WOOD RODGERS

TECHNICAL MEMORANDUM

TO: Michael Milczarek, Program Director, GSA

FROM: David Mueller, Wood Rodgers Inc.

DATE: June 27, 2022

SUBJECT: Technical Memo #3: Hydraulic Study, Tuolumne River at Carpenter Road

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INTRODUCTION

Wood Rodgers, Inc. (WRI) has developed a hydraulic analysis of the Tuolumne River to evaluate the existing condition and two alternatives to provide flood protection from the Tuolumne River in the vicinity of South Carpenter Road in Modesto, California. Properties considered in the analysis include the existing wastewater treatment facility (scheduled to be removed) on Sutter Avenue, the existing landfill to the east and west of Carpenter Road, and the existing Carpenter Road Bridge. **Figure 1** presents a location map of the analysis.

EXISTING FLOOD HAZARDS

Figure 2 presents the Effective Federal Emergency Management Association (FEMA) Special Flood Hazard Area (SFHA), including 1-percent annual chance flood hazard (corresponding to the 100-year storm event) Base Flood Elevations (BFE) shown on the cross sections in the vicinity of Carpenter Road. Inspection of Figure 2 indicates several areas within the SFHA Zone AE, including residential areas upstream and downstream of Carpenter Road.

<u>Effective FEMA Model</u>

WRI Obtained the Effective, unsteady-state HEC-RAS hydraulic model (FEMA Model) from *Task Order 105, FEMA 1-, 0.5 and 0.2-Percent Annual Chance (100-Year, 200-Year, and 500-Year) Floodplain Evaluation and Delineation, Addendum Final Hydraulic Analyses and Results for Tuolumne River and Dry Creek in Stanislaus County* (HDR, May 2014). This model weas developed as a part of the California Department of Water Resources (DWR), Division of Flood Management, and Federal Emergency Management Agency (FEMA) Central Valley Floodplain Evaluation and Delineation (CVFED) Program, Lower San Joaquin River System. The FEMA Model was used to determine the FEMA SFHA and associated floodplain profiles for portions of Dry Creek and Tuolumne River near Modesto, CA.

Existing Conditions Model

WRI revised the FEMA Model used in this analysis to create a combined one-dimensional (1d) and two-dimensional (2d) HEC-RAS model to evaluate the hydraulic characteristics of the Tuolumne River under existing and proposed conditions. **Figure 3** presents the revised model domain presented in the analysis.

The overall model domain remains unchanged from the FEMA Model, excepting for revisions between River Station (RS) 47858 near the upstream end of the Dryden Park Golf Course to approximately 3,250 feet downstream of the Carpenter Road Bridge, adjacent to RS 32023. The following revisions to the FEMA model between RS 47858 and 32023 were performed to develop the existing conditions model:

- Added cross sections to further define the river and overbank areas
- Added cross sections upstream and downstream of the Carpenter Road Bridge to allow for the typical four-cross-section representation of contraction and expansion losses
- Added lateral weirs at the right bank station
- Truncated cross sections to the edge of right bank
- Added a two-dimensional (2d) flow area to represent overbank flows.
- Added ineffective flow areas in cross sections immediately upstream and downstream of Carpenter Road, so as not to double count flows in the 2d areas between these cross sections
- Added a 2d-to-2d connection to represent the Carpenter Road Bridge in the 2d flow area

WRI developed the 2d mesh portion of the HEC-RAS model using available topographic data obtained from Phase I of the *Evaluation of Stormwater Management and Groundwater Recharge Projects in The Dry Creek Watershed* (GSA, 2020). Manning's 'n' values were determined by land use as shown in **Table 1**:

Table 1, Land Cover and Manning's 'n' Values

Land Cover	Manning's 'n'
Golf	0.055
WWTP	0.09
Landfill	0.09
Park/Open Space	0.055
Residential	0.085

Figure 4 presents existing condition land uses used in the development of the HEC-RAS model. The results of the existing model were used to formulate potential alternatives to reduce flood risks in the vicinity of the affected parcels, which were evaluated using the proposed conditions model. The Existing Conditions HEC-RAS model and associated topography is presented in **Figure 5.**

ALTERNATIVE 1: EXCAVATION ONLY

Based on discussions with and information provided by the City of Modesto, WRI developed potential alternatives to be considered for evaluation. Various design elements were incorporated into each alternative. Alternative 1 is defined as "Excavation Only" and includes the following design elements:

Carpenter Road Causeway

Alternative 1 includes replacement of the Carpenter Road Bridge with a causeway. The existing embankment at the north side of the Tuolumne River would be removed and replaced with an open causeway to allow for flows to pass freely through under the bridge. To represent this design element in the HEC-RAS model, the existing condition terrain was modified to remove the embankment on the north side of the bridge, and a 2d-to-2d connection was added to represent the piers that would be added in this section of the overbank.

Excavation of Existing Landfill

Based on as-built drawings and historical photos provided by the City of Modesto, the terrain was modified to remove existing material on the upstream and downstream side of the Carpenter Road Bridge. On the downstream side of the Carpenter Road Bridge the final grade was revised to approximately 54.5 feet on the high side to approximately 53.5 feet near the river. On the upstream side of the Carpenter Road Bridge, the final grade was adjusted to approximately 55 feet on the high side to approximately 54.0 feet near the river.

Excavation of Existing Levee Adjacent to Tuolumne River

Based on discussions with the City of Modesto and inspection of topographic data, an existing levee exists from the from the golf course immediately adjacent to the Wastewater Treatment Plant, to the Carpenter Road Bridge. To remove this levee/high ground and allow for flows to overtop the right bank and flow more freely through the new causeway under the Carpenter Road Bridge, the terrain was modified to remove this existing high ground immediately adjacent to the Tuolumne River. A slope of approximately 3% was applied to the ground where the levee was removed.

Removal of Wastewater Treatment Plant

Based on discussions with the City of Modesto, the existing Wastewater Treatment Plant was removed by reducing the existing high ground to approximate elevations of low points in this area.

<u>**Alternative 1 Model**</u>

It is assumed with replacement of the wastewater treatment plans and landfill that the remaining area will be used as a public park. Therefore, manning's 'n' values for overbank 2d flow areas in Alternative 1 were determined by proposed land use as shown in Table 1 and are presented in **Figure 6**. The revised topography and model schematic for Alternative 1 is presented in **Figure 7**.

ALTERNATIVE 2: EXCAVATION + SETBACK LEVEE

Alternative 2 is defined as "Excavation + Levee" and includes all the design elements in Alternative 1 plus a setback levee on the upstream and downstream sides of the Carpenter Road Bridge. The levee on the upstream side of the Carpenter Road Bridge would be constructed from Hayes Street on the upstream end and would follow John Street until Thomas Street. From Thomas Street until the Carpenter Road Bridge the levee would follow the existing levee centerline. The total length of levee on the upstream side would be approximately 5200 feet. On the south side of Carpenter Road, the levee would begin at the Carpenter Road Bridge and extend downstream for approximately 1520 feet along Robertson Road.

<u>**Alternative 2 Model**</u>

The proposed land use for Alternative 2 is shown in Figure 6, therefore manning's 'n' values for overbank 2d flow areas in Alternative 2 are unchanged from Alternative 1. The model schematic for Alternative 2 showing the terrain revisions and the location of the added levees is included in **Figure 8**.

HYDRAULIC ANALYSIS

The existing condition, Alternative 1, and Alternative 2 models were each ran with two design storm scenarios, both of which were included in the FEMA model. The 1997 storm event represents the calibrated storm event from January 3-4, 1997 and included a peak flow rate of approximately 5,115 cfs in Dry Creek and 55,800 cfs in the Tuolumne River. The 100-year storm event includes a peak flow rate of 11,585 cfs in Dry Creek and 70,000 cfs in the Tuolumne River. The downstream boundary condition is a rating curve and was also maintained from the FEMA model. The models were ran over a 10-day time period, and existing and proposed conditions results are presented herein.

<u>**Model Results - 1997 Storm Event**</u>

Figure 9 presents the maximum Water Surface Elevations (WSE) in the 1997 storm event in the channel and 2d overbank areas for the existing condition. **Figure 10** presents the Maximum WSEs in the channel and 2d overbank areas for Alternative 1 (excavation only). **Figure 11** presents the Maximum WSEs in the channel and 2d overbank areas for Alternative 2 (excavation and setback

levee). **Figure 12** presents the total decrease in maximum WSE with the implementation of Alternative 1 in the 1997 storm event. **Figure 13** presents the total decrease in maximum WSE with the implementation of Alternative 2 in the 1997 storm event. **Exhibit 1** shows the one-dimensional profile in the Tuolumne River for the existing condition and Alternatives 1 and 2 in the 1997 storm event. While the excavation, removal of levees adjacent to the Tuolumne River, and the Carpenter Road Causeway reduce the peak WSE by up to 2.1 feet in the overbank and approximately 2.1 feet in the Tuolumne River, excavation alone does not prevent flooding in residential areas on the north bank of the Tuolumne River in the 1997 storm event. Alternative 2 does provide protection of residential areas with the addition of the setback levee. The required top of levee elevation to provide 1-foot of freeboard in the 1997 storm event would be approximately 67.3 feet upstream of Carpenter Road and 65.5 feet downstream of Carpenter Road.

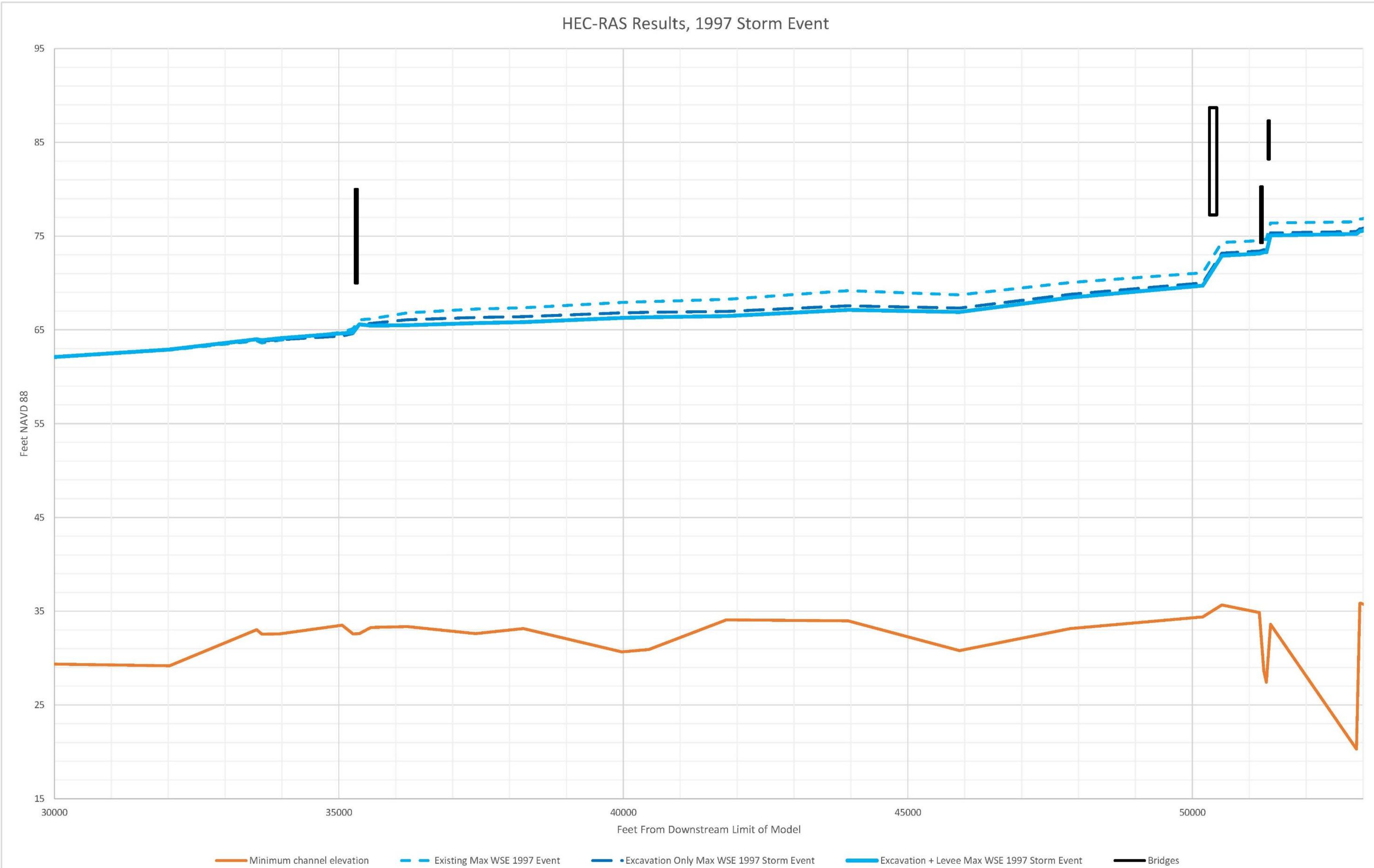

Exhibit 1, Tuolumne River Maximum WSE Profile, 1997 Storm Event

Model Results – 100-Year Storm Event

Figure 14 presents the maximum Water Surface Elevations (WSE) in the 100-year storm event in the channel and 2d overbank areas for the existing condition. **Figure 15** presents the Maximum WSEs in the channel and 2d overbank areas for Alternative 1 (excavation only). **Figure 16** presents the Maximum WSEs in the channel and 2d overbank areas for Alternative 2 (excavation and setback levee) in the 100-year storm event. **Figure 17** presents the total decrease in maximum WSE with the implementation of Alternative 1 in the 100-year storm event. **Figure 18** presents the total decrease in maximum WSE with the implementation of Alternative 2 in the 100-year storm event. **Exhibit 2** shows the one-dimensional profile in the Tuolumne River for the existing condition and Alternatives 1 and 2 in the 100-year storm event. While Alternative 1 results in a reduction of the peak WSE by up to 2.6 feet in the overbank and approximately 2.1 feet in the Tuolumne River, excavation alone does not prevent flooding in residential areas on the north bank of the Tuolumne River in the 100-year storm event. Alternative 2 does provide protection of residential areas with the addition of the setback levee. The required top of levee elevation to provide 1-foot of freeboard in the 100-year storm event would be approximately 69.3 feet upstream of Carpenter Road and 67.3 feet downstream of Carpenter Road.

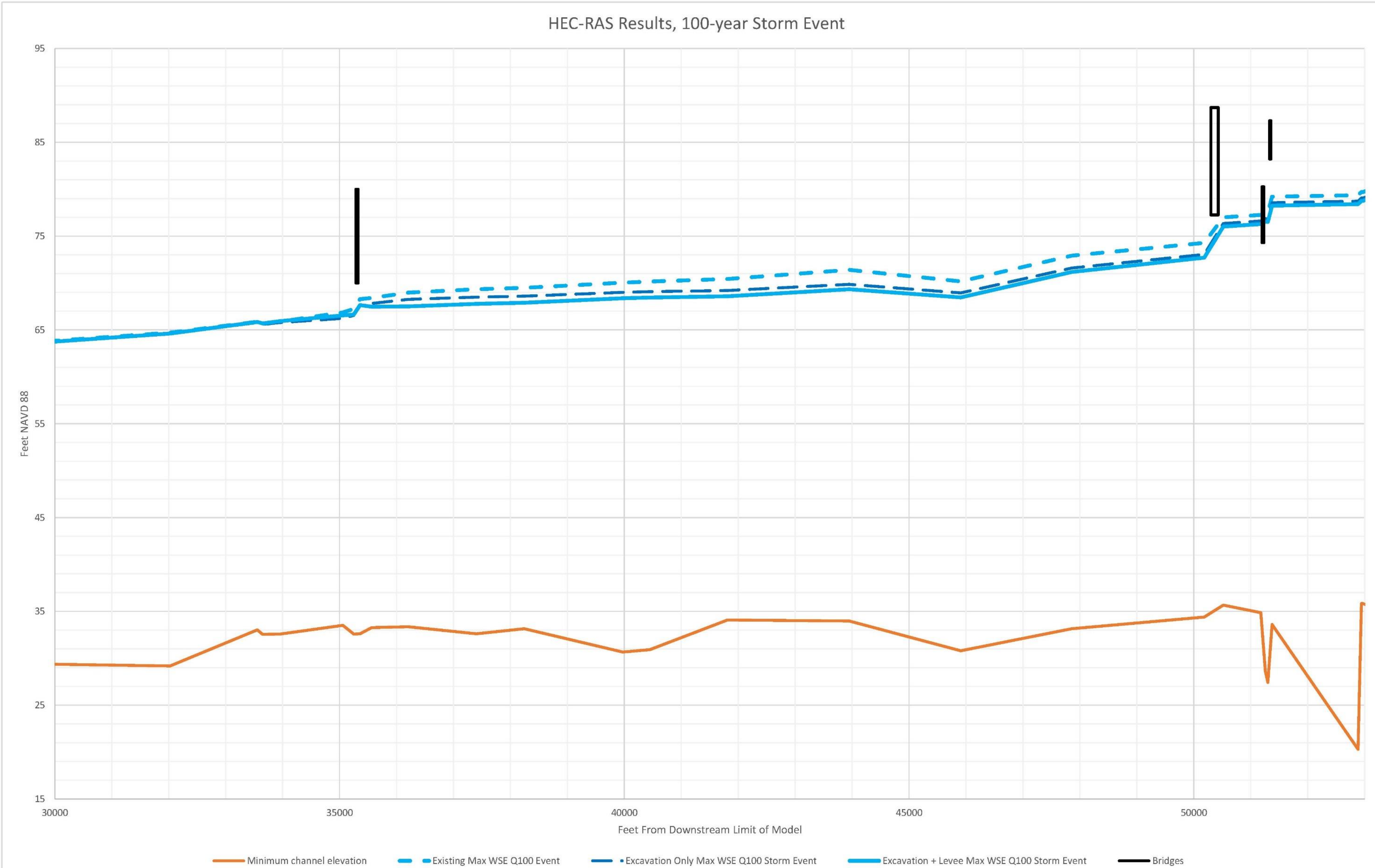

Exhibit 2, Tuolumne River Maximum WSE Profile, 100-year storm event

CONCLUSIONS

Based on the hydraulic analysis presented in this memo, excavation of the existing Wastewater Treatment Plant, landfill, removal of levees, and Carpenter Road Causeway by themselves do result in lowered peak water surface elevations in both the 1997 storm event and 100-year storm event. Combining this alternative with construction of a setback levee for approximately 1520 feet downstream of the Carpenter Road Bridge and 5200 feet upstream of the Carpenter Road Bridge does protect existing residential areas on the north side of the Tuolumne River.

Please note that Figures 12, 13, 17, and 18 indicate slight increases in peak WSE because of Alternatives 1 and 2 in both the 1997 and 100-year storm events. However, the 1d profile for these alternatives show only small increases in WSE in the 1997 storm event (See **Table 2** for 1d decreases in WSE for Alternatives 1 and 2 in the 1997 and 100-year storm events). Further evaluation is required to determine if these increases do occur, and if so, what mitigation measures may be possible if required.

Table 2, WSE Reductions, Alternatives 1 and 2

River Station	WSE Reduction			
	1997 Storm Event		100-year Storm Event	
	Alternative 1 (feet)	Alternative 2 (feet)	Alternative 1 (feet)	Alternative 2 (feet)
RS53087	1.02	1.27	0.63	0.93
RS53086	1.02	1.27	0.63	0.93
RS52970	1.04	1.29	0.64	0.94
RS52944	1.04	1.3	0.64	0.94
RS52885	1.04	1.3	0.63	0.94
RS51374	1.06	1.33	0.64	0.95
RS51302	1.1	1.38	0.65	0.97
RS51256	1.11	1.38	0.65	0.97
RS51179	1.11	1.38	0.65	0.97
RS50520	1.13	1.41	0.65	0.98
RS50183	1.09	1.36	1.23	1.57
RS47858	1.26	1.6	1.33	1.74
RS45909	1.4	1.82	1.22	1.71
RS43949	1.62	2.06	1.54	2.06
RS41811	1.29	1.79	1.23	1.85
RS40448	1.14	1.66	1.07	1.7
RS39973	1.11	1.64	1.03	1.67
RS38244	0.95	1.53	0.89	1.6
RS37403	0.9	1.49	0.84	1.57
RS36205	0.72	1.31	0.71	1.46
RS35564	0.48	0.72	0.58	0.92
RS35361	0.55	0.48	0.71	0.64

River Station	WSE Reduction			
	1997 Storm Event		100-year Storm Event	
	Alternative 1 (feet)	Alternative 2 (feet)	Alternative 1 (feet)	Alternative 2 (feet)
RS35247	0.52	0.43	0.68	0.6
RS35058	0.4	0.12	0.62	0.31
RS33957	-0.06	-0.2	0.1	-0.04
RS33647	-0.19	-0.29	-0.02	-0.12
RS33556	-0.09	-0.16	0.08	0.03
RS32023	-0.02	-0.05	0.11	0.09
RS29985	-0.02	-0.04	0.11	0.09
RS27895	-0.02	-0.04	0.1	0.09
RS25973	-0.02	-0.04	0.08	0.07
RS23986	-0.02	-0.04	0.08	0.07
RS22036	-0.02	-0.04	0.08	0.06
RS20041	-0.02	-0.04	0.07	0.06
RS18064	-0.02	-0.04	0.08	0.06
RS15966	-0.02	-0.04	0.07	0.06
RS14109	-0.02	-0.04	0.06	0.05
RS12168	-0.01	-0.03	0.07	0.06
RS9973	-0.02	-0.03	0.06	0.05
RS7830	-0.02	-0.03	0.06	0.05
RS6106	-0.01	-0.03	0.05	0.04
RS4449	-0.01	-0.03	0.03	0.03
RS2972	-0.02	-0.03	0.03	0.03
RS1635	-0.01	-0.02	0.03	0.02

ENCLOSURES

Figure 1: Vicinity Map

Figure 2: Existing FEMA SFHA

Figure 3: HEC-RAS Model Schematic

Figure 4: Existing Conditions Land Use

Figure 5: Existing Conditions Model

Figure 6: Proposed Conditions Land Use

Figure 7: Alternative 1, Excavation Only Model

Figure 8: Alternative 2, Excavation and Levee Model

Figure 9: Existing Conditions Max WSE, 1997 Storm Event

Figure 10: Alternative 1, Max WSE, 1997 Storm Event

Figure 11: Alternative 2, Max WSE, 1997 Storm Event

Figure 12: Alternative 1, Max WSE Decrease, 1997 Storm Event

Figure 13: Alternative 2, Max WSE Decrease, 1997 Storm Event

Figure 14: Existing Conditions Max WSE, 100-year Storm Event

Figure 15: Alternative 1, Max WSE, 100-year Storm Event

Figure 16: Alternative 2, Max WSE, 100-year Storm Event

Figure 17: Alternative 1, Max WSE Decrease, 100-year Storm Event

Figure 18: Alternative 2, Max WSE Decrease, 100-year Storm Event