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Certification Summary Supplement

FEMA Accreditation Project
Yuba South Levee (Simpson Lane to the Goldfields)
Yuba County, California

November 2013
# Table of Contents

Certification Summary Supplement  
FEMA Accreditation Project  
Yuba South Levee (Simpson Lane to the Goldfields)

1 General [44 CFR § 65.10(a)] ................................................................. 1  
1.1 Purpose of Certification .................................................................... 1  
1.2 Reclamation District 784 Levee System Description .......................... 1  

2 Design Criteria [44 CFR § 65.10(b)] ................................................. 5  
2.1 Freeboard [44 CFR § 65.10(b)(1)] ..................................................... 5  
2.2 Closures [44 CFR § 65.10(b)(2)] ....................................................... 5  
2.3 Embankment Protection [44 CFR § 65.10(b)(3)] ............................... 6  
2.4 Embankment and Foundation Stability [44 CFR § 65.10(b)(4)] ......... 8  
2.5 Settlement [44 CFR § 65.10(b)(5)] .................................................... 12  
2.6 Interior Drainage [44 CFR § 65.10(b)(6)] .......................................... 13  

3 Operations Plans and Criteria [44 CFR § 65.10(c)] ........................... 15  
3.1 Closures [44 CFR § 65.10(c)(1)] ....................................................... 16  
3.2 Interior Drainage Systems [44 CFR § 65.10(c)(2)] ......................... 16  
3.3 Other Operation Plans and Criteria [44 CFR § 65.10(c)(3)] ............ 16  

4 Maintenance Plans and Criteria [44 CFR § 65.10(d)] ....................... 17  

5 Yuba Goldfields .................................................................................. 19  

6 Certification Requirements [44 CFR § 65.10(e) & 65.2] ....................... 21  
6.1 Certification Statement for FEMA Accreditation ................................. 21  
6.2 Definitions and Conditions ............................................................... 22  
   6.2.1 Definitions .................................................................................. 22  
   6.2.2 Certification Conditions ............................................................... 22  

7 Quality Control .................................................................................... 25
List of Supporting Documents

Certification Summary Supplement
FEMA Accreditation Project
RD 784 Levee System (Yuba South Levee, Simpson Lane to the Goldfields)

Plate
Plate 1 TRLIA Repair Program

Figure
Figure 1 RD 784 Levee System

Appendices- Include Engineer’s Opinion Statements in Appendix or Sub-appendix as appropriate

A Freeboard (Engineer’s Opinion and Supporting Report)
B Embankment Protection (Engineer’s Opinion, Supporting Report Separately Bound)
C Embankment and Foundation Stability (Engineer’s Opinion, Supporting Report Separately Bound)
D Settlement (Engineer’s Opinion, Supporting Report Separately Bound)
E Interior Drainage Study (Engineer’s Opinion, Supporting Report Separately Bound)
F Operation & Maintenance Manual for RD 784 (Engineer’s Opinion, Supporting Report Separately Bound)
G BOSC Credentials and BOSC Quality Control Report

Supporting Reports

- MBK Engineers, Three Rivers Levee Improvement Authority Phase 4 Erosion Investigation, dated February 2006.
- Kleinfelder, Problem Identification Report, dated September 29, 2009. Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Simpson Lane to Yuba Gold Fields, Reclamation District No. 784, Yuba County, California. This report contains the results of geotechnical investigations and provided preliminary repair recommendations.
- MWH, Groundwater Impacts Evaluation Report, dated December 2009. Evaluation of Groundwater Impacts from the Upper Yuba River South Levee Repair Activities. This report evaluates the potential for regional and local groundwater impacts from constructing a slurry cutoff wall for the UYLP.
- HDR, Draft Initial Study/Mitigated Negative Declaration, Upper Yuba Levee Improvement Project (Simpson Lane to the Goldfields), Yuba County, California, dated February 2010. CEQA document issued for public review.
- HDR, *Final Initial Study/Mitigated Negative Declaration, Upper Yuba Levee Improvement Project (Simpson Lane to the Goldfields), Yuba County, California*, dated April 2010. CEQA document adopted by the TRLIA Board.

- MBK, *Hydraulic and Hydrologic Analysis Yuba River Patrol Road Levee*, dated March 2010. This report provides the final design water surface elevations.

- Kleinfelder, *Geotechnical Borrow Site Evaluation, dated June 7, 2010, Geotechnical Borrow site Evaluation TRLIA Borrow Area 1, Upper Yuba Levee Improvement Project, Yuba river south Levee Evaluation, Yuba County, California*. This report provides an evaluation of quality and quantity of borrow material in the adjacent borrow site.


- HDR, *Upper Yuba Levee Improvement Project, 100% Design Submittal Design Documentation Report, Upper Yuba Levee Improvement Project, Yuba River Basin, California (Sta. 102+00 to Sta. 303+59)*, dated June 21, 2010. This report identifies the standards used in the design of the UYLIP, describes the design assumptions and design criteria, summarizes the methods and results of the hydraulic and geotechnical analyses of the UYLIP, and describes the key features of the proposed facility.


- U.S. Army Corps of Engineers, Sacramento District, *Final Environmental Assessment, Upper Yuba Levee Improvement Project (Simpson Lane to the Goldfields, Yuba County California)*, dated September 2010. NEPA Document to support Section 408 and Section 104 Credit Requests.


1 General [44 CFR § 65.10(a)]

1.1 Purpose of Certification

The Three Rivers Levee Improvement Authority (TRLIA) has completed repairs to the levees surrounding Reclamation District (RD) 784 in south Yuba County. These repairs have been underway since 2004 with the purpose to provide both Federal Emergency Management Agency (FEMA) 100-year certification and 200-year flood protection to South Yuba County. The purpose of this document is to supply FEMA with additional information, technical evaluations, and certifications in accordance with the provisions of 44 Code of Federal Regulations (CFR) § 65.10 for the RD 784 Levee System to become fully accredited in the National Flood Insurance Program (NFIP). This document covers only a portion of the RD 784 Levee System (Yuba South Levee [Simpson Lane to the Goldfields]) and is a supplement to the Certification Summary Report submitted to FEMA on May 5, 2010.

Evaluation, design, and construction of repairs of the RD 784 Levee System were accomplished by a team of engineering consultants under TRLIA’s management. This team consisted of GEI Consultants, Inc. of Sacramento, California; HDR Inc. of Folsom, California; Kleinfelder Inc. of Sacramento, California; MHM Engineering of Marysville, California; and MBK Engineers of Sacramento, California. Design and construction of the recent repairs were accomplished using the criteria developed by the U.S. Army Corps of Engineers (USACE) and the California Department of Water Resources (DWR). This document briefly summarizes each technical evaluation performed with respect to levee certification and includes a corresponding Engineer’s Opinion, stamped by a licensed Professional Engineer, at the end of the document. These opinions are being submitted by TRLIA to demonstrate that the appropriate standard of care has been followed to certify that the RD 784 Levee System meets the criteria listed in 44 CFR 65.10. TRLIA’s certification, which is also stamped by a licensed Professional Engineer, is provided in Section 5 of this Certification Summary Supplement.

1.2 Reclamation District 784 Levee System Description

To mitigate the risk of flooding and prevent the level of damage experienced during past floods, the RD 784 Levee System was constructed by the USACE and local interests beginning in the early 1900s and continues to be improved (see Figure 1). The completed system consists of the following key features:

- 29.9 miles of earthen embankment
- Two closure structures
- Five pumping stations (PS) at the line of protection (PS 9, PS 3, PS 2, PS 6, and Olivehurst Detention Basin [ODB])
- Three gravity drains at the line of protection (PS 2, PS 6, and ODB)
- Five interior pumping stations (PS 1, PS 4, PS 5, PS 7, and PS 8)
- Appurtenant drainage facilities (62 Miles of Drainage Channels and 9 Detention Basins)

A system of earthen levees was designed and constructed to manage flooding from the Yuba River, the Feather River, the Bear River, and the Western Pacific Interceptor Canal (WPIC).
Five pumping stations were built to remove local runoff when high river levels prevent natural drainage to the rivers. Five additional interior pumping stations lift stored water from detention basins into a system of channels which convey interior drainage to the pump stations at the levees.

Starting in 2004 TRLIA initiated designs and projects to increase the reliability of the RD 784 Levee System. TRLIA has completed the alterations described below (see Plate 1):

- Phase 1 – Construct a 50-foot-deep slurry cutoff wall in the south levee of the Yuba River between Highway 70 and the 1986 levee breach. Phase 1 was completed in November 2004.
- Phase 2 – Raise and strengthen portions of the north levee of the Bear River and the west WPIC levee; construct a seepage berm along the south levee of the Yuba River east of Highway 70 and west of the Union Pacific Railroad (UPRR); construct a new replacement Pump Station No. 6 (PS 6) on the Bear River north levee just west of Highway 70; and construct a detention basin, pump station, and ring levee near Olivehurst. Phase 2 construction was completed in 2006.
- Phase 3 – Construct a two mile setback levee along the Bear River north of the original tie-in of the north levee of the Bear River with the east levee of the Feather River. Phase 3 construction was completed in 2006.
- Phase 4 – Strengthen the south levee of the Yuba River west of the Western Pacific Railroad crossing (Project Levee Mile [PLM] 0.0 to PLM 0.3); strengthen the south levee of the Yuba River between the UPRR (PLM 0.9) and the Yuba Gold Fields (PLM 6.1); and improve the east levee of the Feather River between the south levee of the Yuba River tie-in (PLM 26.1) and the Phase 3 Bear River levee tie-in (PLM 13.3). The status of the Phase 4 work is as follows:
  o South levee of the Yuba River strengthening between PLM 0.9 and PLM 2.2 was completed in 2006.
  o Designs for strengthening of the south levee of the Yuba River from PLM 0.0 to 0.3, east levee of the Feather River from the south levee of the Yuba River tie-in to about one mile north of Murphy Road (PLM 26.1 to PLM 23.4), (Feather Segment 3) and east levee of the Feather River south of Star Bend (PLM 17.2 to PLM 13.3) (Feather Segment 1) were completed in May 2007. Construction of these levee strengthening measures was completed in 2008.Completion of erosion protection at the Erosion Site 2 in Feather Segment 3 was completed in 2009.
  o Designs for a setback levee to replace the east levee of the Feather River from about one mile north of Murphy Road (PLM 23.4) to Star Bend (PLM 17.2) (Feather Segment 2) were initiated in April 2007 and completed in February 2008. Construction of the setback levee started in the summer of 2008 and was completed in 2009.
  o Designs for strengthening of the south levee of the Yuba River from PLM 2.2 to 6.1 were completed in June 2010. Construction of the levee strengthening measures was completed in 2012.
Alterations have been completed on the following system segments (see Figure 1):

1. Yuba River South Levee (Simpson Lane to the Goldfields [Unit 7])
2. Yuba River South Levee (UPRR to Simpson Lane [Unit 1])
3. Yuba River South Levee (WPRR to UPRR [Unit 1])
4. Feather River East Levee Segment 3 (Unit 2)
5. Feather River East Levee Segment 2 (Unit 9)
6. Feather River East Levee Segment 1 (Unit 2)
7. Bear River North Setback Levee (Unit 8)
8. Upper Bear North Levee (Setback Levee to WPIC [Unit 3]) and WPIC West Levee (Unit 4)
   (Including Olivehurst Detention Basin (ODB) Ring Levee)

Certification information on Segments 2-8 was provided to FEMA in a Certification Summary Report on May 5, 2010. At that time Segment 1 (Unit 7) was a Provisionally Accredited Levee (PAL). The PAL agreement for Segment 1 expired in June 2010, and TRLIA subsequently initiated levee repairs in 2011 and completed them in 2012. This Certification Summary Supplement has been prepared to provide similar certification information for the Yuba River South Levee (Simpson Lane to the Goldfields [Unit 7]), Segment 1, as was presented for the rest of the system, Segments 2-8, on May 5, 2010.
Design Criteria [44 CFR § 65.10(b)]

2.1 Freeboard [44 CFR § 65.10(b)(1)]

MBK performed an analysis to determine the amount of freeboard along the Yuba River South Levee (Simpson Lane to the Goldfields) reach of the RD 784 Levee System in accordance with the 44 CFR § 65.10(b)(1). This section states the following:

1. Riverine levees must provide a minimum freeboard of three feet above the water surface level of the base flood. An additional one foot above the minimum is required within 100 feet on either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.

2. Occasionally, exceptions to the minimum riverine freeboard requirement described in paragraph (b)(1)(i) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential and magnitude of debris, sediment and ice accumulation. It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted.

MBK determined freeboard along the levee by calculating the difference in elevation between the top of the levee and the base flood, at intervals of approximately 100 feet. Based on MBK's computations, this reach of the RD 784 Levee System has riverine freeboard of at least 5 feet or more for the 100-year flood event. This freeboard is greater than the required minimum of 3 feet and sufficiently protects against the base flood. No river crossings are present in this reach.

An Engineer's Opinion regarding freeboard signed by a Licensed Professional Engineer is included in Appendix A of this Certification Summary Supplement document. A report that is a supplement to Appendix A (Freeboard) of the May 2010 Certification Summary, FEMA Accreditation Project, RD 784 Levee System, Yuba County, California is also included in Appendix A. This report is entitled Freeboard (Supplement), Yuba River South Levee in the Upper Yuba Levee Improvement Project Yuba County, California, prepared by MBK Engineers (dated May 17, 2013). The Freeboard Report provides information on the Hydrologic and Hydraulic Analyses and provides freeboard values for this reach of the RD 784 Levee System that is the subject of this Certification Summary Supplement Report.

2.2 Closures [44 CFR § 65.10(b)(2)]

All openings in the levee system have been fitted with closure structures in accordance with 44 CFR § 65.10(b)(2). This section states the following:
All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice.

No closure structures are present in the Yuba South Levee from Simpson Lane to the Goldfields. Road crossings occur at Dantoni Road and Griffith Avenue. These crossings are over the top of the levee and do not lower the levee grade.

2.3 Embankment Protection [44 CFR § 65.10(b)(3)]

HDR assessed the adequacy of existing embankment protection over the length of the Yuba River South Levee from Simpson Lane to the Goldfields.

The assessment was conducted in accordance with the 44 CFR § 65.10(b)(3). This section states the following:

Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: Expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.

There are two types of constructed embankment protection along this reach of the RD 784 Levee System: grassed slopes (hydroseed) and riprap revetment. The waterside slope of the levee received hydroseed from Station 103+00 to Station 272+00 (Simpson Lane to the area west of the Goldfields) then riprap revetment from Station 272+00 to 303+59 (Goldfields). Riprap revetment was placed along the last portion of this reach to protect against erosion from concentrated flows which can exit from the Goldfields at the end of the levee. During the 1997 flood event, flows did exit from the Goldfields and eroded a portion of the levee. The 1997 Flood was the only time that this has ever happened.

Based on HDR’s evaluation of this levee reach, the potential for erosion of the levee embankment or foundations from currents, waves, or debris during the base flood is expected to occur infrequently and be localized. This opinion assumes RD 784 will continue regular maintenance of the constructed embankment protection features and that embankment protection for any future levee modifications is designed and constructed in accordance with applicable USACE criteria and guidance. Regular maintenance includes replacement and upkeep of riprap, control of vegetation, and repair of localized erosion and animal burrow damage.

The levee erosion potential of the Yuba River South Levee between Simpson Lane and the Goldfields was evaluated based on anticipated design water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee.
Criteria for maximum permissible water velocities were adopted from USACE’ guidelines for the design of flood control channels (EM 1110-2-1601).

Based on the Hydraulic Basis of Design Report (MBK, March 2010), flows occur along the waterside of this levee very infrequently due to training berms in the floodway which normally and have historically restricted flows to the north side of the floodway. The estimated maximum flow velocity along the Yuba River South Levee in this reach was computed to range from 1 to 2 feet per second (fps). The USACE guidelines, referenced above, show maximum permissible mean channel velocities for bare-earth channels ranging from 2 fps for fine sand to 6 fps for clay. The Yuba River South Levee in this reach was recently reconstructed with clayey soils. For grass-lined channels, maximum permissible velocities range from 5 fps to 6 fps depending on type of soil and grass cover. Based on these guidelines, it was judged that the well-established vegetation on the levee slope would provide adequate erosion protection. This judgment was based on the following factors:

- The calculated water velocities are equal or less than the maximum permissible velocities for vegetated flow channels.

- The existing levee embankment material is free of significant erosion, and there was not significant erosion of the levee reported after previous flood events.

- The existing levee slopes are generally well vegetated.

The analysis of wind setup and wave runup was included in the June 21, 2010, 100% Design Submittal Design Documentation Report by HDR. The maximum water surface capable of generating wind and wave was evaluated for the 1 in 200-year flood event. Three different sections (Station 123+00, Station 187+50, and Station 278+00) were analyzed along the reach. The table below provides input and results for this evaluation adjusted for the 100-year water surface elevations.

<table>
<thead>
<tr>
<th>Wave Evaluation</th>
<th>Station 123+00</th>
<th>Station 187+50</th>
<th>Station 278+00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetch Length (mi)</td>
<td>4.54</td>
<td>3.13</td>
<td>4.45</td>
</tr>
<tr>
<td>Design Wind (mph)</td>
<td>44.48</td>
<td>51.42</td>
<td>44.69</td>
</tr>
<tr>
<td>Design Wave Height (ft.)</td>
<td>2.06</td>
<td>2.36</td>
<td>2.18</td>
</tr>
<tr>
<td>Wave Run-up (ft.)</td>
<td>3.17</td>
<td>3.44</td>
<td>1.96</td>
</tr>
<tr>
<td>Slope Roughness Correction Factor</td>
<td>0.85</td>
<td>0.85</td>
<td>N/A</td>
</tr>
<tr>
<td>Adjusted Run-up (ft.)</td>
<td>2.69</td>
<td>2.92</td>
<td>1.96</td>
</tr>
<tr>
<td>Freeboard above 100-year water elevation (ft.)</td>
<td>6.60</td>
<td>5.40</td>
<td>6.80</td>
</tr>
<tr>
<td>Wind Set-up (ft.)</td>
<td>1.00</td>
<td>0.77</td>
<td>0.88</td>
</tr>
<tr>
<td>Wave Run-up plus Wind set-up (ft.)</td>
<td>3.69</td>
<td>3.69</td>
<td>2.84</td>
</tr>
<tr>
<td>Excess Freeboard above (Wind and Wave Set-up (ft.)</td>
<td>2.91</td>
<td>1.71</td>
<td>3.96</td>
</tr>
</tbody>
</table>

These magnitude waves would be contained within the design freeboard over the base flood elevation. Detailed analysis of wave-driven erosion has not been completed. However, it was concluded that the potential for erosion would be infrequent and localized and any resulting damage
would be mitigated through proper maintenance and flood fighting techniques. Minimal wind erosion
during the 100-year flood event would not jeopardize levee stability.

An Engineer’s Opinion regarding embankment protection for this RD 784 Levee System Reach signed
by a Licensed Professional Engineer is included in Appendix B of this Certification Summary
Supplement document.

2.4 Embankment and Foundation Stability [44 CFR § 65.10(b)(4)]

The Yuba River South Levee from Simpson Lane to the Goldfields consists of approximately 3.9 miles
of earthen levee embankment. Kleinfelder evaluated the embankment and foundation stability.

The evaluation was conducted by performing the following analyses and assessments for this levee
reach:

- Seepage analyses of selected embankment sections.
- Global stability analyses of selected embankment sections.
- Strength and stability analyses of selected embankment sections.
- Impact assessment of penetrations.

The above analyses and assessments were performed in accordance with the 44 CFR § 65.10(b)(4),
which states the following:

*Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, “Design and Construction of Levees” (EM1110-2-1913, Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of loading, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).*

The following information provides a general discussion on the Kleinfelder evaluation for the Yuba
River South Levee from Simpson Lane to the Goldfields reach, and provides an associated report
reference for the embankment and foundation stability evaluations.

The embankment and foundation stability assessment by Kleinfelder for the Yuba River South Levee
from Simpson Lane to the Goldfields reach included seepage and stability evaluations as presented in
the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement
Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California, in
2 Volumes, prepared by Kleinfelder. Levee improvement features, summarized in the table below,
were designed and constructed based on the findings of the seepage and stability assessment.
Details about the construction activities for the levee improvement project, including slope stability and
Levee Improvements for the Yuba River South Levee from Simpson Lane to the Goldfields

<table>
<thead>
<tr>
<th>Design Station Interval</th>
<th>Problem Identified</th>
<th>Levee Improvement Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>102+00 to 105+00</td>
<td>None</td>
<td>No work proposed</td>
</tr>
<tr>
<td>105+00 to 109+00</td>
<td>Geometry Corrections</td>
<td>Provide 20 foot crown width, 3H:1V waterside (WS) slope and 2H:1V landside (LS) slope</td>
</tr>
<tr>
<td>109+00 to 120+00</td>
<td>Geometry Corrections (Crown &amp; LS)</td>
<td>Provide 20 foot crown width and 2H:1V LS slope</td>
</tr>
<tr>
<td>120+00 to 125+00</td>
<td>Geometry Corrections (Crown and WS)</td>
<td>Provide 20 foot crown width and 3H:1V WS slope</td>
</tr>
<tr>
<td>125+00 to 136+50</td>
<td>None</td>
<td>No work proposed</td>
</tr>
<tr>
<td>136+50 to 143+50</td>
<td>Through-Seepage and Underseepage Geometry Corrections</td>
<td>Cutoff Wall WS of Existing Wall 65-foot-deep, 3-foot-wide soil bentonite cutoff wall through levee embankment; Estimated Toe Elevation of Cutoff Wall: +13 feet; Provide 20 foot crown width, 3H:1V WS slope and 2H:1V LS slope</td>
</tr>
<tr>
<td>143+50 to 189+50</td>
<td>Through-Seepage and Underseepage Geometry Corrections</td>
<td>65-foot-deep, 3-foot-wide soil bentonite cutoff wall through levee embankment; Estimated Toe Elevation of Cutoff Wall: +13 feet; Provide 20 foot crown width, 3H:1V WS slope and 2H:1V LS slope</td>
</tr>
<tr>
<td>189+50 to 221+00</td>
<td>Through-Seepage and Underseepage Geometry Corrections</td>
<td>70-foot-deep, 3-foot-wide soil bentonite cutoff wall through levee embankment; Estimated Toe Elevation of Cutoff Wall: 10 feet; Provide 20 foot crown width, 3H:1V WS slope and 2H:1V LS slope</td>
</tr>
<tr>
<td>221+00 to 244+00</td>
<td>Through-Seepage and Underseepage Geometry Corrections</td>
<td>55-foot-deep, 3-foot-wide soil bentonite cutoff wall through levee embankment; Estimated Toe Elevation of Cutoff Wall: +25 feet; Provide 20 foot crown width, 3H:1V WS slope and 2H:1V LS slope</td>
</tr>
<tr>
<td>244+00 to 288+00</td>
<td>Through-Seepage and Underseepage Geometry Corrections</td>
<td>45-foot-deep, 3-foot-wide soil bentonite cutoff wall through levee embankment; Estimated Toe Elevation of Cutoff Wall: +35 feet; Provide 20 foot crown width, 3H:1V WS slope and 2H:1V LS slope</td>
</tr>
<tr>
<td>286+00 to 301+00</td>
<td>Through-Seepage and Underseepage Geometry Corrections</td>
<td>Landside Stability/Seepage Berm: Thickness of 5 feet, Width of 80 feet from levee toe; Provide 20 foot crown width, 3H:1V WS slope and 2H:1V LS slope</td>
</tr>
<tr>
<td>301+00 to 303+59</td>
<td>Through-Seepage and Underseepage Geometry Corrections</td>
<td>Transition at End of Berm into Goldfields. Thickness varies from 5 feet to height of levee, Width varies from 80 feet to 150 feet from levee toe; Provide 20 foot crown width, 3H:1V WS slope and 2H:1V LS slope</td>
</tr>
</tbody>
</table>
Stability Evaluation

The dimensions of the levee geometry improvements as required by the Central Valley Flood Protection Board and the USACE are tabulated below:

- Crown Width: 20 feet minimum
- Patrol Road Width (on Crown): 16 feet minimum
- Waterside Slope (horizontal: vertical): 3:1 maximum
- Landside Slope: (horizontal: vertical) 2:1 maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

Stability of the improved embankment cross-sections (both landside and waterside slopes) and underlying foundation materials was computed for steady-state seepage, and rapid-drawdown stability cases. No stability analysis was performed for end of construction because neither a significant raise nor new levee embankment was constructed. Slope stability analyses were performed using selected cross-section geometry and site-specific strength properties for foundation and improved embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment because the duration of the flood hydrograph is influenced by upstream reservoirs and could be several weeks. The results of the stability analyses performed for the levee are summarized in Section 5.3 and Appendices E2, I, and K of the June 11, 2010 Revised Geotechnical Basis of Design Report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder). The analyses confirmed that the levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

Seepage Evaluation

Seepage analyses of the Yuba River South Levee (Simpson Lane to the Goldfields) and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the improved levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which much of the levee is founded. The seepage evaluation also included an assessment of a previously installed seepage mitigation feature, which consisted of an existing 36-foot-deep soil-cement-bentonite cutoff wall through the embankment crest for a 4,150-foot reach of levee (Station 102+00 to 143+50).

The need for additional seepage remedial features was triggered by at least one of the following criteria:

- An uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer’s thickness) in excess of 0.5 when computed with water at the design water surface elevation.
- An exit gradient in excess of 0.5, also computed with water at the design water surface elevation.
A determination that a potential exists for levee through-seepage based on embankment soil conditions observed in borings performed through the levee embankment.

The detailed methodology and results of the seepage analysis are described in Section 5.2 and Appendices E1, G, H, and J of the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder). Constructed seepage improvement features were listed in the table above.

Construction of the soil-bentonite cutoff wall involved degrading the levee crown to provide a work platform necessary for equipment to construct the wall. The wall tied into a low-permeability layer in the levee foundation in most cases. One length of cutoff wall was left “hanging” in a predominantly sand and gravel foundation. This is the reach of 70 foot depth wall. Following construction of the cutoff wall, the levee embankment was reconstructed to design geometry and crown elevations.

Construction of the seepage berm included clearing and stripping the footprint area of the seepage berm and placing specified seepage berm material to the design dimensions.

As-built drawings and details of the construction activities for the stability and seepage mitigation features are presented in the March 2013 Construction Documentation Report, Upper Yuba Levee Improvement Project, Three Rivers Levee Improvement Authority, prepared by HDR.

Utility Penetrations in the Yuba River South Levee from Simpson Lane to the Goldfields

Utility penetrations through the levee that were no longer needed were removed. Those that remain in service were evaluated and reconstructed if appropriate. At Station 138+00, a PG&E 2-inch steel gas pipeline was removed and replaced by PG&E to current standards. The pipe removal and replacement was necessary to raise the pipeline above the design (200-year) water surface elevation and meet current standards. This gas line modification was authorized by the Central Valley Flood Protection Board (CVFPB) in a letter dated June 17, 2011. At Station 148+60, a Linda County Water District 6-inch steel water pipeline was removed and replaced to current standards. The pipe removal and replacement was necessary to raise the pipeline above the design (200-year) water surface elevation and meet current standards. This water line modification was authorized by the CVFPB in a letter dated July 28, 2011. As-built drawings and details of the construction activities for penetration removal and reconstruction are presented in the March 2013 Construction Documentation Report, Upper Yuba Levee Improvement Project, Three Rivers Levee Improvement Authority, prepared by HDR.

There is one additional utility penetration located within this reach of levee that was not removed or modified during levee improvements. The utility penetration protected in place is at Station 125+20 and is a 2-inch sanitary sewer force main owned by the Peach Tree Country Club. This force main was recently constructed and is above the design elevation and meets current design standards.

Based on the available information, none of the utility penetrations are anticipated to affect embankment or foundation stability of the Yuba River South Levee (Simpson Lane to the Goldfields) within the accreditation period provided that they continue to be monitored and maintained in good operating condition.
Liquefaction and Seismic Evaluation

The detailed methodology and results of the Liquefaction and Seismic Evaluation are described in Section 5.4 and Appendix L of the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder). The potential for some liquefaction-induced deformation was found in approximately .45 miles of the 3.10 mile reach. It is highly unlikely that an earthquake event and the base flood would occur at the same time. As part of the Urban Level of Protection determination required by the State of California, TRLJA will be preparing an earthquake recovery plan to describe how RD 784 will restore its levee system after an earthquake event.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, and low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along the Yuba River South Levee have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential of any clayey foundation soils in the levee was also estimated to be low, based on the relatively low plasticity and thin layering of the clay soils, relatively high moisture content of the near surface foundation soils, and the relatively high levee embankment loads above the foundation soils. Groundwater conditions in the Yuba River South Levee area are generally within 10 to 20 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

Based on Kleinfelder’s evaluation, it is Kleinfelder’s opinion that the Yuba River South Levee (Simpson Lane to the Goldfields) reach meets the requirements for embankment and foundation stability during the base flood. An Engineer’s Opinion regarding embankment and foundation stability for this RD 784 Levee System Reach signed by a Licensed Professional Engineer is included in Appendix C of this Certification Summary Supplement document.

2.5 Settlement [44 CFR § 65.10(b)(5)]

Kleinfelder evaluated the potential for settlement over the Yuba River South Levee (Simpson Lane to the Goldfields). The evaluation was conducted in accordance with the 44 CFR § 65.10(b)(5). This section states the following:

Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using
procedures such as those described in the COE manual, “Soil Mechanics Design – Settlement Analysis” (EM 1110-2-1904) must be submitted.

Kleinfelder evaluated the settlement potential at sections of the RD 784 Levee System that are considered more likely to settle than others due to construction of new seepage berms on the landside of the levee.

The detailed methodology and results of the settlement analysis are described in Section 5.5 and Appendix N of the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder).

Kleinfelder’s settlement evaluation of the seepage berm construction indicates that up to 1.5 inches of settlement could occur. This is less than the construction tolerances for the seepage berm and this potential amount of seepage is insignificant with respect to grading tolerances for the project embankment. The potential settlement of the seepage berm will not reduce the freeboard of the levee embankment below the minimum required for the base flood.

An Engineer’s Opinion regarding settlement for this RD 784 Levee System Reach signed by a Licensed Professional Engineer is included in Appendix D of this Certification Summary Supplement document.

2.6 Interior Drainage [44 CFR § 65.10(b)(6)]

Interior drainage for this reach of the RD 784 Levee System drains south away from the levee and is collected by the Linda Drain which eventually drains to the WPIC and through the WPIC to the Bear River. A detailed Interior Drainage Study for this reach of the RD 784 Levee System has been prepared by MHM, Incorporated in accordance with 44 CFR § 65.10 (b)(6) which states the following:

An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters.

This document is entitled Interior Drainage Study – PAL Area Extension LOMR Application Narrative – East Linda Extension, FEMA Accreditation Project, Three Rivers Levee Improvement Authority, August 10, 2010 (and revised on September 17, 2010). This study provides information on the:

- Hydrologic and Hydraulic Interior Drainage Analysis
- Detention Storage Basin Evaluations
- Pumping Station Hydraulic Evaluations

This document is separately bound and incorporated with Appendix E by reference. An Engineer’s Opinion regarding interior drainage for this RD 784 Levee System Reach signed by a Licensed Professional Engineer is included in Appendix E of this Certification Summary Supplement document.
3 Operations Plans and Criteria [44 CFR § 65.10(c)]

The RD 784 Levee System has been operated and maintained under an existing set of instructions developed by the USACE as the Sacramento River Flood Control Plan (SRFCP) was completed in the RD 784 area. The basic manuals are the Corps Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project (May 1955), the Corp’s Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145-Part No. 1 (August 1955), and the Corp’s Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 149, South Levee of Yuba River Maintenance Area No. 8 (March 1963). As segments of the RD 784 Levee System were recently altered to provide more reliable flood protection, addendums to the basic manuals were prepared. These addendums were coordinated with and provided to USACE, the CVFPB, DWR, and to RD 784. The following addendums have been prepared and adopted by RD 784 for operation and maintenance of the altered levee system:

- Bear River North Levee, WPIC West Levee, and Yuba River South Levee, Addendum to: Supplement to Standard Operation and Maintenance Manual Sacramento River Flood Control Project, Unit No. 145 – Part No. 1, January 2008, Revised March 2010 & June 2013 (Latest revisions added the Upper Yuba Levee Improvement Project features)

The purpose of these addendums was to identify the alterations that were made to the RD 784 Levee System and to provide operation and maintenance direction for any features added to the system. RD 784 has developed and utilizes checklists for operation and maintenance based on these manuals. These checklists are based on the requirements of the DWR Levee Inspection Program, Federal regulations, and system-specific requirements outlined in the Standard Operation and Maintenance Manual, the Supplement Manual, and the Addendums. The Standard Operation and Maintenance Manual, the Supplement Manual, and the Addendums were supplied to FEMA in May 2010 as part of the original Certification Summary Report. The Bear River North Levee, WPIC West Levee, and Yuba River South Levee Addendum was revised to incorporate the features repaired and added by the construction of the Upper Yuba Levee Improvement Project (UYLIP). This revised addendum is provided as part of this Certification Summary Supplement report.

Regulations regarding operation plans and criteria required by FEMA are covered in 44 CFR § 65.10(c). This section states the following:

Operation plans and criteria. For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual, a copy of which must be provided to FEMA by the operator when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.
It is MBK Engineers’ opinion that the existing SRFCP Operation and Maintenance (O&M) Manual along with the Supplemental Manual and the Addendums, as revised, to the Supplemental Manual prepared for the recent levee system alterations meet the requirements for an operation plan as outlined in 44 CFR § 65.10(c). Additionally, all levee system operations are performed by RD 784 which is an agency created by State law under the jurisdiction of the DWR, a State agency. An Engineer’s Opinion signed by a Licensed Professional Engineer is included in Appendix F of this Certification Summary document. A copy of the revised Bear River North Levee, WPIC West Levee, and Yuba River South Levee, Addendum to: Supplement to Standard Operation and Maintenance Manual Sacramento River Flood Control Project, Unit No. 145 – Part No. 1 is separately bound and incorporated as Appendix F by reference.

3.1 Closures [44 CFR § 65.10(c)(1)]

As described in Section 2.2 above, No closure structures are present in the Yuba South Levee from Simpson Lane to the Goldfields. Therefore no operations are required for the levee reach that is the subject of this supplement.

3.2 Interior Drainage Systems [44 CFR § 65.10(c)(2)]

Section 44 CFR § 65.10(c)(2) contains regulatory requirements for operation plans as they pertain to interior drainage systems. Interior drainage systems are defined and requirements summarized as follows:

*Interior drainage systems. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan.*

Interior drainage for this reach of the RD 784 Levee System drains south away from the levee and is collected by the Linda Drain which eventually drains to the WPIC and through the WPIC to the Bear River. All drainage is by gravity and no pump stations or through levee drainage pipes are present which require operation plans.

3.3 Other Operation Plans and Criteria [44 CFR § 65.10(c)(3)]

Section 44 CFR § 65.10(c)(3) provides for the operation plan to include:

*Other operation plans and criteria. Other operating plans and criteria may be required by FEMA to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA determinations will be based.*

FEMA has not requested RD 784 to provide additional operating plans and criteria at this time. However, RD 784, in conjunction with the Yuba County Office of Emergency Services, has developed a flood response plan and provisions for coordination between responsible parties to react in a way that will provide adequate protection to RD 784 in various flood situations.
4 Maintenance Plans and Criteria [44 CFR § 65.10(d)]

The RD 784 Levee System has been operated and maintained under an existing set of instructions developed by the USACE as the SRFCP was completed in the RD 784 area. The basic manuals are the Corps Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project (May 1955), the Corp's Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145-Part No. 1 (August 1955), and the Corp's Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 149, South Levee of Yuba River Maintenance Area No. 8 (March 1963). As segments of the RD 784 Levee System were recently altered to provide more reliable flood protection, addendums to the basic manuals were prepared. These addendums were coordinated with and provided to USACE, the CVFPB, DWR, and to RD 784. The following addendums have been prepared and adopted by RD 784 for O&M of the altered levee system:


The purpose of these addendums was to identify the alterations that were made to the RD 784 Levee System and to provide O&M direction for any features added to the system. RD 784 has developed and utilizes checklists for operation and maintenance based on these manuals. These checklists are based on the requirements of the DWR Levee Inspection Program, Federal regulations, and system-specific requirements outlined in the Standard Operation and Maintenance Manual, the Supplement Manual, and the Addendums. The Standard Operation and Maintenance Manual, the Supplement Manual, and the Addendums were supplied to FEMA in May 2010 as part of the original Certification Summary Report. The Bear River North Levee, WPIC West Levee, and Yuba River South Levee Addendum was revised to incorporate the features repaired and added by the construction of the UYLIP. This revised addendum is provided as part of this Certification Summary Supplement Report. Assessment Districts have been established by both RD 784 and most recently TRLIA in 2009 to provide the revenues required to operate and maintain the RD 784 Levee System. These Assessment Districts are expected to provide in excess of $1,000,000 a year specifically for levee maintenance.

Section 44 CFR §65.10(d) contains regulatory requirements for maintenance plans and criteria. This section states:

*Maintenance plans and criteria. For levee systems to be recognized as providing protection from the base flood, the maintenance criteria must be as described herein. Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner.*
All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance.

Section 10 of the three recent O&M Manual addendums contains inspection and maintenance criteria for the entire levee system. Detailed inspection and maintenance checklists are provided in Table 4 of the Bear River North Levee, WPIC West Levee, and Yuba River South Levee Addendum. Maintenance of this reach of the levee system is under the jurisdiction of DWR, and the inspection and maintenance plan is implemented by the local maintenance agency, RD 784, an agency created by State law under the jurisdiction of DWR. The referenced table specifies maintenance activities to be performed and the frequency of their performance, and who is responsible for performing these activities. In addition, DWR has a long standing and continuing program of levee inspection. The RD 784 Levee System is inspected twice a year (spring and fall) by Department of Water Resources' inspectors and a rating of acceptable, marginal acceptable, or unacceptable is assigned. The RD 784 Levee System has not received an unacceptable rating in the last five years. RD 784 personnel are responsible for performing two additional annual inspections (summer and winter) and reporting on remediation of any problems uncovered by State inspections and on the condition of the levee at the time of the RD 784 inspection. In addition to the annual levee inspections, DWR requires all local maintaining agencies to annually report on conditions for their levee system. This information is supplied through a web page and each agency is required to supply:

1) Information known to the Local Agency that is relevant to the condition or performance of the Project Levee,
2) Information identifying known conditions that might impair or compromise the level of flood protection provided by the Project Levee,
3) A summary of maintenance performed by the Local Agency during the previous fiscal year,
4) A Statement of work and estimated cost for operation and maintenance of the Project Levee for the current fiscal year, as approved by the Local Agency, and
5) Any other readily available information contained in the records of the Local Agency relevant to the condition or performance of the Project Levee, as determined by the CVFPB or DWR.

It is MBK Engineers’ opinion that the existing SRFCP O&M manual along with the Supplemental Manual and the Addendums to the Supplemental Manual prepared for the recent levee system alterations meet the requirements for a maintenance plan as outlined in 44 CFR 65.10. An Engineer’s Opinion signed by a Licensed Professional Engineer is included in Appendix F of this Certification Summary Supplement document. A copy of the revised Bear River North Levee, WPIC West Levee, and Yuba River South Levee, Addendum to: Supplement to Standard Operation and Maintenance Manual Sacramento River Flood Control Project, Unit No. 145 – Part No. 1 is separately bound and incorporated as Appendix F by reference.
5 Yuba Goldfields

The RD 784 Levee System is part of the SRFCP. In a 1953 memorandum between the Federal Government and the State of California, the Yuba Left Bank (South) Levee of the SRFCP was described as extending from the "Feather River to high ground" for an approximate distance of 7.2 miles. The high ground referred to in the memorandum is the Yuba Goldfields (Goldfields). The Goldfields is an area of dredged tailing mounds which give the appearance and have historically served the purpose of high ground. The determination by the Federal, State, and local flood management community that the project levee ties into high ground is a fundamental assumption of the SRFCP.

The TRLIA team has evaluated the topography and hydraulics of the Goldfields and looked at a range of flood failure scenarios and determined that the Goldfields does not function as high ground during large flood events and instead relies on a number of mine tailing piles to prevent flood waters from exiting the Goldfields. Research of the history of the determination of high ground indicates that the determination was made based on the SRFCP design flow of 120,000 cfs in the Yuba River. The flow was increased to 180,000 cfs in 1970 as part of the authorization for New Bullards Bar Dam. However, TRLIA was unable to locate documentation that the USACE or State reaffirmed that the Goldfields would function as high ground at this higher flow. In addition, mining activities consisting of aggregate extraction and dredging for gold, have also significantly affected the landscape without an understanding of how these actions affect the flood risk in the area. With this better understanding of the flood threat from the Goldfields, TRLIA has developed a phased approach to managing flood risk in the Goldfields. The first step was to work with mining interest to construct non leveed embankments in 2011 to address the highest risk areas. Step 2 is to construct features that address moderate risk in 2014 and 2015 that will meet FEMA standards. Step 3 is to construct features that will meet the State of California's 200-year requirements and will be completed prior to 2025.

Work Plan:

With the Goldfields flood threat verified by more recent information and a more stringent analysis; and the mechanism of flooding identified in detail, TRLIA developed a four step work plan for reducing the flood threat and eventually providing sustainable 200-year flood protection for RD 784. TRLIA identified some available funding to initiate the work plan.

Step 1: Consisted of immediately modifying locations within the Goldfields mining areas that had been identified in a TRLIA October 2010 analysis as potential flow paths and completing agreements with mining operators to establish maintenance responsibilities for these features. TRLIA negotiated and signed contracts with the mining companies in the Goldfields to increase the height of dredge tailings mounds at three locations using the mining companies’ authorities to mine in the Goldfields area. This was accomplished in 2011.

Step 2: Will entail modifications of any additional mining areas that are subsequently identified as necessary and initiating monitoring programs at critical sites to certify that the RD 784 area meets FEMA’s criteria for the 100-year flood event. TRLIA has performed additional geotechnical and geomorphic evaluations and hydraulic modeling to determine that the Goldfields cannot reliably retain 100-year flows. Additional modifications to the Goldfields are needed to retain the 100-year flow and
TRLIA has developed and is implementing a plan to construct these improvements and monitor critical sites. TRLIA plans to begin implementation of Step 2 solutions in 2014 and complete them in 2015.

Step 3: Will develop a sustainable 200-year plan involving all stakeholders (Federal, State, local, and private) that:
- Ensures future mining operations do not increase flood risk
- Provides sustainable 200-year flood protection for the RD 784 area
- Repairs or enlarges land features identified that are needed for 200-year flood protection
- Maintains the modified land features identified as needed for 200-year flood protection

This step is proposed to be completed by September 2014 and is one of the purposes of a feasibility study underway which is being cost shared with DWR. The accomplishment of this task will take cooperation from all involved parties: Mining Companies, USACE, BLM, CVFPB, DWR, SMGB (Mining and Geology Board), Yuba County, Yuba County Water Agency (YCWA), and TRLIA.

Step 4: Will implement the 200-year plan developed in Step 3. Physical modifications to the Goldfields as identified in the sustainable 200-year plan will be accomplished. This step will also require the implementation of a long-term mechanism for governance and oversight of Goldfields mining operations to ensure and sustain 200-year protection. This effort will need to be funded from both State and local funding. This step is proposed to be completed by 2025 or earlier to meet the SB 5 date that requires a 200-year flood protection plan be implemented for urban areas to continue to develop.

TRLIA has completed Step 1 and initiated efforts on Steps 2 and 3 of the Goldfields Evaluation Work Plan. With the completion of Steps 1 and 2 the RD 784 flood system will reliably provide 100-year flood protection to the urban area of RD 784 for the next 10 years.
6 Certification Requirements [44 CFR § 65.10(e) & 65.2]

6.1 Certification Statement for FEMA Accreditation

This certification is made in accordance with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 - Emergency Management and Assistance, Part 65 - Identification and Mapping of Special Hazard Areas (44 CFR 65.10). This certification is made solely to the Federal Emergency Management Agency for purposes of obtaining accreditation of the RD 784 Levee System, and is further limited to the base flood protection (i.e., 1-percent chance flood). This certification is made with respect to the Yuba River South Levee (Simpson Lane to the Goldfields) component of the RD 784 Levee System as specifically required by 44 CFR 65.10. All information, calculations, definitions, descriptions, restrictions, limitations, or other pertinent data contained in the overall submission form the basis of this certification.

Acting on behalf of TRLIA, and in accordance with paragraph (b) of 44 CFR 65.2, as supported by the information contained within this submission; this is to certify that:

1. Certification of Data – The data presented in this submission is accurate.

2. Certification of Analysis – The analyses were performed in accordance with sound engineering practices.

3. Certification of Structural Works – The Yuba River South Levee (Simpson Lane to the Goldfields) component of the RD 784 Levee System is designed in accordance with sound engineering practices to provide protection from the base flood.

4. Certification of "As-Built" Conditions – The Yuba River South Levee (Simpson Lane to the Goldfields) component of the RD 784 Levee System has been built in substantial conformance with the construction plans, is in place, and is fully functioning.

*Certified by:

Ric Reinhardt, PE
Program Manager
Three Rivers Levee Improvement Authority
Government Center
915 Eighth Street, Suite 115
Marysville, CA 95901

*Certification made pursuant to the definitions and further conditions described in Section 6.2.
6.2 Definitions and Conditions

6.2.1 Definitions

The meaning and context by which the term “Certification” was used in this document was derived from the definition provided in 44 CFR §65.2(b), which is repeated below.

…a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement that the data is accurate to the best of certifier’s knowledge. Certification of analysis is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of “as built” conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning.

Furthermore, it is assumed that “sound engineering practices” are practices that are performed in a manner consistent with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions.

6.2.2 Certification Conditions

This certification made in Section 6.1 above shall expire, or become invalid, upon the earliest of any of the following events occurring:

1. As is consistent with current practice, this certification and the professional opinions of expected levee system performance upon which the certification is based, are valid for a maximum of 10 years from the date of the TRLIA’s certification, at which time this certification shall become invalid.

2. Activities prescribed in the Operations and Maintenance (O&M) Manual, which is submitted as an integral part of this certification, are not performed in substantial conformance with the O&M Manual.

3. Failure to perform ongoing monitoring activities for any component of the system, which has been identified in the O&M Manual as needing continued observation; or failure to complete any capital improvement determined pursuant to the monitoring to be necessary to meet the system’s continued protection relative to the 1% annual flood.

4. Discovery of any substantive defect in the condition of any component of the Levee System, which was not known at the time this certification, was made, and which materially affects the system’s ability to provide protection relative to the 1% annual flood.
5. Any finding by USACE, DWR, or other governmental agency having jurisdiction, that the Flood Protection System’s rating has fallen to an unacceptable level, or has substantive defects, or that the system is for any reason placed in inactive status.

6. Any newly enacted governmental regulation, law, or policy that renders this certification obsolete or invalid because of lack of conformance to the new requirements for any reason, including, but not limited to, changes in technical standards in the Code of Federal Regulations.
7 Quality Control

All of the design documents utilized for construction of the Yuba River South Levee (Simpson Lane to the Goldfields) component of the RD 784 Levee System repair and utilized to form a basis for this levee certification went through a rigorous quality assurance review as they were completed. This review was accomplished by the different consultant's in-house quality assurance teams, by the different agencies which regulate levee repairs (USACE, CVFPB staff, and DWR) and by a Board of Senior Consultants (BOSC). As part of this final certification process, TRLIA tasked the TRLIA BOSC to perform a review of this Certification Summary Supplement report.

The TRLIA BOSC includes Dr. Faiz Makdisi, Mr. Donald Babbitt, and Dr. David Williams; all are recognized experts in flood protection projects and geotechnical engineering (Makdisi, Babbitt) and hydrologic and hydraulic engineering (Williams). In addition to their design expertise, Dr. Makdisi and Mr. Babbitt have also been involved in the evaluation of construction of large embankments as well as serving as resources in addressing problems arising during construction. The panel members' qualifications are clearly indicated in the resumes included in Appendix G. The members of the panel have no conflicts of interest with respect to the TRLIA repair projects. No conflict of interest means that the BOSC does not possess any financial or other interest which conflicts with the service of the individual because it (1) could significantly impair the individual's objectivity or (2) could create an unfair competitive advantage for any person or organization. The BOSC does not own land in the vicinity of the levee repair footprint nor do they own land in RD 784. Their fields of expertise and practice are in geotechnical adequacy of embankment designs and construction, hydrologic and hydraulic engineering, and they do not carry out or advocate for or against Federal water resources projects.

The BOSC review included a quality assurance review of TRLIA’s Certification Summary Supplement FEMA Accreditation Project Yuba South Levee (Simpson Lane to the Goldfields). The BOSC also reviewed the Construction Completion Report for the repairs to assure that the repairs had been constructed according to the plans and specifications issued for construction. The BOSC made the following findings:

- The design teams had followed the standards of engineering required for the repairs implemented in the Yuba South Levee (Simpson Lane to the Goldfields) of the RD 784 Levee System.
- Adequate and appropriate information had been gathered to perform the analyses needed to support the repairs implemented.
- The analyses performed were appropriate analyses and were accomplished correctly.
- The construction completion report for the repairs documents that the repairs had been constructed in accordance with the plans and specifications issued for construction.
- The references cited in the Certification Summary Supplement report support the Engineer’s Opinions and provide the appropriate and adequate information to support those Opinions.

This independent review was used as an additional quality assurance check to ensure that the certification being offered for the Yuba River South Levee (Simpson Lane to the Goldfields) component of the RD 784 Levee System is adequately supported by appropriate engineering analysis, results, and recommendations. The BOSC report on their review is included in Appendix G.
Plate
Phase 4 Levee Improvements (2011)
- Complete construction of Yuba River Levee strengthen-in-place construction between Simpson Lane and Goldfields area (approximately 4 miles)
- Levee system certification and FEMA Accreditation – TRIJA project complete

Phase 4 Levee Improvements (2010)
- Begin Yuba River Levee strengthen-in-place construction between Simpson Lane and Goldfield area (approximately 4 miles)
- Complete degrade of existing Feather River Levee, and farming/environmental areas in setback
- Levee certification with FEMA PAL (between Simpson Lane and Goldfields) and FEMA Accreditation

Phase 4 Levee Improvements (2009)
- Complete construction of Feather River Setback Levee
  - Deconstruct/replace of existing Feather River Levee replaced by setback and fill soil borrow sites
  - Yuba River Levee between Hwy 70 & UPRR slope flattening work to achieve 200-year flood protection goal
  - Begin construction of farming/environmental areas (includes floodplain swale to mitigate potential fish standing)
  - Placement of rip rap along Feather River Levee at Yuba River confluence (Erosion Site 2)
  - Repair of Feather River Levee segment crack
- TRIJA DBBM Benefit Assessment District Approved

Phase 4 Levee Improvements (2008)
- Acquisition of approximately 1,600 acres for Feather River Setback Levee
- Execution of State Prop 17/TRIJA Feather River funding agreement
- Feather River strengthen-in-place improvements from Bear River to Star Bend (Segment 1) – completed
- Begin construction of new Feather River Setback Levee (approximately six miles long) foundation and levee tie-ins
- Feather River strengthen-in-place improvements from Shanghai Bend to Yuba River (Segment 3) – completed

Phase 4 Levee Improvements (2007)
- TRIJA Board adopts Feather River Setback Levee Alternative February 6, 2007
- Yuba Levee (NE corner of UPRR & Levee intersection: Constructed levee embankment and installed two monitoring wells)
- Feather River levee strengthen-in-place river improvements begun between Shanghai Bend and Yuba River (Segment 3)

Phase 4 Levee Improvements (2006)
- Yuba Levee Cutoff wall between the UPRR and Simpson Lane to protect against wind seepage

Phase 3 Levee Improvements (2006/2007)
- Environmental reactivation of setback area and existing Bear River roadway

Phase 3 Levee Improvements (2006)
- Demolition of existing homes and structures within the setback levee area, clearing and grubbing of remaining trees
- Construction of setback levee embankment (approx. 2 miles) and installation of approximately 18 relief wells
- Removal of portions of the existing Bear and Feather River Levees
- Construction of a floodplain swale to mitigate for potential fish standing

Phase 3 Levee Improvements (2005)
- Clearing, grubbing, and stripping of setback levee foundation
- Excavation and backfilling of approximately 9,500 feet of inspection trench
- Construction of approximately 9,500 feet (430,000 square feet) of soil-bentonite slurry cutoff wall
- Construction of setback levee tie-in embankment with existing Feather River Levee and installation of two relief wells
- Investigation of three archeological areas revealed during construction

Phase 2 Levee Improvements (2006)
- Olivehurst Detention Basin: Ring Levee between SR-70 and the Clerk Lateral Levee
- WPC Levee: Levee crown raise to provide adequate freeboard
- Lower Bear Levee: Levee crown raise to provide adequate freeboard and a waterside impervious zone to prevent through seepage
- Pump Station No. 6 removal and new set back pump station to protect against underseepage at the Algodon Canal. Tie in for the Bear River setback levee

Phase 2 Levee Improvements (2005)
- Yuba Levee: 90- and 300-foot wide landside seepage berms to protect against underseepage
- Olivehurst Detention Basin: New drainage pond adjacent to the Clerk Lateral Canal and a new pump station
- Upper WPC Levee: 300-foot long, 38-foot deep slurry cutoff wall and an 1,105-foot long, 44-foot deep slurry cutoff wall to minimize underseepage at Plumas Lake
- Lower WPC Levee: Landside toe ditch filled to provide protection against underseepage
- Upper Bear Levee: Reconstruction of 100 feet of levee; rock slope protection at confluence with WPC to provide erosion protection

Phase 1 Levee Improvements (2004)
- Yuba Levee: 2,200-foot long, 50-foot deep slurry wall to provide a cutoff of underseepage
Figure
Appendix A

Freeboard

(Engineer’s Opinion and Supporting Report)
Engineer’s Opinion  
Evaluation of Freeboard  
Yuba River South Levee

This opinion (1) is made to assist TRLIA in complying with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 – Emergency Management and Assistance, Part 65 – Identification and Mapping of Special Hazard Areas and to support TRLIA’s certification (2) of the Yuba River South Levee. This opinion is limited to the base flood (i.e., 1-percent chance flood) for the specific area listed below and is made to TRLIA.

Additional information concerning these opinions can be located in the October 2013 Freeboard (Supplement), Yuba River South Levee in the Upper Yuba Levee Improvement Project, Yuba County, California Report included as part of this appendix. All information, calculations, definitions, descriptions, restrictions, limitations, or other pertinent data contained in this appendix form the basis of this opinion.

Summary of Opinion:
In accordance with paragraph (b) of 44 CFR 65.2 and based on the results of our evaluation of freeboard along the Yuba River South Levee, it is our opinion that:

1. Data – The data used in our analysis included various “as-built” drawings, recent field survey data, and the base flood profile developed from the “Hydraulic and Hydrologic Analysis for the Yuba River Patrol Road Levee Project,” Prepared for TRLIA, Prepared by MBK Engineers, dated March 2010. To the best of our information, knowledge and belief, this data is accurate.

2. Analysis - Our analysis consisted of determining the top of levee elevations along the levee system and calculating the difference between those elevations and the base flood elevations. It is our opinion that this analysis was performed in accordance with sound engineering practices (3) appropriate to accurately assess freeboard.

3. Structural Works - We compared our freeboard calculations to the freeboard criteria in 44 CFR § 65.1 0(b)(1) to determine if the levee provides adequate freeboard. Our evaluation shows that the levee, in its existing condition, provides more than the required freeboard. It is our opinion that the levee was designed in accordance with sound engineering practices (3) to provide protection from the base flood.

4. “As-Built” Conditions – It is our opinion that, based on our review of the “as-built” drawings, it appears that the levee was constructed to the elevations shown on the "as-built" drawings, is in place, and appears to be functioning as intended for the base flood.

October 29, 2013
Engineer's Opinion
Evaluation of Freeboard
Yuba River South Levee

Opinion Offered by:

Don Trieu, PE
MBK Engineers
1771 Tribute Road, Suite A
Sacramento, CA 95815

1 — Consistent with current practice, these professional opinions of expected flood control system performance are valid for 10 years from the date of TRLIA's certification.

2 — Per 44 CFR 65.2 §2(b), "...a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement that the data is accurate to the best of certifier's knowledge. Certification of analysis is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning."

3 — It is assumed that "sound engineering practices" are practices that are performed in a manner consistent with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions.

October 29, 2013
APPENDIX A
Page 2 of 2
Freeboard
(Supplement)

Yuba River South Levee in the Upper Yuba Levee Improvement Project
Yuba County, California

Submitted to:

THREE RIVERS
LEVEE IMPROVEMENT AUTHORITY
1114 Yuba Street Suite 218
Marysville, CA 95901

Submitted By

MBK ENGINEERS
1771 Tribute Road Suite A
Sacramento, CA 95815

October 29, 2013
Table of Contents

1. Executive Summary........................................................................................................................... 1
   1.1 Purpose ...................................................................................................................................... 1
   1.2 FEMA Design Criteria ........................................................................................................... 1
   1.3 Summary of Results ............................................................................................................. 1

2. Freeboard Evaluation ........................................................................................................................ 1
   2.1 One Percent-Annual-Chance Flood Profile ........................................................................... 1
   2.2 Levee Elevations ................................................................................................................... 2
   2.3 Freeboard ............................................................................................................................ 2

Attachment 1 – Hydraulic and Hydrologic Analysis for Yuba River Patrol Road Levee Project

List of Tables

Table 1 Freeboard - Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road)...... 2
1. Executive Summary

1.1 Purpose

This report is a supplement to Appendix A (Freeboard) of the May 2010 Certification Summary, FEMA Accreditation Project, RD 784 Levee System, Yuba County, California. This Supplemental Report presents the evaluation of freeboard along the Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road) in the Upper Yuba Levee Improvement Project for the 1-percent-annual-chance flood. This levee reach is part of the Reclamation District No. 784 levee system.

1.2 FEMA Design Criteria

Federal Emergency Management Agency (FEMA) requirements for freeboard are given in Title 44, Chapter I, Section 65.10, paragraph (b)(1) of the Code of Federal Regulations (44 CFR 65.10(b)(1)), which states:

(i) Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.

(ii) Occasionally, exceptions to the minimum riverine freeboard requirement described in paragraph (b)(1)(i) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential, and magnitude of debris, sediment, and ice accumulation. It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted.

1.3 Summary of Results

The freeboard for the Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road) for the 1-percent-annual-chance flood (base flood) was evaluated at approximately 100 foot spacing measured along the levee centerline. Based on the computations, the Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road) has a freeboard of 5 feet or more along the levee alignment, which satisfies the required minimum freeboard.

2. Freeboard Evaluation

2.1 One Percent-Annual-Chance Flood Profile

For the freeboard evaluation, the 1-percent-annual-chance flood profile along the Yuba River South Levee was used and presented in “Hydraulic and Hydrologic Analysis for Yuba River Patrol Road Levee Project, prepared by MBK Engineers, dated March 2010 (See Attachment 1).
The report prepared for TRLIA presented the Yuba River South Levee flood profile in terms of flood elevation (NGVD-1929) versus levee mile. This report provides details on the hydrologic and hydraulic analyses accomplished to determine the 1-percent-annual-chance (base flood) water surface elevations for the Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road). To develop the base flood profile, a correlation of the river cross section location to the corresponding levee stations was developed.

2.2 Levee Elevations

The elevations from as-built construction drawings (see below) were used for the calculation of freeboard. The top of levee elevations are based on NGVD 1929 vertical datum and are at specified levee stations.

- Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road)
  
  "Three Rivers Levee Improvement Authority; Yuba County, CA; Upper Yuba River Levee Improvement Project; As-built Drawings, Magnus Pacific, Feb. 18, 2013"

2.3 Freeboard

Freeboard was calculated as the difference in elevation between the top of the levee and the 1-percent-annual-chance flood profile. The freeboard estimates are provided in Table 1. The minimum required freeboard from paragraph 44 CFR 65.10(b)(1) is 3.0 feet for riverine levees. An additional one-half foot above the minimum freeboard (3.0 feet) at the upstream end of the levee (Station 303+52) was also applied. Based on our freeboard estimates, the Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road) has a minimum freeboard of 5 feet for the base flood, which meets the freeboard requirements of 44 CFR 65.10(b)(1).

For bridges, per paragraph 44 CFR 65.10(b)(1), the minimum required freeboard upstream and downstream of a bridge is an additional 1.0 feet of freeboard. There are no bridge crossings pertaining to the Yuba River South Levee (Simpson Lane to 3,100 feet upstream of Bryden Road).

Table 1 – Freeboard

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Notes:

1. See "Three Rivers Levee Improvement Authority; Yuba County, CA; Upper Yuba River Levee Improvement Project; As-built Drawings, Magnus Pacific, Feb. 18, 2013".
2. All elevations are referenced to NGVD-1929.
Attachment 1
Hydraulic and Hydrologic Analysis for Yuba River Patrol Road Levee Project
Hydraulic and Hydrologic Analysis for Yuba River Patrol Road Levee Project

March 2010

Prepared by

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TABLE OF CONTENTS

1. Background .....................................................................................................................1
   1.1 Purpose ................................................................................................................1

2. Hydraulic Model..............................................................................................................4
   2.1 Description ..........................................................................................................4
   2.2 Corps of Engineers Calibration ............................................................................5
   2.3 MBK Engineers Recalibration ..............................................................................7
   2.4 Results of the MBK Engineers Recalibration .......................................................7

3. Hydrology ................................................................................................................... ....8

4. Levee Performance Assumptions .....................................................................................9

5. Analysis and Methodology ..............................................................................................9
   5.1 Existing Condition ...............................................................................................9
   5.2 Methodology ......................................................................................................10
   5.3 Scenarios ...........................................................................................................11
       Scenario 1: Yuba River South Training Levee Breach Downstream of Goldfields ........................................11
       Scenario 2: Removal of Yuba River South Training Levee Downstream of Goldfields .. ...............11

6. Results .................................................................................................................... ......15

7. Discussion .................................................................................................................. ...15

8. References .................................................................................................................. ...19

LIST OF TABLES

Table 1. January 1997 Flood – Estimated Annual Exceedence Probability, 1-day Duration ......5
Table 2. Calibration Analysis – Available Data at Gages in Study Area.......................................6
Table 3. Corps of Engineers Calibration Study Results – Peak Stages and Flows at Gages .......7
Table 4. MBK Engineers Recalibration Study Results – Peak Stages and Flows at Gages ........8
Table 5. Summary of Major River Peak Flow Rates at Upstream Model Boundaries ..........9
LIST OF FIGURES

Figure 1. Levees South of the Yuba River .................................................................2
Figure 2. Yuba River South Training Levee Profile ....................................................2
Figure 3. Yuba River South Training Levee Section 65+97 ........................................3
Figure 4. Yuba River South Training Levee Section 24+54 .......................................3
Figure 5. Flow Path Through Goldfields ...............................................................10
Figure 6. Scenario 1 and 2 Training Levee Breach and Removal ............................12
Figure 7. Simulated Breaches ..............................................................................13
Figure 8. Flows Entering the Patrol Road Channel from Goldfields, 1-in-100 AEP ....13
Figure 9. Flows Entering the Patrol Road Channel from Goldfields, 1-in-200 AEP ....14
Figure 10. Simulated Degraded Levee .................................................................14
Figure 11. Patrol Road Levee Maximum Water Surface and Levee Profile .............16
Figure 12. Patrol Road Levee Maximum Water Surface and Levee Profile .............17
Figure 13. Patrol Road Levee Maximum Water Surface Profile Comparison ..........18

LIST OF APPENDICES

Appendix A  Refinements Made to HEC-RAS Model
Appendix B  Patrol Road Levee Maximum Water Surface Elevations
Appendix C  Figures
Appendix D  Quality Assurance and Quality Control
1. Background

In order to ensure the protection of local areas which have been developed or are under development, Three River Levee Improvement Authority (TRLIA) is in the process of evaluating the levees along the Yuba River. One of these levees is the Patrol Road levee which prevents Yuba River floodwaters from flowing southward into Linda and Olivehurst.

1.1 Purpose

The purpose of this document is to provide a basis for the determination of a water surface along the Patrol Road levee. The water surface along the lower portion (mouth to Dantoni Rd) of the Patrol Road levee is generally backwater controlled by the combined flows of the Yuba and Feather Rivers. The water surface along the upper portion (Dantoni Rd to Goldfields) of the Patrol Road levee is less understood. Analysis was developed for two potential mechanisms for delivering water to the upper portion of the Patrol Road levee:

- Failure of the Yuba River south training levee downstream of the Goldfields
- Flow through the Goldfields exiting adjacent to the Patrol Road levee

The former is a purely hypothetical scenario, while the latter is the mechanism by which water reached the upper Patrol Road levee during the January 1997 flood event. A map showing the location of the south training levee along with a profile and representative cross sections are provided in Figures 1 through 4. Figure 1 also shows the location of the Patrol Road levee.
Figure 1. Levees South of the Yuba River

Figure 2. Yuba River South Training Levee Profile
Figure 3. Yuba River South Training Levee Section 65+97

Figure 4. Yuba River South Training Levee Section 24+54
2. Hydraulic Model

2.1 Description

MBK Engineers was provided a copy of the Feather River HEC-RAS model, dated Jan. 12, 2004 that was developed by the U.S. Army Corps of Engineers, Sacramento District (Corps) for the Lower Feather River Floodplain Mapping Study (Corps, February 2005). This model was the basis for the results presented in this report. Included with the model were the calibration analysis and synthetic hydrology for 1-in-2, 1-in-10, 1-in-25, 1-in-50, 1-in-100, 1-in-200, and 1-in-500 annual exceedence probabilities (AEP) for two hydrologic centerings: Feather River at Shanghai Bend and Bear River.

The model represents the Feather River and its tributaries from below Oroville reservoir within the basin to its confluence with the Sacramento River. Specifically, the major upstream boundaries of the model are:

- Feather River at Oroville Dam.
- Yuba River at Daguerre Point Dam.
- Bear River near river mile 16.35.
- Sutter Bypass at Highway 20.
- Sacramento River upstream of Fremont Weir.

The model includes the following minor tributaries:

- Honcut Creek (Feather River) – modeled reach, 0.8 miles long.
- Jack-Simmerly Slough (Feather River) – modeled reach, 6.25 miles long.
- Dry Creek (Yuba River) – lateral inflow.
- Deer Creek (Yuba River) – lateral inflow.
- Yankee Slough (Bear River) – modeled reach, 6.2 miles long.
- Dry Creek (Bear River) – modeled reach, 4.4 miles long.
- WP Interceptor Canal (Bear River) – modeled reach, 4.9 miles long.
- Best Slough (WP Interceptor Canal) – modeled reach, 1 mile long.
- Natomas Cross Canal (Sacramento River) – modeled reach, 6.2 miles long.
- Wadsworth Canal (Sutter Bypass) – modeled reach, 4.3 miles long.

The model has two downstream boundaries: Sacramento River at Verona Gage and Yolo Bypass at Woodland Gage. The downstream boundary conditions are represented by rating curves at these locations. The cross-section and reach geometry in this model was derived from the Sacramento-San Joaquin Rivers Comprehensive Study (Comp Study) topography and Sacramento River Basin UNET model. Figure C-1 shows the geographic extent of the model and the waterways contained in the model.
2.2 Corps of Engineers Calibration

The HEC-RAS model was calibrated by the Corps to the January 1997 flood event. For reference, the estimated AEP of the January 1997 flood one-day volume is summarized in Table 1 for locations within the model study area.

Table 1. January 1997 Flood – Estimated Annual Exceedence Probability, 1-day Duration

<table>
<thead>
<tr>
<th>Location</th>
<th>Estimated Annual Exceedence Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feather River at Oroville</td>
<td>1-in-100</td>
</tr>
<tr>
<td>Yuba River at Marysville</td>
<td>1-in-100$^1$</td>
</tr>
<tr>
<td>Bear River at Wheatland</td>
<td>1-in-33</td>
</tr>
<tr>
<td>Sacramento River at Latitude of Verona</td>
<td>1-in-91</td>
</tr>
</tbody>
</table>

Source: Sacramento and San Joaquin River Basins Comprehensive Study  
$^1$ Estimated by MBK Engineers

The following is an excerpt from the model description that accompanied the model when provided by the Corps, which explains the Corps’ calibration methodology (Corps, February 2005).

Manning’s $n$ values, flow roughness factors, and weir coefficients were adjusted to best fit the rising limb of the computed hydrographs with the observed hydrographs at seven stream gage locations. These locations are:

1. Feather River: Yuba City gage.  
2. Feather River: Nicolaus gage.  
5. Bear River: Forty Mile Road gage.  
7. Sacramento River: Upstream end of Fremont Weir.

The model has not been calibrated upstream of the Yuba City gage.

The gages within the study area for which observed data were available for the calibration event are shown in Figure C-1 and summarized in Table 2. A comparison of observed and computed peak stages and flows at the gages for the calibration event is provided in Table 3.
Table 2. Calibration Analysis – Available Data at Gages in Study Area

<table>
<thead>
<tr>
<th>Gage</th>
<th>Agency</th>
<th>Stage Data (source)</th>
<th>Flow Data (source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feather River near Gridley</td>
<td>USGS</td>
<td>Hourly (CDEC)</td>
<td>Hourly (Corps data file)</td>
</tr>
<tr>
<td></td>
<td>11407150</td>
<td>Peak (USGS)</td>
<td>Peak (USGS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean Daily (USGS)</td>
</tr>
<tr>
<td>Feather River at Yuba City</td>
<td>Ca. DWR</td>
<td>Hourly (CDEC)</td>
<td>N/A</td>
</tr>
<tr>
<td>Feather River at Nicolaus</td>
<td>Ca. DWR</td>
<td>Hourly (CDEC)</td>
<td>N/A</td>
</tr>
<tr>
<td>Yuba River near Marysville</td>
<td>USGS</td>
<td>Hourly (Corps data file)</td>
<td>Peak (USGS)</td>
</tr>
<tr>
<td></td>
<td>11421000</td>
<td>Peak (USGS)</td>
<td>Mean Daily (USGS)</td>
</tr>
<tr>
<td>Bear River near Wheatland</td>
<td>USGS</td>
<td>15 min. (Corps data file)</td>
<td>15 min. (Corps data file)</td>
</tr>
<tr>
<td></td>
<td>11424000</td>
<td>Peak (USGS)</td>
<td>Peak (USGS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measured (USGS)</td>
<td>Measured (USGS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12/31/96 15:20</td>
<td>12/31/96 15:20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/1/97 14:55</td>
<td>1/1/97 14:55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/2/97 12:30</td>
<td>1/2/97 12:30</td>
</tr>
<tr>
<td>Bear River at Forty Mile Road (Pleasant Grove Road)</td>
<td>Unknown</td>
<td>15 min. (Corps data file)</td>
<td>N/A</td>
</tr>
<tr>
<td>Sacramento River at Fremont Weir</td>
<td>Ca. DWR</td>
<td>Hourly (CDEC)</td>
<td>N/A</td>
</tr>
<tr>
<td>Sacramento River at Verona</td>
<td>USGS</td>
<td>Hourly (CDEC)</td>
<td>Hourly (CDEC)</td>
</tr>
<tr>
<td></td>
<td>11425500</td>
<td>Peak (USGS)</td>
<td>Peak (USGS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measured (USGS)</td>
<td>Measured (USGS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/2/97 11:30</td>
<td>1/2/97 11:30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean Daily (USGS)</td>
<td>Mean Daily (USGS)</td>
</tr>
<tr>
<td>Yolo Bypass near Woodland</td>
<td>USGS</td>
<td>10 min. (Corps data file)</td>
<td>Peak (USGS)</td>
</tr>
<tr>
<td></td>
<td>11453000</td>
<td>Peak (USGS)</td>
<td>Measured (USGS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measured (USGS)</td>
<td>1/3/97 09:30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1/3/97 11:30</td>
</tr>
<tr>
<td>Sutter Bypass at Pump Plant #1</td>
<td>CA. DWR</td>
<td>Irregular Time Series (DWR Water Data Library)</td>
<td>N/A</td>
</tr>
<tr>
<td>Sutter Bypass at Pump Plant #2</td>
<td>CA. DWR</td>
<td>Irregular Time Series (DWR Water Data Library)</td>
<td>N/A</td>
</tr>
<tr>
<td>Sutter Bypass at Pump Plant #3</td>
<td>CA. DWR</td>
<td>Irregular Time Series (DWR Water Data Library)</td>
<td>N/A</td>
</tr>
<tr>
<td>Sutter Bypass at Willow Slough</td>
<td>CA. DWR</td>
<td>Irregular Time Series (DWR Water Data Library)</td>
<td>N/A</td>
</tr>
<tr>
<td>Sutter Bypass at RD 1500 Pump Plant</td>
<td>CA. DWR</td>
<td>Irregular Time Series (DWR Water Data Library)</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Table 3. Corps of Engineers Calibration Study Results – Peak Stages and Flows at Gages

<table>
<thead>
<tr>
<th>Gage</th>
<th>Peak Stage (ft.-NGVD29)</th>
<th>Peak Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed</td>
<td>Computed</td>
</tr>
<tr>
<td>Feather River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Gridley</td>
<td>97.51</td>
<td>99.15</td>
</tr>
<tr>
<td>at Yuba City</td>
<td>75.23</td>
<td>75.51</td>
</tr>
<tr>
<td>at Nicolaus</td>
<td>47.20</td>
<td>47.34</td>
</tr>
<tr>
<td>Yuba River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Marysville</td>
<td>88.69</td>
<td>88.71</td>
</tr>
<tr>
<td>Bear River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Wheatland</td>
<td>95.65</td>
<td>95.68</td>
</tr>
<tr>
<td>at 40 Mile Rd.</td>
<td>70.78</td>
<td>70.99</td>
</tr>
<tr>
<td>Sacramento River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>at Fremont Weir</td>
<td>39.47</td>
<td>38.97</td>
</tr>
<tr>
<td>at Verona</td>
<td>39.09</td>
<td>38.75</td>
</tr>
<tr>
<td>Yolo Bypass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Woodland</td>
<td>31.43</td>
<td>30.81</td>
</tr>
</tbody>
</table>

2.3 MBK Engineers Recalibration

The Corps Feather River HEC-RAS model has been refined and recalibrated by MBK Engineers for the levee improvement projects proposed by TRLIA Phase I to IV. The refinements and recalibration were necessitated due to the additional detail and accuracy needed in the hydraulic model for design and construction of the project features. All refinements made by MBK Engineers are documented in Appendix A.

2.4 Results of the MBK Engineers Recalibration

Results of the model recalibration made by MBK Engineers are presented in Figures D-2 through D-24. Figures D-2 through D-6 show the computed maximum water surface profile versus the surveyed high water marks for the Bear, Feather and Yuba Rivers. Figures D-7 through D-24 show stage and flow hydrographs at available gage locations within the study area. The following descriptions are included to further identify some of the data shown in these figures:

a. Observed (Corps): from data files compiled by Corps (“1997_event_input.dss” from Lower Feather river HEC-RAS study and “sac97.dss” from Comprehensive Study).

b. Observed – CDEC (datum adjusted): gage height from CDEC adjusted to NGVD 1929 datum.

c. Observed, est. (Corps): from data files compiled by Corps (“1997_event_input.dss” from Lower Feather river HEC-RAS study and “sac97.dss” from Comprehensive Study).
d. Observed (Corps data file): from data files compiled by Corps ("1997_event_input.dss" from Lower Feather river HEC-RAS study and “sac97.dss” from Comprehensive Study).

e. Computed Mean Daily Peak (MBK): mean daily flow from MBK simulated hourly.

Table 4 provides a summary of observed and computed stages and flows at the gage locations in the study area.

<table>
<thead>
<tr>
<th>Gage</th>
<th>Peak Stage (ft.-NGVD29)</th>
<th>Peak Flow (cfs)</th>
<th>% Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed</td>
<td>Computed</td>
<td>Difference (ft.)</td>
</tr>
<tr>
<td><strong>Feather River</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Gridley</td>
<td>97.51</td>
<td>97.88</td>
<td>+0.38</td>
</tr>
<tr>
<td>at Yuba City</td>
<td>75.23</td>
<td>75.07</td>
<td>-0.16</td>
</tr>
<tr>
<td>at Nicolaus</td>
<td>47.20</td>
<td>47.05</td>
<td>-0.15</td>
</tr>
<tr>
<td><strong>Yuba River</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Marysville</td>
<td>88.69</td>
<td>88.29</td>
<td>-0.30</td>
</tr>
<tr>
<td><strong>Bear River</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Wheatland</td>
<td>95.65</td>
<td>Boundary Condition</td>
<td>34,900</td>
</tr>
<tr>
<td>at 40 Mile Rd.</td>
<td>70.78</td>
<td>70.70</td>
<td>-0.08</td>
</tr>
<tr>
<td><strong>Sacramento River</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at Fremont Weir</td>
<td>39.47</td>
<td>39.29</td>
<td>-0.18</td>
</tr>
<tr>
<td>at Verona</td>
<td>39.09</td>
<td>39.10</td>
<td>+0.01</td>
</tr>
<tr>
<td><strong>Yolo Bypass</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Woodland</td>
<td>31.43</td>
<td>31.28</td>
<td>-0.15</td>
</tr>
<tr>
<td><strong>Sutter Bypass</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at Pump Plant 1</td>
<td>44.7</td>
<td>44.94</td>
<td>+0.26</td>
</tr>
<tr>
<td>at Pump Plant 2</td>
<td>48.4</td>
<td>48.20</td>
<td>-0.20</td>
</tr>
<tr>
<td>at Pump Plant 3</td>
<td>52.5</td>
<td>52.23</td>
<td>-0.28</td>
</tr>
<tr>
<td>at Willow Sl.</td>
<td>44.8</td>
<td>44.76</td>
<td>-0.03</td>
</tr>
<tr>
<td>at RD 1500 Pump Plant</td>
<td>40.2</td>
<td>39.65</td>
<td>-0.55</td>
</tr>
</tbody>
</table>

3. Hydrology

The hydrology adopted and used in this hydraulic analysis was developed as part of the Lower Feather River Floodplain Mapping Study (Corps, February 2005). The Corps hydrology has been previously submitted to FEMA under a physical map revision (PMR) for the Lower Feather River Watershed. This PMR submittal to FEMA is believed to be fully supported with necessary data, maps, and documentation.

Two storm centerings over the Feather River basin were developed by the Corps:

1. Feather River at Shanghai Bend (SHY).
2. Bear River (BR).
These storm centerings were developed to hydraulically stress the system at the specified locations. Table 5 shows the peak flow rate at the upstream boundary of each major reach for each of the centerings and for the 1-in-100 and 1-in-200 AEP.

Table 5. Summary of Major River Peak Flow Rates at Upstream Model Boundaries

<table>
<thead>
<tr>
<th>AEP</th>
<th>Feather River</th>
<th>Yuba River</th>
<th>Bear River</th>
<th>Sutter Bypass</th>
<th>Sacramento R.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SHY</td>
<td>BR</td>
<td>SHY</td>
<td>BR</td>
<td>SHY</td>
</tr>
<tr>
<td>1-in-100</td>
<td>150</td>
<td>150</td>
<td>141</td>
<td>122</td>
<td>41</td>
</tr>
<tr>
<td>1-in-200</td>
<td>174</td>
<td>150</td>
<td>211</td>
<td>135</td>
<td>48</td>
</tr>
</tbody>
</table>

Note: All flows 1,000 cfs.

As was done by the Corps (Corps, February 2005), the upstream boundary flows for the Sacramento River and Sutter Bypass were taken from the results of simulations of the same storm centerings made with the Comp Study Sacramento River Basin UNET model.

4. Levee Performance Assumptions

An important assumption in performing hydraulic simulations of leveed systems on a regional basis is defining if, when, and how levee failures will occur. The analysis as presented herein assumes that levees would not fail before or after overtopping.

5. Analysis and Methodology

The analysis consisted of simulating the hydraulic conditions for the 1-in-100 and 1-in-200 AEP flood events to determine design water surface profiles along the Patrol Road levee. The analysis used only the Feather River Shanghai Bend centering hydrology as it produces higher stages at the Patrol Road levee.

5.1 Existing Condition

An existing condition assumption was developed for the model simulations since significant geometric changes in the Feather-Yuba River system have occurred or are ongoing. Construction work on the Patrol Road levee improvements is anticipated to begin in 2010. Since the hydraulic model was calibrated to hydraulic conditions as of January 1997, it was necessary to update the model to reflect the hydraulic conditions expected at the time of construction of the Patrol Road levee improvements. Since January 1997, the Bear River north levee setback and the Feather River east levee setback from RM 17 to 24 (Figure C-25) have been constructed. These two setback levees have been added to the model.

Another project under design is the Star Bend setback levee proposed by Levee District No. 1. The construction of this project is expected to have only a localized hydraulic effect and will not effect the water surface elevations along the Patrol Road levee.

5.2 Methodology

The design water surface profile at the Patrol Road levee was determined for the following two scenarios: 1) with breach of the Yuba River south training levee and 2) with removal of the Yuba River south training levee. Each of these scenarios also included flow exiting the Goldfields.
adjacent to the head of the Patrol Road channel. The two scenarios simulated are described in Section 5.3.

Flow exiting the Goldfields for the 1-in-100 and 1-in-200 AEP events was determined by simulating a potential flow path through the Goldfields. Review of aerial photography identified a flow path from the Yuba River to the head of the Patrol Road channel (Figure 5). Field visits identified three locations where embankments provide some hydraulic control along the flow path. Elevations and dimensions of the embankment and culverts were surveyed. The flow path was simulated in HEC-RAS with one lateral weir, a storage area, one river reach and three inline weirs. Cross sections along the flow path were cut from the Corps Comp Study topo. For the portion of the cross section missing due to water; the bottom width and invert elevation were estimated based on field visits. A Manning’s n value of 0.1 was used for the cross sections.

**Figure 5. Flow Path Through Goldfields**

![Flow Path Through Goldfields](image)

The flow path simulated is one of many flow paths through the Goldfields. Seepage through the tailings is not simulated and could be another source of water entering and exiting the flow path.
5.3 Scenarios

Scenario 1: Yuba River South Training Levee Breach Downstream of Goldfields

For this scenario, a simulation was made with a breach in the Yuba River south training levee just downstream of the Goldfields at RM 6.93 (see Figure 6). Simulated levee breach widths analyzed were 500, 1000, and 2000 feet with levee breach inverts at 88.4 ft, 87.8 ft, and 86.5 ft NGVD29, respectively, see Figure 7. Breach invert elevations are the approximate adjacent ground elevations. The breach trigger elevation was within 0.1 to 0.2 feet of the maximum water surface elevation at the breach location for the 1-in-100 AEP event. For the 1-in-200 AEP event, breach trigger elevations were near the existing top of levee elevations for each breach simulated. Full formation of the breach was assumed to take 5 hours.

This scenario also included the flows exiting the Goldfields into the head of the Patrol Road channel. The methodology for the calculation of the flow was discussed in Section 5.2. Figure 8 and 9 show the flow hydrographs at the head of the Patrol Road channel for the 1-in-100 and 1-in-200 AEP, respectively.

Scenario 2: Removal of Yuba River South Training Levee Downstream of Goldfields

Scenario 2 consists of simulating a levee removal of Yuba River south training levee just downstream of the Goldfields from approximately RM 6.9 to 5.4 (see Figure 6). This scenario is similar to a FEMA floodplain analysis for which this portion of the levee is not certified. The portion of levee removed is approximately 7,300 linear feet and was degraded to adjacent ground elevations ranging from 84 feet to 91 feet NGVD29 as shown in Figure 10.

This scenario also included the flows exiting the Goldfields into the head of the Patrol Road channel. The methodology for the calculation of the flow was discussed in Section 5.2. Figure 8 and 9 shows the flow hydrographs at the head of the Patrol Road channel for the 1-in-100 and 1-in-200 AEP, respectively.
Figure 6. Scenario 1 and 2 Training Levee Breach and Removal
Figure 7. Simulated Breaches

Figure 8. Flows Entering the Patrol Road Channel from Goldfields, 1-in-100 AEP
Figure 9. Flows Entering the Patrol Road Channel from Goldfields, 1-in-200 AEP

Figure 10. Simulated Degraded Levee
6. Results

The 1-in-100 and 1-in-200 AEP maximum water surface elevation profiles for all scenarios along the Patrol Road levee are shown in Figures 11 and 12, respectively. The figures also include the top of levee and waterside toe of levee elevation. The water surface elevations are tabulated by levee station in Appendix B.

7. Discussion

The purpose of this analysis was to determine a design water surface elevation along the Patrol Road levee for the 1-in-100 and 1-in-200 AEP event. The two sources of water to the Patrol Road levee are a potential levee breach on the training levee downstream of the Goldfields and water exiting the Goldfields entering directly to the head of the Patrol Road channel. This analysis combined both sources to determine the potentially worse case water surface elevation against the Patrol Road levee.

With the combined water sources, two different scenarios were simulated for water leaving the Yuba River at the south training levee just downstream of the Goldfields. Scenario 1 simulated a breach along the training levee and Scenario 2 removed the levee downstream of the Goldfields in accordance with procedures set by FEMA for a structure that is not certified. Various breach lengths were simulated to determine the sensitivity of the breach length of delivery of water to the Patrol Road levee.

For the 1-in-100 AEP event, it is recommended that the Scenario 2 (levee removal) maximum water surface elevation be used for design. The development of this water surface profile under Scenario 2 conforms with procedures set forth by FEMA under a 1-in-100 AEP event.

For the 1-in-200 AEP event, it is recommended that the Scenario 1 (500 foot levee breach) maximum water surface elevation be use for design. The selection of this scenario and breach width is based on the fact that a levee breach is more likely to occur on the Yuba River south training levee versus a complete levee degradation. The 500 foot breach width is consistent with historic levee breach widths which have occurred in the Sacramento River Flood Control Project. The Scenario 1 1-in-200 AEP water surface elevation is higher in elevation throughout the Patrol Road versus the 1-in-100 AEP Scenario 2 water surface.

Figure 13 compares the various 1-in-100 and 1-in-200 AEP water surface elevations used for analysis and design over the past few years. The previous 1-in-100 and 1-in-200 AEP water surface elevations are from analysis as part of the TRLIA levee certification (MBK 2007). These water surface elevations differ from the Scenarios 1 and 2 simulations for the following reasons:

1. Scenario 1 and 2 simulations include the Feather River setback levee which reduces water surface elevations at the mouth of the Yuba River.
2. Scenario 1 and 2 simulations include either a levee breach or levee removal on the Yuba River south training levee downstream of the Goldfields. The levee breach or removal allowed water to flow south to the upper portion of the Patrol Road levee.
3. Additional refinements were made to the HEC-RAS model for Scenario 1 and 2 to better simulate flow in the Patrol Road low flow channel and floodplain.
Figure 11. Patrol Road Levee Maximum Water Surface and Levee Profile
1-in-100 AEP

1. Levee elevation information from Corps Comp Study Topo
2. Levee station based on HDR levee alignment.
Figure 12. Patrol Road Levee Maximum Water Surface and Levee Profile
1-in-200 AEP

- Levee elevation information from Corps Comp Study Topo
- Levee station based on HDR levee alignment.
Figure 13. Patrol Road Levee Maximum Water Surface Profile Comparison

1. Levee elevation information from Corps Comp Study Topo
2. Levee station based on HDR levee alignment.

- 1-in-100 AEP - Scenario 2 - (Training Levee Removed)
- 1-in-200 AEP - Scenario 1 - (500 ft Breach)
- Previous (2007) 1-in-100 AEP Profile
- Previous (2007) 1-in-200 AEP Profile
- Waterside Toe
- Top of Levee
8. References


Appendix A
Refinements Made to HEC-RAS Model
Refinements Made to Corps HEC-RAS Model by MBK Engineers, version 12.

Geometric Refinements

1. The Manning’s n value was adjusted at various cross sections in the model to improve the calibration at surveyed high water marks and/or observed gages. See Table 1.

2. The vertical variation in the Manning’s n value in the Bear River Reach: Lower, RS 1.01 to 3.35 was removed. This change was made for simplification. It was difficult to support the level of detail contained in the vertically varying roughness values.

3. Removed vertical and horizontal variation in Manning’s n-value for Yuba River sections upstream of and including section 6.09.

4. Removed vertical and horizontal variation in Manning’s n-value in Feather R Jack Sl-Yuba reach.

5. The flow roughness factors in the following reaches were eliminated
   a. Feather River – Yuba River to Bear River, RM 17 to 24.25.
   b. Feather River – Yuba River to Bear River, RM 24.5 to 27.0.
   c. Feather River – Jack Sough to Yuba River, RM 27.25 to 29.25.
   d. Yuba River (upper) – RM 1.6 to 8.34.

6. For the Feather River (Yuba River to Bear River, RM 17 to 24.25) a single Manning’s n value at each of the cross sections was used.

7. A vertical varying Manning’s n value was added to the following cross sections:
   a. Feather River – Yuba River to Bear River, RM 24.5 to 27.0.
   b. Yuba River (upper) – RM 1.6 to 5.84.

8. On the Sacramento River Reach: 18, RS 82.25 to 84.75; cross sectional areas with ineffective flow area on the right bank were removed. This area already represented in the Yolo Bypass reach, i.e., the area was double counted.

9. Lateral weirs RS 81.51, 81.76, 82.0, 82.27, 82.52, 82.76, 82.77, 83.02, 83.26, 83.75 on the Sacramento River Reach:18, were consolidated into one weir RS 83.74. This was done to simplify the model. The results were not affected by this simplification. The weir also extended eastward to RS 80.39.

10. Lateral weirs 82.28, 82.51, 82.76, 83.01, 83.27, 83.76, 84.26, 84.27 on the Sacramento River Reach: 18, were consolidated into one weir RS 84.24 and RS 84.49. This was done to simplify the model. The results were not affected by this simplification. The weir also extended eastward to RS 80.39.
11. Extended Sutter Bypass upstream to Highway 20 (RM 88.04). Previous Sutter Bypass upstream boundary was just upstream of Feather River at RM 67.38. Used Comp Study UNET model cross-sections.

12. Added Wadsworth Canal. Used Comp Study UNET model cross-sections. Did not include East and West Interceptor.

13. Replaced the SA-Arboga storage area (RD 784) with SA-N Arboga (Comp Study SA 153), SA S Arboga (Comp Study SA 158) and SA E Arboga (Comp Study SA 150).

14. Replaced storage areas SA – Camp Beale, SA – Reeds Cr and SA – Best Sl with Comp Study UNET model storage areas 148, 155, 156 and 157.

15. Replaced storage area SA-Gilsizer with the Comp Study UNET model storage areas: 115, 116, 117, 118, 119, 144, 152.

16. Added Comp Study storage areas 145, 146, 147 and 151 (south of Yuba River and east of Linda).

17. Refined Jack & Simmerly Slough:
   a. Replaced upper sections (RS 3.25 – RS 7.50) with a storage area (SA-Jack Sl).
   b. Removed hardwired pilot channels from remaining cross-sections (RS 1.25 – RS 3.00).
   c. Added obstruction in left bank of RS 2.25 and 2.26 to represent railroad embankment.

18. Changed upstream boundary of Yuba River from section RS 13.84 to RS 11.34 to remove DaGuerre Point Dam from model.

19. Removed hardwired pilot channel from Yolo Bypass and Yuba OB reach sections. Added pilot channels to these reaches using the HEC-RAS pilot channel feature.

20. Refined confluence of Feather River and Sutter Bypass. Based on Nicolaus gage and surveyed high water marks there was a drop in water surface between Nicolaus gage and Sutter Bypass that the model was not replicating, possibly the result of trying to model a somewhat 2-d situation with the 1-d model. Review of aerial photos and topo maps indicate that this drop could be due to hydraulic inefficiency resulting from vegetation, old RR grade, remnant levees, bend in Feather R, etc). Modified model with elevated n-values at this location.

21. Added obstructions to land side of levees in following reaches:
   a. Yankee Slough (all sections downstream and including 2.87)
   b. Cross Canal (all sections)
   c. Bear River (all sections downstream and including 5.66)
   d. Feather River (sections 8.00 to 9.20 and 9.50 to 12.00)
   e. Sacramento River (all sections)
f. Yuba River (sections 5.60 to 8.09)
g. Yuba OB patrol, mid and low (all sections)
h. UP Intercept (all sections)
i. Best Slough, right bank (all sections)

22. UP Intercept: Added lateral structure (RS 4.9) to represent levee on left bank upstream of Best Slough. Top of levee elevation from MHM Engineers survey, October 2006.

23. Best Slough: Added lateral structure (RS 1.2) to represent small levee on right bank. Top of levee elevation from MHM Engineers survey, October 2006.

24. Refined storage connection SC 155 to 156 to reflect MHM Engineers top of levee survey, October 2006.


26. Refinements were made on the Bear River reach Upper as shown below. Additional detail is documented “Hydrology Documentation in Support of FEMA CLOMR Application Bear River North Levee Rehabilitation, December 1, 2006, MBK Engineers.”
   a. Extended reach upstream approximately 5 miles to RS 16.35.
   b. Revised bathymetry from, RS 5.91 to 12.0.
   c. Revised Manning’s n values, RS 5.5 to 12.0.

27. On River “Sutter Bypass” Reach “Wadsworth to Sac River” RS 67.01 – Reversed the cross section stationing to reflect correct left and right bank orientation.

28. On River “Sutter Bypass” Reach “Wadsworth to Sac River” RS. 66.64, RS 66.45, and RS 66.28 – Added obstruction on the left bank to block out duplicate area on the Feather River cross sections.

29. On River “Sutter Bypass” Reach “Hwy 20 to Wadsworth” and “Wadsworth to Sac River” RS 67.01 to 88.04 – Modified the cross section top of levee elevation to reflect updated top of levee elevation data from DWR.

30. On River “Sutter Bypass” Reach “Hwy 20 to Wadsworth” – LS 87.858, 87.108, 87.859, 86.929, 86.548, 85.809, 85.808, 84.868, 84.499 – Modified lateral weir elevations to reflect updated top of levee elevation data from DWR.

31. On River “Sutter Bypass” Reach “Wadsworth to Sac River” – LS 83.569, 83.008, 80.958, & 80.589 – Modified later weir elevation to reflect updated top of levee elevation data from DWR.

32. On River “Yuba OB” – Combined Reach “mid” and “upper”, new Reach name is “upper”
33. Eliminated Junction “OB mid-upper”.

34. Eliminated River “Yuba OB” Reach “mid”.

35. Renamed “Yuba OB-Patrol” to “Yuba OB – Low Fl – Reach1”.

36. Modified cross sections in “Yuba OB-Low Fl-Reach 1” to reflect low flow cross sectional areas; added lateral weirs to adjacent river reaches.

37. Add Storage Area “Dantoni”.

38. Added new River reach “Yuba OB – Patrol Channel” and lateral weirs to connect to adjacent river reaches.

39. Added Storage Area “Ag Plant”.

40. Added lateral weir on River “Yuba R” Reach “upper” at RS 7.6 to reflect inlet into Goldfields.

41. Added lateral weirs on River “Yuba R” Reach “upper” at RS 7.56, 7.08, and 6.51 to represent the Yuba River South Training Levee.

**Hydrologic Refinements**

1. For the calibration model, the hydrologic input for the upstream boundary condition on the Sutter Bypass was modified. DWR has a stream gage near the upstream boundary of the Sutter Bypass, Butte Slough near Meridian (A02972), with stage and flow records. The peak flow reported for the January 1997 event at this location is 173,200 cfs. Using the reported hydrograph in the calibration simulation results in the peak flow at the
latitude of Verona exceeding the observed peak flow by approximately 36,000 cfs as shown in the following table. Additionally, using the reported flow would require unrealistically low roughness coefficients (Manning’s n values) in the Sutter Bypass and other downstream reaches in order to calibrate to observed stream gage peak stages and surveyed high water marks. It was found that reducing the Sutter Bypass near Meridian flow by 30% results in a good calibration of the peak flow at the latitude of Verona (see following table) and of the peak water surface elevations in the Sutter Bypass.

<table>
<thead>
<tr>
<th>Location</th>
<th>Peak Flow (cfs)</th>
<th>Observed</th>
<th>With Unadjusted Butte Slough near Meridian Flow</th>
<th>With Reduced Butte Slough near Meridian Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacramento River at Verona</td>
<td></td>
<td>102,000  (USGS)</td>
<td>108,600</td>
<td>104,600</td>
</tr>
<tr>
<td>Yolo Bypass near Woodland</td>
<td></td>
<td>357,000  (USGS)</td>
<td>386,900</td>
<td>354,100</td>
</tr>
<tr>
<td>Total at Latitude of Verona</td>
<td></td>
<td>~459,000  a</td>
<td>495,000</td>
<td>458,100</td>
</tr>
</tbody>
</table>

a  It is unlikely that the peaks at the Verona and Woodland gages are concurrent, but as demonstrated by the simulation results they are very close. Therefore, the assumption that they are concurrent provides a good estimate that can be used for comparison purposes.

2. The downstream boundary condition rating curve at Yolo Bypass Reach: 59, was refined to reflect observed flows and stages. The original rating curve did not reflect rating shifts in effect. Figure below shows the original and refined rating curve.
3. Deleted dummy pilot flows from unsteady flow files for “Yuba OB-Upper”. “Yuba OB-Patrol”

4. Deleted lateral inflow hydrograph at Yuba OB-low RS 0.74.
Appendix B
Patrol Road Levee Maximum Water Surface Elevations
<table>
<thead>
<tr>
<th>Note: Levee station based on HDR levee alignment converted to miles.</th>
<th>Scenario 1 - 1000 ft Breach</th>
<th>Scenario 1 - 2000 ft Breach</th>
<th>Scenario 2 - Levee Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing Cond (No Levee Breaches)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C
Figures
LIST OF FIGURES

Figure C-1  HEC-RAS Model Extents and Calibration Points
Figure C-2  Maximum Water Surface Profile – January 1997 Flood, Bear River
Figure C-3  Maximum Water Surface Profile – January 1997 Flood, Feather River (Lower)
Figure C-4  Maximum Water Surface Profile – January 1997 Flood, Feather River (Upper)
Figure C-5  Maximum Water Surface Profile – January 1997 Flood, Yuba River (Lower)
Figure C-6  Maximum Water Surface Profile – January 1997 Flood, Yuba River (Upper)
Figure C-7  Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Bear River near Wheatland (11.50) – USGS 11424000
Figure C-8  Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Bear River at Pleasant Grove Road (6.93) – DWR A06535
Figure C-9  Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Feather River at Gridley (50.75) – USGS 11407150
Figure C-10 Feather Basin HEC-RAS Calibration – January 1997 Event Flow Feather River at
Gridley (50.75) – USGS 11407150
Figure C-11 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Feather River at Yuba City (27.952) – DWR A05135
Figure C-12 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Feather River at Nicolaus (8.00) – DWR A05103
Figure C-13 Feather Basin HEC-RAS Calibration – January 1997 – Flow Feather River at
Nicolaus (8.00) – DWR A05103
Figure C-14 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Sacramento River at Verona (78.75) – USGS 11425500
Figure C-15 Feather Basin HEC-RAS Calibration – January 1997 Event Flow Sacramento
River at Verona (78.75) – USGS 11425500
Figure C-16 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Yolo Bypass near Woodland (51.21) – USGS 11453000
Figure C-17 Feather Basin HEC-RAS Calibration – January 1997 Event Flow Yolo Bypass
near Woodland (51.21) – USGS 11453000
Figure C-18 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Yuba River near Marysville (6.09) – USGS 11421000
Figure C-19 Feather Basin HEC-RAS Calibration – January 1997 Event Flow Yuba River near
Marysville (6.09) – USGS 11421000
Figure C-20 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Sutter Bypass at PP#3 (85.06)
Figure C-21 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Sutter Bypass at PP#2 (78.16)
Figure C-22 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Sutter Bypass at PP#1 (69.00)
Figure C-23 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Sutter Bypass at Willow St. (67.38) – DWR A02943
Figure C-24 Feather Basin HEC-RAS Calibration – January 1997 Event Water Surface
Elevation Sutter Bypass at RD 1500 Pump Plant (58.81) – DWR A02927
Figure C-25 Existing Condition Simulation – Bear and Feather River Setback Levee
FIGURE C-3
Maximum Water Surface Profile --- January 1997 Flood
Feather River (lower)
FIGURE C-4
Maximum Water Surface Profile --- January 1997 Flood
Feather River (upper)
FIGURE C-5
Maximum Water Surface Profile --- January 1997 Flood
Yuba River (lower)

Surveyed High Water Marks (USACE)
Gage Peaks
Corps Calibration
MBK Calibration (v12)
FIGURE C-6
Maximum Water Surface Profile --- January 1997 Flood
Yuba River (upper)
FIGURE C-9
Feather Basin HEC-RAS Calibration - January 1997 Event
Water Surface Elevation
Feather River at Gridley (50.75) - USGS 11407150

FIGURE C-10
Feather Basin HEC-RAS Calibration - January 1997 Event
FLOW
Feather River at Gridley (50.75) - USGS 11407150
FIGURE C-13
Feather Basin HEC-RAS Calibration - January 1997 Event
FLOW
Feather River at Nicolaus (8.00) - DWR A05103

FIGURE C-14
Feather Basin HEC-RAS Calibration - January 1997 Event
Water Surface Elevation
Sacramento River at Verona (78.75) - USGS 11425500
FIGURE C-17
Feather Basin HEC-RAS Calibration - January 1997 Event
FLOW
Yolo Bypass near Woodland (51.21) - USGS 11453000

FIGURE C-18
Feather Basin HEC-RAS Calibration - January 1997 Event
Water Surface Elevation
Yuba River near Marysville (6.09) - USGS 11421000
FIGURE C-21
Feather Basin HEC-RAS Calibration - January 1997 Event
Water Surface Elevation
Sutter Bypass at PP#2 (78.16)

FIGURE C-22
Feather Basin HEC-RAS Calibration - January 1997 Event
Water Surface Elevation
Sutter Bypass at PP#1 (69.00)
FIGURE C-23
Feather Basin HEC-RAS Calibration - January 1997 Event
Water Surface Elevation
Sutter Bypass at Willow Sl. (67.38) - DWR A02943

FIGURE C-24
Feather Basin HEC-RAS Calibration - January 1997 Event
Water Surface Elevation
Sutter Bypass at RD1500 Pump Plant (58.81) - DWR A02927
Appendix D
Quality Assurance and Quality Control
Quality Control Certification

for

Hydraulic and Hydrologic Analysis for Yuba River Patrol Road Levee Project

Certification of Internal Quality Control

I hereby certify that I have reviewed the hydraulic analysis and results described in the March 2010 memorandum on the Hydraulic and Hydrologic Analysis for Yuba River Patrol Road Levee Project and that it adequately addresses hydrology and hydraulics of the described project.

Michael Archer, P.E., MBK Engineers

4/16/10

Date
Appendix B

Embankment Protection

(Engineer’s Opinion immediately follows this page,
Supporting Report separately bound)
Engineer's Opinion

Evaluation of Embankment Protection
Yuba River South Levee (Simpson Lane to the Goldfields)
RD 784 Levee System

This opinion\(^1\) is made to assist the Three Rivers Levee Improvement Authority (TRLIA) in complying with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 – Emergency Management and Assistance, Part 65 – Identification and Mapping of Special Hazard Areas (44CFR65.2) and to support TRLIA's certification\(^2\) of the Yuba River South Levee from Simpson Lane to the Goldfields Reach of the RD 784 Levee System. This opinion is limited to the base flood (i.e., 1-percent annual-chance flood) for the subject levee and is made to TRLIA.

Additional information concerning these opinions can be located in the 2010 Final Design Documentation Report. All information, calculations, definitions, descriptions, restrictions, limitations, or other pertinent data contained in this report form the basis of this opinion.

Summary of Opinion:
In accordance with paragraph (b) of 44CFR 65.2 and based on the results of our evaluation of embankment protection for the Yuba River South Levee from Simpson Lane to the Goldfields, it is our opinion that:

1. **Data** – The data used in the analysis includes a review of available hydraulic modeling results, a field review of the levees, existing levee side slope configurations, geotechnical information about the existing levee embankment, channel sinuosity and fetch lengths, maximum wind speeds anticipated during a design flood event, and existing vegetation conditions on the waterside slope of the existing levee. This data is considered accurate to the best of our knowledge.

2. **Analysis** - The analysis consisted of maximum flow velocities and comparing to allowable velocities estimated from embankment material type, density and anticipated vegetative cover conditions, as well as a cursory review of potential erosion due to wave action on the levee slope. It is our opinion that this analysis was performed in accordance with sound engineering practices\(^3\) appropriate to accurately assess the existing levee slopes, including those slope areas modified during the Yuba River South Levee (Simpson Lane to Goldfields) levee improvements.

3. **Structural Works** - The evaluation consisted of reviewing assumptions to confirm the adequacy of revegetation for slope areas modified as part of the Yuba River South Levee (Simpson Lane to Goldfields) levee improvements. No calculated velocities exceeded USACE criteria, therefore no additional slope protection was required. It is our opinion that the associated levee repairs have been designed in accordance with sound engineering practices\(^3\) to provide protection from the base flood, provided that RD 784 continues regular inspection and maintenance of the embankment slopes, which includes, but is not limited to, control of vegetation and repair of localized erosion and animal burrow damage.

June 21, 2013
Engineer’s Opinion

Evaluation of Embankment Protection
Yuba River South Levee (Simpson Lane to the Goldfields)
RD 784 Levee System

4. "As-Built" Conditions – Upon visual inspection of the existing and as-repaired levee slopes and a review of construction test data and record drawings, recent survey data and the analyses discussed herein, it is our opinion that the existing levee embankment and levee mitigation features are in place and appear to be functioning as intended for the base flood.

Opinion Offered by:

Daniel Jabbour, PE
HDR Engineering, Inc.
2365 Iron Point Road, Suite 300
Folsom, CA 97630

[Signature]

Date

1 – Consistent with current practice, these professional opinions of expected flood control system performance are valid for 10 years from the date of the TRLIA certification.

2 – Per 44 CFR 85.2 §2(b), "...a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement that the data is accurate to the best of certifier's knowledge. Certification of analysis is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning."

3 – It is assumed that "sound engineering practices" are practices that are performed in a manner consistent with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions.
Appendix C

Embankment and Foundation Stability

(Engineer’s Opinion immediately follows this page, Supporting Report separately bound)
Engineer's Opinion
Evaluation of Embankment and Foundation Stability
Yuba River South Levee (Simpson Lane to the Goldfields)
RD 784 Levee System

This opinion (1) is made to assist the Three Rivers Levee Improvement Authority (TRLIA) in complying with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 – Emergency Management and Assistance, Part 65 – Identification and Mapping of Special Hazard Areas (44CFR65.2) and to support TRLIA's certification (2) of the Reclamation District 784 Levee System Yuba River South Levee from Simpson Lane to the Goldfields. This opinion is limited to the base flood (i.e., 1-percent chance flood) for the specific areas listed below and is made to TRLIA.

Additional information concerning these opinions can be located in the 2009 Problem Identification Report, the 2010 Revised Geotechnical Basis of Design, the 2011 Plans and Specifications, and the 2013 Construction Documentation Report. All information, calculations, definitions, descriptions, restrictions, limitations, or other pertinent data contained in these reports form the basis of this opinion.

Summary of Opinion:
In accordance with paragraph (b) of 44CFR 65.2 and based on the results of the evaluation of Embankment and Foundation Stability for the Yuba River South Levee Simpson Lane to the Goldfields, it is our opinion that:

1. Data – The data used in the analysis includes historic subsurface information and information from subsurface investigations and laboratory testing programs conducted in 2008, 2009 and 2010. This data is considered accurate to the best of our knowledge.

2. Analysis - The analysis consisted of a review of historic subsurface information, development of soil strength and permeability for the embankment and foundation materials based on historic subsurface information and recently completed subsurface investigations and laboratory testing programs, evaluation of through-seepage and underseepage potential at representative existing levee locations during the base flood, and an evaluation of embankment slope stability at representative existing locations during the base flood for steady-state and rapid-drawdown conditions. An evaluation of potential impact of utility penetrations on levee integrity and performance during the base flood was also performed. It is our opinion that this analysis was performed in accordance with sound engineering practice (3) appropriate to accurately assess the embankment and foundation stability of the Yuba River South Levee (Simpson Lane to Goldfield) repairs.

3. Structural Works - The evaluation consisted of comparing calculated seepage and stability factors of safety to design criteria specified by USACE, as well as through seepage potential. Where these criteria were not met, seepage remediation in the form of seepage berms and cutoff walls were constructed. It is our opinion that the associated levee repairs have been designed in accordance with sound engineering practices(3) to provide protection from the base flood.

September 24, 2013

APPENDIX C
Page 1 of 2
Engineer’s Opinion
Evaluation of Embankment and Foundation Stability
Yuba River South Levee (Simpson Lane to the Goldfields)
RD 784 Levee System

4. "As-Built" Conditions – Upon visual inspection of the improved levee slopes and a
review of construction test data and record drawings, recent survey data and the
analyses discussed herein, it is our opinion that the as-built levee embankment and
levee mitigation features are in place and appear to be functioning as intended for
embankment and foundation stability for the base flood.

Opinion Offered by:

Tim Williams, PE
Kleinfelder, Inc.
3077 Fite Circle
Sacramento, CA 95827

[Signature]
[Date]

1 – Consistent with current practice, these professional opinions of expected flood control system performance
are valid for 10 years from the date of the TRLIA certification.

2 – Per 44 CFR 65.2 §2(b), "...a certification by a registered professional engineer or other party does not
constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement
that the data is accurate to the best of certifier’s knowledge. Certification of analysis is a statement that the
analyses have been performed correctly and in accordance with sound engineering practices. Certification of
structural works is a statement that the works are designed in accordance with sound engineering practices to
provide protection from the base flood. Certification of “as built” conditions is a statement that the structure(s)
has been built according to the plans being certified, is in place, and is fully functioning."

3 – It is assumed that “sound engineering practices” are practices that are performed in a manner consistent
with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the
same locality under similar conditions.
Appendix D

Settlement

(Engineer’s Opinion immediately follows this page,
Supporting Report separately bound)
Engineer's Opinion  
Evaluation of Settlement Potential  
Yuba River South Levee (Simpson Lane to the Goldfields)  
RD 784 Levee System  

This opinion(1) is made to assist the Three Rivers Levee Improvement Authority (TRLIA) in complying with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 – Emergency Management and Assistance, Part 65 – Identification and Mapping of Special Hazard Areas and to support TRLIA's certification(2) of the Reclamation District 784 Levee System Yuba River South Levee from Simpson Lane to the Goldfields improvements (repairs). This opinion is limited to the base flood (i.e., 1-percent chance flood) for the specific areas listed below and is made to TRLIA.

Additional information concerning these opinions can be located in the 2009 Problem Identification Report, the 2010 Revised Geotechnical Basis of Design, the 2011 Plans and Specifications, and the 2013 Construction Documentation Report. All information, calculations, definitions, descriptions, restrictions, limitations, or other pertinent data contained in these reports form the basis of this opinion.

Summary of Opinion:  
In accordance with paragraph (b) of 44CFR 65.2 and based on the results of our evaluation of settlement for the Yuba River South Levee from Simpson Lane to the Goldfields, it is our opinion that:

1. **Data** – The data used in our analysis included historic subsurface information, and information from our subsurface investigations and laboratory testing programs conducted in 2008, 2009, and 2010. To the best of our information, knowledge and belief, this data is accurate.

2. **Analysis** - Our analysis consisted of
   - Review of available historic subsurface information
   - Development of soil settlement parameters based on historic subsurface information and recently completed subsurface investigations and laboratory testing programs.
   - A determination as to where modifications of the Yuba River South Levee from Simpson Lane to the Goldfields would cause increased loads on the existing levee and foundation soils.
   - Calculations to determine estimated future levee settlement at representative locations where a net increase in loading on the existing embankment or foundation soils occurs.
   - Evaluation of the potential for adjacent areas of the levee foundation to settle at different rates (i.e. differential settlement) under increased loads from levee repairs or modifications.

It is our opinion that this analysis was performed in accordance with sound engineering practices(3) appropriate to accurately assess levee settlement.

September 24, 2013

APPENDIX D  
Page 1 of 2
3. **Structural Works** - Our evaluation included review of data and engineering analysis collected and prepared during the design process and observations during construction of improvements to the Yuba River South Levee from Simpson Lane to the Goldfields. Measures performed during construction included monitoring and visual observation for evidence of cracking. It is our opinion that the levee embankment modifications are designed in accordance with sound engineering practices to provide protection from the base flood.

4. **"As-Built" Conditions** – It is our opinion that, based upon visual inspection of the levee slopes, a review of construction data and record drawings and our analyses, the Yuba River South Levee from Simpson Lane to the Goldfields is in place and appears to be functioning as intended for the base flood with regards to potential settlement.

Opinion Offered by:
Tim Williams, PE
Kleinfelder, Inc.
3077 Fite Circle
Sacramento, CA 95827

1 – Consistent with current practice, these professional opinions of expected flood control system performance are valid for 10 years from the date of the TRLIA certification.

2 – Per 44 CFR 65.2 §2(b), "...a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement that the data is accurate to the best of certifier's knowledge. Certification of analysis is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning."

3 – It is assumed that "sound engineering practices" are practices that are performed in a manner consistent with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions.
Appendix E

Interior Drainage Report

(Engineer’s Opinion immediately follows this page,
Supporting Report separately bound)
Engineer’s Opinion
Evaluation of Interior Drainage System Adequacy
Yuba River South Levee (Simpson Lane to the Goldfields)
RD 784 Levee System

This opinion(1) is made to assist the Three Rivers Levee Improvement Authority (TRLIA) in complying with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 – Emergency Management and Assistance, Part 65 – Identification and Mapping of Special Hazard Areas and to support TRLIA’s certification(2) of the Reclamation District 784 Levee System Yuba River South Levee from Simpson Lane to the Goldfields. This opinion is limited to the base flood (i.e., 1-percent chance flood) for the specific drainage areas listed below and is made to TRLIA.

Additional information concerning this opinion can be located in this appendix as referenced. All information, calculations, definitions, descriptions, restrictions, limitations, and other pertinent data contained in this appendix form the basis of this opinion.

**Summary of Opinion:**
In accordance with paragraph (b) of 44 CFR 65.2 and based on the results of our evaluation of the Interior Drainage System, it is our opinion that:

1. **Data** – The data utilized in our analysis includes available original design plans, hydrologic and hydraulic design data, river and rainfall gage data, land use data, and topographic mapping. To the best of our information, knowledge and belief, this data is accurate.

2. **Analysis** – Our analysis consisted of hydrologic and hydraulic analysis of the East Linda Drain sub-basin of the RD 784 Interior Drainage area. The results of the analysis showed:
   - Interior Canal system - The channel and canal system south of the Yuba River South Levee from Simpson Lane to the Goldfields can effectively convey the 1% interior flows to the WPIC with some limited residual flood plain. These residual flood plains have been identified and mapped and are the subject of a LOMR submitted to FEMA.
   - Levee Pumping Stations – No levee pumping stations are present in this reach of the RD 784 Levee System.

It is our opinion that this analysis was performed in accordance with sound engineering practices (3) appropriate to accurately assess the adequacy of the interior drainage system.

3. **Structural Works** – Not applicable for this Appendix. The "structural works" of the RD 784 Levee System was assessed in other appendices that are part of this submission to FEMA.

4. **"As-Built" Conditions** – Not applicable for this appendix. The "As-Built Conditions" of the RD 784 Levee System was assessed in other appendices that are part of this submission to FEMA.

November 8, 2012

APPENDIX E
Page 1 of 2
Engineer's Opinion
Evaluation of Interior Drainage System Adequacy
Yuba River South Levee (Simpson Lane to the Goldfields)
RD 784 Levee System

Opinion Offered by:
Sean Minard, PE
MHM, Incorporated
1204 E Street
Marysville, CA 95901

Signature  8-5-13  Date

1 – Consistent with current practice, these professional opinions of expected levee system performance are valid for 10 years from the date of the TRLIA certification.

2 – Per 44 CFR 65.2 §2(b), "...a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement that the data is accurate to the best of certifier's knowledge. Certification of analysis is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning."

3 – It is assumed that 'sound engineering practices' are practices that are performed in a manner consistent with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions.
Appendix F

Operation & Maintenance Manual
For RD 784

(Engineer’s Opinion immediately follows this page,
Supporting Report separately bound)
Engineer’s Opinion
Evaluation of the Operation and Maintenance Manuals
Yuba River South Levee (Simpson Lane to the Goldfields)
RD 784 Levee System

This opinion (1) is made to assist the Three Rivers Levee Improvement Authority (TRLIA) in complying with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 – Emergency Management and Assistance, Part 65 – Identification and Mapping of Special Hazard Areas and to support TRLIA’s certification (2) of the Reclamation District 784 Levee System along the Yuba, Feather, and Bear Rivers and the Western Pacific Interceptor Canal. This opinion is limited to the base flood (i.e., 1-percent chance flood) for the specific areas listed below and is made to TRLIA.

Additional information concerning this opinion can be located in the Corps of Engineers Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project (May 1955), the Corps of Engineers Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145-Part No. 1 (August 1955), TRLIA’s Bear River Setback Levee, Addendum to: Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145, Part No. 1, May 2007, TRLIA’s Bear River North Levee, WPIC West Levee, and Yuba River South Levee, Addendum to: Supplement to Standard Operation and Maintenance Manual Sacramento River Flood Control Project, Unit No. 145 – Part No. 1, January 2008, Revised March 2010 & June 2013 (Latest revision added the Upper Yuba Levee Improvement project features), and TRLIA’s Feather River Levee Repair Project, Addendum to: Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145- Part No. 1, October 2011 as identified. All information, calculations, definitions, descriptions, restrictions, limitations, and other pertinent data contained in these reports form the basis of this opinion.

Summary of Opinion:
In accordance with paragraph (b) of 44 CFR 65.2 and based on the results of our evaluation of the Operation & Maintenance Manuals and Addendums for the RD 784 Levee System, it is our opinion that:

1. Data – The data utilized in the preparation of the Addendums to the Supplemental Manual to the Standard SRFCP Operation & Maintenance Manual was obtained from many sources including the original manuals developed by USACE; design documents and plans for specific levee system alterations, guidance provided in various USACE and FEMA publications; RD 784 inspection, maintenance, and operational information; and information provided in HDR’s, and Kleinfelder’s levee investigations. To the best of our information, knowledge and belief, this data is accurate.
2. **Analysis** - Our analysis consisted of

- Review of available operation and maintenance manuals.
- Review of federal and state guidelines and regulations for the operation and maintenance of levee systems and interior drainage systems.
- Review of Design Documents and Construction Completion Reports for the different alterations completed for the RD 784 Levee System.
- Review and preparation of O&M manual addendums prepared for the recent levee alterations.
- Evaluation of recent state levee inspections of the RD 784 Levee System.
- Evaluation of how well the recent addendums provide appropriate operation and maintenance guidance for the recently altered Levee System.

It is our opinion that this analysis was performed in accordance with sound engineering practices (3) appropriate to accurately assess adequacy of the operation and maintenance manuals and addendums being used for the RD 784 Levee System.

3. **Structural Works** - Not applicable for this Appendix. The “structural works” of the RD 784 Levee System was assessed in other appendices that are part of this submission to FEMA.

4. **“As-Built” Conditions** – The Construction Documentation Report contains as-built drawings of the alterations and repairs made to this reach of levee. It also contains surveyed crest elevations along the length of the levee. It is our opinion that the Construction documentation Report meets FEMA requirements for providing as-built plans.
1 – Consistent with current practice, these professional opinions of expected levee system performance are valid for 10 years from the date of the TRLIA certification.

2 – Per 44 CFR 65.2 §2(b), “…a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement that the data is accurate to the best of certifier’s knowledge. Certification of analysis is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of “as built” conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning.”

3 – It is assumed that “sound engineering practices” are practices that are performed in a manner consistent with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions.
Appendix G

Quality Control Documents

Board of Senior Consultants Credentials
Board of Senior Consultants Quality Control Report
September 20, 2013

Mr. Larry Dacus
MBK Engineers
1771 Tribute Road
Sacramento, CA 95815

Subject: Three Rivers Levee Improvement Authority
FEMA Certification Summary Supplement
Reclamation District 784 - Upper Yuba South Levee
(Simpson Lane to the Goldfields)

Dear Mr. Dacus:

At your request, we have conducted a quality assurance review of Three Rivers Levee Improvement Authority’s Certification Summary Supplement, to the FEMA Certification Project, Yuba South Levee (Simpson Lane to the Goldfields). We, the undersigned, served as the Board of Senior Consultants (BOSC) during the design and construction of the repair for this reach of levee. The BOSC serves as the Independent External Review Panel for this project.

We reviewed the draft summary report and engineering opinions and made cursory reviews of the following supporting documentation:

- Kleinfelder, Problem Identification Report, dated September 29, 2009. *Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Simpson Lane to Yuba Gold Fields, Reclamation District No. 784, Yuba County, California*
- Kleinfelder, Geotechnical Borrow Site Evaluation, dated June 10, 2010, *Geotechnical Borrow site Evaluation TRLIA Borrow Area 1, Upper Yuba Levee Improvement Project, Yuba river south Levee Evaluation, Yuba county, California.* This report provides an evaluation of quality and quantity of borrow material in the adjacent borrow site.
- HDR, *Upper Yuba Levee Improvement Project, 100% Design Submittal Design Documentation Report, Upper Yuba Levee Improvement Project, Yuba River Basin, California (Sta. 102+00 to Sta. 303+59),* dated June 21, 2010.
We found that:

- The design teams had followed the standards of engineering practice required for design and construction of the repairs implemented in the Yuba South Levee (Simpson Lane to the Goldfields) reach of the RD 784 Levee System.
- Adequate and appropriate information had been gathered to perform the analyses needed to support the repairs implemented.
- The analyses performed were appropriate and were conducted correctly.
- The Construction Documentation Report for the repairs documents that the repairs had been constructed in accordance with the plans and specifications issued for construction, and satisfy the intent of the design.
- The references cited in the Certification Summary Report support the Engineers’ Opinion letters, and provide the appropriate and adequate information to support those opinions.

Respectfully submitted,

Donald H. Babbitt, P.E.  
Board of Senior Consultants

Faiz I. Makdisi, P.E.  
Board Senior of Consultants

David T. William, P.E.  
Board of Senior Consultants
RESUME

EDUCATION

B.S., Civil Engineering, University of California, Berkeley, 1957

PROFESSIONAL REGISTRATION

Registered Civil Engineer, California (No. 13028)
Registered Geotechnical Engineer, California (No. 104)

EXPERIENCE SUMMARY

Don Babbitt is a consultant specializing in dam design and construction, geotechnical, earthquake and water resources engineering. He currently serves on seven consulting boards. He was with the California Department of Water Resources for 40 years. He was one of the lead designers of the State Water Project dams. He subsequently served as the chief of the two major branches of the Division of Safety of Dams.

PROFESSIONAL HISTORY

Individual Consultant (2002-present)
Mr. Babbitt serves on the California Department of Water Resources consulting boards for construction of Dyer Reservoir, modification of Patterson Reservoir and enlargement of Crafton Hills Reservoir; East Bay Municipal Utility District’s San Pablo Dam Technical Review Board; GEI’s Board of Senior Consultants for the Feather River Levee Repair; Levee District No. 1 of Sutter County’s Star Bend Setback Levee Board of Consultants and San Diego County Water Authority/City of San Diego Dispute Resolution Panel for the San Vicente Dam raise.

Principal Engineer, GENTERRA Consultants, Inc. (1999-2004 part time)
Mr. Babbitt developed reconnaissance level designs for dams, reviewed plans and specifications to enlarge and rehabilitate dams, evaluated the safety of existing dams and acted as an expert witness.

California Department of Water Resources, Division of Safety of Dams
As Chief, Design Engineering Branch, (1992-98), Mr. Babbitt was responsible for review of plans, specifications and reports for construction and modification of dams, reevaluation of existing dams and review of structural performance instrumentation data and reports.

As Chief, Field Engineering Branch, (1985-92), Mr. Babbitt was responsible for maintenance inspections and safety evaluations of more than 1200 existing dams, as large as 770-foot high Oroville Dam, and for inspections to confirm safe construction and modification of dams.
As a section chief in Design Engineering Branch (1976-85), Mr. Babbitt supervised the review of plans, specifications and reports for construction and modification of dams; reevaluation of existing dams for seismic stability, spillway adequacy, etc.

**California Department of Water Resources, Division of Design and Construction (1960-76)**
Mr. Babbitt was responsible for completing the design of the embankments of Pyramid and Perris Dams; design of the embankments of Thermalito Forebay and Afterbay, Parish Camp and Bidwell Bar Saddle Dams (Orovilie Reservoir) and Bethany Dams 1, 2, 3 and 4 and design of the proposed Peripheral Canal for the Sacramento-San Joaquin Delta. His last position in the division was Chief of the Dams and Canals Design Unit.

**Military Service, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi - Civil Engineering Assistant (1958-60)**
Mr. Babbitt performed research and testing of pavement subgrades and strength of culverts.

**California Department of Water Resources, Division of Design and Construction, Sacramento, CA - Junior Civil Engineer (1957-58)**
Mr. Babbitt provided canal, pipeline, drainage and small structure design and reservoir operation studies for the State Water Project.

**PROFESSIONAL ACTIVITIES**

- **International Commission on Large Dams**
  - Invited speaker 21st Congress on Large Dams, Montreal, June 2003

- **U.S. Society on Dams**
  - Board of Directors, 1997 – 2003
  - Earthquakes Committee, 1987- present

- **American Society of Civil Engineers**
  - Chairman, Session on Slopes and Embankments, Earthquake Engineering and Soil Dynamics Specialty Conference, 1978
  - President, Sacramento Section, 1980
  - Invited Lecturer, Geotechnical Practice in Dam Engineering, 1993
  - Peer Reviewer, Guidelines for Instrumentation and Measurements for Monitoring Dam Performance, 2000

- **National Research Council - Committee on Safety Criteria for Dams, 1984**

**REFERENCES**

Ted Craddock  
Program Manager, East Branch Extension  
California Department of Water Resources  
1416 Ninth Street, Sacramento, CA 95814  
Telephone: (916) 653-9469

David Gutierrez  
Chief, Division of Safety of Dams  
California Department of Water Resources  
2200 X Street, Sacramento, CA 95818  
Telephone: (916) 227-9800
Dr. Makdisi’s 30-year career has combined applied research and professional practice in geotechnical and foundation/earthquake engineering for critical infrastructure structures. For most of his professional career, he has focused on geotechnical studies and safety evaluations of earth and rockfill dams, embankments, levees and landfills. His work includes feasibility evaluations and preliminary design studies; field investigation design and planning; borrow area material studies; in situ and laboratory testing; and evaluation and interpretation of static and dynamic material properties of dams, levees, and their foundations. His studies also included stability evaluations of embankment slopes, seepage analyses, and static and dynamic stress analyses to evaluate stability during earthquakes.

He has performed studies to determine earthquake-induced permanent deformations in slopes and embankments, and developed and published widely-used simplified procedures for estimating dynamic response and permanent deformations in earth and rockfill dams and embankments. He is a lead participant in earthquake ground motion studies and development of seismic design criteria for key facilities such as dams and nuclear power plants. He was principal investigator of the “Stability of Slopes, Embankments and Rockfalls” chapter of the Seismic Retrofit Manual for the Federal Highway Project prepared for the National Center for Earthquake Engineering Research. He was co-principal investigator of a research study for the United States Geological Survey, National Earthquake Hazard Reduction Program to evaluate the effects of the style of faulting on earthquake ground motions.

Dr. Makdisi has served on technical review boards and as an independent peer reviewer for a number of public utilities and agencies, and several Corps of Engineers Districts. He is currently serving as a member of the Safety Review Consulting Board for Perris Dam for the Department of Water Resource, Division of Safety of Dam. He was a member of the team of Technical Advisors to the Los Angeles District, U.S. Army Corps of Engineers that provided review on the design and construction of the 600-foot-high Seven Oaks Dam in Southern California. He served as peer reviewer of the seismic analyses of Cougar and Blue River Dams, for the U.S. Army Corps of Engineers, Portland District; and peer reviewer of the safety studies of Terminus, Success, and Lake Isabella Dams, for the U.S. Army Corps of Engineers, Sacramento District. He provided independent expert technical review of the White River
seismic remediation project in Seattle, Washington, for the Federal Energy Regulatory Commission (FERC). Dr. Makdisi is also an independent peer reviewer involved in the Safety of Dams Program for Pacific Gas and Electric Company, and for the East Bay Municipal Utility District (EBMUD).

Dr. Makdisi is a member of a senior technical review board providing peer review of the design and construction of the Bear River setback levee, and the Star Bend setback levee on the Feather River. He has also provided expert technical support to the State of California Attorney General’s Office during litigation related to the levee failure on the Feather River near Marysville, California during the flood of 1997; and expert litigation support for a case related to seepage problems of the Madera Canal downstream of Friant Dam.

Representative levee project experience includes:

**Delta Risk Management Study (DRMS), URS Corporation America, San Joaquin River Delta, CA.** Member of Project Team on Levee Fragilities. The overall objectives of the DRMS project are to evaluate the risk of failure of the Delta levees under present as well as foreseeable future conditions and to develop a risk management strategy to reduce and manage the risk. Studies were performed to estimate levee fragility under seismic hazard, hydrodynamic loading, and seepage conditions.

**DWR Urban Levee Investigation, URS Corporation, Sacramento County, CA.** Principal-in-charge of AMEC Geomatrix’s work as part of a consultant team assisting in the geotechnical evaluation of the State of California’s project urban levees (approximately 300 miles).

**South Bay Salt Ponds Project, Phillip Williams Associates, San Francisco Bay, CA.** Principal-in-charge for geotechnical support services related to the restoration of more than 15,000 acres of former salt ponds in South San Francisco Bay. AMEC Geomatrix’s scope of work includes developing geotechnical aspects of the project EIS, reviewing proposed levee sections, developing a baseline condition model of existing project levees, and performing reliability assessments of outboard levee seepage and stability.

**Hollister Seasonal Storage Ponds, City of Hollister, San Benito County, CA.** Principal-in-charge of all field investigations, laboratory testing, seismic evaluations, engineering analyses, design and preparation of plans and specifications for construction of the earthen embankments needed to form recycled water storage ponds at a site next to the San Benito River.

**1997 Feather River Levee Failure, Butte County, CA.** Principal-in charge of geomorphic studies, seepage analyses, finite element stress and settlement analyses, and other technical studies in support of litigation, for the State of California Attorney General’s Office.


**Cactus Basins and Rialto Channel, City of San Bernardino, Rialto, CA.** Participated in the geotechnical design, seepage analysis, and assessment of static and seismic stability of basin embankments, for San Bernardino County Department of Public Works.

**Hamilton Air Force Base Flood Control Levee Design, City of Novato, CA.** Participated in the geotechnical design, assessment of strength of soft foundation soils, settlement analyses, and static and seismic stability analyses of levee slopes.

**New Orleans Levees Failures during Hurricane Katrina** – Advanced numerical modeling of breached levee sections during Hurricane Katrina, including FLAC analysis.
of soil-structure interaction for levees, floodwalls and foundation seepage, for U.S. Army Engineer Research and Development Center.

**New Orleans Levees, Design of T-Wall Structures** - Advanced numerical analyses in support of development of improved design procedures of pile-supported flood walls. Analyses included soil-pile-structure interaction using nonlinear finite difference analyses, performed for the New Orleans District of the US Army Corps of Engineers.

**Analyses of I-Walls** – Advanced numerical modeling in support of design of levee floodwalls. Study included finite difference analysis of soil-pile-structure interaction, and seepage analyses of sheet pile walls, simulating extreme flood loading conditions. Analyses performed for the US Army Corps of Engineers, Headquarters, Washington, DC.

**Bear River Set Back Levee**, Yuba County, CA. Member of a senior board of consultants for review of the design and construction of levees on the Bear and Feather rivers, for the Three Rivers Levee Improvement Authority.

Dr. Makdisi has published more than 40 papers and major research reports. His paper (co-authored with Seed, Lee, and Idriss) on the analyses of the slides in the San Fernando Dams during the 1971 San Fernando earthquake was awarded the 1977 Norman Medal award of the American Society of Civil Engineers.

He has presented lectures at ASCE seminars and workshops in San Francisco, Los Angeles, and Oakland, California; and in Seattle, Washington; as well as lectures at the University of California campuses at Berkeley and Davis and at Stanford University. He was invited to present a keynote lecture on the seismic stability of embankments and slopes at the session on slope stability at the Geo-Denver 2000 conference of ASCE’s Geo-Institute. He also presented a lecture on seismic design criteria for dams at the Federal Energy Regulatory Commission’s Dam Safety Workshop, held in Portland, Oregon, in March 2001.

As a member of a team of Technical Advisors to the Los Angeles District, Corps of Engineers, on the design and construction of Seven Oaks Dam in California, Dr. Makdisi was a co-recipient of the U.S. Army Corps of Engineers, Chief of Engineers “Design and Environmental Honor Award for 2002.”

He has presented lectures at ASCE seminars and workshops in San Francisco, Los Angeles, and Oakland, California; and in Seattle, Washington; as well as lectures at the University of California campuses at Berkeley and Davis and at Stanford University, the University of Illinois at Urbana-Champaign, and the University of Puerto Rico at Mayaguez. He was invited to present a keynote lecture on the seismic stability of embankments and slopes at the session on slope stability at the Geo-Denver 2000 conference of ASCE’s Geo-Institute. He also presented an invited lecture on seismic design criteria for dams at the Federal Energy Regulatory Commission’s Dam Safety Workshop, held in Portland, Oregon, in March 2001.
Education

Ph.D., Civil Engineering, Colorado State University, 1995
M.S., Civil Engineering, University of California, Davis, 1977
B.S., Civil Engineering, University of California, Davis, 1972

Registrations

Professional Engineer (Civil) license number and date
   California 57020, 1997
   Arizona 24349, 1990
   Hawaii 7796, 1993
   Mississippi 8242, 1981
   New Mexico 12187, 1993
   Texas 80003, 1994
   Washington 23201, 1990
   Oregon 16963, 1993
   Colorado – 43253, 2008

Professional Hydrologist (PH)
Certified Professional, Erosion and Sediment Control (CPESC)
Diplomate, American Academy of Water Resources Engineers (D.WRE)
Certified Floodplain Manager (CFM)

Work History

2009 – Present; President, David T. Williams and Associates, Engineers, LLC, Fort Collins, CO


2002 - 2005; National Director for Hydrology and Hydraulics, HDR Engineering, San Diego, CA

1988 - 2002; President and co-founder of WEST Consultants, a premier water resources engineering firm
1979 - 1988; Research Hydraulic Engineer, Hydraulics Lab, Engineering and Research Development Center (formerly Waterways Experiment Station), Vicksburg, MS

1983 - 1984; acting Chief, Hydrology and Hydraulics Section, Baltimore District Corps of Engineers

1977 - 1979; Civil Engineer, Hydrology Branch, Nashville District Corps of Engineers

1975 - 1977; Research Hydraulic Engineer, Planning Branch and Research Branch, Hydrologic Engineering Center, Davis, CA

1972 - 1975; Infantry Platoon Officer and Combat Engineering Unit Officer, 7th Special Forces Group, Fort Bragg, NC

Professional Affiliations

American Society of Civil Engineers (Fellow)
International Erosion Control Association (IECA – past president)
American Society of Testing and Materials (ASTM)
American Institute of Hydrology (Chair, Board of Registration)

Summary

Dr. David Williams is a registered Professional Civil Engineer in eight states, a Fellow of the American Society of Civil Engineers, a Professional Hydrologist and a Certified Professional in Erosion and Sediment Control (CPESC). He served as Principal-in-Charge for several flood insurance studies in San Diego and Orange counties. He has written the new HEC-6 User Manual for the U.S. Corps of Engineers Hydrologic Engineering Center, performed HEC-6 and local scour analysis of pipeline crossings in Arizona and New Mexico, headed the Keene Ranch groundwater modeling study and the Nile River sedimentation evaluations. He is well versed in the computer programs HEC-1, HEC-2, HEC-RAS, HEC-6, STORM, and WQRRS. Dr. Williams is a nationally recognized expert in sedimentation engineering and in developing innovative solutions to difficult hydraulic and hydrologic design problems in rivers and estuaries.

Dr. Williams previously served as a two time President of the International Erosion Control Association. He has served as chair of the ASCE Task Committee on Analysis of Laboratory and Field Sediment Data Accuracy and Availability. He is also a past chair of the ASCE Sedimentation Committee as well as the Computational Hydraulics Committee and currently serves on the ASCE Stream Restoration Committee. While chair of the Federal Interagency Technical Committee on Sedimentation, he worked with hydraulic and sedimentation experts from the Federal Highway Administration, Bureau of Reclamation, U.S. Geological Survey, Bureau of Land Management, Forest Service, TVA, Bureau of Land Management and the Agricultural Research Service. His work with
the Committee involved developing sediment sampling equipment and sediment data collection methods. He is the author of more than 100 technical papers and reports on hydraulics and sedimentation. Dr. Williams was formerly an Associate Editor of the ASCE Journal of Hydraulic Engineering, as well as a reviewer. He was selected the 1993 Small Business Person of the Year by the Carlsbad, California Chamber of Commerce, and served as chair of the Carlsbad Beach Erosion Committee.

His professional experience includes more than eighteen years as a hydraulic engineer with the U.S. Army Corps of Engineers at the Waterways Experiment Station (WES) in Vicksburg, Mississippi, both the Nashville and Baltimore Districts, and the Hydrologic Engineering Center in Davis, California. While at WES, Dr. Williams worked on research applications of sediment transport in rivers and reservoirs and the solution of unusual hydraulic and sediment related problems using computer models and other state-of-the-art techniques. He also worked on the development of the cohesive and network versions of the HEC-6 sediment transport computer model, and wrote the Reservoir Sedimentation Chapter in the U.S. Corps of Engineering Manual on Sedimentation Investigations. At the Nashville District, Dr. Williams performed erosion control and sedimentation studies for the Tennessee-Tombigbee Waterway Project and also conducted sedimentation and floodplain information studies of proposed flood control projects. He was acting Chief of the Hydrology and Hydraulics Section at the Baltimore District Corps of Engineers. During the mid 1970's, Dr. Williams worked at HEC, helping in the development of spatial data management techniques, evaluation of the economic benefits of flood control projects, and sedimentation in rivers and reservoirs.

Dr. Williams has been a frequent short course instructor for ASCE, Federal and State Agencies for computer training workshops on using HEC-2, HEC-RAS, HEC-HMS and HEC-6. In addition, he has taught short courses on channel bed scour for toe protection design, sediment transport, bridge scour and streambank protection.

**Selected Projects**

Member of the Board of Senior Consultants, Natomas Levee System, Sacramento, CA – The Sacramento Area Flood Control Agency (SAFCA) is upgrading the levee system around the Natomas area in Sacramento, CA to the 200 year protection level. Appointed by SAFCA, Dr. Williams is on a 3 member board of consultants to review and provide expert advice on the risk and uncertainty analysis, plan formulations, hydrology and hydraulic aspects of the project.

Uncertainty Analyses Using Simplified Methods for the Flood Control District of Maricopa Co., AZ – The study developed simplified methods to evaluate the uncertainty for flood control projects using cutting edge techniques that are not usually seen in flood control projects. This involved automated execution of hydrologic and hydraulic models with varying inputs to develop probability density functions for use in Monte Carlo simulations. The probability distributions of hydrologic and hydraulic inputs were developed based upon experience and technical literature. The results were the
determination of the uncertainty in the outputs so that decisions could be made such as
the height of freeboard, operation schemes for reservoir operation, etc. Dr. Williams was
the chief technical advisor for this effort.

QA/QC, 50 Bridge Scour Analyses, Caltrans, California - Principal in Charge and Senior
Project Manager. Responsible for quality control and assurance for over 50 bridge scour
analyses that were required under CalTrans seismic retrofit program. The projects ranged
state-wide but were concentrated mostly in desert environments in southern California.
Dr. Williams also acted as project manager for complicated situations that involved
innovative channel designs or scour protection requirements to minimize the impacts of
the bridge retrofit on channel scour. Several of these projects involved fluvial
geomorphic analyses.

Humboldt Bay Highway Seismic Retrofit Scour Evaluation Study - Caltrans planned to
seismically retrofit the highway bridge crossing Humboldt Bay near Eureka in Northern
California. The bridge is approximately 8,000 feet long, and crosses the bay in three
sections with two islands. The proposed retrofit would substantially increase the number
of piles at each pier and the size of the pile caps. Dr. Williams studied the seismically
retrofit using a 2-dimensional hydrodynamic model (using RMA-2) and a 2-dimension
sediment transport model (using SED2D) study was conducted to: (1) determine if the
larger bridge foundation might alter circulation patterns in the northern part of the bay,
(2) to evaluate the scour at the modified individual bridge piers, and (3) determine if
sediment transport processes in the bay might change sufficiently to cause increased
sedimentation in sensitive areas, such as a nearby marina. The study included a detailed
survey within 2,000 feet of the bridge, development of a detailed finite-element grid in
the vicinity of the bridge, model calibration, and model application. A 14-day tide,
including neap and spring cycles, was used to analyze the bay's circulation and sediment
transport response to normal conditions. A 100-year storm surge was used to evaluate
pier scour at the modified bridge.

EPA Selection Panel, Washington D.C. – Dr. Williams has served on 2 EPA selection
panels in the areas of ecological indicators and thresholds. The panel evaluated research
proposals from universities and non-profit organizations and made recommendations to
EPA on which proposals to approve. The panels were comprised of experts in the
engineering and naturals sciences. Dr. Williams was the only private consultant on each
panel, which was composed of academic and government personnel.

Lead Instructor and Course Notes Author – Dr. Williams developed short course notes
for and taught HEC-RAS, HEC-HMS, HEC-6, Bridge Scour, Fluvial Geomorphology,
Sediment Transport and Streambank Protection short courses for such entities as the
Floodplain Management Association of California and Nevada, Association of State
Floodplain Managers, American Society of Civil Engineers, Federal Highway
Administration, Flood Control District of Maricopa County, Riverside County Flood
Control and Water Conservation District, Ventura County Watershed Protection District,
the International Erosion Control Agency and numerous other state and federal agencies.
The courses were very technically oriented and geared to immediate implementation of
Development of State Standards for Floodplain Modeling, Arizona Department of Water Resources - Dr. Williams worked with the Arizona Department of Water Resources State Standards Work Group (SSWG) to develop a State Standard for floodplain modeling. The Standard provides guidance on mathematical modeling of hydraulic processes in watercourses and floodplains. Topics of interest included split flows, floodway encroachments, ineffective flow areas, breakout/overflow zones, alluvial fans, levee analysis, confluences, channel roughness characteristics and other topics. The study included evaluation of several 1-Dimensional hydraulic models. Four of the models were applied to four case studies and evaluated. The final product was the development of State Standard for Floodplain Modeling. This document provided guidelines and criteria for floodplain modeling and procedures for the preparation of submittals for floodplain hydraulic modeling as well as for the review and approval of models by local agencies.

Sevenmile Creek Restoration, SW Oregon – This project involved the restoration of Sevenmile Creek which included features to enhance the migration of various species of fish. Maximum use of historic creek features were implemented using natural channel design concepts. As the QA/QC of the project, Dr. Williams helped oversee the development of the concepts into plans and specification, which he was the engineer of record.

Reservoir Sedimentation Analysis for FERC relicensing, Alcoa Power Generating Inc. – Dr. Williams was in charge of this reservoir sedimentation study for the High Rock Dam in North Carolina. The client needed this information for the application for relicensing of the dam. The sediment transport model was used to evaluate the effects of the dam on sedimentation that had a potential to adversely affect adjacent infrastructure.

Examination of Hydraulic Rollers at Run of the River Dams, Illinios Dept. of Natural Resources, Springfield, IL – As technical advisor to this project, Dr. Williams provided technical guidance in developing solutions to the hydraulic roller problem at the downstream portion of the weir at Geneva Dam. The temporary solution was the placement of rock riprap at this location and its design based upon high turbulence conditions.

Cuddy Creek Restoration Study, Kern County, CA – This study for Kern Co. involved the sediment transport conditions for Cuddy Creek, which has been ravaged by materials mining. The study included evaluation of pre-existing conditions, existing conditions, and proposed conditions. These conditions were then used to determine any mitigation measure that would minimize the continuing adverse impacts of the historic mining as well as the proposed condition.

Sellar Gulch Restoration Study, Castle Rock, CO. – As technical advisor, Dr. Williams provided guidance in the fluvial geomorphology analysis for the restoration of Sellar
Gulch. This included extensive field reconnaissance of the project area and the use of geomorphic principles to determine the best slope and channel dimensions that would be self-sustaining.

Dam Breach Analyses for San Diego County Water Authority (SDCWA) – As principal in charge, Dr. Williams also acted as the technical advisor for this series of contracts to analyse numerous dam breach projects for SDCWA. This contact involved using the NWS DAMBreak model for FERC re-authorization of existing hydroelectric dams as well as for scenarios of raising dams to obtain additional storage and power. The results, which included numerous breach scenarios, output hydrographs and resulting inundation areas, were used to create new or revise Emergency Action Plans.

Evaluation and Re-Design of Palm Canyon Grade Control Structure, Riverside County Flood Control and Water Conservation District, CA – Dr. Williams was called upon to evaluate what caused the failure of the Palm Canyon grade control structure. This structure had a low flow notch in a riprap structure with a riprapped stilling basin. The work involved forensic engineering, examination of design and specification documents, and evaluation of construction techniques. He was then asked to redesign the grade control while salvaging as much material as possible and minimal rearrangement of the remaining existing structure.

Santa Clara River Emergency Streambank Protection for Ventura County Watershed Protection District, California - As the lead technical advisor, Dr. Williams and his team identified potential alternatives to the streambank erosion problem along the Santa Clara Creek which included a No-Action plan, as well as non-structural and structural solutions. The consensus alternative was the use of river training structures such as spur dikes along with minor bank protection. This alternative involved design considerations using geomorphic and natural channel design procedures, determining the dimensions of the low flow channel, scour analyses for preventing undermining of the spur dikes, and the orientation, spacing and dimensions of the spur dikes.

Evaluation of Fluvial-12 Sedimentation Model on Pole Creek for Ventura County Watershed Protection District, California - The sediment transport model Fluvial-12 was used by Chang and Associates to model a sedimentation basin and exit conditions on Pole Creek in Ventura County. The model results were used to justify the location and dimensions of the sedimentation basin as well as the channel dimensions of its outlet to the Santa Clara River. The Ventura County Watershed Protection District required an outside expert, Dr. Williams, to evaluate the Fluvial-12 model results and make recommendations on improvements to the model, if needed.

Santa Paula Creek Emergency Streambank Protection for Ventura County Watershed Protection District, California - As the lead technical advisor, Dr. Williams and his team identified potential alternatives to the streambank erosion problem along the Santa Paula Creek which included a No-Action plan, as well as non-structural and structural solutions. The consensus preferred alternative was the use of river training structures
such as Bendway Weirs and Spur Dikes. This alternative involved design considerations using geomorphic and natural channel design procedures, determining the dimensions of the low flow channel, scour analyses for preventing undermining of the spur dikes, and the orientation, spacing and dimensions of the spur dikes.

Evaluation of Sediment Transport and Scour Analyses of the Agua Fria River, Arizona, for the Flood Control District of Maricopa County - Dr. Williams headed this project in which the PSB&J team was asked to assess the validity of sediment transport and scour analyses that had been conducted on the Agua Fria River as well as conduct an independent study. The analyses included development of an HEC-6T sediment transport model, analyses of levee heights and determination of toe scour depths to protect the levees. The resulting report was use by the Flood Control District of Maricopa County to require the project owners to reconsider their design and use the techniques that were presented in the report.

Approximate Floodplain Study for Orange County, California - Dr. Williams and his team prepared an approximate floodplain study for the Orange County Flood Control District to delineate 100-year floodplains for the East Garden Grove - Wintersburg Channel (C05), the Ocean View Channel (C06), and seven tributaries to the C05 channel. This project was undertaken by the District to facilitate lifting of the Santa Ana River floodplain (zone A99) after the completion of the Santa Ana River flood protection project by the U.S. Army Corps of Engineers (Corps). The Corps project has controlled breakout flows from the Santa Ana River (SAR), but the flooding from other sources underlying the SAR floodplain, needed to be delineated before the A99 zone was lifted by FEMA. The study area is located in the Cities of Huntington Beach, Fountain Valley, Westminster, Santa Ana, Garden Grove, Anaheim, and Orange, in Orange County, California. The C05 and C06 channel system consists of a complex network of leveed channels, storm drains, and detention basins that convey stormwater runoff from highly urbanized low-lying interior areas to the Pacific Ocean. About 16 miles of flood control channels were analyzed using an approximate hydraulic analysis with the Corps HEC-RAS program. The C05 channel laterals were analyzed using various computer programs including the Corps HEC-RAS program and the HEC-2 program with the split-flow option, and the Los Angeles County Flood Control Districts WSPG program. To obtain a model for an approximate level of analysis, all levees, bridges, and culverts, were removed from the cross-sections. Engineering judgment was used to interpret the model results based on output that appeared reasonable in accordance with field observations. Field observations were used to verify flow directions, track flow paths, and evaluate the effect of floodplain features such as elevated highway embankments. Approximate studies in urban environments can be especially challenging because of the need to make appropriate assumptions in order to simplify complex hydrologic and hydraulic phenomena. A Zone A approximate 100-year floodplain was delineated. The results of the study satisfied FEMA requirements and were subsequently published for the benefit of the community. Dr. Williams was the Project Manager and Principal in Charge.

Cherokee Wash Hydraulic/Sediment Analysis, Paradise Valley, Arizona - Hydrologic, hydraulic, and sedimentation studies were performed for the Maricopa County Flood
Control District to evaluate options to alleviate flooding and sediment problems. Existing HEC-1 models were evaluated and modified to reflect current and with-project (flow diversions) hydrologic conditions. The existing HEC-2 model was reviewed and found unsuitable; therefore a new model was created to evaluate current hydraulic conditions including controls and flow break-out points. An HEC-6 model was prepared for sedimentation studies of the wash; a sediment sampling program was designed by WEST, and the gradation results were used in the model. Channel sediment continuity and geomorphic analyses were also performed, and the study results were used to render opinions on the need for grade control, sedimentation basins, and maintenance of the project.

Cumulative Effects Study of Sedimentation Impact, Upper Mississippi River - Dr. Williams helped quantify the cumulative man-made and natural effects on sedimentation, stream morphology and ecology along the Upper Mississippi River (UMR) and IWW and predicted future conditions for the year 2050. The study area involves 5 states, 3 Army Corps of Engineer's Districts, and about 1,200 river miles. The geology and glacial history of the study area was analyzed to define the influences and controls on channel morphology. Hydrologic records were examined to identify changes in discharge and stage along the UMR. Available research was reviewed to define potential impacts of global climate change on basin hydrology. The history and extent of human influences on the fluvial system were characterized. Historic plan form and channel geometry data were analyzed to quantify changes in channel morphology. The sources and sinks of sediment along the UMR were quantified and a sediment budget developed to estimate backwater sedimentation rates in navigation pools. Historic changes in nine geomorphic categories were characterized throughout the study area. Predictions of geomorphic conditions along the UMR and IWW in the year 2050 were developed based on trends identified from historic geomorphic data and results of the sediment budget. Ecological conditions in the year 2050 were predicted based on ecological guilds and the trends established for aquatic habitat.

Eastern Arkansas Water Supply Study - Study included extensive model application and model calibration to analyze the effect of in-basin water transfers on surface water flow magnitude, frequency, and duration in the La Grue Bayou stream network using Corps of Engineers' programs HEC-1, HEC-2, HEC-DSS, and HEC-FFA. A unique feature to this study was the application of the Memphis District's program HUXRAIN to develop long term (50 years) synthetic discharge hydrographs using calibrated antecedent precipitation index coefficients, a long term rainfall data base, and computed unit hydrographs for the sub-basins. Another component of this work was an interior hydrology study for the city of Clarendon, Arkansas. Several scenarios were analyzed using HEC-IFH for continuous simulation with 50 years of data.

IDIQ for Los Angeles District Corps of Engineers - During this IDIQ contract for hydrology and hydraulics with the Los Angeles District, Dr. Williams and his team completed multiple work orders. A spillway inundation study was conducted for Carbon Canyon simulating dam break using HEC-RAS. A two-dimensional link node model was applied to Mission Creek in Santa Barbara to evaluate flooding due to overspilling of the
channels to lower elevations and connector streams. In the Santa Margarita river watershed study, HEC-1, HEC-2 and HEC-6 were used to evaluate flooding extents and sedimentation problems in the river. Two channel restoration and environmental enhancement plans were developed in Phoenix area for the Tres Rios and Rio Salado projects. Tres Rios involved HEC-6 modeling and Rio Salado had both HEC-RAS and HEC-6 models developed for the Salt River. A major flood map revision study and levee analysis report was conducted for the Los Angeles River and Compton Creek, resulting in hundreds of thousands people taken out of the 100 year regulatory floodplain. During this study, numerous HEC-2 models were modified to reflect levee system changes made by the Los Angeles District. Overbank models were also modified to analyze split flow conditions.

Lindo Lake Park Water Quality Study, Lakeside, California - Dr. Williams conducted detailed study of water quality conditions, to evaluate lake rehabilitation alternatives, and to develop a restoration plan to improve water quality conditions and to support a wide array of beneficial uses, including active recreation for Lindo Lake Park. Lindo Lake Park Water Quality Study. The Lindo Lake Park Water Quality Study was comprised of five major tasks: 1) public meetings; 2) report on inventory, bibliography and proposed methodology; 3) Quality Assurance Project Plan according to EPA guidelines; 4) Water quality study and associated technical report; and 5) Implementation plan.

Minnesota and Red River CWMS Watershed Modeling, U.S. Army Corps of Engineers, St. Paul District - To establish a flood forecasting system and reduce future flood damage in the Red River of the North basin (4,010 square miles) and Minnesota River basin (1,770 square miles), Dr. Williams, along with his staff and the U.S. Army Corps of Engineers, St. Paul District (the Corps), developed a Corps Water Management System (CWMS) model to assist in real time operation of the reservoirs to regulate reservoir outflows. Dr. Williams’ team developed snow process, hydrologic, water control, and hydraulic models that will be incorporated by the Corps into CWMS as model components. The modeling work included development, calibration, and verification of the Distributed Snow Process Model (DSPM), HEC-HMS, HEC-ResSim, and HEC-RAS models.

Pipeline Crossings over Desert Rivers and Washes, Arizona and New Mexico - Dr. Williams was Project Manager and Project Engineer for numerous Pipeline Crossings over Desert Rivers and Washes in Arizona and New Mexico for the El Paso Natural Gas Company. These efforts required the understanding of fluvial geomorphology, alluvial fan flooding, sediment transport and short duration/high peak discharge as related to desert hydrology.

Potrero Creek In-Channel Sedimentation Basin Alternative Study, Ventura, California - Ventura County Flood Control District (VCFCD) proposed building one or more in-channel sedimentation basins to reduce the incoming sediment load from Potrero Creek from reaching the homes located in Lake Dr. Williamslake in Ventura, California. Dr. Williams evaluated the effectiveness of their various sedimentation basin plans. Dr. Williams formulated a plan to first estimate the average annual sediment yield from
Potrero Creek and then model the system using HEC-6T, the sediment transport software package developed by the U.S. Army Corps of Engineers. Dr. Williams estimated average annual sediment yield using two different methods. The first method involved numerical integration of sediment yield-frequency curves for four contributing sub-watersheds provided by the VCFCD. The second method applied U.S. Geological Survey methodology based on a curve of long-term sediment yield in nearby mountain watersheds in Los Angeles and Ventura Counties to the VCFCD data. The sediment yield-frequency curve and U.S.G.S. methods provided two cases for input into sediment transport model.

Restoration/Environmental Enhancement Plans, Tres Rios and Rio Salado Projects, Los Angeles Corps of Engineers, Phoenix, Arizona - Principal in charge and Senior Project Manager: Two channel restoration and environmental enhancement plans were developed in Phoenix for the Tres Rios and Rio Salado projects for the Los Angeles Corps of Engineers. Tres Rios involved HEC-6 modeling, and Rio Salado had both HEC-RAS and HEC-6 models developed for the Salt River through Phoenix, AZ. The work involved the use of fluvial geomorphology principles and took into consideration the effects of san/gravel mining activities. The project also required coordination with biologists and botanists to establish a well-balanced environmentally sound project and still meet the flood control requirements.

Wellhead Protection Plan for the Los Angeles Corps of Engineers, Planning Division, San Luis, Arizona - The components included the delineation of wellhead protection areas, the compilation of a contaminant source inventory, the development of management tools to protect the groundwater and the formulation of a contingency plan for both short and long term losses of one or more wells.

Two-Dimensional Study of the Missouri River, Chamois Reach, USACE, Kansas City District IDC - Dr. Williams was Principal in Charge for a 2-D study of the Missouri River called the Chamois reach between RM 116.5 and RM 113.5. The model used was RMA2, which is a part of the WMS system. It was used to identify low and medium flow habitat areas and the depths and velocities associated with those areas. The results were used to determine opportunities for habitat enhancements.

Various Projects for the Flood Control of Maricopa County - Dr Williams was the Principal-in-charge of several sediment transport studies (Agua Fria, Salt, and Gila Rivers) for the Flood Control District of Maricopa County in Arizona. The purposes of these studies were to develop sediment models that could be used as predictive and management tools. The developed sediment transport models served to evaluate potential effects on channel stability of bank protection measures, floodplain encroachments and sand and gravel mining operations along the rivers.

St. Tammany Flood Control Analysis, U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana - Dr. Williams and his engineers developed a conceptual flood management plan for St. Tammany Parish in southeast Louisiana. Flood management in St. Tammany Parish was a unique challenge, with 100 square miles
drained by a complex network of natural bayous and man-made canals. Hydrologic and hydraulic models were needed to evaluate existing conditions and compare flood management alternatives. The results of the hydrologic models provided the input for hydraulic modeling to the New Orleans District Corps of Engineers with useful answers about their proposed flood management plan, allowing the District and the citizens of St. Tammany Parish to make informed decisions about their watershed.

Ventura County Flood Control District, Calleguas Creek Sediment Transport Study, Ventura, California - An HEC-6T sediment transport model was prepared for Calleguas Creek, Arroyo Las Posas, and Arroyo Simi in Ventura County to establish baseline conditions and to evaluate proposed channel improvements. The model extends 25 miles from State Highway 1 near the mouth at Mugu Lagoon to upstream of Hitch Boulevard in the vicinity of Moorpark. Inflowing sediment loads and sediment discharge to Mugu Lagoon were calibrated to records of historical sediment deposition in the lagoon, historical bed changes in the channel, and records of maintenance sediment removals. A long term hydrological simulation (50 years) was used in HEC-6T to evaluate proposed grade control structures, sediment basins, and other channel improvement options in Calleguas Creek and to determine their effectiveness in reducing sediment inflow to the lagoon.

West Tennessee Tributaries Project Limited Evaluation Study, Tennessee - A reconnaissance level analysis was conducted to evaluate the proposed restoration of old river meanders that were cut off from the Middle Fork Forked Deer River by historical channelization projects. This study included an extensive combination of hydrological, hydraulic, and sediment transport simulations, using historical rainfall and runoff records, current field data, and calibration to 1960 and 1979 channel geometry survey data. In addition to Corps of Engineers' programs HEC-1, HEC-2, HEC-DSS, HEC-FFA, and HUXRAIN for surface water flow modeling and standard computer program HEC-6 for sediment transport analysis, the newer HEC-6T, "Sedimentation in Stream Networks", developed by William A. (Tony) Thomas, was used to evaluate the sediment transport of flow converging and diverging at the junctions of the main channel and the old meanders. A sediment-weighted histogram generator modified by WEST Consultants was used to generate the hydrology input for the HEC-6 programs. Designs for rock riprap diversion weirs and bridge protection, and an in-line sediment trap were developed in this study.

White River Unsteady Flow Model, Arkansas - An unsteady flow model using the computer program UNET was developed for 70 miles of the White River in eastern Arkansas. Model parameters were calibrated to historical stage and flow records before executing two 47 year simulations. Simulations were run for existing conditions and conditions after installation of an inlet canal and pumping station for an irrigation scheme. Results were provided to the District to help them evaluate effects of the irrigation project on the river. A second part of this project involved evaluation of the irrigation canals for sediment transport and scour/deposition. The computer program SAM was used to help determine stable channel parameters and the amount of scour/deposition that could be expected with the District's design geometry and slope.
Wolf River Reconnaissance Study, Tennessee - Included a hydraulic and sedimentation analysis for approximately 75 miles of the Wolf River in western Tennessee. An HEC-2 model for the lower reaches was extended with new survey data into the upper watershed. A HEC-6 model was then developed to evaluate the effect of grade stabilization weirs, environmental enhancement weirs with permanent pools, and reductions in inflowing sediment loads from 9 tributaries in the upper watershed. HEC-1 was used to compute unit hydrographs for calibration to stream gage data. The sediment-weighted histogram generator program was used to construct the HEC-6 input hydrology. The results of a 25-year future simulation were evaluated in terms of vertical bed elevation changes over time and volumetric changes in sediment deposited and scoured on a reach by reach basis.

Expert Testimony and Support

Expert Consultant: Subdivision Flooding, for City of Reno, NV
Expert Consultant: Analysis of Milltown Dam Removal and Potential Deposition at Thompson Falls Reservoir, Montana, for Pennsylvania Power and Light
Expert Consultant: FERC relicensing, North Carolina, for Alcoa Power Generating Corporation
Expert Consultant: Scour Evaluation of Grading Plan Changes for Cyrus Wash, for Kern County, CA
Expert Consultant: Baker River FERC relicensing, WA, for Puget Sound Energy
Expert Consultant: Blackfoot and Clark Fork River Restoration Plan, Montana for unnamed client
Expert Consultant: Agua Fria River Streambank Scour Analyses, Phoenix, AZ, for Flood Control District of Maricopa Co., AZ
Expert Consultant: Erosion and Drainage, Newport Beach, California, for private client
Expert Consultant: Subdivision Flooding Problems and Floodplain Mapping Procedures, Dayton, Ohio, for private client
Expert Consultant: Flooding Problems, Unnamed creek, Los Angeles, California, for private client
Expert Testimony: Murrieta Creek Flooding, Riverside County, California, for Riverside Co. Flood Control District
Expert Testimony: Flooding Potential and Analysis of Coconut Grove, Kailua, Oahu, Hawaii, for private client
Expert Consultant: Subdivision Flooding Problems, Waialae Iki V, Oahu, Hawaii, for private client
Expert Testimony: Flood Problems at Carlton Oaks Country Club, Santee, California, for private client
Expert Consultant: Alpine Mobile Home Park Flooding, Alpine, California, for private client
Expert Consultant: River Effects of Sand Mining Operations, San Luis Rey River, California, for private client
Expert Testimony: Pecos Road Pipeline Scour, Phoenix, Arizona, for El Paso Natural Gas Company
Expert Consultant: San Diego Creek Revetment Failure, Irvine, California, for private client
Expert Consultant: San Luis Obispo Creek Flooding, San Luis Obispo, California, for private client

**Floodplain Hydraulics and Flood Protection**

Reconnaissance Study Report and Project Management Plan for the Tijuana River Watershed Study – USACE Los Angeles District
Spillway, Outlet, and Stilling Basin Design for Reelfoot Lake Sedimentation Basin – USACE Memphis District
FEMA Studies of River System near Huntington Beach, Orange County, California
River System Studies near Huntington Beach for Orange County for Submittal to FEMA, Orange County, California
FEMA Studies of 27 Streams in the Unincorporated Areas of San Diego County, California
Hydraulic Analysis and Levee Elevation Design of West Williamson, West Virginia, Flood Control Project
Flood Information Study of Pineville, Kentucky
Murrieta Creek Flood Control and Environmental Restoration Project – USACE Los Angeles District
Hydraulic Design of Supercritical and Subcritical Flood Control Channels for the Rio Puerto Nuevo Flood Control Project, San Juan, Puerto Rico
Flood Control Channel Design, Buena Vista Creek, Vista, California, City of Vista
Forest Falls Community Flood Warning System - USACE Los Angeles District

**Sedimentation and Scour Evaluations**

Harrow Debris Basin Overtopping Analysis, Los Angeles County, California
Bridge Scour Analyses, Various locations, California Department of Transportation
Ashtabula River Hazardous Waste Project, Ohio
Tia Juana River Valley Surface and Groundwater Water Budget Analysis, San Diego, CA
Sedimentation Investigations of Boeuf River and Tributaries, Louisiana
Sedimentation Analysis of a Cutoff for the Barbourville, Kentucky, Flood Control Project
Analysis of the Effects of Strip Mining on Project Life of Martin's Fork Reservoir, Kentucky
Sedimentation Surveys and Analyses of J. Percy Priest Reservoir, Tennessee
Sedimentation Surveys and Analyses of Laurel River Reservoir, Tennessee
Sedimentation Surveys and Analyses of Martin's Fork Reservoir, Kentucky
Sedimentation Study of the St. Lucie River and Estuary, Florida
Sedimentation Analysis and Debris Basin Design for the Rio Puerto Nuevo Flood Control Project, San Juan, Puerto Rico
Determination of Sediment Yields after the Mt. St. Helens Eruption, Washington
Modeling the Sedimentation Effects of the Removal of the Washington Water Power Dam, Lewiston, Idaho
Sedimentation and Dredging Maintenance Requirement Study for the Rochester, Minnesota, Flood Control Project
Sedimentation Study of Tuttle Creek Reservoir, Kansas
Sediment Yield and Debris Basin Evaluation of Goleta, California, Flood Control Project
Sedimentation and Sediment Yield Study of the Harding Ditch, East St. Louis, Missouri, Flood Control Project
Analysis of Sediment Exclusion and Ejection System of the Igdir Irrigation Project, Turkey, for the World Bank
Reservoir Sedimentation Study of Shoccoe Dam, Jackson, Mississippi
Evaluation and Assessment of Sedimentation in the White Nile River and Irrigation Schemes, Sudan, for the World Bank
Zink Dam Sedimentation Study, Arkansas River, Tulsa, OK
Erosion and Sedimentation Analysis of South Coast Materials Mine Reclamation Plan, Buena Vista Creek, Carlsbad, California
Incipient Motion Analysis of Spawning Gravel, Cedar River, Renton, Washington

**Stable Channel Analysis**

San Luis Rey Levee Design and Sediment Transport Analysis
Sediment and Stable Channel Analysis of Pipeline Crossings for El Paso Natural Gas Company, Northern New Mexico and Arizona
Channel Stability Study of the Salt/Gila River Project, Arizona
Sediment and Channel Stability Study of the Gallup, New Mexico, Flood Control Project
Keene Ranch Stable Channel Assessment, Bakersfield, California
Stability Assessment of Sewer Pipeline, Tia Juana River, San Diego, California
Channel Stability Analysis, East Memphis, Arkansas

**Water Quality and Groundwater**

Caltrans NPDES Permit Project, Los Angeles County, CA
Keene Ranch Groundwater Quality and Quantity Modeling, Bakersfield, California
Turbidity Plume Analysis of Open Ocean Disposal for the Tampa Bay Deepening Project, Florida
Predictions of the Effects of Structural Alternatives on Turbidity in the St. Lucie Canal at Port Mayaca, Florida
Determination of Light Extinction Coefficients for Lakes and Reservoirs for use in Water Quality Mathematical Models
Analysis of the Behavior of Fine Sediments in Reservoirs for Environmental and Water Quality Operation Systems (EWQOS) Program
PCB Transport Study for the Hudson River, New York

Other

Analysis of Proposed Hydraulic Dredging for Construction of Gallipolis Lock and Dam, West Virginia
Design of Sedimentation Basins and Erosion Control Measures, Tennessee- Tombigbee Waterway Project
Dredged Material Disposal Site Analysis in an Ocean Environment for the Tampa Bay Deepening Project, Florida
Assisted in the Development of the Cohesive and Network Versions of the Computer Program, "HEC-6, Scour and Deposition in Rivers and Reservoirs"
Evaluation of Structural Alternatives of a Sediment Retention Dam on the Toutle River For Hyper concentration Sediment Conditions from Eruption of Mt. St. Helens, Washington
Debris Analysis of a Proposed Tunnel Cutoff for the Harlan, Kentucky, Flood Control Project
Preparation of the new HEC-6 Manual (Scour and Deposition in Rivers and Reservoirs) for the Hydrologic Engineering Center, Davis, California
Kern River Ordinary Highwater Litigation, Bakersfield, California
Erosion Control Plan, Rancho Verde Development, Escondido, California
Development of Forest Sedimentation Management Plan, Tongass National Forest, Alaska, U.S. Forest Service
Development of Water Resources/Geomorphology Small Stream Classification System, State of Washington, Department of Natural Resources
Development of Computer Based Design Program for Gabion Lined Channels
Development of Computer Based Design Program for Riprap Channels
Development of Channel Design using Geosynthetics Computer Program

Professional Society Activities

American Society for Testing and Materials, Member - D18.25, Committee on Erosion and Sediment Control Technology, 2001 - present
American Society for Testing and Materials, Member - D19 Committee on Water, 1983 – present
American Society of Civil Engineers (ASCE), Past Chair, Sedimentation Committee, 1992 - 1996
American Society of Civil Engineers (ASCE), Past Chair, Computational Hydraulics Committee, 1999 - present
American Society of Civil Engineers (ASCE), Member, Committee on Management Practice for Control of Erosion and Sediment (MPCES), 2005 – present
American Society of Civil Engineers (ASCE), Chair, Committee on River Restoration, 2006 - present
American Society of Civil Engineers (ASCE), Chair-Task Committee; Analysis of Laboratory /Field Sediment Data Accuracy and Availability, 1987-1991
International Erosion Control Association, Board of Directors, 1990
International Erosion Control Association, President, 1994-1995
International Erosion Control Association, Vice President-1995
International Erosion Control Association, Member, 1998
International Erosion Control Association, President, 1998-1999

**Instructional Experience**

P.E. Review Course, Hydrology and Hydraulics; University of California, San Diego
Use of Fluvial Geomorphology Principles in the Design of Natural Channels, for ASFPM
HEC-RAS, Basic and Advanced, taught for various organizations and ASCE at various locations
HEC-HMS, taught for various organizations and agencies at various locations
HEC-2, Basic and Advanced, taught for ASCE at various locations
Advanced HEC-2, Hydrologic Engineering Center, Davis, California
Fluvial Geomorphology, for various organizations
Stream Restoration, for numerous agencies
Streambank Protection, for numerous agencies
Bridge Scour Analysis, taught for ASCE at various locations
Hydrology and Hydraulics for non-Engineers, various locations
Open Channel Hydraulics, San Diego State University, San Diego, California
Water Surface Profile Computation Using HEC-2, Advanced, HEC, Davis, California
Engineering Problem Analysis, San Diego State University, San Diego, California
FESWMS-2DH, WEST Consultants, San Diego, California
Sedimentation in Forested Watersheds, Alaska and Montana
Civil Engineering Planning, University of California, Davis, California
Sediment Transport Course, HEC, Davis, California
Spatial Data Management, HEC, Davis, California
Water Quality in Rivers and Reservoirs, HEC, Davis, California
Sedimentation in Rivers and Reservoirs, HEC-6, HEC, Davis, California
Sedimentation Analysis, Waterways Experiment Station (WES), Mississippi
Sediment Transport in Reservoirs and Inland Waterways, WES, Mississippi
Numerical Modeling for Engineers, WES, Vicksburg, Mississippi
Hydraulic Design of Flood Control Channels, WES, Mississippi
Water Surface Profile Computations on the Microcomputer, Fort Collins, Colorado
HEC-6, Sediment Transport Modeling, various locations
Stable Channel Design, Memphis State University, Memphis, Tennessee
Bank and Channel Protection in Rivers, (IECA), Vancouver, BC, Canada
Short Course on Sediment Problems in Rivers, Oregon State University
Calculus I-IV, Hinds Junior College (HJC), Vicksburg, Mississippi
Differential Equations, HJC, Vicksburg, Mississippi

Other

Analysis of Proposed Hydraulic Dredging for Construction of Gallipolis Lock and Dam, West Virginia
Design of Sedimentation Basins and Erosion Control Measures, Tennessee- Tombigbee Waterway Project
Dredged Material Disposal Site Analysis in an Ocean Environment for the Tampa Bay Deepening Project, Florida
Assisted in the Development of the Cohesive and Network Versions of the Computer Program, "HEC'6, Scour and Deposition in Rivers and Reservoirs"
Debris Analysis of a Proposed Tunnel Cutoff for the Harlan, Kentucky, Flood Control Project
Preparation of the new HEC-6 Manual (Scour and Deposition in Rivers and Reservoirs) for the Hydrologic Engineering Center, Davis, California
Kern River Ordinary Highwater Litigation, Bakersfield, California
Erosion Control Plan, Rancho Verde Development, Escondido, California
Development of Computer Based Design Program for Gabion Lined Channels
Development of Computer Based Design Program for Riprap Channels

Publications

Conference Papers


Williams, David T., “Tips on Using the Dambreak Option in HEC-RAS,” Proceedings,


Williams, David T., and Teal, Martin J., "Between A Rock And A Soft Place: Which Riprap Method Should I Use for My Project?" Proceedings, ASCE and EWRI 2000 Joint


Williams, David T., "Purpose and Activities of the Task Committee on Analysis of Laboratory and Field Sediment Data Accuracy and Availability," Proceedings, ASCE Hydraulics Conference, New Orleans, Louisiana, August 1989.


Selected Reports, Manuals, Journal Papers and Articles


Williams, David T. "Examination of Sediment Exclusion and Ejection Aspects of the Igdir, Turkey Irrigation Project," Prepared for the World Bank, USAE Waterways Experiment Station, Vicksburg, Mississippi, 1987.


Williams, David T. "Tampa Bay Dredged Material Disposal Site Analysis," Miscellaneous Paper HL-83-8, USAE Waterways Experiment Station, Vicksburg, Mississippi, October 1983.

Williams, David T. "Sedimentation Study for Rochester, Minnesota, Flood Control Project," Miscellaneous Paper HL-83-7, USAE Waterways Experiment Station, Vicksburg, Mississippi, October 1983.


**Honors and Awards**

Small Business Person of the Year, Chamber of Commerce, Carlsbad, California, 1993
Fellow, American Society of Civil Engineers
Diplomate, American Academy of Water Resources Engineers
U.S. Army Commendation Medal
U.S. Army Commendation Medal with Oak Leaf Cluster