TECHNICAL MEMORANDUM

DATE: November 27, 2019
TO: Three Rivers Levee Improvement Authority
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SUBJECT: Goldfields 200-Year Levee Project – Hydraulic Analysis for the Determination of the Design Water Surface Elevation for the 100% Basis of Design
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1. Purpose
Three Rivers Levee Improvement Authority (TRLIA) is proposing to extend the existing Yuba River south levee upstream to high ground. The purpose of the levee is to protect the South Yuba and Reclamation District No. 784 (RD 784) areas from floodwaters that could be conveyed through the Goldfields as a result of potential breaches in the Yuba River South Training Wall. The proposed levee alignment extends from the Upper Yuba Levee Improvement Project (UYLIP), near its connection to the Goldfields, southeast to Hammonton-Smartville Road, and then along the north side of Hammonton-Smartville Road to the natural high ground. This proposed levee alignment is shown in Figure 1. The purpose of this technical memorandum is to document the hydraulic model development and the hydraulic analysis in order to determine the design water surface elevation (DWSE), as defined by the State of California’s Urban Levee Design Criteria (DWR, 2012).

2. Hydraulic Model
A hydraulic model of the river system surrounding the Yuba Goldfields was developed for this study using HEC-RAS version 5.0.7 (USACE, 2016). HEC-RAS is capable of simulating one-dimensional (1D) and two-dimensional (2D) unsteady flow calculations through a full network of open channels. The upstream boundary of the HEC-RAS model is on the Yuba River, approximately 4 miles upstream of Daguerre Point Dam. The downstream boundary is on the Feather River, approximately 0.5 miles downstream of the Yuba River confluence (Figure 2). The study area is represented entirely as a 2D flow area in the hydraulic model, bounded by the following high elevation features: Highway 20; the southeasterly and southern portions of the Marysville Ring levee; the project levees of the Feather River; and Hammonton-Smartville Road, near the proposed levee. The model will be referred to as the Yuba Goldfields HEC-RAS model.

2.1. Topography and Sources of Data
The Yuba Goldfields HEC-RAS model and all results are referenced in the Universal Transverse Mercator (UTM) Zone 10 coordinate horizontal system and the North American Vertical Datum of 1988 (NAVD88). All horizontal and vertical units are provided in U.S. survey feet. The primary source of topographic data was Light Detection and Ranging (LiDAR) data, compiled by the California Department of Water Resources (DWR) under the Central Valley Floodplain Evaluation and Delineation (CVFED) Program (Wood Rodgers, 2013). The LiDAR data is comprised of points that densely cover the entire region. The accuracy of the LiDAR data was tested to ensure a 0.6-foot fundamental vertical accuracy at 95 percent confidence level was met.

2.2. Model Calibration
The Yuba Goldfields HEC-RAS model was calibrated to the January 1997 flood event using observed data available within the model domain. The calibration was performed to verify that the selected model parameters are reasonable and that the model can reasonably reproduce an actual flood event. The observed peak flow on the Yuba River during this event was 161,000 cfs, which is estimated to have a 1-in-86 annual exceedance probability. The January 1997 flood event was selected for calibration because it is the largest flood event of record (post New Bullards Bar Dam) on the Yuba River; the flood event was contained within the State-Federal project levee and non-project levees on the Yuba River; there is observed flow and stage data and surveyed high-water marks (HWM) throughout the project reach; and
the order of magnitude is near the peak flow of the design hydrology, which is approximately 183,000 cfs.

The calibration process mainly consisted of adjusting Manning’s roughness coefficients and refining the 2D model mesh resolution so that computed peak stage at the Yuba River near Marysville gage (USGS 11421000) was within 1 foot of the observed peak stage. This gage, and other observed data used to inform the quality of model calibration, is described in Section 2.2.2. Next, the model was checked for calibration with the recorded peak flow at the gage. Finally, the high-water marks available throughout the study area were used to gage the performance of the hydraulic model. Less emphasis was placed on matching the observed high-water marks, due to the uncertainty regarding the accuracy of the high-water marks, and more emphasis was placed on matching the observed peak stage and flow of the Yuba River near Marysville gage (USGS 11421000).

2.2.1 Boundary Conditions
The Yuba Goldfields HEC-RAS model requires boundary condition inputs at the upstream and downstream ends of the model. The flows and stage at the boundary locations were extracted from a simulation of the January 1997 flood event, taken from a 1D HEC-RAS model of the Sacramento River Flood Control Project (SRFCP) (MBK Engineers, 2014). Table 1 shows the location, source of flow, and stage data used in the development of the boundary conditions for calibration. The location of the downstream model boundary contains rating curve data and is approximately 8 miles from the project site wherein imprecise approximation of rating curve data would not have a large influence on model results at the project site. Plots of the upstream flow boundary conditions are provided from Figure 3, Figure 4, and Figure 5. The downstream stage boundary condition used in the calibration is plotted in Figure 6.

<table>
<thead>
<tr>
<th>HEC-RAS Location</th>
<th>Boundary Condition Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yuba River - Approximately 4 miles upstream of Daguerre Point Dam</td>
<td>Upstream Flow</td>
<td>Observed Data Compilation for USACE American River Common Features HEC-RAS Model Rel4</td>
</tr>
<tr>
<td>Dry Creek - At Yuba River</td>
<td>Upstream Flow</td>
<td>Observed Data Compilation for USACE American River Common Features HEC-RAS Model Rel4</td>
</tr>
<tr>
<td>Feather River – At 5th Street Bridge</td>
<td>Upstream Flow</td>
<td>Hydraulic model simulation of January 1997 flood from USACE American River Common Features HEC-RAS Model Rel4</td>
</tr>
<tr>
<td>Feather River – Approximately 1 mile downstream of confluence with Yuba River</td>
<td>Downstream Stage</td>
<td>Hydraulic model simulation of January 1997 flood from USACE American River Common Features HEC-RAS Model Rel4</td>
</tr>
</tbody>
</table>

2.2.2 Observed Data
Observed stage and flow data within the model study area for the January 1997 flood event was available from the USGS gaging station, Yuba River near Marysville (11421000). The observed peak stage, and flow at the gages, were compared with the computed peak stage and flow from the January 1997 flood simulation. The location of the gage, in reference to the Goldfields HEC-RAS model, is shown in Figure 7.
Surveyed high-water marks from DWR (Wood Rodgers, 2013) were available along the Yuba River and Feather River for the January 1997 flood event. These high-water marks were used to calibrate the Yuba Goldfields HEC-RAS model by comparing the high-water mark elevation with the computed maximum water surface elevation (WSE), and then making adjustments to the Manning’s roughness coefficient for each land use type until the model reasonably reproduced observed peak flows, stages, and high-water mark elevation. The locations of the high-water marks are shown in Figure 8.

2.2.3 Manning’s Roughness Coefficient

Manning’s roughness coefficients for the 2D flow area were assigned spatially, using a land-use dataset from a DWR Land Use Survey (DWR, 2005). The Manning’s roughness coefficient for each land use classification was based on Table 3-1 from the HEC-RAS River Analysis System Hydraulic Reference Manual Version 5.0 (February 2016), and was adjusted using engineering judgement to calibrate the model.

Table 2 lists the calibrated Manning’s roughness coefficients for the 2D flow area. The spatial variation of the Manning’s roughness coefficient for the Yuba Goldfields HEC-RAS model is shown in Figure 9.

<table>
<thead>
<tr>
<th>Land Use/Veg/Habitat</th>
<th>Manning’s Roughness Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>0.03</td>
</tr>
<tr>
<td>Riverbed</td>
<td>0.03-0.042</td>
</tr>
<tr>
<td>Idle, Residential</td>
<td>0.035</td>
</tr>
<tr>
<td>Barren, Commercial, Grain and Hay Crops, Industrial, Urban Landscape, Wasteland</td>
<td>0.04</td>
</tr>
<tr>
<td>Channel Beds, Ponds, Sandbars</td>
<td>0.03-0.042</td>
</tr>
<tr>
<td>Citrus and Subtropical Orchards, Field Crops, Pasture, Truck Crops, Nursery and Berry Crops, Urban, Vacant</td>
<td>0.045</td>
</tr>
<tr>
<td>Semi-agricultural and Incidental to Agriculture</td>
<td>0.048</td>
</tr>
<tr>
<td>Deciduous Fruits and Nut Trees</td>
<td>0.055</td>
</tr>
<tr>
<td>Native Vegetation</td>
<td>0.06</td>
</tr>
<tr>
<td>Riparian Vegetation</td>
<td>0.07</td>
</tr>
</tbody>
</table>

2.2.4 Calibration Results

The Yuba Goldfields HEC-RAS model was simulated with the January 1997 boundary conditions from Section 2.2.1. Hydrograph plots comparing the computed values versus observed values are plotted in Figure 10 and Figure 11, respectively. The observed stage data for the Yuba River near the Marysville gage is sourced from the USGS and was adjusted by -3.0 feet in order to convert to the National Geodetic Vertical Datum of 1929 (NGVD29) datum, and then +2.3 feet to yield NAVD 88. The transformation to NGVD29 is done, as per USGS published gage datum information, and the conversion from NGVD29 to NAVD88 is accomplished, as per VERTCON – a datum conversion computer program developed by the National Geodetic Survey. Moreover, original USGS dataset contained missing data points that were subsequently reconstructed by USACE. Both the adjusted and reconstructed observed datasets are plotted with calculated stage in Figure 11. Table 3 tabulates the high-water mark elevation,
computed maximum water surface elevation, and the difference for each of the high-water mark locations, as shown in Figure 9.

Surveyed high-water marks are elevation surveys of evidence of flood water peaks, such as debris lines or water stains on structures. These marks are typically surveyed after high-flow recedes to levels where survey crews can reach these locations. While care is placed into estimating high-water, there is greater uncertainty in high-water mark surveys when compared to recorded gage data as it may not necessarily reflect a stage of the actual peak flow of the event. HWM number 6 in Table 3 illustrates one of these anomalies. Nevertheless, high-water marks and the calculated maximum water surface elevation are plotted in Figure 12. Points closer to the 1-to-1 line indicate that the model predicted a WSE close to the high-water mark at a given location. Based on this observation, the model performs reasonably well in predicting maximum water surface elevations, which indicates that the parameters selected for the model is reasonably calibrated.
Table 3. High-Water Mark and Computed Maximum Water Surface Elevation Comparison

<table>
<thead>
<tr>
<th>HWM ID</th>
<th>Surveyed HWM Elevation (ft.-NAVD88)</th>
<th>Computed WSE (ft.-NAVD88)</th>
<th>Difference (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YCWA</td>
<td>143.00</td>
<td>144.47</td>
<td>1.47</td>
</tr>
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<td>1</td>
<td>127.04</td>
<td>126.91</td>
<td>-0.13</td>
</tr>
<tr>
<td>3</td>
<td>126.94</td>
<td>122.41</td>
<td>-4.53</td>
</tr>
<tr>
<td>4</td>
<td>118.25</td>
<td>117.95</td>
<td>-0.30</td>
</tr>
<tr>
<td>5</td>
<td>109.49</td>
<td>110.35</td>
<td>0.86</td>
</tr>
<tr>
<td>t-3 1990</td>
<td>135.11</td>
<td>110.44</td>
<td>-24.67</td>
</tr>
<tr>
<td>6</td>
<td>105.48</td>
<td>105.00</td>
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<td>7</td>
<td>99.45</td>
<td>101.25</td>
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<td>8</td>
<td>97.22</td>
<td>97.32</td>
<td>0.10</td>
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<td>9</td>
<td>95.35</td>
<td>94.42</td>
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<td>93.77</td>
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<tr>
<td>11</td>
<td>91.57</td>
<td>90.02</td>
<td>-1.55</td>
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<tr>
<td>12</td>
<td>88.29</td>
<td>87.35</td>
<td>-0.94</td>
</tr>
<tr>
<td>13</td>
<td>88.00</td>
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<td>14</td>
<td>93.58</td>
<td>80.58</td>
<td>-13.00</td>
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<tr>
<td>17</td>
<td>83.08</td>
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</tr>
<tr>
<td>YL2</td>
<td>83.17</td>
<td>78.06</td>
<td>-5.11</td>
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<tr>
<td>18</td>
<td>81.44</td>
<td>79.48</td>
<td>-1.96</td>
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<td>20</td>
<td>79.14</td>
<td>77.90</td>
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<td>21B</td>
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<td>77.61</td>
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<tr>
<td>21</td>
<td>70.61</td>
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<td>22</td>
<td>80.46</td>
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<tr>
<td>Y1</td>
<td>77.17</td>
<td>77.23</td>
<td>0.06</td>
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<tr>
<td>L40</td>
<td>77.50</td>
<td>77.18</td>
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<tr>
<td>RF42</td>
<td>73.57</td>
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<td>RF41</td>
<td>75.86</td>
<td>76.66</td>
<td>0.80</td>
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2.3. Model Verification

The Goldfields HEC-RAS model was verified with another historical flood event. The purpose of the verification simulation was to check that the calibrated hydraulic model could reasonably reproduce another flood event other than the calibration event. The January 2006 flood event was selected for verification, as it is the third largest flood of event of record (post New Bullards Bar Dam) on the Yuba River. The observed peak flow on the Yuba River during this event is 114,000 cfs, which is estimated to have a 1-in-32 annual exceedance probability. The flood event was also contained within the State-Federal project levee and the non-project levees of the Yuba River, and there is sufficient observed flow and stage data available.

2.3.1 Boundary Conditions

The Yuba Goldfields HEC-RAS model requires boundary condition inputs at the upstream and downstream end of the model. The flows and stage at the boundary locations were extracted from a simulation of the January 2006 flood event from a 1D HEC-RAS model of the SRFCP (MBK Engineers, 2014). Table 1 shows the location and source of flow and stage data used in the development of the boundary conditions for the calibration. Plots of the upstream flow boundary conditions are provided from Figure 13, Figure 14, and Figure 15. The downstream stage boundary condition used in the calibration is plotted in Figure 16. On Figure 13, the Yuba River peaks at 120,000 cfs at Daguerre dam between New Year’s Eve and New Year’s Day, while Feather River is less than 50,000 cfs. The high flow from the Yuba River creates a hydraulic dam effect, resulting in a temporary reduction in the Feather River flow rate upstream of the Yuba River. This dip in the hydrograph is not seen in the stage hydrograph for this same section, as shown in Figure 16.

2.3.2 Observed Data

Observed stage and flow data for the January 2006 flood event was available at the Yuba River near Marysville USGS gaging station (11421000). Observed high-water marks were not available in this reach for the January 2006 event.

2.3.3 Verification Results

Figure 17 and Figure 18 plot the calculated versus observed flow and stage for the 2006 flood event simulation, respectively. The results show the Yuba Goldfields HEC-RAS model reasonably reproduces the maximum water surface elevation and peak flow in the project area.

3. Hydraulic Analysis

The hydraulic model and hydrology described in the previous sections were used to determine the DWSE. The hydraulic model was configured to criteria set by ULDC, and is described as follows:

3.1. ULDC Criteria

Section 7.1 of the ULDC offers two options to determine the DWSE. The first option is the FEMA Approach, in which the DWSE is computed deterministically, with a hydraulic model using the best available median discharge rate. The second option is the U.S. Army Corps of Engineers (USACE) Approach, which incorporates uncertainty into the determination of the DWSE. The approach selected for this analysis was the FEMA Approach.
The DWSE is defined in the ULDC as the “200-year stage or water level used to design a levee or floodwall”. Section 7.1.1 of the ULDC specifies that the hydraulic modeling used to determine the DWSE must consider the following:

- Upstream, downstream, and nearby levees and floodwalls protecting urban areas are assumed to be raised to the median 200-year water surface elevation, plus 3 feet; and are not allowed to breach, even if overtopped. Overtopping flows are assumed to leave the channel and remain in the 200-year floodplain.

- All project levees and floodwalls are to be modeled to incorporate a minimum crown elevation equal to the authorized (usually the 1955/1957) USACE design profiles – this affects non-urbanized areas for the most part. All such levees and floodwalls are to be allowed to overtop, act as weirs, and to not breach for floods up to and including the median 500-year flood. Overtopping flows are assumed to leave the channel and remain in the 200-year floodplain.

- Non-project levees and floodwalls in non-urbanized areas in the region, to the extent they may affect the DWSE, are to be modeled at their existing or authorized height (whichever is higher) and to act as weirs without breaching if overtopped.

- Debris loading on bridges must be considered. Bridges with less than 3 feet of clearance above the DWSE may experience extraordinary debris loading that must be evaluated in addition to typical pier/bent debris loading. The evaluation should include historic and potential debris transport in the stream, an analysis of loading on the bridge, and analysis of backwater impacts on the DWSE in the vicinity of the bridge.

Section 7.1.3 of the ULDC requires adjustments to the DWSE for the effects of superelevation, if applicable. Superelevation is a tilting of the water surface, which may occur as water flows through a bend in the channel. Computational methods for determining superelevation adjustments are found in USACE Engineering Manual 1110-2-1601 (USACE, 1991).

Section 7.1.3 of the ULDC also states that “...the civil engineer should consider increasing the DWSE to account for the potential increases in water surface associated with climate change, updated hydrology, updated hydraulic models, and sea level rise”. This statement implies that adjustment for sea level rise is optional; however, Section 7.19 of the ULDC states that “the effects of sea level rise are to be estimated and addressed for the duration during which a Finding that the urban level of flood protection exists may be valid”. Based on the second statement, sea level rise adjustment appears to be mandatory.

Additionally, Section 7.1.3 of the ULDC states that:

The civil engineer also needs to address two other situations: (1) whether upstream levee or floodwall breaches could produce overland flows that would reach the area protected by the levee system or increase the water surface elevation along the levee system, and (2) whether flooding in a nearby leveed area could fill that area and breach a nearby levee or floodwall, returning flow to the stream and increasing the DWSE for a portion of the levee system.

Neither of these conditions apply to the study area; therefore, it was not evaluated. The following sections address the requirements in the ULDC and discuss the application of each for project:
3.1.1. **Levees**
As per the ULDC, all urban levees were assumed to have a minimum top elevation of the median 200-year water surface elevation, plus 3 feet. All non-urban State-Federal Project levees were assumed to have a minimum crown elevation equal to the authorized USACE design profiles. The State-Federal Project levees in the Yuba River reach are of a sufficient height, and therefore were not adjusted in the model geometry.

3.1.2. **Debris Loading**
The ULDC specifies that debris loading on bridges must be considered, and that “bridges with less than 3 feet of clearance above the DWSE may experience extraordinary debris loading that must be evaluated, in addition to typical pier/bent debris loading”.

The only bridge in the hydraulic model domain is the Simpson Lane Bridge over the Yuba River. The bridge is approximately 400 feet long in a floodway, which is approximately 9000 feet wide. In review of the widths and the distance downstream (~6 mi) from the proposed levee, any debris loading at the Simpson Lane bridge will not have a significant effect on the DWSE; therefore, it was not included in the analysis.

3.1.3. **Superelevation**
Superelevation is a tilting of the water surface that occurs on the outside of a river bend. The ULDC notes that, “on the outside of a bend, the superelevation needs to be added to the DWSE”. The proposed levee is located in the floodplain and is 7000 feet away from the Yuba River. An adjustment for superelevation is not necessary for the proposed levee.

3.1.4. **Climate Change**
The effects of climate change on extreme precipitation events in the Central Valley are being studied, but there is no actionable science at this time to account for in a design level analysis. Therefore, the hydrology used in the calculation of the 200-year median water surface elevation has not been adjusted for the effects of climate change.

3.1.5. **Updated Hydrology**
This analysis makes use of the most current hydrologic data for the study area, which was developed as part of the Central Valley Hydrology Study (CVHS), and is further detailed in Section 4 of this report. CVHS methodology and data are currently being used on USACE and DWR projects.

3.1.6. **Updated Hydraulic Model**
A 2D model of the project was developed for this project using HEC-RAS version 5.0.5. This is the latest hydraulic model specific for this project.

3.1.7. **Sea Level Rise**
The ULDC notes that, “the effects of sea level rise are to be estimated and addressed for the duration during which a Finding that the urban level of flood protection exists may be valid”.

The Yuba River and project area is of significant distance upstream of the San Francisco Bay and is outside of the influence of sea level rise.
3.2. Goldfields Flow Dynamics

The Yuba River South Training Wall, the location of which is shown in Figure 19, was initially created as a tailings mound to keep the main flows of the Yuba River to the north of this embankment, and to prevent the river from meandering south. Behind the South Training Wall lies a complex of mine tailing mounds and canals, sometimes called “pools”, that direct flows through the Goldfields. Erosion of the South Training Wall along with commercial mining activities that change the alignment and condition of the tailings mounds and pools south of the training wall, result in ever changing flow dynamics within the Goldfields (MBK Engineers, 2011). The key features in the Goldfields and erosion sites along the South Training Wall are shown in Figure 19. Figure 20 shows the potential flow path of floodwaters in the Goldfields if there were a breach at a specific location in the South Training Wall.

3.3. Performance Assumptions of Goldfields

The performance of the features shown in Figure 19 affect water surface elevations along the proposed levee. Numerous combinations of performance assumptions for each of the features were analyzed (MBK Engineers, 2018) and are attached in Appendix B. The MBK Engineers 2018 memorandum recommended a set of performance assumptions adopted for the development of the DWSE. The following is a summary of the performance assumptions taken from the MBK Engineers 2018 memorandum, and the subsequent assumptions added for the DWSE scenario, which are shown in Figure 21:

- The South Training Wall is assumed breached and degraded at Sites A, B, D, E, and F. These sites are actively eroding and/or present a direct pathway for floodwaters to enter the Goldfields. Sites C, G, H, I, and J are assumed intact since they do not present a direct pathway for floodwaters, and erosion is either not actively occurring or is occurring at a rate that does not present a risk in the foreseeable future.

- The 2011 embankments near the Teichert aggregate plant are not included in the model simulations, as these embankments are located on property anticipated for future mining and permanent rights for their existence would be cost prohibitive.

- The 2016 100-Year embankment is not included in the model simulations, as this embankment is located on property anticipated for future mining and permanent rights for its existence would be cost prohibitive.

- The Waterway 13 embankments are not included in the model simulations as these embankments have historically washed away during high flow rates in the Yuba River.

- The MBK Engineers 2018 memorandum also recommended a 1,000 foot degrade of the Upper Yuba River Levee. Through refinement of design subsequent to the MBK Engineers 2018 memorandum, the elevation of the degrade for this portion of the levee has been set to 93.5 feet NAVD88.

- The degrade of the upper Yuba River levee and proposed detention basin is based on topographic grading plans/surface received by Wood Rodgers for the 90% Basis of Design.

- Completion of the Hallwood Side Channel and Floodplain Restoration Project Phase 1, as detailed in Appendix C.
The South Training Wall at the South Yuba-Brophy Diversion is assumed to breach. This encroachment does not meet DWR ULDC requirements. The Yuba South Training Wall at this location was breached to a width of 100 feet and down to the landside embankment elevation of 135.5 ft NAVD88.

In consideration of all performance assumptions and planned project implementations analyzed, the combination that stressed the system the most, which produced the greatest flood extent and highest water surface elevations, was selected for computing the design water surface.

4. Hydrology

The hydrology used for the determination of the DWSE is from the Central Valley Hydrology Study, commissioned by the DWR and prepared by the USACE (David Ford Consulting Engineers, 2012). The CVHS defines a procedure in which a scaled flood event, with a pattern based on a historical flood event, is selected to represent the flood of a specific frequency at a specific location. Hydrologic data for the scaled flood events were also developed as part of the CVHS.

MBK applied the CVHS event selection procedure and determined the CVHS pattern and scaling for n-year flood events on the Yuba River (Appendix A). Table 4 summarizes the CVHS flood event and scaling for the various n-year events. As shown in Table 4, a peak flow of 183,200 cfs on the Yuba River near Marysville is representative of a 200-Year peak flow and is selected as the design flow, as per ULDC.

### Table 4. Event Selection Summary

<table>
<thead>
<tr>
<th>Centering</th>
<th>Historical Pattern</th>
<th>N-Year Event</th>
<th>Scale Factor for Yuba River Flows</th>
<th>Peak Yuba River near Marysville Flow (cfs)</th>
<th>N-Year Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yuba River</td>
<td>1956</td>
<td>2 years</td>
<td>20%</td>
<td>23,500</td>
<td>2</td>
</tr>
<tr>
<td>Yuba River</td>
<td>1956</td>
<td>10 years</td>
<td>60%</td>
<td>65,900</td>
<td>9</td>
</tr>
<tr>
<td>Yuba River</td>
<td>1956</td>
<td>25 years</td>
<td>90%</td>
<td>106,000</td>
<td>25</td>
</tr>
<tr>
<td>Yuba River</td>
<td>1956</td>
<td>50 years</td>
<td>120%</td>
<td>142,300</td>
<td>55</td>
</tr>
<tr>
<td>Yuba River</td>
<td>1956</td>
<td>100 years</td>
<td>145%</td>
<td>173,300</td>
<td>107</td>
</tr>
<tr>
<td>Yuba River</td>
<td>1956</td>
<td>200 years</td>
<td>175%</td>
<td>183,200</td>
<td>189</td>
</tr>
<tr>
<td>Yuba River</td>
<td>1956</td>
<td>500 years</td>
<td>205%</td>
<td>246,600</td>
<td>500</td>
</tr>
</tbody>
</table>

5. Results – Design Water Surface Elevation

The median 200-Year water surface elevation for the design scenario presented in Section 3.3 is 89.5 ft NAVD88. The water surface elevation along the entire alignment of the proposed levee is flat. Table 5 presents the flows from the hydraulic model simulation, adjustments to the water surface elevation, and ULDC parameters.

As a resiliency check, a climate change simulation was prepared based on a DWR, “Draft Technical Memorandum: Climate Change Analysis – Phase IIB”. DWR predicts that Near Term Climate Change (2011-2040 with projected warming of about +1°C ) would result in a 5% increase in flood magnitude on the Yuba River at Smartsville. Table 5 tabulates the flows and median 200-year water surface elevation for the climate change simulation.
Table 5. ULDC Design Water Surface Elevation and Adjustments

<table>
<thead>
<tr>
<th></th>
<th>200-Year Without Climate Change Simulation</th>
<th>200-Year With Climate Change Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow at Yuba River flow upstream of Goldfields for 200-Year simulation</td>
<td>184,600 cfs</td>
<td>228,300 cfs</td>
</tr>
<tr>
<td>Flow at Yuba River near Marysville gage for 200-Year simulation</td>
<td>167,200 cfs</td>
<td>182,200</td>
</tr>
<tr>
<td>Median 200-Year water surface elevation along proposed levee</td>
<td>89.5 ft NAVD88</td>
<td>91.5 ft NAVD88</td>
</tr>
<tr>
<td>Adjustment for uncertainty</td>
<td>6.5 ft NAVD88</td>
<td>N/A</td>
</tr>
<tr>
<td>Final ULDC DWSE</td>
<td>96 ft</td>
<td>N/A</td>
</tr>
<tr>
<td>Wind and wave setup</td>
<td>3 ft.</td>
<td>N/A</td>
</tr>
<tr>
<td>Minimum Top of Levee</td>
<td>99 ft NAVD88</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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Appendix A

Central Valley Hydrology Study Event
Selection for Yuba Goldfields Centering
Appendix B

Approach for Development of the 200-Year Design Water Surface Elevation
Appendix C
Hallwood Side Channel and Floodplain Restoration Project – Phase 1