MBK ENGINEERS

Water Resources ◆ Flood Control ◆ Water Rights

TECHNICAL MEMORANDUM

DATE: March 28, 2019

TO: Jeff Twitchell, P.E., GEI Consultants

FROM: Brian Brown, P.E.

SUBJECT: Flood Risk to Community of Yolo

This memorandum documents the flood risk to Yolo, an unincorporated community in Yolo, California. The community of Yolo is located approximately 5 miles northwest of Woodland, California along Interstate 5. Yolo is located on the left bank of Cache Creek, adjacent to the Cache Creek levee directly downstream of where Interstate 5 crosses Cache Creek as shown in Figure 1.

Figure 1. Community of Yolo in relation to Cache Creek and Interstate 5

Cache Creek drains from west to east, starting near Clear Lake and terminating at the Cache Creek Settling Basin. The Cache Creek Setting Basin is bounded by levees on all sides and flows into the Yolo Bypass by means of an outlet weir. The purpose of the basin is to preserve the capacity of the Yolo Bypass by entrapping sediment from Cache Creek.

The Cache Creek levees were constructed in 1958 (USACE, 1958) with the anticipation of Wilson Valley Dam and Reservoir being constructed for flood control upstream shortly after the levees were completed. Based on the proposed reservoir construction, the design of the levees was minimized and targeted flow of 30,000 cfs with 3-feet of freeboard. This design flow corresponds to roughly a 10-percent annual chance flood. The Wilson Valley Dam and Reservoir project was never constructed upstream of the Cache Creek levees. Over time, subsidence of the levee system has reduced the amount of freeboard available for passing the 10-percent annual chance flood.

1. YOLO COUNTY FLOOD INSURANCE STUDY

The current FEMA Flood Insurance Study (FIS) for Yolo County is dated May 16, 2012 (FEMA, 2012). The countywide FIS investigates the severity of flood hazards Yolo County and maps areas within the 1-percent annual chance floodplain. The FIS uses a flow of 63,680 cfs for Cache Creek at County Road 94B for the1-percent annual chance event. Regarding the Cache Creek levees, the FIS states:

"The restudy of Cache Creek in the City of Woodland indicates that there are no existing local flood-protection measures or structures to reduce flood hazards within the restudied reach of Cache Creek in Yolo County and the City of Woodland. The existing Cache Creek levees are not in compliance with the requirements set forth in the NFIP regulations for protecting against the 1-percent annual chance flood."

The current FIS maps the floodplain for the 1-percent annual chance floodplain on the Floodplain Insurance Rate Maps (FIRM) for Yolo County. The community of Yolo is shown as mapped in Zone A. FEMA defines Zone A as "the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone." Though there is not a detailed study to provide base flood elevations (BFE), the non-compliance of the Cache Creek levees leads to the Zone A determination. The FEMA flood map for Yolo County near the community of Yolo is shown in Figure 2.

Figure 2. FEMA Flood Map for Yolo County Near Community of Yolo

In accordance with FEMA criteria for the accreditation of levee systems, a minimum earthen levee freeboard of 3 feet is required in evaluating the ability of levee systems to provide protection from the 1-percent annual chance flood. If an earthen levee does not provide the specified 3-foot freeboard during a 1-percent annual chance flood, it is assumed to fail. Therefore, the floodplains in the area of such an inadequate levee reflect flood conditions as if this flood-control structure did not exist. The criteria used to evaluate protection from the 1-percent annual chance flood are (1) adequate design, including freeboard, (2) structural stability, and (3) proper operation and maintenance. Levees that do not provide protection from the 1 percent annual chance flood are not considered in the hydraulic analysis of the 1-percent annual chance floodplain.

2. RECENT HYDRAULIC STUDIES IN AREA

The City of Woodland is the local sponsor for the U.S. Army Corps of Engineers (USACE) Lower Cache Creek Feasibility Study (LCCFS). The City has performed In-Kind Services on the LCCFS for the USACE by assessing the hydraulic performance of the without-project conditions. The purpose of the USACE LCCFS is to identify potential alternatives that could reduce flood risk to lands adjacent to Cache Creek, specifically on the right side of the stream where floodwaters flow towards the City of Woodland.

The LCCFS routed multiple probabilistic events through Cache Creek to compute the water surface elevation (WSE) in the creek and determine when the levees would overtop. This routing determined that the nominal capacity of Cache Creek upstream of Highway 113 is approximately 34,500 cfs (LCCFS, 2015). Flows exceeding this capacity spill out of the channel banks, over the top of levees and natural high ground. Due to this, the maximum water surface for storms equal to or greater than the 50-yr event are the same downstream of Interstate 5. The plot showing the

computed WSE from the probabilistic events in relation to the existing top of levee near the community of Yolo is shown in Exhibit 1.

Due to flow spilling out of the channel banks, the area around Cache Creek was mapped for the 1-percent annual chance flood. The hydrology used for the flow routing and subsequent floodplain mapping is based on the Department of Water Resources (DWR) 2012 Central Valley Hydrology Study (CVHS) adopted for the Central Valley Floodplain Evaluation and Delineation (CVFED) program (USACE, 2012). From the CVHS hydrograph for the Cache Creek flows, the peak flow for the 1-percent annual chance flood is 58,300 cfs. This peak value closely correlates to the FIS flow for Cache Creek (63,680 cfs at County Road 94B). The resulting floodplain near the community of Yolo for the 1-percent annual chance flood, assuming all levees are allowed to overtop without failure, is shown in Figure 3.

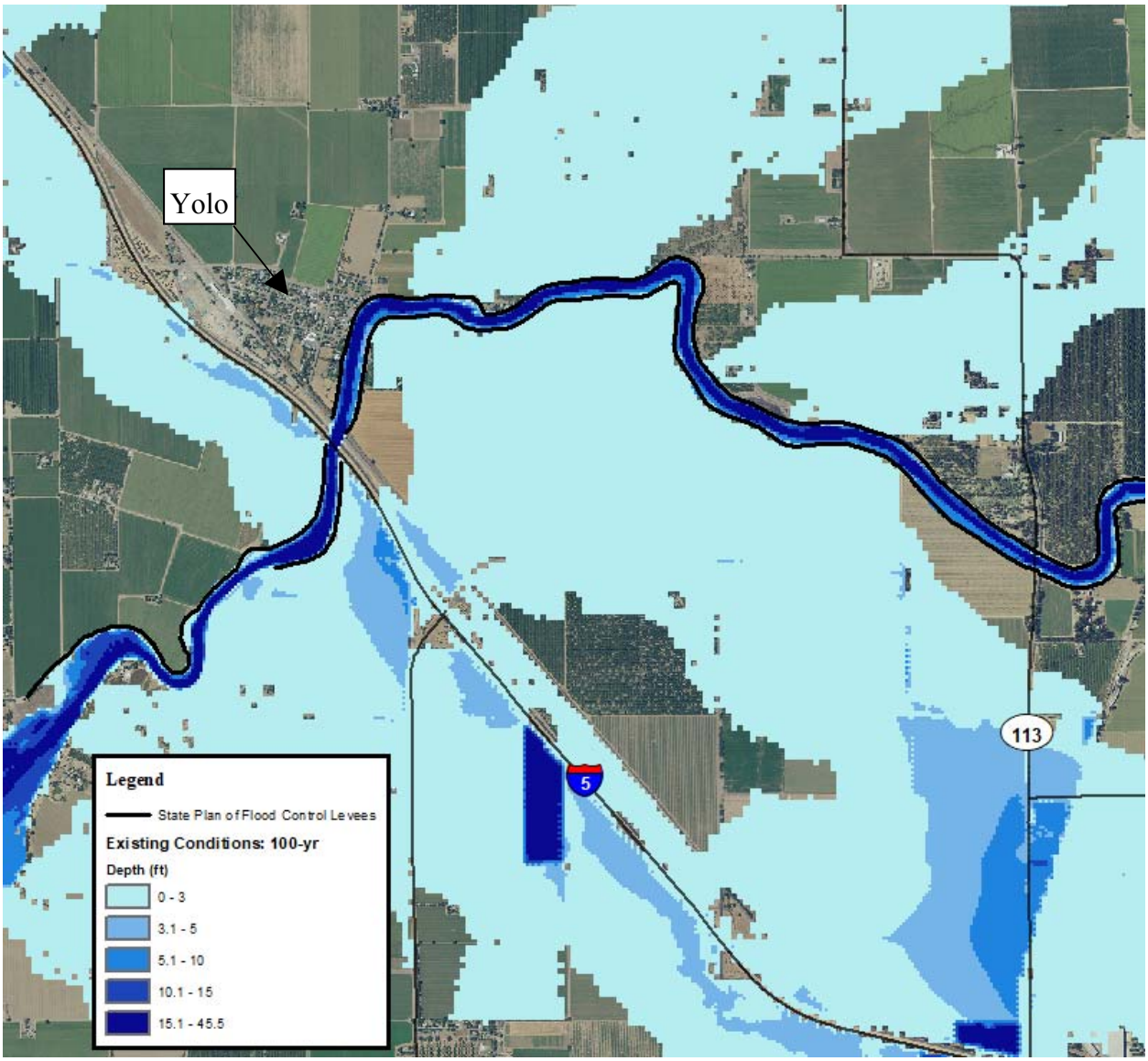

Figure 3. Floodplain for 1-percent annual chance flood near the Community of Yolo, from LCCFS

In the existing conditions for the 1-percent annual chance flood, there is overtopping both upstream and downstream of the community of Yolo. Interstate 5 is raised compared to the adjacent farmland and acts as a berm, preventing upstream overland flow from entering the community of Yolo. The levees on the left bank of Cache Creek are higher than the WSE (as shown on Exhibit 1), which prevents overtopping at the community of Yolo.

At the Yolo community outreach meeting, residents brought up flooding along the right bank of Cache Creek upstream of Interstate 5. The LCCFS shows this as floodwater leaves the channel upstream of the levees at Huff's Corner. The right bank is high ground and no levees are present. Since the system was designed for a target flow (approximately 10-percent annual chance flood) and assumed Wilson Valley Dam would be constructed, it is expected that overtopping would occur in large events.

The floodplain in Figure 2 is based on the assumption of levee overtopping without failure. The levees are not certified and not in compliance with the NFIP for the 1-percent annual chance flood, and would likely have failures in a large event. For areas protected by non-certified levees, FEMA requires a breach analysis to determine the floodplain. A breach was configured on the left bank of Cache Creek, at the community of Yolo. The breach parameters were estimated using the "Development of Levee Breach Parameters for HEC-RAS Application" guidance document developed by the USACE Sacramento District (USACE, 2013). Based on the levee breach at the community of Yolo, the resulting inundation and breach hydrograph are shown on Exhibit 2. The Exhibit shows the community being inundated from the resulting levee breach.

3. FEBRUARY 2019 EVENT

Though the LCCFS determined the channel capacity to be approximately 34,500 cfs, the event on February 27, 2019 had an approximate flow of 26,400 cfs which resulted in overtopping of the left bank levee downstream of Yolo and overtopping of the right banks upstream of the project levees. Though there was overtopping upstream and downstream of the community of Yolo, there was approximately 4-5 feet of freeboard adjacent to the community. During this event there were also numerous boils and seepage concerns along both banks of the Cache Creek levees downstream to Highway 113. DWR and local agencies performed emergency flood fight sandbagging to raise the top of levee along Cache Creek in order to prevent additional overtopping. Additionally, sandbags were used to fight seepage and boils on the land-side of the levees and an emergency rock berm was constructed on the landside of the right bank levee upstream of Interstate 5 where a significant through-seepage boil threatened levee stability. After the event, DWR followed up by repairing and raising the levees at the locations where the overtopping occurred.

4. REASONS FOR REDUCED CHANNEL CAPACITY

Based on the February 27, 2019 event, the current Cache Creek channel capacity near the community of Yolo is approximately 26,400 cfs, far less than the previously determined 34,500 cfs. The reduced capacity can be attributed to several factors including documented subsidence in the area, sedimentation and channel vegetation.

Recent studies including the LCCFS and DWR Survey Report (LCCFS, 2015; DWR, 2018) indicate that subsidence is occurring in the area. The LCCFS ran into difficulties calibrating models to levee heights and determined that subsidence was the likely cause of top of levee discrepancies between 1995 and 2008. Additionally, the 2018 survey report completed by DWR

shows subsidence in the area ranging from 0.59 to 1.19 feet. As a result of the suspected subsidence in the area and channel capacity issues experienced in the February event, more detailed subsidence analysis has been recommended. At this point it is suspected that subsidence may be a major factor in channel capacity issues on Cache Creek.

After the February 27 event, sedimentation was evaluated using available historic models for Cache Creek. This included the Comprehensive Study Model (Comp Study) from 2001 and the CVFED HEC-RAS model for Cache Creek from 2012. Both models contain riverine cross sections that can be compared to determine if there has been sediment build-up over time. Comparing the channel inverts, both models have approximately the same channel profile between the settling basin and the upstream end of the project levees at Huff's Corner. When looking at the cross sections, there are minor differences in storage between the 2001 and 2012 data sets. These minor differences are at the lower point of the channel that does not provide much conveyance area.

To evaluate the potential impact if sediment buildup was occurring, a potential dredging alternative was modeled to compare to the existing conditions. For this comparative analysis, the channel was lowered by 5-feet from the settling basin to the upstream portion of the Huff's Corner levee to approximate dredging. The results from this model run were compared to the existing conditions and showed no significant decrease in the resulting water surface elevation. This results from the low part of the channel having a relatively small conveyance area compared to the upper portions of the channel. Additionally, if dredging was to occur, it would exacerbate erosion and necessitate more bank protection due to the incised channel.

Based on the channel geometry comparison and the model results of a potential dredging alternative, sedimentation does not appear to be causing the reduced capacity in the channel near the community of Yolo.

Vegetation in the channel and settling basin could also decrease the channel capacity. Increased vegetation would increase the roughness, which could reduce channel conveyance capacity and increase water surface elevations. In reviewing historic aerial photos available, this study was not able to determine if vegetation growth has reduced the channel capacity. Further analysis may be warranted to determine the magnitude of channel vegetation impacts on the channel capacity

5. RESULTING FLOOD RISK

The community of Yolo is located on the left bank of Cache Creek, a leveed creek. The current levees are not certified and do not provide adequate flood protection as they were designed for a target flow of 30,000 cfs, which corresponds to a 10-percent annual chance flood. When the LCCFS analyzed a 1-percent annual chance flood and assumed levee overtopping without failure, overtopping does not reach the community of Yolo as Interstate 5 acts as a berm, preventing upstream overtopping from reaching the community. The assumption of levees overtopping without failure is not a realistic assumption for levee performance based on what occurred during the February 27, 2019 event, but this assumption provides a base hydraulic run in the LCCFS.

A levee breach analysis at the community of Yolo shows the community being inundated from Cache Creek. The levee representing the left bank of Cache Creek adjacent to Yolo and the embankment representing Interstate 5 could be certified to provide the community with flood protection. However, the engineer certifying these levees would have to be certain the levees

meet current geotechnical standards based on geotechnical data obtained from field investigations. It is unlikely the levees meet current geotechnical and structural criteria for certification based on preliminary field investigations on other portions of the Cache Creek levees.

DWR is responsible for maintenance of the Cache Creek levee system, with the exception of 0.5 miles on the right bank at Huff's Corner that is the responsibility of Yolo County. The February 27, 2019, flood event demonstrates that the levee system cannot pass the design flow of 33,000 cfs with three feet of freeboard. DWR is aware of this deficiency and is looking into the situation.

6. FUTURE CONSIDERATIONS

In response to this year's February high water events, DWR is preparing a study to investigate the contributing factors causing a decrease in the capacity of the levee system. In addition to this study DWR is undertaking, future conditions will be looked at based on climate change and potential projects along Cache Creek.

The Department of Water Resources looked at climate change as part of the 2017 CVFPP Update (CVFPP,2017), specifically addressing climate change on the hydrology of the Central Valley. The study states that median changes in annual precipitation by the end of the century for the Sacramento River Basin are projected to be about 6 percent. This conclusion is not granular enough to be applied to the smaller Cache Creek watershed that does not contain mountain peaks that receive snowfall. Another component of climate change is sea level rise, which causes the tail water to increase for riverine systems discharging into the ocean. Sea level rise projections for the San Francisco bay are documented by the California Ocean Protection Council Science Advisory Team (OPC-SAT, 2017) based on recent scientific data. The Central Valley Flood Protection Board (CVFPB) and DWR are interested in sea level rise and how it could impact the leveed systems in northern California. These agencies have concluded that sea level rise does not extend far enough up the Sacramento River System to effect Cache Creek.

There is a potential project along Cache Creek, in the LCCFS by the U.S. Army Corps of Engineers for the City of Woodland. The LCCFS proposes to implement structural and flood protection measures to protect the City of Woodland. The proposed structures are offset from the right overbank of Cache Creek, near the City of Woodland. These proposed floodplain structures do not alter the Cache Creek levees or impact the flow leaving the Cache Creek levees.

7. REFERENCES

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