APPENDIX F

Draft Hydrualic Technical Memorandum

Technical Memorandum

To: Steve Mellon, Quincy Engineering, Inc.

From: Cathy Avila, PE, Principal, Avila and Associates

Date: April 1, 2014

RE: **Hydrology and Hydraulic Analysis for the existing County Road #41 Bridge over Cache Creek, Yolo County, California**

This memo presents the preliminary results of the hydraulic analysis for the existing County Road #41 Bridge over Cache Creek. The site is located just north of the City of Rumsey, CA. The datum elevation used for this study is NAVD-88[1].

BACKGROUND

According to the Bridge Inspection Reports (Caltrans, 2010), the bridge was constructed in 1930 as a two span concrete arch bridge. When the left/south abutment was damaged in 1940, the bridge was lengthened from 216-ft to 312-ft. Abutment 3 was converted to a pier as shown in Figure 1.

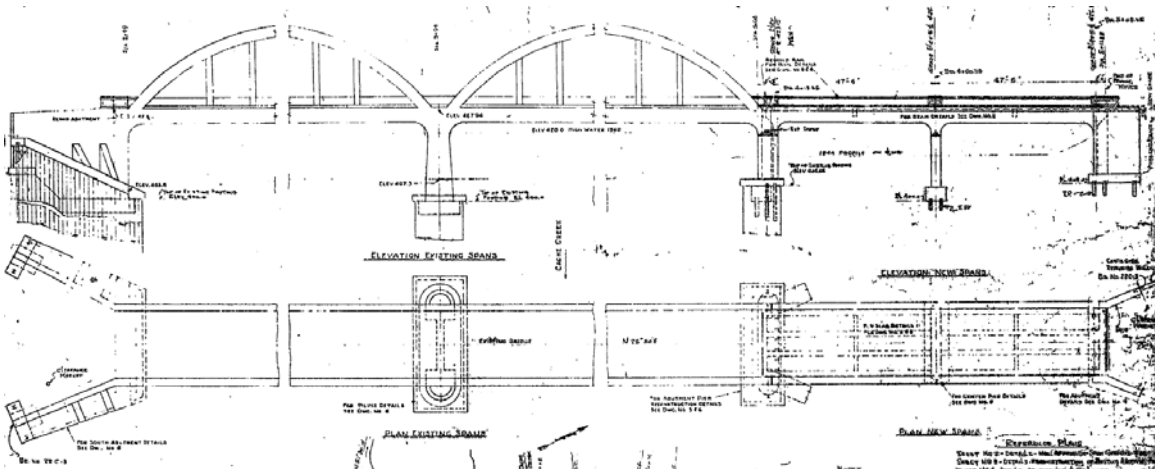


Figure 1: Bridge "as-built" plans showing original bridge on the south and lengthened bridge on the north

[1] E-mail from Jon Wheat, Survey Department Manager, Quincy Engineering Inc., to Cathy Avila, Project Manager, Avila and Associates Consulting Engineers dated 2/6/2013.

HYDROLOGY

The watershed draining to the bridge is 955 square miles. There have been numerous studies estimating the discharge at the bridge, which are summarized in Table 1. The design discharges are shown in Table 2 and details are available in Appendix A.

Table 1: Discharges estimated by other studies

	Flood of Record (1995)	Design	Base
Recurrence Interval (years)	70	50	100
nhc 1995	52,000	51,585	57,768
PHI, 2008 (Guinda)		62,647	72,252
USACOE		56,043	62,047

Table 2: Discharges used for design

	Flood of Record (1995)	Design	Base
Frequency (Years)	40	50	100
Discharge (Cubic feet per second)	52,000	56,000	62,000

HYDRAULICS

Hydraulic parameters (water surface elevations and velocity) were modeled using the U.S. Army Corps of Engineers HEC-RAS (Hydraulic Engineering Center River Analysis System) version 4.1.0 model. The model utilized data from the following sources: 1) survey information supplied by QEI on February 6, 2013, 2) as-built data provided by QEI, and 3) a field investigation conducted by Avila and Associates on January 31, 2007. Cross-sections surveyed for the HEC-RAS model are shown Figure 2:

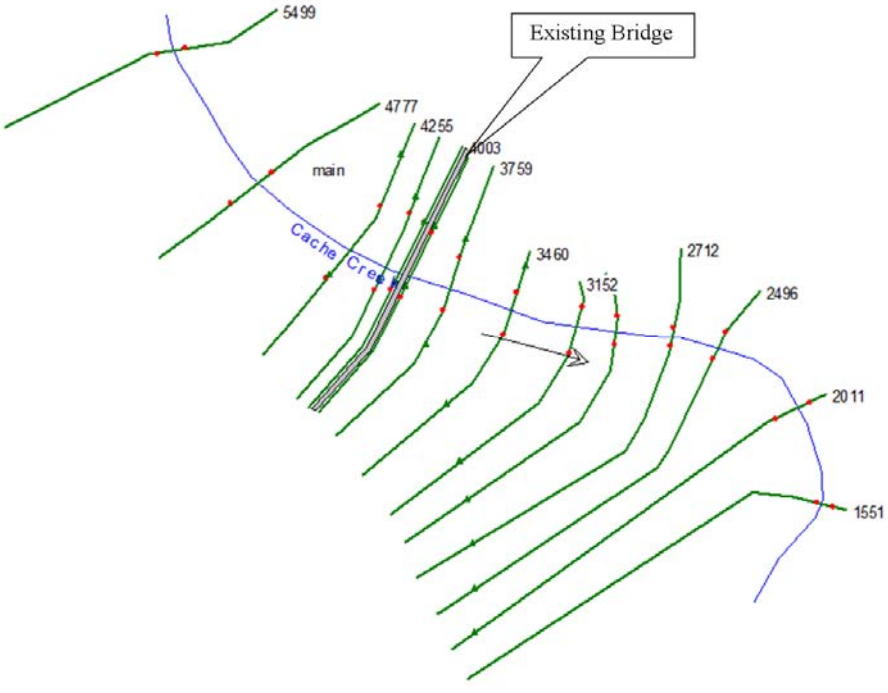


Figure 2: Plan view of HEC-RAS cross section

Existing Conditions:

Manning's "n" values of 0.035 for the channel and 0.04 for the overbanks were used in the model. These are consistent with the field reviews by Avila and Associates as shown in Figure 3. The existing bridge was input into the HEC-RAS model as shown in Figure 4. The results are shown in Table 3. The water extents for the 100-year discharge are shown in Appendix B

Figure 3: Looking at the existing bridge. The channel is sparsely vegetated

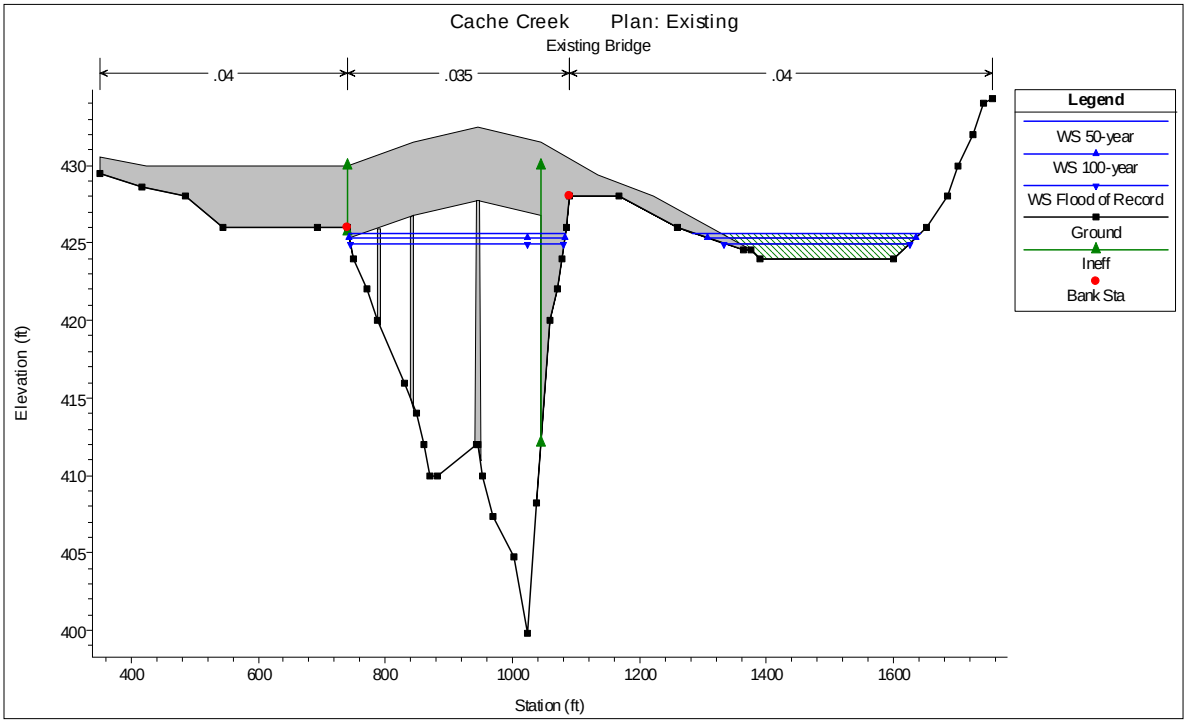


Figure 4: Existing Condition from HEC-RAS model

Table 3: Water Surface Elevation for the 50-year and 100-year discharges

Station	50-year (ft)	100-year (ft)
1551	418.2	418.5
2011	420.0	420.5
2496	421.6	422.1
2712	421.8	422.3
2971	421.6	422.0
3152	421.5	421.7
3460	420.7	423.7
3759	425.6	425.0
3951	425.9	425.6
d/s bridge 3964	425.6	425.3
u/s bridge 3988	425.7	425.3
4003	426.4	426.5
4075	427.6	428.0
4255	428.6	429.3
4777	429.1	429.9
5499	430.5	431.3

SCOUR

The bridge was rated scour critical by Caltrans as part of the National Bridge Inventory System rating of the Item 113 (Scour) in 2001. As noted in the maintenance records (Caltrans, 2010), the 1995 flood damaged Abutment 1 causing the failure of the upstream wingwall as shown in Figure 5 and almost outflanking the bridge as shown in Figure 6.

Figure 5: Wingwall prior to failure (from nhc, 1995)

Figure 6: Erosion at Abutment during March 1995 storms (photo from QEI)

A scour analysis was completed by Caltrans (2001). at which time they rated the bridge scour critical as follows:

- For the preliminary review, the critical pier was assumed to be Pier #2. According to the analysis, the existing thalweg elevation was 3-ft. lower than the bottom of the footing. This is consistent with the field observations from Avila and Associates as well as maintenance reports.

- For the detail review, Caltrans was concerned about the reliability of the bank protection at Abutment 1 due to sinking of the RSP. They were also concerned about the estimated 21-feet of pier scour at Pier #2. This estimate appears to be the maximum potential pier scour (without debris or thalweg migration) that could occur at an 8.5-ft wide pier (i.e., 2.4 times the pier width). Caltrans Structure Ratings section did not complete a stability analysis since the potential local pier scour was below the bottom of the sheet piles at Elevation 390-ft.

Degradation:

The channel sections available at the bridge for 1964 and 2001 do not indicate significant channel bed degradation as shown in Figure 7. In addition, a recent geomorphology report for the region (Kamman, 2010) that compared surveys by the USGS in 1935 to 1983 surveys by Simons Li and Associates found no significant changes at the Rumsey Bridge as shown in Figure 8.

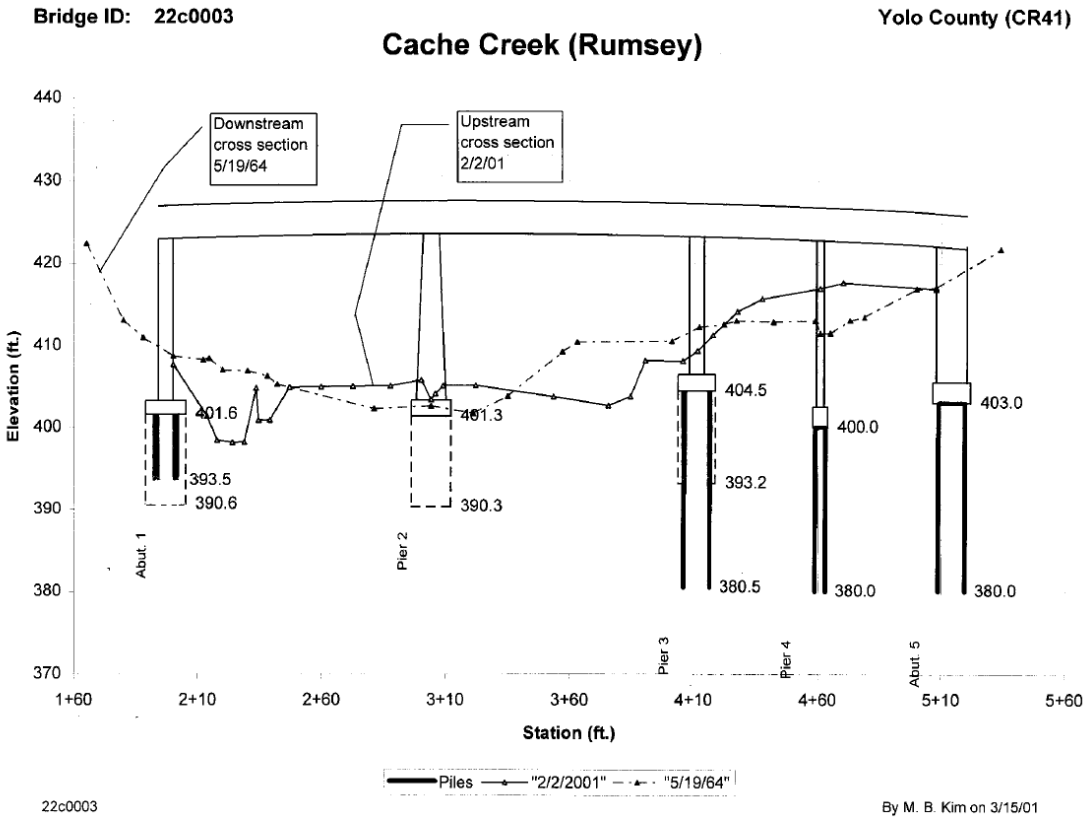


Figure 7: Channel cross sections taken over time (From Caltrans, 2010)

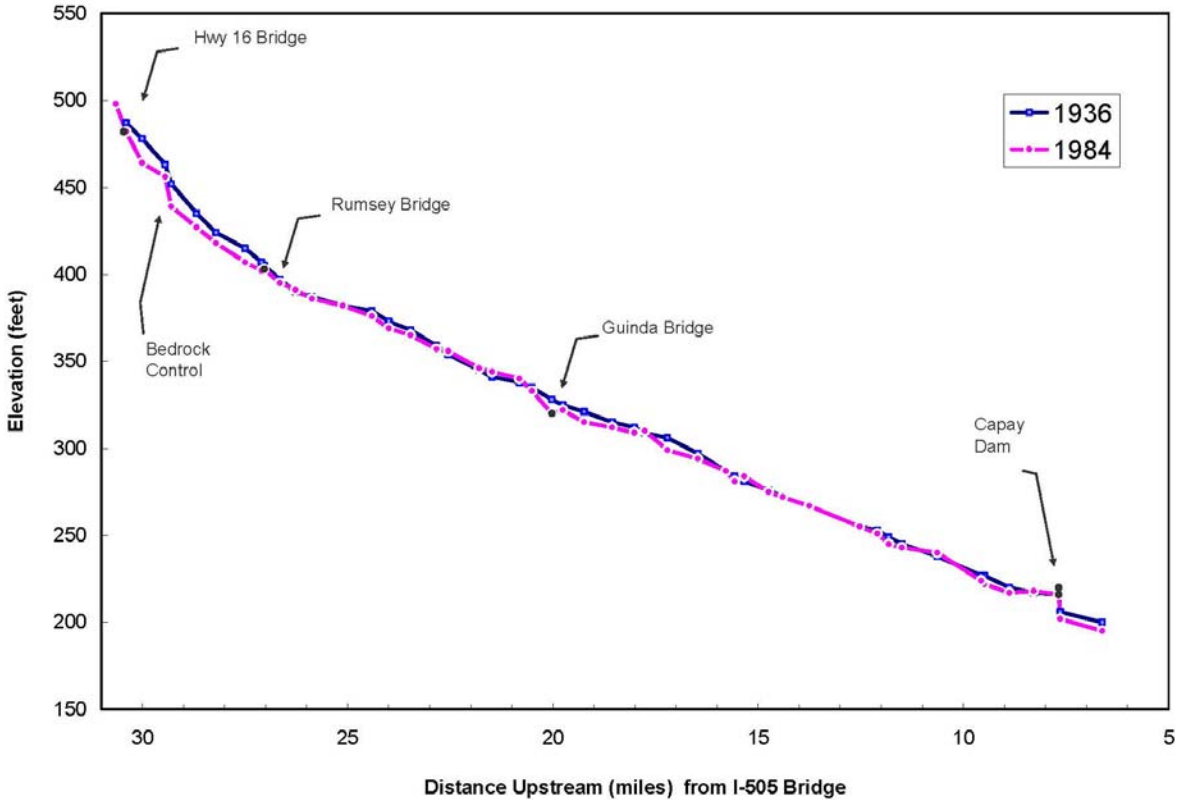


Figure 8: Longitudinal profiles from 1935 and 1983 (from Kamman, 2010)

Contraction Scour

The existing bridge and approach roadway significantly contract the waterway at the bridge which results in a contraction scour estimate of 4 feet at the existing bridge.

Local Pier Scour

Although Piers 2 and 3 are very wide (8 feet), they do not meet the definition of a "wide pier" or even a "transitional pier" under HEC-18 definitions (Arneson, 2012). Therefore, the "classic" scour equations are applicable for local pier scour depth estimates. The relatively rapid velocity (16.6 ft/s) necessitated utilizing the "maximum" pier scour of 2.4 times the pier width. Assuming no hydraulic skew, the local pier scour for the 8-foot wide pier is 19 feet. If a small hydraulic skew is assumed (15 degrees), then local pier scour is increased to 29 feet. Since there is evidence of skew at the piers based upon our field review showing debris caught on one side of the pier as shown in Figure 9, the more conservative estimate of total scour is 29 feet of local pier scour should be used or pier scour calculated additional ways using some of the latest research available for "complex piers".

Figure 9: Debris buildup at Pier 2 (from 2007 field review)

Abutment:

During the 1995 storms, the embankment fill around Abutment 1 almost washed out completely (see Figure 6). For the purposes of the abutment scour analysis, it is assumed that the downstream wingwall would also wash out if Abutment 1 were ever completely outflanked (as almost occurred in 1995). It is unlikely, however, that the outflanking would occur due to 1) the construction of a series

of bendway weirs upstream of the bridge following the 1995 storms, 2) placement of significant rock slope protection in the cavity left behind after the 1995 storms.

If the wingwall did fail, however, the abutment would act like a 4-foot wide pier supported on a 6-foot wide footing as shown in Figure 10. For this case, the local pier scour would be 10 feet assuming the footing was not exposed to the flow field, and 14 feet assuming the footing is exposed to the flow field.

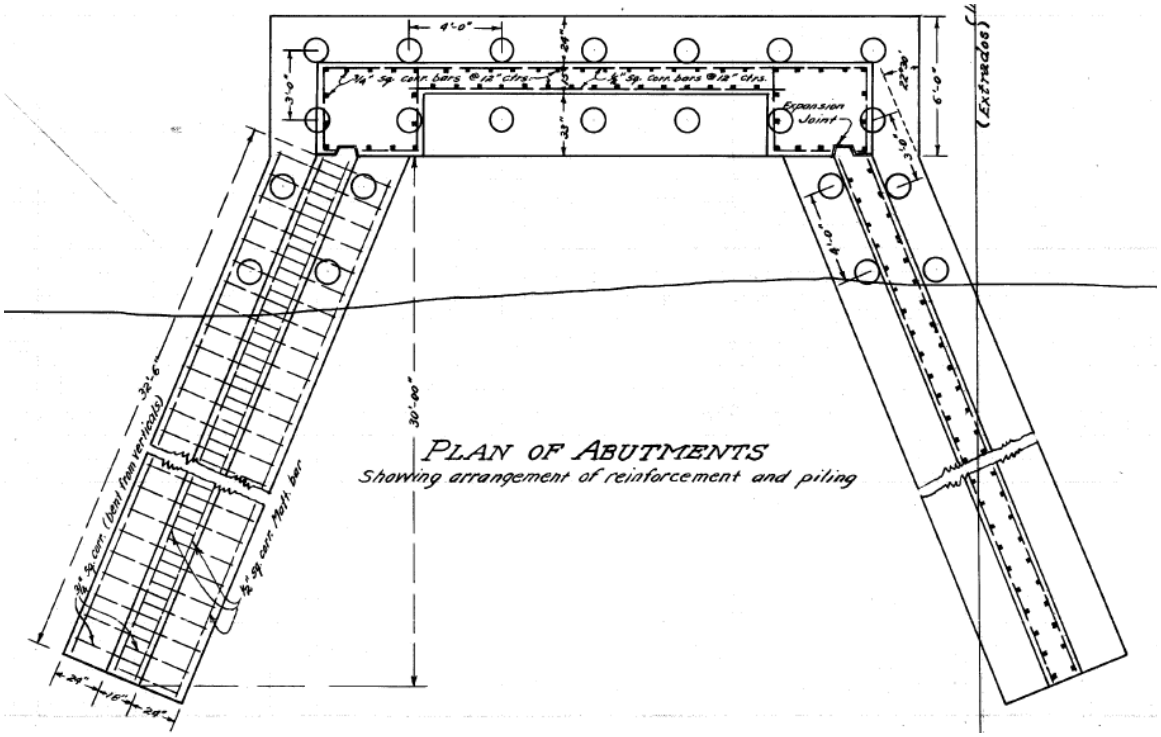


Figure 10: Abutment 1 in plan view (from as-built plans)

Past studies have estimated the scour as shown in Table 4 and Avila estimates in Table 5.

Table 4: Scour estimates from previous studies

	Local Pier Scour (ft)	Local Contraction Scour (ft)	Local Abutment (ft)
Northwest Hydraulic Consultants (1995)	13-23	1-3	13-31
Caltrans Preliminary Review (Caltrans, 2001)	20	--	--
Caltrans Detail Review (Caltrans, 2001	21	--	--

Table 5: Scour estimates from Avila

	Local Pier Scour (ft)	Local Abutment (ft)
Pier Scour	23	10-14
Contraction Scour	4	4
Degradation	--	--
Total Scour	27	18

This Technical Memorandum 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

Arneson, L.S., Zevenbergen, L.W., Lagasse, P.F., Clopper, P.E.. 2012. "Evaluating Scour at Bridges." Hydraulic Engineering Circular 18 Fifth Edition. Federal Highway Administration Report No. FHWA HIF-12-003, Washington, D.C.

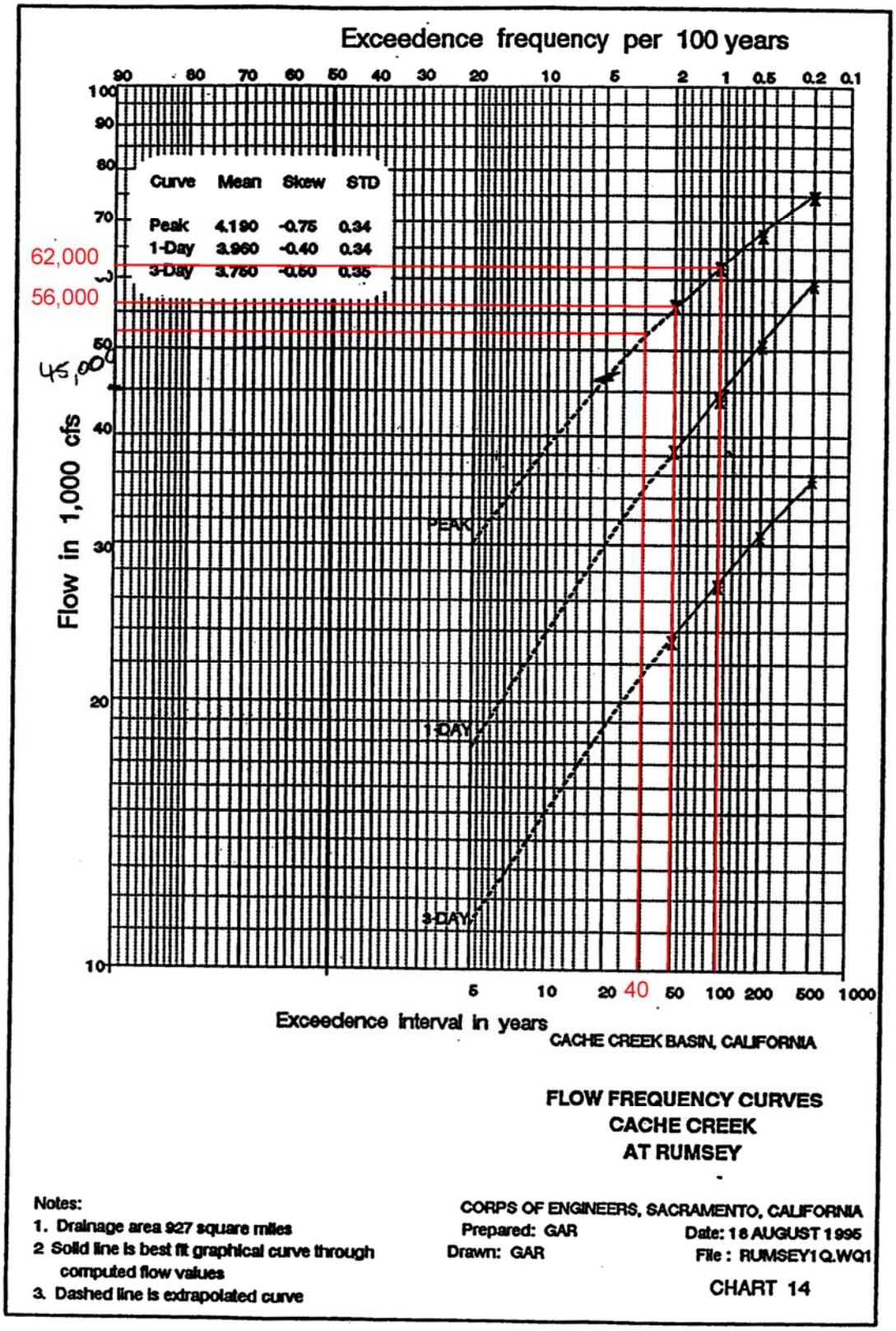
_____. Preliminary and Detail Scour Review for the E. County Road #41 Bridge over Cache Creek (Br #22C0003), 2001.

_____. Maintenance Records and As-Built Plans for the E. County Road #41 Bridge over Cache Creek (Br #22C0003), 2010.

Kamman Hydrology & Engineering, 2010. "Watershed-Based Assessment of Geomorphic Conditions in Cache Creek through Capay Valley"

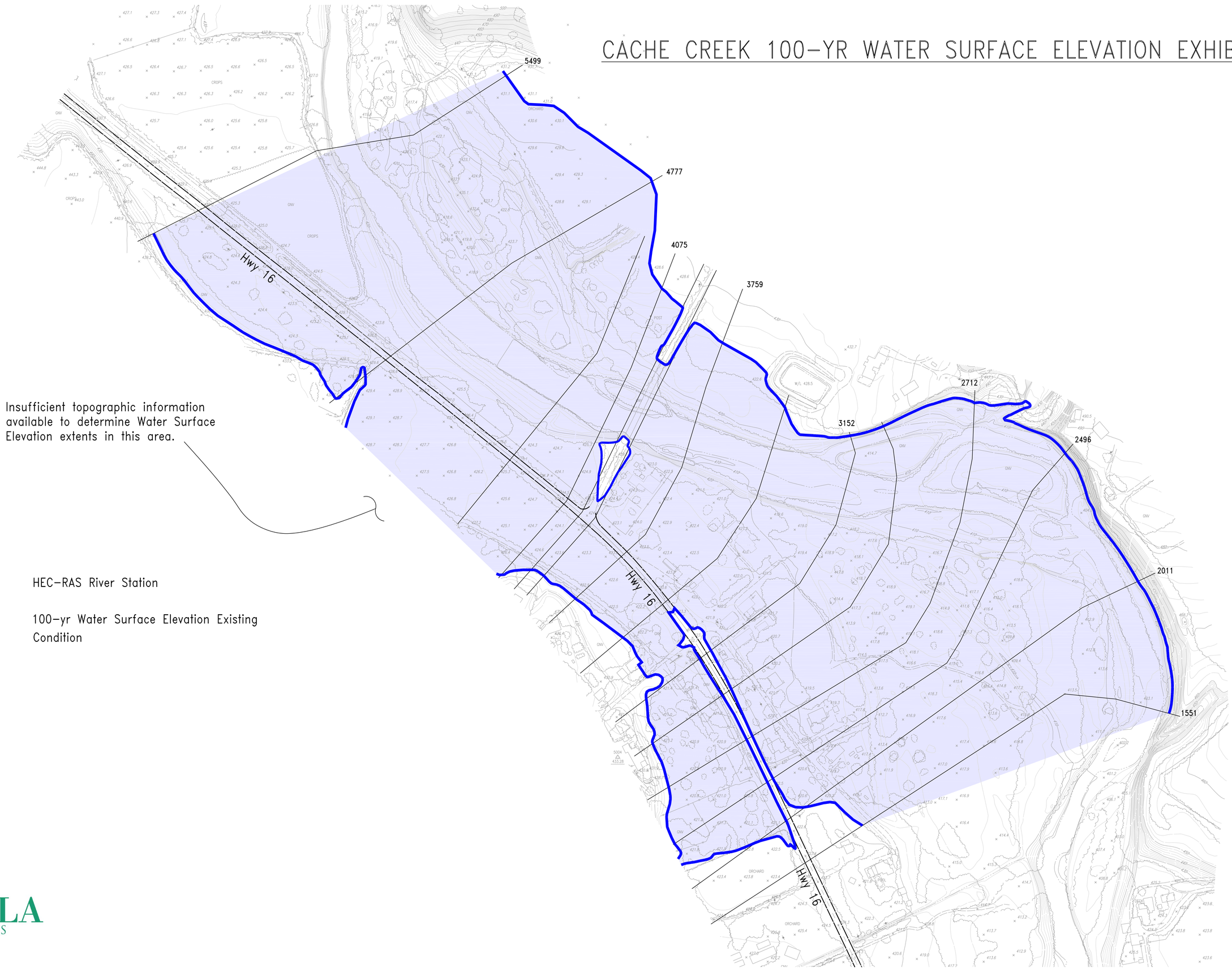
Northwest Hydraulic Consultants, October 2, 1995. "Rumsey Bridge Investigation Report" prepared for Yolo County Department of Public Works and Transportation.

Pacific Hydrologic Incorporated, November 12, 2008. "Design Hydraulic Study Bridge 22C-0074, Yolo County Road 57 "Guinda" over Cache Creek Yolo County"


Exceedence frequency per 100 years
90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1
100 90 80 70 60 50 40 30 20 10
Curve Mean Skew STD
Peak 4.190 -0.75 0.34
1-Day 3.960 -0.40 0.34
3-Day 3.750 -0.50 0.35
62,000
56,000
45,000
PEAK
1-DAY
3-DAY
Flow in 1,000 cfs
5 10 20 40 50 100 200 500 1000
Exceedence interval in years
CACHE CREEK BASIN, CALIFORNIA
FLOW FREQUENCY CURVES
CACHE CREEK
AT RUMSEY
Notes:
1. Drainage area 927 square miles
2 Solid line is best fit graphical curve through computed flow values
3. Dashed line is extrapolated curve
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: GAR
Drawn: GAR
Date: 18 AUGUST 1995
File : RUMSEY1Q.WQ1
CHART 14

APPENDIX B – EXISTING WATER EXTENTS

CACHE CREEK 100-YR WATER SURFACE ELEVATION EXHIBIT



LEGEND:

3759	HEC-RAS River Station
	100-yr Water Surface Elevation Existing Condition

AVILA & ASSOCIATES