPLACEMENT OF THE EL CAMINO REAL BRIDGE OVER SANTA MARGARITA CREEK

Bridge Number 49C0310

San Luis Obispo County, California

AVILA & ASSOCIATES

Final Design Hydraulic Study

SANTA MARGARITA CREEK BRIDGE ON EL CAMINO REAL

SAN LUIS OBISPO COUNTY, CALIFORNIA

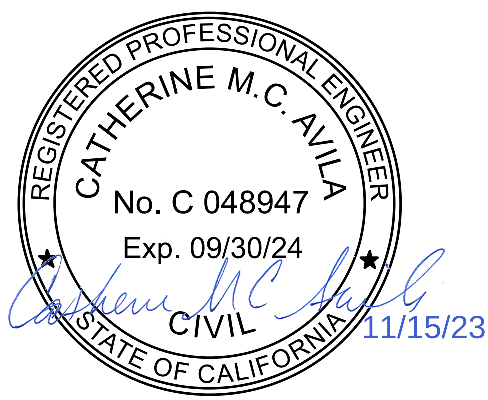
Bridge #49C0310

MAY 28, 2020

PREPARED FOR:
QUINCY ENGINEERING, INC.
AND THE SAN LUIS OBISPO COUNTY PUBLIC WORKS DEPARTMENT

Prepared by:

AVILA AND ASSOCIATES
CONSULTING ENGINEERS, INC.



Catherine M.C. Avila, P.E.

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INTRODUCTION

The Santa Margarita Creek Bridge (bridge) at El Camino Real in San Luis Obispo County, California is proposed for replacement by San Luis Obispo County. The proposed bridge will be a 3-span cast-in-place pre-stressed concrete slab bridge supported by 24-inch diameter columns founded on 48-inch diameter cast-in-drilled hole (CIDH) piles at the piers and 24-inch diameter CIDH concrete piles at the abutments. It will be 142 feet long with a full deck width of 53 feet. It will accommodate two travel lanes and a center turn lane with shoulders and bicycle lanes as shown in the attached General Plan (Appendix A). The bridge is located approximately 2.5 miles north of Santa Margarita, CA. shown in Figure 1.

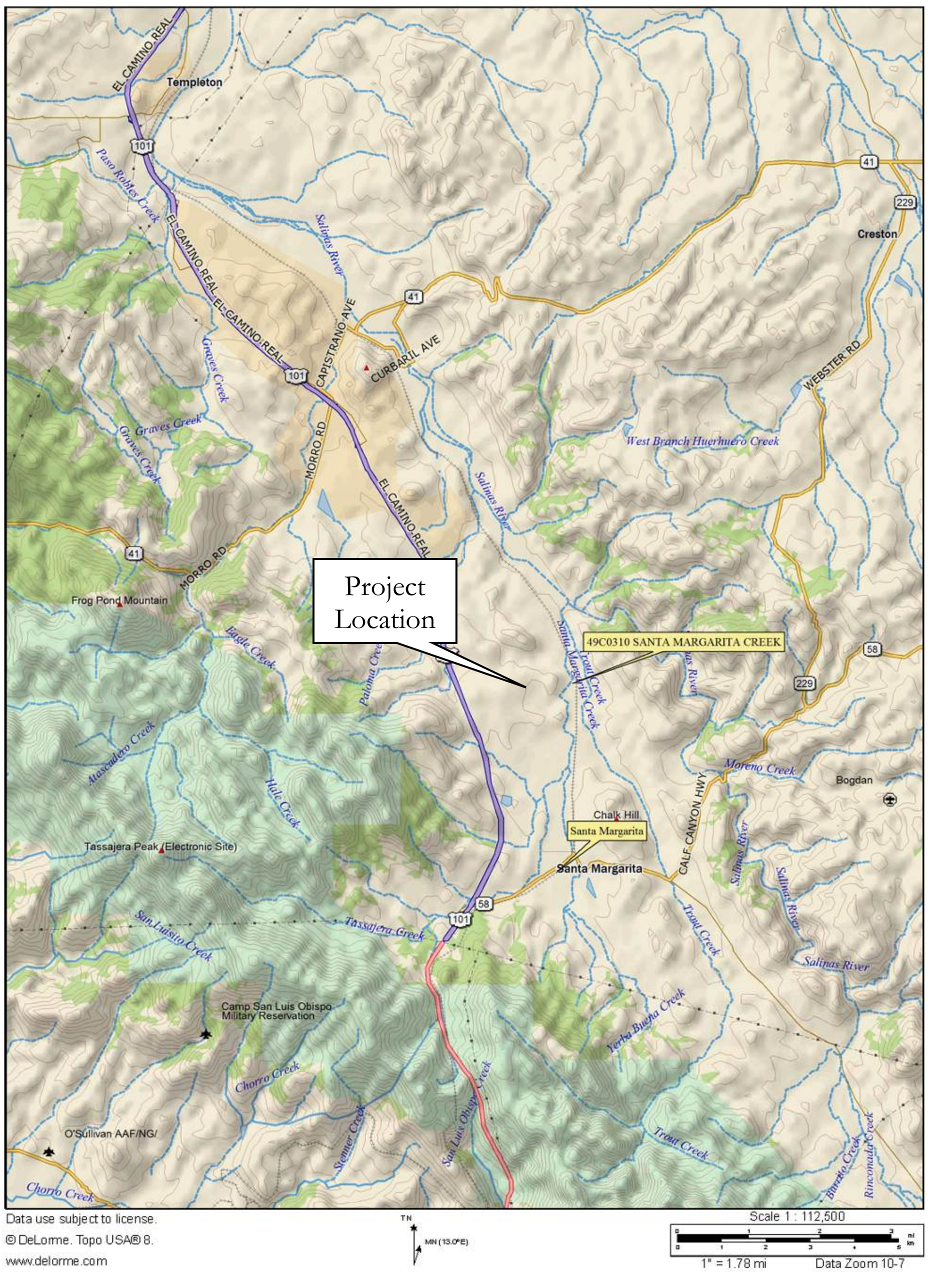


Figure 1. Project Location Map (from Topo usa)

Santa Margarita Creek flows easterly through the central part of the San Luis Obispo County (County) and drains an approximate 22.4 square mile basin at the bridge. The discharges used for the bridge hydraulic analysis are shown in Table 1.

Table 1: Estimated discharges and water surface elevations for bridge design

		Design	Base	Flood of Record
Frequency (Years)	10	50	100	<50
Discharge (Cubic feet per second)	3,450	7,850	9,435	7,332
Water Surface (Elevation at u/s face of Bridge) (ft)	927.1	931.7	932.9	931.3

Hydraulic modeling utilizing a HEC-RAS[1] model was used to estimate the water surface elevation (WSE) for the existing and proposed bridge. Model results indicated that the water surface elevation for the upstream face of the proposed bridge will be slightly less than for the existing bridge. This is due to the fact that the existing bridge has four in-stream piers, while the proposed bridge has only two piers. In addition, the minimum soffit elevation of the existing bridge is approximately 932.8 feet while the proposed bridge will be approximately 1.1 feet higher, at 933.9 feet. The datum elevation used for this study is NAVD88[2].

This memo presents the results of the hydraulic analysis for the replacement of the existing El Camino Real Bridge over Santa Margarita Creek (Br #49C0310). This report follows the Caltrans Final Hydraulic Report Format and has been prepared in accordance with the Caltrans Local Assistance Program Guidelines (Caltrans, 2018) and Memos to Designers 16-1 (Caltrans, 2017).

[1] US Army Corps of Engineers Hydraulic Engineering Center (HEC) River Analysis System (RAS), a backwater hydraulic model designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels.

[2] Electronic Mail from Erin McPherson, QEI, to Cathy Avila, Project Manager, Avila and Associates, on February 7, 2014.

GENERAL

This design hydraulic study has been prepared for the sole purpose of meeting the requirements of the Caltrans "Local Assistance Program Guidelines." Although potentially useful for other purposes, this analysis has not been prepared for any other purpose. Reuse of information contained in this report for purposes other than for which Avila and Associates Consulting Engineers, Inc. (Avila and Associates) intended and without their written authorization is not endorsed or encouraged and is at the sole risk of the entity reusing the information.

Avila and Associates was retained to complete the bridge hydrology, hydraulics, and scour analysis for the bridge. The following scope of work has been completed to develop this report.

1. Obtain backup information and field review
2. Estimate Hydrology
3. Create HEC-RAS model
4. Prepare Draft Report for comment
5. Prepare Final Report
6. Complete Location Hydraulic Study

The proposed design for a replacement Santa Margarita Creek bridge in San Luis Obispo County is shown in Figure 1. The existing bridge was constructed in 1930; it is a 5-span bridge that is approximately 82 feet long. In 2010, the sufficiency rating was 47.9 and the bridge was Structurally Deficient (7). The San Luis Obispo County Public Works Department proposes using Highway Bridge Program (HBP) funding to replace the existing bridge with a new bridge. The proposed bridge will be a 3-span reinforced concrete slab bridge as shown in Figure 1 and in the attached General Plan (Appendix A).

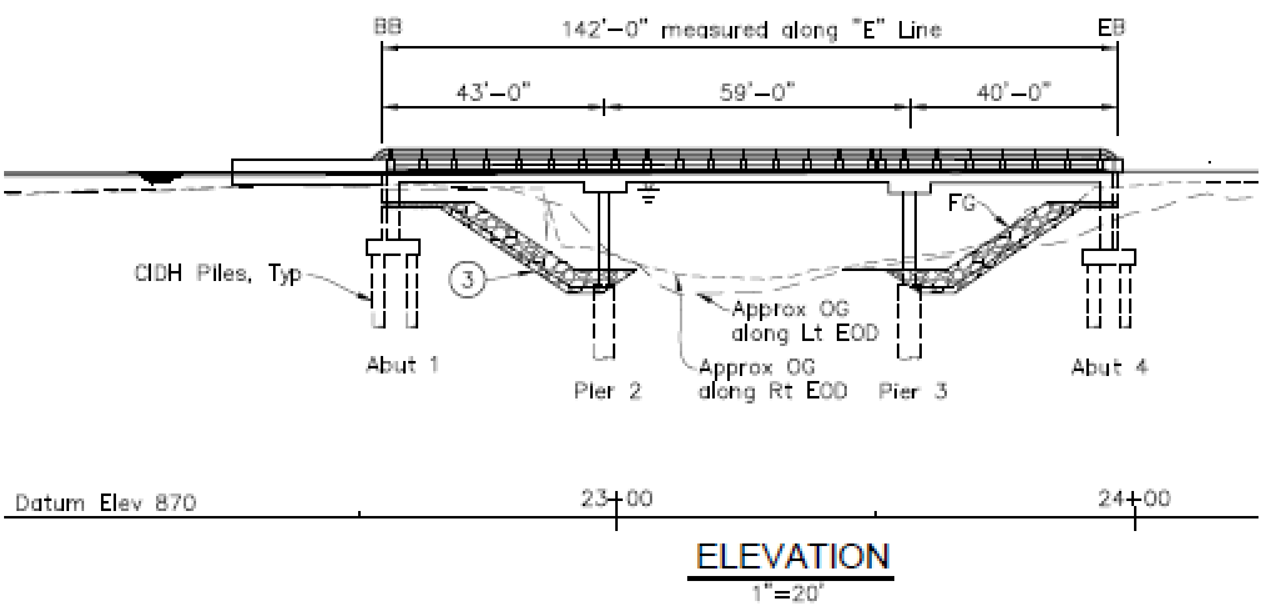


Figure 1: Proposed bridge profile view

BRIDGE HISTORY

Avila and Associates reviewed relevant bridge maintenance records for the existing bridge (San Luis Obispo, 2014) to discern the typical impacts. The relevant information is summarized in *Table 2*.

Table 2: Bridge information from maintenance records.

	El Camino Real at Santa Margarita Creek
Bridge Number	49C0310
Bridge Length (ft)	81
Span Lengths (ft)	5 @ 16
Bridge Type	RC deck with AC overlay on rolled steel beams (12) on RC seat abutments
Debris Challenges	1985[3]
Cross Sections Available for	1977, 1993, 2006, 2014
NBIS Item 113 (scour) code	U
ELI Flag 361 Condition State	2
Pier Type	Riveted steel column (3) bents with rolled steel caps on spread footings
Year Built	1930
Year Widened	1937
Scour Challenges	1987[4], 1989[5], 1993[6], 2004[7], 2006[8], 2008[9], 2010[10]

[3] The exterior web of Column 1 at Bent 2 has been damaged by floating debris.
[4] Abutment 1 is being undermined at the center and there is erosion down to the midpoint of the footing of Pier 2.
[5] There is scour around Pier 3 footing on the right side.
[6] Channel section taken indicates 2-3 ft of bed scoured since reference section taken in 1977. Footings are exposed at Bents 2, 3, and 4.
[7] A type A underwater inspection was conducted. Mild localized scour was observed along Bent 3 and Bent 4.
[8] Same as 2004.
[9] Same as 2006.
[10] The footings are exposed full length with undercutting at Bent 3 approximately 0.3 m and undercutting at Bent 4 to 0.8 m . Abutment 6 exhibits approximately 0.3-1.0 m of exposed footing.

BASIN AND DISCHARGE

Hydrology

The purpose of this hydrologic analysis is to determine the design and base discharges (50-yr and 100-yr) to be used in the hydraulic analysis of Santa Margarita Creek for the replacement of the El Camino Real Bridge, per Chapter 11 of the Local Assistance Procedures Manual (LAPM). Three methods were considered for the design discharges for Santa Margarita Creek and are shown in Figure 2, specifically:

- FEMA discharges (HEC-1)
- Regional Regression calculation per Caltrans Highway Design Manual (HDM)
- Statistical Gage Analysis – nearby USGS gages (USGS Bulletin 17B).

Figure 2 is reduced from a more detailed analysis, which includes the confidence limits for the statistical gage analysis[11] shown in Figure 3. The orange curve in Figure 3 represents the results of the statistical analysis of gage data recorded at a USGS gage on nearby Santa Rita Creek that has been transferred to the project site through a basin transfer[12]. The orange dashed lines represent the confidence limits for the project frequency curve. The red line represents the results of the regional regression calculation for the project. The green dots represent the 50-yr and 100-yr discharges used in the Flood Insurance Study (FIS) for Santa Margarita Creek.

[11] Details of the statistical gage analysis for Santa Rita Creek are shown in the Appendix.

[12] A basin transfer is the process of applying the results from a statistical analysis of a gaged watershed to a geophysiographically similar ungaged watershed. The flows for the ungaged watershed are computed by multiplying the gaged flows by the ratio of the ungaged watershed area to the gaged watershed area raised to the power of the drainage area exponent used in the regression equation (Qu=Qg*(Au/Ag)^b).

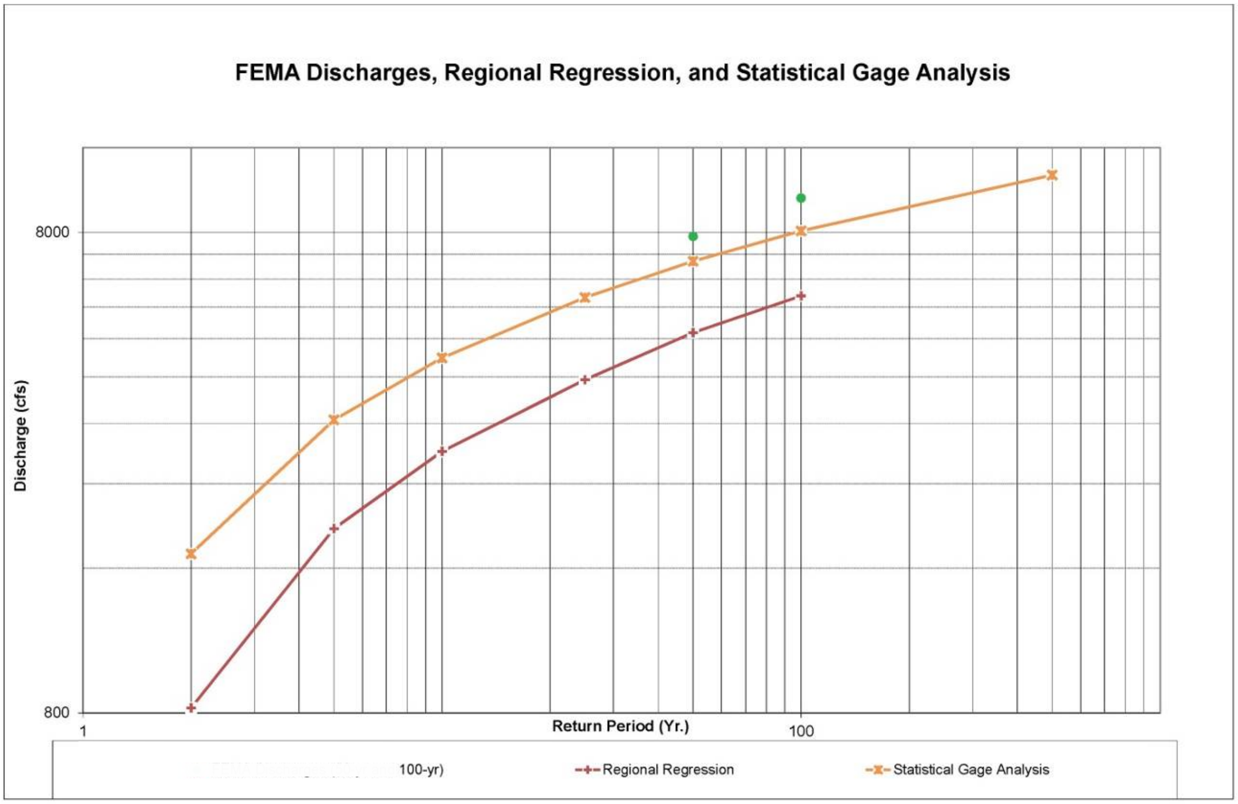


Figure 2: Graphical Hydrology Comparison Results

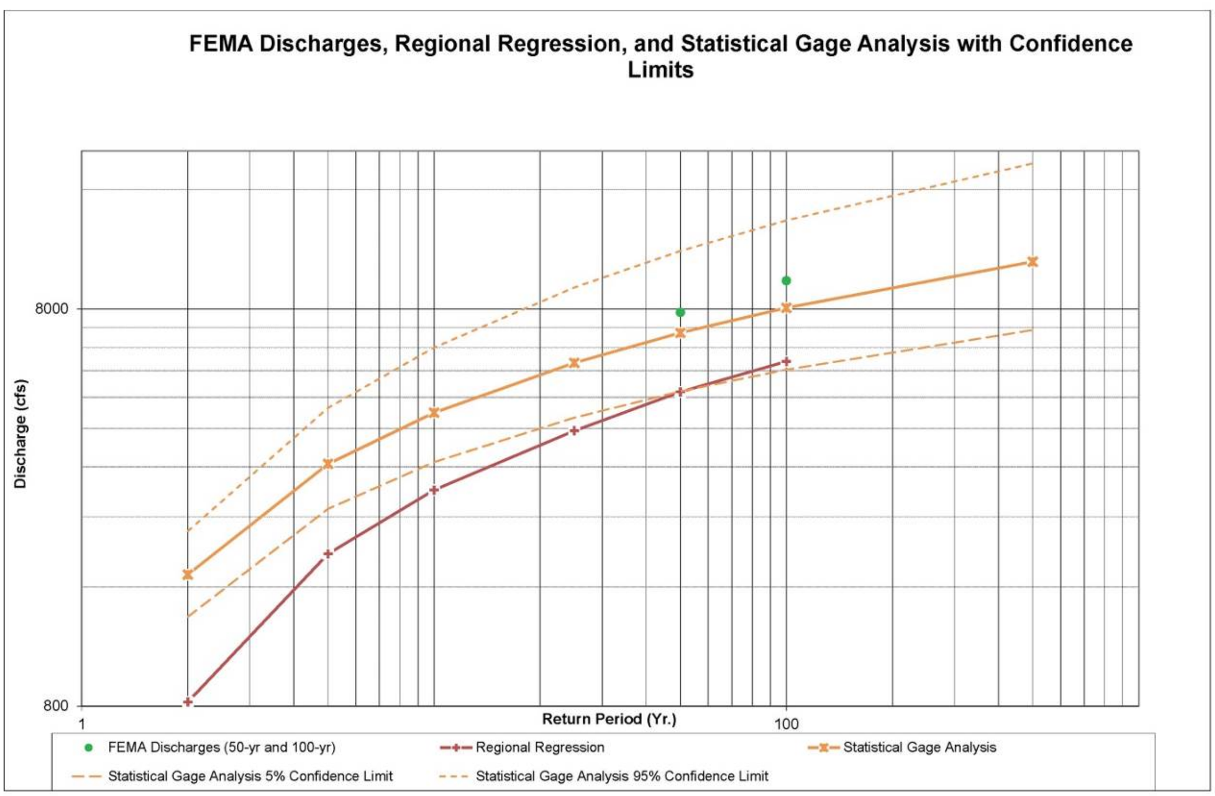


Figure 3: Graphical Hydrology Analyses Results

Regional Regression results (red line), as can be seen in Figure 3, lie almost completely outside the confidence limits of the project frequency curve. For this reason, the results are considered a significant underestimation of the frequency curve for the project and were not considered for the design discharges.

While the **Statistical Gage Analysis** frequency curve of the Santa Rita Creek fits the observed flows well, it appears that it may underestimate the flows for higher return events, because two of the three highest recorded flows are above the computed curve (see Appendix B). In addition to this, there are several differences between the characteristics of the Santa Rita Creek watershed and project watershed, which could cause the Santa Rita Creek frequency curve to underestimate the project. A comparison of key watershed characteristics can be found in the appendix of this summary. However, although likely somewhat underestimated, when the basin transfer is applied to this project flow (orange line), this frequency curve corroborates the FEMA discharges well.

FEMA 50-yr and 100-yr discharges taken from the Flood Insurance Study (FIS) for Santa Margarita Creek (green dots) lie above the project frequency curve (orange line), but are well within the project confidence limits (dashed orange).

This hydrology comparison indicates that the FEMA and Gage Analysis (with basin transfer) validate one another. Since the statistical gage analysis likely underestimates the discharge and the FEMA discharges are within the confidence limits, the FEMA discharges are likely to provide the best estimates of the discharge values without overestimating the discharges. Therefore, the FEMA discharges will be used for the hydraulic analysis of Santa Margarita Creek for the replacement of the El Camino Real Bridge. The following tables summarize the discharges for the hydrology methods considered.

Table 3: Discharges considered for design

Method	**Discharge (cfs)**	
	Recurrence Interval	
	50-year	**100-year**
FEMA (HEC-1)	7,850	9,435
Gage Analysis (USGS 17B)	7,000	8,100
Regional Regression (HDM)	4,947	5,901

Table 4: Discharges used for design

		Design	**Base**
Frequency (Years)	10	50	100
Discharge (Cubic feet per second)	3,450	7,850	9,435

HYDRAULICS

Hydraulic parameters (water surface elevations and velocity) were obtained from the U.S. Army Corps of Engineers HEC-RAS (Hydraulic Engineering Center River Analysis System) version 4.1.0 model, based on: 1) survey information supplied by QEI on February 7, 2014, and 2) as-built data provided by QEI. Cross-sections surveyed for the HEC-RAS model are shown on Figure 4:

Figure 4: Plan view of HEC-RAS cross section

Existing Conditions Model

The Manning's n values of 0.035 for the channel and overbanks at 0.04 were used in the model. These are consistent with the field reviews by Avila and Associates as shown in Figure 5.

Figure 5: Looking upstream from the bridge. The channel is sparsely vegetated with low manning "n" values

The existing bridge was input into the model as a 5-span bridge with a minimum soffit elevation of 932.8 as shown in Figure 6.

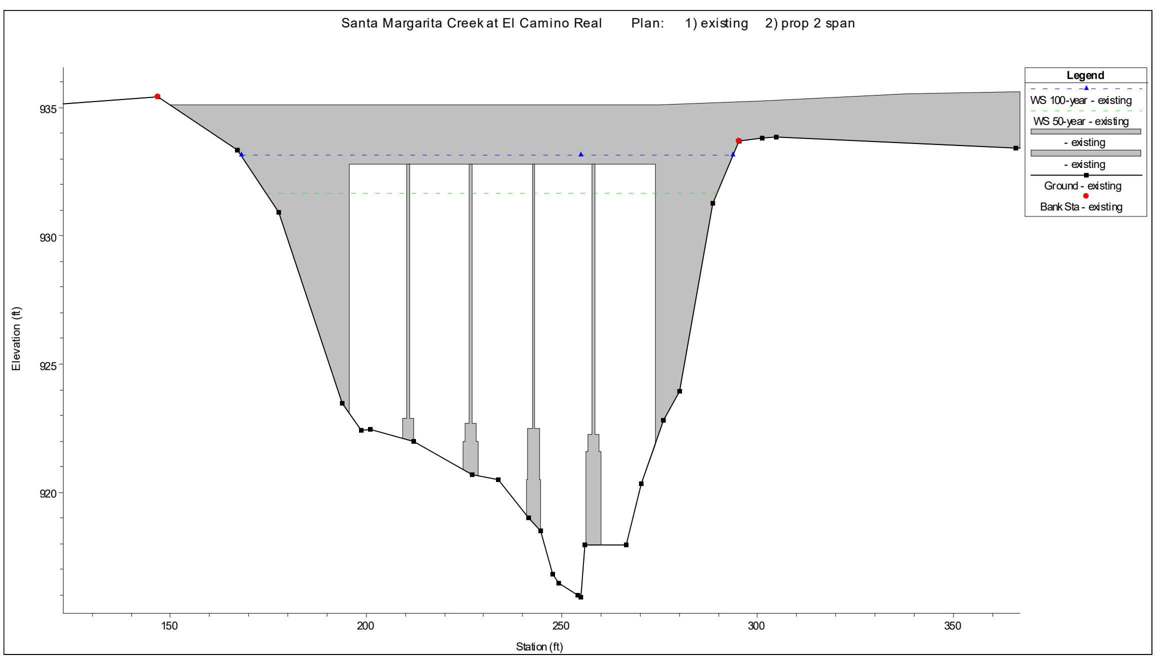


Figure 6: HEC-RAS cross section for the upstream existing conditions for the 50- 100-year Q's

Proposed Conditions Model

The hydraulic analysis for the three alternatives originally proposed are included in Appendix C and HEC-RAS results in Appendix D. The downstream "bridge" carries a water pipe as shown in Figure 7. This backwater caused by the downstream structure is drowning out the incremental impacts of the various bridge options making the hydraulics of the various bridge options look very similar. The downstream water pipe bridge will be moved to the proposed bridge.

Figure 7: Downstream pipe bridge

The hydraulic analysis for the three alternatives originally proposed are included in Appendix C. The preferred alternative, a three-span bridge with 2-foot-wide piers is presented below. The HEC-RAS model was re-run by replacing the existing bridge in the model with the proposed 142-ft long bridge as shown in Figure 8

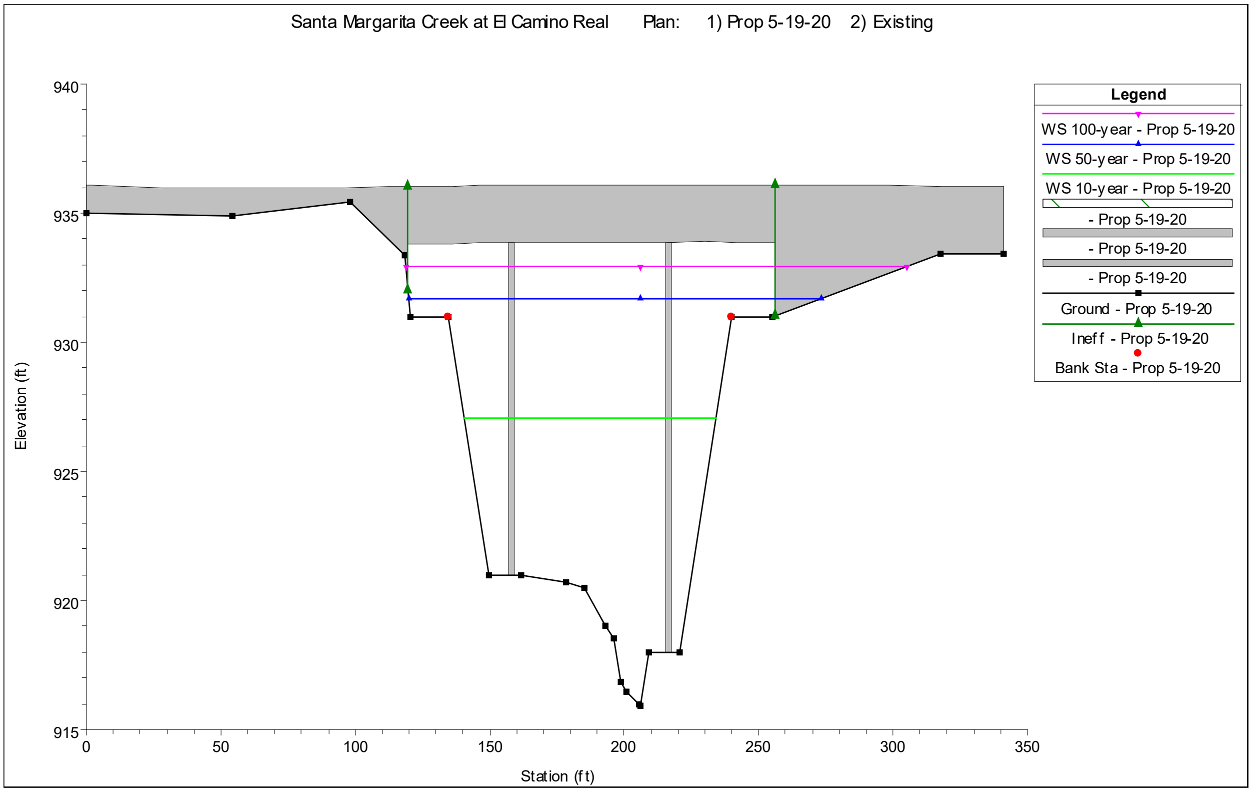


Figure 8: Proposed 142 ft, 3-span Bridge

The proposed bridge was input into the HEC-RAS model to determine the impact to the water surface elevation and velocity. As shown in Figure 9 and Figure 10 the proposed bridge reduced the 10-year, 50-year and 100-year water surface elevations.

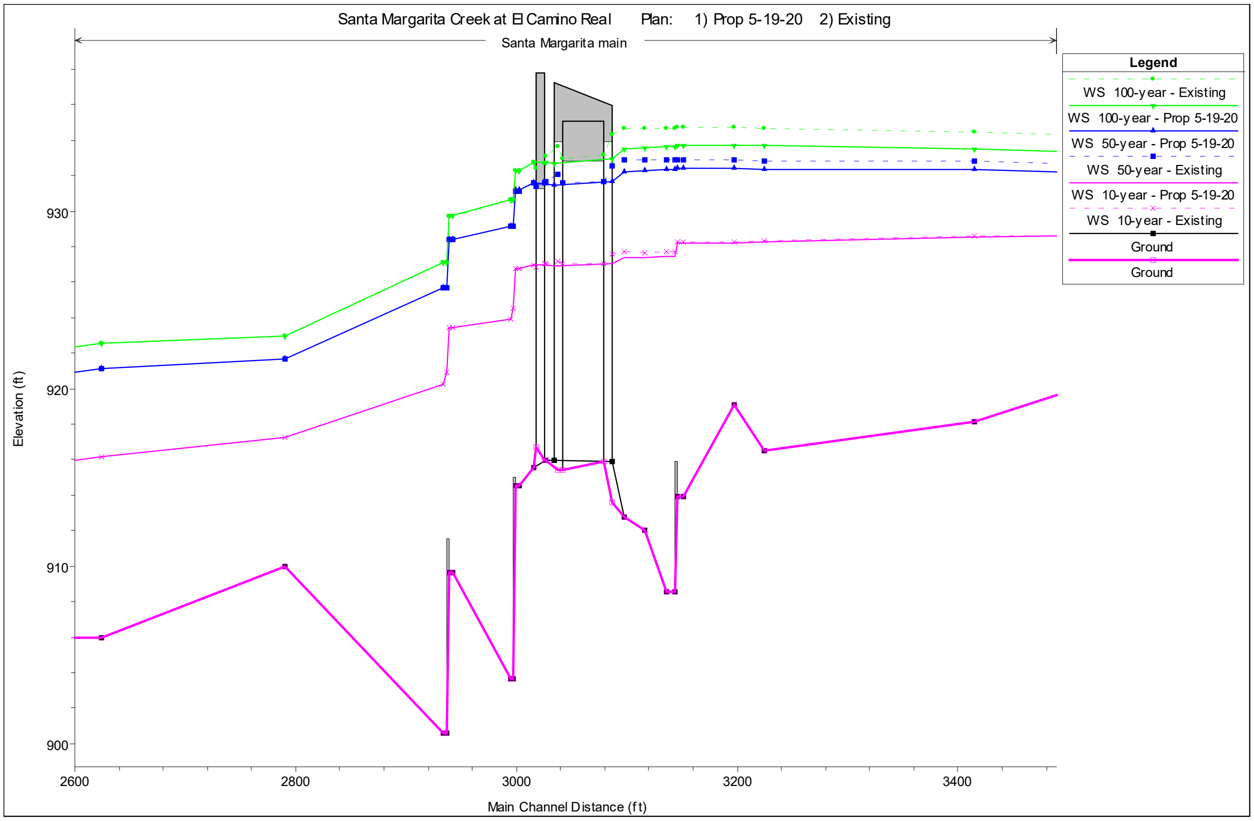


Figure 9: Water surface elevation comparing Existing vs. Proposed

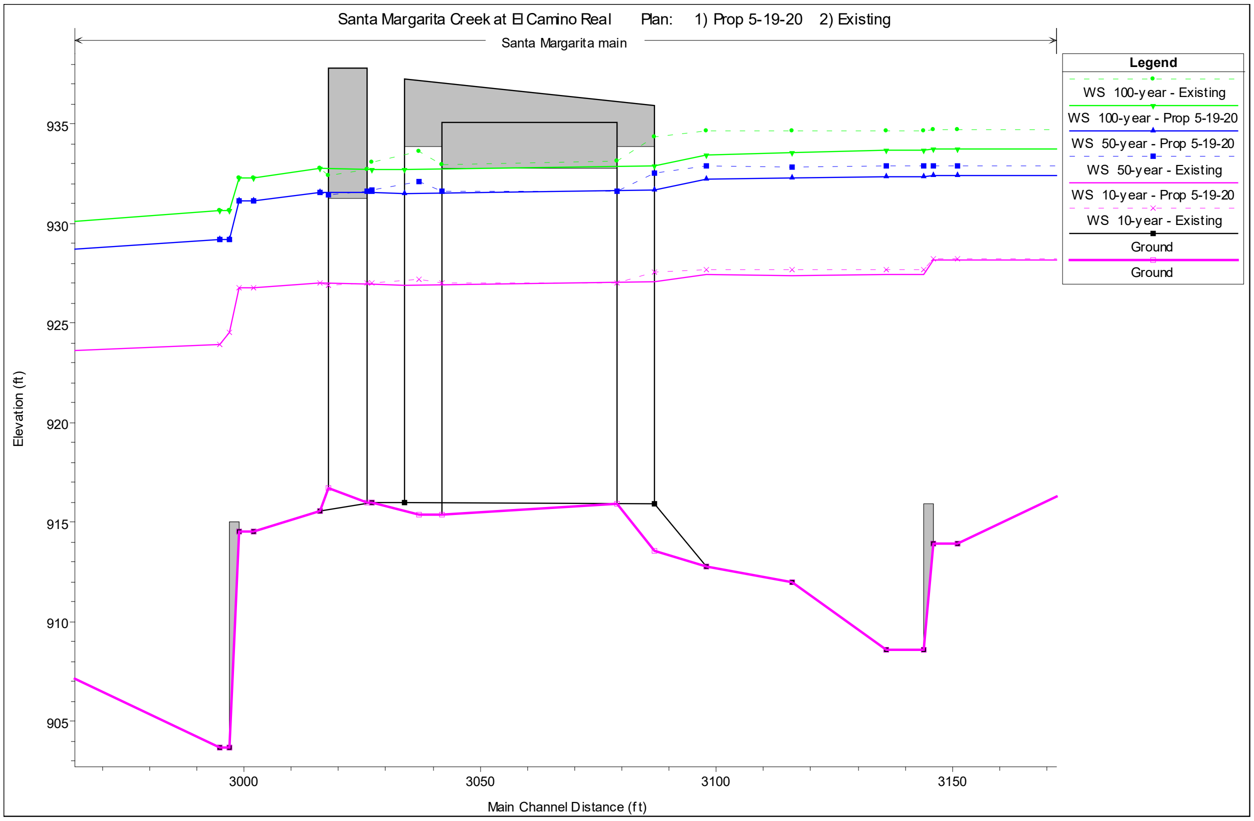


Figure 10: Close up of Figure 9

Chapter 820 of the Caltrans Highway Design Manual (HDM) delineates the hydraulic design criteria for bridges (Caltrans, 2010). The basic HDM rule for hydraulic design is that bridges should be designed to pass the Q_{50} with sufficient freeboard and convey the Q_{100} without freeboard. Although the HDM notes that two feet of freeboard is often assumed for preliminary bridge designs, the freeboard recommendation at each individual bridge is left to the judgment of the hydraulic engineer. The actual amount of freeboard needed can be recommended on a case-by-case basis and is primarily dependent upon the anticipated debris that will need to pass under the bridge.

Avila and Associates researched the available bridge maintenance records for the existing bridge to determine whether floating debris catches on the bridges. Based upon the review of the records, drift potential is low with only one notation of debris capture back in 1985 in the Caltrans Bridge Maintenance reports for the existing bridge during biennial inspections (see Table 2).

The proposed bridge will improve the hydraulics and decrease further the probability of debris capture by:

a) Removing two piers from the channel,

b) Increasing the horizontal driftway from the current 16-ft to 59-ft for the main span and 43-ft for the end-spans

c) Increasing the freeboard for the 50-year discharge from 1.1-ft to 2.2-ft. The 100-year discharge freeboard will increase from -0.4-ft under existing conditions to 1.0-ft.

The 0.7-ft to 2.2-ft of freeboard shown in *Table 5* is sufficient freeboard to pass the drift anticipated at the bridge for the base flow.

Table 5: Freeboard for preferred alternative Cast in Place Concrete Option[13]

Bridge Alternatives	Minimum soffit elevation (ft)	50-year WSE at the upstream face of the bridge (ft)	100-year WSE at the upstream face of the bridge (ft)	50-year freeboard (ft)	100-year freeboard (ft)
Existing	932.8	931.7	933.2	1.1	-0.4
142-ft 3 span	933.9	931.7	932.9	2.2	1.0

SCOUR

The Santa Margarita Creek Bridge was determined to have unknown foundations due to a lack of as-built plans. This structure was once an old State highway but was relinquished to the County of San Luis Obispo in 1957. According to the Inspection Reports (San Luis Obispo County, 2014), the Pier 2, 3 and 4 footings have been exposed dating back to 1987. There has been no undermining of the footings reported. A scour plan of action (POA) is available on file dated August 18, 2010. According to the POA, scour countermeasures were installed at pier 3 following the 1995 storms. The POA recommends a scour analysis or geotechnical study for detailed POA.

Pier Scour

The Colorado State University Equation (CSU) are empirical equations based on laboratory flume studies which utilized sand for estimating local pier scour (Richardson, 2001). Therefore, they are unlikely to be applicable at this location because geotechnical considerations will likely control the scour estimates. Theoretical scour equations for the proposed 2-foot-wide piers assuming no hydraulic skew would produce 5 feet of local pier scour. If the 4-foot portion of the CIDH pier is exposed due to degradation, this theoretical scour increases to 8 feet. Kleinfelder, however, estimated the local pier scour to be a conservative 2 feet based upon the erodibility of the underlying sandstone formation regardless of the pier size. See Appendix G, Kleinfelder memo.

Contraction Scour

The bridge does not significantly constrict the channel therefore contraction scour is expected to be negligible.

Degradation Scour

Avila and Associates reviewed the available channel cross-sections between 1977 and the most recent cross section 2014. The thalweg has lowered approximately 5 feet between 1977 and 2006 with some aggradation between 2006 and 2014 as shown in Figure 11. This aggradation was likely due to the installation of a grade control structure at the existing bridge as shown in Figure 11.

[13] Freeboard for each alternative is based on the Cast in Place deck type. Precast deck type for each alternative will result in 0.17-ft less freeboard.

Figure 11: Concrete check dam downstream of the existing bridge (photo looking upstream)

According to Dave Pearson with Kleinfelder, the downstream cemented shale bed could easily erode approximately 15 feet which would headcut through the bridge during the anticipated 75-year life of the proposed bridge[14].

[14] Telephone conversation between Dave Pearson, Project geotechnical engineer, Kleinfelder and Cathy Avila, project manager, Avila and Associates on September 22, 2014.

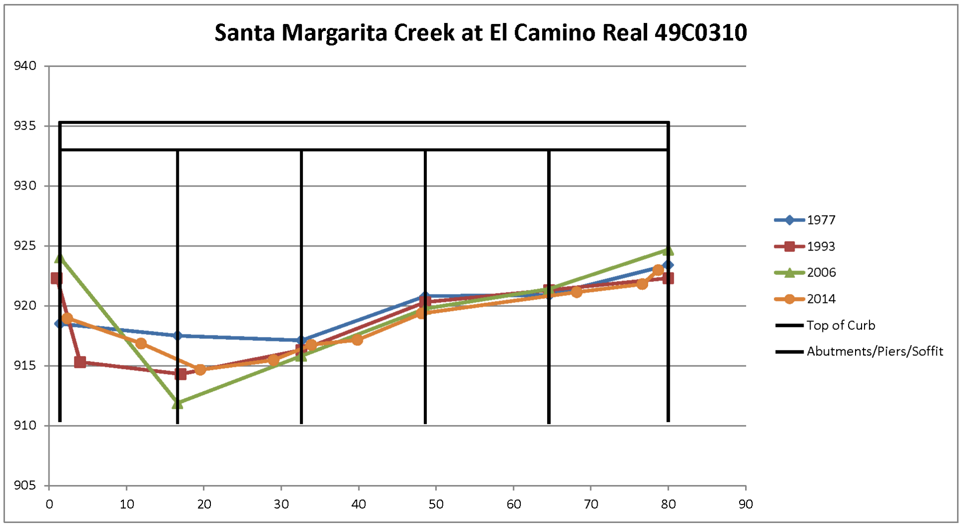


Figure 12: Cross sections taken at the bridge over time (from Caltrans Maintenance Reports)

Abutment Design

In conformance with Caltrans LRFD Specification 2.6.4.4.2, it is recommended that the abutments should be checked for stability to the top of erosion resistant material noted as Santa Margarita Formation (Sandstone) elevation of 921 at Abutment 1 and 919-feet at Abutment 4[15].

Scour depths are outlined in *Table 6*.

Table 6: Scour depths and elevations with geotechnical considerations.

	Pier	Abutment 1	Abutment 4
Degradation (ft)	~15	n/a	n/a
Pier Scour (y_s) (ft)	2	n/a	n/a
Degradation Elevation (per Kleinfelder)	903	n/a	n/a
Total Scour Elevation	901	921	919

ROCK SLOPE PROTECTION

The California Highway Design Manual Methodology (Caltrans, 2016) which is based on HEC-23 guidelines (Lagasse et al, 2012) for bank Rock Slope Protection (RSP) were used. Based on these calculations type 8 fabric is needed overlaid by a 3-foot-thick layer of Class V (1/4 Ton) Method B should be used as shown in Figure 12. The HEC-23 RSP Classes are well graded and do not require a layer of smaller RSP between the filter fabric and the Class V RSP. However, an additional layer of Class I RSP will have no adverse impact on the project. The RSP should be toed down at least 3 feet below the existing thalweg elevation or to the depth of scour resistant material as shown in Figure 13. See Appendix F for rock slope protection calculations.

Note the RSP proposed at the bridge is to protect the embankment fill and not the bridge itself.

[15] Telephone conversation between Dave Pearson, Project geotechnical engineer, Kleinfelder and Cathy Avila, project manager, Avila and Associates on April 3, 2015.

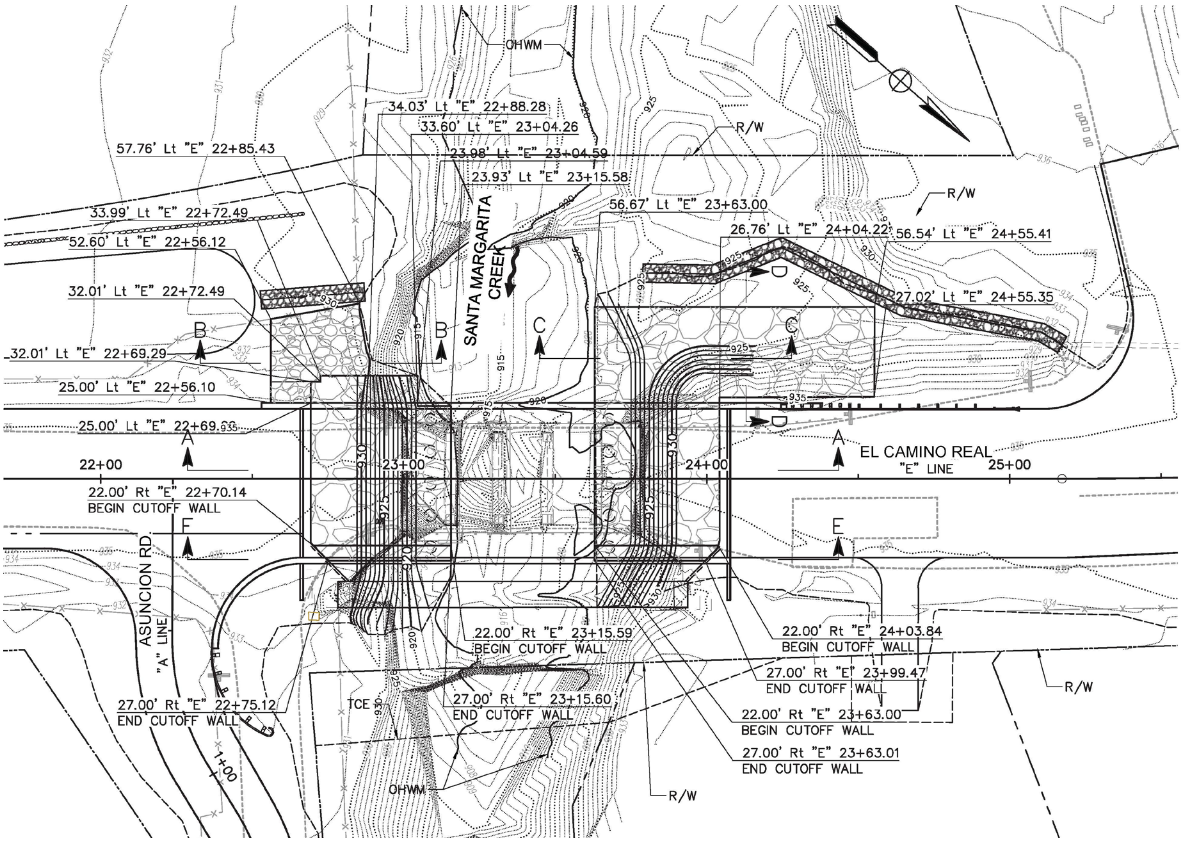


Figure 13: RSP and Contour Grading

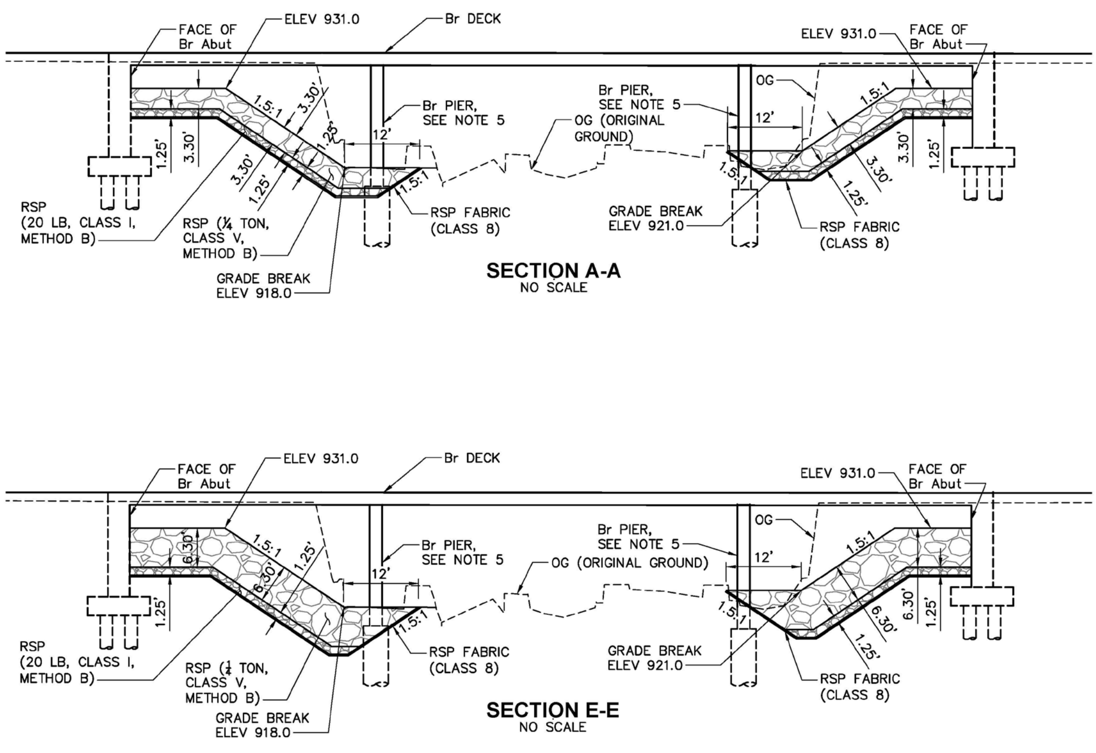


Figure 14: Sections showing RSP under the bridge

SUMMARY TABLES

The following Hydrologic Summary Table is provided for your use for placement on the Foundation Plan:

Drainage Area: 22.4 Square miles

	Design	**Base**	**Flood of Record**
Frequency (Years)	50	100	<50
Discharge (Cubic feet per second)	7,850	9,435	7,332
Water Surface (Elevation at u/s face of Bridge)	931.7	932.9	931.3

Flood plain data are based upon information available when the plans were prepared and are shown to meet Federal requirements. The accuracy of said information is not warranted by the County and interested or affected parties should make their own investigation.

The Scour Table is provided for your use for placement on the Foundation Plan:

Scour Data Table:

Support No.	Long Term (Degradation and Contraction) Scour depth (ft)	Short Term (Local) Scour Depth (or elevation) (ft)
Abut 1	15	n/a (921*)
Pier 2	15	2
Pier 3	15	2
Abut 4	15	n/a (919*)

* Scour Elevation with Geotechnical Considerations

The Floodplain Evaluation Report as outlined in 23 CFR 650 Subpart A, Section 650.111(b)(c)(d) is included in Appendices H and I.

This report has been prepared for the sole purpose of analyzing bridge design alternatives. Although potentially useful for other purposes, this analysis has not been prepared for any other purpose. Reuse of information contained in this report for purposes other than for which Avila and Associates Consulting Engineers, Inc. (Avila and Associates) intended and without their written authorization is not endorsed or encouraged and is at the sole risk of the entity reusing the information.

REFERENCES

1. Arneson, L.A., Zevenbergen, L.W., Lagasse, P.F., and Clopper, P.E. 2012. *Evaluating Scour at Bridges. Fifth Edition.* Hydraulic Engineering Circular No. 18. Federal Highway Administration Publication No. FHWA HIF-12-003, Washington, D.C. April.

2. California Department of Transportation (Caltrans), January, 2018. "Local Assistance Procedures Manual, Processing Procedures for Implementing Federal and/or State Funded local Public Transportation Projects."

3. California Department of Transportation (Caltrans), October, 2010. "Highway Design Manual Chapter 820."

4. California Department of Transportation (Caltrans), December, 2017 "Bridge Memos to Designers 16-1.

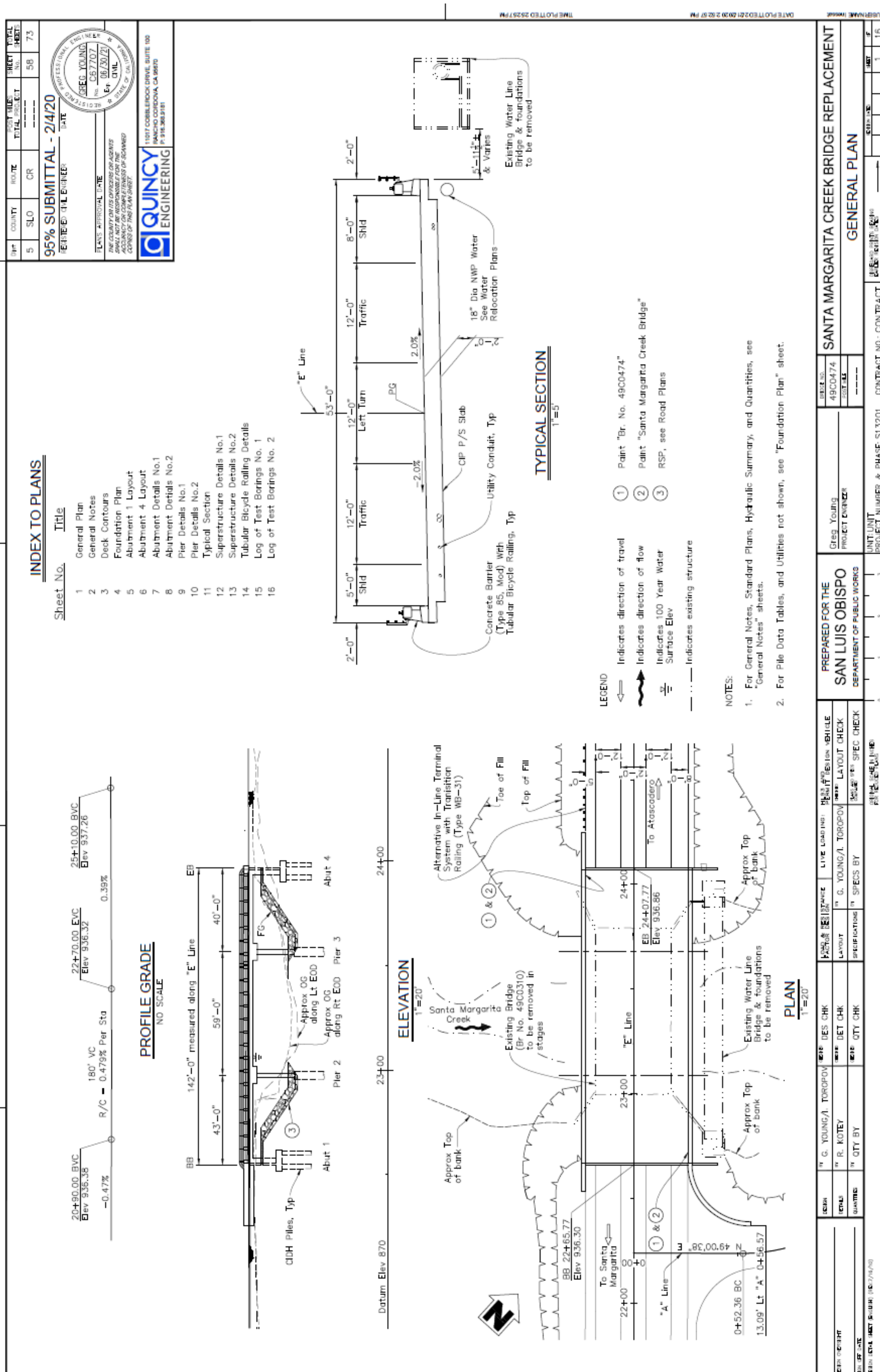
5. Federal Highway Administration, "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges". Report No. FHWA-RD-96-0001, December 1995.

6. Kleinfelder "Potential Scour El Camino Real Bridge Over Santa Margarita Creek, San Luis Obispo County" April 7, 2015

7. San Luis Obispo County, Maintenance Records and As-Built Plans for the El Camino Real (Br #49C0310), 2014.

8. US. Department of the Interior, Geological Survey "Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Subcommittee" Revised September 1981.

APPENDIX A – BRIDGE GENERAL PLANS



APPENDIX B – HYDROLOGY

From FEMA Flood Insurance Study (FIS)

From FEMA, the 50-year and 100-year discharges at the bridge are 7,850 and 9,435 respectively. These flows were determined by a HEC-1 analysis of the watershed.

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
SANTA MARGARITA CREEK					
At confluence with Trout Creek	23.2	4,800	11,300	13,800	18,100
At El Camino Real	22.4	3,450	7,850	9,435	12,300
At confluence with Yerba Buena Creek	19.4	3,390	7,510	8,220	8,500
Near El Camino Real 400 feet southwest of Wilhelmina Avenue	11.2	2,130	4,580	5,400	7,040

Regression Analysis

(Provided by San Luis Obispo County)

PUBLIC WORKS

SAN LUIS OBISPO COUNTY

DATE: **27-Dec-10** LOCATION: **Atascadero, CA**
JOB No: **245R12B501**
JOB NAME: **Santa Margarita Creek Bridge @ El Camino Real**
CALC BY: **MR**

Note:
This program determines the peak stream discharges using regional flood-frequency equations for the Central Coast Region.

Given Data:

Tributary Area, A =	14,449	acres
A =	22.58	square miles
Mean annual precipitation, p =	35	inches
Altitude @ 10% distance =	591	feet
Altitude @ 85% distance =	1580	feet
Altitude index, H =	1.09	in 1000 feet

Peak Discharges:

$Q_2 = 0.0061\ A^{0.92}\ p^{2.54}\ H^{-1.10} =$ **819 cfs**

$Q_5 = 0.118\ A^{0.91}\ p^{1.95}\ H^{-0.79} =$ **1934 cfs**

$Q_{10} = 0.583\ A^{0.90}\ p^{1.61}\ H^{-0.64} =$ **2800 cfs**

$Q_{25} = 2.91\ A^{0.89}\ p^{1.26}\ H^{-0.50} =$ **3948 cfs**

$Q_{50} = 8.20\ A^{0.89}\ p^{1.03}\ H^{-0.41} =$ **4947 cfs**

$Q_{100} = 19.7\ A^{0.88}\ p^{0.84}\ H^{-0.33} =$ **5901 cfs**

Notes:
1. Altitude index, H, is defined as the average of the elevations at the locations 10 % and 85% of the distance from the project site to the basin divide, measured along the main channel of the stream and the overland travel path to the basin divide. main channel of the stream and the overland travel path to the basin divide. $H = \frac{1}{2}(Alt_{.85\%} + Alt_{.10\%}) / 1000$
2. These equations are defined only for basins between 0.2 and 4000 square miles in area, a mean annual precipitation between 8 and 52, and an Altitude Index between 0.1 and 2.4.
3. From Caltrans Highway Design Manual, Figure 819.2C.

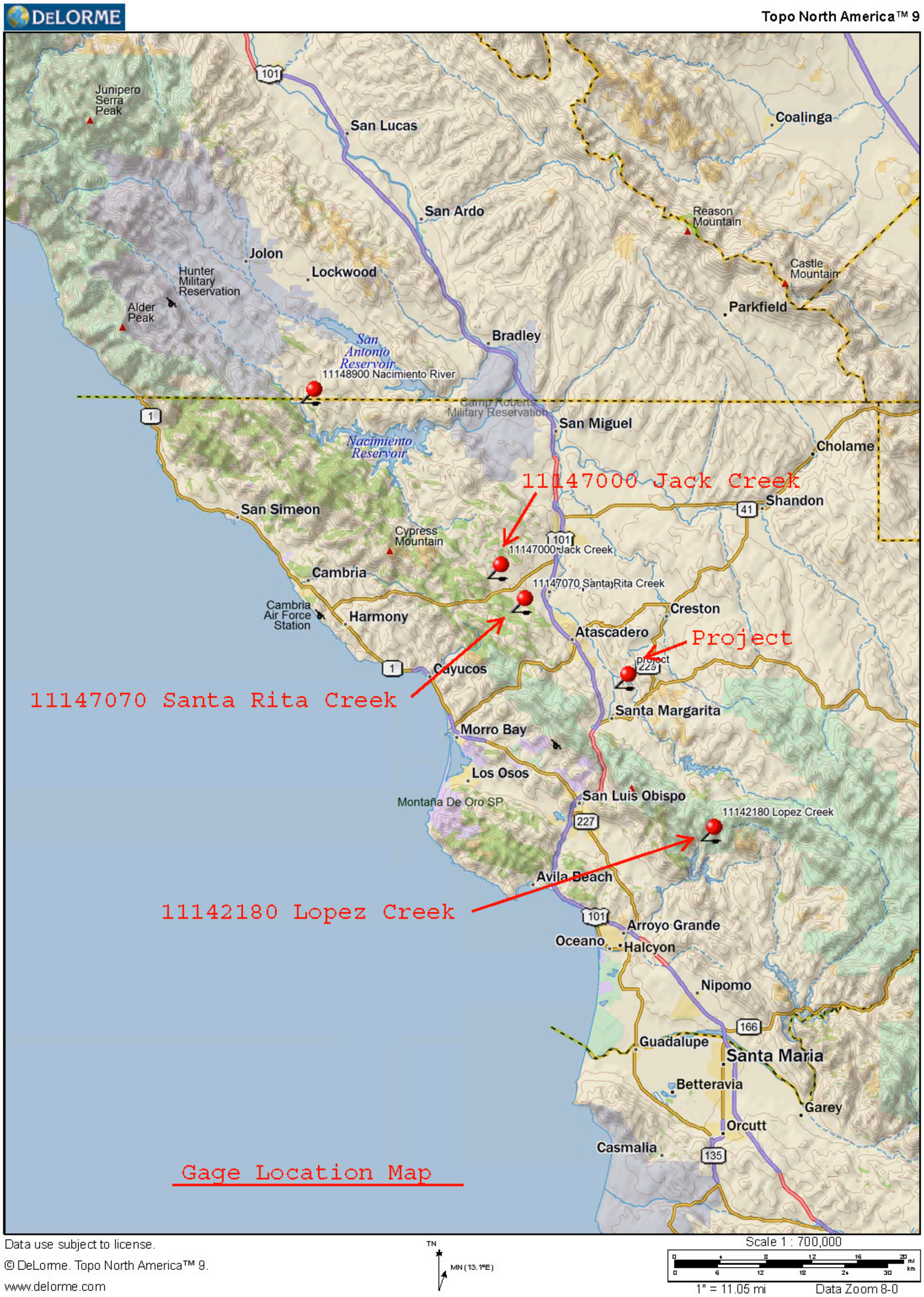
	Q	
Method	50-yr	100-yr
Regression	4,947	5,901
FEMA (HEC-1)	7,850	9,435

Summary of Regression and FEMA flow rates.

Gage Analysis

Because of the disparity between the regression and FEMA flow rates, peak streamflow data from three (3) nearby gages were analyzed (see Gage Location Map) for comparison;

1. Lopez Creek (USGS gage #11142180)
2. Santa Rita Creek (USGS gage #11147070)
3. Jack Creek (USGS gage #11147000)


DeLORME
Topo North America™ 9
11147000 Jack Creek
11147070 Santa Rita Creek
Project
11142180 Lopez Creek
Gage Location Map
11148900 Nacimiento River
11147000 Jack Creek
11147070 Santa Rita Creek
11142180 Lopez Creek
San Lucas
San Ardo
Coalinga
Jolon
Lockwood
Bradley
Parkfield
San Miguel
Cholame
Shandon
San Simeon
Cambria
Harmony
Creston
Atascadero
Cayucos
Santa Margarita
Morro Bay
Los Osos
San Luis Obispo
Avila Beach
Arroyo Grande
Oceano
Halcyon
Nipomo
Guadalupe
Santa Maria
Betteravia
Garey
Orcutt
Casmalia
Data use subject to license.
© DeLorme. Topo North America™ 9.
www.delorme.com
Scale 1 : 700,000
1" = 11.05 mi
Data Zoom 8-0

Summary of Results from Gage Analysis

							Flood - Frequency Analysis			basin transfer	
Description	Gage #	# records	date range	area	MAP	H	Method	50	100	50	100
Project				22.6	29.2	1.15					
Lopez Creek	11142180	47	1967-2012	21.6	27.9	1.49	LPIII	3,570	4,458	3,720	4,640
Santa Rita Creek	11147070	33	1962-1994	18.2	28.9	1.21	LPIII	5,750	6,660	7,000	8,100
Jack Creek	11147000	29	1950-1978	25.3	26	1.32	LPIII	6,901	8,067	6,250	7,305

Discussion

As can be seen from the results of the gage analysis, it is not clear which gage best represents the project for a comparison to the regression and FEMA flow rates. Key basin characteristics of the three gages' watersheds were compared to the project watershed to determine which one is the most geophysiographically similar. They are tabulated as follows (all values from Streamstats):

	Watershed			
Basin Characteristic	Project	Lopez Creek	Santa Rita Creek	Jack Creek
Area (sq mi)	22.6	21.6	18.1	25.2
Mean Annual Precipitation (MAP, in/yr)	29.2	27.9	28.9	26
Maximum Elevation (ft)	2780	2856	2321	2459
Minimum Elevation (ft)	924	564	866	987
Altitude Index	1.15	1.49	1.21	1.32
% of area covered by lakes and ponds	0.0138	0	0.13	0.0387
% of area covered by forest	15.9	44.9	33.6	28.8
% of impervious area	0.8	0	0.1	0.1
Length of longest flow path (m)	16,320	21,656	17,794	14,312

Though the Lopez Creek watershed area and mean annual precipitation (MAP) are almost the same as the project, the two characteristics that stand out are the percent of area covered by forest (44.9 vs. 15.9 project) and length of longest flow path (21,656 vs. 16,320 project). Forested areas tend to have lower runoff coefficients and a longer flow path will typically produce a lower peak flow rate. This may explain why the results of the gage analysis are significantly lower than those from the Santa Rita Creek and Jack Creek analyses (after the basin transfer to the project watershed). For these reasons, the results of the Lopez Creek gage analysis will not be used for comparison to the regression and FEMA flow rates.

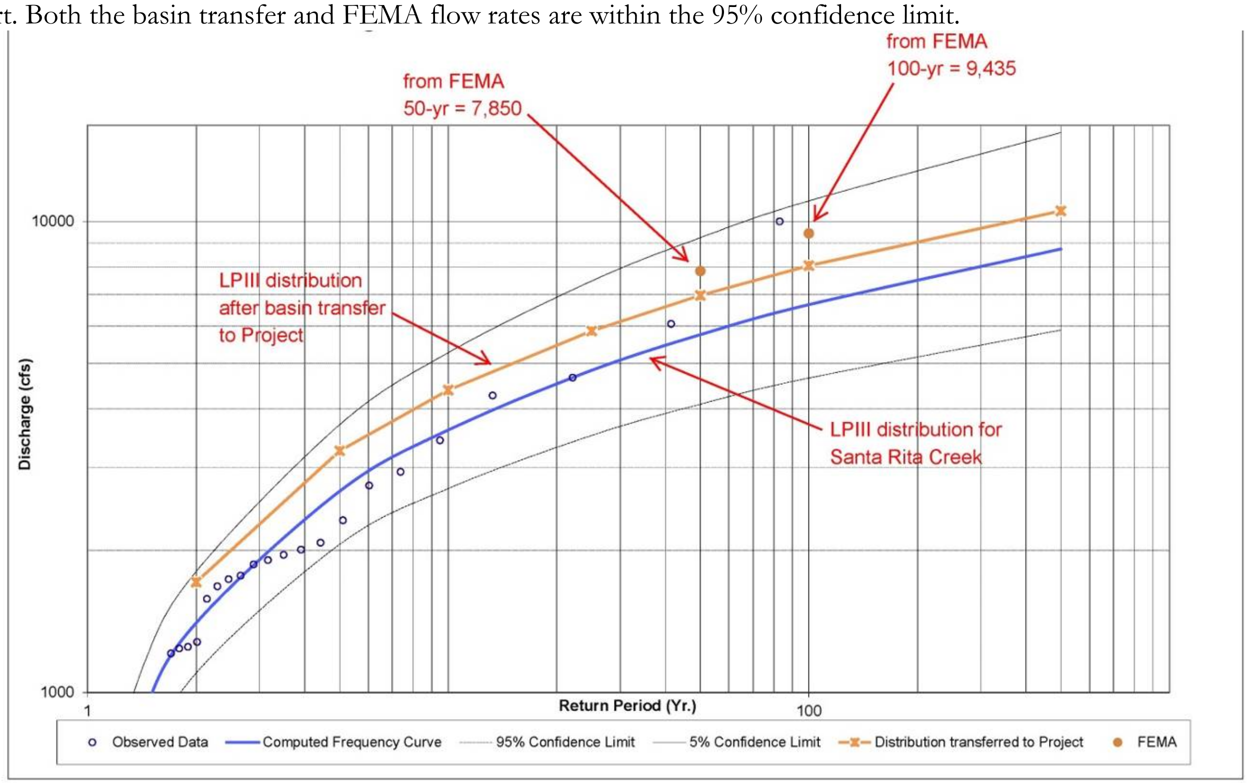
The shape of the Jack Creek gage watershed is the most similar to the project watershed. Because its area is larger (25.2 vs. 22.6 project) and the length of the longest flow path is shorter (14,312 vs. 16,320 project), it would be expected that the peak flow rate produced would be an overestimation after the basin transfer. If all other characteristics were the same, this gage would be ideal for the basin transfer and the results would be considered conservative. However, the MAP is lower (26 vs. 29.2 project), the percent covered by forest is higher (28.8 vs. 15.9

project), and the percent of area covered by lakes and ponds is higher (0.0387 vs. 0.0138 project). It is expected that all three of these factors would contribute to an underestimation of the peak flow rates after the basin transfer. For these reasons, the results of the Jack Creek gage analysis will not be used for comparison to the regression and FEMA flow rates.

Though the area of the Santa Rita Creek gage watershed is smaller than the project (18.1 vs. 22.6), the MAP is almost identical and the length of the longest flow path is similar. The percent of area covered by forest is higher (33.6 vs. 15.9 project) and the percent of area covered by lakes and ponds is also higher (0.13 vs. 0.0138 project). These two factors would be expected to underestimate the peak flow rates after the basin transfer. Though not ideal, the results of the Santa Rita Creek gage analysis are considered the best for making a comparison to the regression and FEMA flow rates.

The Santa Rita Creek gage is the closest to the project and has 33 years of recorded data from 1962-1994. The highest flow rate recorded was 6,060 cfs in 1969. Other significant flows recorded were 4,660 cfs in 1966 and 4,270 cfs in 1973. Three low outlier flows were recorded but not used in the analysis (144 cfs in 1968, 51 cfs in 1976, and 43 cfs in 1977). The LPIII distribution matched the data well (using a perception threshold discharge of 10,000 cfs for missing peaks per Table 1 of SIR 20105260). The 50-yr and 100-yr flows were calculated to be 5,750 cfs and 6,660 cfs respectively. A basin transfer to the project resulted in 50-yr and 100-yr flows of 7,000 cfs and 8,100 cfs respectively. These results are considered to be an underestimation because the Santa Rita Creek watershed has 0.13 percent of its area covered by lakes and ponds (compared to 0.0138 percent for the project watershed) that will provide storage opportunities and will reduce the peak flow rates produced. Also contributing to the underestimated results is the higher percentage of area covered by forest and lower percentage of impervious area (Santa Rita Creek vs. project). Knowing that the results are an underestimation and less than the FEMA flows, the FEMA flow rates were used for design because the method by which they were derived (HEC-1) takes into account all of the basin characteristics that are contributing to the underestimated results of the gage analyses.

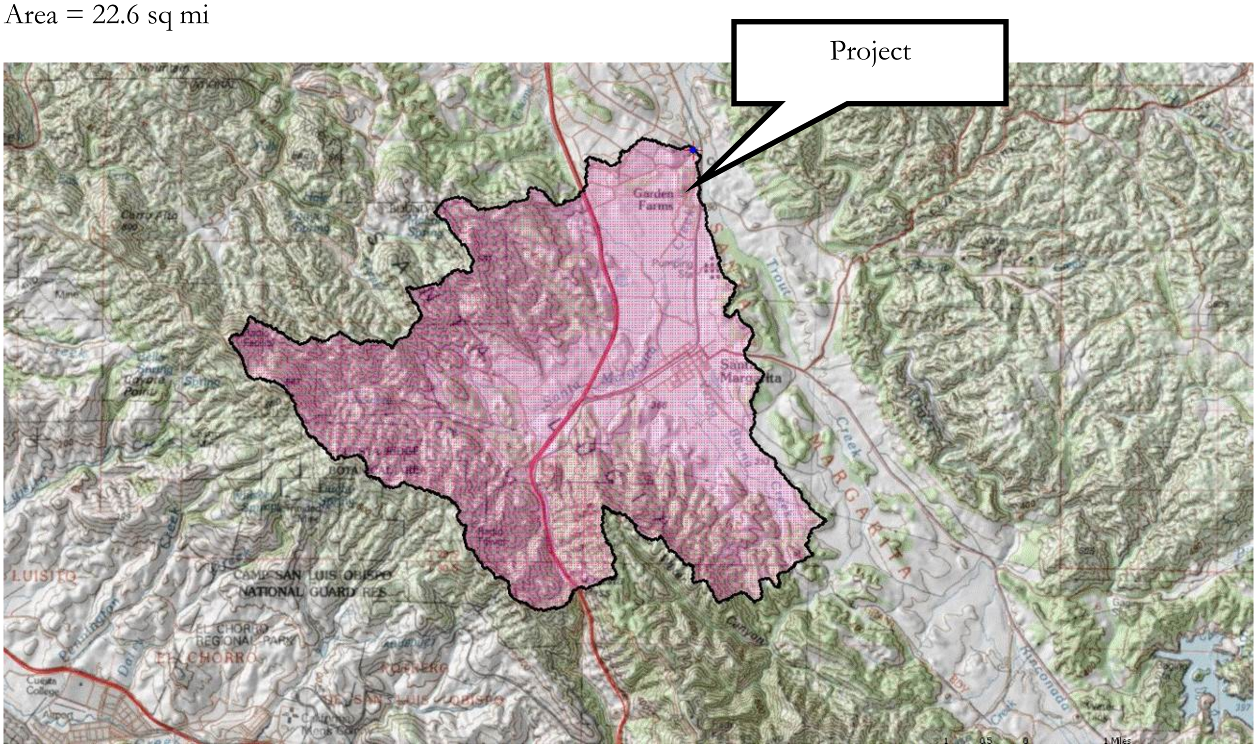
For comparison, a basin transfer of the LPIII distribution for Santa Rita Creek to the project was calculated and superimposed onto the LPIII chart. The 50-yr and 100-yr FEMA flow rates were also superimposed onto the LPIII chart. Both the basin transfer and FEMA flow rates are within the 95% confidence limit.



Project Watershed Map

(per Streamstats)

Area = 22.6 sq mi



Project

USGS California StreamStats

Basin Characteristics Report

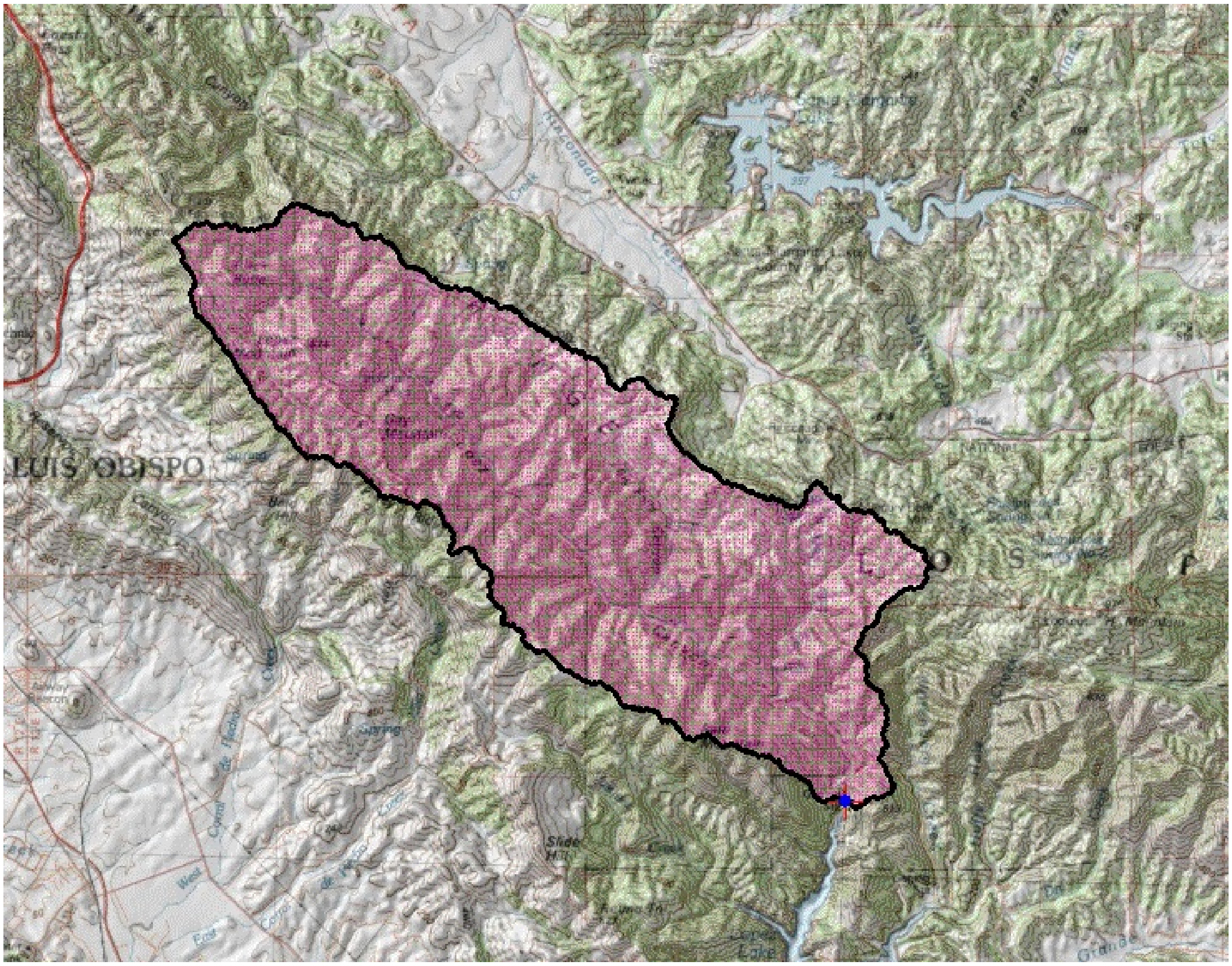
Date: Mon Sep 8 2014 17:57:02 Mountain Daylight Time
NAD27 Latitude: 35.4287 (35 25 43)
NAD27 Longitude: -120.6046 (-120 36 17)
NAD83 Latitude: 35.4287 (35 25 43)
NAD83 Longitude: -120.6057 (-120 36 20)

Parameter	Value
Area, in square miles	22.6
Mean annual precipitation, in inches	29.2
Average maximum January temperature, in degrees Fahrenheit	59.8
Average minimum January temperature, in degrees Fahrenheit	37.3
Maximum elevation, in feet	2780
Minimum elevation, in feet	924
Relief, in feet	1856
Elevation at outlet, in feet	924
Average basin elevation, in feet	1389
Relative relief - Basin relief divided by basin perimeter, in feet per mile	51.9
High Elevation Index - Percent of area above 6000 feet	0
Altitude Index, in thousands of feet. Estimated as 0.00083 times mean basin elevation.	1.15
Mean basin slope computed from 30 m DEM, in percent	21.8
Percentage of basin covered by forest	15.9
Percent of area covered by lakes and ponds	0.0138
Percentage of impervious area determined from NLCD 2001 imperviousness dataset	0.8
X coordinate of the centroid, in map coordinates	-2193795.9
Y coordinate of the centroid, in map coordinates	1655819.9
Latitude of the outlet, NAD83	35.42867
X coordinate of the outlet, in map coordinates	-2190150.0
Y coordinate of the outlet, in map coordinates	1659900.0
Basin perimeter, in miles	35.8
Distance in miles from basin centroid to the coast	11.3
Length of the longest flow path in meters	16320
Elevation relief in meters	566

Lopez Creek

Watershed Map (per Streamstats)

Area = 21.6 sq mi



Lopez Creek

USGS California StreamStats

Basin Characteristics Report

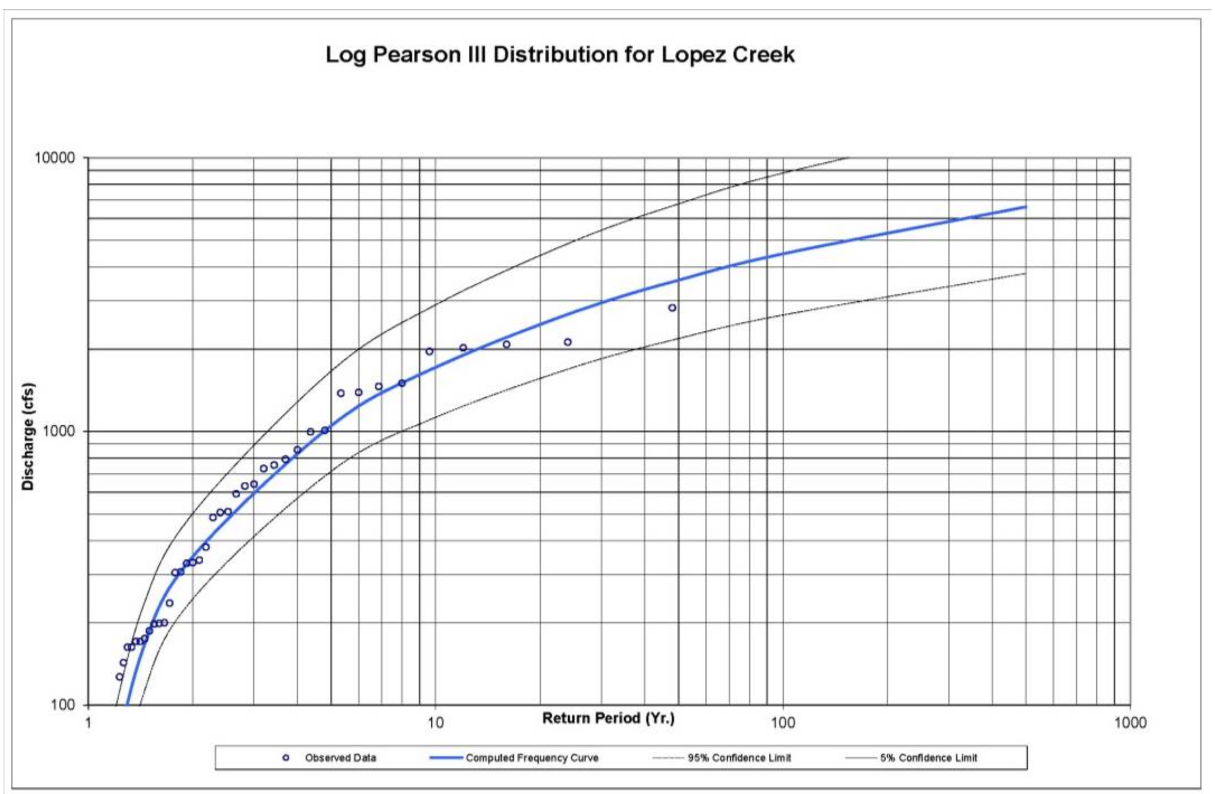
Date: Tue Sep 9 2014 16:58:24 Mountain Daylight Time
NAD27 Latitude: 35.2303 (35 13 49)
NAD27 Longitude: -120.4725 (-120 28 21)
NAD83 Latitude: 35.2303 (35 13 49)
NAD83 Longitude: -120.4735 (-120 28 24)

Parameter	Value
Area, in square miles	21.6
Mean annual precipitation, in inches	27.9
Average maximum January temperature, in degrees Fahrenheit	59.1
Average minimum January temperature, in degrees Fahrenheit	35.6
Maximum elevation, in feet	2856
Minimum elevation, in feet	564
Relief, in feet	2292
Elevation at outlet, in feet	564
Average basin elevation, in feet	1791
Relative relief - Basin relief divided by basin perimeter, in feet per mile	69
High Elevation Index - Percent of area above 6000 feet	0
Altitude Index, in thousands of feet. Estimated as 0.00083 times mean basin elevation.	1.49
Mean basin slope computed from 30 m DEM, in percent	52.5
Percentage of basin covered by forest	44.9
Percent of area covered by lakes and ponds	0
Percentage of impervious area determined from NLCD 2001 imperviousness dataset	0.0
X coordinate of the centroid, in map coordinates	-2187610.2
Y coordinate of the centroid, in map coordinates	1641823.6
Latitude of the outlet, NAD83	35.23028
X coordinate of the outlet, in map coordinates	-2184300.0
Y coordinate of the outlet, in map coordinates	1635390.0
Basin perimeter, in miles	33.2
Distance in miles from basin centroid to the coast	11.4
Length of the longest flow path in meters	21656
Elevation relief in meters	699

Flood Frequency Methods for Lopez Creek at Gage #11142180

General Input		
Name of Stream:		Lopez Creek
Gage No.:		11142180
General Skew		-0.523
Length of Gage Record		47
Historic Length (yrs)		
2-Station Compar.	Equiv. # of Years, Ne	
	Adjust. Mean Log Q	
	Adjust. STDEV Log Q	

OUTPUT				
Return Period	Estimated Discharge			
	LP III (17B)	Normal	Log-Normal	Gumbel
2	349	630	298	522
5	1049	1209	1026	1197
10	1715	1512	1958	1644
25	2729	1835	3901	2209
50	3570	2043	6090	2628
100	4458	2231	9090	3044
500	6616	2610	20452	4005



BASIN TRANSFER

Region :	Central Coast
Name of Gaged Stream:	Lopez Creek
Gage Number:	11142180
Gaged Area :	21.6
Return Period of Q (2, 10 or 100):	50
Gaged Discharge (cfs):	3570

Discharge (cfs)	
Name of Ungaged Stream:	Santa Margarita
Ungaged Area :	22.60
Drainage Area exponent (b):	0.88
Qu (cfs) = Qg * (Au/Ag)^b =	3715

BASIN TRANSFER

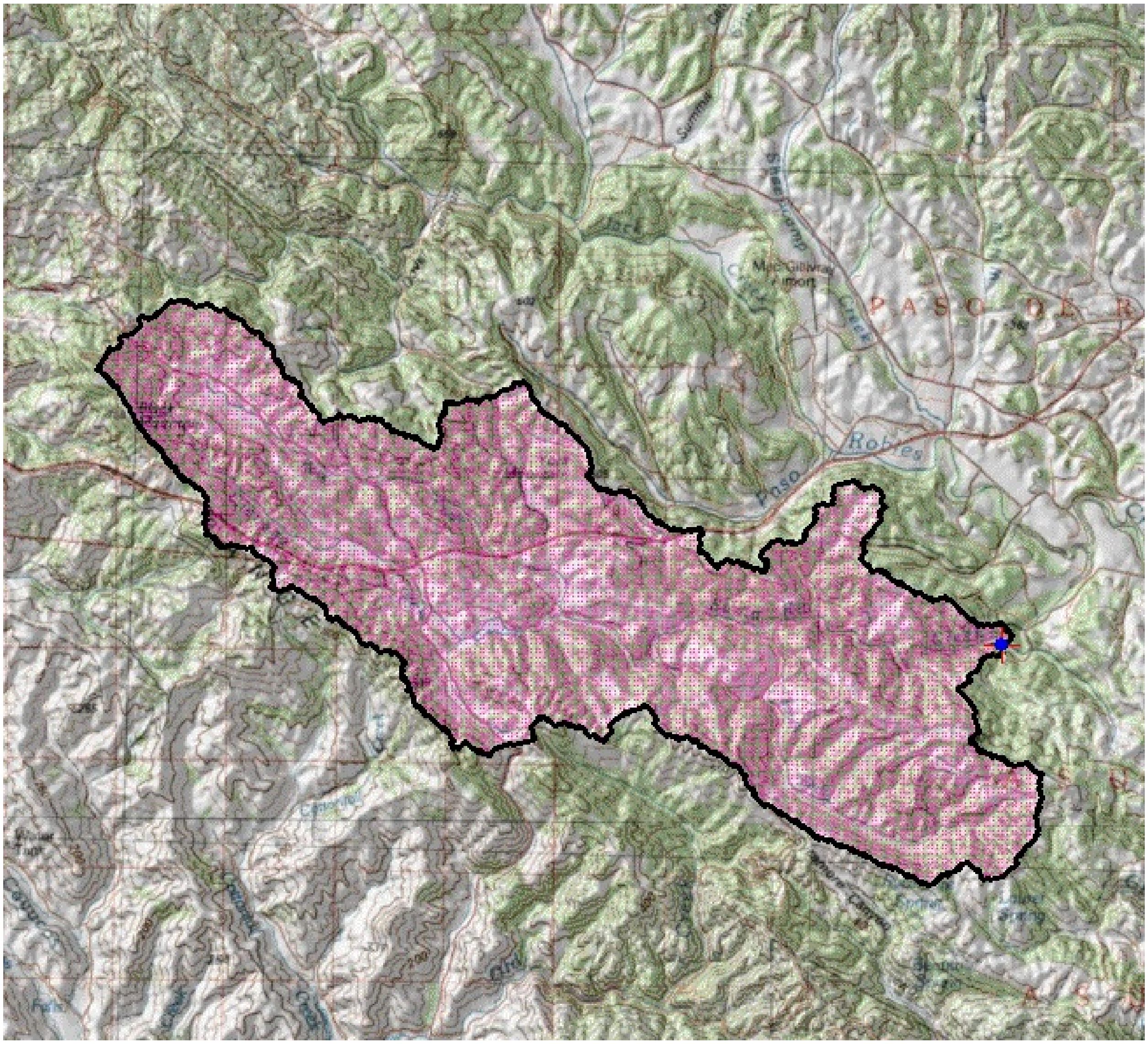
Region :	Central Coast
Name of Gaged Stream:	Lopez Creek
Gage Number:	11142180
Gaged Area :	21.6
Return Period of Q (2, 10 or 100):	100
Gaged Discharge (cfs):	4458

Discharge (cfs)	
Name of Ungaged Stream:	Santa Margarita
Ungaged Area :	22.60
Drainage Area exponent (b):	0.88
Qu (cfs) = Qg * (Au/Ag)^b =	4639

Santa Rita Creek

Watershed Map (per Streamstats)

Area = 18.2 sq mi



Santa Rita Creek

USGS California StreamStats

Basin Characteristics Report

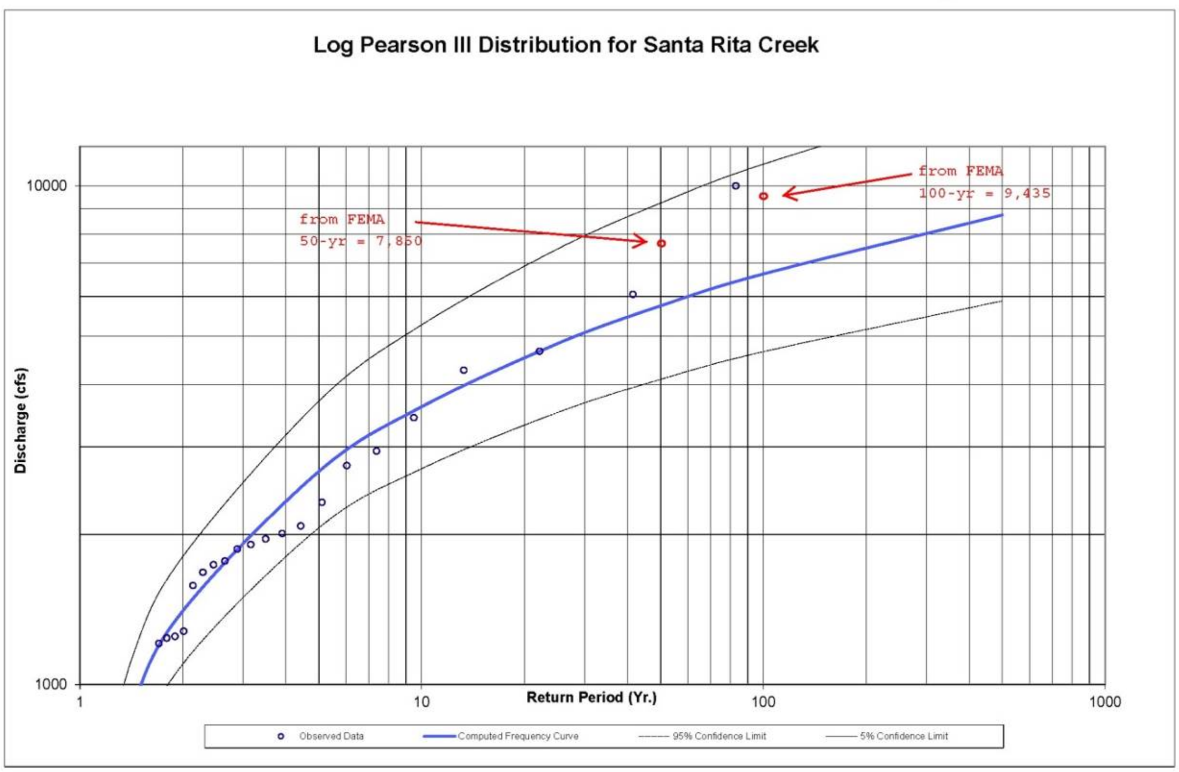
Date: Mon Sep 8 2014 18:58:41 Mountain Daylight Time
NAD27 Latitude: 35.5240 (35 31 26)
NAD27 Longitude: -120.7649 (-120 45 54)
NAD83 Latitude: 35.5240 (35 31 26)
NAD83 Longitude: -120.7659 (-120 45 57)

Parameter	Value
Area, in square miles	18.1
Mean annual precipitation, in inches	28.9
Average maximum January temperature, in degrees Fahrenheit	59.9
Average minimum January temperature, in degrees Fahrenheit	36.3
Maximum elevation, in feet	2321
Minimum elevation, in feet	866
Relief, in feet	1455
Elevation at outlet, in feet	867
Average basin elevation, in feet	1463
Relative relief - Basin relief divided by basin perimeter, in feet per mile	40.8
High Elevation Index - Percent of area above 6000 feet	0
Altitude Index, in thousands of feet. Estimated as 0.00083 times mean basin elevation.	1.21
Mean basin slope computed from 30 m DEM, in percent	28.6
Percentage of basin covered by forest	33.6
Percent of area covered by lakes and ponds	0.13
Percentage of impervious area determined from NLCD 2001 imperviousness dataset	0.1
X coordinate of the centroid, in map coordinates	-2206881.2
Y coordinate of the centroid, in map coordinates	1676029.3
Latitude of the outlet, NAD83	35.52395
X coordinate of the outlet, in map coordinates	-2201340.0
Y coordinate of the outlet, in map coordinates	1673910.0
Basin perimeter, in miles	35.7
Distance in miles from basin centroid to the coast	6.98
Length of the longest flow path in meters	17794
Elevation relief in meters	443

Flood Frequency Methods for Santa Rita Creek at Gage #11147070

General Input		
Name of Stream:		Santa Rita Creek
Gage No.:		11147070
General Skew		-0.556
Length of Gage Record		32
Historic Length (yrs)		82
2-Station Compar.	Equiv. # of Years, Ne	
	Adjust. Mean Log Q	
	Adjust. STDEV Log Q	

OUTPUT				
Return	Estimated Discharge			
Period	LP III (17B)	Normal	Log-Normal	Gumbel
2	1405	1787	1310	1553
5	2675	3077	2642	3115
10	3607	3752	3811	4149
25	4828	4471	5633	5455
50	5746	4935	7251	6425
100	6658	5353	9100	7387
500	8739	6199	14411	9610



BASIN TRANSFER

Region :	Central Coast
Name of Gaged Stream:	Santa Rita Creek
Gage Number:	11147070
Gaged Area :	18.2
Return Period of Q (2, 10 or 100):	50
Gaged Discharge (cfs):	5750

Discharge (cfs)	
Name of Ungaged Stream:	Santa Margarita
Ungaged Area :	22.60
Drainage Area exponent (b):	0.88
Qu (cfs) = Qg * (Au/Ag)^b =	6957

BASIN TRANSFER

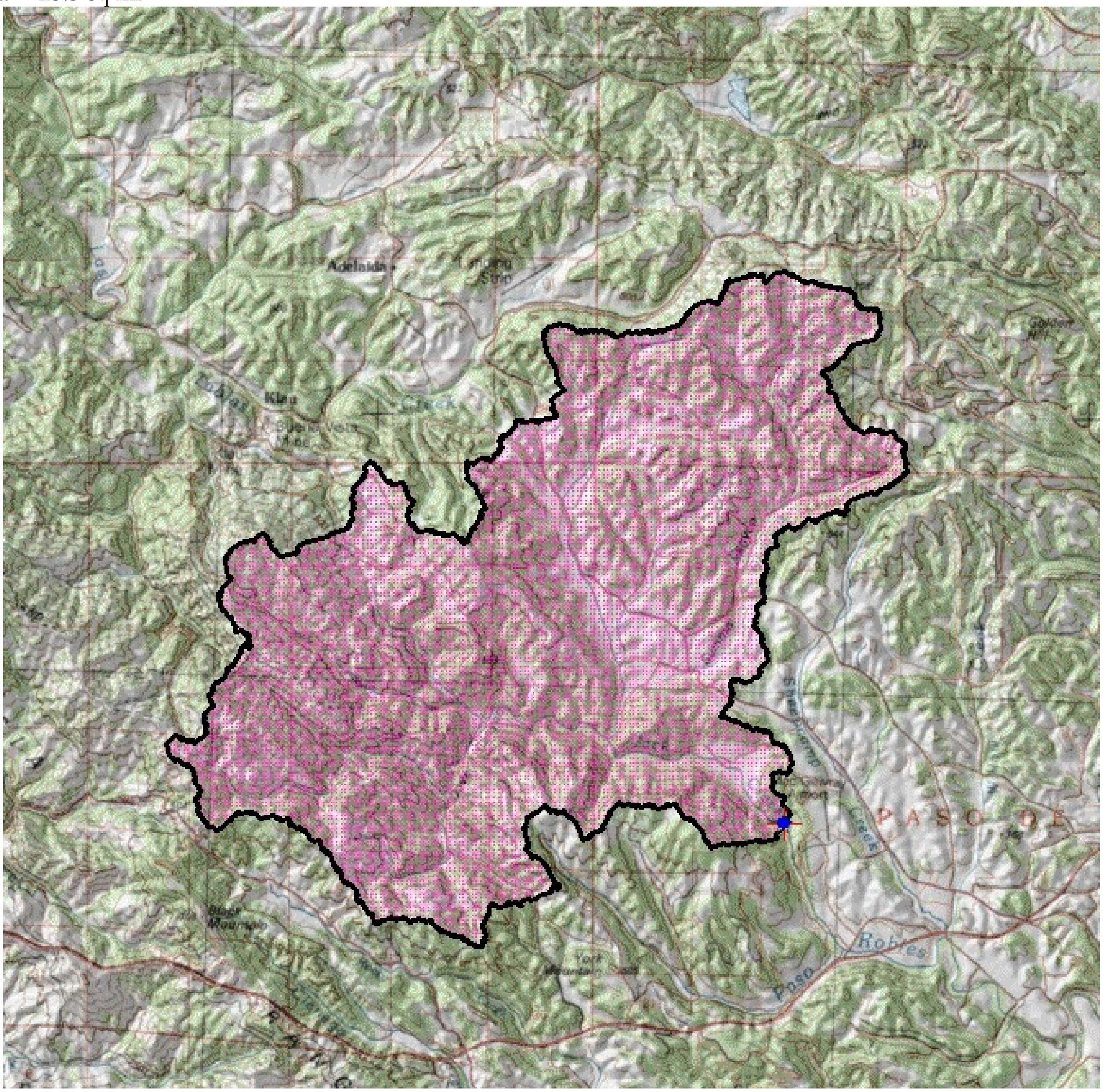
Region :	Central Coast
Name of Gaged Stream:	Santa Rita Creek
Gage Number:	11147070
Gaged Area :	18.2
Return Period of Q (2, 10 or 100):	100
Gaged Discharge (cfs):	6660

Discharge (cfs)	
Name of Ungaged Stream:	Santa Margarita
Ungaged Area :	22.60
Drainage Area exponent (b):	0.88
Qu (cfs) = Qg * (Au/Ag)^b =	8058

Jack Creek

Watershed Map (per Streamstats)

Area = 25.3 sq mi



Jack Creek

USGS California StreamStats

Basin Characteristics Report

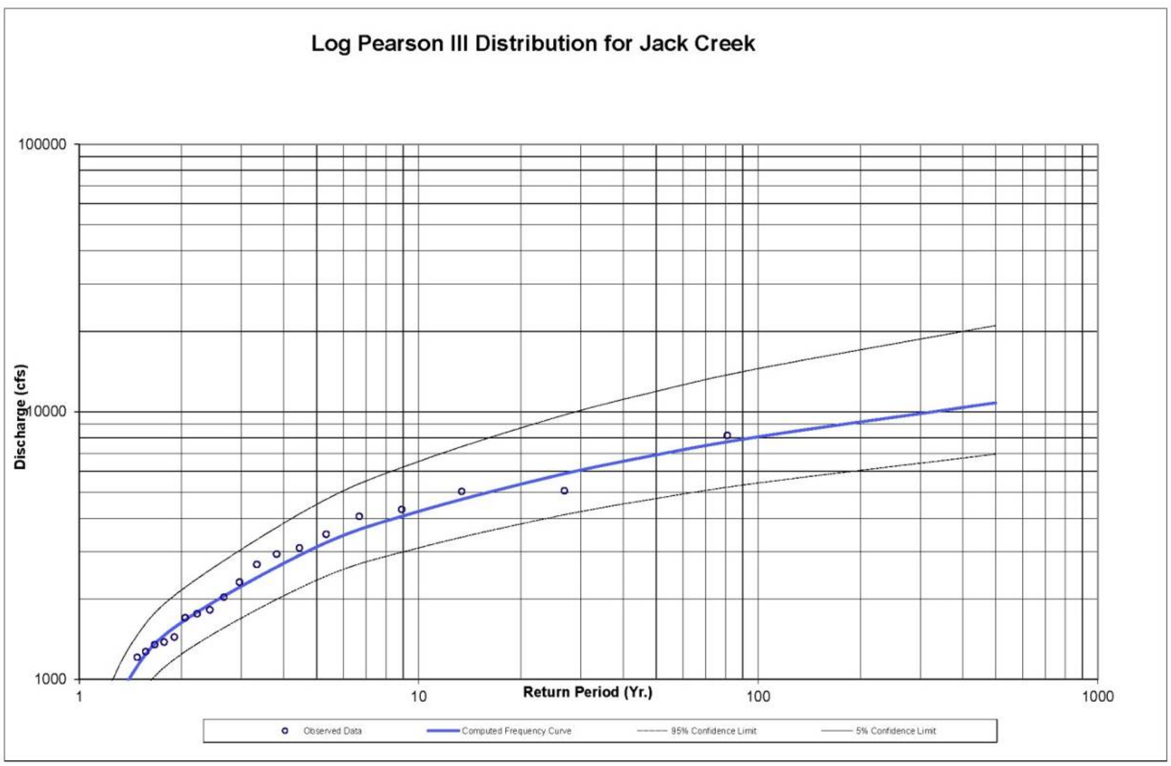
Date: Mon Sep 8 2014 18:24:54 Mountain Daylight Time
NAD27 Latitude: 35.5673 (35 34 02)
NAD27 Longitude: -120.8034 (-120 48 12)
NAD83 Latitude: 35.5673 (35 34 02)
NAD83 Longitude: -120.8045 (-120 48 16)

Parameter	Value
Area, in square miles	25.2
Mean annual precipitation, in inches	26
Average maximum January temperature, in degrees Fahrenheit	59.9
Average minimum January temperature, in degrees Fahrenheit	33.6
Maximum elevation, in feet	2459
Minimum elevation, in feet	987
Relief, in feet	1472
Elevation at outlet, in feet	995
Average basin elevation, in feet	1592
Relative relief - Basin relief divided by basin perimeter, in feet per mile	37
High Elevation Index - Percent of area above 6000 feet	0
Altitude Index, in thousands of feet. Estimated as 0.00083 times mean basin elevation.	1.32
Mean basin slope computed from 30 m DEM, in percent	26.2
Percentage of basin covered by forest	28.8
Percent of area covered by lakes and ponds	0.0387
Percentage of impervious area determined from NLCD 2001 imperviousness dataset	0.1
X coordinate of the centroid, in map coordinates	-2206187.7
Y coordinate of the centroid, in map coordinates	1683608.4
Latitude of the outlet, NAD83	35.56728
X coordinate of the outlet, in map coordinates	-2203440.0
Y coordinate of the outlet, in map coordinates	1679490.0
Basin perimeter, in miles	39.8
Distance in miles from basin centroid to the coast	10.8
Length of the longest flow path in meters	14312
Elevation relief in meters	449

Flood Frequency Methods for Jack Creek at Gage #11147000

General Input		
Name of Stream:		Jack Creek
Gage No.:		11147000
General Skew		-0.556
Length of Gage Record		26
Historic Length (yrs)		80
2-Station Compar.	Equiv. # of Years, Ne	
	Adjust. Mean Log Q	
	Adjust. STDEV Log Q	

OUTPUT				
Return	Estimated Discharge			
Period	LP III (17B)	Normal	Log-Normal	Gumbel
2	1632	2074	1536	1837
5	3125	3392	3089	3457
10	4246	4081	4451	4530
25	5747	4815	6570	5886
50	6901	5290	8450	6891
100	8067	5717	10596	7889
500	10811	6581	16753	10196



BASIN TRANSFER

Region :	Central Coast
Name of Gaged Stream:	Jack Creek
Gage Number:	11147070
Gaged Area :	25.3
Return Period of Q (2, 10 or 100):	50
Gaged Discharge (cfs):	6901

Discharge (cfs)	
Name of Ungaged Stream:	Santa Margarita
Ungaged Area :	22.60
Drainage Area exponent (b):	0.88
Qu (cfs) = Qg * (Au/Ag)^b =	6249

BASIN TRANSFER

Region :	Central Coast
Name of Gaged Stream:	Jack Creek
Gage Number:	11147070
Gaged Area :	25.3
Return Period of Q (2, 10 or 100):	100
Gaged Discharge (cfs):	8067

Discharge (cfs)	
Name of Ungaged Stream:	Santa Margarita
Ungaged Area :	22.60
Drainage Area exponent (b):	0.88
Qu (cfs) = Qg * (Au/Ag)^b =	7304

APPENDIX C - BRIDGE ALTERNATIVES ANALYSIS

The HEC-RAS model was re-run by replacing the existing bridge in the model with the three proposed bridges as shown in Figure 1, 2 and 3.

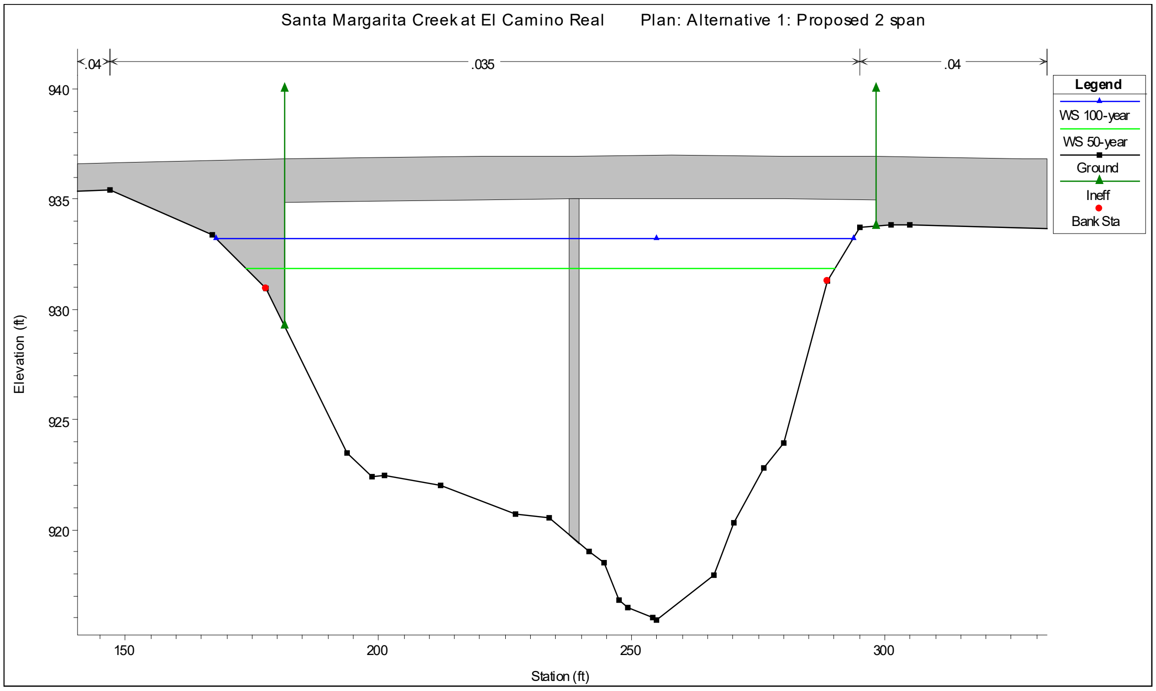


Figure 1: Alternative 1 – 122 ft, 2-span Bridge

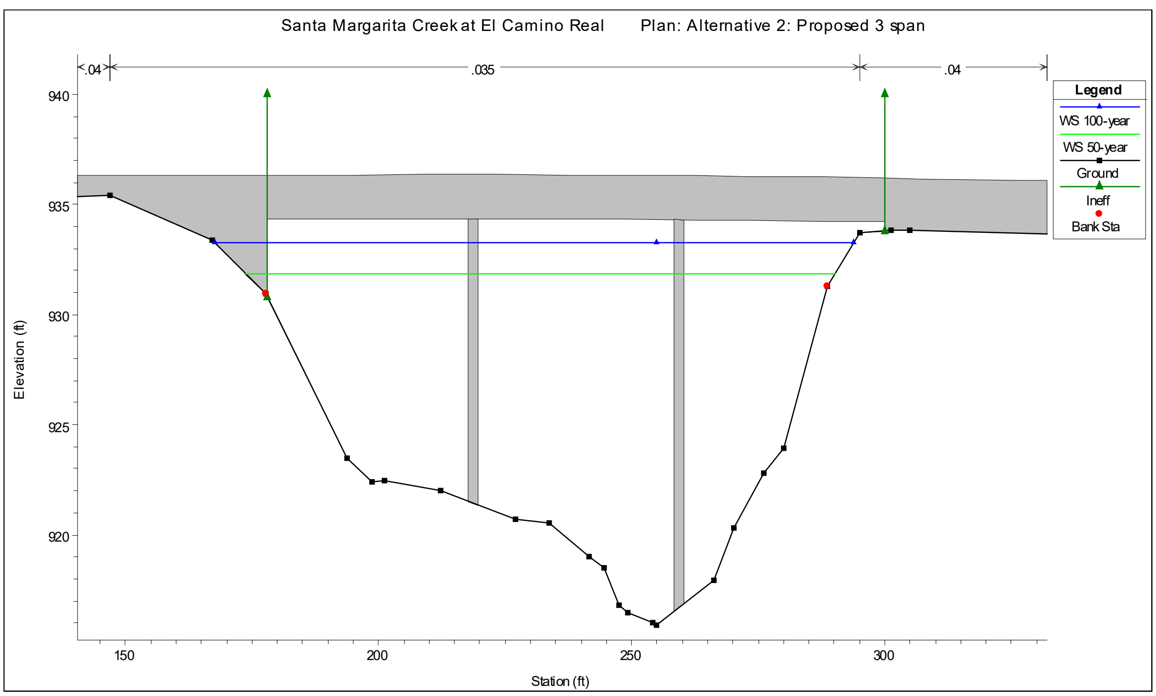


Figure 2: Alternative 2 – 122 ft, 3-span Bridge

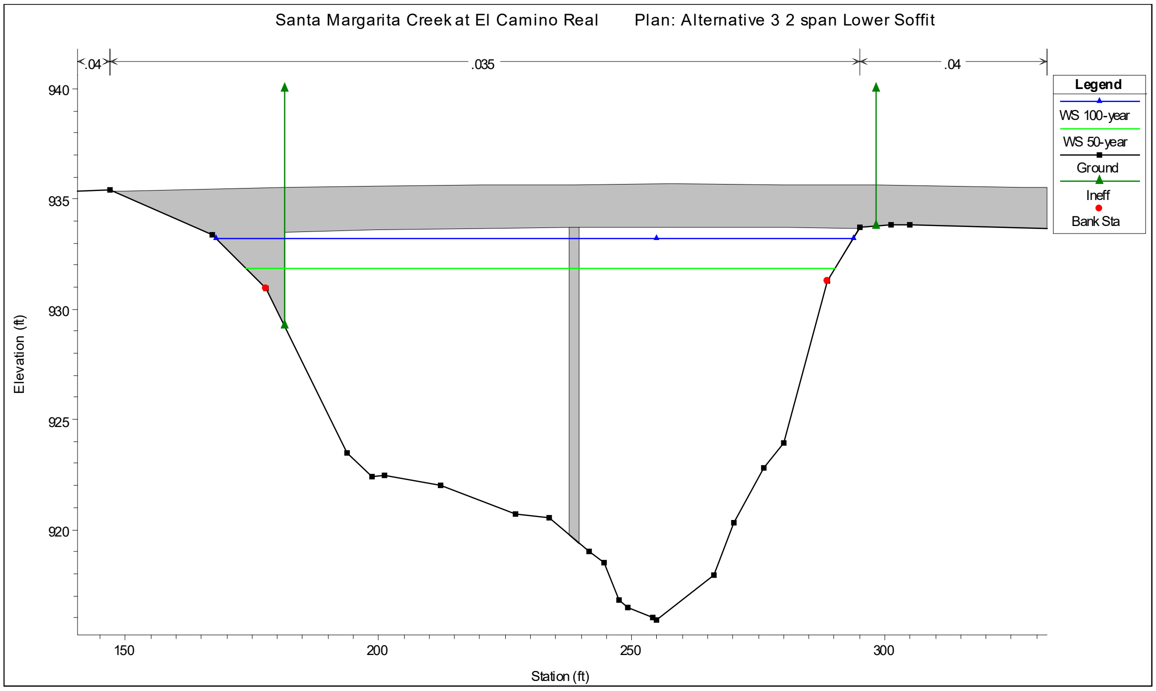


Figure 3: Alternative 3 – 119 ft, 2-span Bridge

The three alternatives were input into the HEC-RAS model to determine the impact to the water surface elevation and velocity. As shown in Figure 5 through Figure 8, the proposed bridge alternatives reduced the 50-year and 100-year water surface elevations.

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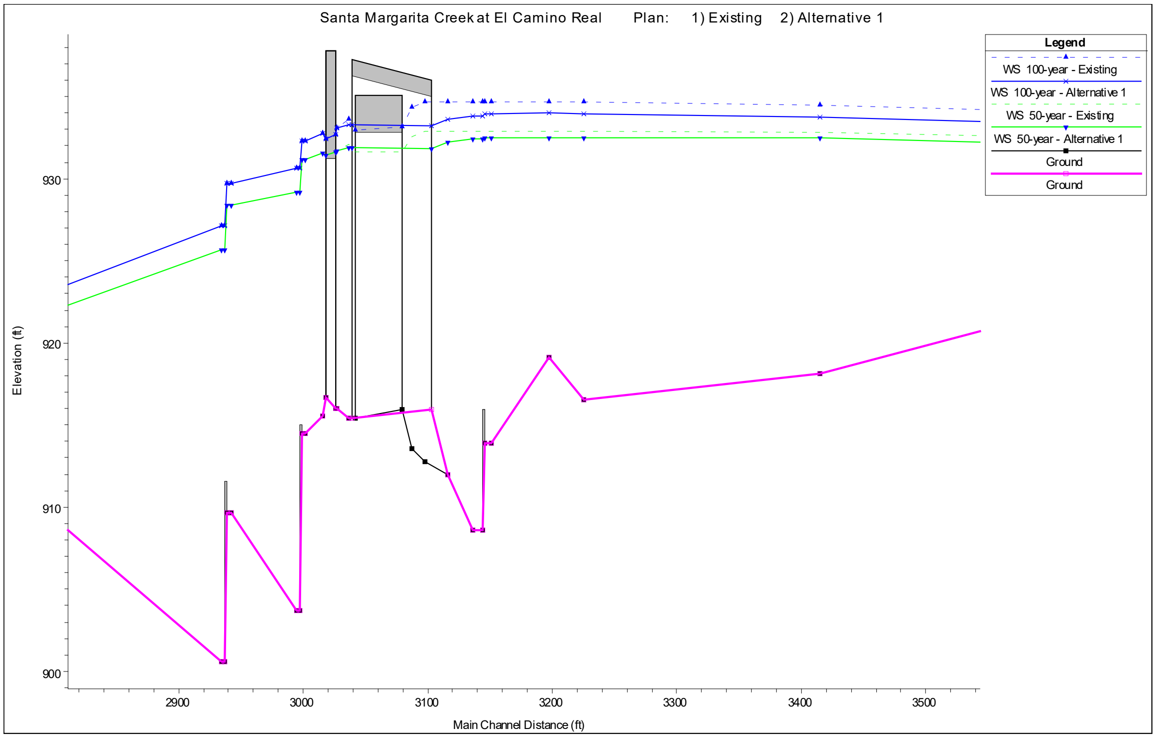


Figure 4: Water surface elevation comparing Existing vs. Alternative 1

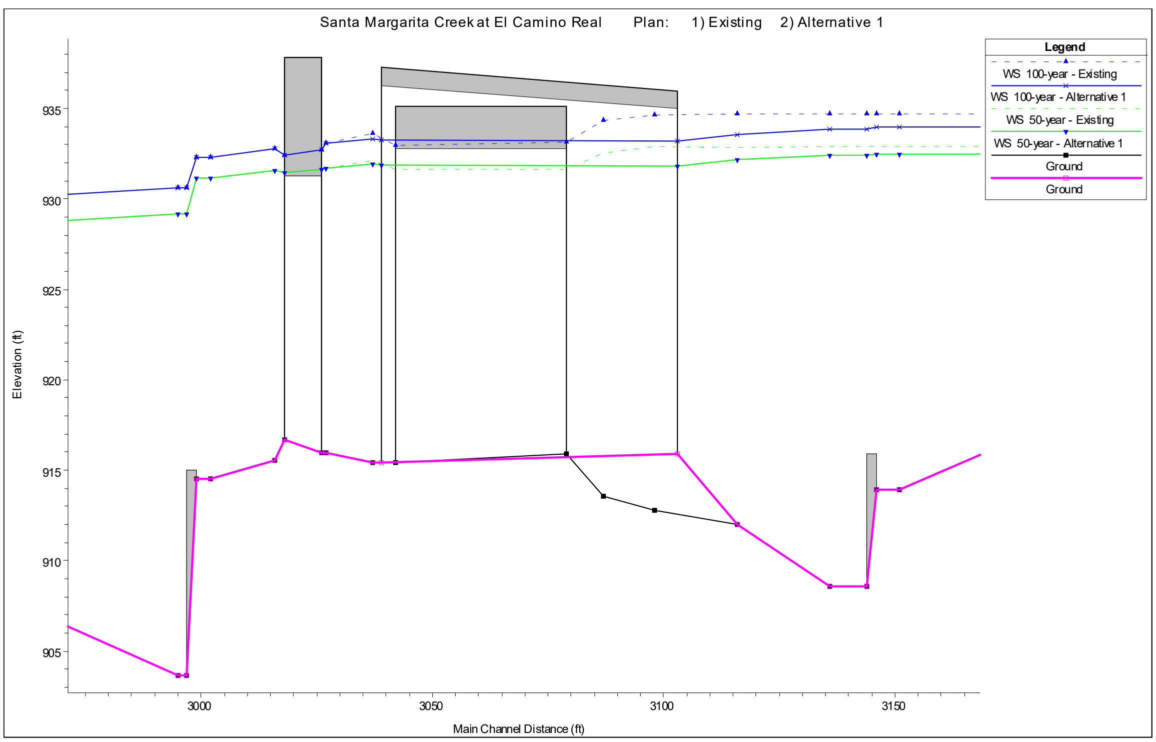


Figure 5: Close-up of Figure 4

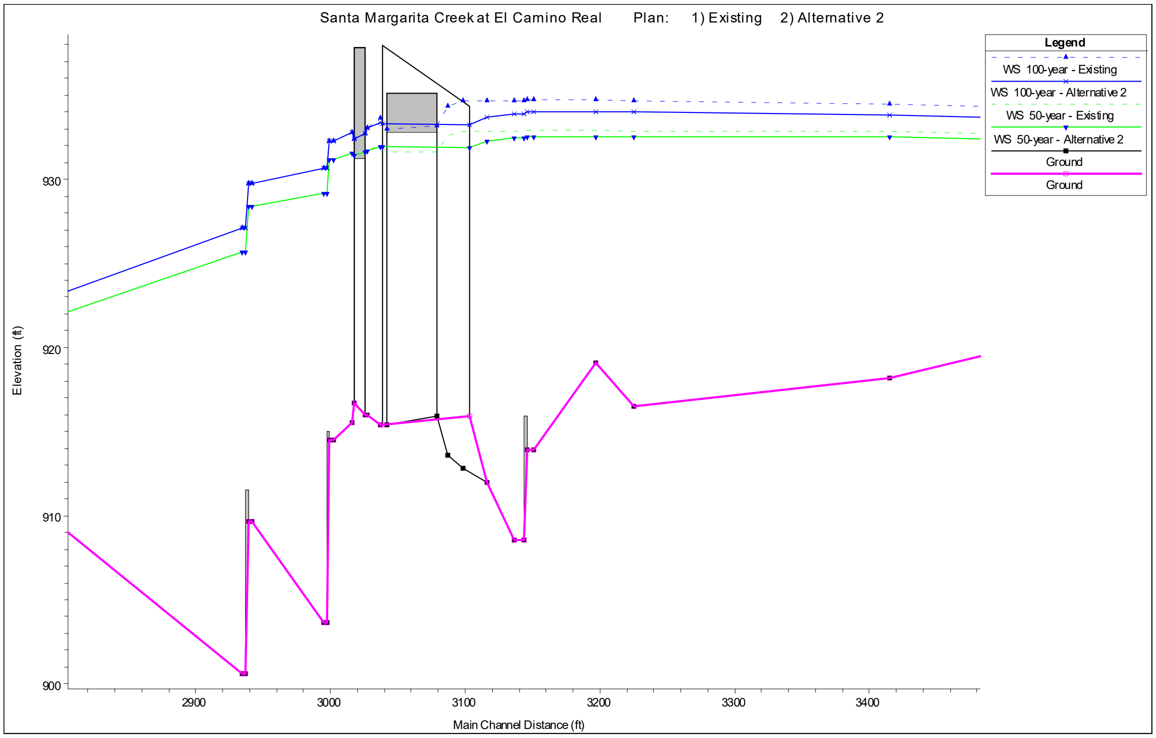


Figure 6: Water surface elevation comparing Existing vs. Alternative 2

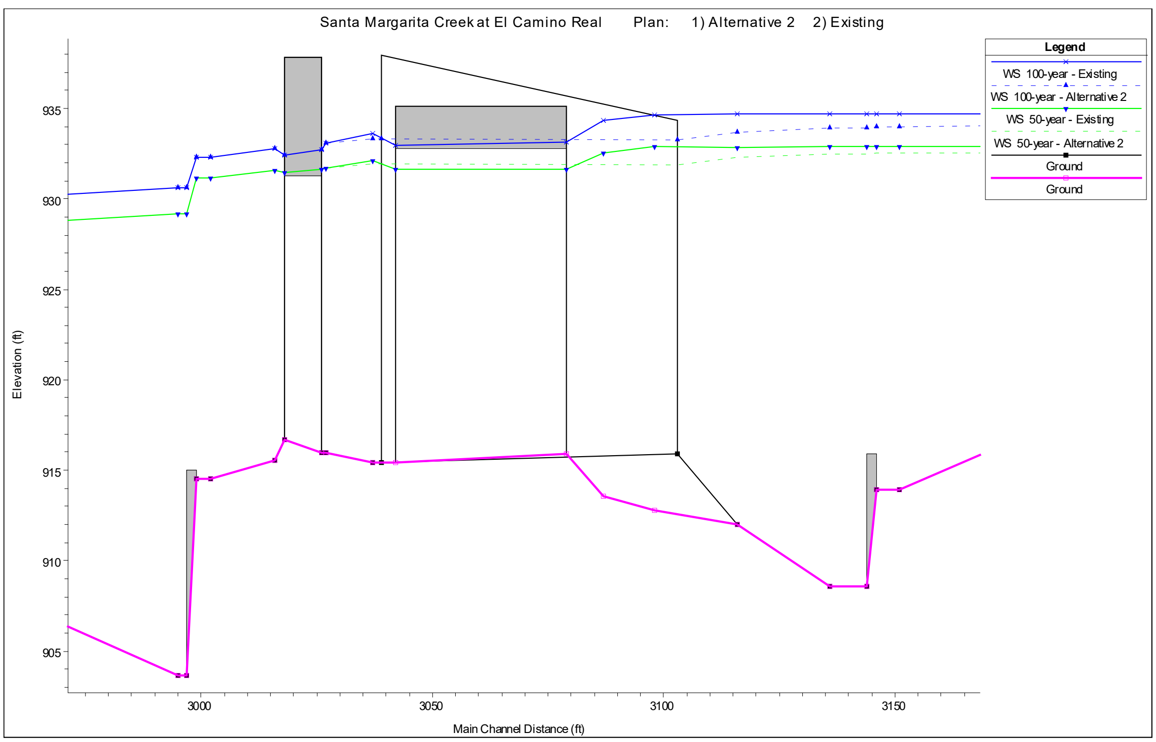


Figure 7: Close-up of Figure 6

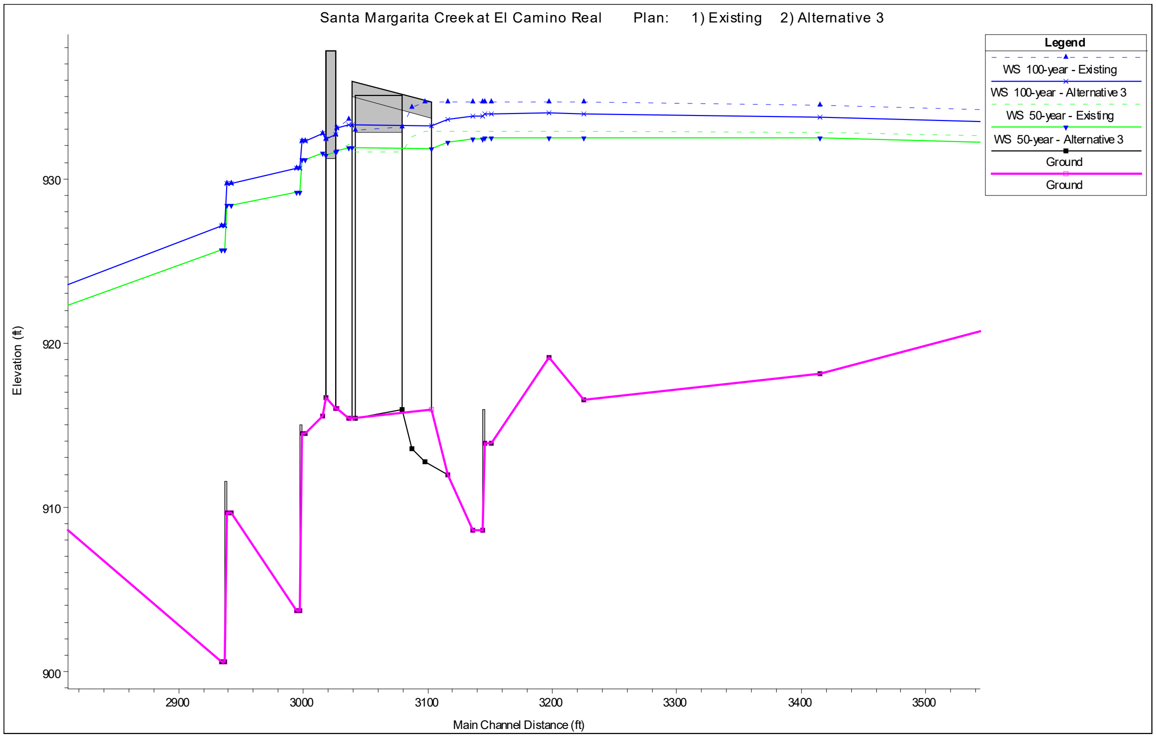


Figure 7: Water surface elevation comparing Existing vs. Alternative 3

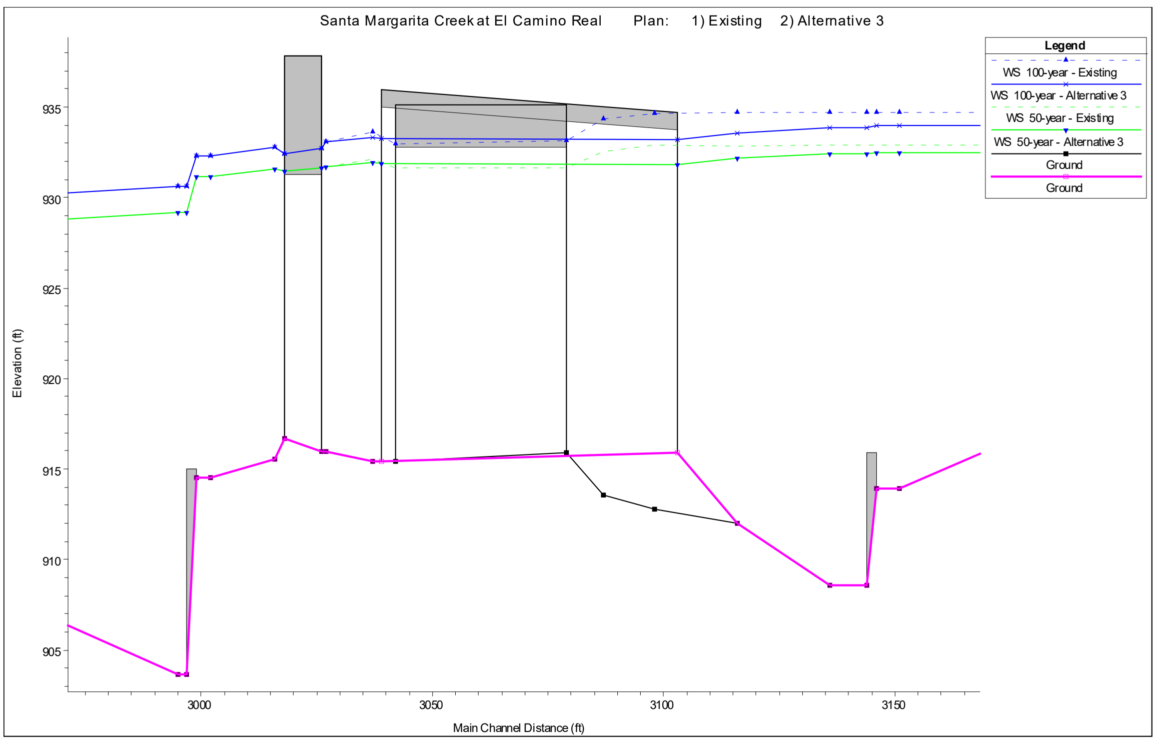


Figure 8: Close up of Figure 7

.

APPENDIX D – HEC-RAS OUTPUT

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
main	3558	10-year	Prop 5-19-:	3450	921	928.63		929.9	0.00482	9.06	380.74	67.65	0.67
main	3558	10-year	Existing	3450	921	928.67		929.93	0.00471	8.99	383.86	67.85	0.67
main	3558	50-year	Prop 5-19-:	7850	921	932.11		934.45	0.005651	12.26	640.12	80.11	0.76
main	3558	50-year	Existing	7850	921	932.58		934.66	0.004792	11.58	678.02	81.55	0.71
main	3558	100-year	Prop 5-19-:	9435	921	933.16		935.79	0.005704	13	725.52	83.32	0.78
main	3558	100-year	Existing	9435	921	934.15		936.26	0.004156	11.65	809.94	89.26	0.67
main	3415	10-year	Prop 5-19-:	3450	918.16	928.53		929.23	0.002658	6.68	516.56	92.65	0.5
main	3415	10-year	Existing	3450	918.16	928.59		929.27	0.002582	6.62	521.53	92.84	0.49
main	3415	50-year	Prop 5-19-:	7850	918.16	932.39		933.57	0.002641	8.73	899.4	106.02	0.53
main	3415	50-year	Existing	7850	918.16	932.84		933.9	0.00227	8.29	947.19	107.57	0.49
main	3415	100-year	Prop 5-19-:	9435	918.16	933.54		934.86	0.002611	9.21	1024.29	110.03	0.53
main	3415	100-year	Existing	9435	918.16	934.47		935.56	0.001975	8.36	1131.79	124.17	0.47
main	3225	10-year	Prop 5-19-:	3450	916.51	928.25	925.36	928.73	0.00196	5.61	615.29	114.85	0.43
main	3225	10-year	Existing	3450	916.51	928.31		928.79	0.001888	5.54	622.97	115.17	0.42
main	3225	50-year	Prop 5-19-:	7850	916.51	932.37	928.13	933.04	0.00154	6.69	1272.73	244.64	0.41
main	3225	50-year	Existing	7850	916.51	932.86		933.44	0.001254	6.24	1404.48	285.46	0.37
main	3225	100-year	Prop 5-19-:	9435	916.51	933.69	928.89	934.32	0.001267	6.61	1624.12	289.92	0.38
main	3225	100-year	Existing	9435	916.51	934.67		935.13	0.000851	5.73	1929.7	291.71	0.31
main	3197	10-year	Prop 5-19-:	3450	919.12	928.19	925.83	928.67	0.002184	5.57	619.54	127.9	0.45
main	3197	10-year	Existing	3450	919.12	928.26		928.73	0.002088	5.49	628.53	128.17	0.44
main	3197	50-year	Prop 5-19-:	7850	919.12	932.41	928.25	932.97	0.001261	6.2	1424.76	272.68	0.37
main	3197	50-year	Existing	7850	919.12	932.9		933.38	0.001037	5.81	1569.12	299.14	0.34
main	3197	100-year	Prop 5-19-:	9435	919.12	933.73	928.95	934.26	0.001043	6.14	1757.05	300.29	0.34
main	3197	100-year	Existing	9435	919.12	934.7		935.09	0.000704	5.33	2111.99	301.65	0.29
main	3151	10-year	Prop 5-19-:	3450	913.9	928.19	924.27	928.55	0.001628	4.84	713.21	141.75	0.38
main	3151	10-year	Existing	3450	913.9	928.26	924.27	928.61	0.001588	4.77	723.36	144.62	0.38
main	3151	50-year	Prop 5-19-:	7850	913.9	932.42	927.25	932.89	0.001024	5.6	1519.55	251.39	0.33
main	3151	50-year	Existing	7850	913.9	932.9	927.22	933.32	0.00086	5.3	1666.95	304.55	0.3
main	3151	100-year	Prop 5-19-:	9435	913.9	933.73	928.34	934.2	0.00089	5.67	1821.65	305.55	0.31
main	3151	100-year	Existing	9435	913.9	934.7	928.28	935.05	0.000608	4.95	2217.03	306.73	0.26
main	3146			Inl Struct									

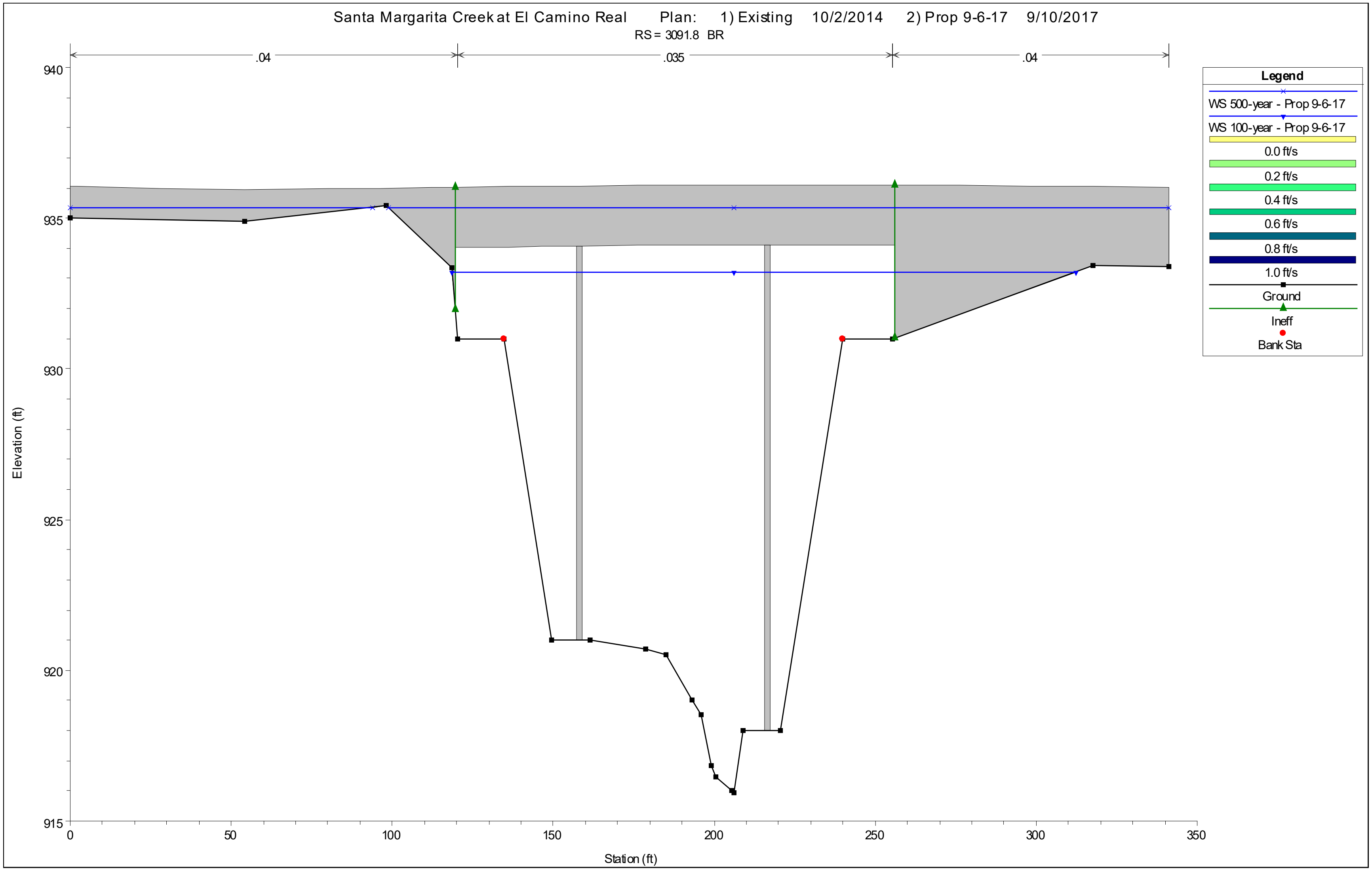
main	3136	10-year	Prop 5-19-	3450	908.58	927.46	918.52	927.64	0.00057	3.43	1007.1	150.06	0.23
main	3136	10-year	Existing	3450	908.58	927.7		927.87	0.000508	3.31	1044.48	152.2	0.22
main	3136	50-year	Prop 5-19-	7850	908.58	932.36	922.77	932.65	0.000475	4.35	1907.85	325.82	0.23
main	3136	50-year	Existing	7850	908.58	932.87		933.13	0.000403	4.11	2127.43	326.75	0.21
main	3136	100-year	Prop 5-19-	9435	908.58	933.66	923.87	933.98	0.000464	4.58	2195.7	328.16	0.23
main	3136	100-year	Existing	9435	908.58	934.67		934.9	0.000326	4.02	2717.82	329.96	0.19
main	3116	10-year	Prop 5-19-	3450	912	927.41	919.96	927.63	0.000587	3.68	936.9	151.51	0.24
main	3116	10-year	Existing	3450	912	927.68		927.86	0.000562	3.4	1015.96	154.11	0.23
main	3116	50-year	Prop 5-19-	7850	912	932.28	923.56	932.63	0.000533	4.79	1713.67	310.09	0.25
main	3116	50-year	Existing	7850	912	932.87		933.12	0.000413	4.06	2152.65	420.01	0.22
main	3116	100-year	Prop 5-19-	9435	912	933.57	925.02	933.96	0.000525	5.11	1949.8	465.03	0.25
main	3116	100-year	Existing	9435	912	934.68		934.89	0.000309	3.84	2986.73	486.64	0.19
main	3098	10-year	Prop 5-19-	3450	912.8	927.42	920.43	927.61	0.00044	3.53	976.53	159.29	0.22
main	3098	10-year	Existing	3450	912.8	927.7		927.85	0.000423	3.09	1115.47	160.3	0.21
main	3098	50-year	Prop 5-19-	7850	912.8	932.22	924.17	932.62	0.000538	5.02	1564.7	276.83	0.25
main	3098	50-year	Existing	7850	912.8	932.87		933.11	0.00037	3.88	2079.11	278.61	0.21
main	3098	100-year	Prop 5-19-	9435	912.8	933.48	924.88	933.94	0.000559	5.46	1735.99	280.27	0.26
main	3098	100-year	Existing	9435	912.8	934.65		934.88	0.000314	3.9	2606.59	341.04	0.2
main	3091.8			Bridge									
main	3087	10-year	Existing	3450	913.57	927.56	921.24	927.83	0.000598	4.13	834.91	98.66	0.25
main	3087	50-year	Existing	7850	913.57	932.57	924.51	933.07	0.000779	5.7	1376.73	121.52	0.3
main	3087	100-year	Existing	9435	913.57	934.36	925.4	934.85	0.000743	5.7	1883.63	423.93	0.29
main	3037	10-year	Existing	3450	915.4	927.21		927.49	0.000869	4.26	809.34	123.56	0.29
main	3037	50-year	Existing	7850	915.4	932.11		932.5	0.000745	5.11	1669.39	410.57	0.29
main	3037	100-year	Existing	9435	915.4	933.64		933.98	0.000561	4.89	2416.95	508.75	0.26
main	3027	10-year	Prop 5-19-	3450	915.99	926.95	923.05	927.42	0.001341	5.51	626.23	89.11	0.37
main	3027	10-year	Existing	3450	915.99	927.04	922.77	927.46	0.001214	5.26	655.83	93.42	0.35
main	3027	50-year	Prop 5-19-	7850	915.99	931.54	926.07	932.38	0.001428	7.32	1082.18	243.49	0.4
main	3027	50-year	Existing	7850	915.99	931.71	925.92	932.46	0.001248	6.98	1138.35	114.66	0.38
main	3027	100-year	Prop 5-19-	9435	915.99	932.75	926.97	933.69	0.001413	7.83	1234.08	246.77	0.41
main	3027	100-year	Existing	9435	915.99	933.08	926.8	933.92	0.001221	7.4	1296.26	115.68	0.38
main	3016	10-year	Prop 5-19-	3450	915.56	927		927.38	0.000995	4.99	691.42	91.7	0.32

main	3016	10-year	Existing	3450	915.56	927		927.38	0.000995	4.99	691.39	91.7	0.32
main	3016	50-year	Prop 5-19-:	7850	915.56	931.59		932.33	0.001104	6.92	1147.62	112.85	0.36
main	3016	50-year	Existing	7850	915.56	931.59		932.33	0.001105	6.92	1147.31	112.83	0.36
main	3016	100-year	Prop 5-19-:	9435	915.56	932.79		933.66	0.00114	7.51	1286.89	119.91	0.37
main	3016	100-year	Existing	9435	915.56	932.78		933.65	0.001141	7.51	1286.54	119.89	0.37
main	3002	10-year	Prop 5-19-:	3450	914.51	926.81	922.59	927.35	0.001379	5.92	582.98	74.31	0.37
main	3002	10-year	Existing	3450	914.51	926.81	922.59	927.35	0.001379	5.92	582.96	74.3	0.37
main	3002	50-year	Prop 5-19-:	7850	914.51	931.17	925.89	932.28	0.001808	8.46	933.71	93.22	0.45
main	3002	50-year	Existing	7850	914.51	931.16	925.89	932.27	0.001809	8.46	933.48	93.19	0.45
main	3002	100-year	Prop 5-19-:	9435	914.51	932.28	926.87	933.59	0.001934	9.2	1049	114.38	0.47
main	3002	100-year	Existing	9435	914.51	932.28	926.86	933.59	0.001935	9.21	1048.66	114.33	0.47
main	2999			Inl Struct									
main	2995	10-year	Prop 5-19-:	3450	903.67	923.91		924.11	0.000258	3.51	981.52	64.77	0.16
main	2995	10-year	Existing	3450	903.67	923.92		924.12	0.000258	3.51	982.18	64.79	0.16
main	2995	50-year	Prop 5-19-:	7850	903.67	929.19		929.71	0.000577	5.81	1351.09	75.92	0.24
main	2995	50-year	Existing	7850	903.67	929.19		929.72	0.000577	5.81	1351.13	75.92	0.24
main	2995	100-year	Prop 5-19-:	9435	903.67	930.63		931.28	0.000667	6.45	1466.43	86.63	0.26
main	2995	100-year	Existing	9435	903.67	930.63		931.28	0.000667	6.45	1466.26	86.61	0.26
main	2942	10-year	Prop 5-19-:	3450	909.64	923.43	917.93	924.04	0.001381	6.24	552.67	62.79	0.37
main	2942	10-year	Existing	3450	909.64	923.44	917.93	924.05	0.001376	6.23	553.43	62.82	0.37
main	2942	50-year	Prop 5-19-:	7850	909.64	928.39	922.32	929.6	0.001864	8.83	889.48	72.43	0.44
main	2942	50-year	Existing	7850	909.64	928.39	922.32	929.6	0.001863	8.82	889.59	72.43	0.44
main	2942	100-year	Prop 5-19-:	9435	909.64	929.74	923.5	931.15	0.002061	9.52	990.85	77.55	0.47
main	2942	100-year	Existing	9435	909.64	929.74	923.5	931.14	0.002062	9.52	990.72	77.54	0.47
main	2939			Inl Struct									
main	2934	10-year	Prop 5-19-:	3450	900.61	920.23		920.52	0.000431	4.3	802.95	52.81	0.19
main	2934	10-year	Existing	3450	900.61	920.23		920.52	0.000431	4.3	802.84	52.81	0.19
main	2934	50-year	Prop 5-19-:	7850	900.61	925.68		926.44	0.00097	6.96	1128.22	67.6	0.3
main	2934	50-year	Existing	7850	900.61	925.68		926.43	0.00097	6.96	1128.04	67.59	0.3
main	2934	100-year	Prop 5-19-:	9435	900.61	927.12		928.04	0.001126	7.69	1227.58	70.81	0.33
main	2934	100-year	Existing	9435	900.61	927.12		928.03	0.001126	7.69	1227.38	70.8	0.33
main	2790	10-year	Prop 5-19-:	3450	910	917.23	917.23	920.09	0.01163	13.57	254.33	44.48	1

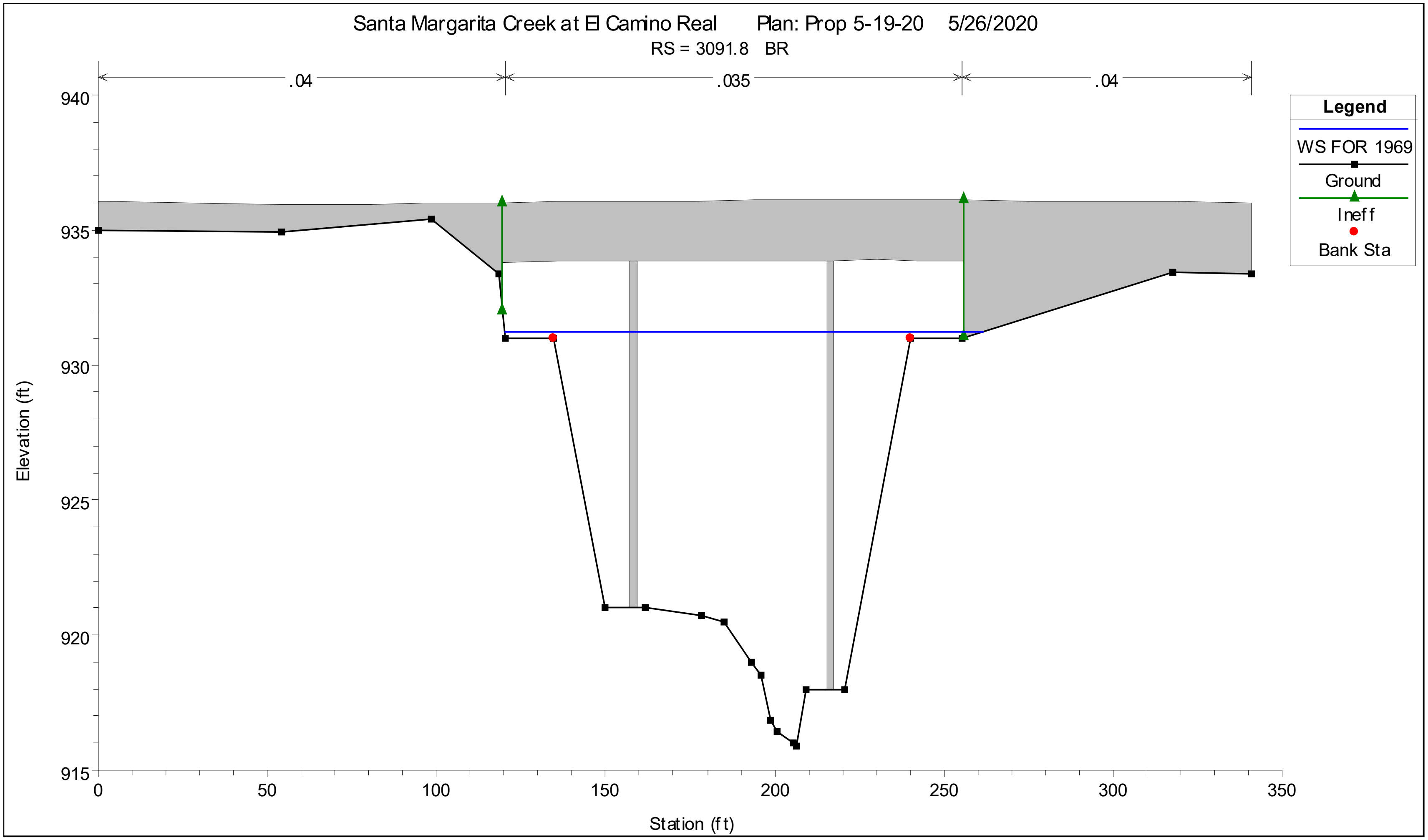
main	2790	10-year	Existing	3450	910	917.23	917.23	920.09	0.011641	13.57	254.24	44.47	1
main	2790	50-year	Prop 5-19-:	7850	910	921.71	921.71	925.78	0.010531	16.18	485.03	59.59	1
main	2790	50-year	Existing	7850	910	921.7	921.7	925.77	0.010541	16.19	484.86	59.58	1
main	2790	100-year	Prop 5-19-:	9435	910	922.95	922.95	927.33	0.010343	16.78	562.21	64.53	1
main	2790	100-year	Existing	9435	910	922.95	922.95	927.32	0.010351	16.79	562.03	64.52	1
main	2624	10-year	Prop 5-19-:	3450	906	916.15		916.74	0.002092	6.15	561.25	96.99	0.45
main	2624	10-year	Existing	3450	906	916.15		916.74	0.002092	6.15	561.17	96.98	0.45
main	2624	50-year	Prop 5-19-:	7850	906	921.13		921.84	0.001575	6.79	1155.58	138.34	0.41
main	2624	50-year	Existing	7850	906	921.13		921.84	0.001576	6.79	1155.34	138.33	0.41
main	2624	100-year	Prop 5-19-:	9435	906	922.59		923.33	0.001444	6.91	1365.73	149.18	0.4
main	2624	100-year	Existing	9435	906	922.59		923.33	0.001444	6.91	1365.46	149.17	0.4
main	2413	10-year	Prop 5-19-:	3450	906	914.77		916.04	0.004584	9.06	380.91	64.24	0.66
main	2413	10-year	Existing	3450	906	914.77		916.04	0.004585	9.06	380.9	64.24	0.66
main	2413	50-year	Prop 5-19-:	7850	906	919.17		921.2	0.00424	11.42	687.68	74.91	0.66
main	2413	50-year	Existing	7850	906	919.17		921.2	0.004241	11.42	687.62	74.91	0.66
main	2413	100-year	Prop 5-19-:	9435	906	920.45		922.7	0.004202	12.01	785.44	78.2	0.67
main	2413	100-year	Existing	9435	906	920.45		922.69	0.004203	12.01	785.37	78.19	0.67
main	1900	10-year	Prop 5-19-:	3450	904	911.82		913.39	0.005734	10.05	343.38	57.55	0.73
main	1900	10-year	Existing	3450	904	911.83		913.39	0.005733	10.05	343.4	57.56	0.72
main	1900	50-year	Prop 5-19-:	7850	904	915.81		918.52	0.006199	13.22	593.86	68.2	0.79
main	1900	50-year	Existing	7850	904	915.81		918.52	0.006196	13.22	593.97	68.2	0.79
main	1900	100-year	Prop 5-19-:	9435	904	916.9		919.98	0.00639	14.09	669.66	71.11	0.81
main	1900	100-year	Existing	9435	904	916.9		919.98	0.006388	14.09	669.74	71.11	0.81
main	1400	10-year	Prop 5-19-:	3450	898	906.8	906.8	909.38	0.011311	12.89	267.6	51.98	1
main	1400	10-year	Existing	3450	898	906.8	906.8	909.38	0.01132	12.9	267.51	51.98	1
main	1400	50-year	Prop 5-19-:	7850	898	910.75	910.75	914.5	0.010202	15.55	504.98	67.76	1
main	1400	50-year	Existing	7850	898	910.75	910.75	914.5	0.010215	15.55	504.75	67.74	1
main	1400	100-year	Prop 5-19-:	9435	898	911.85	911.85	915.94	0.009965	16.23	581.41	71.56	1
main	1400	100-year	Existing	9435	898	911.84	911.84	915.94	0.009974	16.23	581.21	71.55	1
main	901	10-year	Prop 5-19-:	3450	895	905.66		906.43	0.002334	7.02	491.25	72.55	0.48
main	901	10-year	Existing	3450	895	905.66		906.43	0.002334	7.02	491.22	72.55	0.48
main	901	50-year	Prop 5-19-:	7850	895	910.15		911.44	0.002574	9.12	861.28	93.34	0.53
main	901	50-year	Existing	7850	895	910.15		911.44	0.00257	9.11	861.69	93.39	0.52
main	901	100-year	Prop 5-19-:	9435	895	911.22		912.71	0.002643	9.81	971.75	123.89	0.54

main	901	100-year	Existing	9435	895	911.22		912.71	0.002644	9.81	971.61	123.89	0.54
main	444	10-year	Prop 5-19-:	3450	895	904.79		905.44	0.001861	6.46	533.72	76.54	0.43
main	444	10-year	Existing	3450	895	904.79		905.44	0.001862	6.46	533.66	76.53	0.43
main	444	50-year	Prop 5-19-:	7850	895	909.14		910.31	0.002213	8.7	901.9	92.88	0.49
main	444	50-year	Existing	7850	895	909.14		910.32	0.002209	8.7	902.49	92.9	0.49
main	444	100-year	Prop 5-19-:	9435	895	910.13		911.53	0.002414	9.47	996.35	96.71	0.52
main	444	100-year	Existing	9435	895	910.13		911.53	0.002416	9.47	996.18	96.71	0.52
main	7	10-year	Prop 5-19-:	3450	893	901.22	901.22	903.62	0.011278	12.43	277.46	57.99	1
main	7	10-year	Existing	3450	893	901.22	901.22	903.62	0.011289	12.44	277.37	57.98	1
main	7	50-year	Prop 5-19-:	7850	893	905	905	908.32	0.00987	14.61	537.38	79.48	0.99
main	7	50-year	Existing	7850	893	904.97	904.97	908.32	0.009979	14.67	534.98	79.24	1
main	7	100-year	Prop 5-19-:	9435	893	906.38	906.38	909.44	0.01034	14.04	671.82	110.3	1
main	7	100-year	Existing	9435	893	906.38	906.38	909.44	0.010335	14.04	671.94	110.3	1

APPENDIX E – OVERTOPPING AND FLOOD OF RECORD



As described in Appendix B, the best USGS Gage for comparison to the project is the Santa Rita Creek which had a flood of record in 1969 of 6,060 cfs. A basin transfer, as described in Appendix B was completed for this discharge which resulted in a Flood of Record at the project site of 7,332 cfs. The HEC-RAS model was re-run for this discharge which resulted in an upstream water surface elevation of 931.3 ft as shown below.



$$d_{30} = y(S_f C_S C_V C_T)\left[\frac{V_{des}}{\sqrt{K_1(S_g - 1)gy}}\right]^{2.5}$$

C_S = Stability coefficient (for blanket thickness $1.5d_{50}$ or d_{100}, whichever is greater) = 0.30 for angular rock;

C_V = Velocity distribution coefficient;

= 1.0 for straight channels or the inside of bends;

= 1.283 – 0.2 log (R_c/W) for the outside of bends (1.0 for R_c/W > 26);

= 1.25 downstream from concrete channels;

= 1.25 at the end of dikes;

C_T = Blanket thickness coefficient = 1.0;

S_g = Specific gravity of stone (2.5 minimum);

g = Acceleration due to gravity, 32.2 ft/s^2;

V_{des} = Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s;

K_1 = Side slope correction factor;

$$K_1 = \sqrt{1 - \left[\frac{\sin(\theta - 14°)}{\sin 32°}\right]^{1.6}}$$

Where:

θ = is the bank angle in degrees.

Table 873.3A

RSP Class by Median Particle Size(3)

Nominal RSP Class by Median Particle Size(3)		d_{15}		d_{50}		d_{100}	Placement
Class (1), (2)	Size (in)	Min	Max	Min	Max	Max	Method
I	6	3.7	5.2	5.7	6.9	12.0	B
II	9	5.5	7.8	8.5	10.5	18.0	B
III	12	7.3	10.5	11.5	14.0	24.0	B
IV	15	9.2	13.0	14.5	17.5	30.0	B
V	18	11.0	15.5	17.0	20.5	36.0	B
VI	21	13.0	18.5	20.0	24.0	42.0	A or B
VII	24	14.5	21.0	23.0	27.5	48.0	A or B
VIII	30	18.5	26.0	28.5	34.5	48.0	A or B
IX	36	22.0	31.5	34.0	41.5	52.8	A
X	42	25.5	36.5	40.0	48.5	60.5	A
XI	46	28.0	39.4	43.7	53.1	66.6	A

OTES:

(1) Rock grading and quality requirements per Standard Specifications.

(2) RSP-fabric Type of geotextile and quality requirements per Section 96 Rock Slope Protection Fabric of the Standard Specifications. For RSP Classes I thru VIII, use Class 8 RSP-fabric which has lower weight per unit area and it also has lower toughness (tensile x elongation, both at break) than Class 10 RSP-fabric. For RSP Classes IX thru XI, use Class 10 RSP-fabric.

(3) Intermediate, or B dimension (i.e., width) where A dimension is length, and C dimension is thickness.

Table 873.3B

RSP Class by Median Particle Weight[(3)]

Nominal RSP Class by Median Particle Weight		W_{15}		W_{50}		W_{100}	Placement
Class [(1), (2)]	Weight	Min	Max	Min	Max	Max	Method
I	20 lb	4	11	15	27	140	B
II	60 lb	14	39	50	94	470	B
III	150 lb	32	94	120	220	1,100	B
IV	300 lb	63	180	250	440	2,200	B
V	1/4 ton	110	300	400	700	3,800	B
VI	3/8 ton	180	520	650	1,100	6,000	A or B
VII	1/2 ton	250	750	1000	1,700	9,000	A or B
VIII	1 ton	520	1,450	1,900	3,300	9,000	A or B
IX	2 ton	870	2,500	3,200	5,800	12,000	A
X	3 ton	1,350	4,000	5,200	9,300	18,000	A
XI	4 ton	1,800	5,000	6,800	12,200	24,000	A

NOTES:

(1) Rock grading and quality requirements per Standard Specifications.

(2) RSP-fabric Type of geotextile and quality requirements per Section 96 Rock Slope Protection Fabric of the Standard Specifications. For RSP Classes I thru VIII, use Class 8 RSP-fabric which has lower weight per unit area and it also has lower toughness (tensile x elongation, both at break) than Class 10 RSP-fabric. For RSP Classes IX thru XI, use Class 10 RSP-fabric.

(3) Values shown are based on Table 873.3A dimensions and an assumed specific gravity of 2.65. Weight will vary based on density of rock available for the project.

Caltrans HDM Methodology

Santa Margarita @ El Camino Real	d30	br u/s	br d/s	upstream	downstream	
Hydraulic Depth	y	9.59	9.71	13.69	11.89	
Safety Factor (typically 1.1)	Sf	1.2	1.2	1.2	1.2	
Stability Coefficient	Cs	0.3	0.3	0.3	0.3	
Velocity distribution coefficient	Cv	1.25	1.25	1.25	1.25	
Blanket thickness coefficient	CT	1	1	1	1	
Specific Gravity of stone (2.5 min)	Sg	2.65	2.65	2.65	2.65	
Acceleration due to gravity	g	32.2	32.2	32.2	32.2	
Average Velocity	Vavg	7.43	7.81	5.37	7.64	
Characteristic velocity	Vdes	10.98	11.54	7.93	11.29	
Radius of curvature of bend	Rc	600	600	600	600	
Width of WS u/s channel bend	W	187.75	187.75	187.75	187.75	
	Rc/W	3.20	3.20	3.20	3.20	
	K1	0.72	0.72	0.72	0.72	
	d30	1.08	1.22	0.44	1.09	feet
	d50	1.29	1.46	0.53	1.31	feet
side slope correction factor	K1	0.72	0.72	0.72	0.72	
bank angle (degrees)	theta	33.69	33.69	33.69	33.69	1.5:1
	sin term	0.34	0.34	0.34	0.34	
	sin32	0.53	0.53	0.53	0.53	
	constants	4.32	4.37	6.16	5.35	
	numerator	10.98	11.54	7.93	11.29	
	denominator	19.13	19.25	22.85	21.30	
	d30	1.08	1.22	0.44	1.09	ft
		12.93	14.60	5.25	13.14	inches
	d50	15.51	17.52	6.30	15.76	inches
	Class	V	V	II	V	
	Size	18	18	9	18	
	1.5*d50	27	27	13.5	27	
	d100	36	36	18	36	
	Thickness	36	36	18	36	
			1/4 ton Method B			

KLEINFELDER
Bright People. Right Solutions.

April 7, 2015
File No: 20143900

Quincy Engineering
11017 Cobblerock Drive, Suite 100
Rancho Cordova, California 95670

Attention: Mr. Mario Quest

Subject: Potential Scour
El Camino Real Bridge Over Santa Margarita Creek
San Luis Obispo County, California

Dear Mr. Quest;

This letter is to confirm previous conversations between Kleinfelder and Avila & Associates regarding the potential for pier scour at the project site.

The material below about elevation 922 to 920 feet, and exposed in the channel is a massive sandstone with laterally interspersed steeply inclined conglomeratic shell beds. The test borings indicated the sandstone consistency stays relatively similar with depth.

As noted in the Draft Foundation Report, dated October 7, 2014, long-term degradation is the more significant form of scour at the site. With failure of the downstream conglomeratic shell bed, which is presently a stationary nick point, long-term degradation will likely accelerate at the bridge site. Design is considering the long-term degraded channel elevation at 903 feet (about 15 feet below the present channel).

The sandstone is a competent "soft to moderate" rock. Exposure results in a relatively slow weathering (chemical alteration) of the sandstone surface. The weathering process is likely fractions of an inch each year. The weakened and softened weathered surface of the sandstone is the material which will be subject to potential scour. As the more weathered material is transported away by channel flow, fresher sandstone which is more resistant to scour is exposed. Consequently, single event localized scour due to pier obstruction will be a function of event regularity.

Considering the apparent relative consistency of the sandstone with depth, the potential for localized pier scour would not be expected to differ as the channel degrades from the present elevation to the future design elevation. The greatest potential for localized single event pier scour would be after a prolonged drought. This would allow for the thickest development of weathered material. It is believed a very conservative estimation of a single event pier scour depth would be two (2) feet. Generally, pier scour is a function of pier width. However, at this site, the incremental increase in impinging velocity for wider piers is not going to have any significant impact on fresher sandstone. Pier scour will remove only the significantly weathered sandstone material. Consequently, the same pier scour depth should be used, regardless of

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pier width. As a note, pile capacity is essentially derived from deeper sandstone. Therefore, deviations in actual pier scour will not have significant impact on the available pile capacity.

The alluvial soil overlying the sandstone at abutments will be protected by rock slope protection (RSP). RSP designed (size and thickness) for the anticipated design flood velocity and RSP slope angle should be placed on fresh sandstone. It is recommended a toe bench be excavated two (2) feet below the alluvial/sandstone contact prior to placing the RSP.

Should there be any questions or if further information is required, please contact this office.

Respectfully,

KLEINFELDER, Inc.

REGISTERED PROFESSIONAL ENGINEER
DAVID L. PEARSON
No. 674
Exp. 12/31/15
GEOTECHNICAL
STATE OF CALIFORNIA

David L. Pearson, PE, GE
Senior Principal Geotechnical Engineer

CC. Cathy Avila, Avila & Associates.

APPENDIX H – LOCATION HYDRAULIC STUDY

LOCATION HYDRAULIC STUDY FORM cont.

Dist. 05 Co. San Luis Obispo Rte. El Camino Real P.M.

Federal-Aid Project Number: BRLS-5949(131)

Project ID 500020367 Bridge No. 49C0310

PREPARED BY:

Signature:

I certify that I have conducted a Location Hydraulic Study consistent with 23 CFR 650 and that the information summarized in items numbers ..., 8, and 9 of this form is accurate

Date

District Hydraulic Engineer *(capital and "on" system projects)*

Date 1/10/18

Local Agency/Consulting Hydraulic Engineer *(local assistance projects)*

Exp. 9/30/18

CIVIL

Is there any longitudinal encroachment, significant encroachment, or any support of incompatible Floodplain development? NO x YES

If yes, provide evaluation and discussion of practicability of alternatives in accordance with 23 CFR 650.113

Information developed to comply with the Federal requirement for the Location Hydraulic Study shall be retained in the project files.

I certify that item numbers 1, 2, 6 and 7 of this Location Hydraulic Study Form are accurate and will ensure that Final PS&E reflects the information and recommendations of said report:

Date

District Project Engineer *(capital and "on" system projects)*

Date 1/10/2018

Local Agency Project Engineer *(local assistance projects)*

CONCURRED BY:

I have reviewed the quality and adequacy of the floodplain submittal consistent with the attached checklist, and concur that the submittal is adequate to meet the mandates of 23 CFR 650

Date

District Project Manager *(capital and "on" system projects)*

Date 1/10/2018

Local Agency Project Manager *(Local Assistance projects)*

Date 2/26/18

District Local Assistance Engineer *(or District Hydraulic Branch for very complex projects or when required expertise is unavailable. Note: District Hydraulic Branch review of local assistance projects shall be based on reasonableness and concurrence with the information provided).*

I concur that the natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis

Date 2-26-18

District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding

APPENDIX I – SUMMARY FLOODPLAIN ENCROACHMENT REPORT

SUMMARY FLOODPLAIN ENCROACHMENT REPORT

Dist. __05_____Co. __San Luis Obispo County___ Rte.___El Camino Real____ K.P. ______________
Federal-Aid Project Number *(Local Assistance)*_________BRLS-5949(131)_____________________________
Project No.: ___0500020367_______________ Bridge No. __49C0310_____________________

Limits:

The County proposes to replace the existing El Camino Real Bridge (Bridge Number 49C0310) over Santa Margarita Creek and to improve the roadway approaches with FHWA funding from the federal Highway Bridge Program (HBP).

Implementation of the project will occur in two phases, so that through traffic can be maintained and at least one lane of traffic within the roadway will remain open during construction. The new bridge will be a cast-in-place (CIP) pre-stressed (PS) concrete slab type bridge, approximately 140 feet long with three unequal spans (42 feet, 58.5 feet, and 39.5 feet), and a structure depth of two feet to clear the hydraulic opening of the creek.

Due to the extensive history of scour on-site, the new bridge design includes cast-in-drilled-hole (CIDH) piles under each column extension. Given the exposed sandstone at the site, driven piles cannot be used. Installation of the CIDH piles will require contractor equipment access within the creek channel to drill these foundations. Installation of the cast-in-place pre-stressed concrete slab will require installation of temporary falsework within the creek channel.

Four sets of columns and piles will support the new structure. Two sets would be located at the existing location of the abutments on the creek banks and another two sets would be located within the creek channel. The sets in the creek channel will consist of seven two-foot-diameter columns spaced approximately eight to 10 feet apart. Each column will be supported on a four-foot CIDH pile. The abutments will be supported on two-foot CIDH piles.

Ungrouted RSP will be placed around the abutments along the banks to prevent potential erosion. Based on the current project goals and plans, RSP would be placed immediately below the bridge abutments and extend beyond the bridge rails on the northeast, northwest, and southeast banks. The RSP would range from 2.5 feet thick to 4.5 feet thick and include 0.25-ton material.

Floodplain Description:

Within the project area, Santa Margarita Creek runs in a northeasterly direction near the town of Santa Margarita in San Luis Obispo County (County) which drains an approximate 22.4-square mile basin at the bridge. The area surrounding the project site is rural. The channel near the site is approximately 105-feet from top of bank to top of bank. Depth from the top of bank to the toe is approximately 15-feet. The banks are heavily vegetated and the channel bed is composed of soft rock.

The area of the proposed bridge is within an existing FEMA Flood Zone.

		No	Yes
1.	Is the proposed action a longitudinal encroachment of the base floodplain? *The proposed bridge is not a longitudinal encroachment.*	_x_	___
2.	Are the risks associated with the implementation of the proposed action significant? *The level of risk to the floodplain of the project site is low because the action is to replace the existing bridge with a bridge that is no longer under pressure flow and will have fewer piers in the channel. This will slightly improve the hydraulics through the structure.*	_x_	___

3. Will the proposed action support probable incompatible floodplain development? _x_ ___
The proposed bridge replacement will replace an existing bridge with a bridge that is no longer under pressure flow and will have fewer piers in the channel. This will slightly improve the hydraulics through the structure and not support probable incompatible floodplain development.

4. Are there any significant impacts on natural and beneficial floodplain values? _x_ ___
The proposed construction will have only minor impact to the existing riparian habitat in the creek at the bridge site.

5. Routine construction procedures are required to minimize impacts on the floodplain. Are there any special mitigation measures necessary to minimize impacts or restore and preserve natural and beneficial floodplain values? If yes, explain. _x_ ___
Best management practices for erosion control measures should be used for proposed construction to minimize temporary impacts to the floodplain during construction.

6. Does the proposed action constitute a significant floodplain encroachment as defined in 23 CFR, Section 650.105(q). _x_ ___

7. Are Location Hydraulic Studies that document the above answers on file? If not explain. ___ _x_

PREPARED BY:

_______________________________ *Date* ______________
District Project Engineer *(capital and 'on' system projects)*

Mark L. Pavo *Date* 1/10/2018
Local Agency Project Engineer *(local assistance projects)*

CONCURRED BY:

_______________________________ *Date* ______________
District Project Manager *(capital and 'on' system projects)*

Heidi Borders *Date* 2/26/18
District Local Assistance Engineer *(Local Assistance projects)*

I concur that impacts to natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis.

[signature] *Date* 2.26.18
District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding.