East Fork Flood Analysis Report
March 2023

PREPARED FOR:
Flood Control Zone 9
San Luis Obispo County Flood Control & Water Conservation District
County Government Center, Rm 206
San Luis Obispo, CA 93408

COUNTY of SAN LUIS OBISPO

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Introduction

The San Luis Obispo County Flood Control and Water Conservation District, Flood Control Zone 9 (County) contracted Schaaf & Wheeler to complete a hydrologic and hydraulic analysis to investigate the cause of and possible solutions for flooding that occurs on Buckley Road at the intersection of Vachell Lane. The sources of flooding are Tank Farm Creek and East Fork San Luis Obispo Creek (East Fork), which flow parallel to and across Buckley Road and are tributaries to San Luis Obispo Creek.

Buckley Road regularly floods at the intersection of Vachell Lane during larger storm events, causing the County to close the road periodically and limiting access to the horse farm located south of the intersection. The flooding also causes damage to road asphalt and shoulders. While the East Fork was included in the City & County's Waterway Management Plan (Questa Engineering, 2003), this report expands upon the previous analysis of this specific area and utilizes updated technical methods. The study area of focus is shown in Figure 1.

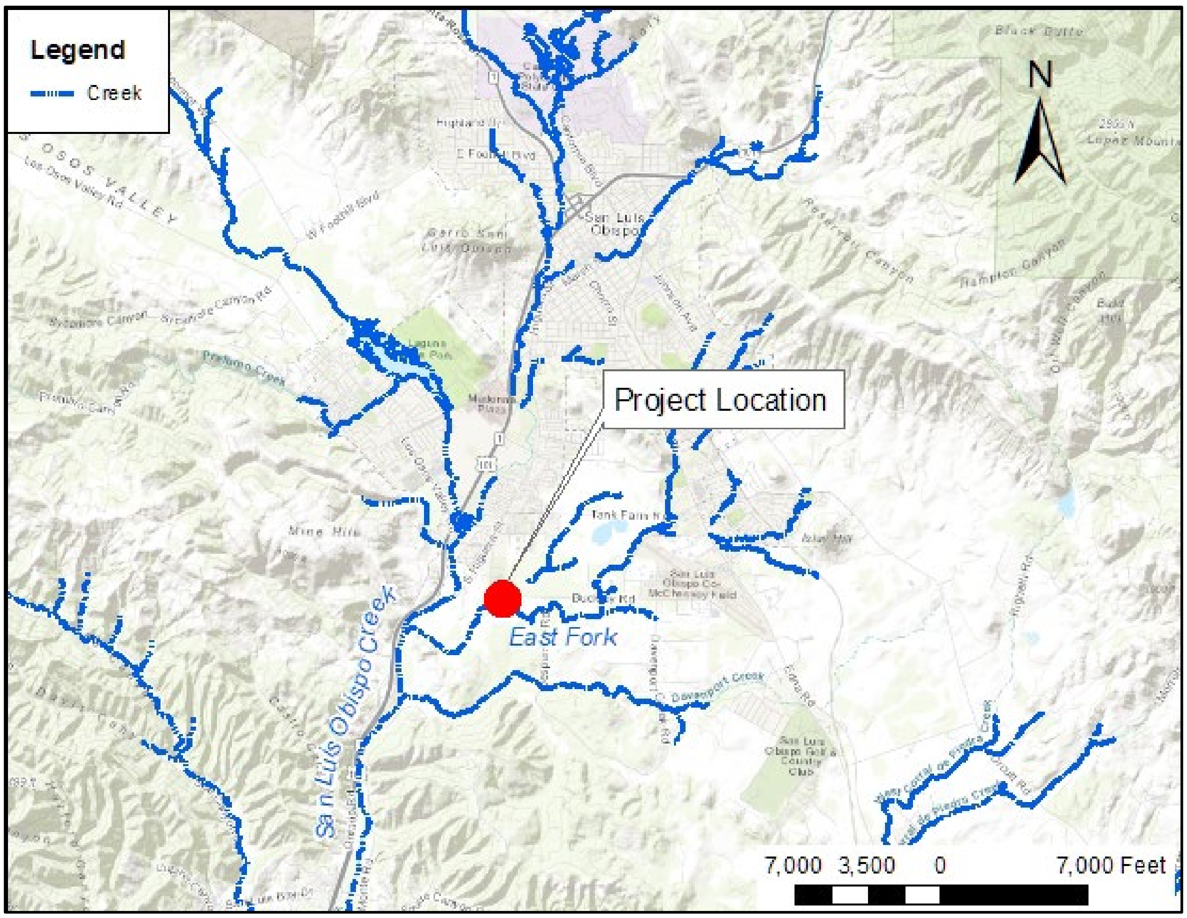

Figure 1 – Vicinity Map

Schaaf & Wheeler used data from multiple sources in this study, including field investigations, FEMA flood insurance study (FIS) data, ground survey data, LiDAR and other regional topography, regional USGS stream gage data, and previous reports by Questa Engineering and Avocet Environmental. This information was used to create a HEC-HMS hydrologic model of the East Fork watershed and a two-dimensional HEC-RAS hydraulic model of the lower East Fork.

Flood risks in the study area were evaluated for 2-year, 5-year, 10-year, 25-year and 100-year flows with both existing and near-term topographic and land use conditions. Four improvement concepts were then modeled to determine their potential benefits in reducing flooding in the project area.

History of Flooding

The East Fork watershed has experienced significant flooding over the past 50 years. The region's historic flooding events of this period include March 1995, February 1998, and December 2004, as well as recent events, like January 2019. Each of these events produced runoff that exceeded the capacity of the East Fork channel below Buckley Road. Flood impacts included road closures, property damage, and hazardous conditions for residents.

With increasing urbanization within the overall watershed and in the vicinity of Buckley Road, longstanding flood risks are becoming more noticeable. Moreover, as climate change accelerates, these events have the potential to become more severe and more frequent.

Figure 2 – January 2019 Downstream of Buckley Road

Hydrologic Analysis

This report analyzes the hydrology of the East Fork watershed in detail. The analytical methodology employed follows the standardized engineering approach of characterizing the watershed and then incorporating this information into a hydrologic model.

Watershed Characteristics

The East Fork San Luis Obispo Creek watershed is 12.3 square miles. The watershed starts in the hills east of the City of San Luis Obispo and converges with San Luis Obispo Creek downstream of the city limits. The only named tributary to East Fork is Tank Farm Creek, which has a watershed area of 1.6 square miles.

The topography of the East Fork watershed is dominated by a pattern of steep hillsides transitioning to flat valley lands. Figure 3 shows the watershed topography. This topographic regime naturally creates wetland areas that drain slowly to receiving waters. Such areas in Central California have historically been productive for agricultural uses and less desirable for urbanization, partially due to inherent flood risks.

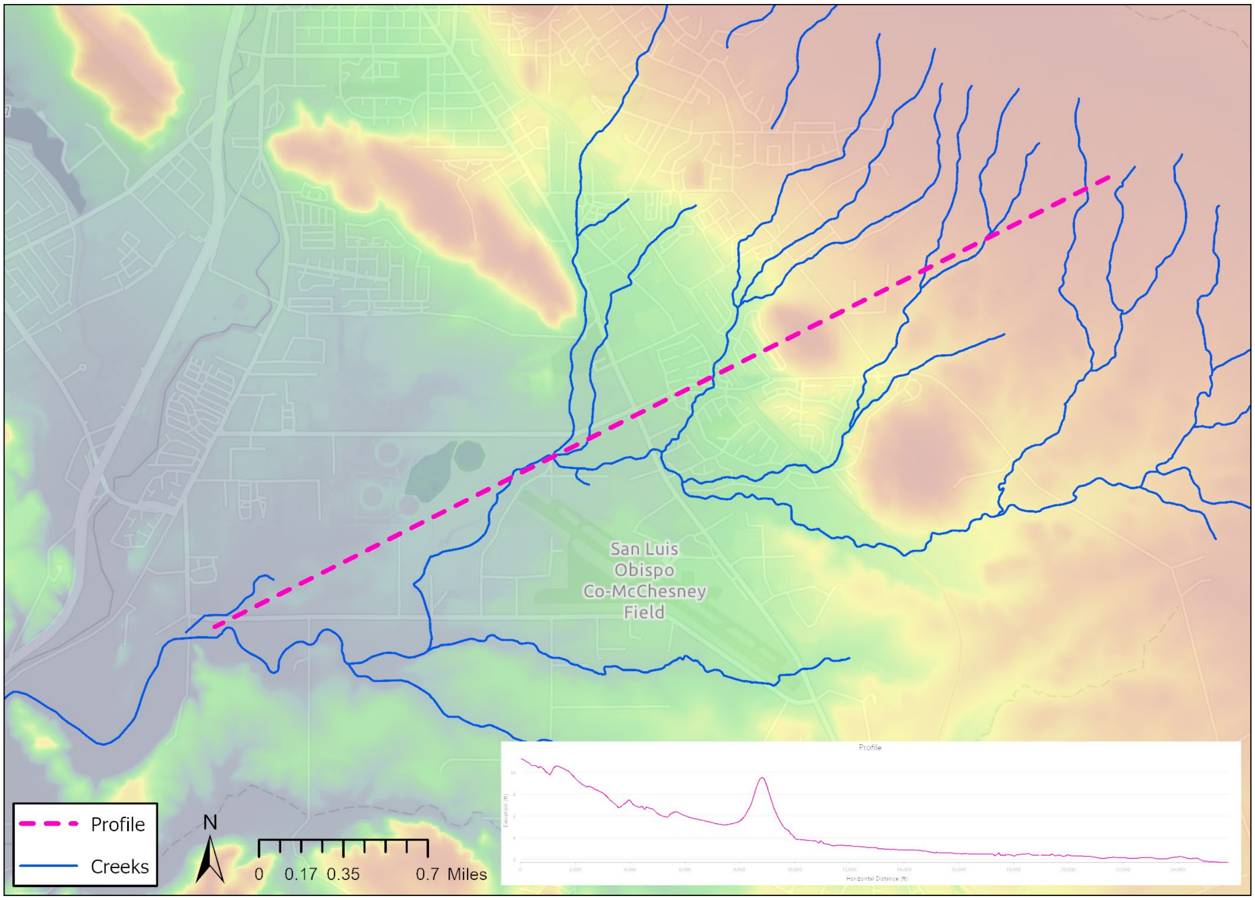

Figure 3 – Topographic Map

The upper watershed is mostly undeveloped with open space and range land. Runoff from the upper watershed is conveyed quickly through gullies and channels. Based on NRCS soils data mapping (Figure 4) the upper watershed has mostly very slow (Type D) infiltrating soils. With steep slopes and higher rainfall intensities due to orographic effects, these hills can produce sharply peaked (rapid) runoff patterns. The approximate time of concentration from the upper-most peak to Buckley Road is 2.5 hours.

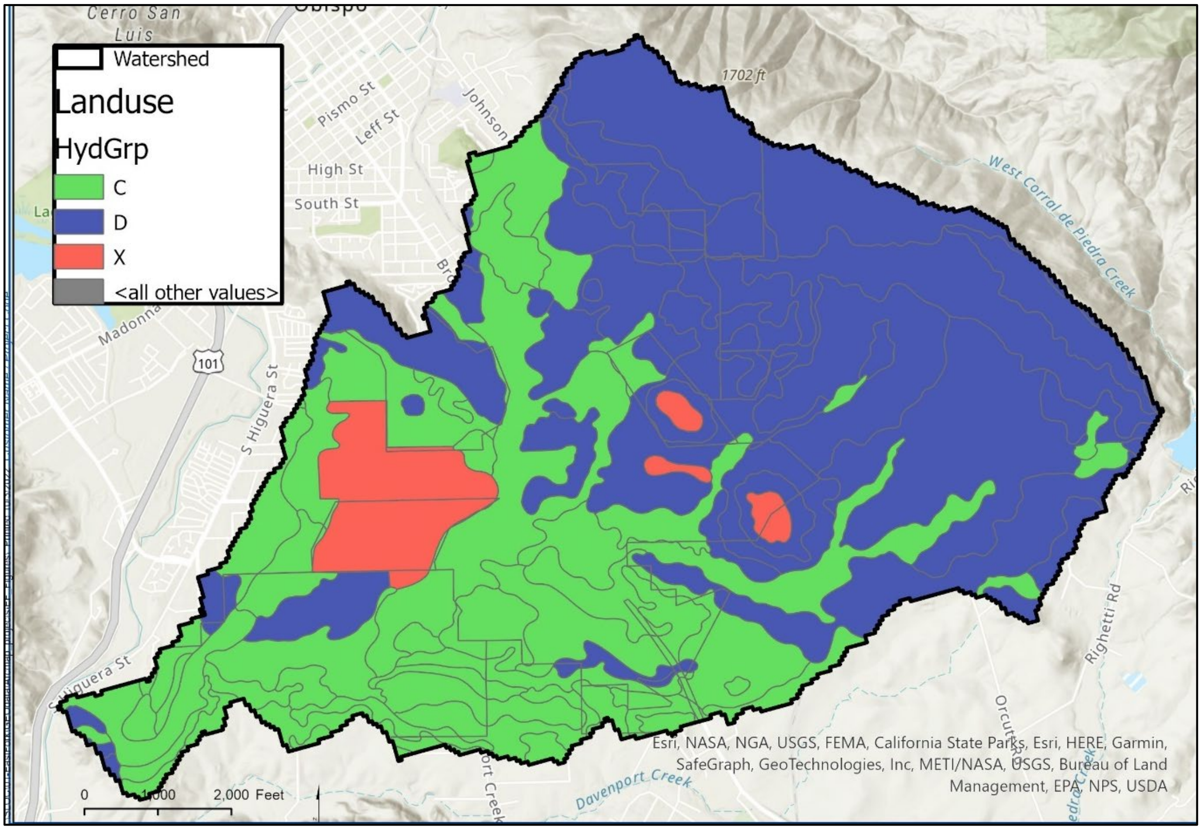

Figure 4 – NRCS Soils Map

The lower watershed is partially urbanized, mainly within the City of San Luis Obispo. The urban land uses are a combination of residential and commercial. The remainder of the lower watershed is agricultural and open space. The lower watershed is flat and has slow infiltrating (Type C) soils.

Storm hydrographs tend to attenuate within the lower watershed as the floodplains store local and upstream runoff. As flows spill from the channel, they pond along the floodplains and are slowly released back to the channels as the storm peak recedes. These floodplains are naturally occurring and can reduce downstream peak flows. The development pattern of the lower watershed has likely reduced the floodplain storage and increased peak flows over time.

The watershed's proximity to the Pacific Ocean causes higher rainfall totals than nearby watersheds to the east. Most of the total annual rainfall in the East Fork watershed occurs between November and March. Storms capable of producing flooding can occur throughout this period, as demonstrated in the history of flooding above.

It has been noted by County staff that antecedent moisture conditions in the East Fork watershed are often wet immediately prior to flood-producing rain events. Antecedent moisture conditions refer to how dry or wet the soils of a watershed are at the time of a rain event. An increase in antecedent moisture conditions can result in higher runoff due to diminished initial abstraction (reduction of absorptive capacity) in otherwise reasonably pervious (infiltrative) soils.

This concept can be explained by taking the March 1995 flood event as an example. The March 1995 storms produced an approximately 50-year flood event, the worst since the 1960s –

1970s. A 1995 report by Church and Associates, referenced in the Waterway Management Plan, analyzed data from the Cal Poly rain gage to investigate the 1995 flood events. This analysis concluded that 24-hour rainfall totals from the March 1995 storms were likely 5- to 10-year events. However, these relatively modest rainfall events still produced severe flooding.

January 1995 had been an extremely wet month, so the watershed was still wetted on a seasonal timescale going into March 1995. Furthermore, the storms of March 1995 occurred back-to-back. Although the first and second 24-hour storms produced similar amounts of rain, the worst flooding came with the second storm.

Only one other year in the Cal Poly rain gage record of over 100 years had two months as wet as January and March 1995. These wet antecedent moisture conditions caused higher runoff than would otherwise be expected, producing approximately 50-year flooding from less than 10-year 24-hour rainfall.

Hydrologic Approach

The hydrology of San Luis Obispo Creek and its tributaries (including East Fork) was previously studied by Questa Engineering as part of the expansive Waterway Management Plan (WMP) published in 2003. The WMP included a HEC-HMS rainfall-runoff model of the entire San Luis Obispo Creek watershed, which was calibrated to the March 1995 flood events with County rain and stage gage data, historical radar, and high water marks.

Following more moderate flood events from 2003 – 2005, it was observed that the WMP HMS model overpredicted flooding from recorded precipitation in these events. Questa Engineering attempted to recalibrate the model to these events but concluded that the WMP HMS model still performed poorly in predicting runoff from storm events following relatively dry antecedent moisture conditions.

Unfortunately, the period between the above efforts and preparation of this report has been dominated by drought conditions. Concerns remain that the WMP HMS model is not capable of accurately describing recent flood behavior due to the predominantly dry antecedent moisture conditions.

After reviewing the WMP HMS model and documentation, Schaaf & Wheeler concluded that it would be more efficient and technically defensible to create a new hydrologic model for the East Fork watershed rather than attempt to update the WMP model. Challenges identified with utilizing the WMP HMS model include:

- The WMP hydrologic model was developed in HEC-HMS version 2.1.3 (released 2001) and is not compatible with updated versions of the HMS software. The most recent HEC-HMS release that County staff and Schaaf & Wheeler were able to use to successfully run the WMP HMS model was version 3.2 (released 2008). As of the drafting of this report, the most recently released HMS version is 4.10 (released 2022).

- The WMP model utilized a pre-existing, now-obsolete City of San Luis Obispo Storm Drainage Master Plan’s delineation of sub-basins in the East Fork watershed. This resulted in the East Fork modeling being unnecessarily overcomplicated and difficult to adjust.

- GIS files of delineated sub-basins utilized in the WMP hydrologic analysis were never provided to the County. Questa could not locate these files upon County inquiry in 2022.

Calibration of Rainfall-Runoff Factors

General watershed rainfall-runoff behavior was calibrated utilizing long-term USGS gage records in the region. Calibration of antecedent moisture condition (AMC) using gage statistics provides a better estimate of uncertainty than the Questa approach. This does not imply that the Questa hydrology is less accurate than the new hydrology. The new approach is intended to better explore a range of storm events without biasing the results around a single event calibration.

Schaaf & Wheeler used two long-term gaged watersheds to calibrate the AMC for each storm frequency. Both the Lopez and Huasna (Figure 5) watersheds are undeveloped and have 55 and 63 years of records respectively. USGS StreamStats flow frequency statistics were utilized. USGS StreamStats also provided the estimated imperviousness of each watershed.

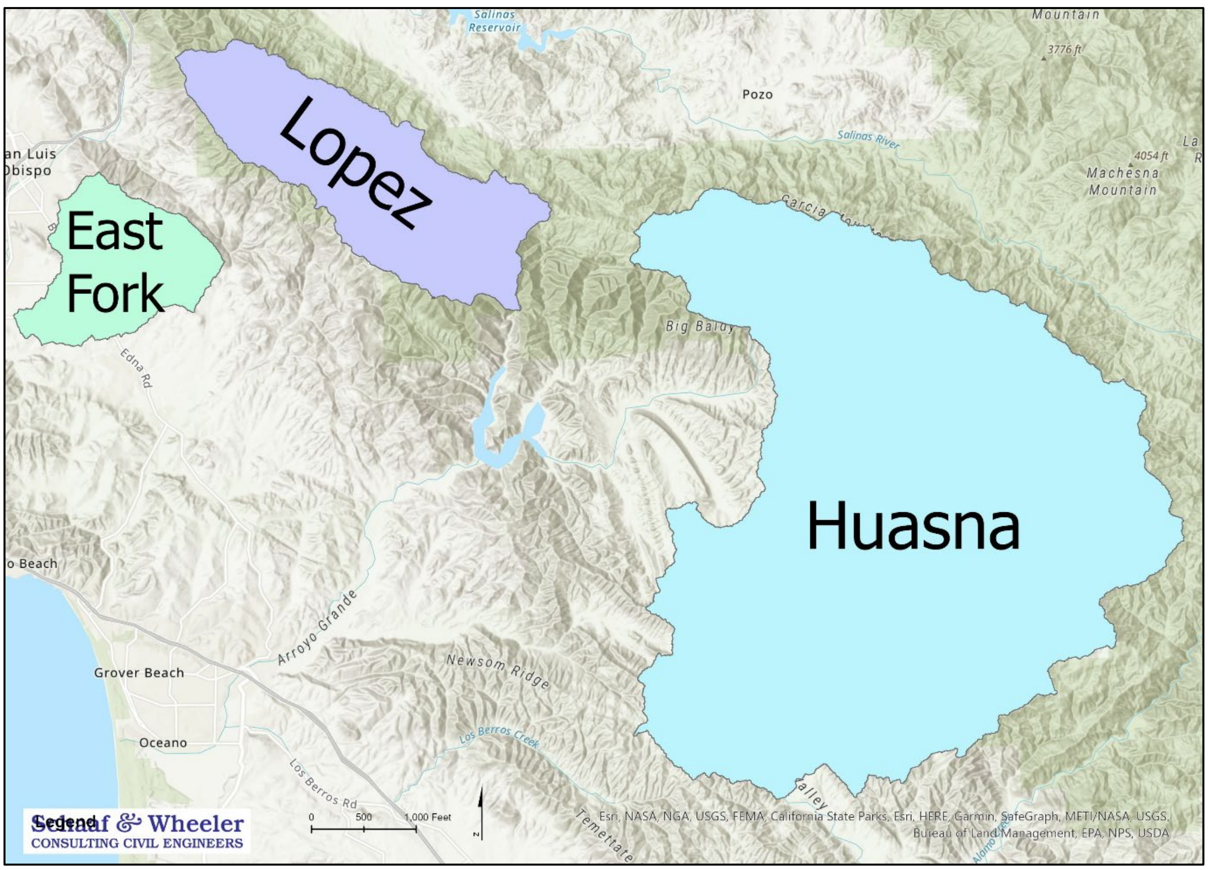

Figure 5 – Gaged Watersheds

A HEC-HMS model of each gaged watershed was developed. Hydrologic parameters were determined with readily available data and appropriate methods.

Topography was based on FEMA/USGS DEM (1 meter, 2017) and used for lag time calculations. The design rainfall patterns for each storm frequency match the WMP 24-hour calibration pattern (HYDRO-35, Fredrick, Myers, and Auciello, 1977) for East Fork. Precipitation depths were identified from NOAA Atlas 14 estimates.

Basin lag was estimated with the lag equation from the Santa Clara County Drainage Manual developed by Schaaf & Wheeler in2006:

$$t_{lag} = (0.862)\, 24\, N \left(\frac{L\, L_c}{\sqrt{S}} \right)^{0.38} - \frac{D}{2} \qquad (4\text{-}1)$$

Where	t_{lag}	=	SCS basin lag (hours)
	N	=	watershed roughness value (dimensionless)
	L	=	longest flow path from catchment divide to outlet (miles)
	L_c	=	length along flow path from a point perpendicular with the basin centroid to its outlet (miles)
	S	=	effective slope along main watercourse from Chapter 3 (feet/mile)
	D	=	duration of unit hydrograph (hours)

The calculated lag values were compared to estimates using other lag equations, including TR55, Alameda County, Snyder, and the procedure utilized in the WMP, and deemed acceptable for use.

The HEC-HMS models of the gaged watersheds utilize the NRCS Unit Hydrograph loss and transform methods. This method requires determination of curve numbers (CNs).

The CN for a given basin is estimated as a function of hydrologic soil group, land use, and antecedent moisture condition (AMC), with AMC defined as the moisture content of a soil prior to any precipitation event. The AMC generally varies depending on the severity or recurrence interval of a given storm. AMC is characterized by the NRCS as:

AMC I	soils are dry
AMC II	average conditions
AMC III	heavy rainfall, or light rainfall with low temperatures; saturated soil

CNs vary from 0 to 100, with 0 equating to no runoff from a basin and 100 indicating that all precipitation will run off. USDA-NRCS Technical Release 55 (TR-55) Urban Hydrology for Small Watersheds was used to determine CNs for various land uses depending on soil type for a range of AMCs. Soil hydrologic groups for the watershed were obtained from the NRCS Web Soil Survey and land uses were based on County land use data.

Peak flows generated by each gaged watershed HEC-HMS models for various AMCs at the gage location were then compared to peak flows estimated by the flood-frequency analysis of that gage. The AMC corresponding to the closest match in runoff was identified for each storm event. It is critical to note that the resulting calibrated AMC only applies to the specific rainfall pattern, storm frequency, precipitation data, and loss and transform methods used in this analysis. In other words, if revisions to this analysis were to modify the rainfall pattern or lag equation, the AMC should be recalibrated.

Table 1 summarizes the results of this AMC calibration analysis.

Table 1: Results of AMC Calibration

Recurrence Interval	Lopez Creek		Huasna Creek	
	FFA Peak Flow (cfs)	Assigned AMC	FFA Peak Flow (cfs)	Assigned AMC
100-Year	3,880	I.5	12,700	I.75
25-Year	2,390	I.5	7,420	I.75
10-Year	1,520	I.5	4,500	I.75
5-Year	930	I.5	2,640	I.75
2-Year	335	I.5	869	I.5

The calibrated AMCs for Lopez Creek are similar to but slightly lower than Huasna Creek. The Lopez Creek watershed is closer in size and location to East Fork than the Huasna Creek watershed and is more likely to be an appropriate proxy for the East Fork watershed. This calibration indicates that utilizing an AMC of I.5 for analysis of the East Fork watershed is expected to produce the most accurate hydrologic modeling.

HEC-HMS Model

A hydrologic model of the East Fork watershed was developed using HEC-HMS version 4.8. This model was utilized to generate runoff hydrographs for subbasins within the overall East Fork watershed for later incorporation as inflows into a hydraulic model of the core study area.

Subbasin Delineation

The East Fork watershed was broken up into five catchments based on key hydrologic features. These areas are shown in Figure 6 and are designated as Upper Buckley, Airport, Tank Farm, Lower East Fork, and Buckley to Tank Farm.

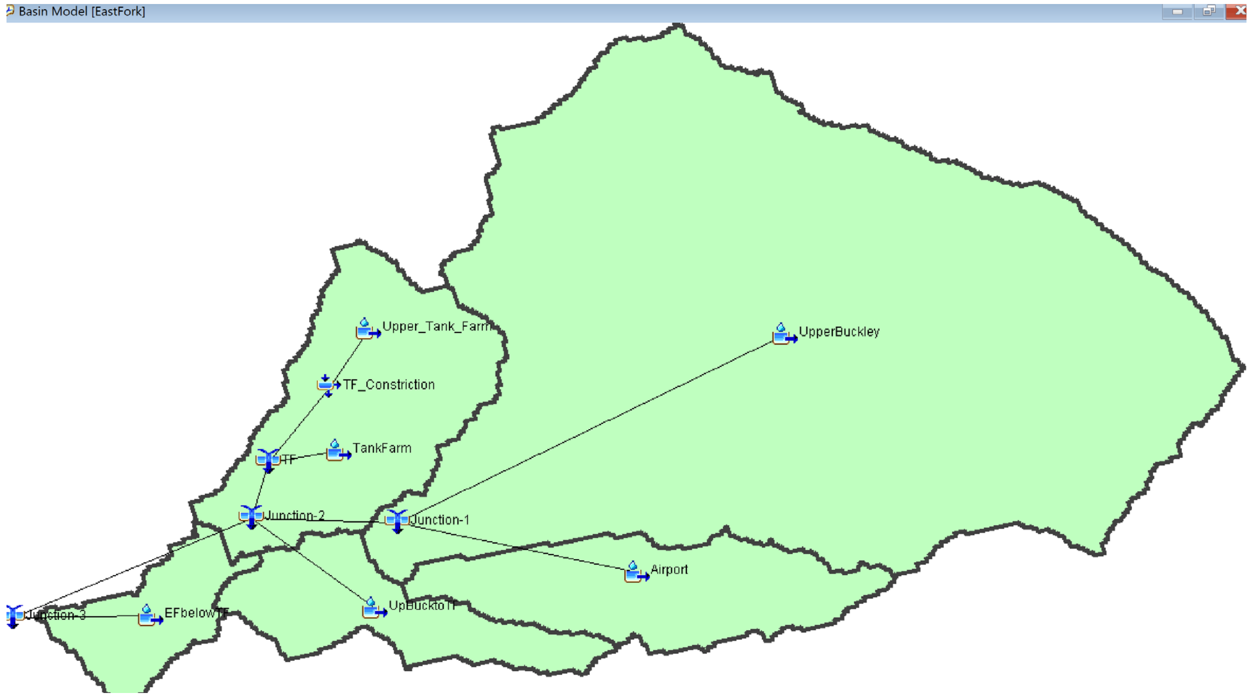

Figure 6 – HEC-HMS Basin Model Schematic

The Tank Farm catchment is the most complex and includes several structures that limit flows through culverts and storage areas. The Tank Farm watershed was studied by Avocet Environmental in "Revised Hydrology Study: Former San Luis Obispo Tank Farm" dated August 13, 2014. This study determined that the maximum flow from the upper reaches of the watershed was 81 cfs with the lower system being unlimited.

The HMS model includes an Upper Tank Farm catchment that passes through a diversion that limits downstream discharges to 81 cfs. The resulting restructured hydrograph is combined with the lower Tank Farm area flows to form a single hydrograph for inflows into the hydraulic model area.

Model Methodology and Parameters

The East Fork HMS model was structured similarly to the calibration models detailed above.

The design rainfall patterns for each storm frequency match the WMP 24-hour storm pattern (HYDRO-35, Fredrick, Myers, and Auciello, 1977) for East Fork. Precipitation depths were identified from NOAA Atlas 14 estimates at centroids of the each catchment.

Subbasin lag times were estimated with the lag equation from the Santa Clara County Drainage Manual. Topography used for lag time calculations was based on FEMA/USGS DEM (1 meter, 2017).

The NRCS Unit Hydrograph method was used for subbasin loss and transform. To calculate CNs, soil hydrologic groups for the watershed were obtained from the NRCS Web Soil Survey (Figure 4), and land uses were based on County and City land use data (Figure 7).

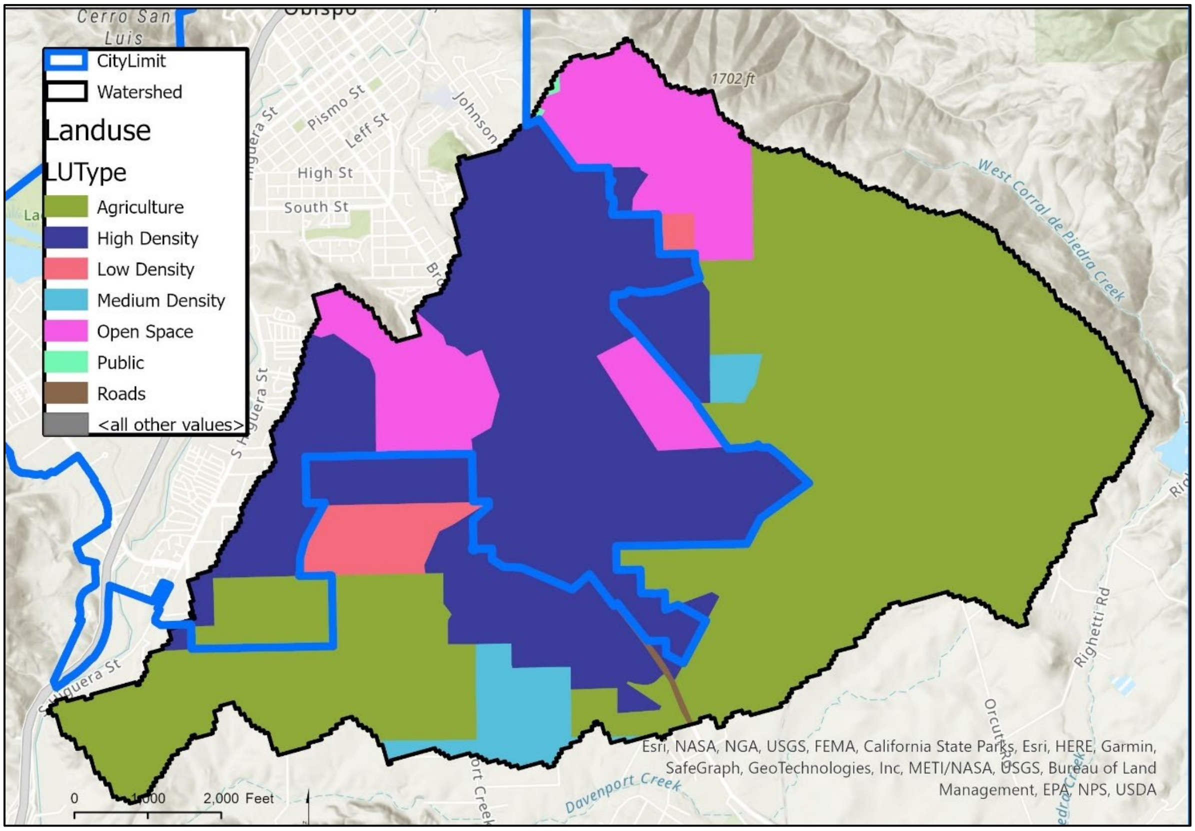

Figure 7 – Land Use Map

Per the calibration above, NRCS CNs were calculated for AMC 1.5. CNs were also calculated for AMC III to evaluate conditions more like those used to calibrate the WMP.

Table 2 summarizes NRCS CNs for an AMCs I.5 and III used to calculate CNs for each catchment. Areas without a defined soil group were assumed to be Type D.

Table 2: NRCS Curve Numbers

Land Use	Impervious %	AMC I.5 Soil Group			AMC III Soil Group		
		C	D	Unknown	C	D	Unknown
High Density	70	71	76	76	91	93	93
Medium Density	50	71	76	76	91	93	93
Low Density	40	71	76	76	91	93	93
Open Space	2	62	72	71.5	86	91	91
Public	2	62	72	71.5	86	91	91
Road	98	71	76	76	91	93	93
Manufacturing	80	71	76	76	91	93	93
Commercial	80	71	76	76	91	93	93

Table 3 lists the resulting CNs for each catchment under AMC I.5 and III conditions.

Table 3: Catchment Loss Parameters

Catchment	Impervious %	AMC I.5 CN	AMC III CN
Upper Buckley	26.7	61.4	86.1
Airport	23.4	58.4	84.4
Upper Tank Farm	30.3	68.6	88.6
Tank Farm	41.8	70.3	82.1
Buckley to Tank Farm	12.4	52.2	79.2
Lower East Fork	3.5	48.2	74.2

No hydrologic routing was performed in the HMS model as the unsteady two-dimensional hydraulic model will more accurately route the runoff from each basin through the study area.

Results

Peak flows generated by the East Fork HMS model are listed in Table 4. The 2-, 5-, 10-, 25- and 100-year events were modeled with the calibrated soil moisture condition of AMC I.5. The 10-year event with an AMCIII was also modeled to compare against WMP values from the East Fork watershed.

Table 4: Hydrology Results (cubic feet per second)

Catchment	2-year	5-year	10-year	25-year	100-year	10-year AMCIII
Upper Buckley	870	1,340	1,760	2,350	3,310	3,220
Airport	100	150	200	280	420	460
Tank Farm	190	230	270	320	400	310
Buckley to Tank Farm	20	30	40	70	110	160
Below Tank Farm	4	5	9	19	40	76

Hydraulic Analysis

Hydraulic Features

The core intent of this study is to better understand the floodplains and flood risks in the lower East Fork watershed. The existing system is comprised of a natural earthen channel with several bridge and culvert crossings (Figure 8). Below the confluence with Tank Farm Creek the natural channel and floodplain is artificially constrained by a private, non-engineered levee system.

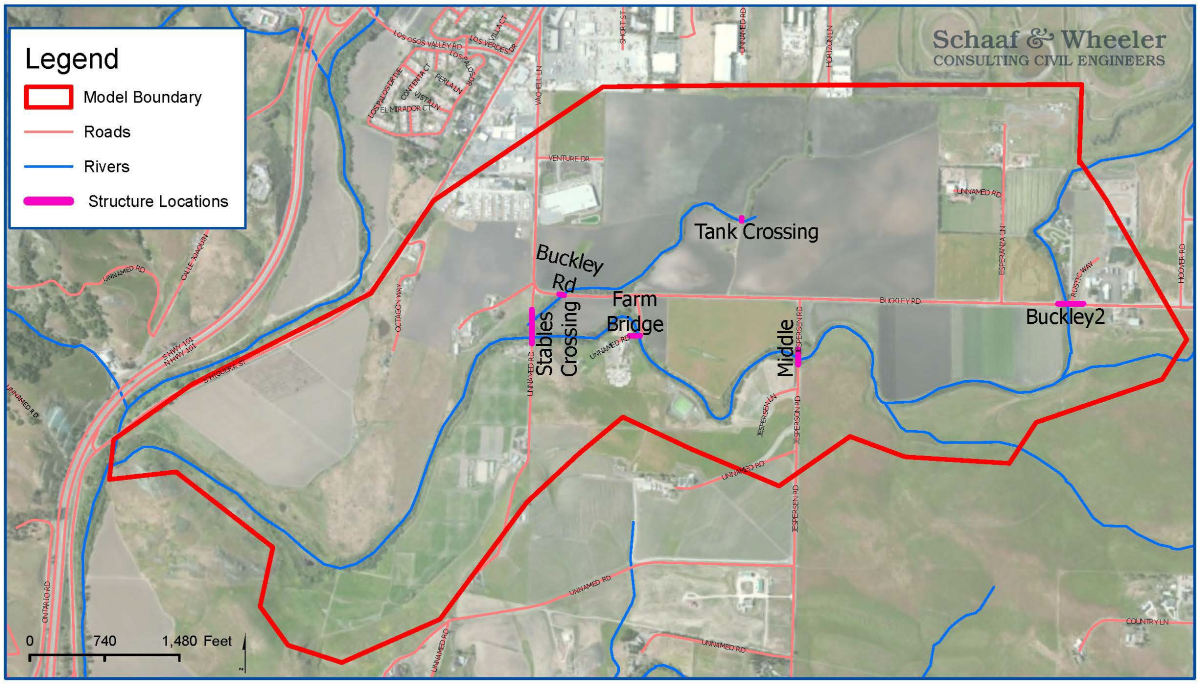

Figure 8 – Hydraulic Structure Locations

There are seven key channel crossings throughout the hydraulic study area. The East Fork crossings analyzed are Buckley Road, Jesperson Road, a private farm bridge, and a private road leading to horse stables. The channel crossings on Tank Creek Farm include Buckley Road, a private farm crossing, and a private road leading to horse stables.

The private road leading to horse stables crosses both Tank Farm Creek and East Fork just upstream of their confluence. This study utilizes modern hydraulic modeling software to provide a better understanding than previous studies of how the channel, crossings and levees interact during storm events.

HEC-RAS Model

A two-dimensional hydraulic model of the project area was developed using HEC-RAS Version 6.2. HEC-RAS is hydraulic modeling software developed by the U.S. Army Corps of Engineers. Modeling parameters include boundaries, inflow hydrographs, the downstream boundary condition, geometry (bridges, culverts, levees, and ground surface terrain), and Manning's n values. Figure 9 provides an overall schematic view of the model with surrounding topography.

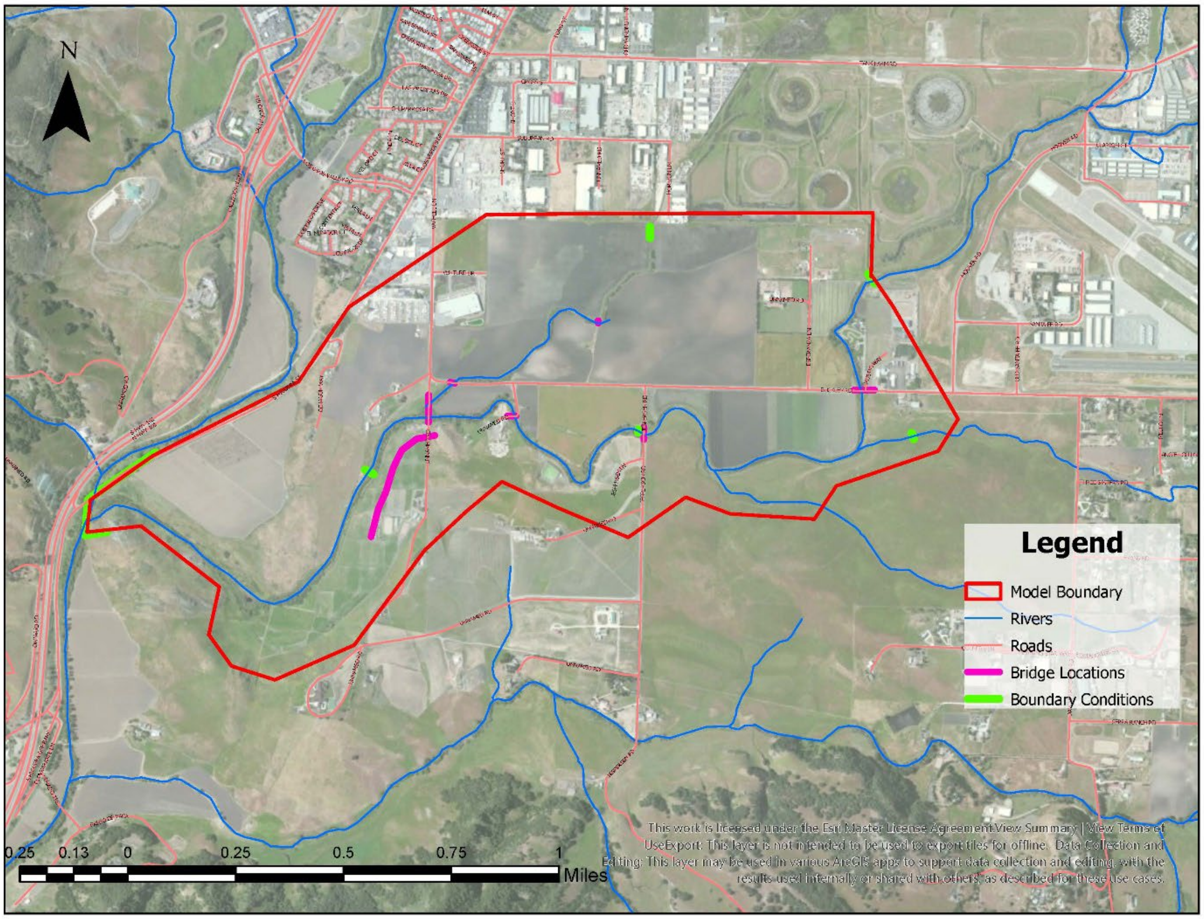

Figure 9 – Hydraulic Model Schematic

Model Bounds

The model boundary extends far enough upstream to capture floodplains and channel crossings that may impact flow at the key area of concern. The model's downstream boundary is near its confluence with San Luis Obispo Creek.

Boundary Conditions

Inflow hydrographs were added at locations corresponding to their representation in the HEC-HMS model. The downstream boundary condition was set to normal depth with a downstream channel slope of 0.01 feet/feet. A sensitivity analysis of potential boundary conditions at the confluence of SLO Creek was performed. The results, discussed later in this report, demonstrate that varying boundary conditions do not impact water levels at Buckley Road.

Existing Condition Geometry

The existing condition model terrain was developed with topographic data and field survey topographic data. 2017 USGS/FEMA 1-meter LiDAR data was used as the basis of the ground surface terrain, and the terrain was refined by "burning" in detailed field survey data.

MBS Land Surveys, the project's surveying contractor, collected topographic survey data in September 2021 along Buckley Road at the Vachell Lane intersection, at the Tank Farm crossing at Buckley Road, the East Fork crossing at the private road, the next two upstream East Fork crossings, and along East Fork from Tank Farm to 2,500 feet downstream. Survey point locations are shown in Figure 10.

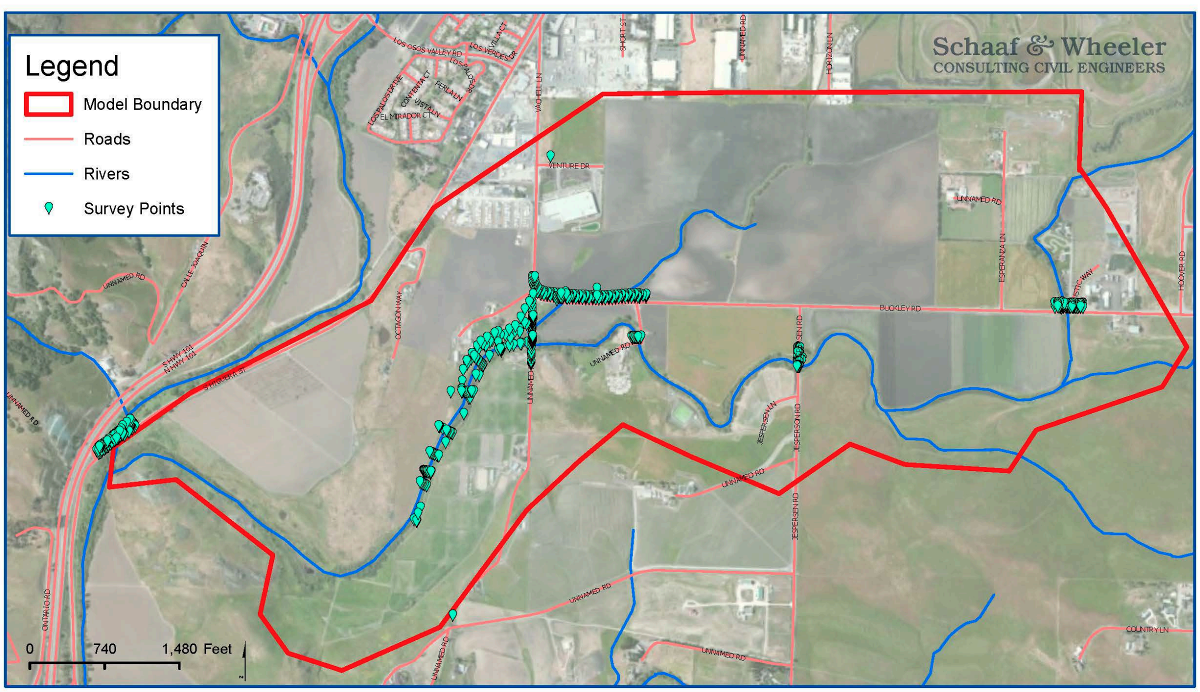

Figure 10 – Survey Locations

Near-Term Condition Geometry

The near-term scenario includes changes from existing topography reflecting two key projects that have the potential to affect flood behavior in the study area in the near future: the Avila Ranch development and the extension of Buckley Road to Highway 101.

The Avila Ranch project, currently under construction, encroaches on and grades the existing floodplain upstream of Buckley Road. These modifications affect the floodplain stage/storage relationship. This project will also remove the farm crossing of Tank Farm Creek.

The Buckley Road extension project, completed in 2022, raised the roadway profile of Buckley Road from the Tank Farm Creek culvert to west of the Vachell Lane intersection (Figure 11). This change should provide additional flood protection to the Buckley Road and Vachell Lane intersection.

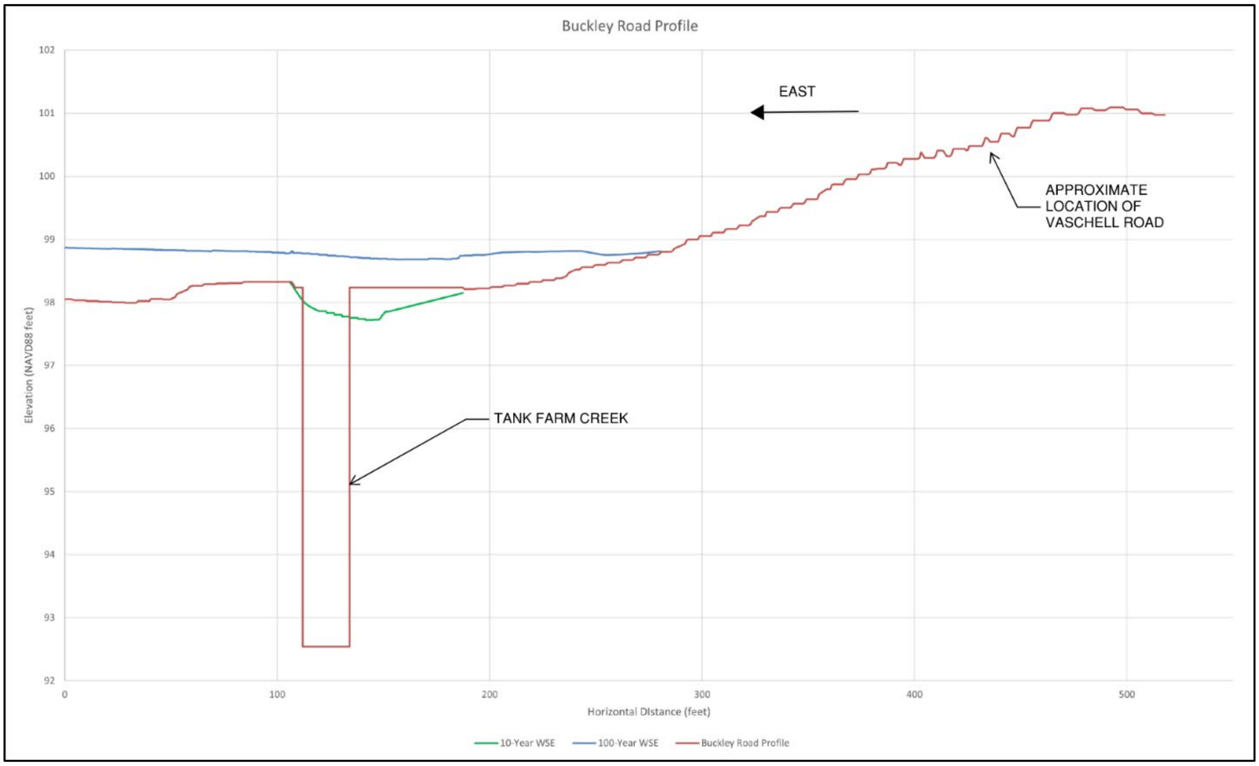

Figure 11 – Buckley Road Profile (Looking Downstream)

The existing condition ground surface terrain was modified to represent these conditions. CAD improvement plan files were used to incorporate the Buckley Road extension. Because similar files were not available for the Avila Ranch project, future Avila Ranch topography was approximated from development plans. The resulting near-term terrain is shown in Figure 12.

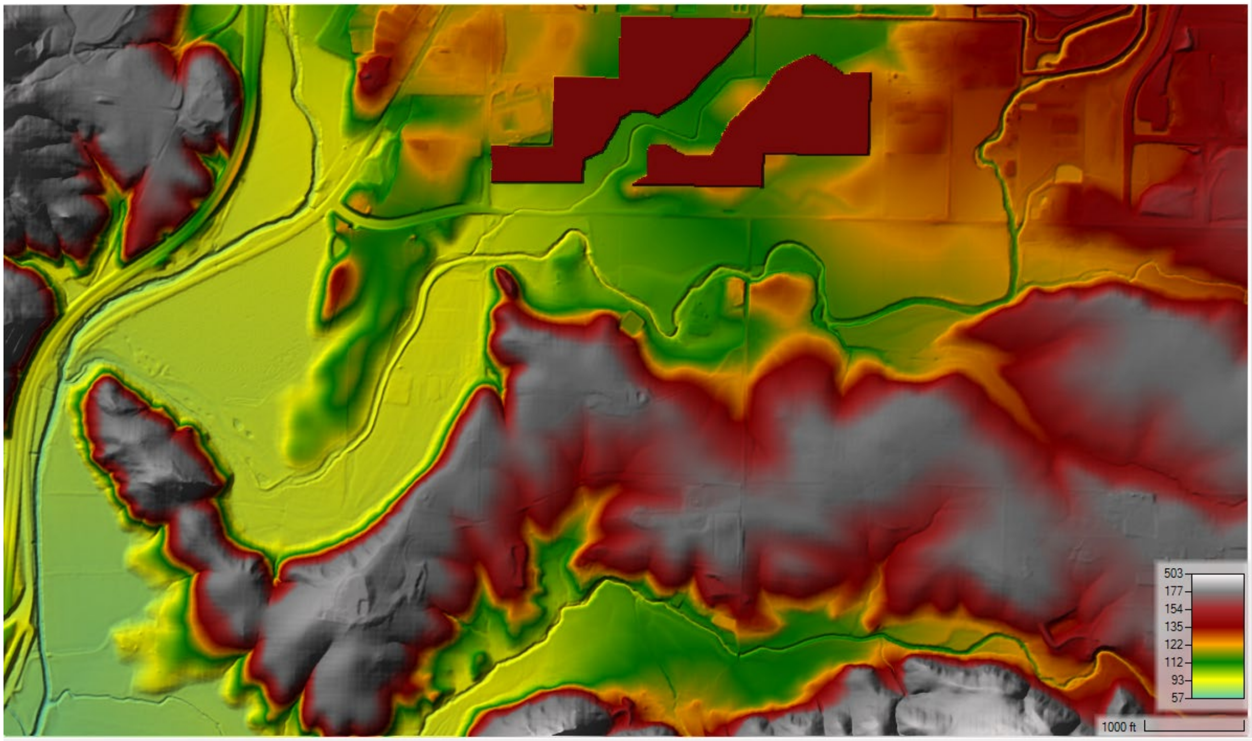

Figure 12 – Near Term Terrain

Manning's n Values

Manning's *n* values are assigned to the ground surface terrains based on land use and surface cover. The majority of the floodplain is characterized as agriculture and assigned a value of 0.04. Channel *n* values were estimated using field photographs, aerial images, and Fig. 5-5: "Typical channels showing different *n* values," from *Open-channel Hydraulics* (Chow, 1973). Manning's *n* values in the channels range from 0.035 for clean, straight channels to 0.07 for channels with bends and heavy vegetation. Land use and Manning's *n* values are shown in Figure 13.

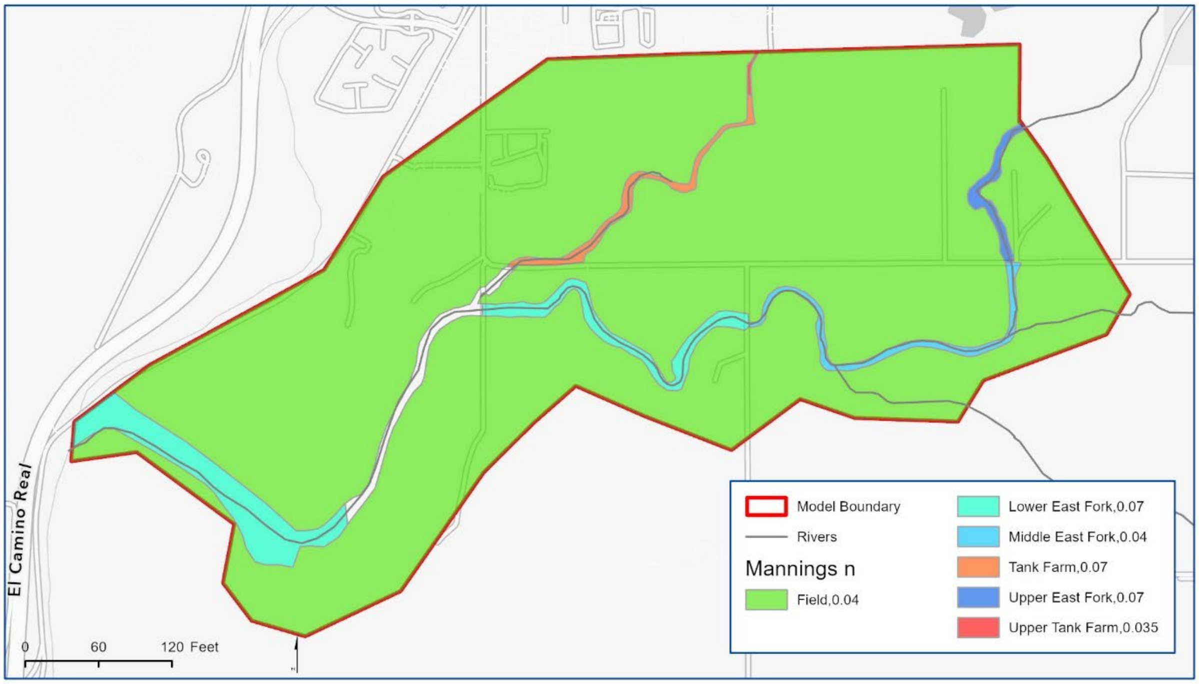

Figure 13 – Land Use, Manning's n Values, and Survey Locations for Existing Conditions

Results

All modeled scenarios and storm severities ran stable at a five-second computational time step.

Downstream Boundary Sensitivity Analysis

The confluence with San Luis Obispo Creek (SLO Creek) creates a hydraulic boundary for East Fork with varying tailwater conditions dependent on the stage of SLO Creek. A sensitivity analysis was performed using the near-term scenario to determine how conditions at the confluence may impact flooding upstream on East Fork.

Figure 14 shows the extent where a static 100-year tailwater at 91-feet NAVD on SLO Creek would increase water surface elevations from 100-year flows on East Fork. These results demonstrate that increased water surface elevations on East Fork from any backwater effects from SLO Creek are isolated to the stream reach below the confluence of East Fork and Tank Farm Creeks.

Flooding on SLO Creek does not impact the Buckley Road area. During the course of this study, FEMA informed the County in discussions of a separate modeling effort of SLO Creek that their analysis reached the same conclusion.

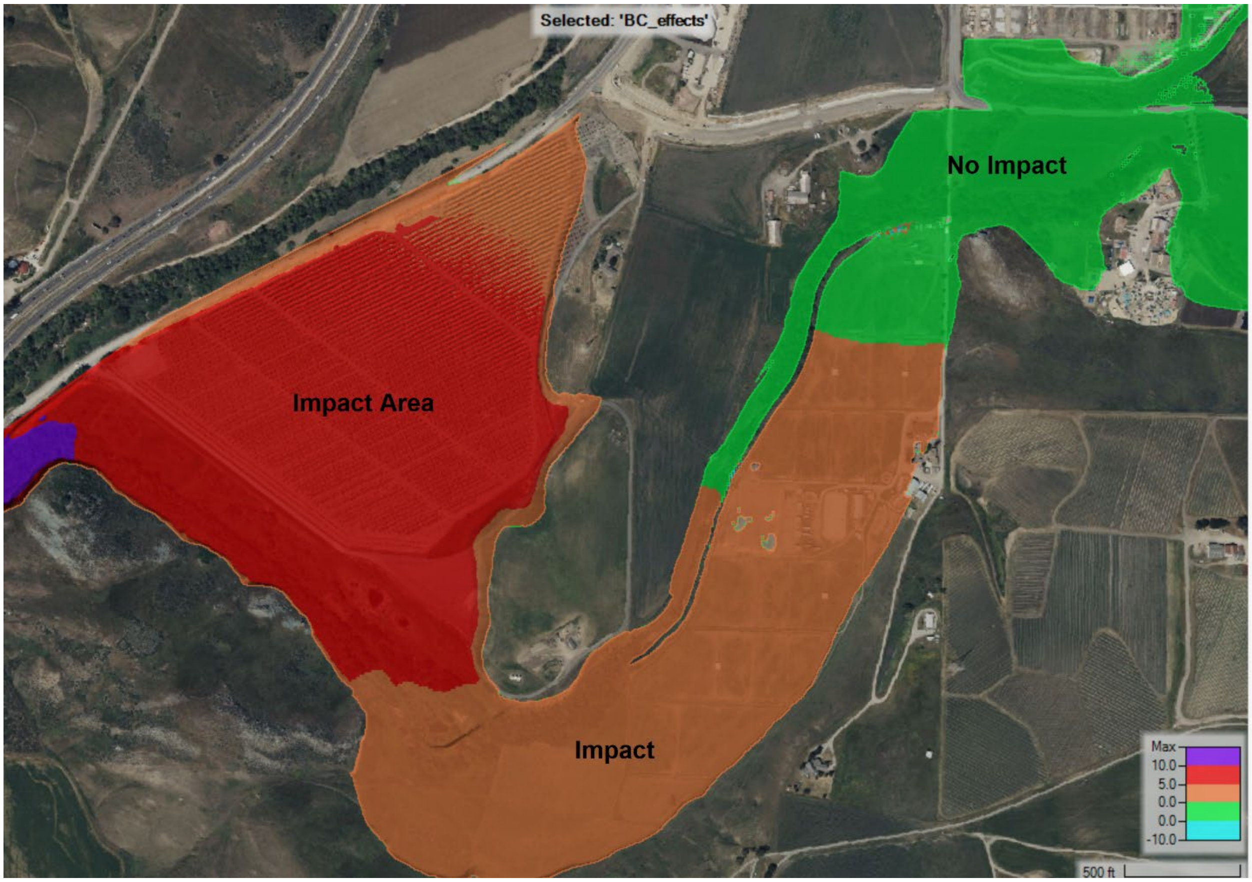

Figure 14 – SLO Creek Impact Area (100-year)

Near-Term Scenario

The HEC-RAS near-term model was run for the 2-, 5-, 10-, 25-, and 100-year events. The 24-hour events ran stable at a 5-second computational time-step. The results of the near-term conditions are shown in Figures 15 – 19.

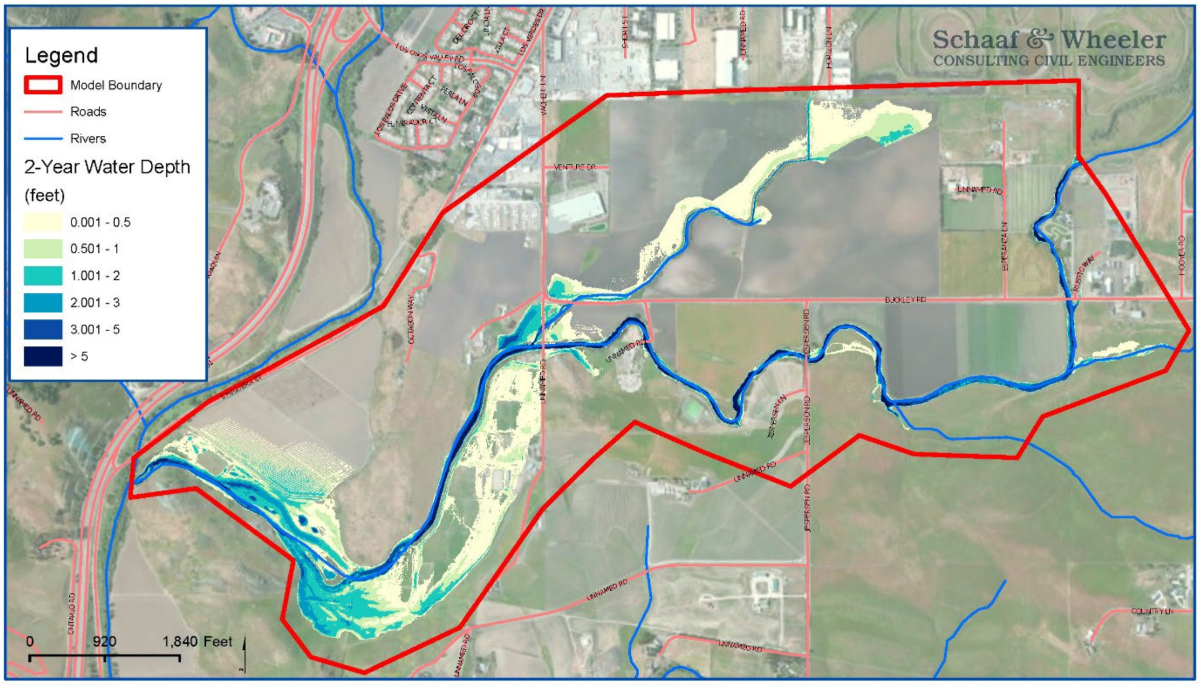

Figure 15 – 2-Year Near-Term Floodplain

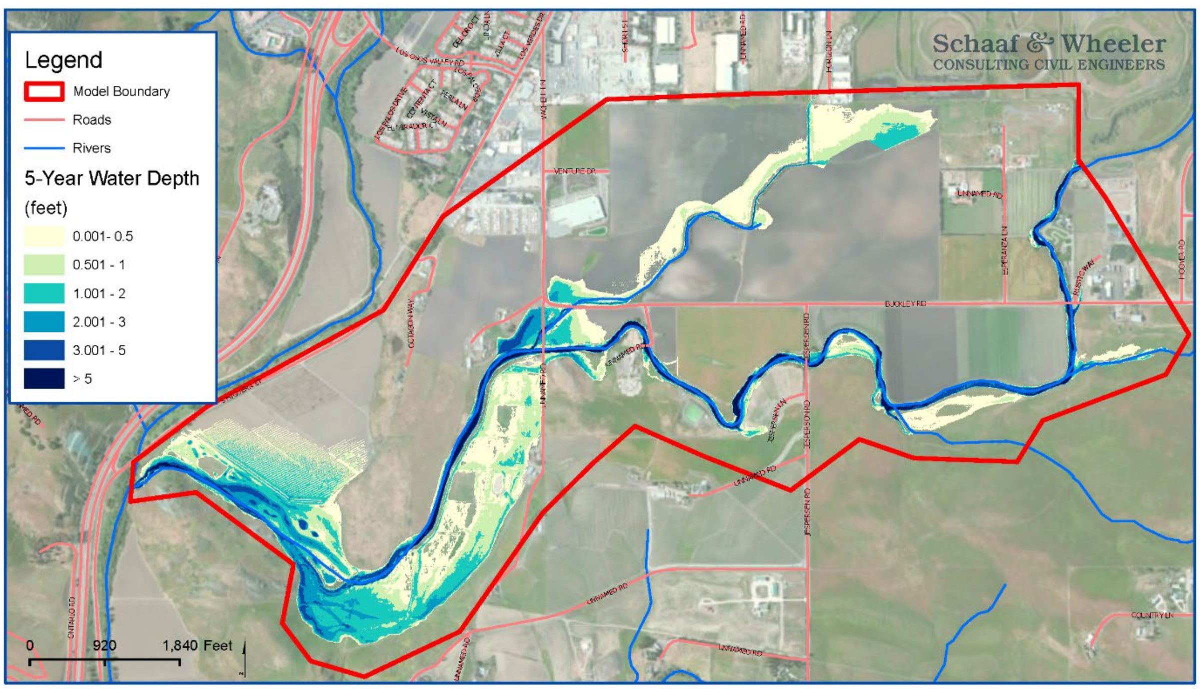

Figure 16 – 5-year Near-Term Floodplain

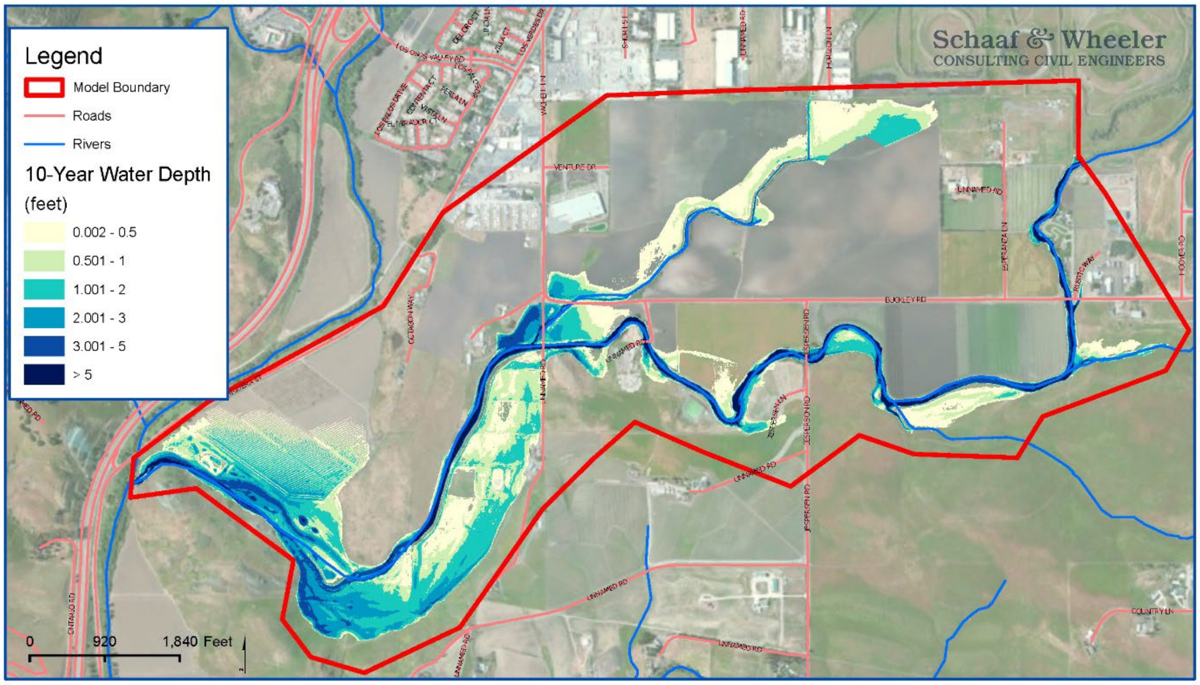

Figure 17 – 10-year Near-Term Floodplain

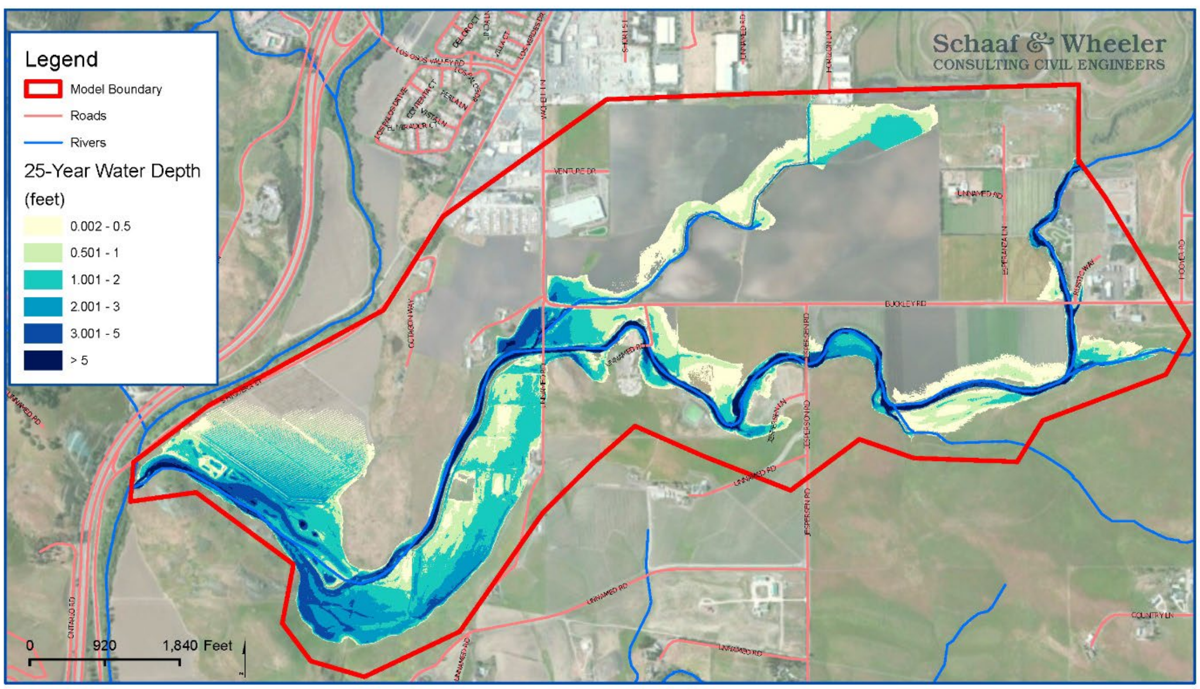

Figure 18 – 25-year Near-Term Floodplain

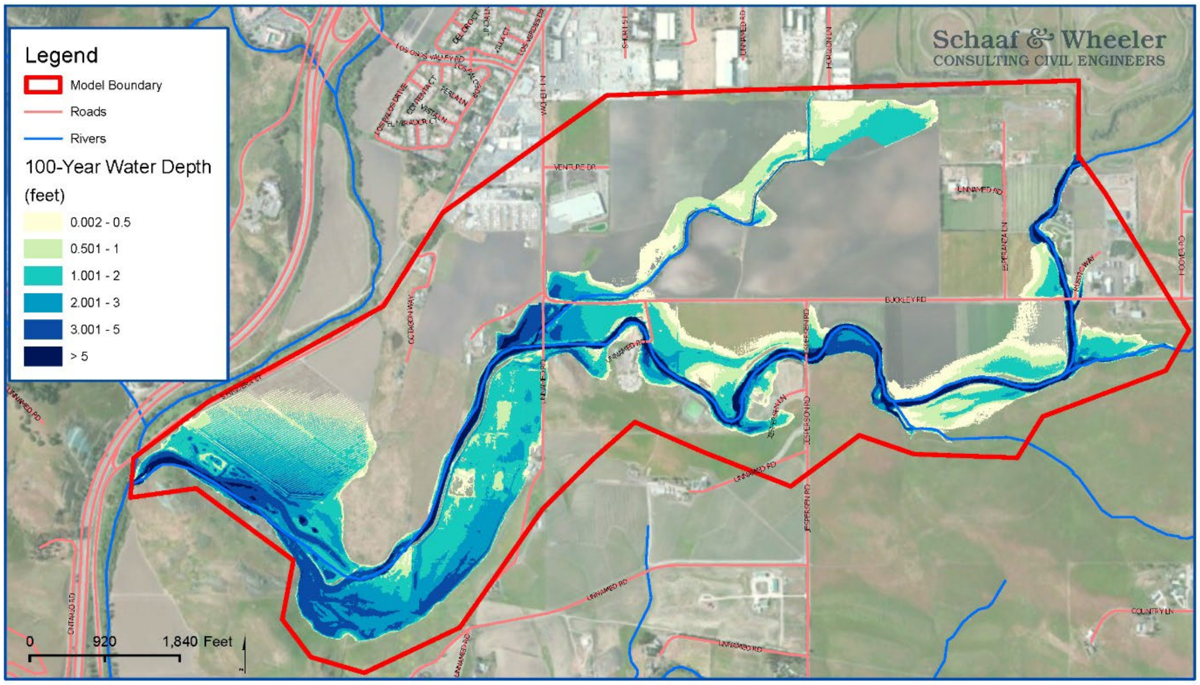

Figure 19 – 100-year Near-Term Floodplain

Near-Term vs. Existing Scenario

There is no significant difference in the Survey versus Near-Term WSE. The 10-year and 100-year events were considered at three key locations: Tank Farm at Buckley Road, East Fork at Farm Bridge, and East Fork at Stable Road (Private Road). The WSE is the same at all locations except at Tank Farm at Buckley Road. The Survey WSE is approximately 0.1 feet higher than the Near-Term WSE.

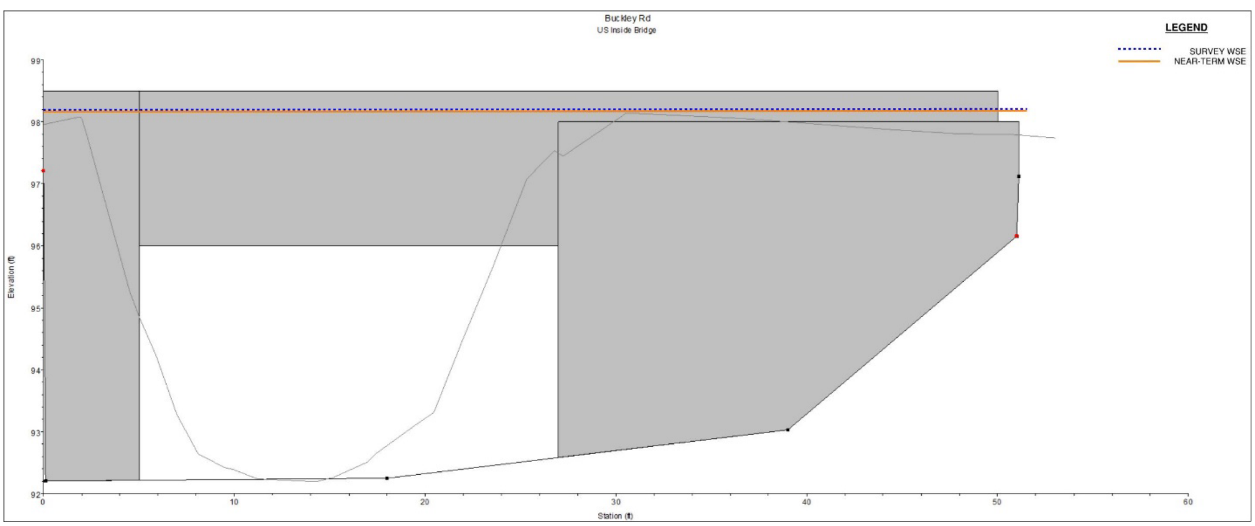

Figure 20 – 10-year Survey vs. Near-Term WSE Tank Farm at Buckley Road

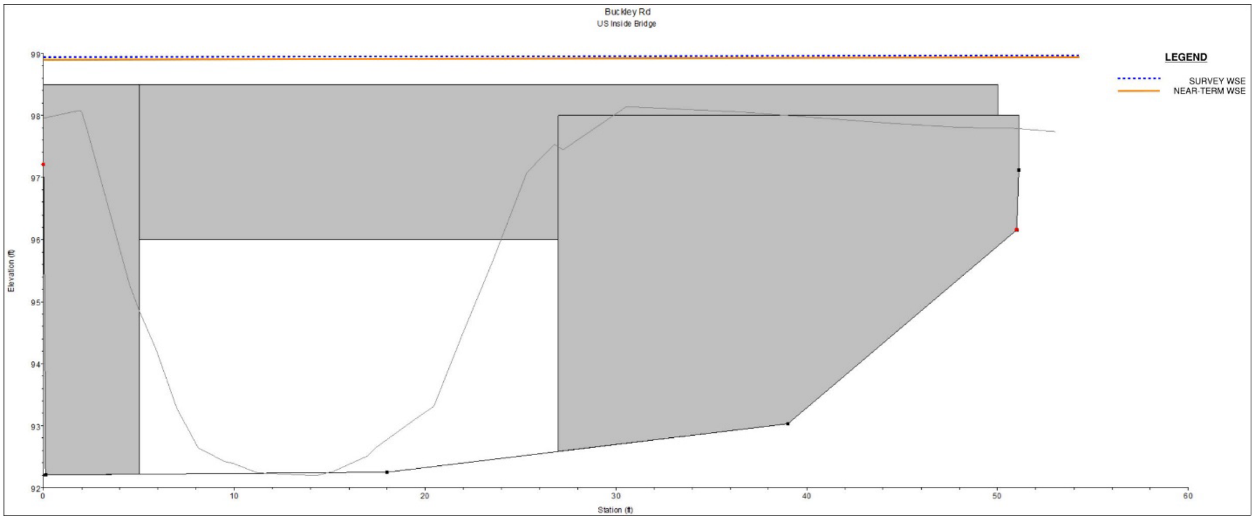

Figure 21 – 100-year Survey vs. Near-Term WSE Tank Farm at Buckley Road

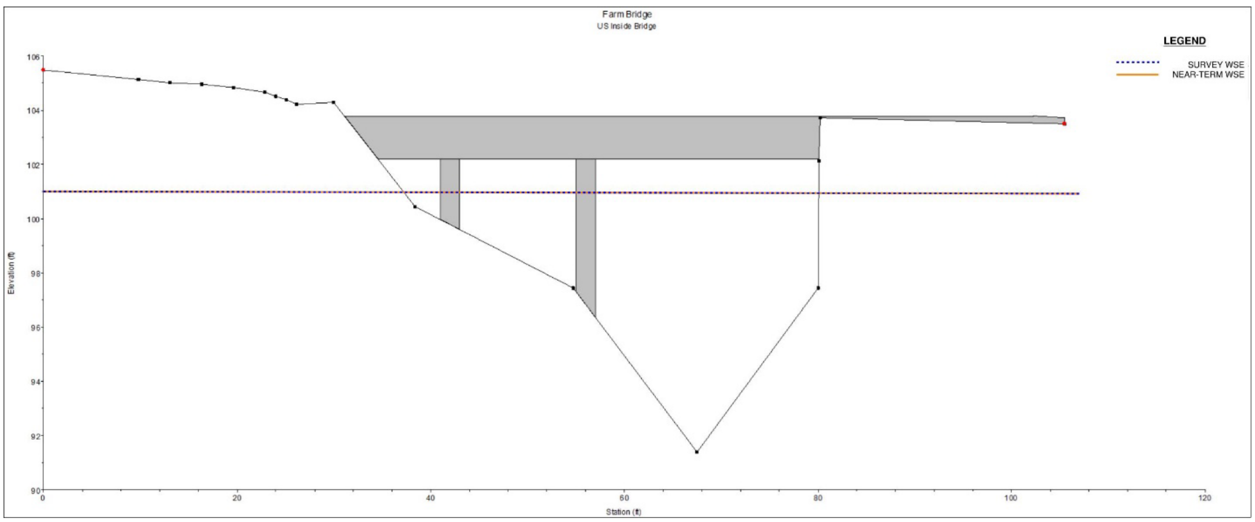

Figure 22 – 10-year Survey vs. Near-Term WSE East Fork at Farm Bridge

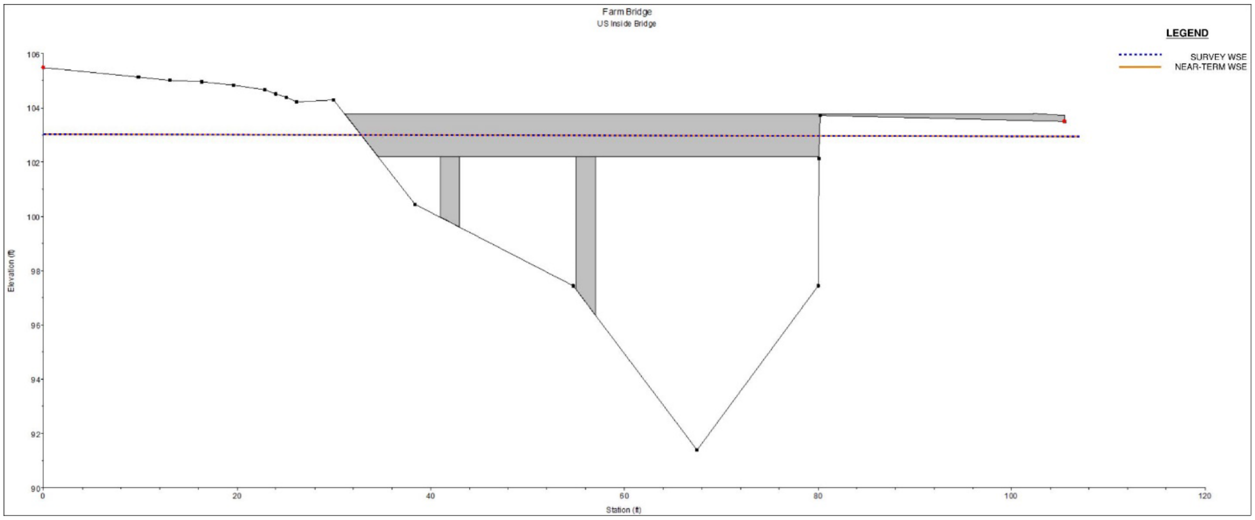

Figure 23 – 100-year Survey vs. Near-Term WSE East Fork at Farm Bridge

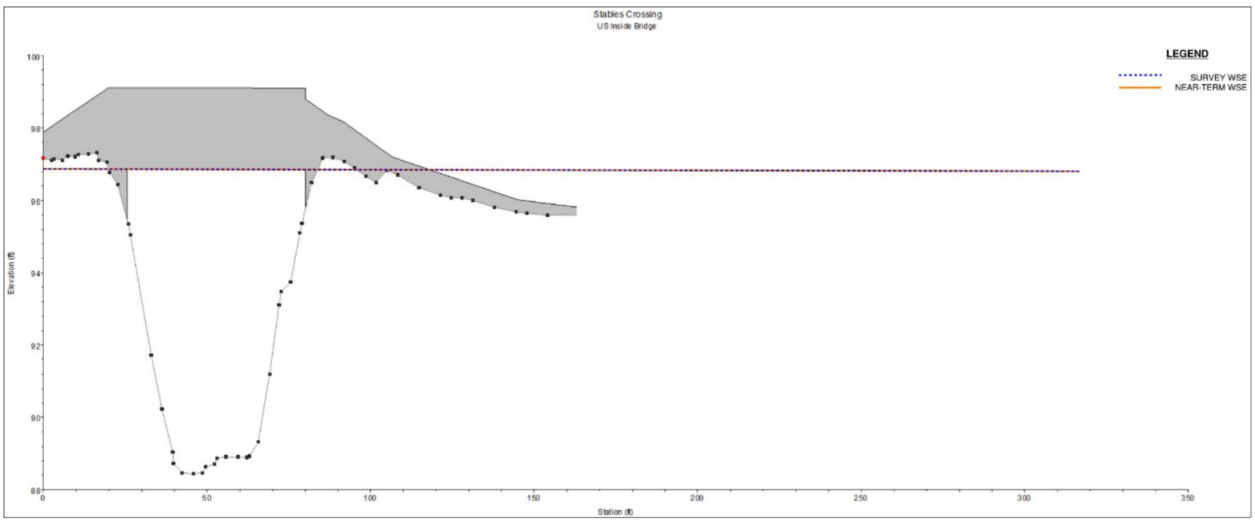

Figure 24 – 10-year Survey vs. Near-Term WSE East Fork at Private Road (Stables)

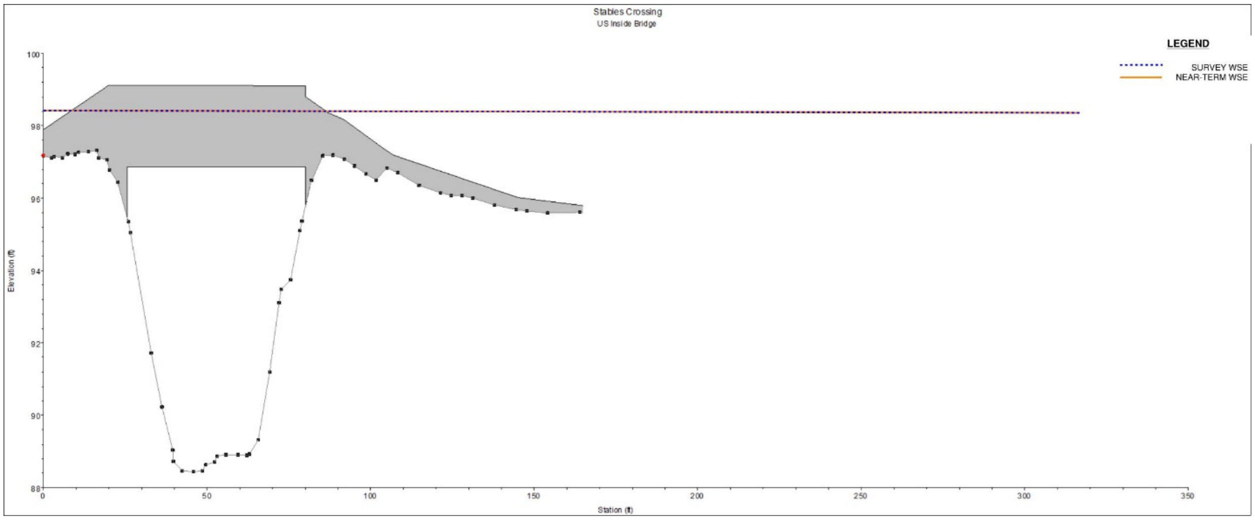

Figure 25 – 100-year Survey vs. Near-Term WSE East Fork at Private Road (Stables)

Bridge Hydraulics

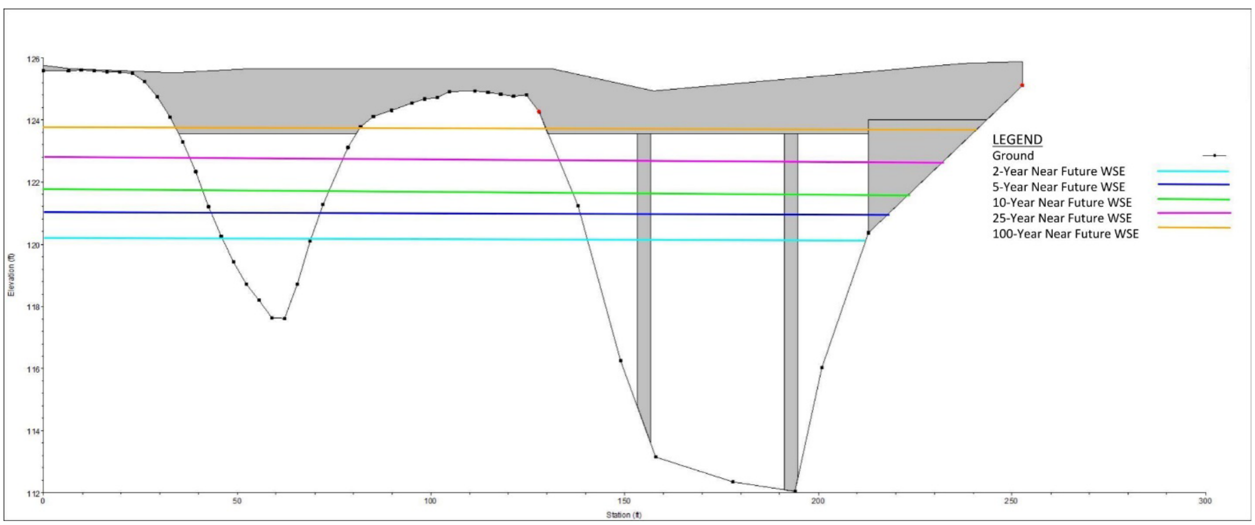

Figure 26 – East Fork at Buckley Road

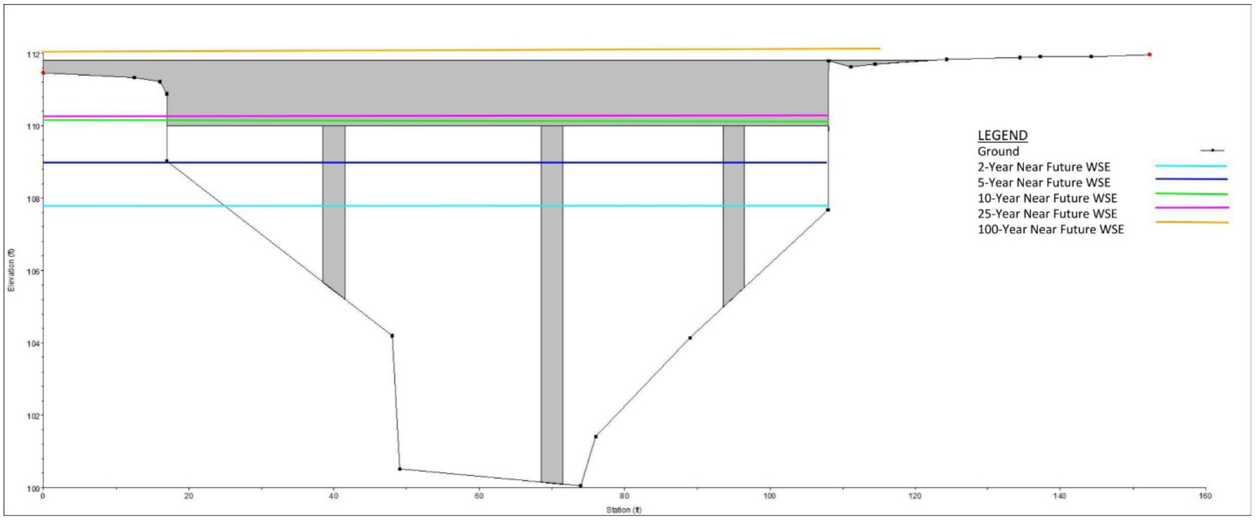

Figure 27 – East Fork at Jesperson Road

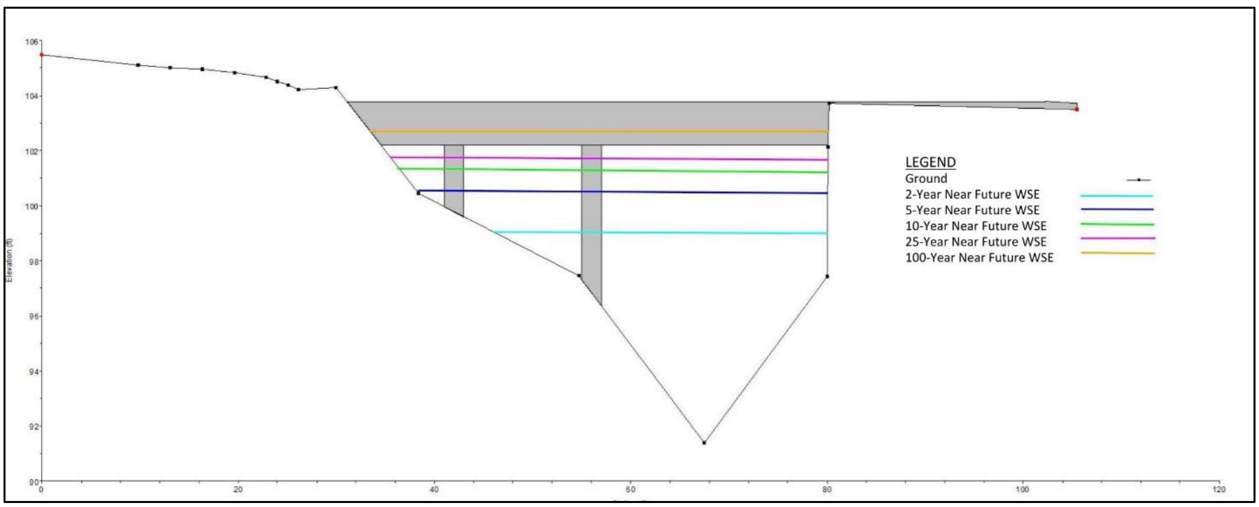

Figure 28 – East Fork at Farm Bridge

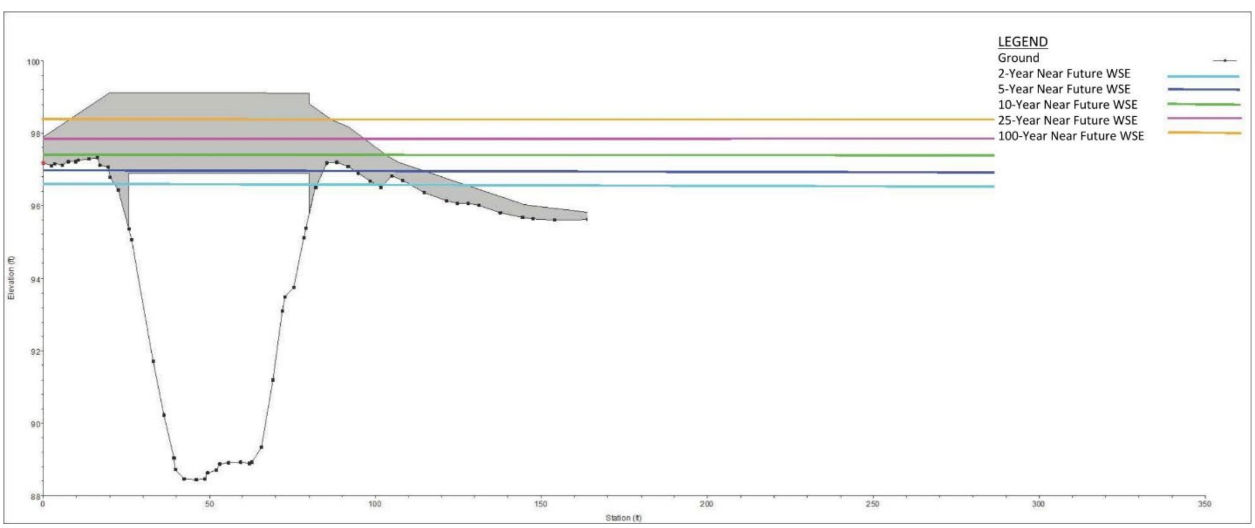

Figure 29 – East Fork at Private Road (Stables)

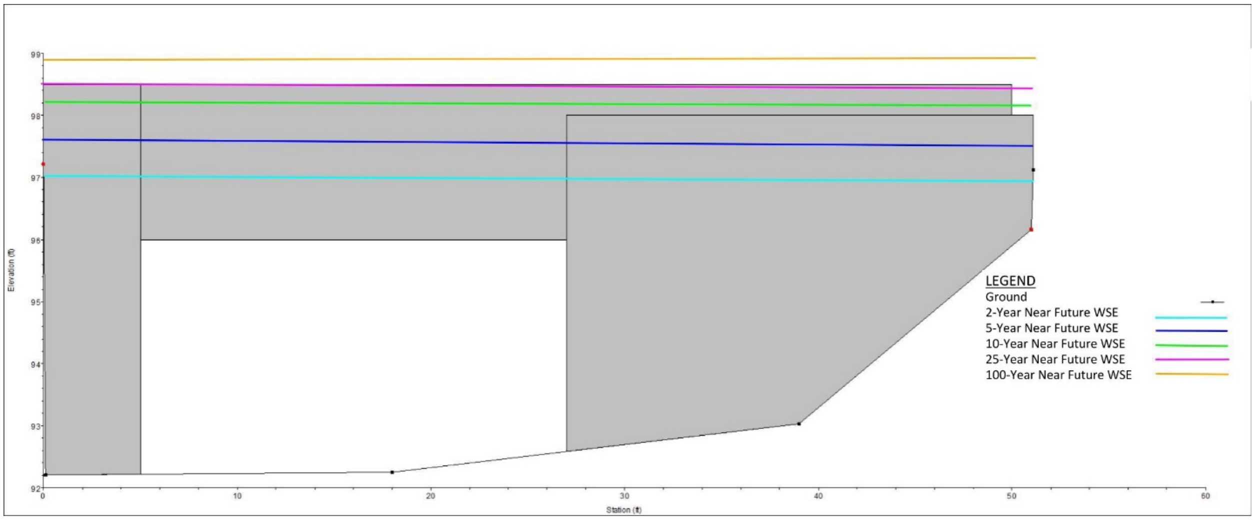

Figure 30 – Tank Farm at Buckley Road

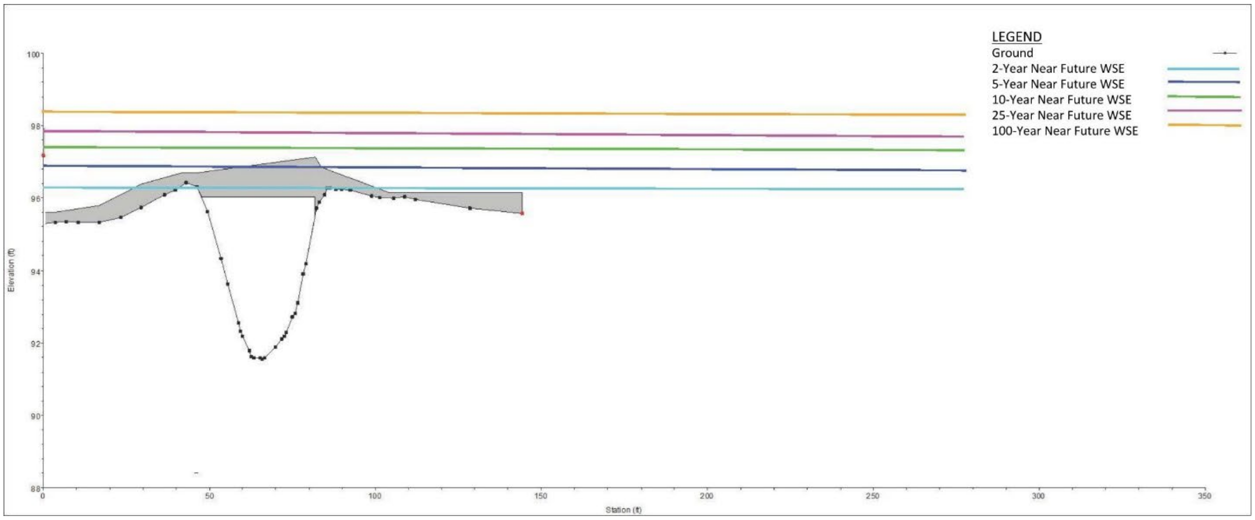

Figure 31 – Tank Farm at Private Road (Stables)

Table 5: Near-Term Water Surface Elevations at Bridges (feet NAVD88)

Bridge	Creek	Top of Road	2-year	5-year	10-year	10-year AMCIII	25-year	100-year
Buckley	**East Fork**	125.6	120.2	121.2	121.9	123.8	122.8	123.8
Jesperson Road	**East Fork**	112.0	107.8	109.1	110.1	111.5	110.2	112.5
Private Road (Stables)	**East Fork**	99.1	96.6	97.1	97.5	98.4	97.9	98.4
Buckley	**Tank Farm**	98.1	97.0	97.6	98.2	98.9	98.5	98.9
Private Road (Stables)	**Tank Farm**	97.1	96.2	97.1	97.5	98.4	97.9	98.4
Farm Bridge	**East Fork**	104.1	99.1	100.4	101.3	102.7	101.9	102.7

Discussion

The near-term changes to land uses, topography, and roadways slightly modify the floodplains and water levels upstream of Buckley Road on Tank Farm Creek. The Buckley Road extension raises the roadway surfaces and helps the travel lanes stay dry more often.

Buckley Road does not overtop during the 2-, 5- or 10-year events in the near-term scenario, although the road shoulders and surrounding areas are inundated. Buckley Road is expected to be overtopped during the 25- and 100-year events. The maximum flood depth over the road is approximately 1 foot.

It is important to note that, per standard engineering practice, all bridges and culverts are assumed free of debris blockages. If crossings are not maintained, there is a higher potential for flows to backup and overtop the roadways. Using a 25% blockage on the Buckley Road crossing of Tank Farm Creek, the model shows that flows do overtop the roadway more frequently. This emphasizes the need for routine maintenance and provides a good example of the variability between model results and potential real-world conditions.

Since hydraulic conditions on East Fork nearest the confluence with SLO Creek appear to have little effect on water surface elevations at Buckley Road, this study concludes that the hydraulics in the vicinity of the confluence of Tank Farm Creek and East Fork are the key driver of flooding at Buckley Road.

There are three primary causes of poor conveyance in this area. First, this portion of the watershed is notably flat. Prior to the construction of the levee in this area, it is likely that the area naturally experienced high sedimentation due to floodwaters slowing and spreading through what is now primarily the Buckley Stables and City properties.

Second, the levee both significantly reduces available floodplain storage and hydraulically impairs the progression of flows from the confluence of Tank Farm Creek and East Fork to East Fork's curve back to the west. These conditions produce increased water surface elevations directly upstream of the levee, eventually causing East Fork to crest its southern bank and return to its historical floodplain behind the levee.

Third, a lack of channel maintenance further hinders conveyance in this area, particularly where the channel is more shallow and more constrained than much of the upstream reaches. To address the maintenance issue, the County and City have recently collaborated to address stream maintenance in the East Fork Area.

2022, the first year of this pilot program, saw over 3000 linear feet of Tank Farm and East Fork creek channel cleared of dead and down debris, which is consistent with environmental permitting requirements and guidelines of Appendix II of the SLO Creek WMP.

Since large storms can be sequential or spread apart, it is important to analyze the impacts of soil conditions. The 10-year storm with an AMC III model scenario simulates an event where fully saturated soils can produce high runoff rates. For this event, the peak flow rates are near the 100-year calibrated rates.

The hydrologic and hydraulic models were not calibrated to stream gage observations on the East Fork, such as the Jesperson Road Crossing gage maintained by the County. Calibration could be pursued in the future to evaluate and improve model predictive capability.

Improvement Alternatives

Schaaf & Wheeler suggested four conceptual approaches to reducing the flooding in the lower East Fork watershed, particularly at Buckley Road and Vachell Lane:

1. improve existing bridge and culvert crossings;
2. provide upstream storage;
3. improve downstream conveyance; or
4. increase channel capacity.

Rough approximations of each alternative were added to the near-term scenario HEC-RAS model. The resulting reductions in peak water levels at Buckley Road and Vachell Lane and the overall extent of the floodplain were compared to evaluate effectiveness. Despite the limited nature of these analyses, they provide valuable information on how each concept may affect flood risks.

Crossing Improvement Alternative

The crossing improvement alternative proved ineffective since even the removal of all crossings produced negligible reductions in flooding (Figure 32). This result emphasizes that flooding is the result of inadequate overall channel capacity rather than a product of deficient crossing structures.

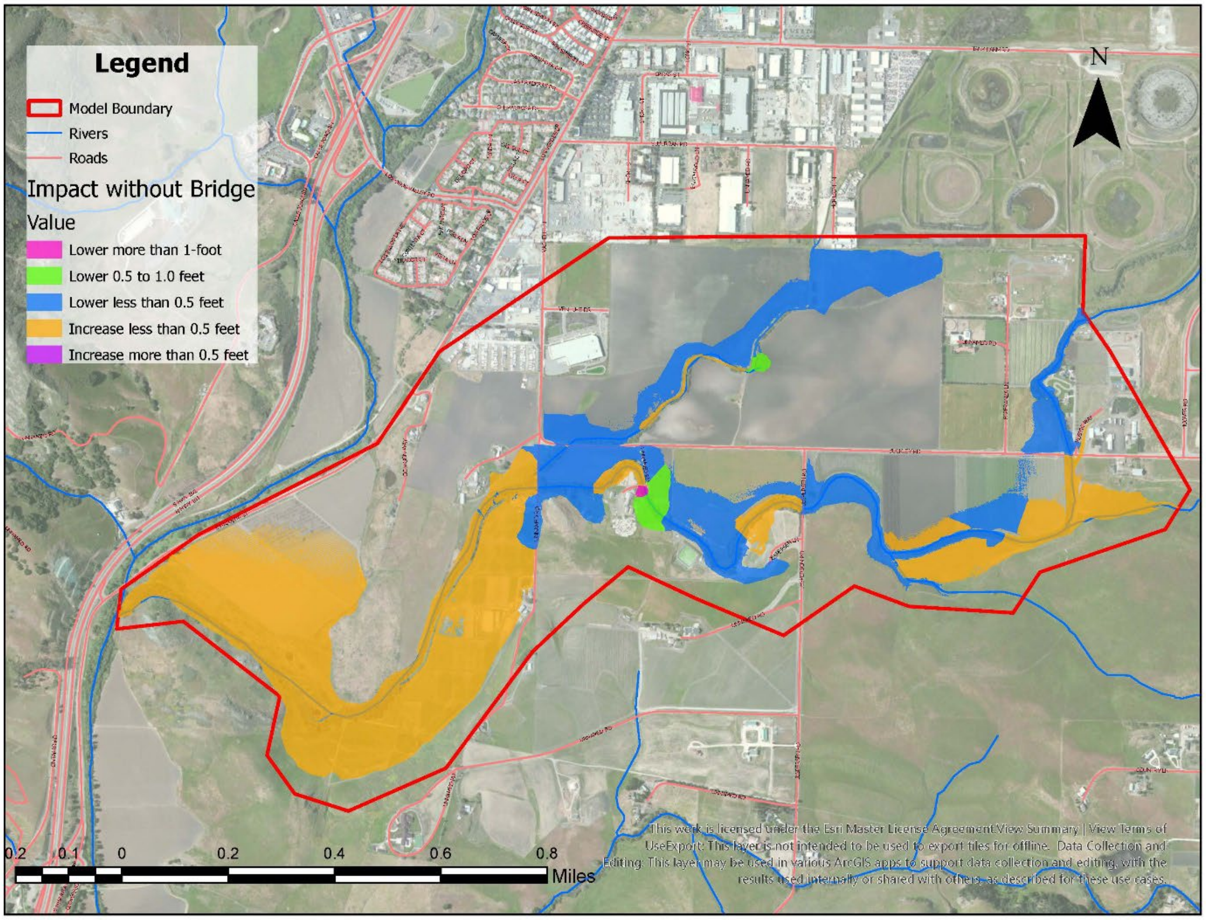

Figure 32 – Bridge Improvement Floodplain 100-year

Storage Alternative

With limited capacity in the channel, providing upstream storage for diverting peak flows would likely reduce the prevalence of flows overtopping the East Fork channel. A regional detention basin is a common approach to flood risk reduction and could potentially be implemented as a multi-benefit project to provide environmental and habitat enhancements, create recreational areas, and improve water quality.

A regional basin has been identified as a possible solution to East Fork flooding as early as 1986. In 1999, the City of San Luis Obispo proposed formally adopting a plan for a regional detention basin as part of the Airport Area Specific Plan. This iteration was incorporated by reference in the Waterway Management Plan. However, in 2005, the City determined such a project would be cost prohibitive and removed it from the Airport Area Specific Plan.

Around the same time, the County pursued an expansion to the primary runway of the San Luis Obispo Regional Airport. The extension of the runway required filling of the East Fork floodplain just upstream of the HEC-RAS model bounds used in this study. Two potential localized detention alternatives were studied to offset impacts to floodplain storage. The design selected for construction was an overflow bypass channel immediately southeast of the East Fork as it passes along the airport's boundary. The bypass channel, constructed in 2007, was solely intended to mitigate loss of storage and is assumed to not provide any additional detention capacity.

The alternative that was not pursued required reopening the historical oxbows on the Chevron Tank Farm property immediately northwest of the East Fork as it passes the airport. These oxbows were a part of the original East Fork channel system but were closed off with dirt berms in the early 1900s during industrial operation of the Tank Farm site.

As part of current remediation efforts of the Tank Farm property, Chevron has committed to reopening the historical oxbows, primarily for habitat benefits. The reopening is also expected to reduce flood flows on the East Fork. A hydraulic evaluation of these changes is expected to be provided to the County in early 2023.

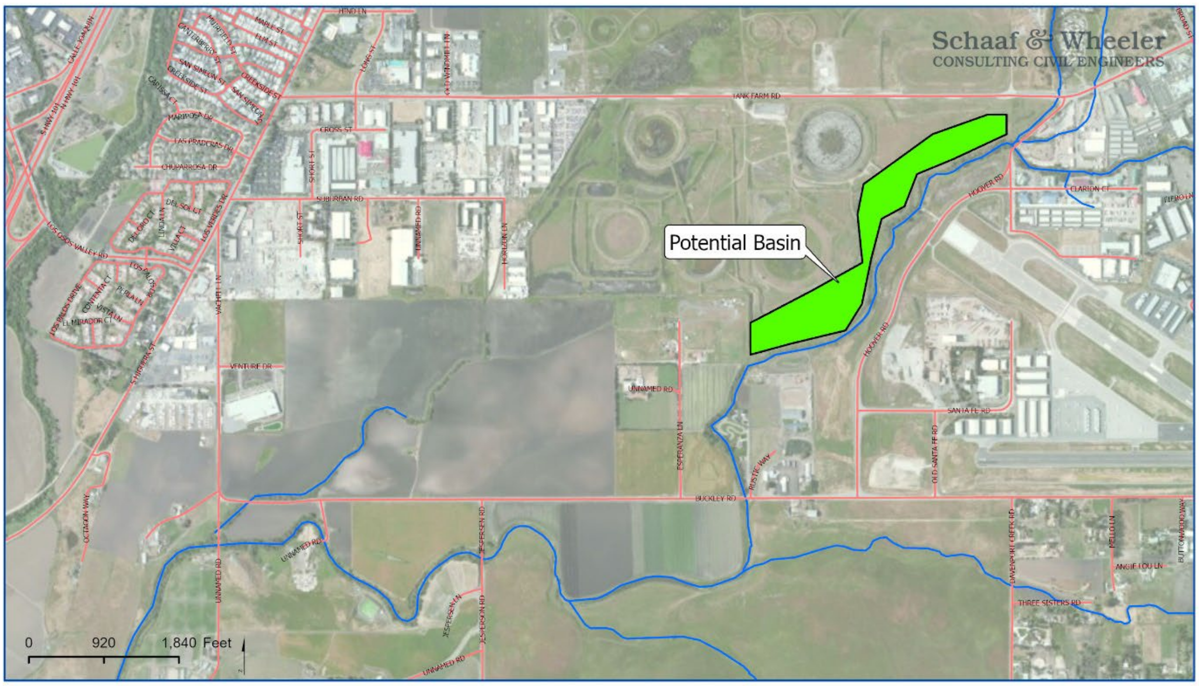

Figure 33 – Conceptual Basin Location

This study evaluated a potential expansion of the storage capacity in the oxbow area. A storage alternative HEC-HMS model was developed that simulated a diversion of East Fork flows immediately upstream of the HEC-RAS model bounds. The model utilized a 70-acre theoretical basin with a depth of 12 feet. Flows under 1,000 cfs were assumed to remain in the channel with larger amounts being diverted to the basin.

Table 6 shows the flow reductions and volumes diverted for various storm frequencies. The reduction in peak water levels is significant from this approach. Figure 36 shows the reduction in water level for the 100-year event. The 100-year flood depth over Buckley Road was lowered from approximately 1.0 foot to 0.6 feet.

Table 6: Channel Flow with Basin Diversion

Event	2-year	5-year	10-year	25-year	100-year
Existing Flow (cfs)	874	1337	1761	2355	3310
With Diversion Flow (cfs)	874	1000	1000	1000	1000
Diverted Volume (acre-feet)	0	38	122	272	562

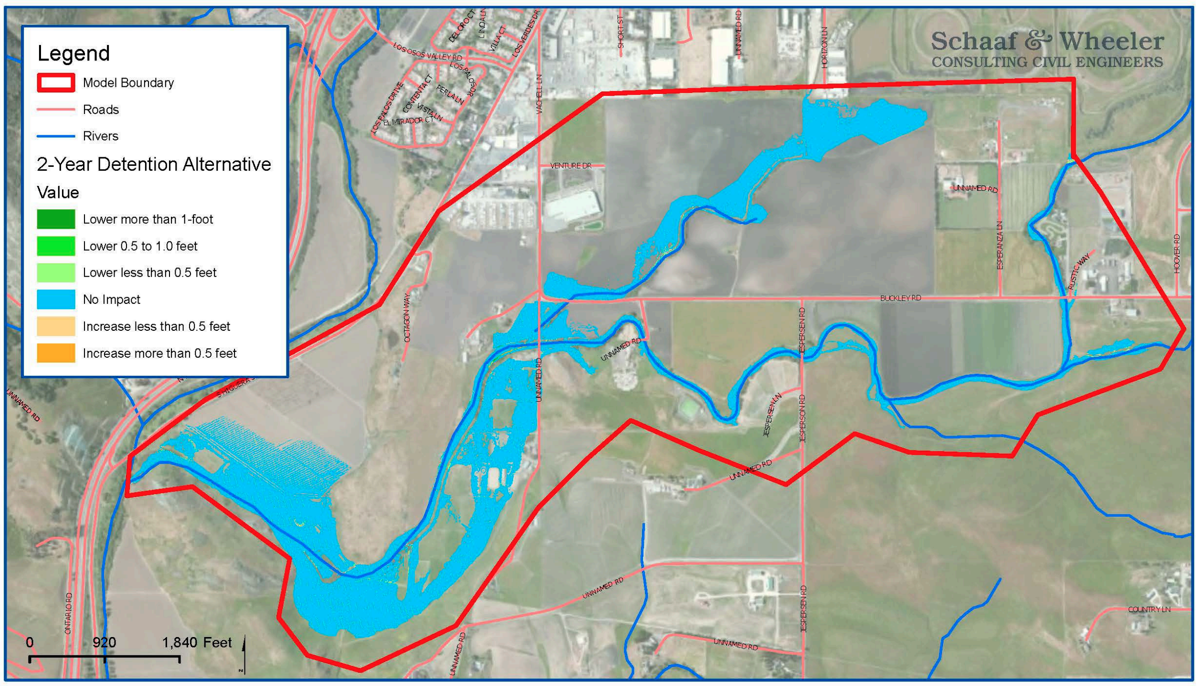

Figure 34 – Detention Alternative 2-year Water Level Changes

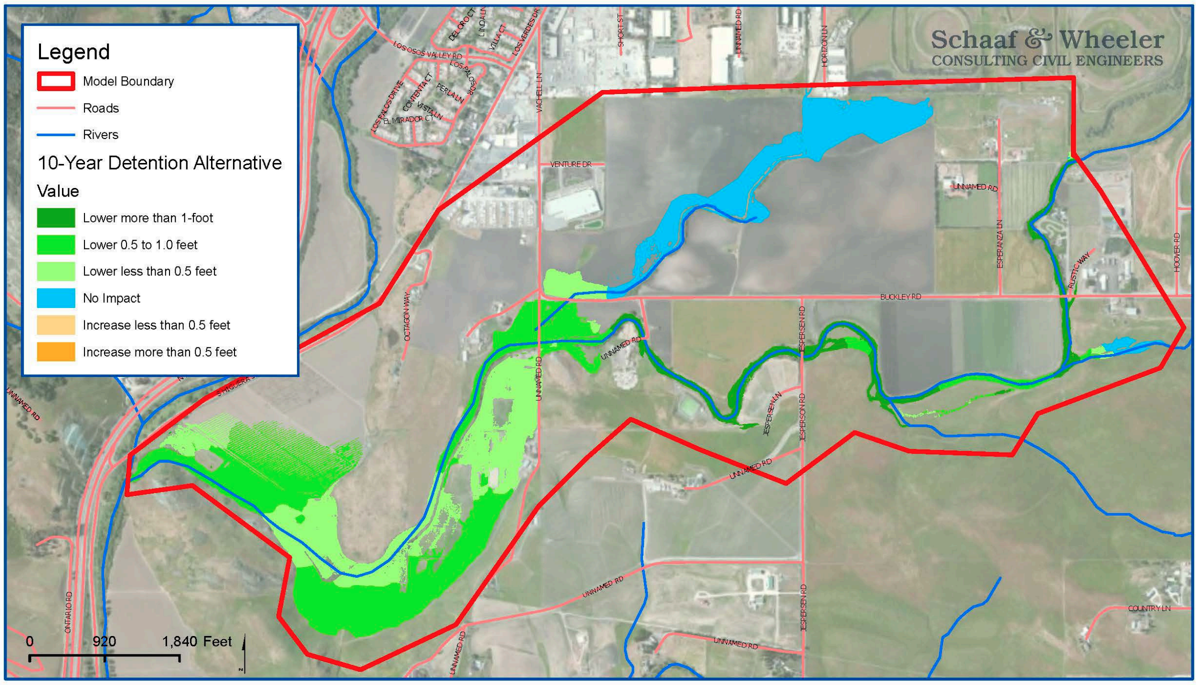

Figure 35 – Detention Alternative 10-year Water Level Changes

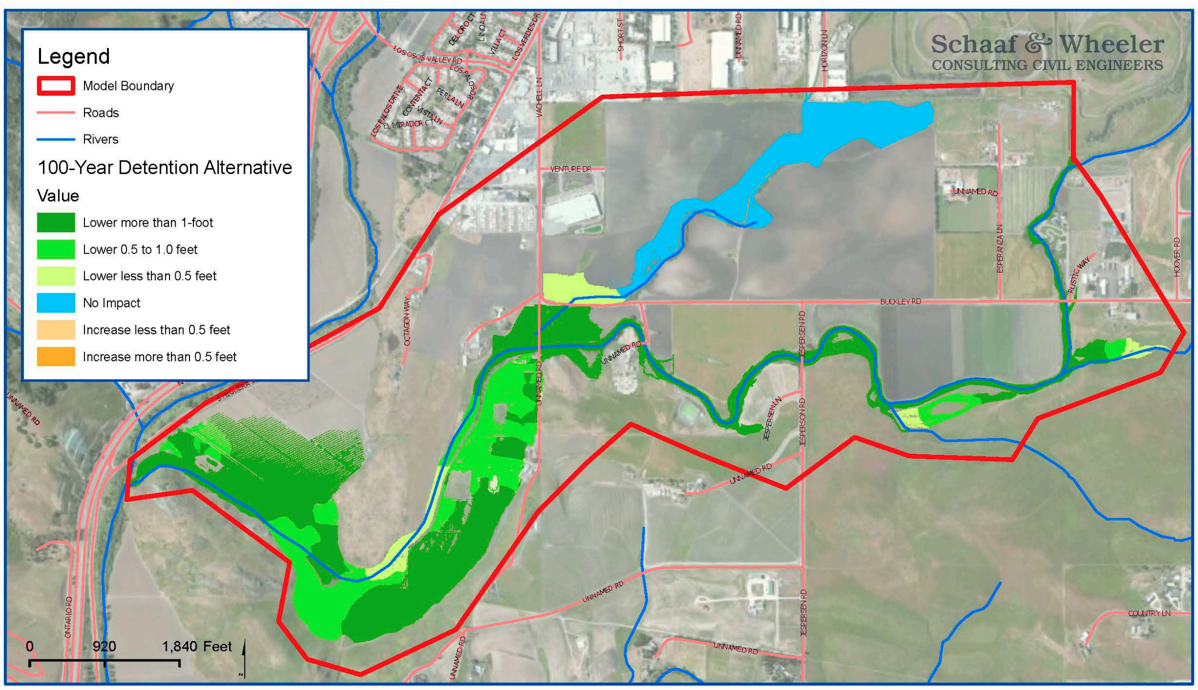

Figure 36 – Detention Alternative 100-year Water Level Changes

Downstream Conveyance Alternative

This approach would widen and deepen the floodplain at the lowest end of East Fork near the confluence with SLO Creek in order to potentially decrease backwater effects and lower water surface elevations at Buckley Road. Modeling this approach resulted in no impact to the water levels at Buckley, consistent with the previously discussed results of an increased tailwater from SLO Creek at flood stage.

Channel Widening Alternative

This approach would widen the East Fork channel downstream of the confluence of Tank Farm and East Fork. The analysis also assumed the existing left (east) farm levee would be lowered, allowing higher flows to inundate the overbank areas. A set-back levee was added to the model to keep the floodplain from inundating the entire stable area. This alternative did lower the floodplain surrounding Buckley Road and Vachell Lane. The 100-year flood depth over Buckley Road was lowered from approximately 1.0 foot to 0.7 feet. The modeled results are shown in Figures 37 through 39.

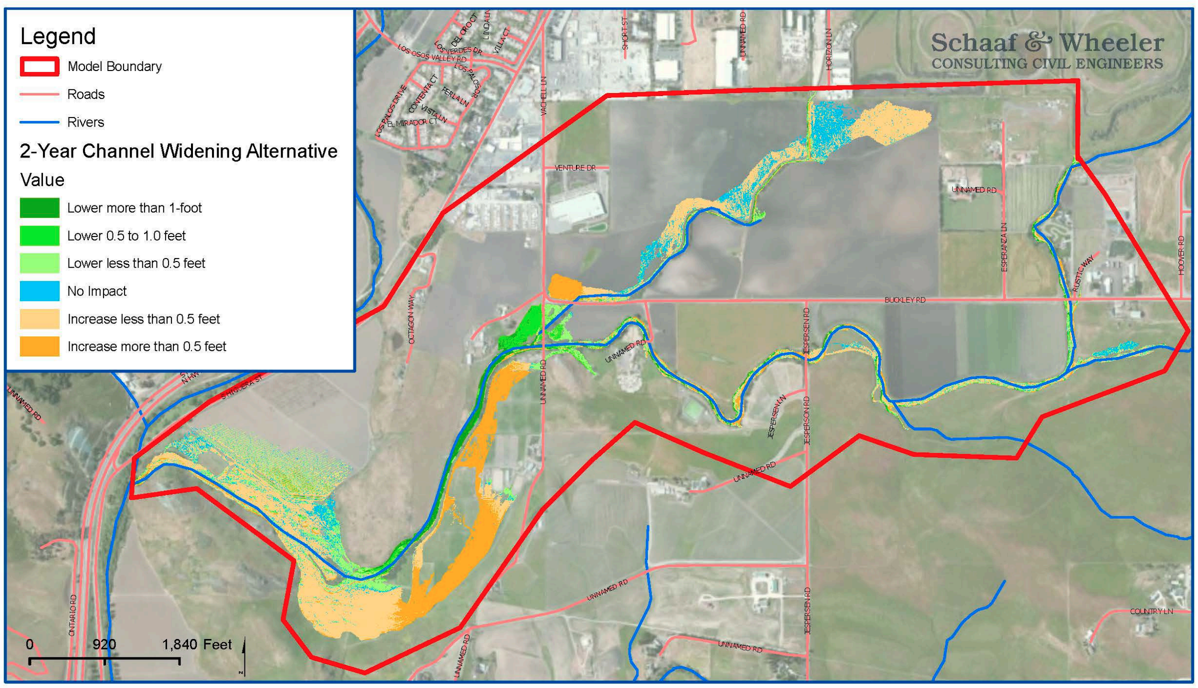

Figure 37 – Channel Widening Alternative 2-year Water Level Changes

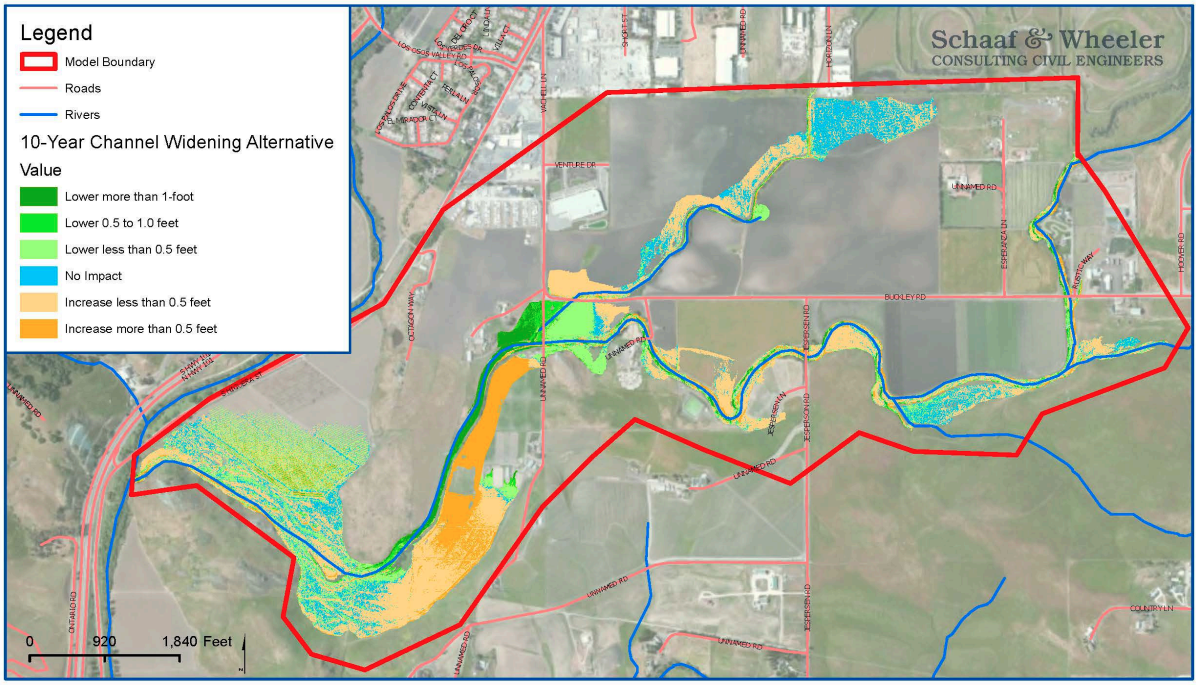

Figure 38 – Channel Widening Alternative 10-year Water Level Changes

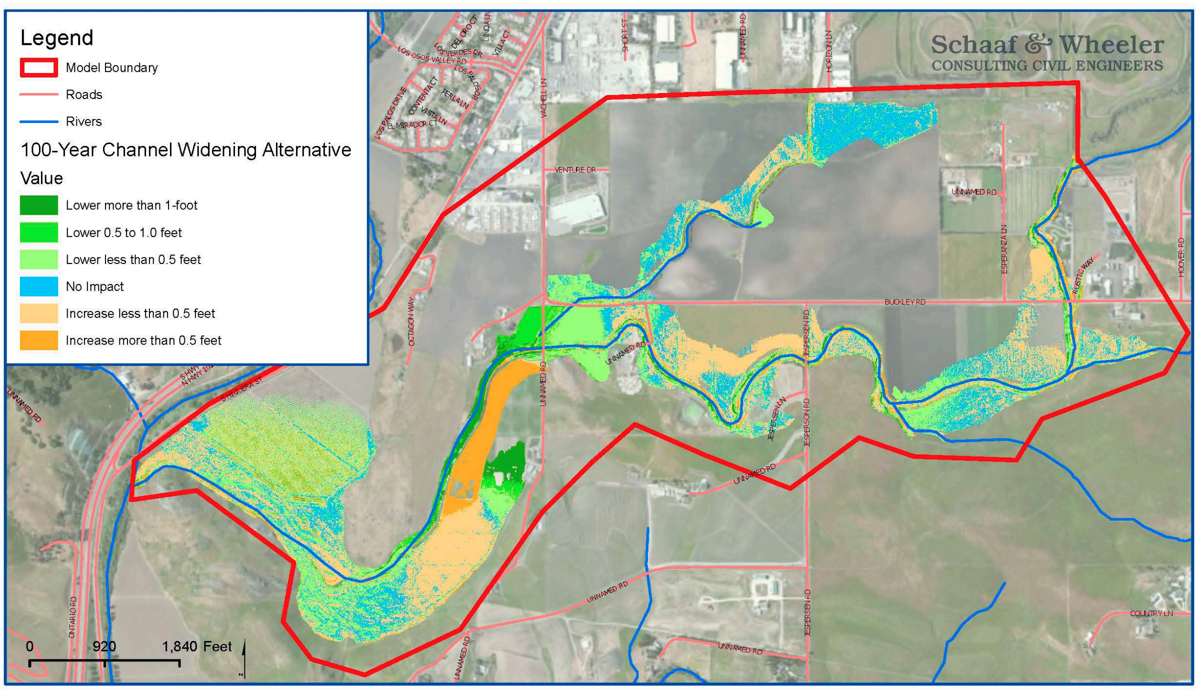

Figure 39 – Channel Widening Alternative 100-year Water Level Changes

Summary of Alternatives

The bridge and lower downstream alternatives showed no significant benefit on flooding at Buckley Road. The widened channel alternative and upstream storage alternatives have the potential to decrease the maximum flood depth on the roadway. However, they are unlikely to fully prevent inundation in severe flood events.

The logistics of upstream storage have several variables of which land acquisition is the most important. A better understanding of future land uses above the Buckley Road bridge on East Fork, whether on the Tank Farm site or elsewhere, is necessary to clearly determine the viability of this project concept.

A conceptual cost estimate of the widen channel alternative has been prepared. It includes widening approximately 2,500 feet of the East Fork channel and upsizing three road crossings. This will increase the capacity of the channels in the project area and decrease the water surface elevation at Buckley Road. The project cost, including engineering and inspection, is estimated to be $3.4 million. This cost does not include easement acquisition or environmental work, such as permit acquisition.

Conclusion

The historical flooding that occurs at Buckley Road at the intersection with Vachell Lane is confirmed by the 2D HEC-RAS hydraulic models. As confirmed by the near-term modeling results, the extension and raising of Buckley Road reduces the overall risk of flooding over the road.

While this project improved the availability of Buckley Road during storm events, this study confirms that historical flooding will continue in the area since it is a known floodplain for the East Fork of San Luis Obispo Creek. With the last mile of the East Fork being essentially flat, the 12.3 sq-mi watershed of the East Fork simply spills into this historical floodplain and slowly metes out into the main channel of SLO Creek.

Several conceptual alternatives were analyzed to mitigate the flooding including channel widening, bridge and culvert modifications, upstream detention storage, and downstream channel modifications. The bridge and lower downstream alternatives showed no significant mitigation to flooding at Buckley Road. The widened channel alternative and upstream storage alternatives decrease the predicted maximum flood depth on the roadway by approximately 0.7 feet during the 100-year event.

This report provides a more detailed understanding the historical and near-term flood condition of the East Fork area. It also provides order-of-magnitude understanding for potential improvement projects and what impact, if any, they would have on the properties in and around the floodplain.

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